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QUATERNARY GEOLOGY OF THE TUKTOYAKTUK COASTLANDS, NORTHWEST TERRITORIES

V.N. Rampton

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Cover

Deformed ice till exposed in headwall of retrogressive-thaw flow slide just north of Mallock Hill.

Critical Reader

J-S. Vincent

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Preface

The Quaternary geology of the Tuktoyaktuk Coastlands was initially investigated by the Geological Survey of Canada in the 1960s because of active exploration for oil and gas. Continuing exploration in the Beaufort Sea region has resulted in the need for support and transportation facilities throughout the Tuktoyaktuk Coastlands and has emphasized the importance of the surficial geology studies.

This report by Dr. Rampton synthesizes the observations made during the last two decades. It establishes the sequence and age of Quaternary deposits and landforms; the distribution of permafrost and ground ice relative to the various Quaternary landforms and stratigraphic sequences; and the effect of modern, especially periglacial, process upon the landscape. These data provide an essential background for planning rational land use in an area of thick Quaternary sediments and permafrost.

R.A. Price
Assistant Deputy Minister
Geological Survey of Canada

Préface

La géologie du Quaternaire du littoral de Tuktoyaktuk a fait l'objet de travaux par la Commission géologique du Canada dès 1960 à cause d'une exploration active du pétrole et du gaz. L'exploration continue de la région de la mer de Beaufort a commandé un développement de l'infrastructure et des moyens de transport et partant à amplifier l'importance des recherches en géologie des formations en surface.

Ce rapport de V.N. Rampton constitue une synthèse d'observations d'une dizaine d'années; il établit la séquence et l'âge de sédiments et de paysages quaternaires; il met en évidence la distribution du pergélisol et de la glace dans le sol en fonction de multiples séquences stratigraphiques et de paysages du Quaternaire et de l'effet récent, notamment périglaciaire, de processus agissant sur le relief. Ces données apportent un apport essentiel dans la planification rationnelle de l'occupation du sol dans les régions à sédiments et pergélisols profonds quaternaires.

R.A. Price, sous-ministre adjoint
Commission géologique du Canada

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QUATERNARY GEOLOGY OF THE TUKTOYAKTUK COASTLANDS, NORTHWEST TERRITORIES

Abstract

The Tuktoyaktuk Coastlands consist of a thick wedge of Pleistocene marine and fluvial sediments that contain much ground ice and have been modified by glaciation and thermokarst. East of Nicholson Peninsula the Stanton Sediments, consisting of a basal clay member, lower complex member, thinly bedded member, and an upper sandy member, represent Middle Pleistocene deposition in marine and alluvial environments. West of Nicholson Peninsula, Kendall sediments and Hooper clay of marine origin underline the Kidluit Formation of alluvial origin. Kidluit Formation is overlain by the Kittigazuit Formation, a thick fine grained deltaic sand of likely glaciofluvial origin.

Northwesterly moving continental (Laurentide) ice defined a glacial limit on Cape Bathurst peninsula around unglaciated terrain to the north during the Mason River Glaciation of Middle Pleistocene age. Major strandlines marking marine limits were formed in this area during the Horton and Harrowby marine episodes (seas) of Middle Pleistocene age. Also in this region low marine benches, some inset into glaciated terrain, are likely Sangamonian in age as they contain organic-bearing deposits (Ikpisugyuk Formation) indicative of interglacial climate.

Northwesterly flowing continental ice again covered most of the area during the Toker Stade of Early Wisconsinan age. Sediments were glacially deformed in peripheral areas; till (Toker Point Member) and outwash (e.g., Turnabout Member, Garry Island Member, and Cape Dalhousie Sands) grading to relatively high sea levels were deposited. During the likely equivalent Franklin Bay Stade, westerly moving ice from Amundsen Gulf impinged on the eastern coast of Cape Bathurst peninsula. Ground ice, common to most of the area, was formed during deglaciation. During the Sitidgi Stade of Late Wisconsinan age, Laurentide ice persisted in the southern Mackenzie Delta and Sitidgi Lake areas and deposited till (Sitidgi Member). Sediments of a large proglacial valley train (Portage Point Sands) and a large proglacial lake (Eskimo Lakes Member) formed in the unglaciated Eskimo Lakes area during this stade.

Extensive thermokarst activity during the Holocene produced thermokarst deposits (Parsons Lake Formation) and resulted in the formation of the ice-cored topography. During Late Wisconsinan and Holocene, valleys that had been eroded during the Wisconsinan were drowned and filled with thick fine grained alluvium. The Mackenzie Delta, consisting mainly of fine sand and silt (Aklavik Formation) and characterized by many thermokarst lakes, was formed. Rapid retreat of exposed coastlines has occurred. Periglacial processes and minor eolian activity and peat accumulation continued throughout the Holocene.

Ground ice and subsidence resulting from its thaw represent major hazards to development as does flooding of low-lying areas. Sand fill is a common resource, but coarser aggregate is only locally available.

Résumé

La zone côtière de Tuktoyaktuk comprend un épais biseau de sédiments marins et fluviatiles du Pléistocène; ces derniers contiennent une grande quantité de glace dans le sol et ont été modifiés par les glaciations et le thermokarst. A l'est de la péninsule de Nicholson, les sédiments de Stanton, qui se composent d'un membre argileux basal, d'un membre complexe inférieur, d'un membre finement lité, et d'un membre sableux supérieur, représentent la sédimentation du Pléistocène moyen dans les milieux marins et alluviaux. A l'ouest de la péninsule de Nicholson, les sédiments de Kendall et l'argile de Hooper, d'origine marine, reposent sous la formation de Kidluit, d'origine alluviale. Cette dernière est recouverte par la formation de Kittigazuit constituée, elle, d'un épais sable deltaique à grain fin, d'origine probablement fluvio-glaciaire.

La glace continentale se déplaçant vers le nord-ouest (inlandsis des Laurentides) a défini au nord, durant la glaciation de Mason River survenue au cours du Pléistocène moyen, une limite glaciaire sur le péninsule du cap Bathurst, autour de terrains non recouverts par les glaces. Durant les épisodes marins de Horton et de Harrowby (mers) au cours du Pléistocène moyen, s'y sont formées d'importantes lignes de rivage indiquant les limites marines. Toujours dans cette région, des banquettes marines basses, certaines situées dans des terrains ayant été recouverts par les glaces, datent probablement du Sangamonien, puisqu'elles contiennent des dépôts renfermant des matières organiques (formation d'Ikpisugyuk) qui témoignent de la présence d'une période de climat interglaciaire.

Les glaces continentales s'écoulant vers le nord-ouest ont de nouveau recouvert la majeure partie de la région durant le stade de Toker, survenu au cours du Wisconsinien inférieur. Les sédiments ont été déformés par les glaces dans les zones périphériques; le till (membre de Toker Point) et les dépôts d'épandage fluovio-glaciaire (p. ex. membre de Turnabout, membre de Garry Island, et sables de Cape Dalhousie) sont inclinés en direction de niveaux marins relativement élevés. Durant le stade probablement équivalent de Franklin Bay, des glaces se déplaçant vers l'ouest à partir du golfe d'Amundsen ont empiété sur la côte est de la péninsule du cap Bathurst. Durant la déglaciation, il s'est formé de la glace dans le sol, très répandue dans la majeure partie de la région. Durant le stade de Sitidgi au cours du Wisconsinien supérieur, les glaces de l'inlandsis des Laurentides ont subsisté dans les régions du sud du delta du Mackenzie et du lac Sitidgi, et ont déposé du till (membre de Sitidgi). La mise en place des sédiments d'une grande traînée morainique d'origine proglaciaire (sables de Portage Point) et la formation d'un vaste lac proglaciaire (membre d'Eskimo Lakes) dans la région non recouverte par les glaces des lacs des Esquimaux, ont eu lieu durant ce stade.

Durant l'Holocène, une activité thermokarstique de grande envergure a donné lieu à des dépôts de thermokarst (formation de Parsons Lake) et à la formation d'une topographie de monticules à noyaux de glace. Durant le Wisconsinien supérieur et l'Holocène, des vallées qui avaient subi les effets de l'érosion au Wisconsinien ont été inondées et remplies d'épaisses couches d'alluvions à grain fin. La formation du delta du Mackenzie, principalement composé de sables fins et de limons (formation d'Aklavik) et caractérisé par de nombreux lacs de thermokarst, date de ce moment. Les lignes de rivage exposées ont rapidement reculé. Les processus périglaciaires, une activité éolienne peu importante, et l'accumulation de tourbe, se sont poursuivis pendant tout l'Holocène.

La présence de glace dans le sol et l'affaisement du sol résultant du dégel de cette glace, présentent de sérieux dangers à tout travail d'aménagement, de même que l'inondation des zones basses. Les matériaux de remblai sableux sont une ressource bien répandue, mais on ne trouve que par endroits des agrégats plus grossiers.

SUMMARY

Tuktoyaktuk Coastlands consist of that part of the Arctic Coastal Plain characterized by thick Pleistocene marine and fluvial sediments, which are capped by till and which are much modified by thermokarst. Mackenzie Delta is a large Holocene delta whose surface is marked by numerous lakes. Anderson Plain borders the southeast edge of Tuktoyaktuk Coastlands and Yukon Coastal Plain and Richardson Mountains border the west edge of Mackenzie Delta (Fig. 1).

Bedrock underlying the Quaternary deposits is primarily Cretaceous and Tertiary, although older rocks are present west of Mackenzie Delta and south of Inuvik (Fig. 6).

The area is characterized by long cold winters and short cool summers; precipitation is meagre. Low arctic tundra covers most of the area with forest-tundra and boreal forest present only along its southern fringe (Fig. 8).

Permafrost exists throughout the area, although taliks are present under lakes and river channels. Maximum permafrost thickness is believed to be 700 m under northeastern Richards Island. Annual near-surface ground temperatures are as low as -10°C at the north end of Tuktoyaktuk Peninsula, whereas those on the distal part of the Mackenzie Delta are as high as -2°C.

Ground ice in the form of ice crystals, lenses, sheets, wedges, seams, and irregular masses is common throughout the area. Extensive sheets of massive ice, overlain by materials of variable composition but underlain generally by coarse grained sediment, are commonly more than 13 m thick. The presence of ground ice and its irregular thaw has resulted in the formation of a number of phenomena such as polygons (Fig. 10), pingos (inset, Map 1647A), ice-cored topography including involuted hills (Fig. 2, 18) and retrogressive-thaw flow slides (Fig. 14; inset, Map 1647A).

The Horton Sea marine limit is marked by an escarpment eroded in bedrock at elevations near 75 m on Cape Bathurst peninsula (Fig. 20). Horton Sea is believed to be an interglacial sea of Middle Pleistocene age. Some unconsolidated sediments lying on the wave-planated surface may have been deposited during the Horton Sea episode.

SOMMAIRE

La zone côtière de Tuktoyaktuk est formée de cette partie de la plaine côtière de l'Arctique caractérisée par d'épais sédiments marins et fluviatiles du Pléistocène, sur lequels repose une couverture de till et dont l'aspect original a été grandement modifié par le thermokarst. Le delta du Mackenzie est un vaste delta d'âge holocène, dont la surface porte de nombreux lacs. La plaine d'Anderson borde la marge sud-est de la zone côtière de Tuktoyaktuk, tandis que la plaine côtière du Yukon et les monts Richardson se dressent à la limite ouest du delta du Mackenzie (fig. 1).

La roche de fond sous-jacente aux dépôts du Quaternaire date principalement du Crétacé et du Tertiaire, mais des roches plus anciennes existent à l'ouest du delta du Mackenzie et au sud d'Inuvik (fig. 6).

Cette région est soumise à des hivers longs et rigoureux, et à des étés brefs et frais; les précipitations y sont peu abondantes. La toundra de type bas-arctique couvre la majeure partie de la région, et la toundra arbustive et la forêt boréale n'existent que le long de sa limite sud (fig. 8).

On rencontre le pergélisol dans toute la région, bien qu'il existe des taliks sous les lacs et les lits des cours d'eau. On estime que l'épaisseur maximale du pergélisol atteint 700 m au-dessous de la partie nord-est de l'île Richards. Les températures annuelles du sol à proximité de la surface sont aussi basses que -10°C à l'extrémité nord de la péninsule de Tuktoyaktuk, tandis que dans la partie distale du delta du Mackenzie, elles atteignent -2°C.

La glace dans le sol, qu'elle se présente sous forme de cristaux de glace, de lentilles, de nappes, de biseaux, de filons ou de masses irrégulières, est très répandue dans toute la région. De vastes nappes de glace massive, recouvertes par des matériaux de composition variable, mais reposant habituellement sur des sédiments à grain grossier, dépassent généralement 13 m d'épaisseur. La présence de glace dans le sol et le dégel irrégulier de cette dernière ont créé un certain nombre de structures comme des sols polygonaux (fig. 10), des pingos (cartouche, carte 1647A), une topographie à noyaux de glace, y compris des collines à involutions (fig. 2, 18) et des coulées régressives associées au processus de dégel (fig. 14; cartouche, carte 1647A).

Un escarpement érodé dans le socle rocheux à une altitude de près de 75 m sur la péninsule du cap Bathurst (fig. 20) marque la limite marine de la mer de Horton. On estime qu'il s'agit d'une mer interglaciaire formée au cours du Pléistocène moyen. Certains sédiments non consolidés reposant sur la surface aplanie par les vagues ont peut-être été déposés durant l'épisode de la mer de Horton.

The Harrowby Sea marine limit is marked by escarpments eroded mainly in unconsolidated sediments at elevations between 30 and 50 m on Cape Bathurst peninsula (Fig. 20, 23). The escarpments appear continuous within the maximum limit of glaciation east of Mason River. Harrowby Sea is likely a glacioisostatic sea associated with the Mason River Glaciation of Middle Pleistocene age.

East of Nicholson Peninsula a suite of sediments, assigned to the Stanton Sediments (Formation), is present in most coastal exposures. The sediments consist of a basal clay member, a lower complex member, a thinly bedded member and an upper sandy member (Fig. 24). Baillie Clay, noted in other sections in the area, may correlate with the basal clay member.

Baillie Clay and the basal clay member of the Stanton Sediments commonly contain mollusc shell fragments, show diapiric-type folding, and are normally magnetized. They were deposited in deep water and likely predate a Middle Pleistocene glacial event (Illinoian?) as the basal clay member appears to underlie drift of the Mason River Glaciation.

The lower complex member of the Stanton Sediments consists of interbedded sand, silt, clay, and rarely gravel. The sediments contain scattered organic detritus including wood, ice-wedge casts, peat layers, and soil horizons. Peat layers and soil horizons at the top of the underlying basal clay member are included in the lower complex member and mark a period of low sea level following deposition of the clay. The lower complex member is likely a mixture of alluvium and shallow marine sediments (perimarine sequence), which were frequently subaerially exposed during their deposition. They are normally magnetized and of Middle Pleistocene age.

The thinly bedded member consists of thinly bedded fine sands, silts, and clays with layers of organic detritus. These deposits were probably deposited in shallow marine waters, possibly during the waning phase of the Mason River Glaciation of Middle Pleistocene (Illinoian?) age.

The upper sandy member primarily consists of massive sandy beds; locally silty beds and gravelly beds are present. Much of this unit was deposited in shallow marine or subaerial environments. Deposition of all the upper sandy members probably postdates Mason River Glaciation. Deposition of woody channel deposits and beach gravel at low elevations might well have occurred during a time (Sangamon Interglaciation) quite separate from the underlying more massive sands.

Throughout Tuktoyaktuk Coastlands, a sequence of Quaternary sediments consisting of the Kendall sediments, Hooper clay, Kidluit Formation, Kittigazuit Formation, and the Turnabout Member underlie the Toker Point Member of Early Wisconsinan age and Holocene deposits (Fig. 53).

Kendall sediments consist of interbedded clay, silt, and sand containing abundant marine shells. Hooper clay contains isolated fragments of driftwood and few marine shells. Kendall sediments represent a fluctuating sea level, whereas Hooper clay represents a stable relatively high sea level. Both units are believed to be of Middle Pleistocene age.

Des escarpements principalement incisés dans des sédiments non consolidés, et situés à une altitude comprise entre 30 et 50 m sur la péninsule du cap Bathurst (fig. 20, 23), marque la limite marine de la mer de Harrowby. Ces escarpements paraissent continus à l'intérieur de la limite de l'étendue maximum de la glaciation, à l'est de la rivière Mason. La mer de Harrowby est probablement une mer glacio-isostatique associée à la glaciation de Mason River survenue au cours du Pléistocène moyen.

À l'est de la péninsule de Nicholson, une série sédimentaire, que l'on place dans les sédiments de Stanton (formation de Stanton), se manifeste dans la plupart des affleurements côtiers. Cette série se compose d'un membre argileux basal, d'un membre complexe inférieur, d'un membre finement lité, et d'un membre sableux supérieur (fig. 24). Il est possible qu'il existe une corrélation entre l'argile de Baillie, observé dans d'autres coupes de terrains de la région, et le membre argileux basal.

L'argile de Baillie et le membre argileux basal des sédiments de Stanton contiennent souvent des fragments de coquilles de mollusques, montrent des plissements de type diapirique, et sont habituellement magnétisés. Ces sédiments, déposés en eau profonde, précèdent sans doute un épisode glaciaire du Pléistocène moyen (Illinoien?), étant donné que le membre argileux basal semble reposer sous les matériaux de transport glaciaires de la glaciation de Mason River.

Le membre complexe inférieur des sédiments de Stanton se compose de sables, limons, argiles et, plus rarement, de graviers interstratifiés. Les sédiments contiennent des débris organiques épars, notamment des débris ligneux, des remplissages de coins de glace, des couches de tourbe et des horizons de sol. Les couches de tourbe et horizons de sol au sommet du membre argileux basal sous-jacent font partie du membre complexe inférieur, et signalent une période d'abaissement du niveau de la mer, suite à l'épisode de sédimentation de l'argile. Le membre complexe inférieur est probablement un mélange d'alluvions et de sédiments marins peu profonds (séquence périmarine), qui ont souvent été en contact avec la couche inférieure de l'air durant leur sédimentation. On a établi qu'ils sont habituellement magnétisés et datent du Pléistocène moyen.

Le membre finement lité est constitué de sables fins, limons et argiles finement lités, accompagnés de couches de débris organiques. Ces dépôts se sont probablement formés en eaux marines peu profondes, peut-être durant la phase terminale de la glaciation de Mason River au Pléistocène moyen (Illinoien?).

Le membre sableux supérieur est principalement constitué de lits sableux massifs; on trouve par endroits des lits limoneux et des lits graveleux. Une grande partie de cette unité a été mise en place dans des milieux marins peu profonds ou subaériens. La mise en place de tous les membres sableux supérieurs a probablement eu lieu après la glaciation de Mason River. La sédimentation de dépôts ligneux dans des chenaux et celle de graviers de plage à basse altitude ont bien pu se produire à une toute autre époque (interglaciaire de Sangamon) que la sédimentation des membres sableux sous-jacents plus massifs.

Dans toute la zone côtière de Tuktoyaktuk, une séquence de sédiments quaternaires comprenant les sédiments de Kendall, l'argile de Hooper, la formation de Kidluit, la formation de Kittigazuit et le membre de Turnabout, repose sous le membre de Toker Point, mis en place au Wisconsinien inférieur, et aux dépôts de l'Holocène (fig. 53).

Les sédiments de Kendall comprennent des argiles, limons et sables interstratifiés contenant en abondance des coquilles marines. L'argile de Hooper contient des fragments isolés de bois flottant, et quelques coquilles marines. Les sédiments de Kendall correspondent à une période de fluctuation du niveau marin, tandis que l'argile de Hooper correspond à une période de stabilité d'un niveau marin relativement élevé. On estime que ces deux unités datent du Pléistocène moyen.

Kidluit Formation consists of a clean, medium grained, grey sand. It commonly contains coal and woody detritus. Kidluit Formation was likely deposited during an interglaciation on a braided alluvial plain under climatic conditions at least as warm as those of today. The age of the formation has not been established.

Kittigazuit Formation consists of fine brownish sand, commonly silty, deposited in foresets up to 24 m in depth. It is believed to represent rapid deltaic deposition to a relative sea level about 50 m above present and under cool climatic conditions. It predates the Wisconsinan and may have been deposited during the Mason River Glaciation and/or associated Harrowby Sea episode of Middle Pleistocene (Illinoian?) age (Fig. 19).

The Turnabout Member of Tuktoyaktuk Formation consists of grey sands and gravels with much organic detritus and coal fragments. It is commonly found within channels eroded into Kittigazuit Formation. It is probably outwash deposited during the Toker Point Stade of Early Wisconsinan age.

In upper Eskimo Lakes, fluvial sediments underlying glacial deposits of the Toker Point Stade can be divided into an upper brownish unit with silty beds and a lower greyish unit. The upper unit locally contains a peat bed with wood beyond the range of radiocarbon dating, but having amino acid ratios of 0.16 to 0.22 (Table 16). The lower unit contains much woody detritus with amino acid ratios of 0.30 to 0.31. The lower unit possibly correlates with Kidluit Formation, whereas the upper unit probably was deposited during the Liverpool Bay Interglaciation of Sangamonian age (Fig. 19).

Along East Channel, south of Tununuk, fluvial, deltaic, and lacustrine sediments can be divided into a lower greyish sandy member with much organic detritus, a brownish member with a peat bed and an upper greyish sandy member. The lower sand was deposited on a braided alluvial plain, whereas the brownish member consisting of sand and silt was deposited by a meandering stream on a deltaic plain under a climate similar to that of today. The upper grey sands may be glaciofluvial in origin. The lower greyish member is tentatively correlated with Kidluit Formation and the brownish member probably was deposited during the Liverpool Bay Interglaciation (Fig. 19).

Ikpisugyuk Formation consists of pond deposits, driftwood mats, and associated sediments in low benches to 7 m above sea level east of Nicholson Peninsula. Ikpisugyuk Formation is believed to have been deposited during the Liverpool Bay Interglaciation of Sangamonian age as the benches are inset into terrain glaciated during the Mason River Glaciation of supposed Middle Pleistocene (Illinoian?) age and wood from these sediments gave nonfinite radiocarbon ages and amino acid ratios of 0.10 to 0.15. Gravels and woody sands at slightly higher elevations assigned to the Stanton Sediments may also date from this interval.

During the Mason River Glaciation, ice advanced to near Maitland Point on Bathurst Peninsula (Fig. 55 and Map 1647A). Sea level may have initially been low with meltwater eroding large valleys such as the one east of Maitland Point. Subsequently, coastal areas may have been drowned by Harrowby Sea. The Mason River Glaciation is thought to predate the Sangamon

La formation de Kidluit est constituée d'un sable gris délavé, à grain moyen. En règle générale, ce dernier contient du charbon et des débris ligneux. La formation de Kidluit a probablement été mise en place durant un interglaciaire, sur une plaine alluviale anastomosée, dans des conditions climatiques au moins aussi chaudes qu'aujourd'hui. On n'a pas établi l'âge de la formation.

La formation de Kittigazuit se compose d'un fin sable brunâtre, généralement limoneux, mis en place en lits deltaïques frontaux atteignant 24 m de profondeur. On estime qu'elle correspond à une sédimentation deltaïque rapide jusqu'au niveau marin propre à cette époque, soit 50 m environ au-dessus du niveau actuel, et survenue dans des conditions climatiques froides. Cette formation précède le Wisconsinien, et sa mise en place a peut-être eu lieu durant la glaciation de Mason River ou l'épisode associé de la mer de Harrowby, survenu au cours du Pléistocène moyen (Illinoien?), ou les deux (fig. 19).

Le membre de Turnabout, dans la formation de Tuktoyaktuk, se compose de sables et graviers gris contenant beaucoup de débris organiques et de fragments charbonneux. On le trouve généralement dans des chenaux creusés par l'érosion dans la formation de Kittigazuit. Il s'agit probablement de sédiments fluvio-glaciaires déposés durant le stade de Toker Point, qui date du Wisconsinien inférieur.

Dans la partie supérieure des lacs des Esquimaux, on a subdivisé les sédiments fluviatiles sous-jacents aux dépôts glaciaires du stade de Toker Point en une unité supérieure brunâtre à lits limoneux et en une unité inférieure grisâtre. L'unité supérieure contient, par endroits, un lit tourbeux dont les débris ligneux trop anciens ne se prêtent pas à la datation par la méthode au carbone radioactif, et dont les teneurs en acides aminés se situent entre 0,16 et 0,22 (tabl. 16). L'unité inférieure contient une grande quantité de débris ligneux, dont les rapports d'acides aminés se situent entre 0,30 et 0,31. L'unité inférieure peut probablement être corrélée avec la formation de Kidluit, tandis que la mise en place de l'unité supérieure date probablement de l'interglaciaire de Liverpool Bay, d'âge sangamonien (fig. 19).

Le long d'East Channel, au sud de Tununuk, on a subdivisé des sédiments fluviatiles, deltaïques et lacustres en un membre inférieur sableux et grisâtre contenant une grande quantité de débris organiques, un membre brunâtre contenant un lit tourbeux, et un membre supérieur sableux et grisâtre. Le sable inférieur a été déposé sur une plaine alluviale anastomosée, tandis que le membre brunâtre, composé de sable et de limon, a été mis en place par un cours d'eau à méandres sur une plaine deltaïque, dans des conditions climatiques semblables aux conditions actuelles. Le sable grisâtre du membre supérieur est peut-être d'origine fluvio-glaciaire. On a provisoirement établi une corrélation entre le membre inférieur grisâtre et la formation de Kidluit; la mise en place du membre brunâtre date probablement de l'interglaciaire de Liverpool Bay (fig. 19).

La formation d'Ikpisugyuk est constituée de dépôts vaseux, d'accumulations de bois flottant, et de sédiments associés, formant des banquettes basses jusqu'à 7 m au-dessus du niveau de la mer, à l'est de la péninsule de Nicholson. On estime que la formation d'Ikpisugyuk a été mise en place durant l'interglaciaire de Liverpool Bay d'âge sangamonien, étant donné que les banquettes sont emboitées dans des terrains recouverts par les glaces durant la glaciation de Mason River, survenue sans doute au cours du Pléistocène moyen (Illinoien?); la datation par la méthode du carbone radioactif des résidus ligneux provenant de ces sédiments n'a pas donné de résultats concluants; l'analyse a établi des rapports d'acides aminés se situant entre 0,10 et 0,15. Les graviers et les sables à résidus ligneux, situés à des altitudes légèrement plus élevées, et attribués aux sédiments de Stanton, pourraient aussi appartenir à cet intervalle.

Interglaciation based on the presence of a low interglacial marine bench inset into topography glaciated during it and on the general absence of massive ice and ice-cored topography within its limits (indicating thaw during an interglaciation?).

During the Toker Point Stade, glacier ice covered most of Tuktoyaktuk Coastlands and adjacent terrain (Fig. 55). During the maximum extent of Toker Point ice, thrusting of unconsolidated sediments resulted in the formation of elevated areas such as Mackenzie Bay Islands and Nicholson Peninsula.

Glacial expansion in adjacent areas, attributed to the Buckland Glaciation (Yukon Coastal Plain) and the Franklin Bay Stade (southern Amundsen Gulf), is believed to have occurred during the same time interval as the Toker Point Stade.

Stony clayey till (Toker Point Member) was deposited over much of the area during the Toker Point Stade, but locally the till is thin to absent. Large outwash fans on Tuktoyaktuk Peninsula (Cape Dalhousie Sands) and valley trains along Horton River (North Star Outwash) were deposited during the Toker Point Stade. A number of eskers and valley trains (now forming terraces along East Channel, Anderson River, etc.) were deposited on Tuktoyaktuk Coastlands during deglaciation (Fig. 56). The "fingers" in the Eskimo Lakes were likely formed as tunnel valleys by subglacial fluvial erosion, and the ridge of hummocky glaciofluvial deposits marking the supposed Tuk phase glacial limit was likely formed by meltwater debouching from these tunnel valleys. A glacial lake may have existed for a short period of time within Eskimo Lakes during deglaciation.

Glacier ice appears to have persisted in the Mackenzie Delta trough for a time during the Toker Point Stade deglaciation. Valley trains grading to sea levels between 6 and 10 m were formed along East Channel and throughout the Mackenzie Islands (Garry Island Member). Terraces along Kugaluk and Anderson rivers, which grade to marine(?) terraces between 3 and 8 m elevation in Liverpool Bay, may also have formed at this time.

Permafrost probably disappeared from under much of the ground covered by Toker Point Stade ice, the peripheral zone being the exception. During deglaciation permafrost aggradation at and subglacial meltwater flow to the edge of the ice sheet likely resulted in the formation of massive ice and icy sediments, which presently characterize the area (Fig. 58).

The Toker Point Stade is believed to be Early Wisconsinan because fresh-looking shells with intact periostracum in a glaciomarine terrace, which is likely associated with a glacioisostatic sea related to the Toker Point ice advance at Garry Island, gave nonfinite radiocarbon ages and no interglacial deposits or weathering horizons have been found on Toker Point Stade deposits. Dates to near 18 ka on lacustrine sediments within the Toker Point Stade limit also indicate that it predates a Late Wisconsinan stade dated at 13 ka.

During the Sitidgi Stade ice advanced to the south end of Eskimo Lakes and into the Mackenzie Delta trough (Fig. 59) and deposited a till (Sitidgi Member). During the Sitidgi Stade a large valley train (Portage Point Sands) was deposited in Eskimo Lakes. The level

Durant la glaciation de Mason River, les glaces ont progressé jusqu'à proximité de la pointe Maitland sur la péninsule du cap Bathurst (fig. 55 et carte 1647A). Il est possible que le niveau de la mer ait initialement été bas, et que les eaux de fonte aient creusé de grandes vallées comme celle située à l'est de la pointe Maitland. Par la suite, les régions côtières ont peut-être été inondées par la mer de Harrowby. On estime que la glaciation de Mason River précède l'interglaciaire de Sangamon, en raison de la présence d'une banquette marine peu élevée, d'origine interglaciaire, emboitée dans des reliefs modelés par cette glaciation, et de l'absence générale de structures de glace massive et de structures à noyaux de glace dans les limites de celle-ci (ce qui pourrait indiquer un dégel durant un interglaciaire?).

Durant le stade de Toker Point, la glace de glacier a recouvert la majeure partie des zones côtières de Tuktoyaktuk et des terrains adjacents (fig. 55). Durant l'extension maximale des glaces de Toker Point, le charriage de sédiments non consolidés a créé des zones élevées, comme les îles de la baie Mackenzie et la péninsule de Nicholson.

On estime que dans les zones adjacentes, l'expansion des glaces, que l'on attribue à la glaciation de Buckland (plaine côtière du Yukon) et au stade de Franklin Bay (sud du golfe d'Amundsen), a eu lieu durant le même intervalle que le stade de Toker Point.

Un till argileux et pierreux (membre de Toker Point) a recouvert une grande partie de la région durant le stade de Toker Point mais, par endroits, l'épaisseur de la couverture de till varie de mince à absente. Durant le stade de Toker Point, se sont formés de vastes cônes d'épandage fluvio-glaciaires sur la péninsule de Tuktoyaktuk (sables de Cape Dalhousie) et des traînées fluvio-glaciaires le long de la rivière Horton (sédiments fluvio-glaciaires de North Star). Un certain nombre d'eskers et de traînées fluvio-glaciaires (formant maintenant des terrasses le long du chenal East, de la rivière Anderson, etc.) se sont formés sur les terres côtières de Tuktoyaktuk durant la déglaciation (fig. 56). La forme digitée des lacs des Esquimaux est probablement le produit des ravins sous-glaciaires créés par l'érosion fluviatile sous-glaciaire; la crête de dépôts fluvio-glaciaires bosselés marquant la limite glaciaire présumée de la phase de Tuk a probablement été formée par les eaux de fonte débouchant de ces ravins sous-glaciaires. Il a pu exister un lac glaciaire pendant un court intervalle, à l'intérieur des lacs des Esquimaux, lors de la déglaciation.

Il semble que la glace de glacier ait subsisté dans la dépression du delta du Mackenzie pendant un certain temps durant la déglaciation correspondant au stade de Toker Point. Des traînées glaciaires inclinées en direction des niveaux marins situés entre 6 et 10 m par rapport au niveau actuel, se sont formées le long du chenal East et dans toutes les îles Mackenzie (membre de Garry Island). La formation des terrasses qui bordent les rivières Kugaluk et Anderson avant de passer à des terrasses marines(?) entre 3 et 8 m d'altitude dans la baie Liverpool, a peut-être aussi eu lieu à cette époque.

Le pergélisol a probablement disparu d'une grande partie du sol recouvert par les glaces du stade de Toker Point, sauf dans la zone périphérique. Durant la déglaciation, l'aggradation du pergélisol au bord de l'inlandsis, et l'écoulement sous-glaciaire des eaux de fonte en direction du rebord de cet inlandsis, ont probablement favorisé la formation de glaces massives et de sédiments englacés, qui actuellement caractérisent la région (fig. 58).

On estime que le stade de Toker Point date du Wisconsinien inférieur, étant donné que la datation par la méthode du carbone radioactif de coquilles en bon état, au périostracum intact et trouvées dans une terrasse glacio-marine (probablement associée à une mer glacio-isostatique créée par l'avancée des glaces de Toker Point à l'emplacement de l'île Garry) n'a pas donné de résultats concluants; en outre, l'on n'a trouvé aucun dépôt interglaciaire ou horizon d'altération dans les sédiments du stade de Toker Point. À l'intérieur de la limite du stade de Toker Point, la datation de sédiments lacustres indiquant un âge proche de 18 000 ans montre aussi que ce stade précède un stade du Wisconsinien supérieur daté à 13 000 ans.

of Eskimo Lakes was higher at this time as the present outlet to the east was not yet formed or at least was blocked with sediment being deposited in a terrace along Kugaluk River.

During the waning phase of the Sitidgi Stade a drawdown of glacier ice into Mackenzie Delta from east of Inuvik occurred.

A large proglacial lake (Eskimo Lakes Member), expanding through thermokarst, was present in the Eskimo Lakes basin during the Sitidgi Stade until ice retreated from Mackenzie Delta and allowed its drainage to the west. Isostatic rebound subsequently blocked this outlet, and erosion of terraces along Kugaluk River resulted in the drainage of Eskimo Lakes eastward into Liverpool Bay.

Glacier ice was at its maximum at about 13 ka as mats of grass in the valley train in Eskimo Lakes date from this time. High lake levels in the Eskimo Lakes basin probably persisted until the early Holocene as terraces along Kugaluk River were still forming about 11 ka and dates from around 9 ka have been obtained on benches in the Eskimo Lakes basin.

During much of the Middle and Late Wisconsinan relative sea levels may have been low in the area as evidenced by large drowned valleys within the limits of the Toker Point Stade and thick submarine permafrost under shallow offshore waters.

Thermokarst was extremely active between 10 and 9 ka when the climate was warming. Thermokarst proceeded primarily through the development and expansion of retrogressive-thaw flow slides. This resulted in the formation of the ice-cored topography (superficially similar to morainic topography) that characterizes most of Tuktoyaktuk Coastlands. Following this time interval, thermokarst slowed as the climate cooled. This stabilization of the landscape has allowed many of the thermokarst basins to drain, permafrost to re-establish in these basins, and frost heave and pingo formation to proceed.

During the Holocene a major transgression has occurred resulting in the drowning of valleys and local rapid coastal erosion of up to 7.5 m per year. The mouths of drowned valleys and the trough underlying Mackenzie Delta were filled with thick, fine grained alluvium during this time. Locally, large alluvial fans have formed.

During the Holocene, earth hummocks have formed through a cell type of gravity circulation under bare areas. Downslope movement of these hummocks at rates of up to 1 cm per year is common on moderate slopes. Solifluction and frost creep is somewhat more rapid in mountainous areas.

Peat accumulation has occurred slowly during the Holocene.

Sandy sediments have been subject to reworking and redeposition by wind during the Holocene. Wind has played a role in the orientation of some lakes during their thermokarst development. Presently, blowouts and cliff-top dunes are actively forming at the top of scarps eroded in sand.

Durant le stade de Sitidgi, les glaces ont avancé jusqu'à l'extrémité sud des lacs des Esquimaux et jusque dans la dépression du delta du Mackenzie (fig. 59) et y ont déposé un till (membre de Sitidgi). Durant le stade de Sitidgi, une vaste traînée fluvio-glaciaire (sables de Portage point) a été déposée dans les lacs des Esquimaux. À cette époque, le niveau de ces lacs était plus élevé qu'actuellement, puisqu'ils n'avaient pas encore de débouché vers l'est, ou tout au moins, ce dernier se trouvait obstrué par des sédiments qui édifiaient une terrasse le long de la rivière Kugaluk.

Durant la phase terminale du stade de Sitidgi, s'est produite une descente de la glace de glacier dans le delta du Mackenzie, à partir de l'est d'Inuvik.

Un vaste lac proglaciaire (membre d'Eskimo Lakes), occupant progressivement la zone de thermokarst, était présent dans le bassin du lac des Esquimaux durant le stade de Sitidgi, jusqu'à ce que la retraite des glaces du delta du Mackenzie permette au lac de s'écouler vers l'ouest. Ensuite, la remontée isostatique du terrain a bloqué ce débouché, et l'érosion des terrasses bordant la rivière Kugaluk a permis aux lacs des Esquimaux de s'écouler vers l'est et de se déverser dans la baie Liverpool.

La glace de glacier a atteint son maximum il y a environ 13 000 ans, comme l'indique l'âge de tapis d'herbe présents dans les traînées fluvio-glaciaires des lacs des Esquimaux. Dans le bassin de ces lacs, l'eau est probablement restée à un niveau élevé jusqu'à l'Holocène inférieur, puisque des terrasses se formaient encore le long de la rivière Kugaluk il y a environ 11 000 ans; on a daté à environ 9 000 ans des banquettes du bassin des lacs des Esquimaux.

Durant une grande partie du Wisconsinien moyen et supérieur, il semble que le niveau relatif de la mer dans cette région ait été bas, comme l'indiquent la présence d'importantes vallées submergées dans les limites d'influence du stade de Toker Point, et la présence d'une épaisse couche de pergélisol sous-marin sous les eaux peu profondes du large.

Le thermokarst était extrêmement actif entre 10 000 et 9 000 ans avant le présent, alors que le climat se réchauffait. Le thermokarst a principalement progressé en raison du développement et de l'expansion des coulées régressives associées au processus de dégel. Il en a resulté la formation d'une topographie à noyaux de glace (superficiellement semblable à la topographie des moraines), soit la topographie caractéristique de la majeure partie de la zone côtière de Tuktoyaktuk. Après cet intervalle, la progression du thermokarst a ralenti au fur et à mesure que se refroidissait le climat. Cette stabilisation du paysage a permis l'assèchement d'une grande partie des bassins thermokarstiques, le rétablissement du pergélisol dans ces bassins, la formation de structures de soulèvement par le gel et la formation de pingos.

Une importante transgression survenue durant l'Holocène a eu pour effet l'inondation des vallées et une rapide érosion du littoral atteignant par endroits jusqu'à 7,5 m par an. Les embouchures des vallées submergées et la dépression sous-jacente au delta du Mackenzie ont été remplies d'épaisses alluvions à grain fin à cette époque. De vastes cônes de déjection se sont formés par endroits.

Des buttes à lentilles de glace se sont formées durant l'Holocène, en raison de l'existence d'un type cellulaire de circulation par gravité sous les zones dénudées. Sur les pentes modérées, le glissement des buttes atteint fréquemment 1 cm par an. Dans les zones plus montagneuses, la solifluxion et la reptation du sol due au gel progressent à un taux légèrement plus rapide.

L'accumulation de tourbe s'est produite lentement au cours de l'Holocène.

Les sédiments sableux ont été remaniés et redéposés par les vents durant l'Holocène. Les vents ont joué un rôle dans l'orientation de certains lacs durant l'étape thermokarstique de leur développement. La formation active de creux de déflation et de dunes surmontant les falaises se poursuit actuellement au sommet des escarpements creusés par l'érosion dans les sables.

Major ground subsidence resulting from ground disturbance and melting of underlying icy sediments and ground ice is a hazard to development. Thawing of ice wedges may also result in local subsidence and lead to gullying.

Heaving of ground due to permafrost aggradation and ice-wedge development also must be considered as a hazard to development.

Retrogressive-thaw flow slides are a threat to any development. These features naturally occur along coastlines, lakes, and streams where active wave or stream erosion can cause rapid retreat of slopes.

Flooding is a hazard along all floodplains and throughout Mackenzie Delta where ice jams and storm tides can occur. Areas up to 3 m above normal high tide may be flooded during storm tides in the fall.

Sand for general fill is available throughout most of the area. Coarse sand and gravel is locally available. The sand and gravel may be silty and contain wood and coal fragments, and high proportions of chert or shale. Extraction of sand and gravel generally involves removal of silty or peaty overburden, thawing and drainage of the sand and gravel, and planning for resulting thermokarst development.

Une importante subsidence du sol, résultant de la perturbation du sol et de la fonte des sédiments englacés sous-jacents et de la glace dans le sol, présente un danger à tous les travaux d'aménagement. Le dégel des coins de glace peut aussi provoquer par endroits des affaissements, puis du ravinement.

On doit aussi considérer comme un danger pour tout effort d'aménagement le soulèvement du sol dû à l'aggradation du pergélisol et à la formation de coins de glace.

Les coulées régressives associées au processus de dégel représentent aussi un danger du même type. On rencontre naturellement ce phénomène le long du littoral, des lacs et des cours d'eau, où les vagues actives ou bien l'érosion fluviatile peuvent causer un rapide recul des pentes.

Il existe aussi un danger d'inondation le long de toutes les plaines d'inondation, et dans toute la région du delta du Mackenzie, où peuvent survenir des embâcles et des marées de tempête. Durant les marées de tempête d'automne, certains secteurs peuvent être inondés jusqu'à 3 m au-dessus du niveau normal des marées hautes.

On trouve dans tout le secteur du sable pouvant servir de remblai habituel. On rencontre aussi, par endroits, du sable grossier et du gravier. Ces derniers peuvent être limoneux et contenir des fragments ligneux et charbonneux, ainsi que des proportions élevées de chert ou de schiste argileux. En règle générale, pour extraire le sable et le gravier, on doit enlever la couverture limoneuse ou tourbeuse, dégeler le sable et le gravier puis les drainer, et prévoir la formation ultérieure de thermokarst.

INTRODUCTION

Objective

This report presents a synthesis of the knowledge of the Quaternary geology and geomorphology of the Tuktoyaktuk Coastlands and adjacent areas gained during the last three decades, particularly by J.R. Mackay (University of British Columbia) and personnel of the Geological Survey of Canada. Observations, descriptions, and interpretations of Quaternary phenomena are placed in a historical framework and related to maps of Quaternary materials and landforms. In addition, permafrost, ground ice, and other periglacial phenomena are described and their effects on construction or other human activity are outlined.

Previous studies

Prior to investigations conducted by J.R. Mackay, few systematic observations of the Quaternary geology of the area had been recorded. Mackay's early investigations, which were initiated in 1951 and completed by 1960, were undertaken to give a complete geographical overview of the Anderson River (Mackay, 1958a, c) and the Mackenzie Delta areas (Mackay, 1963a). He addressed not only the Quaternary history of the area, but gave observations concerning physiography, drainage, modern geomorphic processes including periglacial processes, ground ice and related phenomena, climate, vegetation, and human geography. Mackay's later works have concentrated on periglacial phenomena, especially those related to ground ice. His studies include topics related to the origin and distribution of massive ground ice and associated slumps (Mackay, 1966a, 1971, 1972a, d, 1978a, b, 1983; Mackay and Stager, 1966a; Rampton and Mackay, 1971; Mackay et al., 1972); the occurrence and formation of pingos (Mackay, 1962, 1963b, 1966b, 1972b, d, 1973, 1976a, 1977a, b, 1978c, 1979a; Mackay and Stager, 1966b); fossil and modern ice wedges (Mackay, 1972c, 1974a, 1975a, b, 1976b, 1977c; Mackay and Matthews, 1983); permafrost distribution and the nature of its formation (Mackay, 1967a, 1974d, 1975c, d, e); solifluction and related periglacial process (Mackay, 1958b, 1967b, 1974b, 1979b, c, 1980a, b, 1981a; Mackay and Mackay, 1976); the presence and origin of glacially ice-thrust features (Mackay, 1956a; Mathews and Mackay, 1960; Mackay and Stager, 1966a); oriented lakes (1956b); and other regional phenomena (Mackay, 1965, 1970, 1974c, 1978d, 1981b, c, 1982; Mackay and Terasmae, 1963).

The Geological Survey of Canada in the 1960s commenced investigations more directly related to the Quaternary history of the area. Initial investigations were undertaken by Fyles (1966, 1967) and continued by Rampton, 1970, 1971, 1972a, b, c; Fyles et al, 1972; Rampton and Dugal, 1974). Numerous maps describing the surficial materials have resulted from these investigations (Rampton, 1972d, e, 1979a, b, c, d; Bouchard and Rampton, 1972; Rampton and Bouchard, 1975). Rampton has also investigated the distribution of ground ice (Rampton and Mackay, 1971; Rampton and Walcott, 1974) and evaluated different geomorphic processes (Rampton, 1974a, b) throughout the region. During the summer of 1983, the stratigraphy of the Tuktoyaktuk Coastlands and adjacent Yukon Coastal Plain was studied by J-S. Vincent, J.V. Matthews, Jr., and the author.

Other investigators have completed studies related to the Quaternary history and paleolecology (Terasmae, 1959; Kerfoot, 1969; Ritchie and Hare, 1971; Ritchie, 1972, 1977, 1984; Hyvarinen and Ritchie, 1975; Zoltai and Tarnocai, 1975; Delorme et al., 1977; Harington, 1978, 1980; Zoltai and Zalasky, 1979; Forbes, 1980; Ritchie et al., 1983; Spear, 1983); geomorphology (Porsild, 1938; Legget et al., 1966; Kerfoot, 1969, 1972a; Kerfoot and Mackay, 1972; Gill, 1972a, b; Kennedy and Melton, 1972; Tarnocai and Zoltai, 1978; Zoltai et al., 1978; Lawrence et al., 1984);

stratigraphy (Johnston and Brown, 1965); permafrost and ground ice (Muller, 1962; Brown et al., 1964; Johnston and Brown, 1964; Williams, 1968; Smith, 1972; Gell, 1974, 1975, 1976; Scott and Hunter, 1977; Michel and Fritz, 1978, 1980, 1981, 1982; Burgess et al., 1982); and effects of disturbance (Heginbottom, 1972; Kerfoot, 1972b).

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PHYSICAL ENVIRONMENT AND PRE-QUATERNARY GEOLOGY

The Tuktoyaktuk Coastlands, Mackenzie Delta, and adjacent areas border the southern edge of the Beaufort Sea, mainly between the Yukon Territory-Northwest Territories boundary and Cape Bathurst peninsula (Fig. 1). The study area includes parts of the Aklavik (107B), Mackenzie Delta (107C), Stanton (107D), Cape Dalhousie (107E), and Malloch Hill (97F) map areas.

Physiography

Much of the Tuktoyaktuk Coastlands study area lies within Bostock's (1970a) Mackenzie Delta Division of the Arctic Coastal Plain; the southeastern edge of the area lies within his Anderson Plain. In this study, Bostock's Mackenzie Delta has been divided into two areas. The term, Mackenzie Delta, has been relegated to only the modern or Holocene delta (Table 1, Fig. 1). The remainder of Bostock's Mackenzie Delta has been called the Tuktoyaktuk Coastlands as the Quaternary sediments within this segment of the Arctic Coastal Plain bear little resemblance to those of the Holocene Mackenzie Delta and probably, owe their existence, in large part, to former rivers having courses located well to the east of the modern Mackenzie River. The boundary between the Tuktoyaktuk Coastlands and the Anderson Plain has been redrawn to parallel more closely the line separating areas of thick Quaternary sediments, where pre-Quaternary bedrock is not exposed above sea level and has little control on the topography, from areas of relatively thin Quaternary sediments, where pre-Quaternary bedrock occurs at the surface and controls the topography. This boundary closely follows the southern limit of Mackay's (1963a) Pleistocene Coastlands, and the southern limit of the Pleistocene Coastal Plain of Fyles et al. (1972) and Mackay (1978a).

Table 1. Physiographic subdivisions of Tuktoyaktuk Coastlands and adjacent areas

Region (Bostock, 1970)	Divisions	Subdivisions (modified from Mackay, 1963a)
Porcupine Mountain Area (Eastern Cordilleran)	Richardson Mountains	
	Yukon Coastal Plain	(Mountain Fringe)
	Mackenzie Delta	
Arctic Coastal Plain	Tuktoyaktuk Coastlands	Mackenzie Bay Islands Big Lake Delta Plain Tununuk Low Hills Kittigazuit Low Hills Kugmallit Plain "Low Involuted Hills" West Tuk Peninsula Axis Parsons Lake Plain East Tuk Peninsula Axis McKinley Bay Coastal Plain Eskimo Lakes Pitted Plain Eskimo Lakes Fingerlands Liverpool Coastal Area Nicholson Peninsula Rufus Lake Lowland Kaglik Lake Plain Stanton Lowland Harrowby Coastal Plain
Interior Plains	Anderson Plain	North Caribou Hills South Caribou Hills Dolomite Lake Upland Campbell-Sitidgi Lowland Campbell Plain Hyndman Lake Hills Sitidgi Scarp Miner River Plain "Fluted Plains" Anderson River Upland Malloch Hill Upland

West of the Mackenzie Delta, the area lies within Bostock's (1948, 1970a) Arctic or Porcupine Plateau and Richardson Mountains. This study has assigned Bostock's Arctic or Porcupine Plateau to the Yukon Coastal Plain (Table 1) after Rampton (1982). Farther to the west the bedrock-cored plain flanking the Richardson and other mountains grades into part of the Yukon Coastal Plain, which is underlain by thick Quaternary deposits. Adjacent to the Mackenzie Delta this bedrock-cored plain is separated by a series of bedrock scarps from the Mackenzie Delta (Rampton, 1982).

Mackenzie Delta

Mackenzie Delta is an elongated north-northeast trending estuarine delta, about 200 km long and 65 km wide (Mackay, 1978a). The delta surface slopes gently from an elevation of 10 m at its apex to sea level at its northern edge. All parts of the delta are subject to flooding; towards the head of the delta flooding occurs during spring breakup, especially when ice jams occur, whereas towards the coast flooding often occurs during storm surges (Mackay, 1963a).

Channel shifting, which is continuously occurring within the delta, generally is a slow sporadic process except at isolated localities where fluvial and thermal erosion, wave action, ice abrasion, and slumping due to thawing are concentrated (Gill, 1972a).

The delta surface is a complex network of lakes and anastomosing channels (Fyles et al., 1972). Lakes cover more than 30% of the upper part of the delta, 15 to 30% of the middle part, and less than 15% of the distal part north of Shallow Bay (Mackay, 1963a). Lakes consist of abandoned channel lakes, small ephemeral arcuate point bar lakes, floodplain lakes formed through the buildup of alluvium (levees) on the outer delta, dammed lakes where streams entering the delta are blocked by delta alluvium, and thermokarst lakes (Mackay, 1963a). Thermokarst lakes are most common on the upper part of the delta (Fyles et al., 1972) where permafrost is thick; degradation of the permafrost leads to significant subsidence and results in the formation of lakes. The lakes then in turn perpetuate the degradation of permafrost and lake expansion. Lakes often are infilled when channels breach them and discharge sediment into them (Mackay, 1963a).

Tuktoyaktuk Coastlands

The Tuktoyaktuk Coastlands, as previously indicated, include the Arctic Coastal Plain between the Mackenzie Delta and Amundsen Gulf and are characterized by thick unconsolidated sediments and few bedrock outcrops. This area has been previously termed the Pleistocene Coastlands (Mackay, 1963a) and the Pleistocene Coastal Plain (Fyles et al., 1972; Mackay, 1978a). The Tuktoyaktuk Coastlands are for the most part low, rarely rising more than 60 m above sea level. Commonly 30% of the area is covered by lakes and rarely less than 15% (Mackay, 1963a). Some of it is poorly drained and marked by irregular deranged drainage patterns because of thermokarst activity. Pingos, massive ice, and retrogressive-thaw flow slides are common to most of the Tuktoyaktuk Coastlands (Mackay, 1963a).

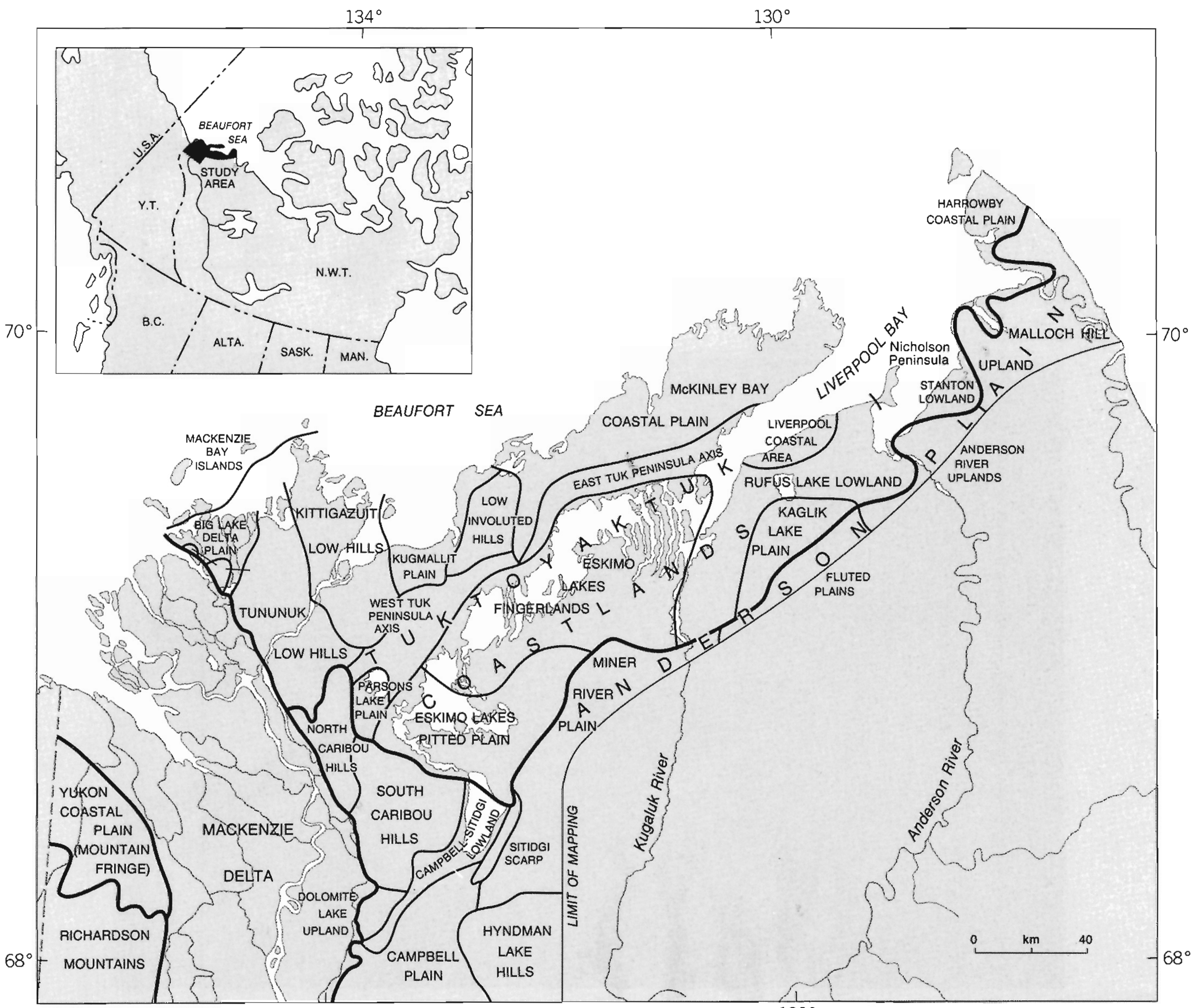


Figure 1. Location map and physiographic subdivisions of the Tuktoyaktuk Coastlands and adjacent areas.

The Tukoyaktuk Coastlands have been subdivided on the basis of common characteristic landforms and orientation of geomorphic features (Table 1, Fig. 1). The subdivision boundaries follow Mackay (1963a) except for minor modifications.

Mackenzie Bay Islands consist of numberous islands whose elevations rise to 60 m. Some of these islands may have simply become detached from Richards Island to the east through erosion (Mackay, 1963a), others may owe their existence to glacier ice-thrust and elevation of preglacial sediments. Coasts facing the Beaufort Sea are receding rapidly due to the nature of materials exposed in coastal bluffs. Elevated parts of this island group are generally well drained.

Big Lake Delta Plain is an northeastward extension of the Mackenzie Delta near its periphery. It is separated from the main part of the delta by a discontinous series of low hills and terraces rising above the delta surface. Big Lake Delta Plain is poorly drained and characterized by lakes and alluvial channels. Deltaic sediments forming Big Lake Delta Plain

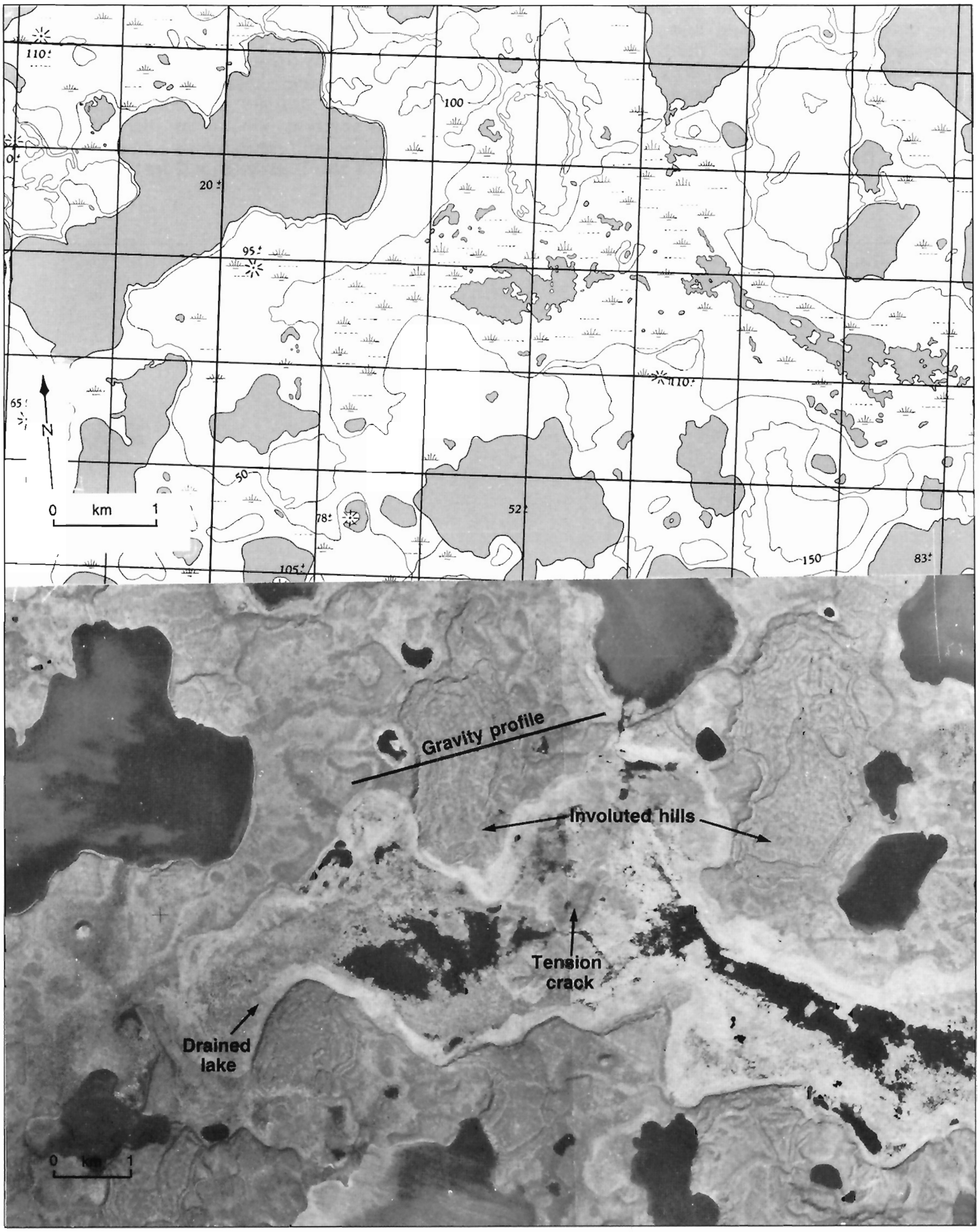


Figure 2. Involuted hills east of Tuktoyaktuk; ground ice core of involuted hills was confirmed by drilling and gravity profiling along line of gravity profile. NAPL A12902-52

are likely thin as they appear to fill only shallow depressions between Mackenzie Bay Islands and low hills forming Richards Island. In contrast, deltaic sediments underlying Mackenzie Delta proper are thick as they fill a broad, deep trench.

Tununuk Low Hills form the western part of Richards Island and adjacent land to the south of Mackenzie River East Channel. Tununuk Low Hills are characterized by rolling topography and are underlain by sediments with textures ranging from clay to sandy gravel. Generally lakes and ridges are of irregular size and orientation except in the west-central part of Richards Island where they trend northeasterly. Broad depressions are poorly drained.

Kittigazuit Low Hills are characterized by deeply inset lakes with moderately steep slopes on adjacent well drained ridges. Thin surface tills cap thick, brown, fine grained sands, which form most hills and ridges. The axis of lakes and ridges have a strong northeast trend.

Kugmallit Plain consists of the low ground bordering the south and east side of Kugmallit Bay. It is characterized by broad, poorly drained flats, generally underlain by fine grained lacustrine sediments. A few hills interrupt the plain, many of which are characterized by surfaces showing involuted patterns on aerial photographs (Mackay, 1963a).

The "Low involuted hills" are marked by broad hills, capped with clayey till, and intervening poorly drained depressions filled with fine grained lacustrine sediments. The involuted hills have a pattern (Fig. 2) that on air photographs resembles "the wrinkled skin of a well-dried prune ... The wrinkles are curving branching ridges, ranging up to several hundred yards in length, several score yards in width, and 20 feet in height. When seen from a lower altitude in the field, some involuted slopes appear to rise in a succession of terraces." (Mackay, 1963a, p. 138).

West Tuk Peninsula Axis is the western part of Mackay's (1963a) morainic hills, which form a drainage divide between Eskimo Lakes and Kugmallit Bay. The West Tuk Peninsula Axis consists of a system of low hills, which forms a broad ridge that stands above ground to its north and south. The hills are underlain by a complex of sediments, which are generally capped by till or glaciofluvial sediments (Fig. 3). Numerous lakes dot the landscape, and along the northwestern flank of this subregion the lakes have a northerly and northwesterly orientation.

The Parsons Lake Plain separates the southwestern end of the Tuktoyaktuk Peninsula from the Caribou Hills. This poorly drained plain, which slopes gently eastward towards Parsons Lake, is underlain by a complex of morainal, glaciofluvial, and lacustrine sediments.

East Tuk Peninsula Axis consists of a narrow band of hills between a broad plain leading down to the Beaufort Sea to the north and the Eskimo Lakes and Liverpool Bay to the south. The hills are well drained and underlain by gravelly and sandy materials. Moderately steep slopes are common due to the deeply inset nature of most lakes.

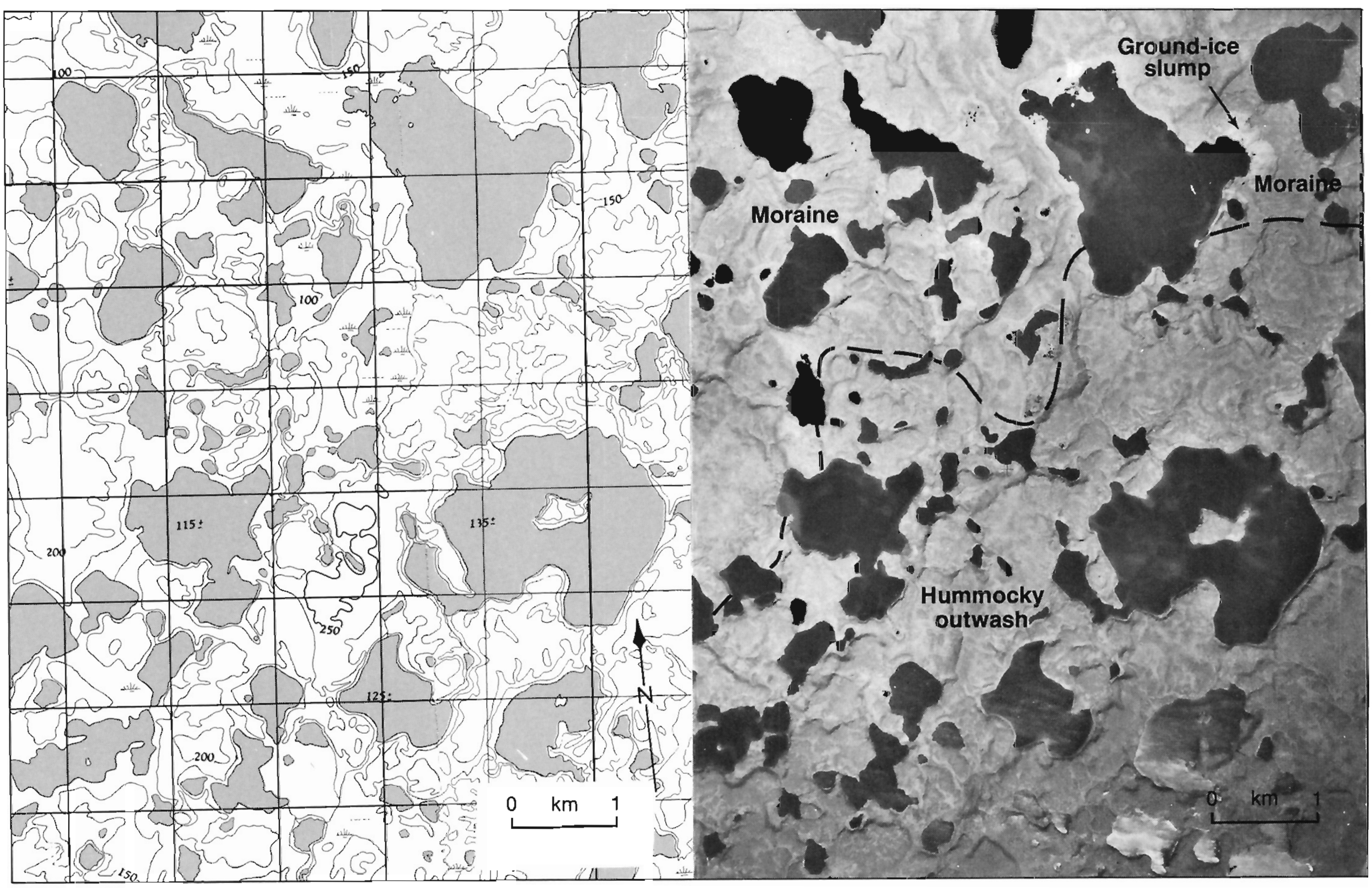


Figure 3. Typical ice-cored topography and distribution of landforms and materials along the West Tuk Peninsula Axis. NAPL A12902-48

McKinley Bay Coastal Plain, constituting the northeastern end of the Tuktoyaktuk Peninsula, is a gently sloping plain underlain primarily by sand. The seaward edge of this plain is marked by long, gently recurving sandy spits and bars. Oriented lakes (Fig. 4), with a northerly trending axis and parabolic sand dunes, mark the surface of this flat, poorly drained plain (Mackay, 1956b, 1963a).

Eskimo Lakes Pitted Plain, at the southern end of Eskimo Lakes (Fig. 5), consists primarily of "pitted outwash plains....composed of many flat-topped mesa-like areas interspersed among numerous large and small irregularly shaped highly indented lakes." (Mackay, 1963a, p. 139). Ridges rising to more than 20 m elevation and characterized by rolling hummocky topography and numerous lakes border the southern edge of the pitted outwash plain. The complexity of the landscape is added to by other areas of rolling terrain interspersed throughout the plain. Much of this subregion is well drained due to its sharp relief.

Eskimo Lakes Fingerlands occupy the central and northern Eskimo Lakes; the landscape is dominated by long finger-like arcuate peninsulas that partition the Eskimo Lakes and Liverpool Bay into four separate water bodies. The ridges forming these peninsulas and the intervening valleys or channels extend to the south of the Eskimo Lakes. Much of the area has relief of up to 20 m and is well drained, except for low flat areas bordering the Eskimo Lakes.

Liverpool Coastal Area lies immediately south of Liverpool Bay and is characterized by sands, capped by thin tills, and deeply inset lakes. The axes of the lakes and intervening ridges trend from northwest at the west end of the area to northeast at the east end. Sandy strata and moderately steep slopes lead to much of the area being well drained.

Nicholson Peninsula, which rises to over 90 m elevation, owes it height to glacier ice-thrusting (Mackay, 1956a). The high western edge of the peninsula is well drained, whereas the low flat plain forming its remainder is imperfectly drained. The narrow strip of land that connected the Peninsula to the mainland was breached in 1964, leaving it as an island.

Rufus Lake Lowland is marked by rolling topography with low hills interspersed throughout the low, poorly drained flats surrounding lakes. A complex of unconsolidated

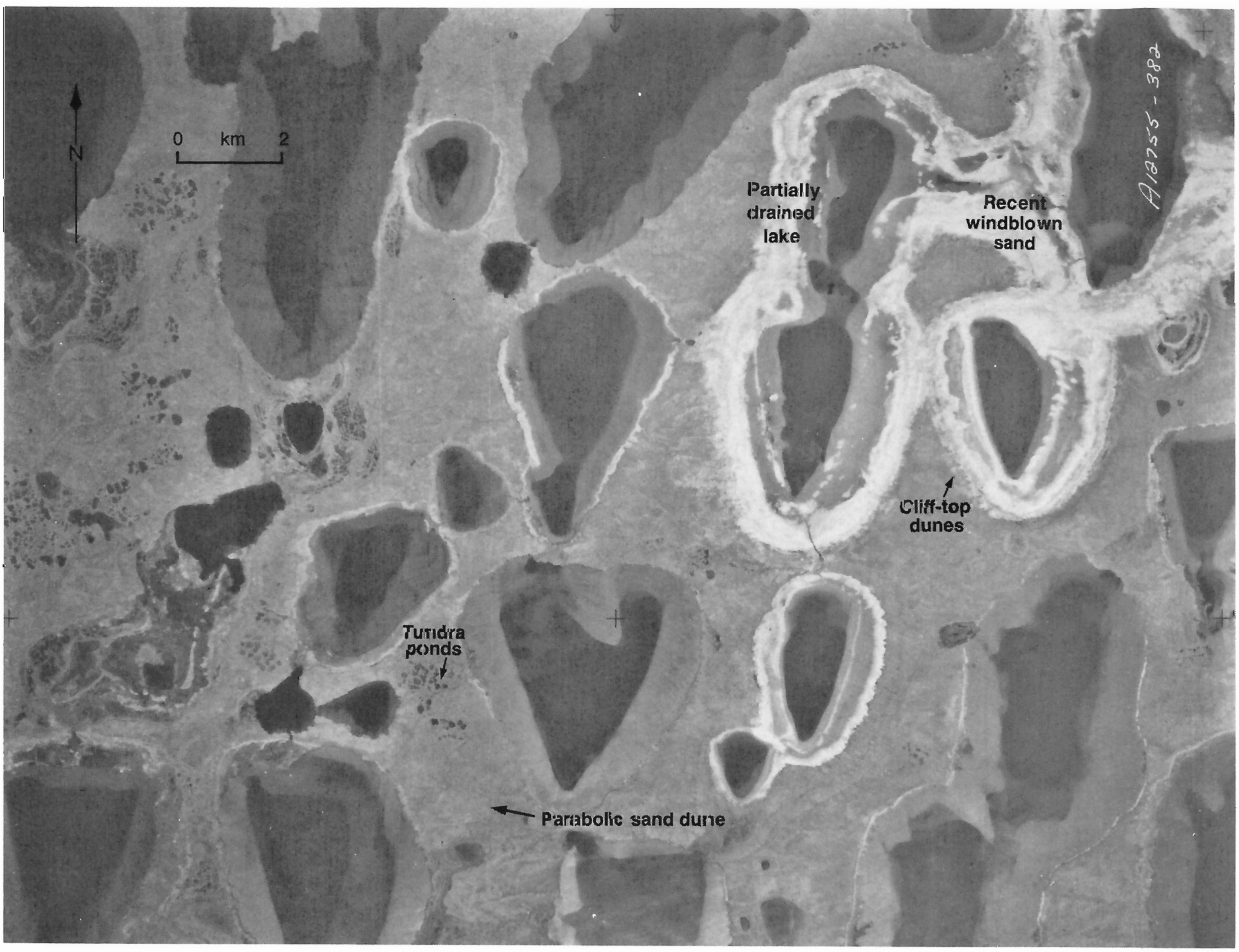


Figure 4. McKinley Bay Coastal Plain showing oriented lakes and associated features. NAPL A12755-382

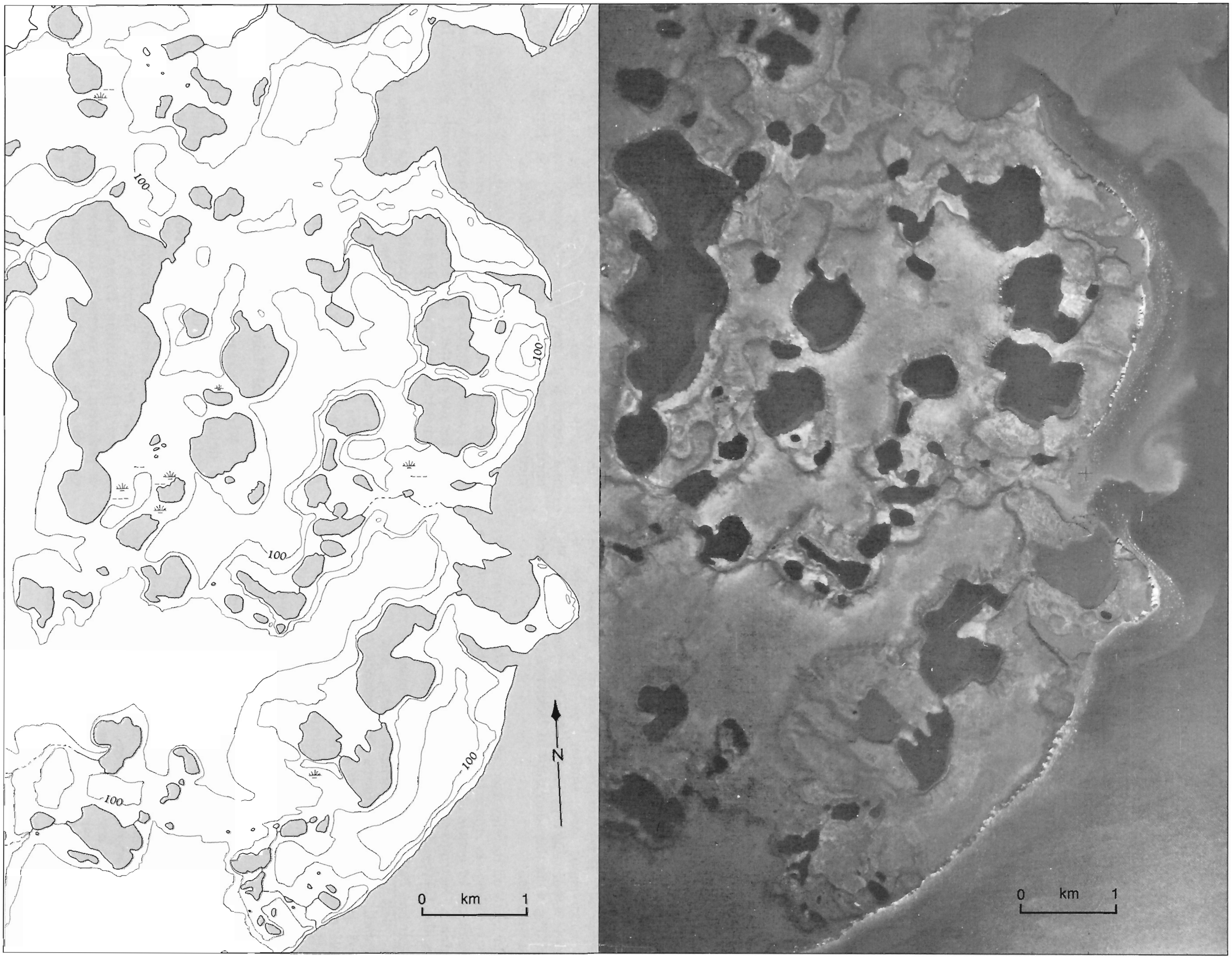


Figure 5. Pitted outwash plain near the southern end of Eskimo Lakes. NAPL A12918-112

sediments of variable thickness are present. South of the Smoke River bedrock is common at the base of many exposures.

Kaglik Lake Plain is a broad, sloping to gently undulating plain lying between Rufus Lake Lowland, marked by its low hilly relief, and Anderson River Plain, which rises rapidly to the southeast. Kaglik Lake Plain is characterized by relatively thin unconsolidated sediments over shale. Its surface is imperfectly drained.

Stanton Lowland is composed of two parts; the western part consisting of gently rolling low hills and broad, poorly drained lacustrine flats, and the eastern part consisting of the alluvial plains bordering the lower course of Mason River. Fine grained sediments of significant thickness underlie Stanton Lowland.

Harrowby Coastal Plain constitutes a flat to gently sloping alluvial and marine plain north of Mason River. This plain is underlain by fine grained sediments, except for the gravely terraces bordering Harrowby Bay. Sediments are generally thick, although bedrock is exposed in coastal scarps south of Maitland Point. Harrowby Coastal Plain is marked by drowned valleys and lakes whose axis have a northerly orientation (Mackay, 1956b, 1958a).

Anderson Plain

"The Anderson Plain is characteristically undulating and rises inland" (Bostock, 1970b). Bedrock relief exerts a control over much of the topography, even though a significant thickness of unconsolidated materials may be present. Bedrock outcrops in many escarpments and on steep slopes. Except for the Caribou Hills, which project 80 km to the northwest between Mackenzie Delta and Tuktoyaktuk Coastlands, only the northern edge of the Anderson Plain, most of which lies below 100 m elevation, is within the map area (Fig. 1). Anderson Plain has been subdivided on the basis of geomorphic characteristics. West of Anderson River these subdivisions are similar to those proposed by Mackay (1963a). East of Anderson River the Malloch Hill Upland (Fig. 1) is the equivalent of Mackay's (1958a) Lakeless Tundra Uplands.

In spite of its elevation and general sloping character, Anderson Plain is imperfectly drained because of the predominance of gentle slopes, broad basins and valleys, and permafrost. Retrogressive-thaw flow slides are less common than on the Tuktoyaktuk Coastlands and pingos are rare.

Caribou Hills consist of a broad upland or ridge, which stands well above Mackenzie Delta and Tuktoyaktuk Coastlands. Major landforms are bedrock controlled and most of the outer perimeter of Caribou Hills is marked by bedrock escarpments. The most notable escarpment lies along the east edge of Mackenzie Delta, rising 150 m over much of its length and at one point to over 240 m. North Caribou Hills rise steeply above the surrounding land and are characterized by radial drainage. Unconsolidated deposits are relatively thin and the area is well drained except for small depressions on the flat-crested hills. South Caribou Hills have gently sloping to hummocky topography due to variability in the thickness of unconsolidated deposits. Depressions and broad flat areas can be poorly drained.

Dolomite Lake Upland is a small, flat, rocky mesa-like plateau; "the local physiography consists of bedrock plateaus at 120 to 155 m above sea level, bedrock scarps and cliffs with colluvial fans and talus slopes, a few wide (200-600 m) valleys with irregular cliffs and scree sides and many irregular, lake-filled depressions". (Ritchie, 1977, p. 405). Although marked by a deranged drainage pattern, this plateau is markedly well drained.

Campbell-Sitidgi Lowland separates Caribou Hills and Dolomite Lake Upland from the remainder of Anderson Plain. This subregion is a poorly drained, lake-infested trench marked by steep bedrock escarpments along its edge. Southwest of Campbell Lake the lowland has been infilled with Mackenzie River alluvium. The divide between the Eskimo Lakes (Sitidgi Lake) drainage system and the Mackenzie River drainage system lies below 10 m elevation.

Campbell Plain gradually rises to an elevation of just over 200 m south of Campbell-Sitidgi Lowland. This gently rising slope of the Campbell Plain is interrupted rarely by bedrock-controlled, moderately steep slopes and escarpments. The plain is moderately well drained except for poorly drained broad flat areas. Depressions on the undulating plain, which forms the crest of this subregion, are also poorly drained. A number of streams have eroded deeply incised canyons into the plain.

Hyndman Lake Hills "are a distinctive region with higher terrain than adjacent areas, rocky escarpments, large Pleistocene valleys, and numerous lakes." (Mackay, 1963a, p. 146). Locally the area is characterized by hummocky to rolling topography.

Sitidgi Scarp rises 200 to 280 m above Sitidgi Lake to its southeast and here forms the boundary of the Anderson Plain. A number of steep ravines have been formed along the escarpment by small streams crossing it.

Miner River Plain has been described by Mackay (1963a, p. 145) as unfluted plains: "The unfluted plains include the drainage basin of the "Miner River" (local name) and much of that Kugaluk River. Although there are a few hills in the area, the terrain is mainly flattish, sloping from an altitude of 1000 feet in the south to about 100 feet in the north .... Major glacial features are conspicuously absent."

The "fluted plains" form a broad crescentic band around high ground that lies between the plains and Anderson River. "The plains are strongly fluted, with individual linears being traceable for many miles" (Mackay, 1963a, p. 145). Swales and depressions are commonly poorly drained. At their northern edge within the map area the fluting is only moderately defined and lakes are numerous.

Only the northern part of Anderson River Upland is included within the map area. The terrain is undulating to rolling with a scattering of lakes. Unconsolidated deposited may locally be thick, but bedrock is commonly exposed in escarpments along streams and the coast.

Malloch Hill Upland consists of large ridges and hills that rise up to 170 m above the surrounding ocean and lowlands. Thinly covered bedrock slopes are marked by radial dendritic drainage. Except for the steep escarpment bordering Franklin Bay, most slopes are gentle to moderate. As noted by Mackay (1958a), this area is marked by a paucity of lakes.

Yukon Coastal Plain

Within Northwest Territories, the Yukon Coastal Plain as defined by Rampton (1982) consists of Bostock's (1948) Arctic Plateau or his (1970a) Yukon Coastal Plain and Porcupine Plateau. Near the Northwest Territories/Yukon Territory boundary the Yukon Coastal Plain as shown in Figure 1 all lies within Rampton's (1982) Yukon Coastal Plain 'mountain fringe'. Rampton (1982, p. 6) has described it as follows: "The mountain fringe is primarily an erosion surface or pediment that sweeps up to the edge of the mountains and extends into the mountains along major streams .... the coastward slope of the terrain is clearly a reflection of the surface of the underlying erosion surface developed on bedrock....

Adjacent to the Mackenzie Delta, just west of Aklavik, a 60- to 125-m-high escarpment separates the main part of the Coastal Plain from a segment bordering the Delta whose surface generally ranges between 60 and 155 m elevation .... This segment is separated from the Mackenzie Delta by a 30 to 60 m rise, whereas near the mouth of Big Fish River the main part of the coastal Plain is separated from the Mackenzie Delta by a 125-m-high escarpment". The mountain fringe is moderately well drained. Streams, which drain the mountains to the southwest, lie in deeply incised canyons.

Richardson Mountains

The Richardson Mountains rise to more than 1100 m above the surface of the Mackenzie Delta just southwest of Aklavik. A 600 m-high escarpment forms the easternmost ridge – the Aklavik Range – of the mountains. The elevation of this ridge and adjacent ridges gives the topography a mountainous appearance, even though it consists of little more than high hills (Rampton, 1982). The eastern part of the Richardson Mountains "consists of a narrow belt of rounded ridges, separated by moderately wide valleys. The entire complex is dissected deeply by steep-sided canyons and gullies. Upland relief does not exceed 250 m but the canyons, such as that of Willow River, commonly add another 150 m to the relief". (Rampton, 1982, p. 5).

Pre-Quaternary geology

Geological maps (Yorath et al., 1969, 1980; Yorath and Balkwill, 1970; Norris, 1981a, b), correlation charts (Yorath et al., 1980; Norris, 1983), and summary discussions (Norris, 1973; Yorath, 1973; Yorath and Norris, 1975; Young et al., 1976; Young and Norris, 1978) of the pre-Quaternary geology form the basis of most of the following discussion. Figure 6 shows the distribution of the main geological units.

Anderson Plain is formed on the northwestern flank of the Interior Platform. Here Paleozoic rocks dip westward and overlying Cretaceous rocks dip in a more northerly direction (Yorath et al., 1969). South and east of Liverpool Bay, the terrain is underlain by Upper Cretaceous shales. Some shales contain abundant bentonitic and bituminous beds (Yorath et al., 1969; Yorath and Balkwill, 1970). Some of the bituminous shale contains beds of yellow jarosite, which are oxidized to hematite where the shales are burned. Gravel and sand consisting mainly of quartzite, dolomite, and black chert, but with some wood fragments, cap Cretaceous shales near the headwaters of Mason River (Fig. 6) and have been assigned to the Beaufort Formation (Yorath et al., 1969). Small patches of similar gravel have been noted farther north.

Tuktoyaktuk Coastlands, Mackenzie Delta, and adjacent Yukon Coastal Plain and Richardson Mountains are underlain by a thick sequence of Mesozoic and Cenozoic rocks, which have been deposited in the Beaufort-Mackenzie Basin. Sedimentation began in this basin during the Triassic (Young et al., 1976). From Triassic through Early Cretaceous time this basin was filled with clastics eroded from surrounding highlands, notably the Barrow Arch to the north (located under the present continental shelf), the British and Barn mountains to the west (parts of the Romanzof Uplift), and the Eskimo Lakes Arch to the southeast. During this time period the focus of deposition often shifted due to structural activity, mainly in the areas of the Eskimo Lakes Fault Zone and the Cache Creek Uplift (Fig. 6). Also at this time, shale and siltstone were deposited in basins during major transgressions, and sandstone along shorelines and in deltaic wedges. Near Inuvik, silty shales of the Horton River Formation (Norris, 1981b) are representative of the fine grained facies. West of the Mackenzie Delta a complex of fault blocks exposes shales, siltstones, and sandstones of the Jurassic Bug Creek Group and Kingak, Porcupine River, and Husky formations and numerous Lower Cretaceaous formations (Norris, 1981b). Generally, ridges consist of resistant sandstone members of this group of rocks.

During the Late Cretaceous thick sequences of shale were deposited in basins centred under Kugmallit Bay and Richards Island to the east of Mackenzie Delta and along Blow River to the west of Mackenzie Delta in the Yukon. A major contribution to development of the eastern basins was fault activity along the Eskimo Lakes Fault Zone (Fig. 6). Along with the Barn and British mountains to the west and part of the Eskimo Lakes Arch, which continued to contribute sediment, the Richardson Mountains were uplifted during the Laramide Orogeny and also became sources of sediment (Young et al., 1976). North and east of Inuvik mudstones of the Upper Cretaceous Tent Island Formation are exposed (Norris, 1981b). West of Mackenzie Delta, thick sequences of mudstone and shale of the Upper Cretaceous Boundary Creek and Tent Island formations outcrop (Norris, 1981b). The Moose Channel Formation, which is the uppermost Cretaceous unit in the area, contains numerous sandstone and conglomeratic beds rich in chert, volcanic, and metamorphic lithic fragments (Young et al., 1976).

Tertiary time marked continued deposition centred near the south end of Richards Island. "The major source-area was still the western tectonic highland, but uplifts along the Eskimo Lakes Fault zone also were starting to shed coarse debris into Richards Island Basin. Thus, a wide, fringing coastal plain was formed consisting of paludal, fluvial and alluvial fan lithofacies". (Young et al., 1976, p. 57-58). This was succeeded by a marine transgression with deposition of shale and a second clastic influx dominated by coarse grained sediments. Representative sediments of this Neogene sequence, including the coarse clastics of the Reindeer Formation, are exposed along the west edge of the Caribou Hills (Norris, 1981b; Young, 1978). Neogene clastics also outcrop to the west of Mackenzie Delta near the Yukon border (Yorath et al., 1980).

The final episode of deposition in the Beaufort-Mackenzie Basin is represented by "a series of Paleogene and Quaternary clastic wedges prograded far out onto the continental shelf of the Beaufort Sea" (Young et al., 1976, p. 58). Gravels and sands of the Beaufort Formation deposited during this time interval form the cap of the Caribou Hills (Norris, 1981b). Although clay and shale are common in the section, gravels and sands with abundant pebbles composed of chert and quartzitic sandstone as well as peat layers are present (Young, 1978).

Throughout the history of the Beaufort Mackenzie Basin, uplift was centred along a complex structural element called the Aklavik Arch Complex (Young et al., 1976). This northeast trending feature includes the Cache Creek and Campbell uplifts (Fig. 6) where Paleozoic and Proterozoic rocks are exposed. In the Campbell Uplift, Proterozoic argillites, quartzites and dolomites and Cambrian and Devonian dolomites and limestones are exposed (Norris, 1973). In the Cache Creek Uplift, Permian carbonates and clastics, mainly shales and siltstones dominate (Norris, 1981b).

The Campbell-Sitidgi Lowland is formed in a graben (Norris, 1981b). The trough occupied by Mackenzie Delta and extending offshore to the Continental Shelf would seem also to be a modified graben-like feature (Yorath, 1973). It cannot be ruled out, however, that the trough may be in part or totally the result of fluvial and glacial erosion.

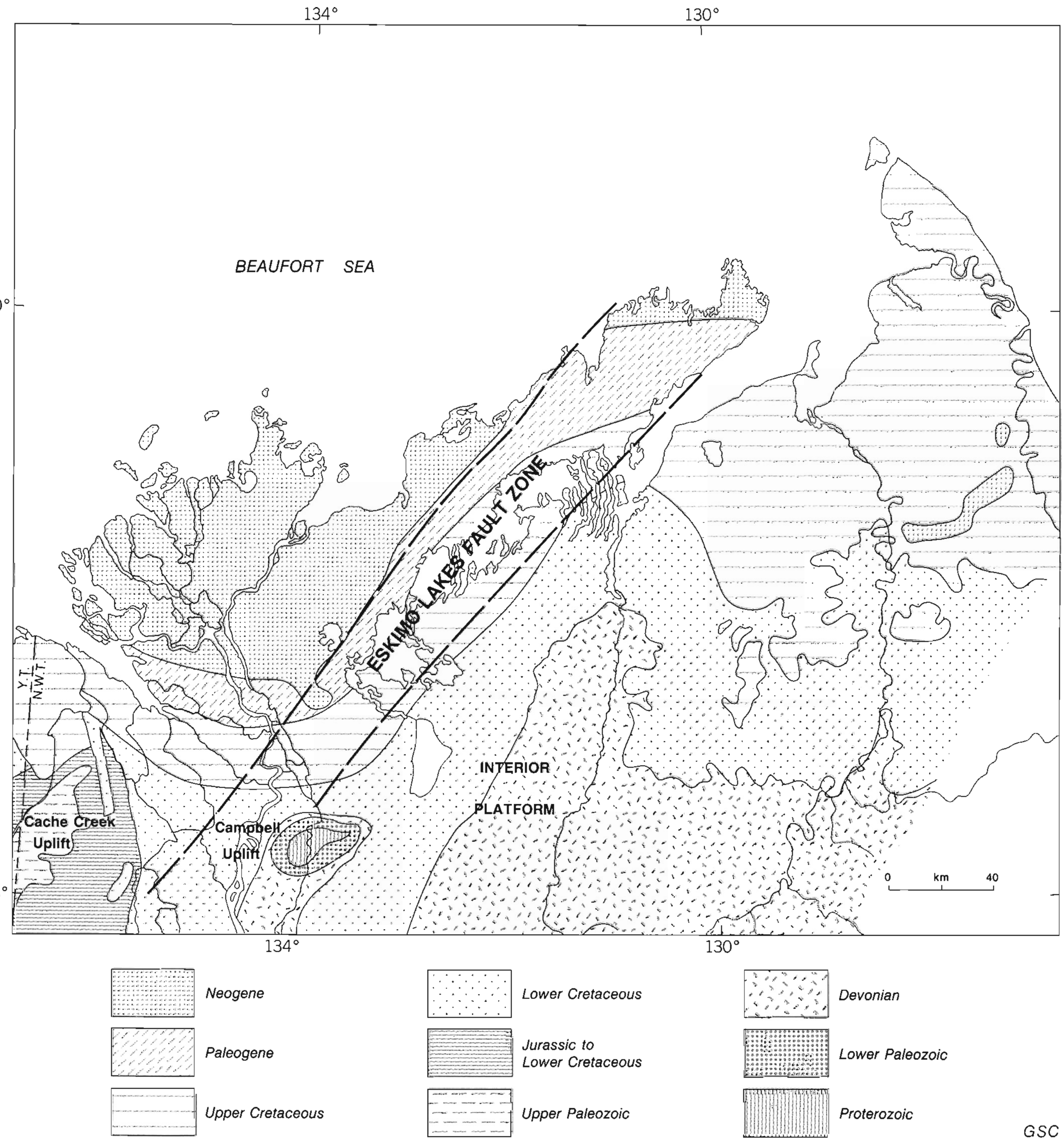


Figure 6. Bedrock geology (modified from Young et al., 1976).

Climate, vegetation, and permafrost

Climate

Most of the study area is characterized by an arctic coastal climate in that long cold winters extending from October to April are interrupted by short cool summers (Ritchie, 1984). Most strong winds occur during fall and winter (Burns, 1973). The area is dominated by continental arctic air except during the summer when maritime arctic air develops along the coast. Precipitation is meagre. Snow, which falls mainly in October, is redistributed and compacted by wind; this has a secondary effect on climate in that the snowpack melts slowly and through its high albedo delays seasonal warming (Ritchie, 1984). In the summer, cyclonic activity brings an increase in precipitation (Burns, 1973). Temperatures and precipitation recorded at Tuktoyaktuk (Fig. 7) are typical of the arctic coastal climate.

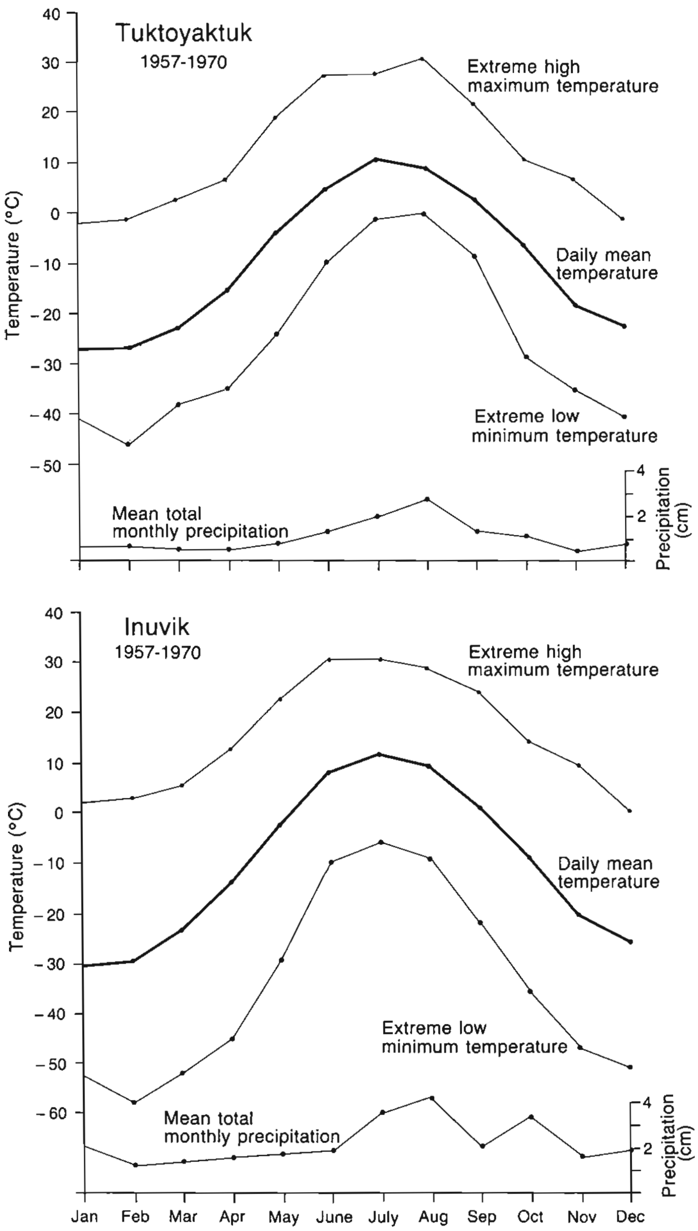


Figure 7. Climatic data for Tuktoyaktuk and Inuvik (adapted from Burns, 1973).

Continental subarctic climate characterizes the area south of treeline; winters may be colder with stronger temperature inversions than along the coast. Spring comes faster than along the coast as the albedo effect of the snow is counteracted by absorption of radiation by the spruce trees (Ritchie, 1984). Temperatures and precipitation recorded at Inuvik (Fig. 7) are typical of the northern edge of this climatic zone.

The breakup of sea ice in the Beaufort Sea occurs adjacent to Mackenzie Delta and progresses to the east where it is usually completed during July (Burns, 1974). Ice can be blown landward by persistent westerly winds. Cloud and fog are common along the coast in summer when warm moist air travels over cold ice-water surfaces and is subsequently moved inland by light onshore winds (Burns, 1974).

Vegetation

Tuktoyaktuk Coastlands are covered mainly by low arctic tundra vegetation with only forest-tundra being present along its southern periphery (Fig. 8). Anderson Plain is also covered by low arctic tundra vegetation except for southwest of Kugaluk River where forest-tundra is present and near Sitidgi Lake where boreal forest prevails. Mackenzie Delta is covered by vegetation typical of an active fluvial plain; however its vegetation reflects the increasing severity of the climate as the Beaufort Sea is approached. Richardson Mountains and Yukon Coastal Plain are covered by low arctic tundra vegetation (Mackay, 1963a).

The northeastern end of Tuktoyaktuk Peninsula, terrain north of Rufus Lake along Liverpool Bay, and terrain north of Mason River are covered by sedge tundra, mainly **Eriophorum vaginatum** (Mackay, 1958a, 1963a; Ritchie, 1984). In poorly

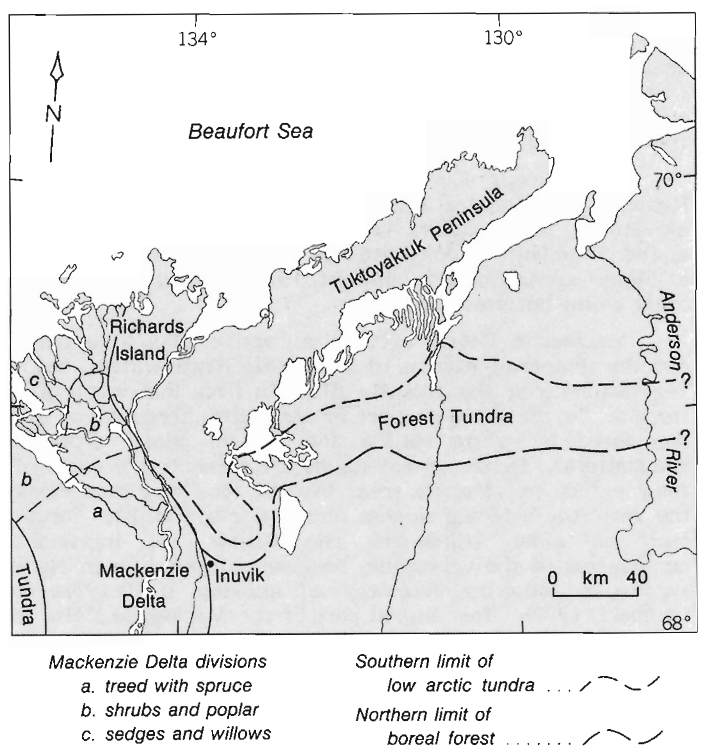


Figure 8. Vegetation of Tuktoyaktuk Coastlands and adjacent areas (adapted from Mackay, 1963a; Ritchie and Hare, 1971).

drained areas tussocks develop (Lambert, 1972). Small shrubs may be present in south-facing locales protected from the wind. On mud boils and on the dry crests of hills some bare patches occur. Mackay (1958a) noted that 25% of the ground surface was bare at Baillie Island where the climate is most severe within the study area.

Shrub tundra, described by Mackay (1958a, 1963a) as being composed of "scrub willow and ground birch" covers much of the southern limit of low arctic tundra zone (Fig. 8). This community is dominated by dwarf birch (**Betula glandulosa**), willow (mainly **Salix glauca**), and numerous heaths (cf. **Vaccinium** sp., **Ledum decumbens**, **Empetrum nigrum**). Sedges still abound within the ground cover (Mackay, 1958a, 1963a; Lambert, 1972; Ritchie, 1972, 1984). The height and density of the shrubs increase towards treeline.

The forest-tundra is the narrow transition belt where boreal forest gives way to low arctic tundra. Trees are scattered and in clumps amongst the dense shrub cover dominated by scrub birch, willows, and heaths (Lambert, 1972). Mesic sites are characterized "by an open-canopy stand of Picea glauca .... whereas poorly drained areas are occupied by Picea mariana bog communities" (Ritchie, 1972). The northern treeline is formed by clumps and individuals of white spruce (**Picea glauca**). A few individuals and clumps of spruce, occasionally showing a krummholz growth form, extend well north of a definable treeline. Mackay (1963a) has observed spruce to within 15 km of the mouth of Anderson River and suggested that it may recently have grown near the mouth of the river (1958b). Spruce has also been recorded 10 km beyond treeline near Tuktoyaktuk (Spear, 1983).

South of Inuvik and Sitidgi Lake, boreal forest, albeit quite open near its northern extent, is present. The forest is dominated by black spruce (**Picea mariana**) and white spruce (**Picea glauca**) with some birch (**Betula** sp.) and popular (**Populus** sp.). The composition is generally determined by the drainage and successional history following fire (Ritchie, 1974). Both the northern boreal forest and woodland-tundra have been continuously ravaged by fires in this area (Mackay, 1963a; Lambert, 1972).

The Yukon Coastal Plain (mountain fringe) and Richardson Mountains are covered by shrub tundra at low elevations, sedge tundra at intermediate elevations, and alpine communities (dominated by **Dryas** sp. and other herbs) at higher elevations (cf. Lambert, 1972). Popular is present along valley bottoms.

Mackenzie Delta, because of active alluvial activity and the tempering effects of Mackenzie River waters, has a vegetation cover significantly different from the surrounding terrain. In the southern part of the delta, treed areas are dominated by white spruce and balsam poplar (**Populus balsamifera**). Dense spruce stands are present well north of their extent in adjacent areas (except for the spruce along the xeric south-facing slopoes of the Caribou Hills). Shrubs such as alder (**Alnus** sp.) and willow are important components of the vegetation because of their role in plant succession following deposition of alluvium (Gill, 1972a, b; Lambert, 1972). The central part of the Mackenzie Delta is dominated by willow and alder, although low areas are characterized by marshy vegetation (Mackay, 1963a). Poplar extends into this belt, well beyond the limit of spruce. The outer islands are covered mainly by sedges and willows due to constant flooding and the cooling affects of the adjacent Beaufort Sea.

Permafrost

Distribution and temperatures

Tuktoyaktuk Coastlands and adjacent areas lie within the zone of continuous permafrost. Thawed zones or taliks exist under large lakes and major river channels (Mackay, 1962, 1979a; Smith, 1976). Mackay (1979a) has calculated that on Tuktoyaktuk Peninsula lakes older than 10 000 years with diameters greater than 650 m will be underlain by through-going taliks. Beneath small, younger lakes closed taliks occur whose dimensions are related to the size and age of the lake, the temperature of the lake bottom, and the temperature of the surrounding ground. Geophysical surveys (Scott and Hunter, 1977; Geophysicon Ltd., 1983) confirm this. In the Mackenzie Delta, drilling has also demonstrated that even some smaller lakes have through-going taliks under them (Johnston and Brown, 1964, 1965). Hunter et al. (1981) have traced in detail through geophysics and drilling the extent of a talik, up to 40 m thick, under a 300 m-wide lake on Richards Island.

Permafrost thickness varies throughout the area. Mackay (1979a), based on data from Judge et al. (1979) and Taylor and Judge (1977), indicated that much of Richards Island and the northwestern edge of Tuktoyaktuk Peninsula are underlain by more than 600 m of permafrost. Judge (1986) has identified an area under northeastern Richards Island and adjacent water bodies where permafrost exceeds 700 m thick. Along the northern edge of the Eskimo Lakes permafrost attenuates to 200 m (Judge, 1986). North of Inuvik, permafrost is nearly 400 m thick to the edge of the Mackenzie Delta (Mackay, 1979a; Burgess et al., 1982). In the Mackenzie Delta, permafrost is much shallower; for example, thicknesses of 74 to 90 m have been recorded in the distal portion (Burgess et al., 1982). In the southern part of the delta, near Inuvik, permafrost is at least 80 m thick (Johnston and Brown, 1965).

Temperatures within permafrost are partly related to its thickness (Mackay, 1975e, 1979a). The northern end of Tuktoyaktuk Peninsula and terrain north of Mason River have mean annual near-surface ground temperatures of -9° to -10°C. Temperatures range from -8° to -9°C in the northwest corner of Richards Island, from -5° to -6°C in Caribou Hills, and from -3° to -4.6°C around Inuvik. In the Mackenzie Delta, the southern part is characterized by mean annual near-surface ground temperatures of -3° to-4°C, and the northern part by temperatures of -2° to -3°C.

Figure 9. Ice wedge and ice-wedge cast in lacustrine and perimarine sediments near Maitland Point on Bathurst Peninsula. Ice wedge is approximately 1.5 m across at its top and 4 m deep. (Photo by J-S. Vincent) (GSC 204056-D)

Mackay (1975e) analyzed active layer thickness for different soil and vegetation types in the area using data presented by Tarnocai (1973) and Zoltai and Tarnocai (1974). Generally active layer thicknesses are 0.2 to 0.5 m in vegetation-covered terrain and slightly thicker in bare sandy or gravelly areas.

Ground ice and related features

Ground ice is ubiquitous throughout the area in the form of small ice crystals or as a bonding agent within the soil. Distinct, more or less clean ice bodies of various dimensions are also irregularly distributed in the subsurface in the form of ice-wedge ice, pingo ice and associated tension crack ice, ice veins, ice lenses, and massive ice (Mackay, 1971, 1972a, b, c, d, 1974c; Rampton, 1974a). Where a relatively thick body of ice is present (i.e. with vertical dimensions of at least 10 to 100 cm) it is termed massive ice (Brown and Kupsch, 1974). Where sediments enclose numerous small ice bodies, be they lenses, seams, or irregular veinlets, they are termed icy sediments (Rampton, 1974a). Both phenomena are common in the area. Icy sediments were noted in about 20% of seismic shot hole logs of up to 40 m depth in the area (Rampton and Mackay, 1971).

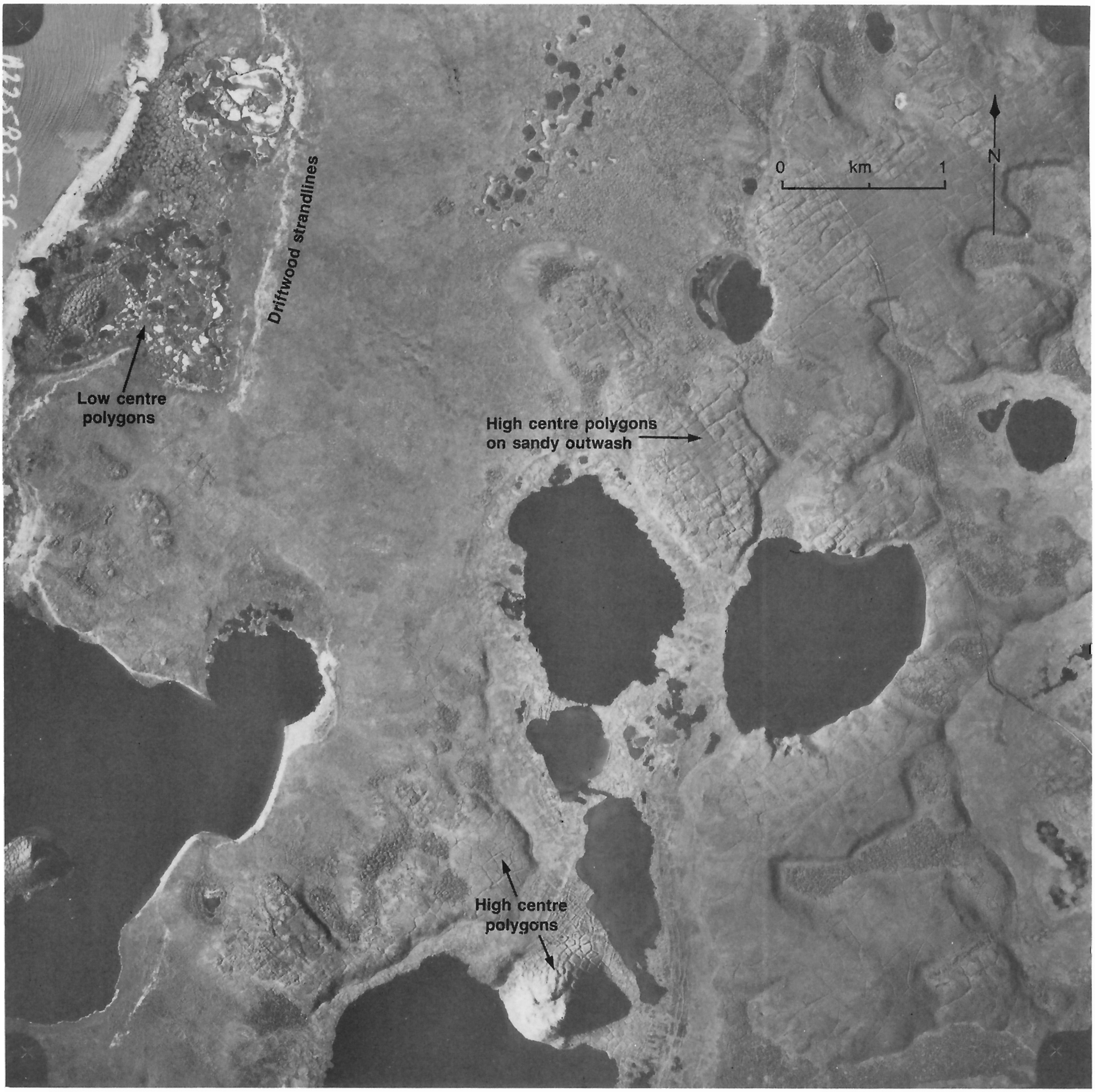


Figure 10. Polygonal ground underlain primarily by lacustrine sediments, northeast of Tuktoyaktuk; rectangular patterns occur on sandy outwash. Note driftwood strandlines. NAPL A22535-36

Ice wedges in this area are commonly between 0.6 and 1.5 m in width (Fig. 9) and 3 m deep, and form polygonal networks throughout the near-surface permafrost (Mackay, 1972a, 1974a, 1980a; Rampton, 1974a). High centre polygons are typical where the surface expression of the ice wedges is formed by trenches (Fig. 10), whereas low centre polygons are typical where the trenches are flanked by elevated rims (Mackay, 1963a). Mackay (1963a) has noted that the diameter of most polygons ranges between 6 and 30 m, a factor largely controlled by the physical properties of the enclosing materials and the age of the terrain surface (Rampton, 1974a; Rampton and Bouchard, 1975). Ice wedges are characterized by foliations paralleling their edges and commonly contain many inclusions of mineral and organic material (Gell, 1974). "Ice wedges grow by the opening of thermal contraction cracks in winter with infilling by water in spring to form an incremental ice veinlet ..... Repeated cracking over several thousand years can result in the growth of ice wedges 1 m or more wide at the top and 5 to 8 m deep" (Mackay, 1980a, p. 287). Mackay (1972c, 1974a, 1975b, 1980a) detailed the processes involved in the formation of ice wedges and polygonal ground.

Reticulate ice, which is common to some fine grained frozen sediments typically forms veins, 1 to 10 cm thick, that define rectangular to rhombic blocks, 10 to 100 cm long (Mackay, 1974c). Although present in most fine grained sediments, it is best developed in marine clay near Baillie Island in lacustrine clay and around Eskimo Lakes (Fig. 11). Reticulate ice forms where ice lenses develop from water drawn from frozen sediments causing the sediments to shrink; ice veins then also form in the shrinkage cracks (Mackay, 1974c).

Pingos are a common phenomenon on Tuktoyaktuk Coastlands, but occur with less frequency on the adjacent Mackenzie Delta and Anderson Plain. Mackay (1962, 1963a, b) has mapped at least 1350 closed system pingos on the Tuktoyaktuk Coastlands and about 80 on the seaward edge of the Mackenzie Delta (inset, Map 1647A). A few open system pingos are present on large alluvial fans along the west edge of Mackenzie Delta. Pingo diameters generally vary between 30 and 600 m with heights ranging between 3 and 50 m; they generally have convexly rounded, asymmetric summits with side slopes of up to 45° (Mackay, 1962, 1979a). Pingos collapse if their ice cores are exposed to thawing; their craters commonly fill with water (Fig. 12) and/or are surrounded by circular ridges (Mackay, 1973). The volume of ice within a pingo can generally be estimated by determining the actual volume of the pingo (Rampton and Walcott, 1974; Mackay, 1979a). The shape of the pingo reflects that of the ice core. The ice core is located immediately under the pingo, but only part of it is actually contained within that part of the pingo standing above the surrounding land (Mackay, 1962, 1979a). Large pingos have thick overburden – up to 14 m (Mackay, 1962). Pingo ice can consist of injection ice, segregated ice (Fig. 13), dilation crack ice, or a combination of these (Mackay, 1979a). Injection ice forms when water is expelled from freezing sediments and accumulates as a water lens in a shallow area of permafrost. Segregation ice forms from "the migration and freezing, of pore water added from below to the freezing plane" (Mackay, 1971). The growth of pingos is due to the freezing of water and from the accumulation of sub-pingo water lenses. Ice wedges and dilation crack ice can intersect the upper part of pingo ice cores (Rampton and Bouchard, 1975). Dilation cracks (also termed tension cracks by Mackay, 1979a) commonly form on pingos where the overburden is fissured due to stretching (Mackay, 1972b). Typically they radiate from the summit of the pingo and may extend out onto the surrounding flats (Mackay, 1979a). The cracks may continue to open throughout the year due to sustained pingo growth. During the summer, meltwater flows into them and eventually freezes to form dilation crack ice.

Massive ice and icy sediments, the latter consisting mainly of multiple ice lenses, are common throughout the area; they have been observed in coastal exposures and seismic shot holes and recorded by geophysical methods (Mackay, 1971; Rampton and Mackay, 1971; Rampton and Walcott, 1974). Massive ice can be viewed in fresh exposures around lakes and along the coast (Fig. 14A). One extensively studied exposure is located just 5.5 km southwest of Tuktoyaktuk (Fyles et al., 1962; Mackay, 1983). Such exposures are typically abundant during exceptionally warm summers or following severe summer or fall windstorms as both phenomena lead to increased coastal erosion. For example during the warm summer of 1970 ground ice was exposed extensively throughout Eskimo Lakes (Fig. 14B). The abundance of ground ice, not only in the form of massive ice but as extensive ice lensing, is confirmed by data from seismic shot hole logs. For example Mackay (1971) and Rampton and Mackay (1971) found that over 6% of the holes drilled in the Tuktoyaktuk Coastlands encountered massive ice and nearly 30% encountered icy sediments. Massive ice was found to be most common between depths of 6 and 25 m, but was present to depths of more than 46 m (Rampton, 1974b). True mean thickness of massive ice bodies was estimated to be more than 13 m (Mackay, 1971). Massive ice is most commonly found beneath hills and ridges, as has been shown by Mackay's (1971) analysis of seismic shot hole log data and by Rampton and Walcott's (1974) gravity profiling. Much of the topography of the Tuktoyaktuk

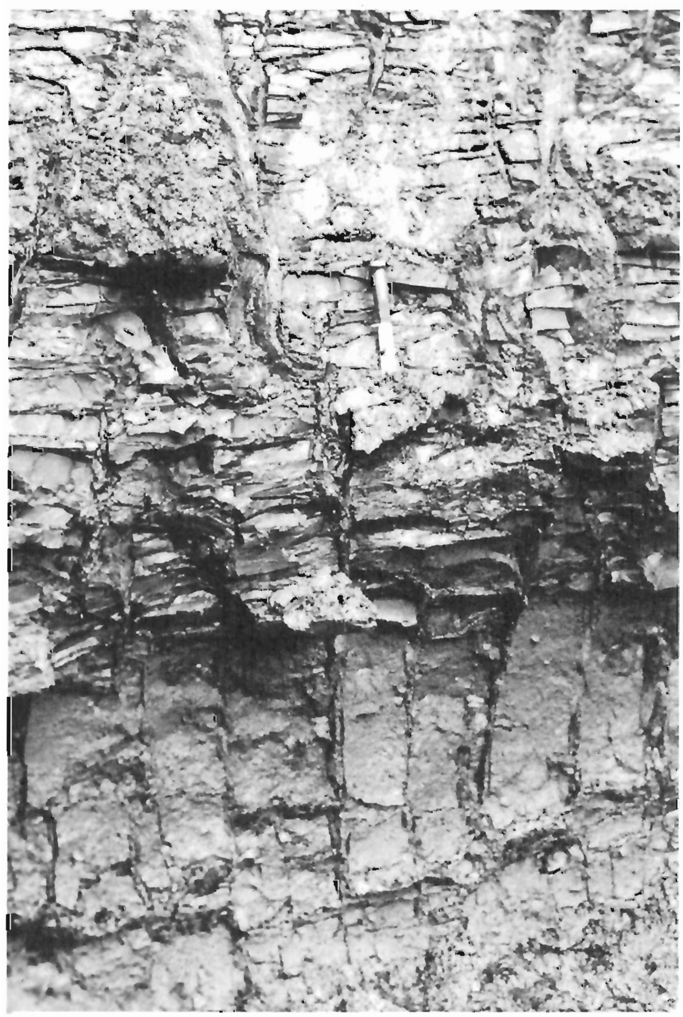


Figure 11. Reticulate ice in clayey till and lacustrine clay as exposed on Eskimo Lakes.

Coastlands can be attributed to the presence or absence of subsurface ground ice (Fig. 3, 15). For this reason such terrain has been termed ice-cored topography (Rampton, 1974a). Massive ground ice is also common in specific stratigraphic settings: "The material lying above the massive ice is variable in composition whereas the material underlying the ice is generally a coarse-grained sediment. Of the 176 bodies of massive ice that were drilled completely through, 4 percent were overlain by peat, 19 percent by gravel, or sand, 3 percent by sandy clay, 26 percent by clay, and 48 percent by clay and rocks, which is interpreted as till or material derived from the reworking of till. The material lying below the massive ice was 92 percent gravel and sand, 2 percent sandy clay and 6 percent clay". (Rampton and Mackay, 1971 p. 5).

Massive ice and icy sediments generally show near-horizontal banding in undisturbed exposures although gentle folds or arches, due to differential overburden pressures through time (Rampton and Mackay, 1971), may be present (Fig. 16). In some areas, notably on the islands in Mackenzie Bay and beneath Tuktoyaktuk, massive ice and icy sediments have been severely tilted, folded, and faulted (Fig. 17), almost certainly by glacial deformation (Mackay and Stager, 1966a; Mackay, 1971; Rampton and Mackay, 1971).

One of the most dramatic features related to the occurrence of massive ice are the involuted hills (Fig. 2); curving to branching ridges and benches on their upper surface give them their involuted character. These hills are flat-topped with steep edges and stand 15 to 45 m above surrounding topography (Rampton, 1974a). Most investigations indicate that the ice core of an involuted hill is capped by clayey diamicton (till and till-derived materials) and underlain by sand or gravel (Fig. 18; Rampton, 1974a; Scott and Hunter, 1977). Another phenomenon related to the occurrence of massive ice is topography resembling pitted outwash. This results from large thermokarst basins developing on outwash plains, for example on Eskimo Lakes Pitted Plain in the upper Eskimo Lakes (Rampton, 1974a; Rampton and Walcott, 1974). On outwash plains where thermokarst basins are shallow and the sediments homogeneous, the basins may be oriented due to wind-related patterns of bank erosion.

Massive ice and ice lenses are of segregation origin (Mackay, 1971, 1972a). Segregation of ice occurs when aggrading permafrost encounters sediments with high pore pressures and an abundant supply of groundwater. These conditions are favoured when the frost line is penetrating fine grained sediments that are immediately underlain by

Figure 12. Collapsed pingo developed in sandy sediments north of Tuktoyaktuk. GSC 159065

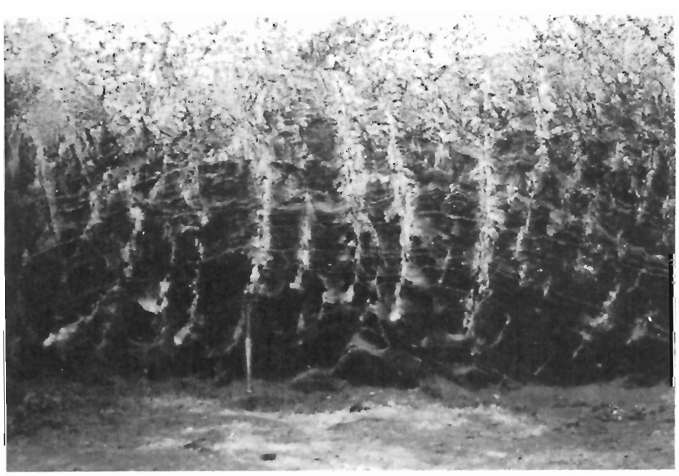


Figure 13. Segregated ice forming core of pingo at Tuktoyaktuk; dark bands are ice, light bands are silty sand. (GSC 158961)

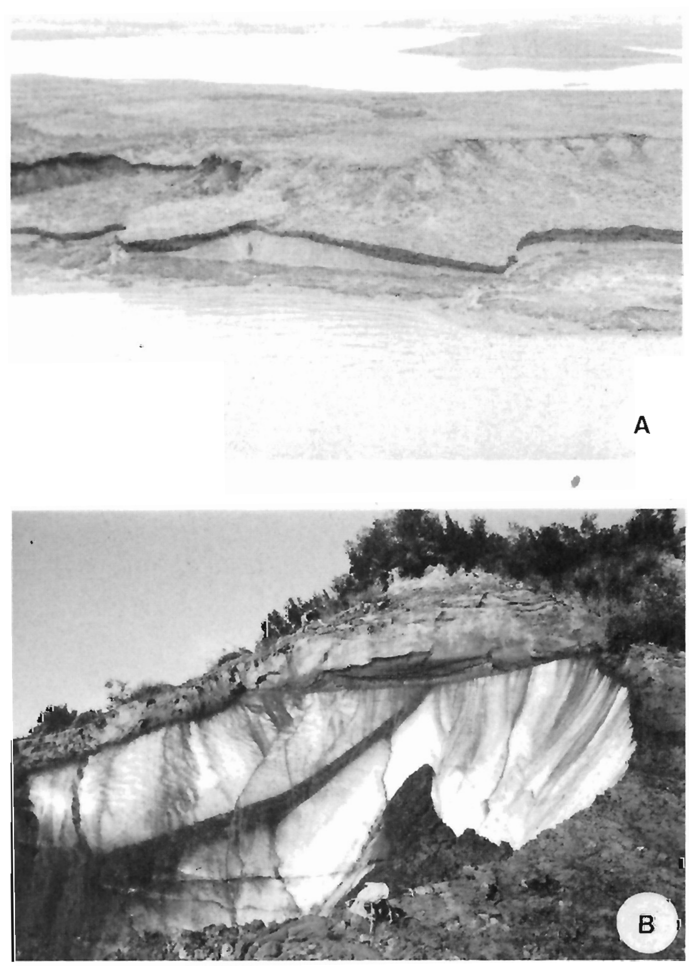


Figure 14. A. Massive ice exposed at base of partially stabilized retrogressive-thaw flow slide southwest of Tuktoyaktuk; the polycyclic rejuvenation of this flow slide is due to wave erosion at its base. **B.** Massive ground ice exposed under glaciofluvial sand in the southern Eskimo Lakes. Scale is given by person on slope. (GSC 159045)

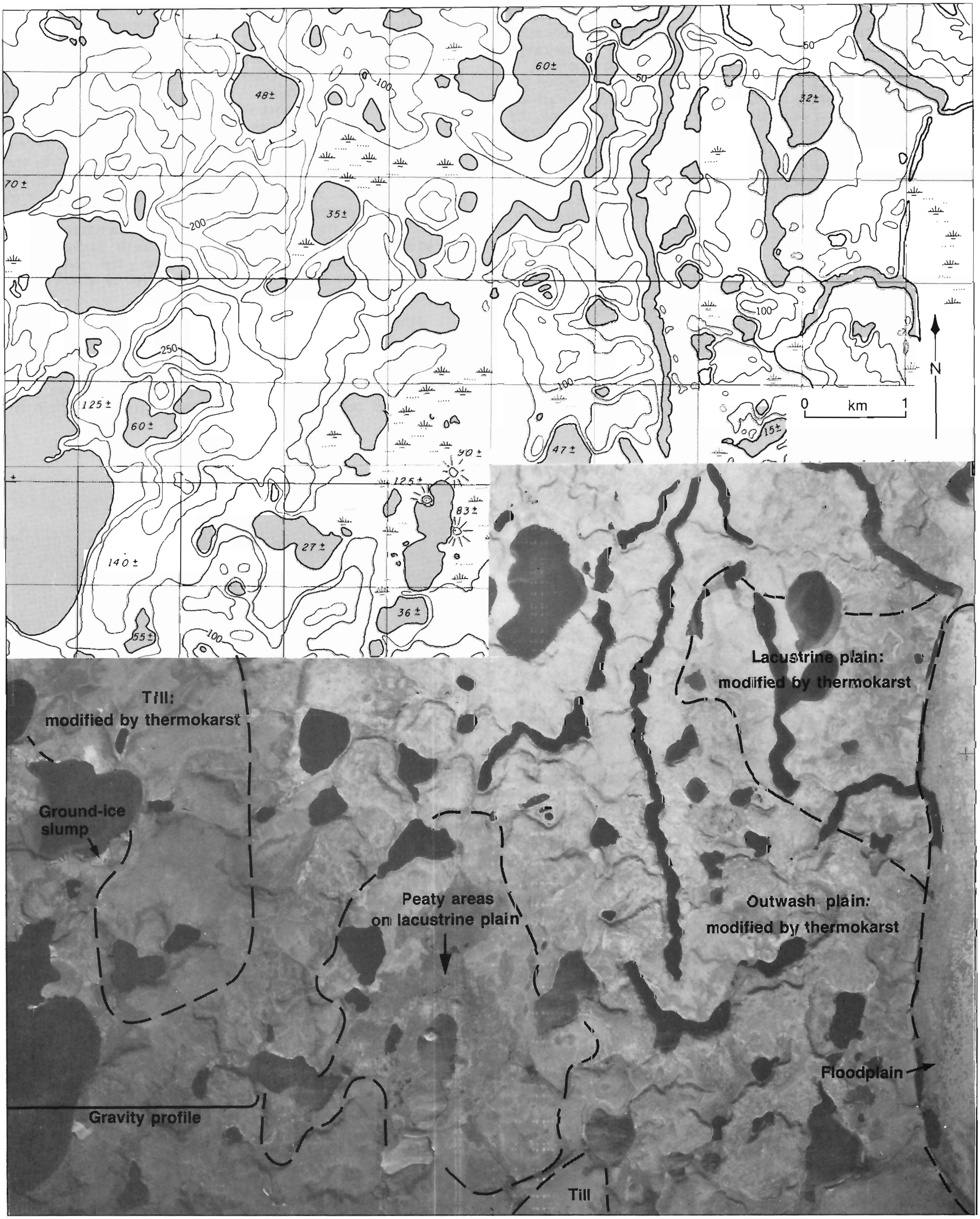


Figure 15. Ice-cored topography on Richards Island. Results from gravity profile along line shown in lower left indicated that relief here was primarily due to the presence and absence of ground ice. Linear lakes are probably due to thermokarst being concentrated along former stream courses. NAPL A12857-338

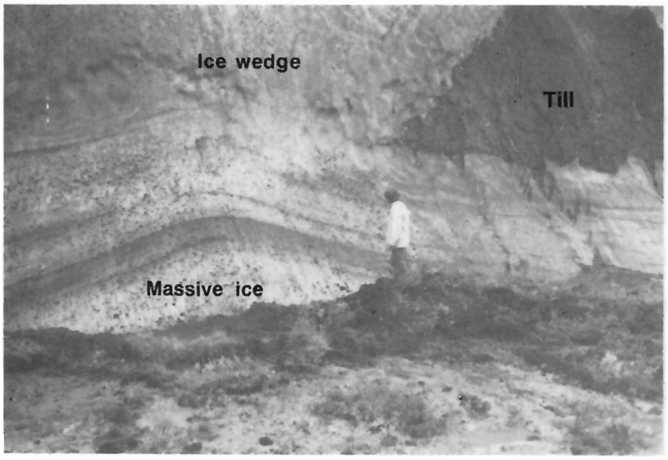


Figure 16. Massive ground ice under ice wedge showing gentle upward warping. (GSC 159013)

Figure 17. Folded ice and sand in ice cellar at Tuktoyaktuk; dark bands are ice, light bands are silty sand. (GSC 158980)

coarse grained sediments (low values of pore water pressures allow ice lensing in fine grained sediments, and coarse grained sediments allow the migration of water to the freezing plane).

Physical and thermal disturbance of slopes underlain by ground ice leads to the abundant development of retrogressive-thaw flow slides (inset, Map 1647A). These features commonly form where stream or wave erosion exposes massive ice in a slope (Fig. 14A). Parallel retreat then proceeds through the rapid melting of the ice in the exposed face. The icy face generally has slopes of 60° near its crest and 20° to 30° near its base and retreats at rates of between 1.5 and 5 m per year (Mackay, 1966a). Mineral material within the ice or overlying it slides down to the foot of the face and mixes with meltwater to form a soupy mixture. This mixture then flows farther downslope on gradients as low as 2° until the mass dehydrates and stabilizes (Kerfoot, 1969, 1972b). The surface of the stabilized mudflow debris eventually intercepts the original land surface and the flow slide is stabilized. Further erosion at the base of the slope often initiates a new retrogressive-thaw flow slide, producing a polycyclic slump (Mackay, 1966a).

QUATERNARY DEPOSITS, LANDFORMS, AND STRATIGRAPHY

The Quaternary deposits and landforms are discussed firstly according to their age beginning with the oldest, and secondly according to their location, from east to west. The deposits and landforms can most easily be grouped according to (1) those that date from the Middle Pleistocene and Sangamonian (predate the Wisconsinan), (2) those that likely date from the Early to Middle Wisconsinan, (3) those that are Late Wisconsinan and (4) those that are Holocene. Much of the area is believed to have been glaciated during the Early Wisconsinan and thus most stratigraphic units underlying till are assigned to the Middle Pleistocene or Sangamonian. Further assignment of these deposits relative to glacial periods is difficult, because although the area is believed to have been subjected to multiple glaciation, multiple tills have not been identified in the sections examined.

Most Quaternary deposits have been assigned to named formations or to informal lithostratigraphic units. Events responsible for the formation of most major landforms and the deposition of most major lithostratographic units have also been named. Figure 19 shows a tentative chronology and correlation of lithostratigraphic units and geological events. Map 1647A, which accompanies this report, shows the surficial geology of Tuktoyaktuk Coastlands.

Middle Pleistocene and Sangamonian

Middle Pleistocene and Sangamonian deposits are present in sections throughout the study area. Only east of Nicholson Peninsula, however, have these deposits and landforms been mapped over a large area (Map 1647A). Following a description of the mapped Middle Pleistocene and Sangamonian landforms and deposits east of Nicholson Peninsula, the sediments of this age present in sections will be described.

East of Nicholson Peninsula

Perimarine deposits and landforms

Perimarine deposits and landforms are common northeast of the mouth of Mason River, primarily in areas indirectly affected by glaciation (Map 1647A). A thick wedge of interbedded silts, sands, and gravels is traceable from sea level to near an elevation of 75 m[1]. In some areas a trimline in the form of a bedrock escarpment (Fig. 20), commonly up to 30 m high, appears to mark a limit of marine submergence

[1] Contours shown on Cape Bathurst peninsula topographic maps were determined to be more than 50 feet (15 m) in error, and, therefore, the accuracy of elevations of geomorphic features approximated from these contours should be viewed with this in mind.

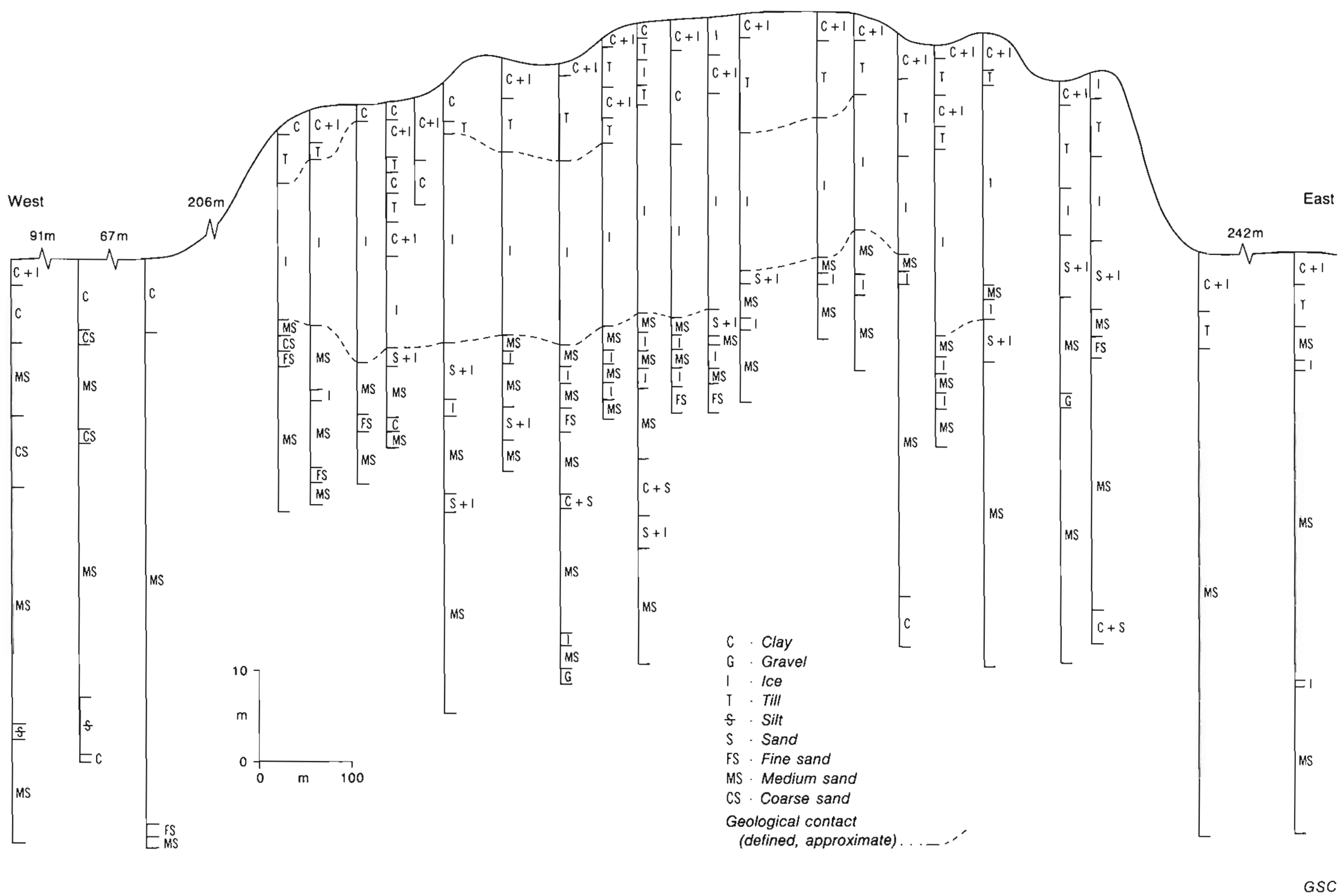


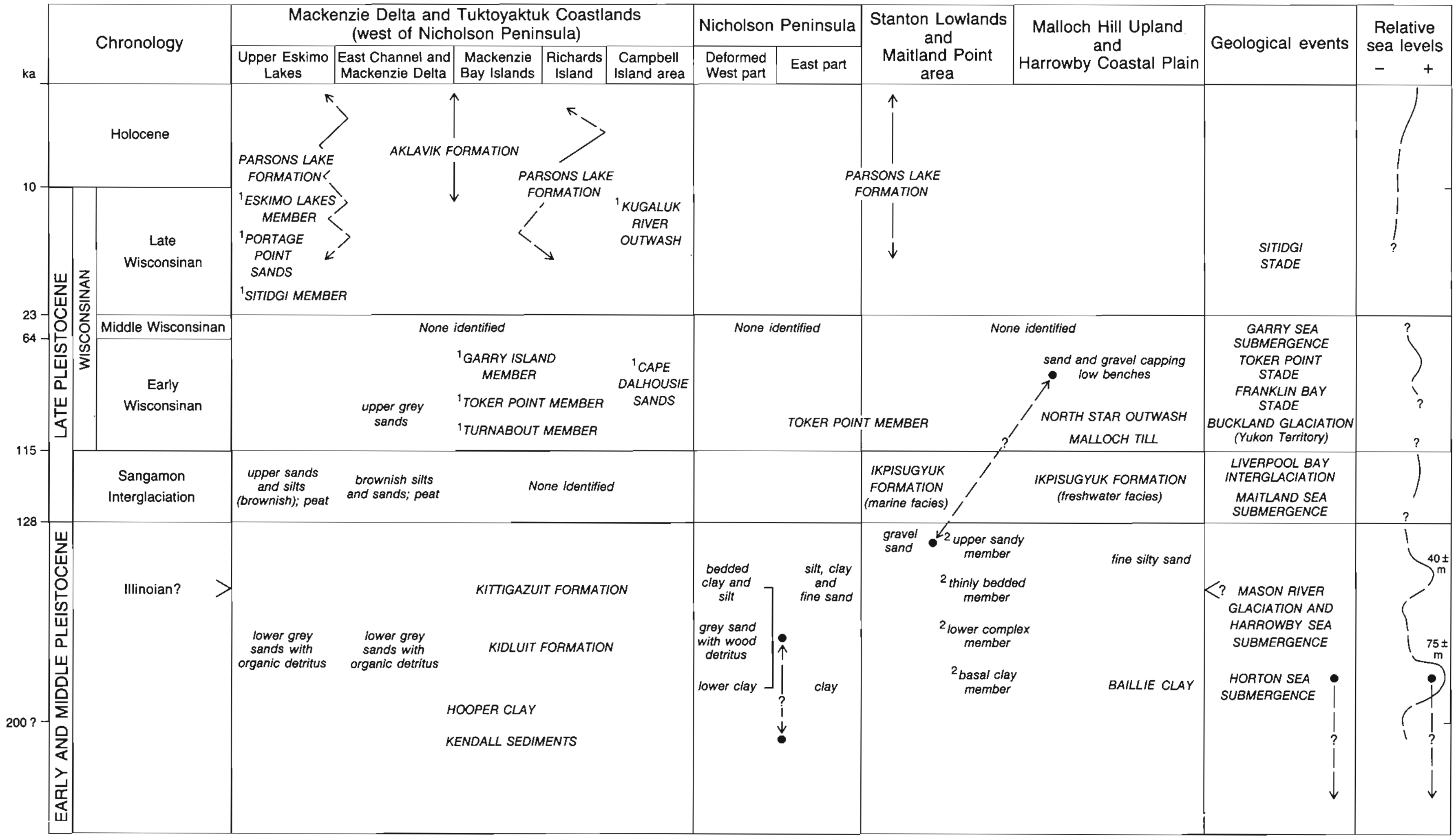
Figure 18. Cross-section across an involuted hill east of Tuktoyaktuk (see Figure 2 for location) showing relation of different sediment types to ice; near-surface ice is probably ice wedges.

at 75 m; this is shown as the Horton Sea marine limit on Map 1647A. Terrain below this trimline is usually gentle sloping to flat with local areas of rolling topography. Significant thicknesses of Pleistocene sediments appear to underlie flat and gently sloping areas whereas Cretaceous bedrock appears to be near the surface in areas of rolling terrain.

Numerous bluffs along the west coast of Cape Bathurst peninsula are formed by complex sequences of Pleistocene perimarine sediments, which will be discussed later. In coastal escarpments along the east coast of Cape Bathurst peninsula similar sequences of sediments, either present to sea level or underlain by bedrock are also present. The sediments generally coarsen with elevation. Southeast of Cape Bathurst about 2 m of silty fine sand overlies 3 m of clay containing marine shells. Farther east opposite McKinlay Lake, the stratigraphic sequence is more complex with interbedded silt, sand, and gravel (Table 2).

Farther east to the south of Trail Point, 12 m of sand and gravel cap about 30 m of shale in a steep cliff. The sand is fine to coarse with gravelly beds, whereas the gravel is pebbly with cobbles and boulders to 0.3 m diameter. Thick-walled marine pelecypod fragments were noted in the gravels. At one locality, a 0.5 m-thick bouldery clayey unit was present between the gravel and shale. The presence of granites from the Canadian Shield within this bouldery clay raises the possibility that this unit is a till. Interestingly, although a thin, discontinuous lag of quartzite and dolomite pebbles and cobbles is present on the low bedrock hill rising to more than 90 m elevation just to the west of this site, no granite erratics are present. The lag is probably a remnant of Beaufort Formation gravels, which are present on highlands west of Horton River just south of 70°N. No other erratics or till-like deposits were identified beyond the mapped limit of the Franklin Bay Stade and Mason River Glaciation (Map 1647A). However, a bench along the west edge of Franklin Bay Stade morainal deposits west of Franklin Bay (Map 1647A), which is dissected by meltwater channels (cut during the Franklin Bay Stade) is presumed to be composed of glaciofluvial deposits predating the Franklin Bay Stade.

Inland exposures of unconsolidated sediments at high elevations are rare and the actual nature of the perimarine sediments can only be postulated to coarsen (to sand and gravel) with elevation from the silt typically exposed along the east side of Cape Bathurst peninsula near sea level. Gravel was noted along the middle course of a stream draining to Cy Peck Inlet; however, clay was noted under pebbly sands along the north shore of McKinlay Lake. At low



AKLAVIK FORMATION: silt, clay, fine sand (deltaic)
PARSONS LAKE FORMATION: diamicton, clay, silt, peat (thermokarst)
ESKIMO LAKES MEMBER: clay, silt, sand, gravel (lacustrine)
PORTAGE POINT SANDS: sand, silty sand, rare gravel (glaciofluvial)
SITIDGI MEMBER: till and ice-contact gravel and sand
KUGALUK RIVER OUTWASH: sand, rare gravel (glaciofluvial)
GARRY ISLAND MEMBER: sand, pebbly sand (glaciofluvial/marine)

[1]TUKTOYAKTUK FORMATION: deposits attributed to Wisconsinan Glaciation

CAPE DALHOUSIE SANDS: sand, silty sand, rare gravel (glaciofluvial)
TURNABOUT MEMBER: sand and gravel (glaciofluvial)
TOKER POINT MEMBER: till and ice-contact gravel and sand
NORTH STAR OUTWASH: sand and gravel (glaciofluvial)
MALLOCH TILL: till, rare gravel and sand
IKPISUGYUK FORMATION: sand, silt, rare gravel, peat, wood (perimarine)
KITTIGAZUIT FORMATION: brown sands, large foresets (deltaic)

[2]STANTON SEDIMENTS (perimarine)

KIDLUIT FORMATION: grey crossbedded sands with much organic detritus (fluvial)
HOOPER CLAY: massive clay, marine shells (marine)
KENDALL SEDIMENTS: interbedded clay and sand, marine shells, woody detritus (fluvial)
upper sandy member: massive brown sand, wood, bones; woody sands?; gravels at top
thinly bedded member: clay, silt, fine sand, fine organic detritus
lower complex member: thickly bedded sand, silt, clay; soils, ice-wedge casts
basal clay member: clay, marine shells, deformed
BAILLIE CLAY: massive clay, marine shells (marine)

Figure 19. Tentative correlation chart of Quaternary lithostratigraphic units of the Tuktoyaktuk Coastlands.

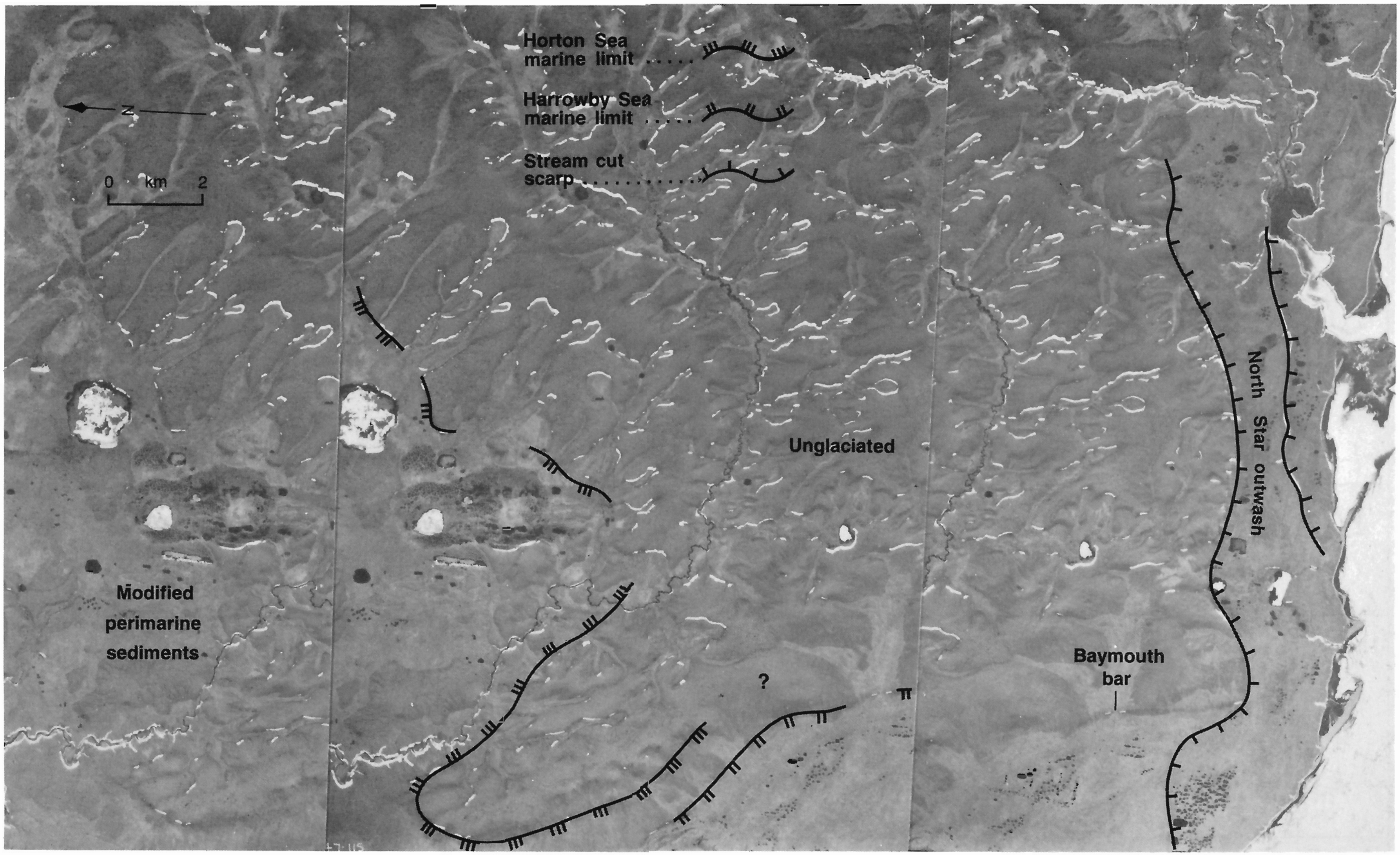


Figure 20. Marine limits of the Horton Sea and Harrowby Sea north of Harrowby Bay on Cape Bathurst peninsula. Outwash terraces along drowned former mouth of Horton River are also shown. NAPL A14147-114-116

Table 2. Stratigraphy exposed on coast near McKinlay Lake on Cape Bathurst peninsula

Thickness	Material
9 m	Medium brown sand with thin fine gravelly and silty beds
4 m	Fine brown sand with silty laminae
2 m	Medium brown sand with planar crossbeds dipping to west
12 m	Covered; appears to be silty gravel near base
5 m	Cobbly gravel
2 m	Shale to sea level

elevations, the peninsula north of Harrowby Bay is characterized by 1 to 5 m of sand over more than 2 m of clay, whereas south of Harrowby Bay the sand overlies a complex of silt, sand, and clay (Rampton, 1979a).

The flat to gently sloping topography below the Horton Sea marine limit is only interrupted by oriented lakes slightly inset, through thermokarst processes, into the land; some long linear northwest-trending ridges southeast of Baillie Island; and a number of small escarpments (Fig. 21). The ridges southeast of Baillie Island are generally only 30 to 60 m wide, 1 to 3 m high, have gentle slopes, and consist of silty fine sand (Mackay, 1958a). Rampton (1972a, 1979a) originally interpreted these features as sand dunes, but their silty fine sandy texture suggests that perhaps they are offshore bars, which have been preserved following emergence of this area during the Quaternary.

A relatively continuous shoreline – the Harrowby Sea marine limit (Map 1647A) – is present on the perimarine plain at elevations between 30 and 50 m. North of Harrowby Bay, thermokarst generally makes it difficult to delineate any strandline at this elevation, but immediately north of Harrowby Bay, a small escarpment is present at the 30 to 50 m level, which appears to be continuous with a ridge (baymouth bar?) across one valley (Fig. 20). South of Harrowby Bay, an escarpment is present above 30 m elevation within a low area connecting Harrowby Bay and the estuary to the south of Harrowby Bay. This same escarpment may be present to the north and south, but meltwater and stream activity has obscured the situation. East and south of Maitland Point an escarpment appears to be cut in unconsolidated sediments just above the 30 m level, although thermokarst activity has again complicated tracing it throughout this area (Fig. 22). East of the Mason River an escarpment inset into terrain covered by ice during the Mason River Glaciation appears continuous with the Harrowby Sea marine limit to the north beyond the Mason River glacial limit (Fig. 23). It would seem to form the upper limit of nonglacial perimarine sediments in the area covered by ice during the Mason River Glaciation and not glaciated during subsequent glaciations (Map 1647A).

Stanton Sediments (Formation)

Northeast of the mouth of Anderson River a sequence of sediments, which underlies till or till-like materials just north of Stanton, can be traced northward along the west coast of Cape Bathurst peninsula past Maitland Point. This sequence of sediments has been named Stanton Sediments and given formation status. Stanton Sediments can be subdivided into three distinctive, and possible four, members. The members are, respectively, from top to bottom: the upper sandy member, the thinly bedded member, the lower complex member, and a possibly distinctive basal clay member. Figure 24 describes sections exposed on localities shown on Figures 22, 25, and 26. Generally, the stratigraphic units appear to be traceable from the air along the coast (Fig. 27). This is difficult to confirm on the ground because no beaches exist at the base of the steep cliffs and wave-cut overhangs are present.

North of Mason River, the sequence is most complete at localities VH-83-035 and VH-83-036 (Table 3; Fig. 22, 24). The sections described in Table 3 are composite as the upper parts had to be examined at the head of gulleys leading to the coast and the lower parts in the coastal cliffs. In the estuary to the east of Maitland Point, the thinly bedded member is generally thick – more than 7.5 m at locality 32Z (Fig. 22, 24). The thinly bedded member also appears to grade upwards there into more thickly interbedded sands and silts, which have been tentatively assigned to the upper sandy member. The lower complex member appears to be thin along the south side of the estuary, but on the north side at locality 35Z (Fig. 24), over 5 m of oxidized sands and silts with thin organic beds underlie the thinly bedded member. At locality 32Z, a clay is present near sea level that shows similar diapiric structures to those at locality VH-83-036 (Fig. 29). Ice-wedge casts and an oxidized sandy bed clearly separate the basal clay member from the thinly bedded member at locality 32Z.

At locality VH-83-036, J.V. Matthews, Jr. (personal communication, 1983) collected a bison bone fragment from the base of the upper sandy member. He described fragmented and sorted fossils (chara?, fungal sclerotia, **Potentilla**, moss, flatworm cocoons, spider fragments, Leafhopper, Bryozoa, Psyllidae, **Lepiduris**, **Cladocera ephippia**, Coleopetran elytral fragments, Dipteran puparial fragments; Geological Survey of Canada Plant Macrofossil Report 18 and Fossil Arthropod Reports 84-17, 18, 19 by J.V. Matthews, Jr.) from the lenses of detritus in the thinly bedded member. An organic detrital layer near the base of the thinly bedded member contained fragments of fungal sclerotia, mosses, **Ranunculus hyperboreus** (?), **Carex aquatilis**, **Salix**, **Scripus validus**, **Potentilla**; **Cladocera ephippia**, Bryozoa, Psyllidae, **Hydroponis**, spiders, **Tachinus apterus** type, **Cyrobius**, **Lepiduris** (unpublished GSC Fossil Arthropod Report No. 84-14 and GSC Plant Macrofossil Report No. 84-15 by J.V. Matthews, Jr.). Cryoturbated peat in the lower complex member near locality VH-83-036 was found to contain the following plant macrofossils – **Carex aquatilis**, **Ranunculus**; **Potentilla**, **Melandrium**, **Salix**, **Empetrum nigrum**; invertebrate fossils – **Rhynchaenus arctica** type, **Micralymma**, Dytiscidae, **Cleonus**, **Lepiduris**, Aleocharinae, **Stenus**, **Helophorus**, spiders; and vertebrate fossils – **Dicrostonyx** molar, bone fragments and mammal feces.

Marine clays are overlain by silty sands along the coast from Harrowby Bay to Baillie Island. Generally no more than 4 m of clay and 4 m of sand are exposed above sea level. The clay, which has been called the Baillie Clay and given formation status here, may well correlate with the basal clay member of the Stanton Sediments, whereas the sand is probably a correlative of the upper sandy member. Mackay (1963a) reported the following fauna from the clay near Cape Bathurst (fauna identified by Dr. F.J.E. Wagner): Foraminifera: **Quinqueloculina seminula** (Linne), **Globulina glacialis** Cushman & Ozawa, **Elphidium clavatum** Cushman, **Elphidium frigidum** Cushman, **Elphidium orbiculare** (Brady), **Elphidiella groenlandica** (Cushman); Pelecypoda: **Yoldia arctica** (Gray); Ostracoda: **Cyprideis sorbyana** (Jones), **Cytheridea pencitillata** Brady, **Cytheris** sp., **Cytheropteron** sp. Mackay also reported that these species

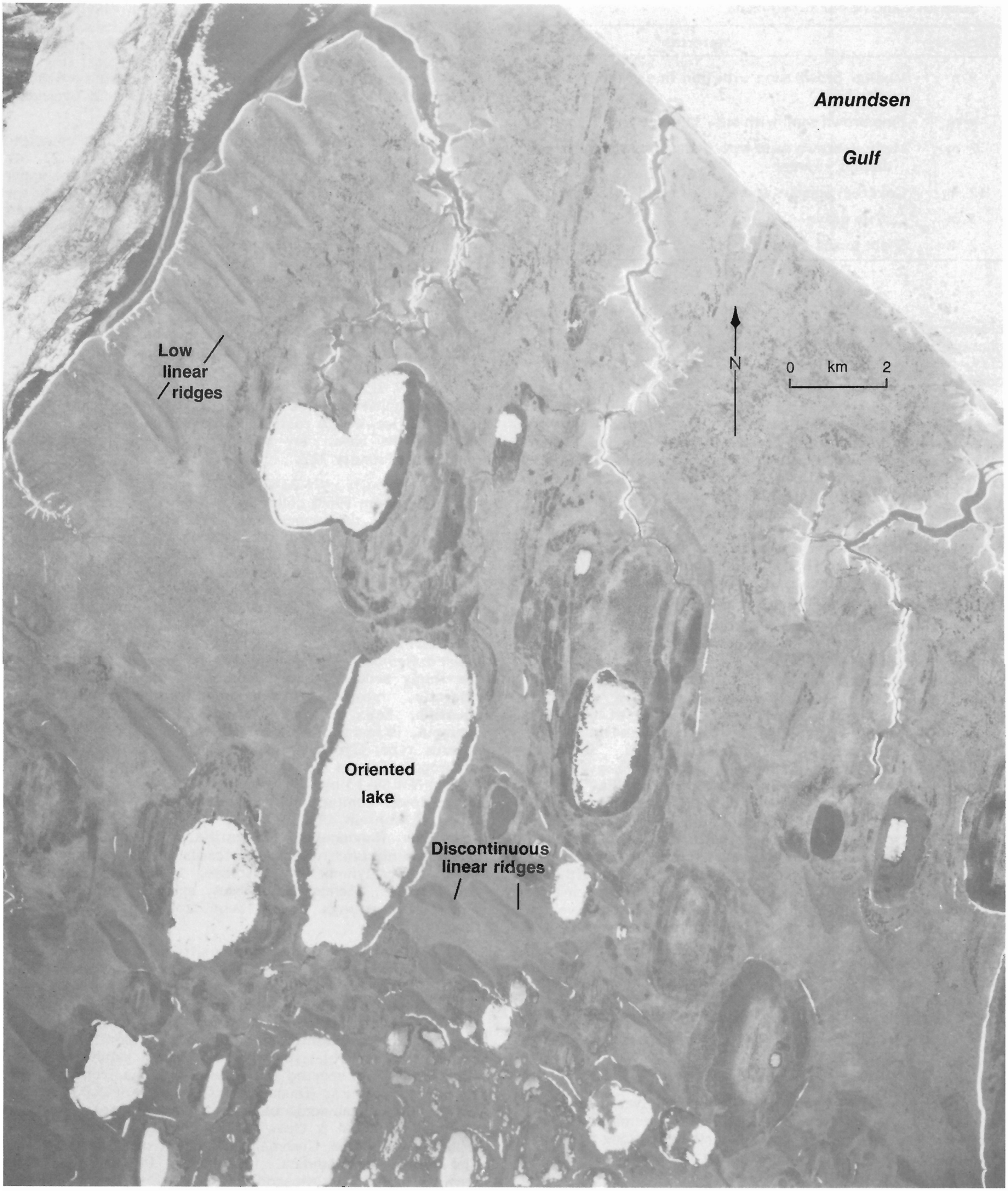


Figure 21. Oriented thermokarst lakes and low linear ridges developed on perimarine sediments just south of Cape Bathurst. NAPL A14209-32

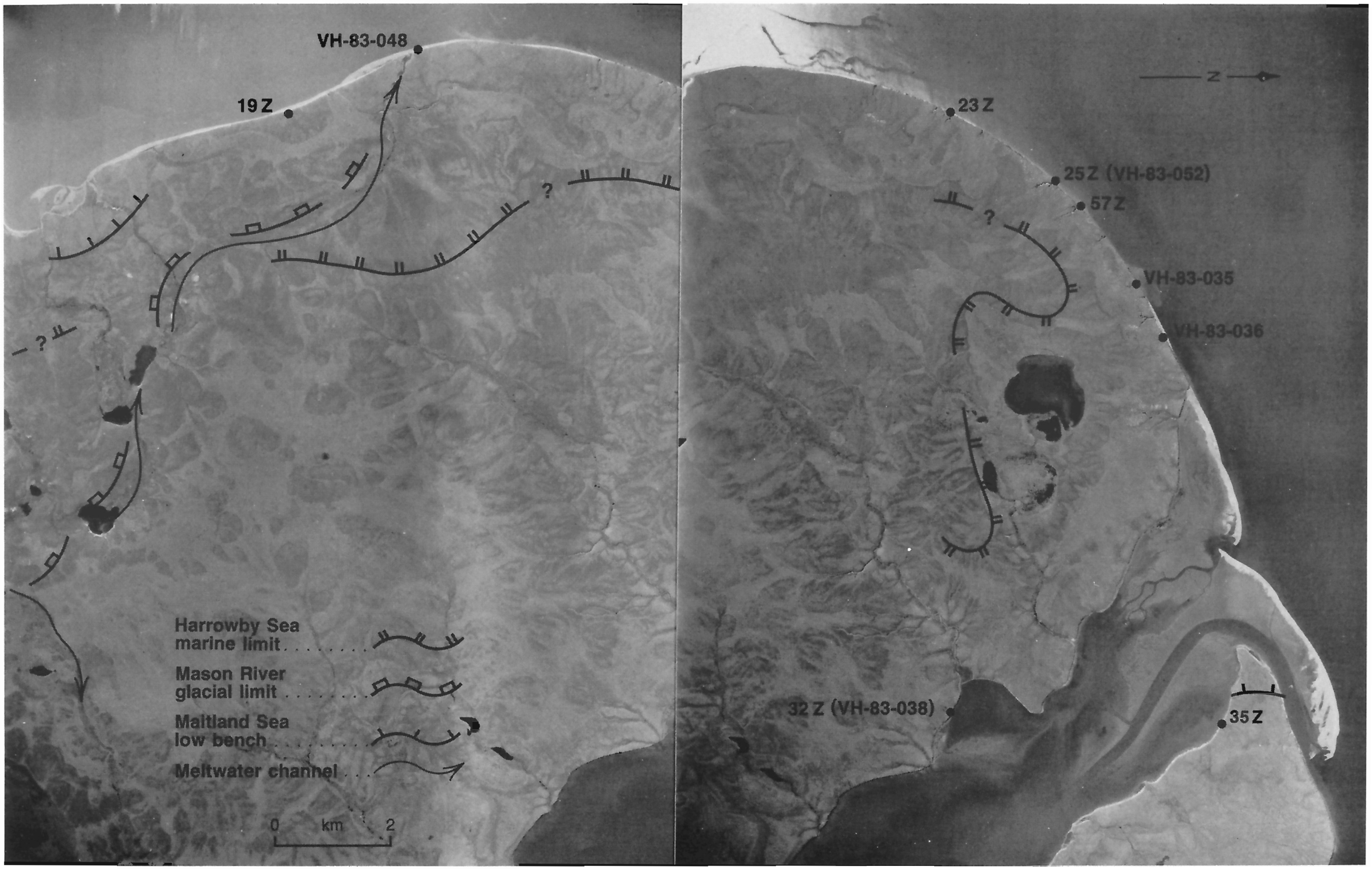


Figure 22. Probable Harrowby Sea marine limit near Maitland Point on Cape Bathurst peninsula, Maitland Sea low benches, Mason River glacial limit, and locations of described exposures of perimarine sediments along coast. NAPL A13784-174, 175

are common in arctic seas today at depths of 25 to 55 m, and that the assemblage from Cape Bathurst probably dates from the Late Pleistocene.

Towards the southwest of Maitland Point and locality VH-83-035, a channel in the bedrock appears to be filled with more than 9 m of sand and clay of the lower complex member. Peaty and pebbly layers, oxidized layers, and possibly ice-wedge casts are present in this unit. These sediments clearly underlie the thinly bedded member and perhaps owe their elevation and thickness to their protected location within a channel. South of this locality bedrock is commonly capped by gravels (lacking granites) and sands (cf. 23Z, Fig. 22). These gravels are considered to be a facies of the upper sandy member. The same gravels overlie sand containing a 2 m-thick layer of driftwood, just northeast of the Mason River delta at locality VH-83-048 (Fig. 30). The gravel has an open structure, suggestive of a beach gravel. The woody sands at locality VH-83-048 have been assigned to the upper sandy member (Fig. 24), but no doubt they could correlate with the lower complex member if the upper sandy and thinly bedded members have been eroded from this site. Notably sands containing an abundance of wood underlie the thinly bedded member at locality 10Z near Stanton (Fig. 24, 26).

West of Mason River, the sequence so well exposed at Maitland Point appears to be repeated under a diamicton – the diamicton being either till or till-derived material. At locality VH-83-045 (Table 3(c), Fig. 24, 26) a typical sequence was logged. Slightly farther to the west at locality VH-83-047 (Fig. 24, 26), a horizon containing peat and a large ice-wedge cast occurs within the interbedded sand and silt composing the lower complex member (Fig. 31A). Farther west, all contacts seem to rise in elevation (cf. 10Z, Fig. 24), and Cretaceous bedrock is

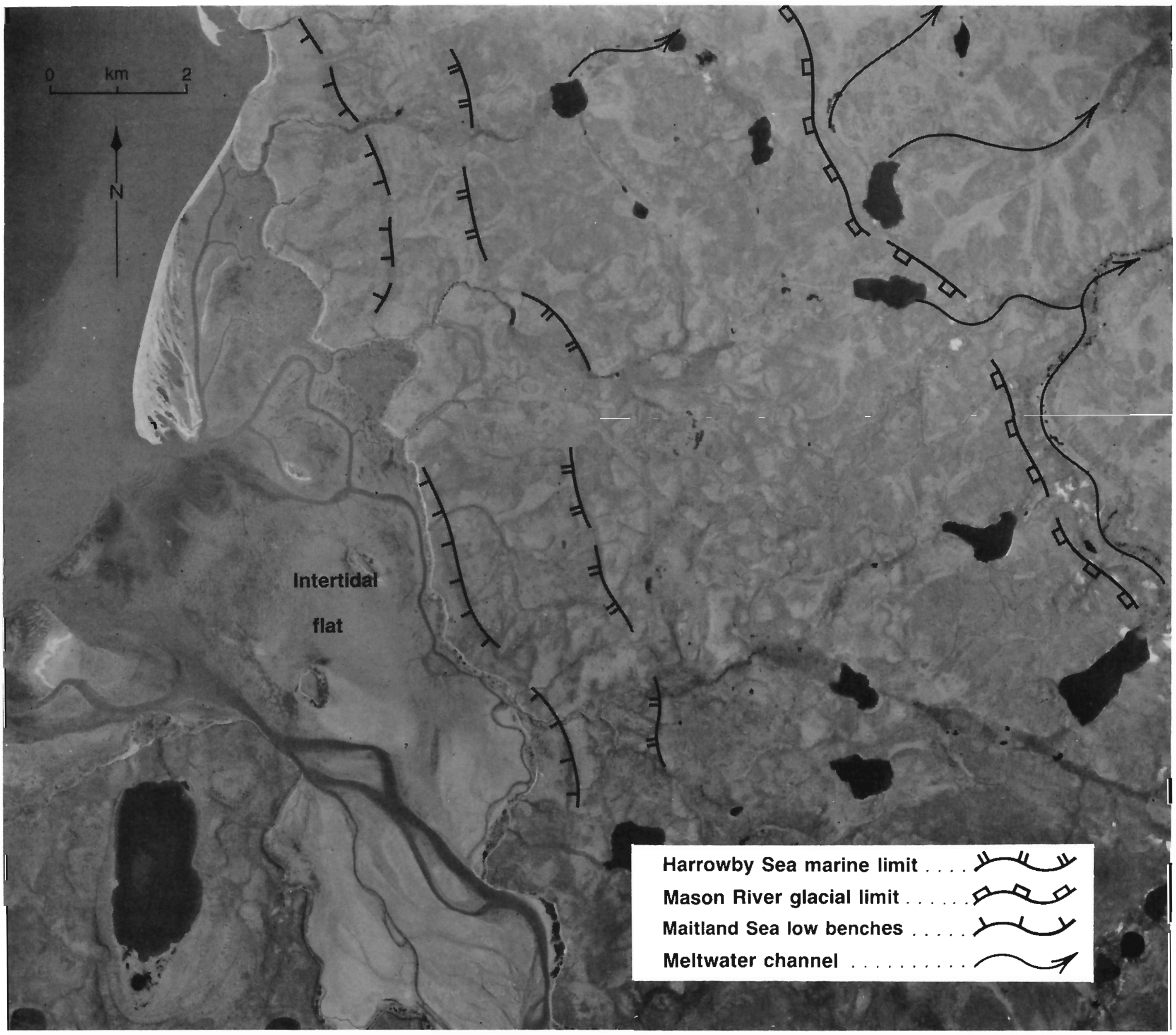


Figure 23. Probable Harrowby Sea marine limit and Maitland Sea low benches east of Mason River on Cape Bathurst peninsula. NAPL A13784-177

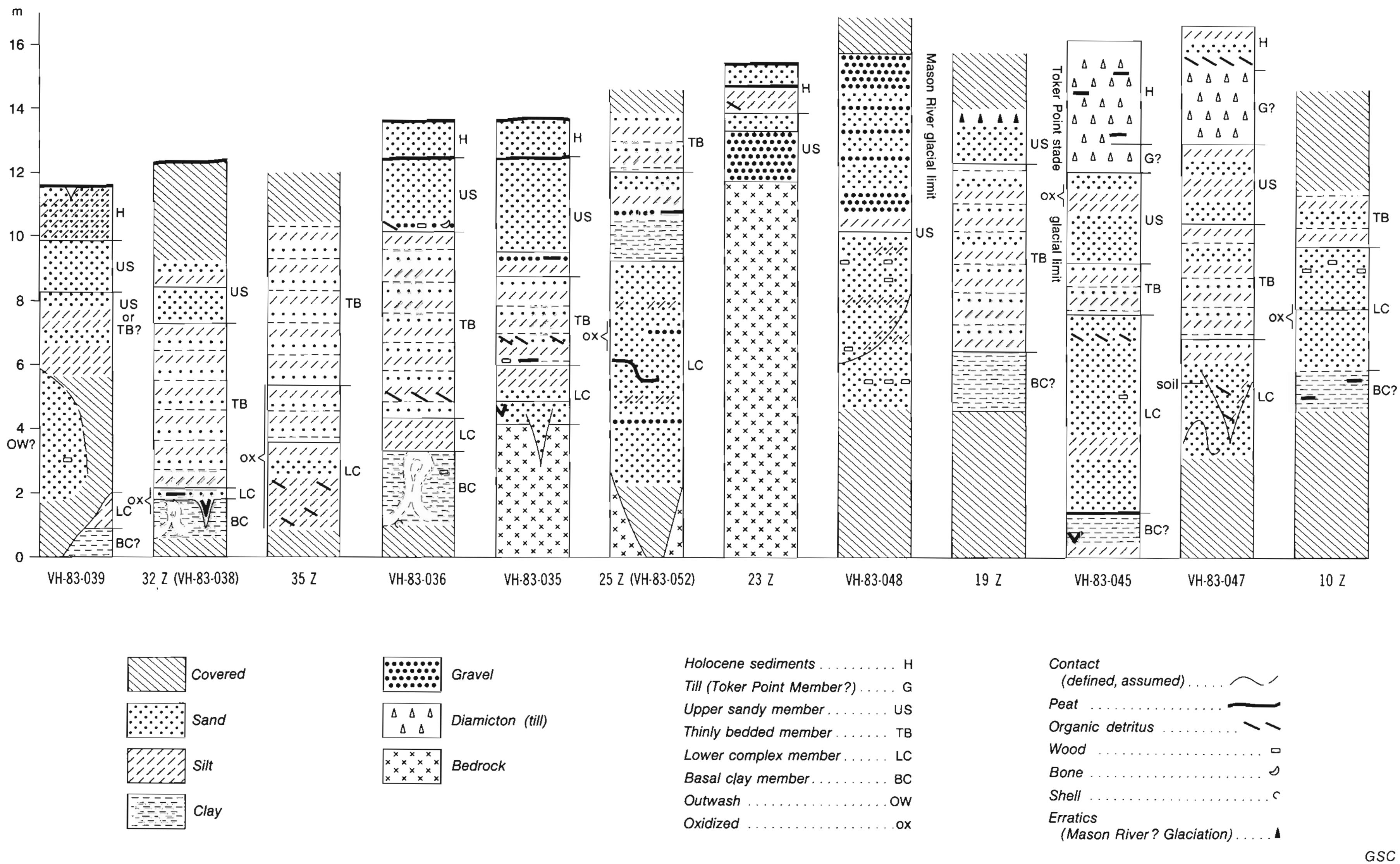


Figure 24. Major sections containing Stanton Sediments northeast of Anderson River.

Table 3. Stratigraphy of sections east of Nicholson Point containing Stanton Sediments

Thickness	Material (unit)
A. Stratigraphy at site VH-83-035 on Cape Bathurst peninsula	
2.5 m	Sand, fine, light brown, thinly laminated, few shells, peaty layer at base (Holocene, lacustrine)
3 m	Sand, fine, brown, faint horizontal laminations (upper sandy member)
0.6 m	Thinly bedded, medium-fine sand and clayey silt; pebbly layer with detrital wood fragments near crest (upper sandy member?)
2.4 m	Thinly bedded, medium-fine sands and clayey silts; peaty layer with wood at base; layer of organic detritus with few freshwater shell fragments near base (thinly bedded member).
0.9 m	Interbedded fine sand and silt, few clay pockets, banded; massive appearance on weathered surface (lower complex member).
0.8 m	Sand, silty, brown, banded; contains small ice-wedge casts containing peat and wood (lower complex member).
4.5 m	Cretaceous shale
B. Stratigraphy at site VH-83-036 on Cape Bathurst peninsula	
1.2 m	Sand, fine, horizontally bedded, peaty layer at base (Holocene, lacustrine)
2.0 m	Sand, fine brown, massive; pebbly layer with fine organic detritus, wood, and bone fragments at base (upper sandy member)
6.4 m	Thinly bedded fine sandy and silt; organic detrital layers near base (Fig. 28); one layer locally convoluted (thinly bedded member)
0.9 m	Clay, silty; contains rare wood and marine shells; bedding locally show diapiric folds (Fig. 29) (lower complex member or basal clay member)
C. Stratigraphy at site VH-83-045 to west of Mason River	
3.0 m	Diamicton, clayey, pebbly, peaty pods (Holocene, colluvium)
2.4 m	Interbedded medium-fine sand and loamy silt; beds moderately thick (upper sandy member)
1.6 m	Thinly bedded, fine sand and silt (thinly bedded member)
6.0 m	Sand, fine, brown; silty layers near base; near top few thin beds of silt; massive 0.5 m sand layer containing "leafy" detritus layer at base; unit contains wood and ice-wedge casts (lower complex member)
0.2 m	Peat, powdery, few twigs (lower complex member)
1.0 m	Clay, silty, light grey; peaty layers near base; possible ice-wedge cast near base (basal clay member)

exposed above sea level near Stanton. At one locality near Stanton about 1.5 m of gravel was observed overlying shale and underlying 15 m of poorly exposed Quaternary sediments.

The basal clay member was clearly deposited in marine water as can be deduced from its texture and fossil content; however, the origin of the other members is less obvious. Soil horizons, ice-wedge casts, and gravels within the lower complex member indicate frequent aerial exposure of ground surfaces and probably stream or beach activity. Whether the fine grained facies of the lower complex member was deposited above or below sea level is not clear, although an alluvial origin is favoured given the lack of marine fossils. The thinly bedded member is thought to have formed as delta-front silts and sands, thin prodeltaic turbidites or intertidal muds and sands (cf. Walker, 1979; Reineck and Singh, 1980). Rapid and frequent or periodic introduction of transported sediment into a relatively quiet marine environment with little wave or current action is favoured over floodplain deposition as related channel and point bar deposits are absent, even though the thinly bedded member is marked by a paucity of marine fossils. The upper sandy member may have been deposited in shallow marine or alluvial environments. Channel sands containing abundant driftwood indicate fluvial deposition, and open-structure clean gravels indicate beach deposition.

Deposits of Mason River Glaciation

Only morainal and glaciofluvial deposits near the river of that same name east of Nicholson Peninsula have been assigned to the Mason River Glaciation. Outwash of the same age probably occupies the base of meltwater channels present near the Mason River glacial limit (Fig. 22). Gravels noted near where the Mason River glacial limit intercepts the coast near locality VH-83-048 (Fig. 22) may be outwash reworked by wave action; however, no granite clasts were observed in these gravels. Similarily, sand noted in a sequence at locality VH-83-039 east of Maitland Point (Fig. 24, 25) may also be outwash deposited during the Mason River Glaciation and subsequently covered by the upper sandy and thinly bedded members of the Stanton Sediments. Mason River morainal deposits appear to be generally thin; east of Mason River they primarily overlie bedrock; adjacent to and west of Mason River they primarily overlie Stanton Sediments.

Ikpisugyuk Formation

Ikpisugyuk Formation consists of organic-bearing sediments that were noted in low benches at two localities east of Nicholson Peninsula. At both localities the organic-bearing sediments were overlain by sterile grey sands. The sequence at the first locality on the north side of the large inlet east of Mainland Point (VH-83-040, Fig. 25) is described in Table 4. Ice-wedge casts were noted near the base of this sequence. A number of fossils were identified in woody organic silt near the base of the sequence, namely **Carex,** fungal sclerotia, flatworm (?) cocoons, **Cristatella mucedo, Cryobius, Dyschirius,** Hydrophilidae, Lathridiidae, **Olophrum** (?) **rotundicolle,** Donaciinae, Colymbetes (unpublished GSC Fossil Arthropod Report No. 84-15 and GSC Plant Macrofossil Report No. 84-16 by J.V. Matthews, Jr.). These sediments were probably deposited in a shallow tundra pond, whose bottom was frequently exposed to the air.

The sequence at the second locality (VH-83-050, Fig. 26) west of Mason River is also described in Table 4. The unit containing the driftwood (Fig. 32) was not observed to the west beyond the extent of a low bench covered by Toker Point Stade outwash. This unit was obviously deposited as an intertidal beach complex.

Nicholson Peninsula

Nicholson Peninsula, which rises to more than 90 m elevation, was formed through glacier ice-thrusting or deformation (Mackay, 1956a, 1963a). This has resulted in the exposure of a complex sequence of Quaternary sediments, albeit sheared, tilted and folded (Fig. 33), which are mostly below sea level in adjacent areas. Unfortunately, it is difficult to establish the stratigraphic sequence of all the exposed strata with any certainty, because of the probable overturning of beds during folding and the repetition of strata due to faulting and thrusting.

Along the east edge and southern end of the peninsula the beds do not seem as severely deformed as in exposures along its elevated northwestern quadrant. Just south of Hepburn Spit (Fig. 34), clay with **Yoldia arctica** (Mackay, 1956a) is present near sea level at the base of the sections and is overlain by interbedded silt and clay and fine brown sand. Along the central part to the east coast (cf. 61Z, Fig. 34), at least 0.5 m of medium grey sand underlies fine brown sand (unfortunately the lower 6 m of section is covered). Table 5 illustrates the best exposed sequence (site 60Z, Fig. 34) in the southwestern part of the

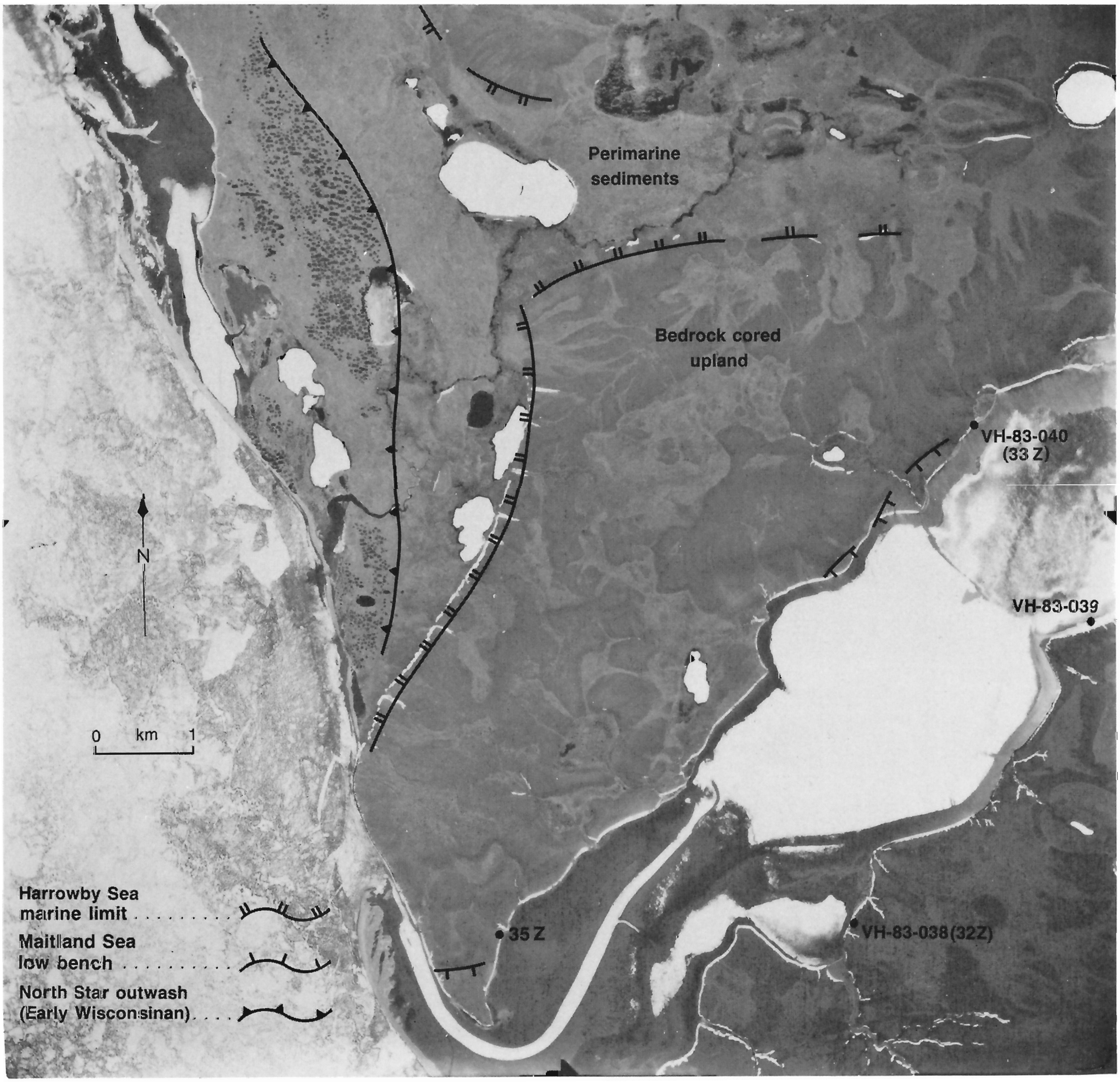


Figure 25. Location of sections VH-83-038, -039, -040, and 33Z, 35Z in drowned valley east of Maitland Point on Cape Bathurst peninsula. Note also Harrowby Sea marine limit and Maitland Sea low benches. NAPL A14209-25

peninsula. The possibility that unit 4 is the equivalent of unit 6 (Table 5) due to thrusting must be considered, even though no evidence of faulting was noted in the section.

The stratigraphic sequence in the highly deformed and elevated northwestern part of the peninsula is difficult to define because of deformation. Study of sections in the vicinity of sites 183W and 192W (Fig. 34), however, suggests that thinly bedded clays and silts overlie grey sands. The sequence in the lower part of the coastal bluffs at site 192W and that west of 191W both suggest that the grey sands are underlain by clay. The interbedded clay and sand at 191W probably underlie the lower clay unit at 192W, if the 3.5 m of fine grey sand at site 191W is representative of the grey sand unit at 183W and 192W. Alternatively, all the sediments exposed at 191W may be stratigraphic equivalents of the units exposed at 192W. The low clay unit noted at 192W may also owe its stratigraphic position relative to the grey sand to thrusting of the grey sand over the clay. In summary, the general stratigraphic sequence from top to bottom would appear to be thinly bedded clay and silt; grey sand; clay; interbedded clay and sand with organic detritus. The lower two units may be stratigraphic equivalents of the upper two units and may only owe their stratigraphic position to folding and faulting.

Generally, the upper clay and silt unit consists of thinly bedded grey to brownish-grey clay, silty clay and silt. Rare pods and thin lenses of organic detritus are contained within the unit. The grey sand unit consists of fine to medium grained sands, which are massive to thinly bedded; generally bedding is horizontal, but some crossbedding is present. Fine grained sand within the grey sand unit is brownish grey. Rare pebble beds up to 5 cm thick are present within the sand. Orange mottles are present locally and a few beds have an orangish brown coloration. Abundant woody detritus,

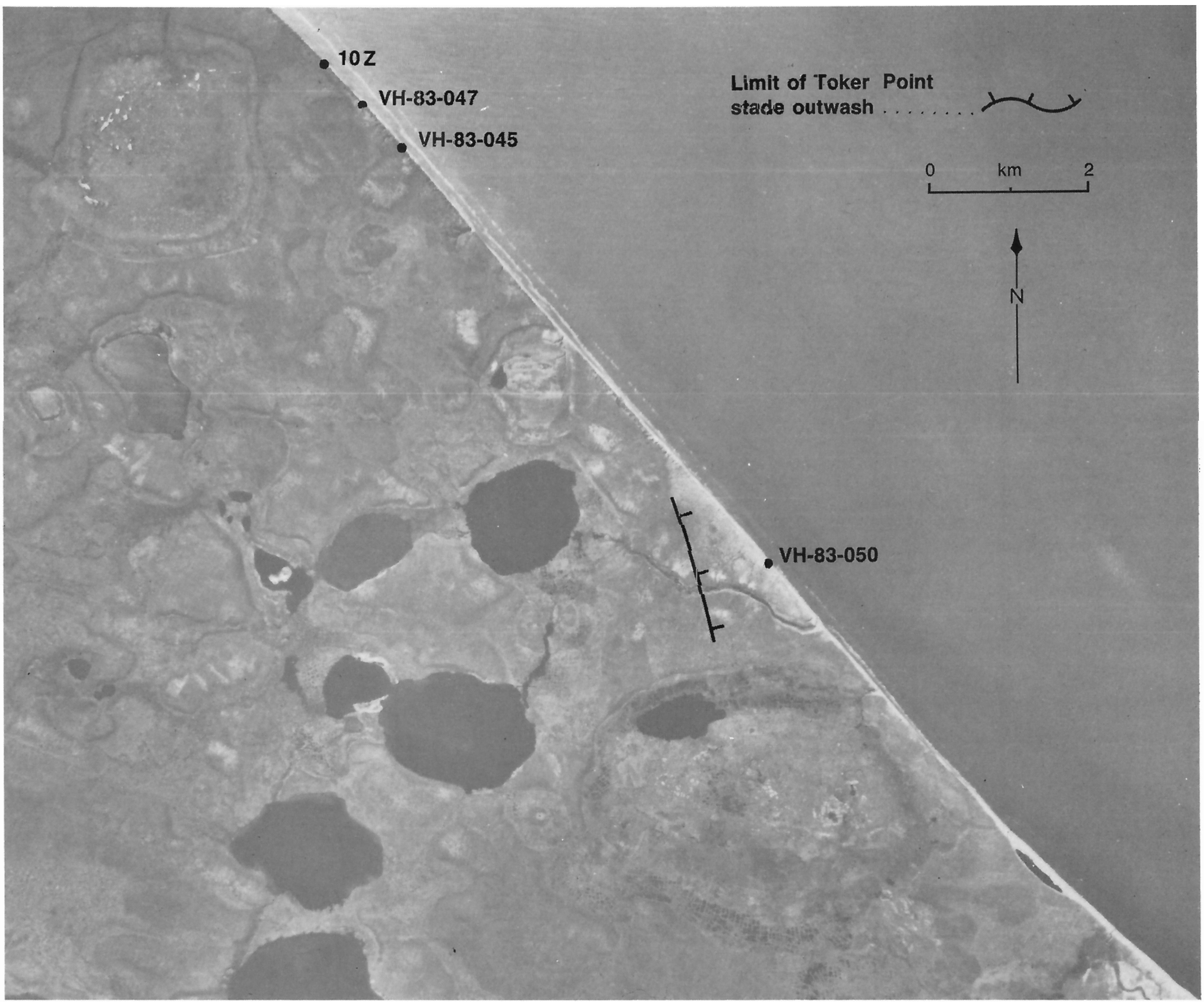


Figure 26. Location of sections VH-83-045, -047, -050, and 10Z west of Mason River. Most of the area shown is thermokarst-modified morainal topography of Mason River Glaciation and Toker Point Stade outwash. NAPL A12724-34

Table 4. Stratigraphy of sections containing Ikpisugyuk Formation

Thickness	Material (unit)
A. Stratigraphy at site VH-83-040	
0.5 m	Peat and silt (Holocene)
3.0 m	Sand, medium, grey; shale chips common (?)
1.0 m	Silt, grey; sandy lenses; few organic lenses (Ikpisugyuk Formation)
0.5 m	Sand, fine, brown; peaty lenses with freshwater shells and wood with bark (Ikpisugyuk Formation)
0.5 m	Sand, fine, silty, brownish grey (Ikpisugyuk Formation)
1.0 m	Covered; appears to be underlain by clay (?)
B. Stratigraphy at site VH-83-050	
1.0 m	Silt, brown; peaty layer near top (Holocene eolian sediments)
4.0 m	Sand, medium to coarse, pebbly, crossbedded (Toker Point Outwash)
2.0 m	Sand, silty; clayey beds with much organic material; driftwood mat at top with logs to 0.5 m diameter (Ikpisugyuk Formation)

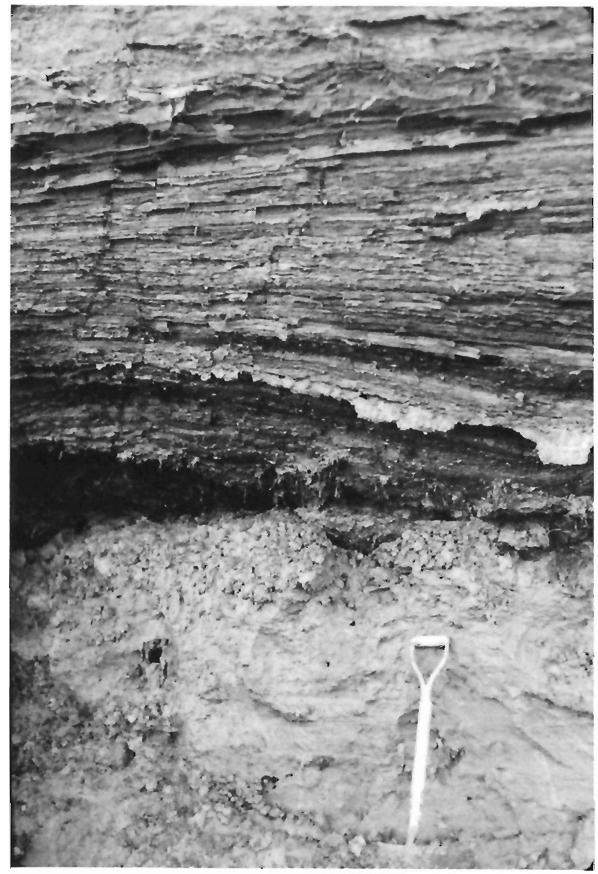


Figure 28. Base of thinly bedded member of Stanton Sediments with organic detrital layers as exposed near site VH-83-035 on Cape Bathurst peninsula. (Photo by J-S. Vincent) (GSC 204056-G)

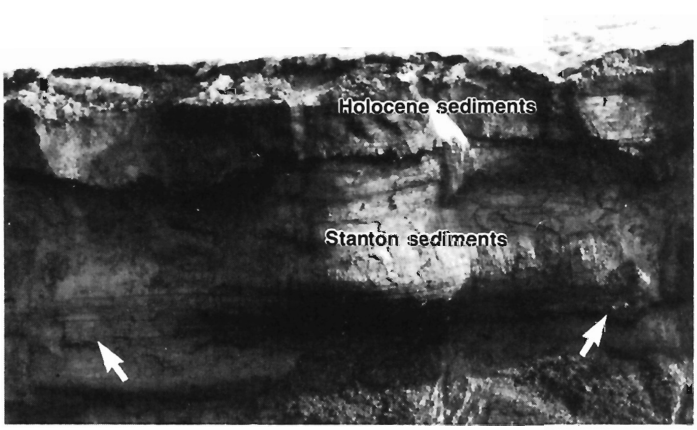


Figure 27. Sea cliff on Cape Bathurst peninsula between sites VH-83-035 and VH-83-036 showing Stanton Sediment sequence and Holocene lacustrine sediments. Note ice-wedge casts (arrows) in lower complex member. (Photo by J-S. Vincent) (GSC 204056-S)

Table 5. Stratigraphy at site 60Z on southwestern Nicholson Peninsula

Thickness	Material (depositional environment)
3 m	Organic silts and peat (lacustrine)
0.5 m	Silty sand (lacustrine)
2.8 m	Clay; pebbly near top (till ?)
9.8 m	Thinly bedded clay and sand (perimarine)
1.8 m	Brown fine sand (perimarine)
4.6 m	Thinly bedded silt and clay, grey, few sand laminae (perimarine)
1 m	Clay (perimarine)
3 m	Covered to sea level

including twigs and water worn logs, is a common feature within the sand unit. Beds with high concentrations of woody detritus vary from 1 to 5 cm thick, and rarely to 20 cm. Broken marine shell fragments were noted only rarely in the sand.

West of Nicholson Peninsula

Pleistocene sands directly underlie till (of the Toker Point and Sitidgi stades) throughout southern Tuktoyaktuk Peninsula, much of Richards Island, and adjacent areas around Eskimo Lakes and Liverpool Bay (Mackay, 1963a; Rampton, 1970, 1974b; Fyles et al., 1972). These sands consist of a lower fluvial unit, the Kidluit Formation; a middle deltaic unit, the Kittigazuit Formation; and an upper fluvial or glaciofluvial unit, the Turnabout Member of the Tuktoyaktuk Formation. These units are easily distinguishable only where the Kittigazuit Formation is present and can be identified as such. In those areas where the units have not been distinguished, they have been mapped as Pleistocene sands (Map 1647A). Directly underlying Kidluit Formation is a clay which has been informally called Hooper clay (Fig. 19), and an interbedded unit consisting of clay and sand, which has been informally called Kendall sediments.

Kendall sediments and Hooper clay

In deformed sediment sequences on Summer, Hooper, Pelly, and Kendall islands, the lowermost stratigraphic units are a silty clay and a unit consisting mainly of sand, but with some interbeds of silty clay. The underlying interbedded sand and clay have been informally termed "Kendall sediments", and the upper silty clay "Hooper clay"; both units immediately underlie sands of Kidluit Formation.

The Kendall sediments are characterized by sands that contain an abundance of marine shell fragments and shells and that are commonly mottled orange. The best examples are at localities 228W and 229W (Table 6) on Kendall Island (Fig. 35). At locality 229W, the sequence is tilted and complex. Mackay (1963a) reported that **Macoma balthica**, **Natica** sp., **Yoldia arctica**, and **Elphidium** sp. were found in sediments on Kendall Island. Near locality 210W on Hooper Island (Fig. 35) silty clays containing abundant marine shells are interbedded with the sands. In some fresh exposures along the north edge of Hooper Island, sands interbedded with clay and presumed to be part of the Kendall sediments are mottled black and fetid smelling – oxidation of these black sands produces the orange mottling in some exposures. The

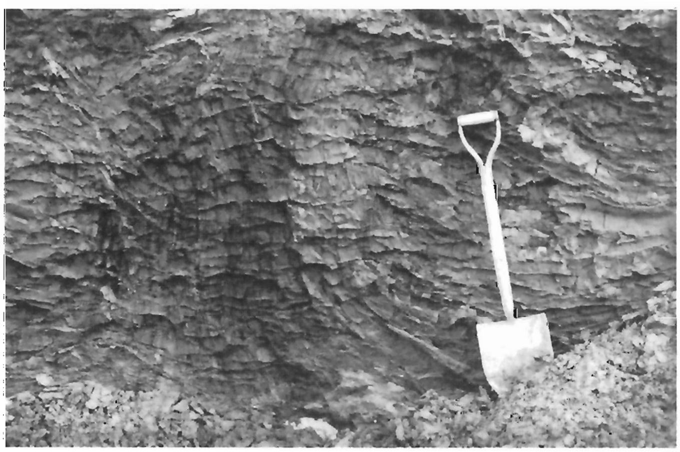


Figure 29. Diaperic fold in basal clay member of Stanton Sediments at site VH-83-036 on Cape Bathurst peninsula. (Photo by J-S. Vincent) (GSC 204056-H)

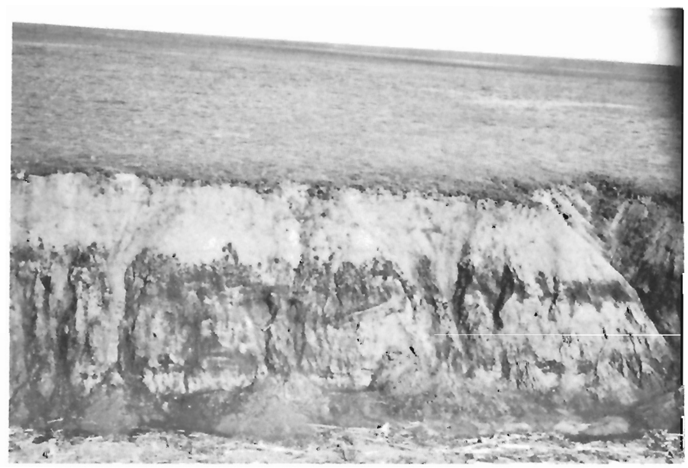
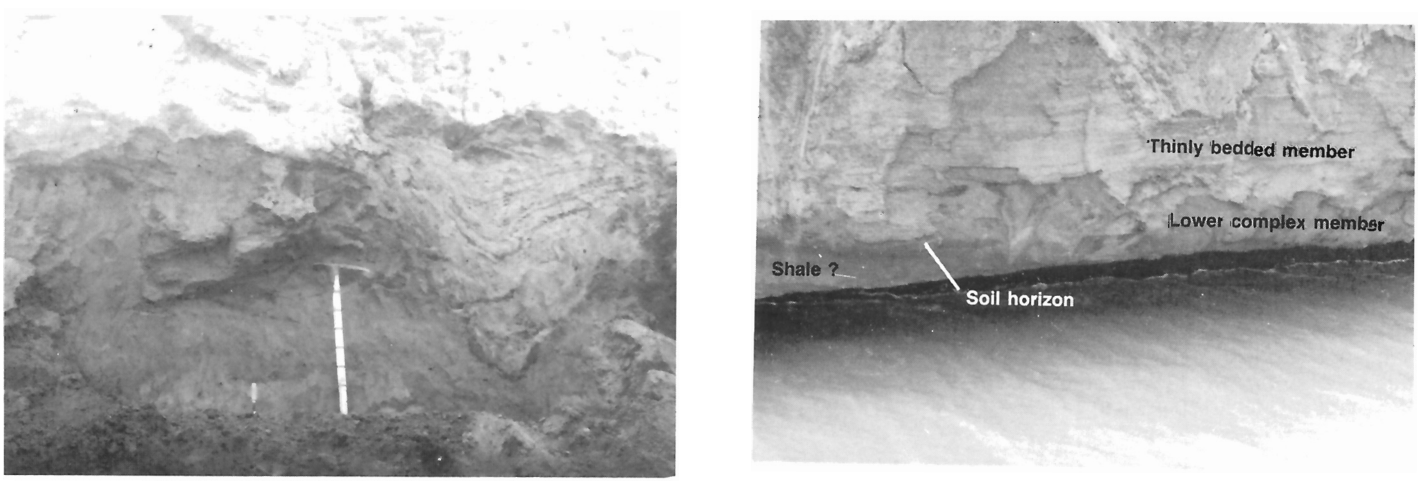


Figure 30. Gravels overlying sand with driftwood at site VH-83-048, east of Mason River. (GSC 204057-K)



A

B

Figure 31. Large ice-wedge cast in lower complex member (**A**) at site 10Z near Stanton and (**B**) near Maitland Point on Cape Bathurst peninsula. (GSC 204058-K, 5-15-73)

abundance of marine shells and interbeds of clay and fetid-smelling sands indicate that the Kendall sediments have a marine origin.

The maximum thickness of the Hooper clay was measured at Summer Island (Table 7), where the clay is banded and contains some driftwood and shells (e.g. **Macoma balthica** and **Portlandica arctica**). At locality 228W (Fig. 35) on Kendall Island, the clay is much thinner, but still contains marine shell fragments. At Hooper Island, the clay is commonly up to 10 m thick; thin laminae of silt and sand were noted at locality 210W (Table 8, Fig. 35). Similar clay with marine shell fragments is common in exposed cliffs along southwestern Garry Island (Kerfoot, 1969) and under many of the low hills of western Richards Island.

The geographic distribution of Hooper clay and Kendall sediments is not completely known. They appear to be restricted to the Mackenzie Bay islands and parts of Richards Islands. Clays were commonly not recorded in the base of shothole logs on Richards Island. No clay, which might be correlated with the Hooper clay, was noted in holes drilled as deep as 94 m north of Denis Lagoon on Richards Island (Hardy Associates (1978) Ltd., 1983). Clays at depth were generally absent from holes drilled at Tuktoyaktuk (Rampton and Bouchard, 1975) and from holes drilled in the involuted hills east of Tuktoyaktuk (Fig. 18). Whether the Hooper clay and Kendall sediments have an irregular local distribution or lie beyond the depth of most shotholes is not clear. Clays at Nicholson Peninsula and to the east may be their stratigraphic correlative (Fig. 19).

Figure 32. Ikpisugyuk Formation consisting of brown silty sand separated from the overlying grey sand by a driftwood mat (arrows), capped by (S) silt (loess), section VH-83-050 west of Mason River.

Figure 33. Folded and faulted sands containing much organic detritus on western shore of Nicholson Peninsula. (GSC 159025)

Kidluit Formation

Kidluit Formation is well exposed and easily identifiable in the 'outer fingers' (the arcuate peninsulas that separate Liverpool Bay from Eskimo Lakes) and on Richards and Hooper islands. The most easterly exposures of identifiable Kidluit Formation sediments are at 148V and 195X near Campbell Island (Fig. 35). Generally it is exposed throughout the 'outer fingers' where the base of the overlying Kittigazuit Formation has been noted. Here its base is

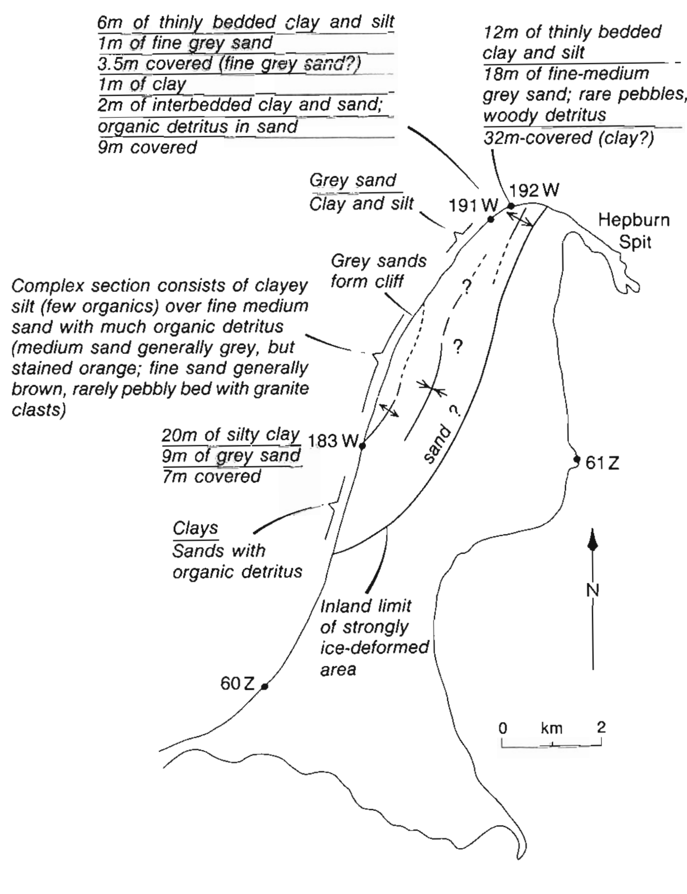


Figure 34. Location and description of Pleistocene sediments at Nicholson Peninsula.

probably well below sea level. Along the East Channel, Kidluit Formation is exposed under Kittigazuit Formation at localities 30W and 39W and in glacially deformed sequences at localities 48W on Summer Island (Table 7), 212W and 210W (Table 8) on Hooper Island, 225W and 228W (Table 6) on Kendall Island, and 253W on Pelly Island (Fig. 35). The upper and bottom contacts of the Kidluit Formation are well exposed on Summer, Kendall, and Hooper islands.

Kidluit Formation is consistently a grey, well sorted ("clean"), medium to medium-fine grained sand. Typical sand/silt/clay ratios and grain-size distribution curves are given in Appendixes 1 and 2. Microscopic examination of two samples indicates that it consists primarily of clean subangular quartz grains and amphibole with some calcite, biotite, and plagioclase and other minor components (Appendix 3). Commonly the bedding is planar and horizontal to gently dipping (Mackay, 1963a; Mackay and Matthews, 1983). Coal and wood detritus are common, particularly on Hooper Island (site 210W, Table 8) and Kendall Island (site 228W, Table 6). Many lenses of wood detritus and coal fragments were also noted in crossbedded (thicknesses to 20 cm) sands at localities 198X and 227X (Fig. 35). Mackay and Matthews (1983) and Mackay (1976b) described an organic-rich silty sand of probable lacustrine origin underlying grey sands common to Kidluit Formation on Hooper Island; these silty sands may well be a facies of Kidluit Formation. One noted character of this formation is that pebbly lenses or pebbles, some of granitic composition, may be present within the unit.

Mackay and Matthews (1983) listed identified plant and insect remains collected from Kidluit Formation. They include spruce, which grows just to the south of Hooper Island, and plants and insects that thrive in a climate similar to that of Hooper Island and/or are common to well drained sandy floodplains. At locality 48W on Summer Island (Table 7) both freshwater (**Succincea strigata** West, **Oxyloma groenlandica** Moller, and **Valvata sincera** Say) and marine molluscs[1] (**Macoma** cf. **balthica** L. and **Macoma** sp.) were collected from Kidluit Formation sediments. The freshwater specimens were generally more fragile and complete suggesting little transportation, whereas the marine specimens were fragmented suggesting possible reworking from underlying clay.

Table 6. Stratigraphy of selected sections on Kendall Island

Thickness	Material (unit)
A. Glacially deformed stratigraphy at site 228W on Kendall Island	
0.5 m	Sand, brown, organic (Holocene cliff-top dune)
0.5 m	Covered
2 m	Sand, fine grained, grey; contains many thin beds (1 to 8 cm thick) of coal fragments and woody detritus; layer of coarse wood and coal fragments at base; tiny shells (probably freshwater) noted in one bed (Kidluit Formation).
2 m	Covered
2.5 m	Clay, dark grey; contains marine shell fragments (Hooper clay)
4.5 m	Sand, fine grained, grey; much orange mottling and staining, especially near base; few silty layers and shell fragments (Kendall sediments)
3.5 m	Covered to sea level
B. Stratigraphy at site 229W on Kendall Island (composite)	
6 m	Covered, but grey gravel with coal fragments and clay probably present
2 m	Sand, fine grained, grey; mottled orange; shell fragments (Kendall sediments)
2 m	Covered; interbedded sand and clay? (Kendall sediments)
1 m	Clay, grey (Kendall sediments)
3.5 m	Thinly bedded silty fine sand and clay; clay contains shell fragments and appears organic (Kendall sediments)
2.5 m	Silt, light brown; contains thin organic beds; fine sand and orange mottles common near top (Kendall sediments)
1.5 m	Silt, brown, peaty (Kendall sediments?)
2.5 m	Covered

Table 7. Stratigraphy at site 48W on Summer Island

Thickness	Material (unit)
2.4 m	Sand, fine grained, light greyish brown; many rootlets and peaty layers (Holocene cliff-top dune)
0.2 m	Gravel, sandy (lag from glaciofluvial deposit?)
1.5 m	Sand, fine grained, olive brown; silty beds near base; thinly bedded (Kittigazuit Formation)
11 m	Sand, medium grained, light greyish brown; stratified; contains logs, some marine shell fragments and freshwater shells and mats of woody detritus (Kidluit Formation)
14 m	Clay, silty, light brown; banded; contains fragments of iron-stained wood and shells (some hinged); driftwood mat with many marine shells near base (Hooper clay)
9 m	Covered to sea level; laterally foliated massive ice with clayey and sandy bands present (Kendall sediments)

Table 8. Stratigraphy at site 210W on Hooper Island

Thickness	Material (unit)
0.5 m	Sand, brown; peaty layers (Holocene cliff-top dune)
10.5 m	Sand, fine grained, brown, massive (Kittigazuit Formation)
3.5 m	Sand, medium grained, grey; lower part planar bedded with horizontal to gently dipping, colour laminated; upper part contains beds of woody detritus to 10 cm thick, some crossbeds and small channels (Kidluit Formation).
6.5 m	Covered
3.5 m	Clay, brownish grey; massive except for thin laminae of silt and sand (Hooper clay)
8 m	Covered to sea level

[1] Molluscs identified by F.W. Grun and M.F.I. Smith, National Museum of Natural Science

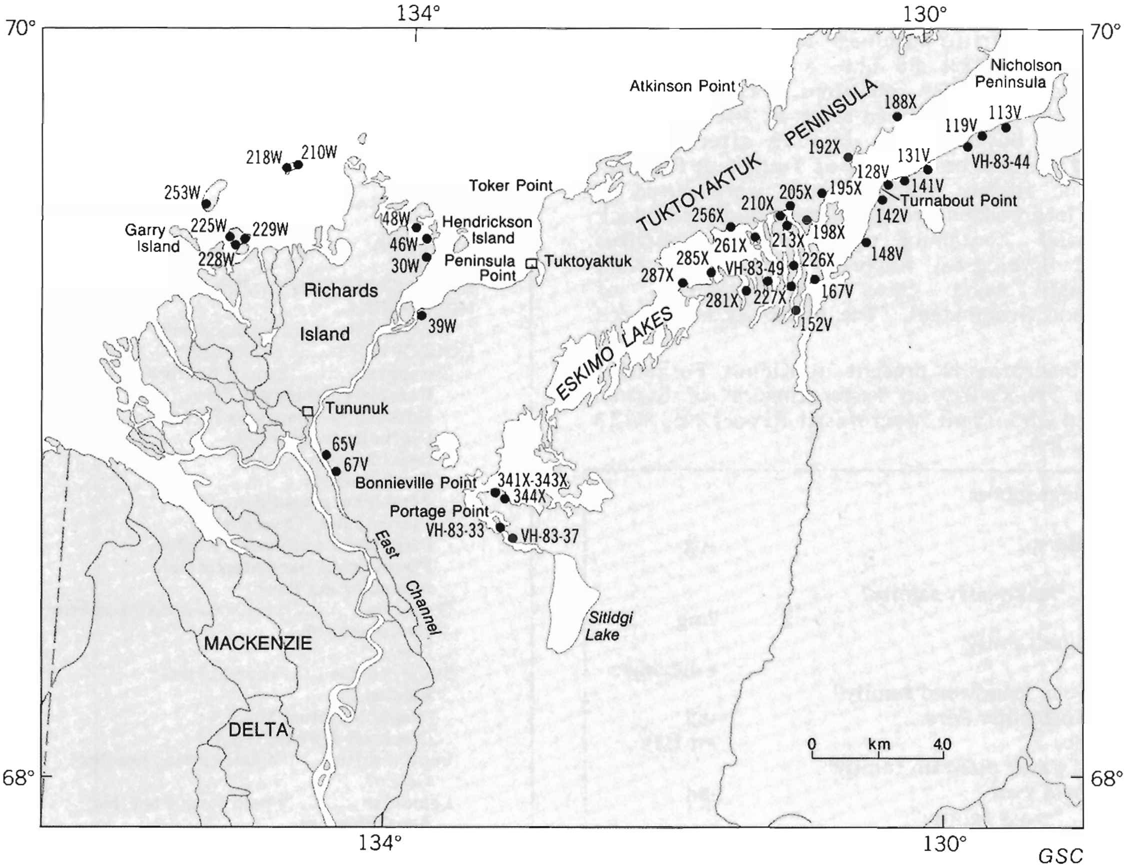


Figure 35. Location of critical sections of Middle Pleistocene sediments and Turnabout Member on Mackenzie Bay Islands, Richards Island, Eskimo Lakes, and East Channel.

In the 'outer fingers' at site VH-83-049 (Fig. 35) a pocket of organic detritus was examined and remnants of a number of biota were noted (Tables 9 and 10). This assemblage has some similarities to those from Hooper Island reported by Mackay and Matthews (1983).

Kidluit Formation was probably deposited on a broad alluvial plain characterized by streams with braided channels. Macrofossils examined at Hooper Island (Mackay and Matthews, 1983) and at site VH-83-049 on the 'outer fingers' of the Eskimo Lakes (Tables 9 and 10) indicate deposition during a period when the area was characterized by climate typical of the northern boreal forest.

Kittigazuit Formation

Kittigazuit Formation is best exposed on those parts of Richards Island and Tuktoyaktuk Peninsula adjacent to East Channel and along the southern edge of Liverpool Bay east of Campbell Island (Map 1647A). Kittigazuit Formation is typically a light brown, thinly bedded sand; individual beds are commonly 0.5-8 cm thick, and rarely up to 20 cm thick (Fig. 36). Individual beds may grade from silty fine sand to a clean fine sand or from a clean fine sand to a medium-fine sand. Typical sand/silt/clay contents and grain-size distribution curves are give in Appendixes 1 and 2. A cursory microscope examination of one sample of Kittigazuit Formation indicated that it consists primarily of subangular frosted quartz grains with some amphibole and biotite grains and other minor components (Appendix 3). Generally the

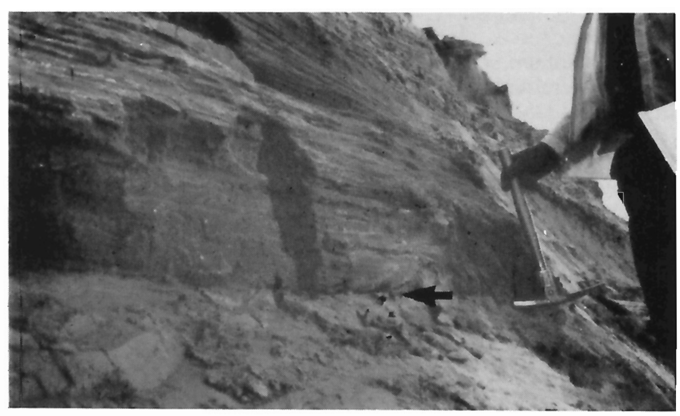


Figure 36. Contact of Kittigazuit and underlying Kidluit formations at site 46W on Richards Island. Note finer texture and thinner bedding of the Kittigazuit Formation compared to the Kidluit Formation. (GSC 158989)

sand is devoid of macrofossils (cf. Mackay and Matthew, 1983), although rarely individual small twigs and lenses of fine organic detritus have been observed in the unit. Mackay and Matthews (1983) did note a few macrofossils indicative of marine or brackish conditions. Organic detritus was observed near the base of brown sands at sites 131V and 167V along Liverpool Bay (Fig. 35). In 1980, after a severe storm had exposed the base of this unit at Turnabout Point on Liverpool Bay, the freshly exposed sands were noted to consist of thinly interbedded brownish grey sand and black fetid-smelling sand containing fine organic detritus (unpublished GSC Bryological Report No. 34, by M. Kuc, noted only small wood chips and fragments of **Potamogeton** sp. and Gramineae). The black sands oxidized

Table 9. Plant macrofossils present in Kidluit Formation sediments at site VH-83-049 on "outer fingers" of Eskimo Lakes (unpublished GSC Plant Macrofossil Report No. 84-13 by J.V. Matthews, Jr.)

Pre-Quaternary Megaspores	+
Characeae	
Chara or **Nitella** sp.	+og
Bryophytes	+
Selaginellaceae.... "spikemoss family"	
Selaginella sp.	?mg
Pinaceae .... "pine family"	
Picea sp.	++nd,sd,sc
Potamogetonaceae .. "pondweed family"	
Potamogeton filiformis Pers.	+sd
Potamogeton sp.	+st (ff)
Alismaceae .... "water plantain family"	
Alisma/Sagittaria type	+sd
Gramineae .... "grass family"	
Bromus sp.	+sd
Cyperaceae .... "sedge family"	
Carex aquatilis Wahlenb.	+sd
Carex sp.	++sd
Eleocharis palustris-uniglumis typ.	+sd
Juncaceae .... "rush family"	
Juncus/Luzula type	+cp
Betulaceae .... "birch family"	
Alnus crispa Ait(Pursh)	+sd,br
Betula glandulosa type	+sd,br
Chenopodiaceae .... "goosefoot family"	
Chenopodium sp.	+sd
Corispermum hyssopifolium L.	++sd
Caryophyllaceae ... "pink family"	
Genus?	+sd
Ranunculaceae ..... "crowfoot family"	
Ranunculus trichophyllus type	+sd
Ranunculus Macounii/pensylvanicus type	+sd
Cruciferae .... "mustard family"	
Draba type	+sd
Rorippa islandica type	+sd
Rosaceae .... "rose family"	
Potentilla norvegica L.	+sd
Potentilla anserina L.	+sd
Potentilla sp.	+sd
Rubus idaeus L.	+sd
Linaceae .... "flax family"	
Linum sp.	+sd
Umbelliferae ...... "parsley family"	
Sium suave Walt.	+sd
Ericaceae .... "heath family"	
Empetrum nigrum L.	+sd
Arctostaphylos alpina/rubra type	+sd

ABBREVIATIONS: ++ = taxon abundant; + = taxon present; sd = seed (achene, fruit, nutlet, etc.); nd = needle(s); sc = cone scale; mg = megaspore; st = stem; cp = capsule; br = bractlet; og = oogonium; ff = fragments

Table 10. Fossil arthropods present in Kidluit Formation sediments at site VH-83-049, on "outer fingers" of Eskimo Lakes (unpublished GSC Fossil Arthropod Report No. 84-12 by J.V. Matthews, Jr.)

BRYOZOA	
Cristatella mucedo L.	+st
ANNELIDA	
HIRUDINEA .... "leeches"	?cc
ARTHROPODA	
INSECTA	
EPHEMEROPTERA ......"mayflies"	+ff
HOMOPTERA	
Cicadellidae ...... "leafhoppers"	+hd,wg
COLEOPTERA .... "beetles"	
Carabidae .... "ground beetles"	
Carabus chamissonis Fisch.	?el
Notiophilus sylvaticus Eschz.	+el
Diacheila polita Fald.	+pr,el
Dyschirius sp.	+el
Bembidion sp.	+el
Bembidion scopulinum Kby.	+pr
Pterostichus (Cryobius) sp.	+el(ff)
Pterostichus sublaevis J.Sahlb.	+el
Pterostichus haematopus Dej.	+pr
Amara alpina Payk.	+pr(ff)
Dytiscidae .... "predaceous diving beetles"	
Hydroporus sp.	+el
Genus?	+ff
Staphylinidae ..... "rove beetles	
Bledius sp.	?el
Olophrum latum Makl.	+pr
Olophrum boreale (Payk.)	+pr
Leptodiridae ...... "small carrion beetles"	
Genus?	?el
Leiodidae .... "round fungus beetles"	
Agathidium sp.	+el
Scarabaeidae ...... "scarab beetles"	
Aegialia sp.	+el(ff)
Aphodius sp.	+el(ff)
Byrrhidae .... "pill beetles"	
Simplocaria sp.	+el
Morychus sp.	+el,hd
Byrrhus sp.	+el
Elateridae .... "click beetles"	
Genus?	+el(ff)
Chrysomelidae ...... "leaf beetles"	
Phratora sp.	?pr
Curculionidae ..... "weevils"	
Lepidophorus lineaticollis Kirby	+el,pr
Vitavitus thulius Kiss.	+el
Lepyrus sp.	+el(ff)
Dorytomus sp.	+el
Rhynchaenus sp.	+el
Scolytidae .... "bark beetles"	
Carphoborus sp.	+el
DIPTERA .... "flies"	
Tipulidae .... "crane flies"	+ov
Culicidae .... "mosquitoes"	?hd
Xylophagidae	+pp(ff)
CRUSTACEA	
Cladocera .... "water fleas"	
Daphnia sp.	+eh
Notostraca .... "tadpole shrimp"	
Lepiduris sp.	+tl(ff)
ARACHNIDA	
Acari .... "mites and ticks"	
Oribatei .... "oribatid mites"	+
Araneae .... "spiders"	
Erigone sp.	+ch

ABBREVIATIONS: + = taxon present; el = elytron(a); hd = head(s); pr = pronotum(a); pp = puparia; ov = oviposter; wg = flight wing; ch = cephalothorax; tl = telson fragment; ff = fragments; cc = cocoon; eh = ephippia; st = statoblasts to a brownish colour. This colour likely results from oxidation of unstable iron sulphide compounds or very fine organic detritus within Kittigazuit Formation sediments. Where thin lenses of organic detritus have been noted (e.g., at sites VH-83-044, 131V and 167V, Fig. 35) they generally contain water-worn organic materials including many plant macrofossils (Table 11) and fossil arthropods (Table 12).

The most conspicuous characteristic of Kittigazuit Formation is the presence of thick foreset beds with a common strike and dip; they are up to 24 m thick along Liverpool Bay (Fig. 37) and up to 12 m thick on northern Richards Island. Commonly they dip up to 40°, although some show a gentler dip (some of the measured gentler dips may only be apparent). Generally the beds dip in a easterly direction along Liverpool Bay and in northerly directions at the east end of Eskimo Lakes and on Richards Island. Thinly bedded brown sands were only noted as far east as site 119V (Fig. 35) along the south side of Liverpool Bay. Farther east, similarly textured and coloured sands are present but they show no distinct bedding and contain a few thin clay beds. Also, at site 128V (Fig. 35) the upper part of the Kittigazuit Formation showed only massive bedding.

In the upper part of Liverpool Bay near Campbell Island and throughout the 'outer fingers' of Eskimo Lakes, the base of Kittigazuit Formation generally lies between 3.5 and 10.5 m a.s.l. (Fig. 38). The lowest elevations lie north of Thumb Island and along an east-west trending line paralleling the south end of Thumb Island. Along East Channel the base of Kittigazuit Formation has been measured at 4.5 and 6 m elevation (Fig. 38). Its base has also been noted in glacially deformed sections to the north and west, but because of the deformation, the original elevation of its base is difficult to determine.

The unconformity between the Kittigazuit Formation and the underlying Kidluit Formation is generally a sharp line with no sign of channelling of the underlying sands (Fig. 36).

Table 11. Plant macrofossils present in Kittigazuit Formation sediments at site VH-83-044 on Liverpool Bay (unpublished GSC Plant Macrofossil Report No. 84-14 by J.V. Matthews, Jr.)

Characeae	
Chara or **Nitella** sp.	+og
Bryophytes	r
Pinaceae ..... "pine family"	
Picea sp.	r(nd)
Potamogetonaceae .. "pondweed family"	
Potamogeton sp.	+sd
Gramineae .... "grass family"	
Genus?	r(sd)
Cyperaceae .... "sedge family"	
Carex aquatilis Wahlenb.	+sd
Carex sp.	+sd
Juncaceae .... "rush family"	
Juncus/Luzula type	+cp(ff)
Salicaceae .... "willow family"	
Salix sp.	+cp
Chenopodiaceae .... "goosefoot family"	
Corispermum hyssopifolium L.	++sd
Portulacaceae ..... "purslane family"	
Montia sp.	++?sd
Caryophyllaceae ... "pink family"	
Cerastium sp.	?rsd
Ranunculaceae ..... "crowfoot family"	
Ranunculus trichophyllus type	+sd
Ranunculus hyperboreus type	+sd
Rosaceae .... "rose family"	
Potentilla sp.	r(sd)
Rubus idaeus type	+sd
Haloragaceae ...... "water milfoil family"	
Hippuris sp.	r(sd)
Gentianaceae ...... "gentian family"	
Menyanthes trifoliata L.	r(sd)

ABBREVIATIONS: ++ = taxon abundant; + = taxon present; r = taxon rare; sd = seed (achene, fruit, nutlet, etc.); nd = needle(s); og = oogonium; cp = capsule; ff = fragments

Table 12. Fossil arthropods present in Kittigazuit Formation sediments at site VH-83-044 on Liverpool Bay (unpublished GSC Fossil Arthropod Report No. 84-13 by J.V. Matthews, Jr.)

BRYOZOA	
Cristatella mucedo L.	+st
ARTHROPODA	
INSECTA	
COLEOPTERA .... "beetles"	
Carabidae .... "ground beetles"	
Dyschirius sp.	+hd
Pterostichus nearcticus Lth.	+el
Pterostichus (Cryobius) sp.	?pr
Pterostichus (Cryobius) ventricosus Eschz.	+pr
Pterostichus (Cryobius) brevicornis Kby.	+pr
Amara alpina Payk.	+pr
Dytiscidae .... "predaceous diving beetles" Genus?	+ff
Hydrophilidae ..... "water scavenger beetles" Genus?	+el(ff)
Leiodidae .... "round fungus beetles"	
Agathidium sp.	+el
Byrrhidae .... "pill beetles"	
Morychus sp.	+el
Chrysomelidae ..... "leaf beetles"	
Chrysolina sp.	+el
Curculionidae ..... "weevils"	
Apion sp.	+el
Sitona large type.	+hd
Leptopiini, genus A	+el,hd
Lepidophorus lineaticollis Kirby	++el,hd,pr
Vitavitus thulius Kiss.	+hd,el
Rhynchaenus sp.	+el(ff)
Cleonus sp.	+pr
Genus?	+hd
TRICHOPTERA .... "caddisflies"	
Family?	+cs(ff)
DIPTERA .... "flies"	
Family?	+pp
HYMENOPTERA .... "wasps and ants"	
Ichneumonoidea ... "ichneumons and braconids"	+hd
CRUSTACEA	
Cladocera .... "water fleas"	
Daphnia sp.	+eh
Notostraca .... "tadpole shrimp"	
Lepiduris sp.	+md
ARACHNIDA	
Acari .... "mites and ticks"	
Oribatei .... "oribatid mites"	+

ABBREVIATIONS: + = taxon present; el = elytron(a); hd = head(s); pr = pronotum(a); cs = larval case; pp = puparia; md = mandible(s); ff = fragments; eh = ephippia; st = statoblasts

Figure 37. Foresets in Kittigazuit Formation along south shore of Liverpool Bay near Turnabout Point. (GSC 154019)

No sign of weathering or a buried soil profile along this unconformity have ever been observed by either Mackay (1963a) or the author.

Kittigazuit Foundation is commonly between 10 and 20 m thick in the 'outer fingers' and along East Channel (Fig. 38). At one location in the 'outer fingers', a thickness of 45 m was measured. Where Kittigazuit Formation has been noted to elevations of 18 and 20 m in northern Richards Island and 30 and 36 m along the southern edge of Liverpool Bay (Fig. 38), these elevations may represent a minimum thicknesses. The lower bluffs were generally covered by colluvium, and the base of the Kittigazuit Formation could be below sea level at these locations. Part of the irregularity in its thickness may be due to glacial and fluvial erosion of its upper surface.

Kittigazuit Formation has not been identified with any certainty between Kittigazuit and the 'outer fingers'. In some areas thick sequences of planar and crossbedded sands and gravels that resemble those overlying and underlying it indicate that the formation is absent. In other areas it may simply not be exposed. This may be the case in the area immediately surrounding Tuktoyaktuk where at Peninsula Point (a breached pingo where strata have been elevated during formation of the pingo), a unit is present that is believed to be the equivalent of the Kittigazuit Formation (Table 13). The lateral continuity of this section seems limited as a similar sequence was not positively identified at Ibyuk Pingo nor in drillholes at Tuktoyaktuk (Rampton and Bouchard, 1975).

Kittigazuit Formation with it's large foresets represents deltaic deposition. A rapid influx of terrestrial material into the sea is suggested by the sparseness of marine fossils within the formation. Possibly the sands of Kidluit Formation were deposited from glacial meltwater. Most fossils identified within Kittigazuit Formation (Tables 11, 12) suggest a cold dry climate during its deposition.

Upper Eskimo Lakes

Middle Pleistocene stratigraphy is complicated in the upper Eskimo Lakes by the fact that virtually all gravel and sand, even those suspected as being Wisconsinan glaciofluvial gravel, contain much detrital wood (Fyles, 1967). A number of exposures east of Bonnieville Point and at Portage Point (Fig. 35), however, reveal some continuity in stratigraphic

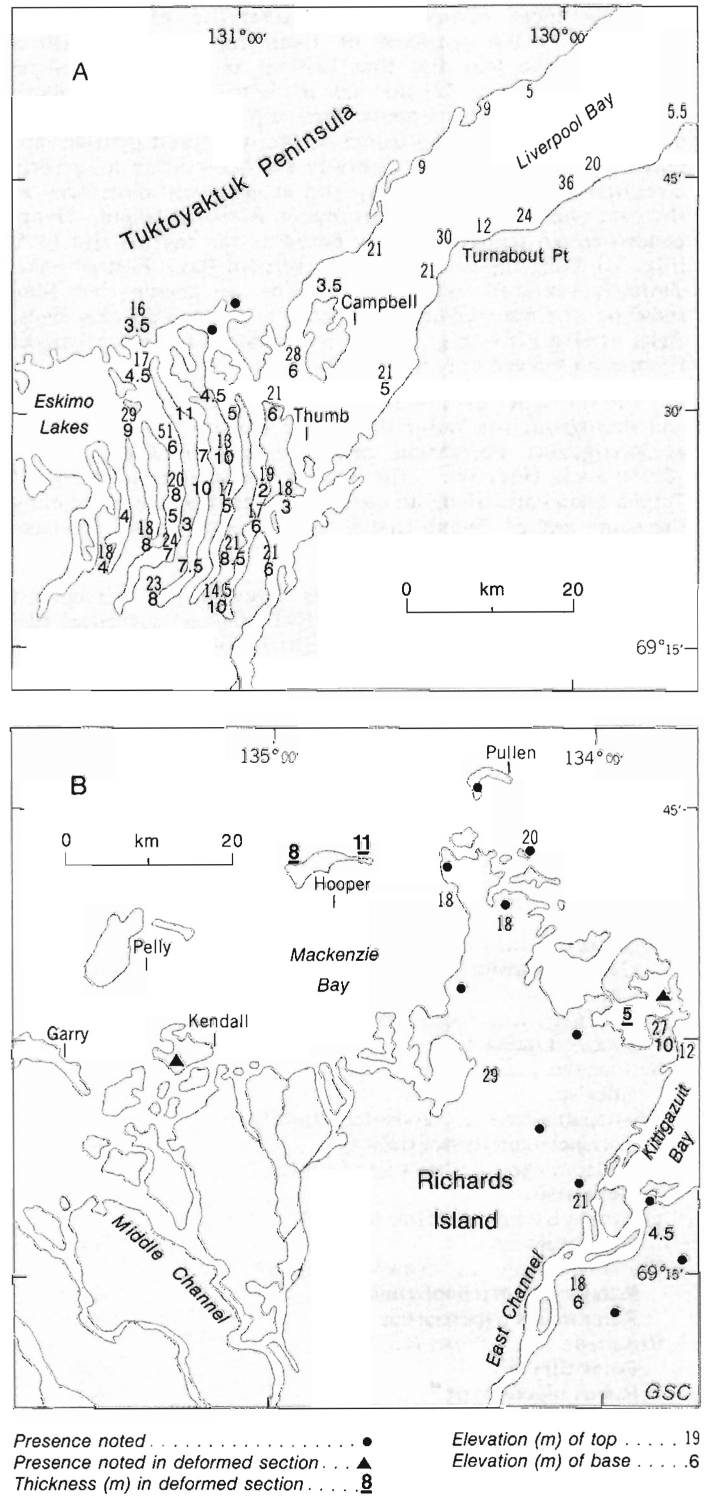


Figure 38. Distribution of Kittigazuit Formation along (A) Liverpool Bay and Eskimo Lakes and (B) adjacent to East Channel.

units. At localities 341X, 342X, and 343X sediments underlying glaciofluvial gravels (Table 14) can be subdivided into two units. The stratigraphic division is somewhat hampered by the discontinuity of beds – for example, although localities 342X and 343X are within 60 m of each other, beds cannot be easily correlated from one section to the next. However, the upper units are characterized by brownish hues, silty beds, and a paucity of detrital organic material, and the lower units are characterized by greyish hues, albeit with much orange staining, and many lenses and beds of woody detritus and coal fragments. In this area a pinkish coarse grained sand, which appears to underlie till at locality 344X (Fig. 35), may be a separate stratigraphic unit. A similar pinkish sand was noted at localities 285X and 287X (Fig. 35) in the lower Eskimo Lakes.

Near Portage Point, a peat is exposed in sections along the east shore of the upper Eskimo Lakes (Fig. 39A). The peat is mostly highly oxidized compressed fibrous organic material. At one locality (VH-83-037, Fig. 35) the peat was noted to be quite woody and one small log was observed (Fig. 39B). Immediately above and below the peat the sediments are primarily clayey silts, silts, and fine sands interbedded with medium grained grey sand (Table 15A). The sediments, including the peat, are believed to be a fine grained facies of the 'upper unit' present in sections to the east of Bonnieville Point (Table 14). The medium grained sands with much woody detritus at the base of sites VH-83-037 and VH-83-033 (Table 15) are believed to be the equivalent of the 'lower unit' in the Bonnieville sections. Wood in the lower medium-grained sand at locality 343X (343X3A, Table 14C) gave a D-aspartic/L-aspartic ratio (Table 16) of 0.31; wood in the base of the lowest interbedded silt and sand unit at locality VH-83-033 (Table 15B) gave a ratio 0.30, whereas wood within the overlying peat at locality VH-83-033 (Table 15B) had ratios ranging from 0.16 to 0.22 (six samples).

The lower unit likely was deposited in a braided channel environment as this unit contains no associated fine grained floodplain sediments. The upper unit with its mixture of sandy and silty sediments and peat beds appears to have been deposited on an alluvial plain characterized by meandering streams and floodplains.

Table 13. Stratigraphy at Peninsula Point

Thickness	Material (unit)
0.5	Sand, fine grained (Holocene cliff-top dune)
1 m	Peat and organic silt (lacustrine facies of Parsons Lake Formation)
2 m	Clay, pebbly; twigs and peat near base (colluviated Toker Point Stade till)
14 m	Sand, medium grained, grey; rare pebble and coal fragment, generally planar, rare crossbed to 20 m thick (Toker Point Stade glaciofluvial?)
3.5 m	Sand, fine grained, silty, brown; beds 5 to 20 cm thick (Kittigazuit Formation?)
1.5 m	Sand, medium grained, grey; planar beds 5 to 60 cm thick, crossbeds 10 to 75 cm thick; few thin gravel layers, (granitic and Rapitan Formation pebbles), rare thin silty layer near base (glaciofluvial or Kidluit Formation?)
7 m	Covered to sea level

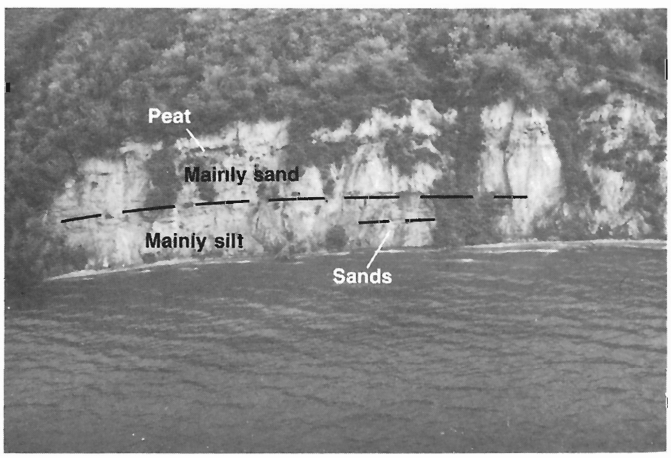
Table 14. Stratigraphy of selected sections east of Bonnieville Point, Eskimo Lakes

Thickness	Material (unit designation)
A. Stratigraphy at locality 341X	
16 m	Much cover, but gravel with boulders near base and medium grained sand in upper part (glaciofluvial, Portage Point Sands)
32 m	Much cover, but grey (stained orange) medium to coarse grained sand (crossbedded) common (upper unit?)
2.5 m	Sand, medium to fine grained, olive brown; planar beds, 1-20 cm thick (upper unit; 341ROX3, Appendix 3)
1.5 m	Sand, medium grained, grey, crossbedded; contains lenses of organic detritus (lower unit)
3 m	Covered to sea level
B. Stratigraphy at locality 342X	
0.5 m	Peat and silty peat
6.5 m	Sand, medium to coarse, olive grey; some crossbedding; few lenses of woody detritus and coal; unit partly covered (glaciofluvial, Portage Point Sands; 342ROX7, Appendix 3)
0.5 m	Gravel, sand (glaciofluvial, Portage Point Sands)
5.5 m	Much cover, but coarse grained sand with few pebbles underlies much of unit (glaciofluvial or upper unit?)
14 m	Sand, medium to coarse grained, yellowish brown to pale brown; few gravelly and silty beds near top; basal 0.5 m orangish (upper unit)
4 m	Sand, colour laminated; crossbedded, crossbeds up to 1.5 m thick; much organic detritus in lower part (lower unit)
4 m	Covered to sea level
C. Stratigraphy at locality 343X	
2 m	Covered
4.5 m	Sand, medium to coarse grained, brownish grey; few crossbeds; few lenses of coal fragments (glaciofluvial, Portage Point Sands)
1.5 m	Gravel and medium sand, grey; crossbeds to 0.5 m depth (glaciofluvial, Portage Point Sands)
3 m	Fine sand and silt, light brown; silty beds are 1 to 10 cm thick, sandy beds 20 to 50 cm thick (upper unit)
4 m	Covered
10 m	Sand, medium grained, greyish brown; horizontal bedding; thin beds of organic detritus and coal fragments in lower part; one log (343X3A) noted (lower unit?)
1 m	Sand, medium grained, light orange (lower unit)
5.5 m	Covered

The peat and associated sediments at site VH-83-033 have been the subject of a number of palynological studies. J. Terasmae (unpublished GSC Palynological Report No. 62-43) reported pollen assemblages in two samples taken from this peat. One sample contained 15% **Picea**, 60% **Betula**, 4% **Alnus**, and 15% **Ericaceae** pollen – an assemblage indicative of shrub trundra; the other sample contained 26% **Picea**, 27% **Betula**, 22% **Alnus**, 2% **Ericaceae** and 16% **Cyperaceae** pollen – an assemblage indicative of boreal forest (cf. Ritchie, 1984). Similarly, Ritchie (1984) has reported pollen assemblages from an interval of 1 m, including the peat layer, that were interpreted to be primarily indicative of boreal forest. L.D. Delorme has identified ostracods from a number of stratigraphic levels at VH-83-033 (Table 17). Ostracods from silt at VH-83-033 indicate a freshwater environment of deposition. A fluvial environment of deposition in other strata is suggested by the absence of ostracods.

East Channel, Mackenzie River

A number of partially covered exposures along East Channel upstream from Tununuk (Fig. 35) contain fluvial, deltaic, and lacustrine sediments that predate Wisconsin



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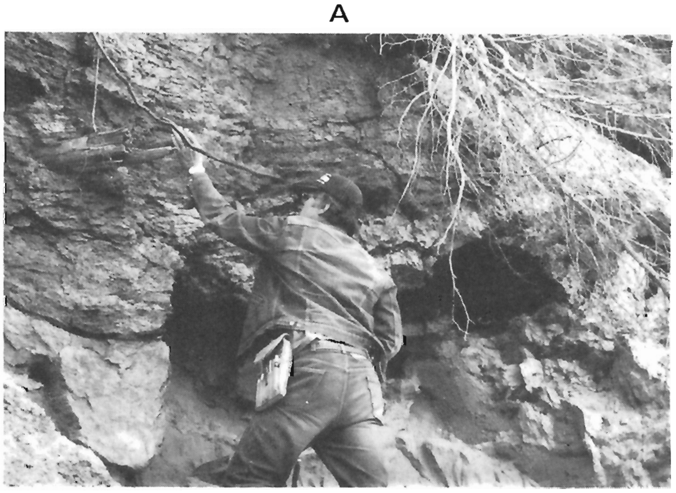


B

Figure 39. A. Peat exposed at site VH-83-037 near Portage Point (southern Eskimo Lakes); see Table 15A for details of stratigraphy. B. Close view of a log within the peat. (Photos by J-S. Vincent) (GSC 204057-Q, 204057-R)

Table 15. Stratigraphy of sections near Portage Point, Eskimo Lakes

Thickness	Material (unit designation)
A. Composite stratigraphic section at site VH-83-037 (360X)	
15 m+	Covered; sequence probably includes glaciofluvial gravels (Portage Point Sands), till (Toker Point Stade), and ground ice over silt and sand
3 m	Silt, clayey, banded (upper unit)
0.5 m	Peat, compact, woody at base (upper unit)
5 m	Sand, medium grained, grey; finer grained and channelled towards base; crossbedded pebbly sand with small mammal bones 1.5 m above base (upper unit)
5 m	Silt; few fine sand and organic detrital beds and laminae; few twigs; lens of organic detritus 2 m above base; pebbly sand near base (upper unit)
2 m	Sand, medium grained, light grey; channelled; few beds of organic detritus and twigs; thickens to south (lower unit)
2 m	Covered to sea level
B. Stratigraphy at site VH-83-033 (359X, 164HH)	
8 m	Covered; mainly sand and gravel (glaciofluvial, Portage Point Sands)
7 m	Gravel, pebbly, greyish brown; few cobbles and boulders (glaciofluvial, Portage Point Sands)
5 m	Sand, medium grained, brownish grey; mica flakes common (glaciofluvial, Portage Point Sands)
5 m	Silt, brown, thinly bedded with few thin fine sand laminae and peaty stringers; rare fragile freshwater shells near top (upper unit)
0.5 m	Peat, reddish at top, black at base; decomposed and oxidized organic fibres; few identifiable plants and twigs; rare fragile freshwater shells (upper unit)
4.5 m	Interbedded silt, clayey silt, silty fine sand, and medium sand; silt is brown to black, sand is greyish; horizontally bedded; few finely crosslaminated beds (upper unit)
0.5 m	Sand, medium grained, grey; crossbedded (upper unit; 359ROX6, Appendix 3)
4 m	Silt and clay; few thin sandy beds; thinly bedded; partly covered (upper unit)
6 m	Interbedded silt, fine sand, and medium sand; crossbedded at top and bottom; lenses woody detritus (359X4f) in troughs (upper unit, except for base)
3 m	Covered; sand with woody detritus? (lower unit)
1.5 m	Sand, medium grained, light brown (lower unit)
2 m	Covered to sea level

Table 16. D-asparatic/L-asparatic ratios of wood samples. Determination completed by Dr. N.W. Rutter of the Department of Geology and Chemistry, University of Alberta.

Sample no.	D/L aspartic ratios	Details of sample site and location		
Outwash of Toker Point Stade and Turnabout Member				
13Z-B	0.08	Outwash (?) west of Mason River	69°53'N,	128°33'W
130V	0.22	Turnabout Member near Turnabout Point, Liverpool Bay	69°42'N,	130°17'W
188X2A	0.23	Upper grey sands (Cape Dalhousie Sands?), north side of Liverpool Bay (Fig. 35)	69°51'N,	130°14'W
84V	0.23	Upper grey sands south of McKinley Bay (Cape Dalhousie Sands)	69°47'N,	131°05'W
83W2C	0.26	Terrace sands (Garry Island Member) at Garry Island	69°27'N,	135°31'W
Kidluit Formation				
210W4a	0.13	Lower grey sand from deformed sequence at Hooper Island (Table 8)	69°42'N,	134°53'W
46WA	0.13	Lower grey sand north of Kidluit Bay (Fig. 35)	69°33'N,	133°47'W
148V2a	0.19	Lower grey sand near Campbell Island (Fig. 35)	69°34'N,	130°28'W
213Xa	0.10	Lower grey sand at entrance to Eskimo Lakes (Fig. 35)	69°34'N,	131°05'W
Fluvial sediments - upper Eskimo Lakes				
343X3A	0.31	East of Bonnieville Point; near base of lower sand at 343X (Table 14C)	68°51'N,	133°12'W
359X4f	0.30	Portage Point area; base of lowest interbedded silt and sand unit VH-83-033 (Table 15B)	68°45'N,	133°16'W
Peat layer - upper Eskimo Lakes				
FG-66-107d	0.19	Site near Portage Point;		
360X12a	0.19	all from peat at	68°44'N,	133°10'W
360X12b	0.16	VH-83-037 (Table 15A)		
360X12c	0.19			
359X9b	0.22	Both from peat at VH-83-033	68°45'N,	133°16'W
359X9c	0.18	(Table 15) near Portage Point		
East Channel				
67V7a	0.07	Detrital-rich sands (Table 18A)	68°53'N,	134°30'W
Ikpisugyuk Formation east of Maitland Point (Fig. 25)				
33Z3A	0.14	Peat near base of probable		
33Z3B	0.15	lacustrine sequence	70°06'N,	127°50'W
33Z7A	0.12	Peat with snail shells in		
33Z7B	0.10	ice wedge near base of probable lacustrine sequence		
Stanton Sediments				
30Z4A	0.14	Peat from near top of lower complex member near VH-83-036 (Fig. 24)	70°08'N,	128°17'W
57Z3A	0.14	Peat from gravel and sand, apparently part of lower complex member near 25Z (Fig. 22)	70°07'N,	128°22'W
109V	0.12	Wood in brown sand under till just west of 10Z (Fig. 26)	69°52'N,	128°38'W

Glaciation. All these sections lie just downstream from where the Tertiary strata of the Caribou Hills disappear below river level (Mackay, 1963a). The sections of Pleistocene sediments exposed farthest upstream (cf. locality 67V, Fig. 40 and Table 18A) contain a peat. Although most sediments at locality 67V when examined in 1969 were noted to have a greyish hue, investigations in 1966 and 1983 indicated that the silt and fine sand associated with the peat had a brownish hue. Farther downstream as far as locality 65V (Fig. 40, Table 18B) the sequences typically show greyish sand to be separated by brownish sand and silt (Fig. 41). The brownish sand typically shows foreset structure and includes a plug of silt, which is probably a channel fill.

In sections to the north, such as localities 65V and 71V (Fig. 41, Table 18C), the predominantly brownish silts and sands contain ostracod assemblages (Table 17) indicative of a fluvial-deltaic environment with lakes on its surface (L.D. Delorme, personal communication, 1970). The massive brown sands with silty beds underlie crossbedded grey sands and overlie grey sands with much organic detritus at localities 68V and 69V (Fig. 40). North of Tununuk, towards Pullen Lake, grey sands, commonly crossbedded and containing much organic detritus, are present up to 12 m above sea level. A discontinuous brown sand, up to 1 m thick, has been noted under the till in this area.

The grey sands in all the above sequences were likely deposited within a braided channel complex, whereas the brownish sands and silts were likely deposited on an alluvial plain characterized by meandering streams and floodplain lakes.

Macrofossils, pollen, and ostracods from a number of localities have been examined. Terasmae (1959), presumably from locality 67V or very nearby, identified parts of **Larix laricina, Chamaedaphne calyculata, Ledum** sp., **Oxycoccus microcarpus**, and **Sphagnum** sp. Pollen from four samples contained 3 to 17% **Picea**, 2 to 7% **Pinus**, 0 to 3% **Larix**, 30 to 55% **Alnus**, 9 to 27% **Betula**, 6 to 16% Ericacaeae (percentages based on total pollen contents); these assemblages would most closely match modern assemblages from the forest tundra. Ritchie (1984) similarily studied a number of samples from locality 67V and concluded that the pollen represented boreal forest or shrub tundra communities. M. Kuc (unpublished GSC Bryological Report No. 119, 120, 154-168) identified amber, insects, needles of **Picea**, parts of **Salve**, **Carex**, **Myriophyllum** sp., **Potomageton** sp., and the mosses **Scorpidium scorpioides**, **Calliergon aftonianum**, **C. giganteum**, **Aulacominium turgidum**, **Camptothecium nitens**, **Tomenthypnum nitens**, **Drepanocladus exannulatus**, **Campylium polyganum**, **Dicranum elongatum**, **Hylocomium splendens**, **Ditrichium flexicaule**, **Hypnum** sp., and **Messia** sp. Kuc concluded that the assemblage was fluvially transported and was a redeposited mixture of biota from a boreal forest bog and Tertiary material.

Wisconsinan

Most surface or near-surface glacial deposits west of Mason River are considered to be Wisconsinan in age – further separation of these deposits is only possible according to geomorphic and geographic criteria as sections showing multiple tills and definitive chronological indicators

Table 17. Frequency of ostracods in samples from VH-83-033 (359X), Eskimo Lakes and 65V and 71V, East Channel, Mackenzie River (unpublished Fossil Freshwater Ostracod Report No. 70-23 and 72-55, identifications by Dr. L.D. Delorme, Canada Centre for Inland Waters.)

Sample number	Candona sp.	Candona actula	Candona protzi	Candona rawsoni	Candona rectangulata	Candona candida	Candona distincta	Candona ikpikpukensis	Cyclocypris ampla	Cyprinotus glaucus	Cytherissa lacustris	Eucypris foveata	Limnocythere camera	Limnocythere posterolimba	Limnocythere sancti-patrici	Limnocythere liptoreticulata	Prionocypris glacialis	Ilyocypris bradyi	Cypria opthalmica	
359 X 10a				2		1			1							1			12	Samples at 0.3 m regular intervals from lower half of silt overlying peat at VH-83-033 (Table 15)
359 X b				2																
359 X c	9			5	3					1			6			3				
359 X d	6		1		2								1			2				
65V9b				10				5			14		7			11	3			(Table 18B)
7b																				
6c					1					2		1		1						
6a	1		3	11	6					2			8	14	3	11				
5a		2	6		2							3	13			4				
3d	1			4												2				
3b				1																
71V 5g		10		11	22	14	8			5		14	10			10	7	6		Samples spaced at 0.5 m regular intervals, beginning 0.5 m from base of silt and silty fine sand (Table 18C)
5f	10	4		12	10	10					16	6	2			125	1	5		
5e	44	7		4	10	1	2			5	16	1	14			65	4			
5d	1	10	2	1	4					4		1	10			1	1			
5c	7		2		5					2		3	2			5	1			
5a	11	21				17						2	8			16	2			

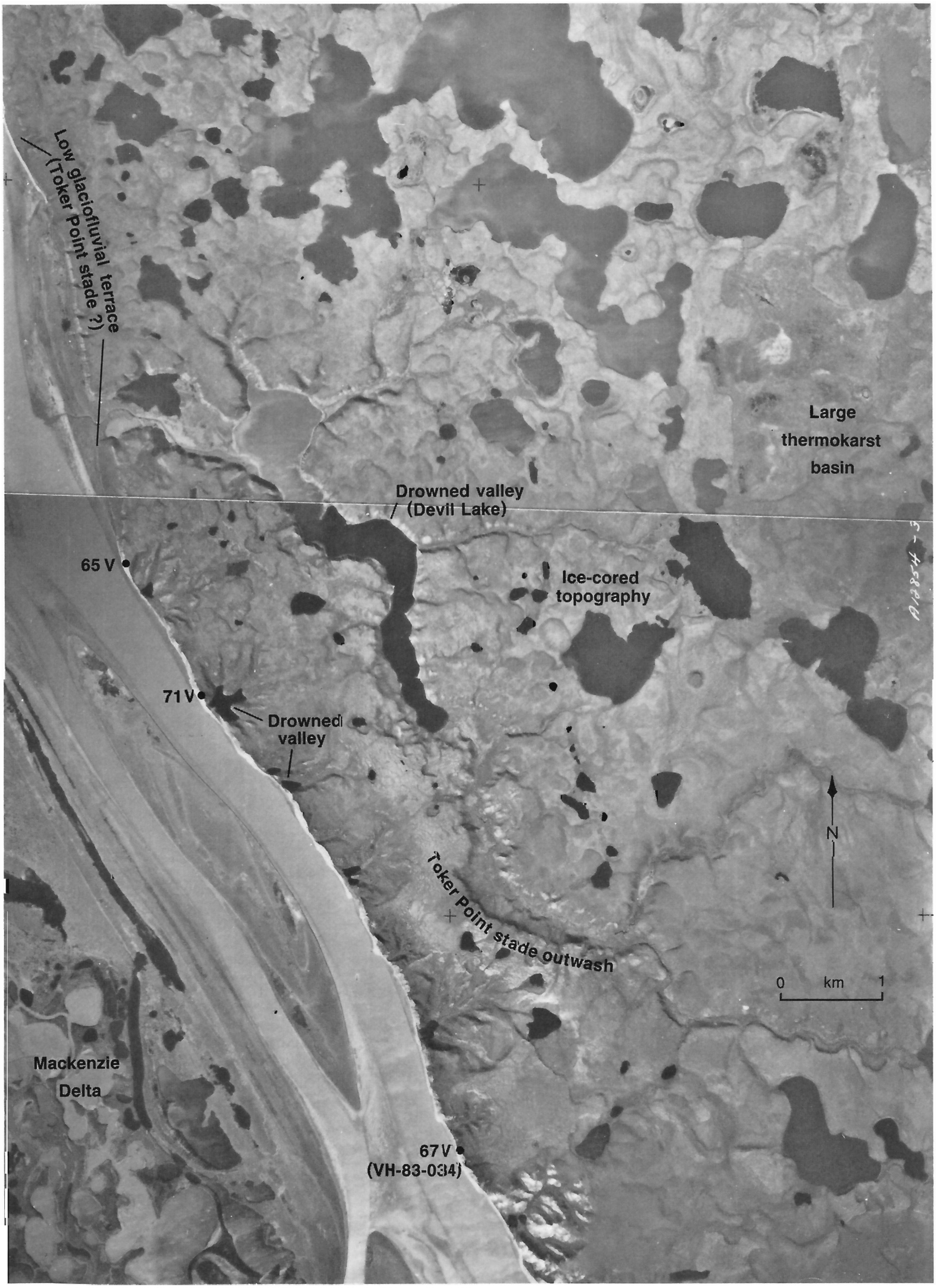


Figure 40. Location of sections and geomorphic features along East Channel. NAPL A12854-348, 350

Table 18. Stratigraphy at selected sections along East Channel, Mackenzie River

Thickness	Material
A. Composite section at site 67V	
18 m	Covered to crest of bank; mainly silt and sand in lower part, gravel in upper part
2.5 m	Sand, medium to fine grained, grey; many layers of organic detritus (finely disseminated to twig size) up to 15 cm thick
5 m	Sand, medium grained, grey, coarsens to gravel near top; finer grained sand is crossbedded
3.5 m	Covered
5 m	Sand, grey; organic laminae; small-scale crossbeds
0.5 m	Peat, medium to coarse plant detritus including wood fragments (67V7a)
1 m	Sand, fine and silt, grey
0.1 m	Peat; composed of plants; semi-autochtonous
2 m	Sand, fine, grey to greyish brown; some silty lenses; crossbedded; few pebbles
0.5 m	Gravel, iron stained; cobbles to 10 cm diameter
4 m	Covered to high water level
B. Stratigraphy at site 65V	
0.5 m	Interbedded turf, peat, silt, sand
1.5 m	Toker Point Stade? till, brownish grey
0.5 m	Gravel
13 m	Sand, grey; horizontal bedding up to 1 m thick; few beds of silt and coarse sand; upper 7 m partly covered
0.5 m	Sand, fine, brown; organic detrital lenses (65V9b, Table 17)
4.5 m	Covered
2.5 m	Sand, grey; thin beds of silt and organic detritus; crossbeds (65V7b at base)
1 m	Silt, brownish black; unit has lens-like configuration (65V6a, 6b)
1 m	Sand, fine, greyish brown; lenses and pods of sand (65V5a)
2 m	Sand, grey; locally iron stained; silt and organic detritus near top (65V3b, 3d)
6 m	Covered to mean water level
C. Stratigraphy at site 71V	
9.5 m	Covered
7.5 m	Silt and silty fine sand, brown; partly covered
9.5 m	Sand, fine, grey; iron stained; driftwood mats; few logs and pebbly layers; laminae of organic detritus near base
4.5 m	Covered to high water level

have not been identified. Deposits assigned to the Buckland Glaciation west of the Mackenzie Delta, to the Toker Point Stade east of the Mackenzie Delta, and to the Franklin Bay Stade on eastern Cape Bathurst peninsula are considered to be Early Wisconsinan equivalents, either deposited by separate glacier lobes or geographically separated by a major nonglacial feature such as Mackenzie Delta. Deposits assigned to the Sitidgi Stade, which are confined to the southern part of the area near the Mackenzie Delta, are considered to be definitely of Late Wisconsinan age. Various sediments laid down during the Wisconsinan have been given member status and assigned to the Tuktoyaktuk Formation. The Turnabout Member, which generally underlies till assigned to the Toker Point Member, is believed to be a glaciofluvial member of Tuktoyaktuk Formation, but it may in part be a fluvial unit predating the Wisconsinan.

Turnabout Member

Grey sands are commonly present in channels incised into Kittigazuit Formation. These channel sands have been called the Turnabout Member and assigned to Tuktoyaktuk Formation. Just west of Nicholson Peninsula the Turnabout Member sands are probably present to below sea level. At site 113V (Fig. 35) for example, 4 m of grey sands (Turnabout Member), which are generally horizontally bedded but contain a few crossbeds to 90 cm thickness, are present to within 3.3 m of sea level (the base is covered). These sands contain a few thin (4 cm thick) silty beds, pebbles, and lenses of fine gravel and do not appear to be overlain by till. Sand-filled channels within Kittigazuit Formation are even more common near Turnabout Point to the west. For example at site 141V (Fig. 35) about 8 m of upper grey sand and gravel overlie about 12 m of Kittigazuit Formation in a channel cut into the same formation. Turnabout Member here is medium to coarse textured with many pebbles and coal fragments; 1 m-thick sandy and cobbly gravel beds with boulders to 0.5 m diameter and waterworn twigs are present. Organic detritus ranging in size from small particles to twigs and chips were noted in some beds in other nearby sections. At locality 142V (Fig. 35), Turnabout Member sands overlie a diamicton (Table 19).

Similar sequences have been noted in the 'outer fingers' of Eskimo Lakes. For example at sites 226X, 152V, and just north of VH-83-049 (Fig. 35), grey sand and gravel of the Turnabout Member overlie Kittigazuit and Kidluit formations. At site 152V Turnabout Member is represented by over 3 m of pebbly gravel. At 226X and 152V clayey and silty beds were noted within the Turnabout Member. Till was not noted at any of the above localities. At two other localities however, 261X and 281X (Fig. 35), clayey diamicton was noted to overlie the Turnabout Member. Whether the diamicton was Toker Point Stade till or colluviated till was not clear.

At the northern end of the 'outer fingers' of Eskimo Lakes, some relatively thick sequences of grey sand and gravel of the Turnabout Member are inset into Kittigazuit Formation. At locality 210X (Fig. 35), 7.5 m of grey sand with beds of woody detritus and 25 m of gravel overlies 6 m of Kittigazuit Formation. At locality 205X thick gravel similarily caps brown sand of the Kittigazuit Formation. At locality 213X (Table 20) the "channel sands" (Turnabout Member) are underlain by a pebbly clay, which may be Toker Point Stade till.

To the north at locality 192X (Fig. 35) on Liverpool Bay, 3.5 m of gravel with a few Rapitan Formation pebbles[1] and 20 m of a grey, medium grained sand, both assigned to the Turnabout Member, overlie 10 m of Kittigazuit Formation. Farther northeast, beginning at locality 188X

[1] Rapitan Formation is an iron formation containing much jasper that outcrops in Mackenzie Mountains, along the Yukon/Northwest Territories border. The presence of large numbers of pebbles composed of the Rapitan Formation in glaciofluvial gravels implies that the gravels have been deposited by meltwater from a glacial lobe that flowed down Mackenzie River valley, at least north of 65°N.

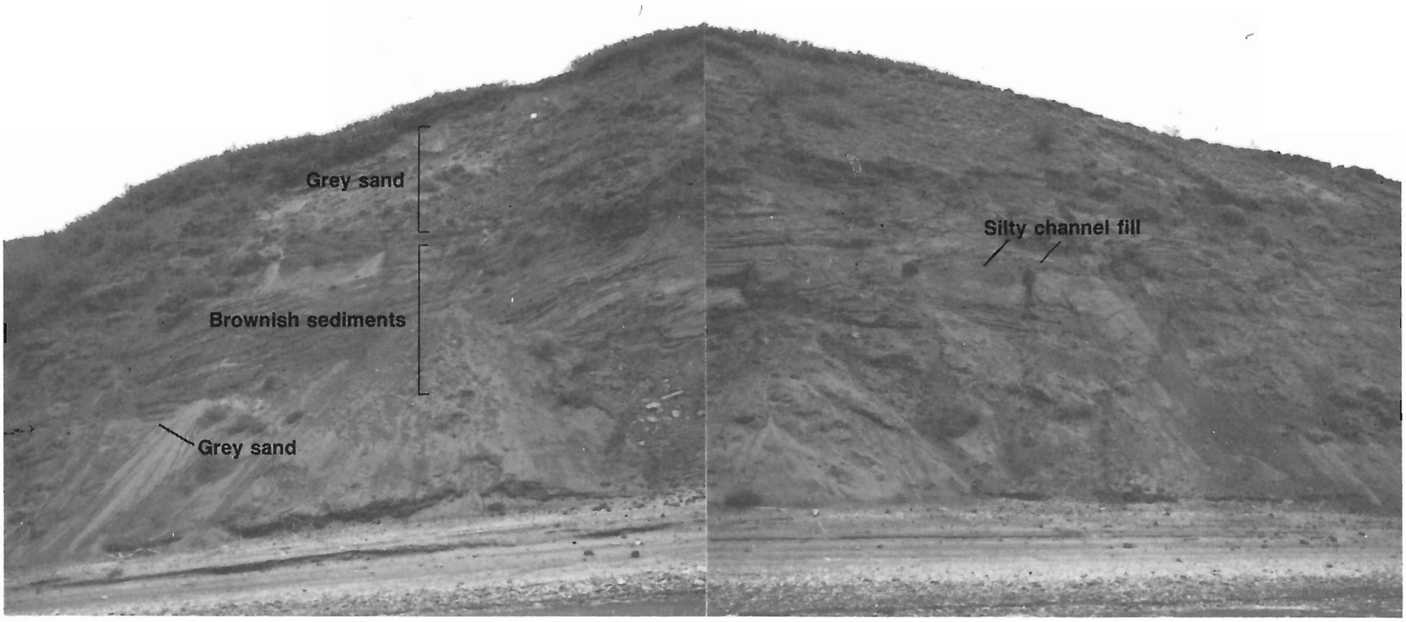


Figure 41. Section at site 65V on East Channel. (GSC 154007, 154008)

grey sands assigned to the Cape Dalhousie Sands (see discussion later) overlie Kittigazuit Formation. In this area the Cape Dalhousie Sands and the Turnabout Member appear to be stratigraphic equivalents. The Cape Dalhousie Sands are believed to form a glaciofluvial outwash plain due to their geomorphology and geographic location.

Along the north shore of Eskimo Lakes, Kittigazuit Formation has not been identified to the west of locality 256X (Fig. 35). Thus, thick grey sands and pebbly sand that are present west of locality 256X as far as Kittigazuit may be Kidluit Formation, Turnabout Member, some unnamed grey sand unit, or a combination of the above. Grey, medium grained sands with pebbly beds, which are clearly overlain by Toker Point Stade till, are present throughout west-central Tuktoyaktuk Peninsula (cf. Rampton and Bouchard, 1975). At Ibyuk Pingo near Tuktoyaktuk, more than 8 m of mainly grey, medium grained sand with a few silty beds, thin gravel beds, coal, and wood fragments underlies colluvium derived from Toker Point Stade till and lacustrine deposits. In other places similar sands are not overlain by till. In the latter case, their surface generally has the form of a thermokarst-modified outwash plains or kame and kettle complexes. Rampton and Bouchard (1975, p. 8) have described all the sands near Tuktoyaktuk as follows: "medium to coarse grained, cross bedded, contains rare pockets and lenses of fragmented coal and driftwood and a few silty and gravelly beds". Gravel and grey sands, which in part may belong to the Turnabout Member, are present in ice cellars and tunnels at Tuktoyaktuk (Fig. 17; Rampton and Mackay, 1971) and at Flagpole Point (where Rapitan Formation pebbles are common in the beach gravels eroded from the retreating headland). Only at Peninsula Point, do grey sands of the Turnabout Member and Kidluit Formation(?) seem to be separated by a fine grained brown sand tentatively assigned to Kittigazuit Formation (Table 13); even here, both the supposed Kidluit Formation and Turnabout Member have similar characterisitics.

Morainal deposits (Toker Point Member, Malloch Till, Buckland Glaciation morainal deposits, Sitidgi Member)

Morainal deposits, primarily the till and till-related facies, of Early Wisconsinan age on the Tuktoyaktuk Coastlands have been assigned to the Toker Point Member of the Tuktoyaktuk Formation. Early Wisconsinan morainal deposits on eastern Cape Bathurst peninsula have been called the Malloch Till as they appear to be primarily till in that area. Early Wisconsinan morainal deposits west of the Mackenzie Delta they have been attributed to the Buckland Glaciation. Within the Late Wisconsinan glacial limit in the southwest part of the region, morainal deposits have been assigned to the Sitidgi Member.

Materials

Morainal deposits of both the Toker Point and Sitidgi members consist primarily of a stony clayey diamicton. Typically the material contains 3 to 25% clasts greater than 2 mm in size and the remainder contains 10 to 30% sand, 25 to 45% silt, and 30 to 50% clay (cf. Appendix 1). The clayey matrix of the morainal deposits has presumably been derived from Cretaceous shales to the south and east, which glaciers crossed as they moved into the area (Rampton, 1972b). In some areas where the diamicton directly overlies sandy or gravelly materials, its base has a coarser texture. Rampton and Bouchard (1975, p. 8) noted that "beds and lenses of sandy, stony, diamicton occasionally occur within this unit where it abuts against or is underlain by gravel" in the Tuktoyaktuk area.

Some of the clayey diamicton within the morainal deposits is truly till, but much of it, especially the upper part of the deposits, has undoubtedly been reworked into colluvium and lacustrine deposits (Rampton 1972b, 1982; Rampton and Bouchard, 1975; Hardy Associates (1978) Ltd., 1983). These materials have become incorporated into

Table 19. Stratigraphy at site 142V near Turnabout Point, Liverpool Bay (Fig. 35)

Thickness	Material (unit)
7 m	Sand and gravel, grey; poorly exposed (Turnabout Member)
0.6 m	Diamicton, clayey, pebbly; sandy bands near base (Toker Point Stade till or debris flow)
13.5 m	Sand, fine grained, brown; top is dark brown (Kittigazuit Formation)
6.5 m	Covered to sea level

Table 20. Stratigraphy at locality 213X in "outer fingers", Eskimo Lakes (Fig. 35)

Thickness	Material (unit)
2.5 m	Peat, logs near base
0.5 m	Colluvium, bouldery
6.0 m	Sand, grey (Turnabout Member)
0.5 m	Clay, few pebbles (Toker Point Stade till ?)
4.5 m	Sand, brown (Kittigazuit Formation)
4.5 m	Sand, grey, some crossbeds; much woody detritus (Kidluit Formation)

the morainal deposits as a result of thermokarst processes. The colluvium may be formed via downslope creep or soliflucition, but primarily it is the product of retrogressive-thaw flow slides. These features, which result from the thawing of steep ice-rich slopes, lead to till and other materials (including organic materials) sliding down a steep face and mixing with the water from thawing ground ice. This soupy mixture then flows farther downslope until it is dehydrated to a point where it stabilizes and accumulates. The redeposited till resembles the original material; occasional alluvial bedding structures formed by flowing water and incorporated loose peat in the material are the only clues to its redeposited origin (Rampton and Bouchard, 1975). Lacustrine and pond deposits, commonly lacking the coarser clasts common to the till and colluvium, may form in irregular-shaped thermokarst depressions found on morainal deposits. They form an integral part of terrain mapped as morainal deposits as they can only be distinguished upon detailed examination (cf. Fig. 18). In complex exposures of till or till-like diamicton, the upper part can be considered to be reworked where it is relatively structureless or contains uncompressed organic material and to be in situ till where it is jointed (cf. Hardy Associates (1978) Ltd., 1983). Commonly the lower boundary of the till will have a sharp contact with the underlying material, whereas its upper boundary will grade into colluvium and lacustrine materials.

Landforms and thicknesses

Morainal deposits have been separated into hummocky moraine, rolling moraine, morainal blanket, and morainal veneer according to their thickness and morphology.

Hummocky and rolling moraine generally have local relief between 20 and 30 m, with hummocky moraine showing slightly steeper slopes than rolling moraine. Slopes are moderately well drained, hill crests imperfectly to moderately well drained, and depressions poorly drained. The relief in many places is due to the presence of massive ground ice under hills and ridges; only in some areas is it truly morainic topography. The latter is particularly true of terminal moraines forming the eastern limit of the Sitidgi Stade ice advance. Hummocky and rolling moraine deposits, including diamicton of colluvial origin and lacustrine deposits, are commonly 4 to 12 m thick (Rampton, 1979a-d).

Morainal blanket has only been mapped where glacial deposits have been assigned to the Buckland Glaciation west of the Mackenzie Delta or to the Sitidgi Stade in the southern part of the study area near the delta (Map 1647A). Both areas are characterized by relatively thin morainal deposits over bedrock. Surface morphology and slopes generally reflect those of the underlying bedrock, be they flat or sloping. In some areas the bedrock has been glacially fluted. Most sloping areas are well drained, but depressions and swales on flat areas are imperfectly to poorly drained. The diamiction and associated materials composing the deposits are generally 2 to 10 m thick, except west of Sitidgi Lake where they are generally less than 5 m thick and may be less than 1 m thick over rocky promontories.

Morainal veneer has been mapped only in areas where glacial deposits have been assigned to the Toker Point Stade. These areas have a unique morainal or fluted aspect that is indirectly related to glaciation since the morainic-like morphology is probably the result of thermokarst activity (cf. Fig. 3, 15). It is certainly not glacially constructed topography as the till or till-derived sediments appear to be less than 1 m thick on the average in areas where the relief is up to 70 m and no less than 10 m. Generally, relief is greater where the till is underlain by sand than where it is underlain by finer textured materials. In some areas where oriented lakes are common, the topography appears to have a fluted nature; whether this is simply glacial fluting followed by thermokarst preferentially developing along swales or due to subglacial meltwater erosion of sandy materials is not known. The slopes and crests of most hills are well drained, although intervening depressions can be poorly drained.

The clayey diamicton forming the till and till-derived deposits, mapped as morainal veneer (Map 1647A), is generally 0.5 to 3 m thick and rarely up to 6 m thick (Rampton, 1979c, d). Depressions may contain up to 8 m of lacustrine deposits derived through thermokarst development. In some areas, namely adjacent to East Channel or to the southern edge of Liverpool Bay west of Nicholson Peninsula, morainal deposits appear to be absent except for very thin lenses of clayey diamicton (cf. Table 19) or a bouldery gravelly lag over the underlying sediments. These areas were originally mapped as "glacially-modified marine and fluvial deposits" by Rampton (1972b) because of the thinness of the glacial drift. Locally, morainal deposits within the morainal veneer map unit may be thick. In some areas, shothole log data indicate thicknesses of well over 2 m on the crests of hills and in depressions. This is true even in areas where ground examination indicates that only thin lenses of clayey diamicton or a boulder lag are present. It may be that mass wastage has caused the removal of the diamicton from the edge of hills and scarps (where the stratigraphic sequences are best examined).

Glaciofluvial deposits (Toker Point Member, Garry Island Member, Cape Dalhousie Sands, North Star Outwash, Sitidgi Member, Kugaluk River Outwash, Portage Point Sands)

Early Wisconsinan ice-contact deposits are considered to be a glaciofluvial facies of Toker Point Member, whereas Late Wisconsinan ice-contact deposits are considered to be a glaciofluvial facies of the Sitidgi Member. Early Wisconsinan outwash has been assigned to the Garry Island Member, Cape Dalhousie Sands, and North Star Outwash based on its areal distribution. Similarily, Late Wisconsinan outwash has been assigned to Kugaluk River Outwash and Portage Point Sands.

Landforms

Glaciofluvial deposits have been mapped as outwash and ice-contact deposits (Map 1647A). In some cases, thermokarst has so modified the glaciofluvial deposits that it is difficult to classify them as outwash or ice-contact deposits on the basis of landform or sedimentary structures. These deposits have been classified as ice-contact deposits where no vestige of a flat-topped outwash surface is identifiable.

Only two major eskers have been mapped, one on Richards Island just north of Tununuk Point (known as the Yaya esker, Fig. 42) and one east of Eskimo Lakes near Urquhart Lake (Fig. 43). Smaller eskers are present near Willow Lake on Richards Island and south and east of Sitidgi Lake. Isolated hills and clusters of hills containing significant amounts of gravel on parts of Richards Island, Tuktoyaktuk Peninsula, and around Eskimo Lakes are considered to be kame and kettle complexes.

The large deposit that forms the crest of Tuktoyaktuk Peninsula, and other areas, such as north of the Caribou Hills, have been included with the ice-contact deposits because their morphology is similar to the morphology of kame and kettle complexes. Also their location relative to perceived glacier margins suggests that they could reasonably have been formed from sand and gravel being deposited on glacier ice. In some areas, however, they may simply be outwash deposits modified by thermokarst (cf. Fig. 3), and in other areas they may be till-capped sands and gravels whose till cover is thin or has been removed from hill tops and scarps through mass wasting. As these subtill sands and gravels are easily confused with glaciofluvial sands and gravels, this situation could lead to hummocky topography being incorrectly identified as ice-contact deposits.

Outwash plains and valley trains are common throughout the area. The largest outwash plain forms the northern part of Tuktoyaktuk Peninsula (Cape Dalhousie Sands). Much of its surface is covered by windblown sand and marked by oriented thermokarst lakes (Map 1647A). A highly dissected outwash plain also forms part of Garry Island and some islands to the east of Garry Island (Garry Island Member). Parts of a large outwash plain are present along Eskimo Lakes from near their southern end to their mid-point (Portage Point Sands). This outwash plain is pitted by thermokarst depressions as it is underlain throughout much of its extent by massive ice (Fig. 5, 14B). Indeed it probably covered most of the area occupied by the upper Eskimo Lakes prior to extensive melting of ground ice in this area.

Most major valley trains parallel the larger streams, such as East Channel of Mackenzie River, and Kugaluk (Kugaluk River Outwash) and Anderson rivers and Old Horton Channel (North Star Outwash). Another large valley train crosses Tuktoyaktuk Peninsula towards Kittigazuit and one crosses Richards Island west of Kittigazuit Bay.

Relief within the rolling to hummocky ice-contact deposits can be up to 50 m (Rampton, 1979b, c, d). Except for large flat-bottomed depressions, these features are well drained. The outwash plains and valley trains are generally flat or terraced. Thermokarst basins may be inset into these plains up to 50 m, but generally relief due to thermokarst and sand dune activity is less than 5 m. Drainage is poor to imperfect in broad flat areas but improves close to slopes.

Materials

Glaciofluvial deposits consist primarily of sand and pebbly sand (Appendixes 1 and 2), although locally areas of gravel or concentrations of gravelly beds may be present (cf. Northern Engineering Services Company Limited, 1976; R.M. Hardy and Associates Ltd. and Terrain Analysis and Mapping Services Ltd., 1976; R.M. Hardy and Associates, 1977; BBT Geotechnical Consultants Ltd. et al., 1983). Many glaciofluvial deposits also have significant silt contents.

Gravel is a common component of the glaciofluvial deposits bordering and originating from the Sitidgi Stade glacial limit north of Sitidgi Lake; bordering the Caribou Hills where glacial meltwater has eroded and redeposited Tertiary gravels; adjacent to Lost Reindeer lake southeast of Campbell Lake; near the mouth of Willow River west of Mackenzie Delta; within parts of the Yaya esker north of Tununuk Point; in the large glaciofluvial system that begins near Five Hundred Lake and extends northeast past Urquhart Lake; in channels cutting across the arcuate peninsula separating Eskimo Lakes from the Kugaluk estuary; in terraces parallel to Anderson River; and in terraces flanking Old Horton Channel (Map 1647A). Locally concentrations of gravel may be present within areas where most glaciofluvial material is sandy; for example, gravel beds are common in parts of a glaciofluvial system near Tuktoyaktuk (Rampton and Bouchard, 1975; R.M. Hardy and Associates Ltd., 1977). This gravel was likely more extensive at one time as it appears to extend under Tuktoyaktuk Harbour (Hardy Associates (1978) Ltd., 1979), which probably developed through thermokarst (Rampton, 1974a). Gravel is also concentrated locally in hills and clusters of hills throughout the morainal deposits and glaciofluvial deposits forming the southern part of Tuktoyaktuk Peninsula (cf. R.M. Hardy and Associates Ltd., 1977; BBT Geotechnical Consultants Ltd. et al., 1983).

Thin beds and lenses of pebbly gravel are present throughout most sandy beds within the glaciofluvial deposits. These gravel lenses decrease in frequency from south to north throughout the area as does the coarseness of the sand. Pockets of coal fragments and wood detritus are commonly associated with the gravel lenses.

Many of the glaciofluvial deposits south of Sitidgi Lake have high silt contents (Northern Engineering Services Company Limited, 1976). This results from glacial meltwater eroding shales and redepositing the silt-sized sediment. The upper part of the glaciofluvial sands forming the outwash plain in the Eskimo Lakes basin (Portage Point Sands) also tends to be silty.

Lacustrine deposits

Glaciolacustrine deposits

Silty and clayey lacustrine deposits that are likely glaciolacustrine in origin are present only in the central part of Eskimo Lakes where silt and clay underlie some areas whose upper surfaces lie between 18 and 30 m (Rampton, 1972b). These areas have been affected by thermokarst and have a general rolling aspect with relief to 30 m (Rampton, 1979c). An equivalent clayey unit has been observed to overlie ground ice and clayey diamicton and underlie glaciofluvial sediments (Fig. 44) in the west-central part of Eskimo Lakes (Rampton, 1972a). The lacustrine clay and silt are generally 3 to 10 m thick. Varved structure is not obvious, but the unit is banded and laminated at some localities. These clay and silts are generally devoid of sand (cf. Appendix 1, samples 105ROW and 139ROW). Stones have been rarely noted in the unit.

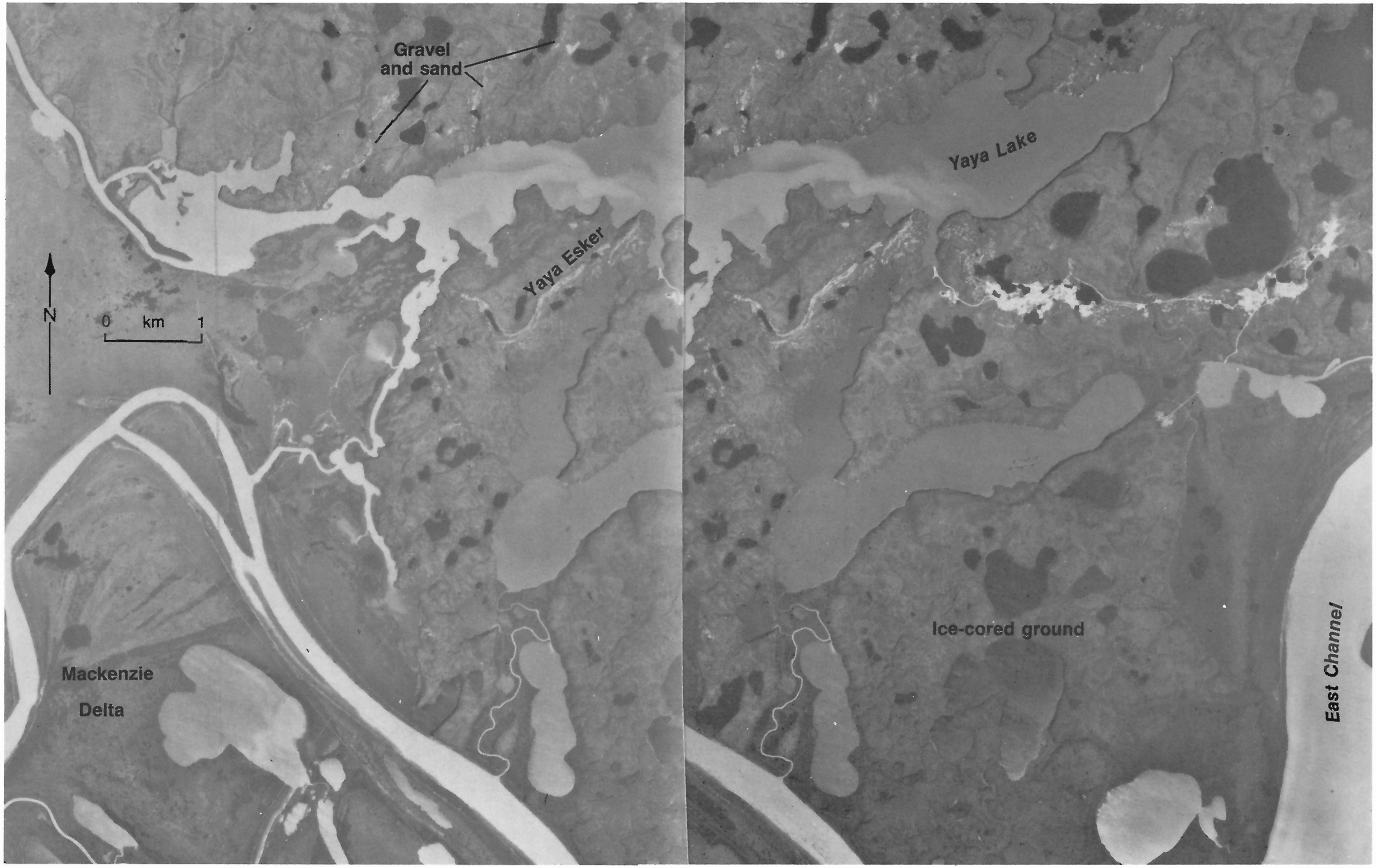


Figure 42. Meandering Yaya esker on Richards Island; portions of the eastern part of esker have been extracted. Note that Yaya Lake and the lake to the south of the esker are drowned valleys, partly filled with Mackenzie Delta alluvium (Aklavik Formation). NAPL A23476-130, 131

Figure 43. Large esker at Urquhart Lake southeast of Eskimo Lakes. (GSC 159028, 159029)

Lacustrine deposits (Eskimo Lakes Member)

In the Eskimo Lakes basin, a broad lacustrine bench or plain flanking the lake and generally lying below 10 m elevation is believed to have been formed through thermokarst when the present outlet of Eskimo Lakes was infilled and blocked by outwash (Rampton, 1972b). The flat surface is swampy and contains many thaw pools (Rampton, 1979b, c, d).

This unit (Eskimo Lakes Member) is composed of interbedded silt, clayey silt, and silty sand with organic lenses and layers. Silty sand and sand predominate in areas of sandy outwash and till-veneered sand, and sandy gravel in areas of gravelly outwash. These sediments are generally between 1.5 and 8 m thick with patches of peat, 1.5 to 3 m thick, on their surface.

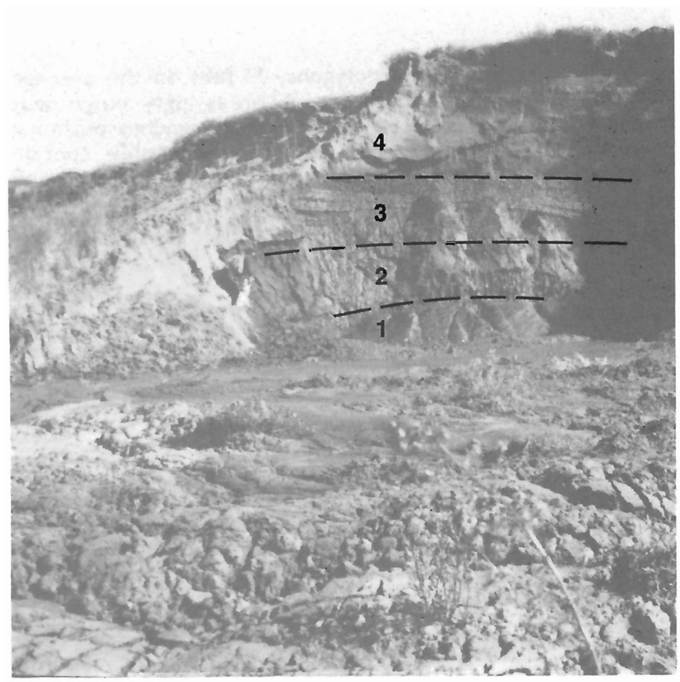
Holocene

Deposits mapped as Holocene were deposited primarily during this period, although initial deposition may have started at some localities during the Late Wisconsinan. Holocene deposits continue to be actively deposited or modified.

Organic deposits

Much ground throughout the area is covered by a thin peaty layer, generally less than 0.5 m thick; only on Cape Bathurst peninsula were major areas of bare ground noted. Locally areas underlain by gravel or being affected by active processess lack significant cover of organic matter. Commonly a discontinuous organic layer is also present within a metre of ground surface (Mackay, 1958b).

In the low arctic tundra zone, peat occurs primarily within thermokarst basins (Fig. 45) or on poorly drained areas and is generally no more than 2 m thick (Rampton and Bouchard, 1975; Hardy Associates (1978) Ltd., 1983). These organic deposits are commonly patterned (cf. Fig. 10, 45) as they lie in the zone of lowland polygons (Zoltai and Tarnocai, 1975). "Most organic deposits in the Tuktoyaktuk area have a surface pattern: the most common pattern is high-centre peat polygons; less common are low-centre polygons. High-centre peat polygons generally have smaller



1. Pure massive ground-ice
2. Clayey till
3. Lacustrine clay with many thin ice lenses (1.3 cm thick)
4. Outwash sands

Figure 44. Retrogressive-thaw flow slide in central Eskimo Lakes, exposing outwash (4) of Sitidgi Stade, lacustrine clay (3) and till (2) of Toker Point Stade, and massive ground ice (1). (GSC 201831)

Figure 45. Peat, marked by polygonal ground, in a drained thermokarst basin. Note marshy areas inset into the level of most of the basin. (GSC 159039)

diameters than low-centre polygons, 35 feet on the average as compared to 60 feet or more. Whereas high-centre peat polygons only have standing water in the trenches outlining the polygons, low-centre peat polygons commonly contain water in the central depressions". (Rampton and Bouchard, 1975, p. 12) In the boreal forest south of Inuvik, peat in bogs can be up to 6 m thick and thin sedge peat forms along fens.

Lacustrine deposits (Parsons Lake Formation)

The large amount of thermokarst activity in the area has resulted in the formation of large coalescing thermokarst basins (Rampton, 1974b), which have been occupied by lakes. Sediments, which have been deposited in these basins, have been assigned to the Parsons Lake Formation. These lakes have drained through drainage integration and coalescence of basins to lower base levels (Rampton, 1973). The lake plains are generally flat except for scarps and trenches formed through secondary thermokarst or ground ice development (Fig. 45). Their surfaces are usually marshy with many thaw pools and small lakes (Rampton, 1979a-d).

The thermokarst lacustrine deposits, which form through wave and current reworking of debris introduced into the lakes by retrogressive-thaw flow slides, are similar in texture to the materials constituting the surrounding terrain. For example "Lacustrine deposits in areas of moraine, or surrounded by morainal deposits, are typically fine, because the morainal deposits supplied fine material to the expanding thermokarst basins. The lacustrine deposits are generally thinly bedded clay, silt, and fine sand and commonly are high in organic content (Fyles et al., 1972). In many places their base grades into colluvium and contains a large number of stones and fragments of wood and peat. Of course the shore zones generally have a concentration of stones, although well-sorted gravel beaches are the exception" (Rampton and Bouchard, 1975, p. 8). In areas where the surrounding units are predominately sand or gravel, the lacustrine deposits also contain a high proportion of gravel and sand. They generally range between 1.5 and 8 m in thickness (Rampton, 1979a-d).

Eolian deposits

Sand dunes cover much of the area underlain by fine sandy outwash on the northeastern end of Tuktoyaktuk Peninsula and along Kugaluk River estuary. Parabolic dunes are most common (cf. Fig. 4), but cliff-top (Fig. 46, 47), crescentic, and linear dunes are also common (Mackay, 1963a; Rampton, 1972b). Dunes on Tuktoyaktuk Peninsula are usually 1.5 to 3 m high, exceptionally up to 7 m high (Rampton, 1979d). Flat areas are poorly drained with many thaw pools. Cliff-top dunes are usually associated with coastal bluffs eroded in sand, namely the Kittigazuit Formation (Fig. 47), scarps around thermokarst lakes in sandy outwash (Fig. 46), or recently drained sandy lacustrine basins. Sand dunes at these localities are also subject to continued blowouts. Just northeast of Malloch Hill, a yardang is continuing to develop in thick eolian sands (Fig. 48).

Most eolian sand within the area is fine to very fine grained, locally it may be silty and contain peaty lenses or layers of roots and twigs (Rampton, 1979c, d). Generally eolian sand is 1.5 to 3 m thick, although in a few localities deposits are up to 7 m thick. One area of thick eolian sand near Malloch Hill was noted to be 15 m thick (Rampton, 1979a).

Alluvial deposits

Alluvial deposits constitute terraces, fans, deltas, and floodplains. Where alluvial deposits grade to sea level, they interfinger with estuarine and marine deposits; in such cases, all deposits have been mapped as alluvial as the source of the sediment is primarily fluvial. Generally, alluvial terraces are not subject to active sedimentation as they are no longer subject to inundation by streams. Parts of the alluvial fans and higher parts of Mackenzie Delta are only subject to rare inundation (Mackay, 1963a). The fans are only inundated during avulsion. The higher parts of Mackenzie Delta are only flooded when massive ice jamming occurs. Most of the fans and deltas and all the floodplains are subject to periodic, often annual, inundation and alluviation.

Figure 46. Cliff-top dunes formed along western scarp of drained thermokarst lake on sandy outwash plain (Cape Dalhousie Sands) near northeast end of Tuktoyaktuk Peninsula. Blowouts are still active. (GSC 159066)

Figure 47. Cliff-top dune at crest of Kittigazuit Formation near mouth of East Channel. Dune formation is presently active. Note multi-level drained thermokarst basins in background. (GSC 158966)

Terraces

Alluvial terraces have been identified in areas where streams are incised into bedrock, such as Yukon Coastal Plain (Mountain Fringe) and Anderson Plain. The terraces are flat except for minor scarps formed during terracing. Generally their surfaces are imperfectly to poorly drained, except near the scarps (Rampton, 1979a, b).

In the area surrounding Mackenzie Delta, the alluvium in the terraces consists of 0.5 to 3 m of clayey silt and silt sand having high organic contents overlying silty sand and gravel. In many places the gravel is cobbly due to the presence of ironstone concretions, which have been weathered out of shale and sandstone in the area (Northern Engineering Services Company Limited, 1976; Rampton, 1979a). Terraces along Anderson River consist of sandy gravel (cf. Appendix 1, sample 101ROVI).

Fans

Large alluvial fans are located at the west edge of Mackenzie Delta where it abuts directly against Richardson Mountains. Smaller alluvial fans occur where alluvium has accumulated at the base of steep slopes underlain by shale (such as just north of Inuvik, Map 1647A) or other poorly consolidated bedrock lithologies. The large alluvial fans adjacent to Mackenzie Delta have relatively steep slopes near their apex (up to 8°) and long low slopes over the remainder of their surface (generally less than 2°) (Legget et al., 1966). At the apex of the fans, a distinct channel is generally incised into the fan, but within 0.5 km of its apex the stream beds become braided and eventually poorly defined. Rapid accumulations of bed-load material lead to rapid avulsion.

Data from boreholes in the alluvial fans west of Mackenzie Delta indicate that most of the alluvium is clayey silt and silty sand with common organic beds (Legget et al., 1966). Pebbly and sandy beds are present throughout the sequence. These alluvial fans are estimated to be more than 20 m in thickness (Rampton, 1979b). Alluvium composing other fans is more clayey and silty (cf. Appendix 1, sample 60ROV3B), as their source of material is generally shale, as opposed to the shale, sandstone, conglomerate, and quartzite that feeds the large fans west of Mackenzie Delta.

Figure 48. Yardangs in old stabilized cliff-top dunes along Old Horton Channel on Bathurst Peninsula. Dunes lie on Wisconsinan (Franklin Bay Stade) glaciofluvial terrace. (GSC 159055)

Floodplains and deltas (Aklavik Formation)

Although the area is dominated by Mackenzie River Delta, other rivers such as the Mason, Anderson, and Smoke, and East Channel of Mackenzie River have also formed deltas. These deltas are less conspicuous than Mackenzie Delta in that other than the Smoke River delta, they are infilling drowned valleys and grade upstream imperceptibly into their floodplains.

Mackenzie Delta is a complex maze of lakes and anastomosing channels, many of the lakes providing episodic interconnections for the channels. Distributary, tributary, network, reversing, and tidal channels are all present (Mackay, 1963a). Most channels have a meandering to sinuous nature. Abandoned channel, point bar, floodplain, damned, and thermokarst lakes are common; floodplain lakes are most common in the outer delta, and thermokarst lakes in the middle and upper delta (for details of delta channel morphologies and lakes see Mackay, 1963a). Much of the delta surface is subject to frequent inundation and is poorly drained. Other floodplains and deltas are characterized by poorly drained marshy surfaces (Rampton, 1979b). Numerous lakes and channels also characterize these features.

The deltas and floodplains are composed primarily of silt, fine sand, and clayey silt (Appendixes 1 and 2), commonly with organic detritus, wood fragments, and small freshwater shells in their upper parts (Johnston and Brown, 1965; Rampton, 1979b-d). The sediments range in thickness from 2 m to more than 10 m. At one locality on Mackenzie Delta southwest of Inuvik, they were measured to be about 55 m thick (Johnston and Brown, 1965). In the Mackenzie Delta the alluvium is underlain by either glaciolacustrine or glaciomarine clays (Johnston and Brown, 1965). Sediments composing the Mackenzie Delta have been assigned to the Aklavik Formation.

Floodplains along streams incised into bedrock also consist in part of organic-rich, fine grained sediments, especially their upper parts. However the fine grained sediments are generally underlain by sand and gravel within a

Figure 49. Beaches and baymouth bars west of Tuktoyaktuk. Major beaches form a barrier across the drained lacustrine basin in the foreground and the lacustrine basin inundated with marine water in middle part of photograph. Headland in the background is actively receding due to wave erosion and thaw of its ice core. Note the driftwood on the beaches. (GSC 159007)

metre of the surface. Point bars and channel bottoms generally consist of pebbly and cobbly gravels (cf. R.M. Hardy and Associates Ltd. and Terrain Analysis and Mapping Services Ltd., 1976).

Marine deposits

Beaches, bars, spits, intertidal flats, and lagoons are common throughout the area to the east of Mackenzie Delta. These features are all best developed along irregular coastlines where former stream channels and lacustrine basins have been inundated by marine waters and erosion is actively attacking headlands (Fig. 49).

Narrow beaches flank most coastlines where the eroding coastal scarps contain any significant amount of sand or gravel sized clasts. Spits and bars are most common near headlands, especially along the northern side of Tuktoyaktuk Peninsula; here long curved ridges rise to 3 m above sea level (Rampton, 1979c, d).

Many lacustrine basins along the gently sloping northern edge of Tuktoyaktuk Peninsula have been flooded by marine water and intertidal flats have formed in these lagoons. Their surfaces are characteristically poorly drained and marshy. A peculiar type of patterned ground, "pitted peat", has developed in some intertidal lagoons (Rampton and Bouchard, 1975). It appears that brackish waters have led to a unique development of peatland or that brackish waters have caused a peculiar thawing of ice upon inundation. Intertidal flats beyond the main coastlands are flat and inundated on a near annual basis during high tide and storm surges. Intertidal flats extend over significant areas between Richards and Pelly islands and in the large drowned valley at the mouth of Old Horton Channel (Map 1647A).

The composition of the beaches, bars, and spits largely reflects the materials in the adjacent coastline scarps from which they were eroded. Thus these features contain significant amounts of gravel (cf. Appendix 1) where the sea is eroding morainal deposits and glaciofluvial or alluvial deposits containing gravel beds such as around Richards Island (Lawrence et al., 1984) and Harrowby Bay. In other areas where fine sand is the primary terrestrial material being eroded (areas along the south side of Liverpool Bay or towards the north end of the Tuktoyaktuk Peninsula), the beaches, bars, and spits are predominantly sand (Rampton, 1979d; Lawrence et al., 1984). Some offshore shoals are composed of coarse gravel (R.M. Hardy and Associates Ltd., 1977). Beach, bar, and spit deposits range between 0.5 and 2 m thick; some of the larger spits are up to 3 m thick (Rampton and Bouchard, 1975; R.M. Hardy and Associates Ltd., 1977; Rampton, 1979a, c, d).

Figure 50. Driftwood incorporated into intertidal deposits in lagoon near Tuktoyaktuk. Mound in the background is a small pingo. (GSC 158983)

Interbedded silt, clayey silt, and silty sand constitute most intertidal deposits (cf. Appendix 1). Those located in lagoons commonly have high organic contents. Much of the organic material is fine grained, but driftwood can be a significant constituent (Fig. 50). Intertidal lagoonal deposits are generally 1 to 3 m thick, whereas intertidal flat sediments are probably greater than 5 m thick in many areas (Rampton, 1979c, d; Hardy Associates (1978) Ltd., 1983).

Colluvial deposits

Colluvial deposits occur in three main environments: (1) on moderate to steep slopes not exposing bedrock west of Mackenzie Delta; (2) on structural, stream-cut and wave-cut scarps developed in bedrock throughout much of Anderson Plain; and (3) on the unglaciated rolling Malloch Hill Upland (Fig. 20). Some colluvium is present on most surfaces throughout Tuktoyaktuk Coastlands, but it has not been mapped separately from the underlying material as it is generally thin and differs little in texture from it.

In the area west of Mackenzie Delta, the texture of the colluvium is largely governed by the underlying bedrock (Rampton, 1982, p. 41). "In gently sloping areas underlain by less competent rock types, stones generally constitute a small proportion of the colluvium but may comprise up to 15 percent. In some areas of colluvium underlain by shale, the surface layers are stony because concretions and bedrock fragments tend to accumulate at the surface due to frost action. On steep slopes and in areas where resistant rock types are present, the stone content ranges between 20 and 50 percent. In areas where resistant rock types, mainly highly indurated sandstones, are dominant, colluvium consists of a coarse, bouldery rubble. Bouldery rubble is particularly common on steep ridge crests and on altiplanation terraces in the Richardson Mountains". The organic content of the fine grained colluvium may be high. Colluvium is 0.5 to 2 m thick on most slopes (Rampton, 1979b).

Colluvium on most escarpments in the Anderson Plain is generally silty or clayey as the escarpments are developed in shale. Only where weakly indurated Tertiary conglomerate and sandstone beds outcrop along escarpments in the Caribou Hills does the colluvium become gravelly and sandy. Generally this colluvium is 0.5 to 2 m thick (Rampton, 1979b), except near the base of slopes where it may be more than 2 m thick.

A clayey to silty clayey colluvium containing rare boulders and cobbles covers the Malloch Hill Upland (Rampton, 1979a). These deposits are generally 1 to 2 m thick, but may be thicker in swales where they have high organic contents and are interbedded with peat. Generally the colluvial slopes are well drained, but small thaw pools may occur in depressions.

QUATERNARY HISTORY

The Quaternary history can best be divided into four parts: (a) that part occurring prior to the Toker Point Stade, which is believed to be Early Wisconsinan, (b) the Toker Point Stade, which encompasses an Early Wisconsinan glaciation and related events, (c) the Sitidgi Stade, which is Late Wisconsinan, and (d) the Holocene. It is necessary to discuss the Middle Pleistocene and Sangamonian history for different areas separately as Pleistocene phenomena and causative events are not easily correlated from area to area.

Middle Pleistocene and Sangamonian

East of Nicholson Peninsula

Horton Sea

Much of the terrain of Cape Bathurst peninsula and area to the south adjacent to Horton River does not show any evidence of glaciation. Glacial landforms are absent and no shield erratics have been found on the uplands. Rare cobbles and small boulders, which are scattered over its surface, are likely a lag from eroded Tertiary gravels (Rampton, 1970).

The presence of perimarine sediments on a relatively flat surface below a well defined escarpment cut in the bedrock at an elevation of approximately 75 m in this area attests to a sea standing near this relative sea level for a long period of time. The marine event that produced the escarpment coastal cliff and the associated wave-truncated plain has been named the Horton Sea. A relatively consistent sea level, which would be required to erode the broad plain sloping up to the wave-cut bedrock escarpment, may imply that these features were cut during a long interglaciation rather than during a sea level related to glacially induced depression of the landscape (the latter is generally an unstable phenomenon with only short-lived sea level stillstands at any one level). The elevation of the Horton Sea marine limit suggests that a significant amount of tectonically induced uplift has affected the area in order to raise this shoreline to near its present level.

Direct evidence of the environment during the Horton Sea episode is not available as it is difficult to specifically assign any of the unconsolidated sediments lying on the plain below the Horton Sea marine limit to the Horton Sea. Some sediments in the lower parts of exposures near McKinlay Lake and south of Trail Point may have been deposited contemporaneously with erosion of the wave-truncated plains; however, they have not been studied in enough detail to discern the paleoenvironment during their deposition. The Horton Sea is also difficult to date. It likely predates the Middle Pleistocene (Illinoian) Mason River Glaciation as deposits of that glaciation are thought to be present on the Horton Sea wave-cut plain. In any event, glacial deposits of the Franklin Bay Stade, of supposed Early Wisconsinan age, clearly occur on the surface of the Horton Sea wave-cut plain on eastern Cape Bathurst peninsula (Map 1647A) and indicate that the Horton Sea at least predates the Early Wisconsinan.

Stanton Sediments

Stanton Sediments were likely all deposited subsequent to the Horton Sea episode. South of Maitland Point, especially south of site VH-83-035 (Fig. 22), the lower complex member lies on a flat bedrock surface (presumably planated by the Horton Sea). At lower elevations north of locality VH-83-035, the basal clay member would also appear to lie on a planated bedrock surface. Generally, however, the base of the basal clay member, and Baillie Clay to the north, is not exposed and a definitive relationship between the wave-truncated Horton Sea surface and the clays is not discernable. The clays could thus predate Horton Sea.

Both the basal clay member of the Stanton Sediments and Baillie Clay were deposited in relatively deep water. Fauna (identified by Dr. F.J.E. Wagner) are common to depths of 28 to 55 m in todays arctic seas (Mackay, 1963a). The clays could have been deposited when sea level stood at the Horton Sea marine limit, about 75 m above sea level. As in the case of the Horton Sea, it is difficult to date the time of their deposition. The basal clay member would appear certainly to predate the Mason River Glaciation of probable Illinoian age as it is exposed in locality 19Z northeast of the mouth of Mason River (Fig. 22) where erratics, probably deposited during the Mason River Glaciation, were present on the cliff-face well above the basal clay member (Fig. 24). The erratics were not observed in situ, but were probably eroded from a till unit higher in the slope. The basal clay member also appears to lie under a sandy unit at VH-83-039 (Fig. 24), which is believed to be outwash deposited during the Mason River Glaciation. The basal clay member certainly predates the Toker Point Stade of Early Wisconsinan time as it is overlain by the Toker Point Member west of Mason River. It also predates the Liverpool Interglaciation as benches consisting of the Ispisugyuk Formation are inset into the Stanton Sediments east of Maitland Point and near the mouth of Mason River (Fig. 22, 25). As Baillie Clay and lower basal member are normally magnetized (J-S. Vincent, personal communication, 1984) they were all deposited during the Brunhes Epoch and must postdate 730 ka.

A period of lower sea levels followed deposition of the basal clay member. At a number of sites (cf. 32Z and VH-83-045, Fig. 24, 25, 26) the top of the basal clay member is oxidized, covered by a thin peat or marked by ice-wedge casts. Continued deposition on an alluvial plain, probably in a perimarine environment, is indicated by the mixture of silt and sand containing organic detritus, wood, and pebbly layers that constitute the lower complex member. Frequent subaerial exposure of the ground surface is also indicated by numerous soil horizons and ice-wedge casts within and at the top of the lower complex member (Fig. 31). Gravels within the lower complex member south of locality VH-83-035 (cf. 25Z, Fig. 22) also indicate a period of stream or more probably wave activity. The lower complex member probably predates the Middle Pleistocene (Illinoian?) Mason River Glaciation and is younger than 730 ka for reasons similar to those invoked for the basal clay member. D-aspartic/L-aspartic ratios of 0.14 on wood from peats in the lower complex member (Table 16) are indicative of a relative youthful age if compared to results obtained by Vincent (1982, 1983) on Banks Island. However, N.W. Rutter (personal communication, 1984) has noted that the D-aspartic/L-aspartic ratios of wood in mid-Pleistocene sediments from the Arctic Coastal Plain of northern Alaska can be relatively low, especially if they are enclosed within fine grained sediments. Fossils from an autochonous peat in the lower complex member have been interpreted by J.V. Matthews, Jr. (unpublished GSC Fossil Arthropod Report No. 84-16) as having been deposited in a low arctic tundra environment.

Following deposition of the lower complex member, a period occurred during which a unit of thinly bedded fine sand and clayey silt was deposited over a large area extending from near Stanton to east of Maitland Point. The individual beds generally range from 0.5 cm to 4 cm thick; lenses of organic detritus are common (Fig. 28). These deposits probably formed as delta front silts and sands, thin prodeltaic turbidites, or intertidal muds and sands (cf. Walker, 1979; Reineck and Singh, 1980). The thinly bedded member sequence suggests deposition in an environment of frequent or periodic introduction of transported sediment into relatively quiet water with little wave or current modification of the deposited sediments. Such a scenario would be favoured in an embayment where rapid erosion of fine grained (clay, silt, and fine sand) sediments was occurring along the coastline, or where streams were rapidly discharging fine grained terrestrial material into it. A paucity of marine fossils has been noted in these sediments, but rapid deposition of terrestrial material into a marine environment is favoured over floodplain deposition as related channel and point bar deposits are absent in the thinly bedded member. Whether the thinly bedded member was deposited under glacial or interglacial constraints is not known. Chronologically these sediments are within the Bruhnes Epoch, as are other members of the Stanton Sediments, and probably predate the Illinoian. However, if grey sands at locality VH-83-039 (Fig. 24, 51) are outwash deposited during Mason River Glaciation, it would imply that the thinly bedded member postdates the maximum expansion of ice during Mason River Glaciation.

Deposition of the upper sandy member appears to have occurred in shallow marine or subaerial environments as the unit is commonly characterized by massive beds of sand. Also, the base of the upper sandy member is marked by an accumulation of bone, wood, and peaty fragments (cf. localities VH-83-035 and -036, Fig. 24). At locality VH-83-048 channel sands containing abundant driftwood indicate a fluvial environment of deposition, and open-structure clean gravels indicate a beach environment (Fig. 52). All evidence indicates a shoaling of water following deposition of the thinly bedded member.

Sand assigned to the upper sandy member underlies a diamicton (till) southwest of Mason River (cf. localities VH-83-045 and VH-83-047, Fig. 24, 26). If this till belongs to the Toker Point Member, deposition of the sandy facies of the upper sandy member is only required to predate the Toker Point Stade. If this till was in part or in total deposited during the Mason River Glaciation, the upper sandy member must predate the Mason River Glaciation.

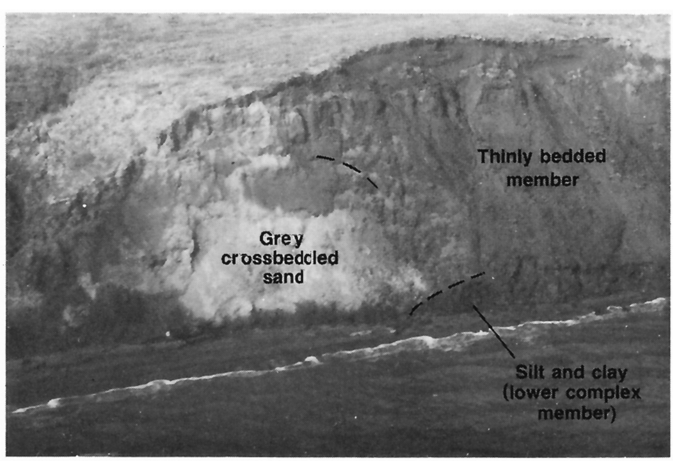


Figure 51. Wedge of grey sand at site VH-83-039 east of Maitland Point on Bathurst Peninsula (Fig. 25). Lower complex member appears to be truncated by this sand unit, which in turn appears to be covered by the thinly bedded member. (Photo by J-S. Vincent) (GSC 204058-A)

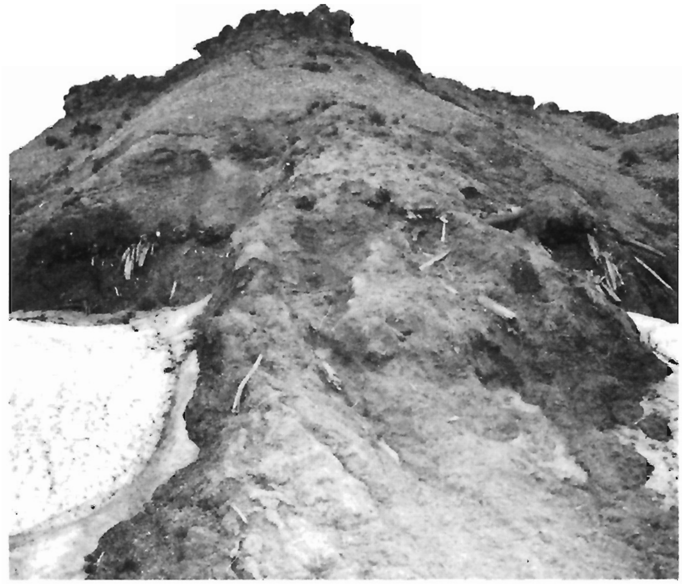


Figure 52. Gravel capping silt and sand containing much driftwood near site VH-83-048 east of Mason River on Cape Bathurst peninsula. (GSC 4-4-73)

The upper sandy member must postdate the Mason River Glaciation, however, if the underlying sand at site VH-83-039 (Fig. 24) is outwash deposited during the Mason River Glaciation. The upper sandy member is also the uppermost unit exposed in sections lying within the maximum extent of the Harrowby Sea, which submerged terrain previously glaciated during the Mason River Glaciation. If this is the case, erratics found on the slopes at 19Z (Fig. 24) must owe their stratigraphic position to shoreline erosion during deposition of the upper sandy member. Gravels assigned to the upper sandy member at sites 23Z and VH-83-048 are not present under the till that caps sections southwest of Mason River. The gravel facies of the upper sandy member may simply never have been deposited there or their deposition may postdate whichever glaciation deposited the till there. However the gravelly facies probably postdates the Mason River Glaciation but predates the Toker Point Stade, because the supposed Harrowby Sea marine limit is inset only into terrain glaciated during the Mason River Glaciation, and not into terrain glaciated during the Toker Point Stade, and the gravelly facies is the uppermost unit exposed in sections lying below the limits of the Harrowby Sea.

In summary, the basal clay member was probably deposited when relative sea level stood at the Horton Sea marine limit, 75 m above present sea level. This was followed by a period of low sea levels during which soils and peat developed on the basal clay member and within the silts and sands of the lower complex member, which appears to have been deposited as a broad alluvial plain. This was followed by the rapid deposition of fine grained sediments – the thinly bedded member – into a relatively quiet marine embayment. Deposition of the thinly bedded member may have been contemporaneous or just subsequent to the Mason River Glaciation – perhaps being deposited in the Harrowby Sea. Gradual emergence then resulted in shoaling and the deposition of the upper sandy member. The Stanton Sediments were likely all deposited during the Middle Pleistocene with the thinly bedded and upper sandy members being possibly deposited during the Mason River Glaciation of probable Illinoian age. The gravelly facies of the upper sandy member may be somewhat younger than the sandy facies; it may have been deposited contemporaneously with the Ikpisugyuk Formation during the Liverpool Bay Interglaciation as will be explained in a later section.

Mason River Glaciation

During the Mason River Glaciation, glacier ice from the southwest advanced to the southwestern edge of the Malloch Hill Upland (Map 1647A and Fig. 1). The glacial limit of this advance is also likely the maximum extent of Quaternary glaciers in this area. The limit can be traced 80 km south and east of the map area to where it clearly stands beyond a glacial limit defined during the Franklin Bay Stade, the presumed equivalent of the Toker Point Stade in the southern Amundsen Gulf. During the Mason River Glaciation channels were eroded in the unglaciated area by meltwater crossing the drainage divide east of Mason River (cf. Fig. 22). Grey sands at locality VH-83-040 on the south side of the inlet west of Maitland Point may have been deposited by this meltwater. Alternatively, the grey sands at locality VH-83-040 may be associated with another event, especially if the upper sandy member of the Stanton Sediments overlying them predates the Mason River Glaciation.

It is unfortunate that till of the Mason River Glaciation was not identified in any of the exposures within the Mason River glacial limit, even though erratics attributed to this glaciation are present on the slopes at site 19Z (Fig. 22, 24). During the Mason River Glaciation an ice-dammed lake likely formed a large flat plain in the upper reaches of the Mason River drainage, and drained through a large meltwater channel into the stream channel leading into the inlet east of Maitland Point.

Relative sea level during the maximum extent of ice was likely at least as low as, if not lower than, today's sea level. A subaerial meltwater channel system associated with the Mason River Glaciation, which intercepts the coast south of Maitland Point (Fig. 22), appears to be drowned. The large drowned valley (inlet) east of Maitland Point also appears to also have been carved by water draining from a lake at the head of Mason River during the Mason River Glaciation.

The Mason River Glaciation predates the Early Wisconsinan as its limit is well beyond the limits of Toker Point Stade and Franklin Bay Stade ice, which are assigned to the Early Wisconsinan. Surface morphology of its landforms are also much subdued compared to those of Early Wisconsinan age, although this may be due to the general absence of buried massive ice in Mason River glacial deposits. Even the absence of buried massive ice, however, may be evidence of antiquity as its melting may have required an interglaciation. Terrain glaciated during the Mason River Glaciation also appears to have been submerged to much higher levels by the Harrowby and Maitland seas than immediately adjacent terrain covered by Toker Point ice.

Wood from a driftwood layer in a bench formed by the Maitland Sea during the Liverpool Bay Interglaciation into terrain glaciated by Mason River ice at locality VH-83-050 (Fig. 26) has been dated at >38 000 BP (GSC-3759; Appendix 4). Wood from a peaty pond sequence from a presumed equivalent bench east of Maitland Point also yielded an age of >39 000 BP (GSC-3722; Appendix 4), but gave relatively low amino acid ratios of 0.10 and 0.15 (Table 16). Thus, the Mason River Glaciation predates an interglaciation that, on the basis of amino acid ratios, was relatively recent – presumably Sangamon. Its maximum extent also predates the Harrowby Sea, which is presumed to be a Late Illinoian event (Fig. 19). If the Mason River Glaciation postdates the lower complex member of the Stanton Sediments, as is suggested by the sequence at locality VH-83-039 (Fig. 24), it postdates sediments (lower complex member) containing wood having relatively low amino acid ratios (Table 16). If the amino acid ratios can be taken as giving true relative ages, this would then indicate an Illinoian age. The Mason River Glaciation could be older if the amino acid ratios in the lower complex member were due to factors other than age, if the lower complex member did not actually predate the Mason River Glaciation, or if the Mason River Glaciation were the equivalent of the basal clay member. In summary, all evidence points to a Middle Pleistocene age for the Mason River Glaciation, most probably Illinoian.

Harrowby Sea

A marine limit that lies between 30 and 50 m elevation throughout the area north and east of Mason River was apparently formed subsequent to the Mason River Glaciation as it appears to be traceable from beyond the Mason River glacial limit to within its limit (Fig. 23). The shoreline may have been caused by a combination of high late glacial sea levels and local isostatic depression due to glacial loading, or by high interglacial sea levels in combination with tectonic uplift. Harrowby Sea would have to be a late glacial event rather than a full glacial event, if it is indeed a glacial event, as meltwater channels associated with the maximum position of Mason River Glaciation ice appear to grade to below present sea level (see above).

The thinly bedded and upper sandy members of the Stanton Sediments may have been deposited during the marine transgression associated with the formation of the Harrowby Sea marine limit. This would especially be true if the sand identified at VH-83-039 is outwash from the Mason River Glaciation and is overlain by these two members. Even if the thinly bedded member and the sandy facies of the upper sandy member of the Stanton Sediments were deposited during the later part of the Mason River Glaciation, the gravelly and woody facies of the upper sandy member was likely deposited during a later interglaciation when sea level did not reach the 30-50 m level of the Harrowby marine limit. The presence of large amounts of driftwood are more reconcilable with an interglacial climate.

Harrowby Sea, if of glacioisostatic origin, most probably occurred during the later part of the Mason River Glaciation, assumed to be Middle Pleistocene (Illinoian?) in age. If it is an interglacial sea, it probably occurred during the Sangamon as it clearly postdates the Mason River Glaciation.

Liverpool Bay Interglaciation (Maitland Sea)

West of the mouth of Anderson River low benches, up to 7 m above sea level, are present. The nature of the materials within these benches indicates that they were deposited under at least two different environments. The upper parts are generally sandy, sterile of organics, and have structures indicative of fluvial or beach environments. In contrast, the lower sediments at locality 33Z on the inlet east of Cape Maitland (Fig. 25) are indicative of a small pond in a low arctic tundra environment (unpublished GSC Fossil Arthropod Report No. 84-15 by J.V. Matthews, Jr.) and the lower sediments at locality VH-83-050 south of Mason River (Fig. 26) are indicative of a marine strandline containing much driftwood. The driftwood indicates that rivers were supplying wood from treed terrain to the Beaufort Coast in a similar fashion as today. The interglacial sea, upon whose beaches the driftwood was deposited, has been named the Maitland Sea. Fossils at both sites suggest interglacial conditions. These sediments have been assigned to the Ikpisugyuk Formation.

Both the woody sands assigned to the upper sandy member of the Stanton Sediments and the overlying gravels at locality VH-83-048 (Fig. 24) just north of the mouth of Mason River (Fig. 22) may actually have been deposited during the same interglaciation – the Liverpool Bay Interglaciation – as the sediments on the low benches assigned to the Ikpisugyuk Formation rather than during the earlier deposition of the upper sandy member of the Stanton Sediments. This would imply that relative sea level was at about 16 m for at least part of the Liverpool Bay Interglaciation, rather than 7 m as is suggested by the height of benches known to be underlain by sediments of the Ikpisugyuk Formation.

Radiocarbon dates of >39 000 BP (GSC-3722; Appendix 4) and >38 000 BP (GSC-3759; Appendix 4) on the organics at localities 33Z and VH-83-048, and low D-aspartic/L-asparatic ratios of between 0.10 and 0.15 on wood at locality 33Z suggest a Sangamonian age for the Ikpisugyuk Formation.

West of Nicholson Peninsula

Pre-Wisconsinan events on Nicholson Peninsula and between Nicholson Peninsula and Mackenzie Delta are recorded mainly by sediments of the Kendall sediments, Hooper clay, Kidluit and Kittigazuit formations. These unconsolidated sediments must represent events predating the Wisconsinan as all underlie glacial materials deposited during the Toker Point Stade assigned to the Early Wisconsinan (see section on Early Wisconsinan). The relative age of most pre-Wisconsinan formations and events has been related to the easily identifiable marker horizon defined by the Kidluit Formation/Kittigazuit Formation disconformity, which can be traced over a large area (Fig. 53).

Kendall sediments and Hooper clay

The oldest units present are Kendall sediments and Hooper clay, which are best exposed in deformed sequences at Summer and Kendall islands (Fig. 35). Kendall sediments, consisting of interbedded clay, silt, and sand, were deposited in a marine environment as evidenced by the abundance of marine shells and shell fragments in all exposures. The apparent rich fauna suggests an interglacial environment of deposition. The different grain size distribution of individual beds points to varied environments of depositions that might be caused by fluctuating sea level or deposition in a delta-front environment. Kendall sediments have been positively identified only west of East Channel of Mackenzie River, but they may be present at depth under Tuktoyaktuk Peninsula. West of East Channel they owe their elevation to glacial deformation. Their presence is also suspected in the deformed sequence at the north end of Nicholson Pensinsula where interbedded clay and sand were noted under a clay believed to be the equivalent of Hooper clay (Fig. 34). The interbedded clay and sand at Nicholson Peninsula, however, lacked the shells common to the Kendall sediments at Kendall Island; either they are a distinct facies of the Kendall sediments, are part of the Kidluit Formation owing their relative stratigraphic position to ice thrusting, or are a unique stratum.

Hooper clay is well exposed throughout the area west of East Channel of Mackenzie River and most probably at Nicholson Peninsula (Fig. 53). The Hooper clay underlies Kidluit Formation in deformed sequences exposed in the Mackenzie Bay Islands and Summer Island. A clay in deformed sequences on northern Nicholson Peninsula similarily underlies sands assigned to Kidluit Formation. This distribution suggests lateral continuity of Hooper clay throughout the Tuktoyaktuk Coastlands, even though the clay has not been positively identified on Tuktoyaktuk Peninsula. The basal clay in relatively undeformed sequences exposed on eastern and southern Nicholson Peninsula is also presumed to be an equivalent of Hooper clay. Hooper clay likely represents a stable period of high sea level – much as the basal clay member of the Stanton Sediments. Most likely, these two clays were deposited in the same sea.

It is difficult to assign an age to Hooper clay and Kendall sediments. They most certainly predate the Early Wisconsinan given their stratigraphic position, and may well predate the Mason River Glaciation (Illinoian?), especially if Hooper clay is the chronological equivalent of the basal clay member of the Stanton Sediments.

Kidluit Formation

Kidluit Formation sediments are known to have been deposited over an extensive area and are exposed as far west as Pelly Island and as far east as upper Liverpool Bay. Most of the grey sand with woody detritus exposed in the deformed sequence at Nicholson Peninsula is also believed to be part of Kidluit Formation. Thus, it is likely that Kidluit Formation was deposited over an area at least as extensive as the Tuktoyaktuk Coastlands between Mackenzie Delta and Nicholson Peninsula, and possibly a good distance offshore beyond the modern shoreline.

Kidluit Formation was likely deposited on a broad alluvial plain characterized by streams with braided channels as suggested by its sandy nature and the paucity of any

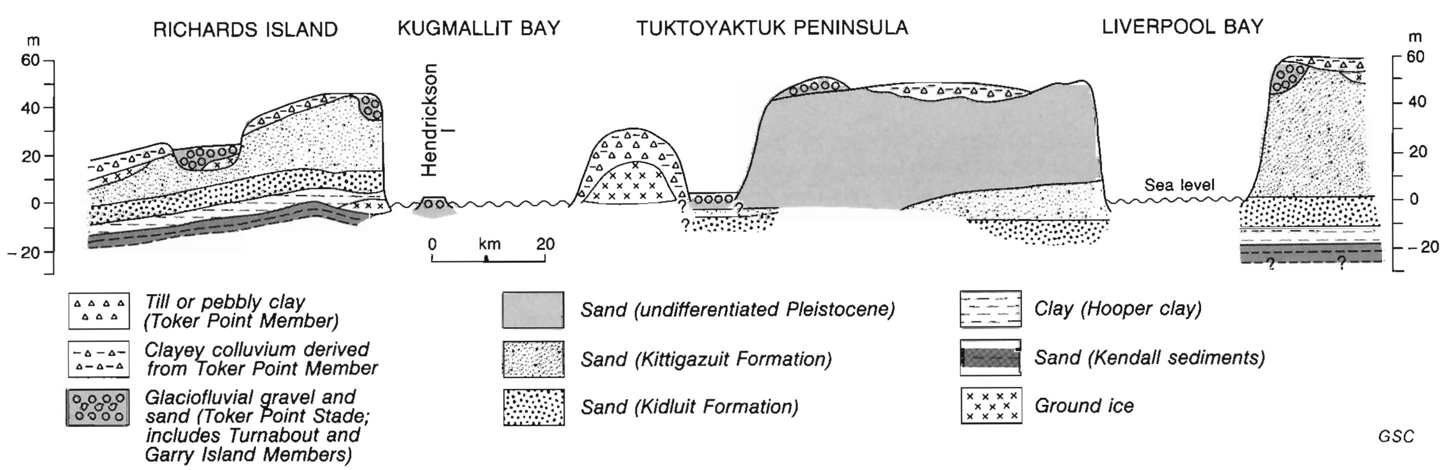


Figure 53. Diagrammatic representation of the stratigraphic succession, Tuktoyaktuk Coastlands (modified from Rampton, 1972c).

floodplain facies. Crossbedding within the unit indicates a general northern flow direction of the braided streams. Macrofossils examined in Kidluit Formation at Hooper Island (Mackay and Matthews, 1983) suggest that the climate was either similar or slightly warmer than that of today. Plant and insect macrofossils identified at site VH-83-049 on the outer fingers of the Eskimo Lakes (Tables 9, 10) indicate a warm climate typical of the northern boreal forest, even though J.V. Matthews, Jr. (personal communication, 1984) has recently identified plant and insect macrofossils in fluvial and marine deposits along the Beaufort coast that were necessarily transported some distance to the north from southern sources. It would be difficult, however, for transport of some fossils to VH-83-049 from their present northern limits: for example **Sium suave** with its present limit in the upper Mackenzie River drainage; **Ranunculus pensylvanica** and **R. macounii** with their present limits well south of the coast; and the ground beetle, **Notiophilous sylvaticus** with a present distribution along the western coasts of Alaska and British Columbia. Mackay and Matthews (1983) also observed that the oxygen isotope ratios of pore ice and the limited vertical extent of ice wedges in Kidluit Formation (their grey sand) at Hooper Island suggest deposition during a slightly warmer climate than at present. Therefore all evidence points to a warmer climate than at present during deposition of Kidluit Formation. It should nevertheless be remembered that the fossil evidence could lead to erroneous conclusions if major reworking of older Quaternary or Tertiary formations have produced the assemblages found in Kidluit Formation (amber of probable Tertiary origin has been noted in pockets of organic detritus within Kidluit Formation).

Whether the Kidluit Formation was deposited proglacially or during an interglaciation is still open to question despite the preponderance of evidence pointing to a relatively warm climate during its deposition. Fluvial systems along the Beaufort coast characterized by braided channels are associated with relatively high gradients and ample sediment supply; this, for example, is the case near Herschel Island where streams draining the British Mountains discharge material onto the Yukon Coastal Plain (Rampton, 1982). For such conditions to prevail to the east of Mackenzie Delta, the presence of a glacier immediately to the south would be required to provide the water to erode Tertiary formations (i.e., the Caribou Hills) and deposit the eroded material on a large alluvial plain. Today's rivers deliver only silt and sand to the coast as they are inset primarily into shale. Caribou Hills and the Tertiary formations composing them may well have been more extensive when Kidluit Formation was deposited. Parts of the Caribou Hills may have been completely eroded from the area surrounding Sitidgi Lake. Many of the large channels within the Caribou Hills could also have acted as meltwater channels during this interval.

Another scenario is that during a moist and warm climatic interval, a local upland underlain by Tertiary sediments, for example a more extensive Caribou Hills, was eroded and its sediments deposited on alluvial fans covering much of the Tuktoyaktuk Coastlands. This is favoured over the glacial meltwater hypothesis in that the gravels in Kidluit Formation generally lack cobbles, boulders, or exotic components. The few granitic pebbles present may indicate only that the deposition of Kidluit Formation postdated a Laurentide glaciation of the area or that the drainage system during their deposition was such that long distance transport of a few pebbles from the Precambrian Shield was possible.

The actual age of Kidluit Formation is difficult to determine. All wood dated by the radiocarbon technique has yielded nonfinite ages (Fig. 54). The D-aspartic/L-aspartic ratios of the wood from Kidluit Formation are generally lower than wood contained in Toker Point Stade outwash (Table 16). This indicates that these ratios are not entirely related to the age of the wood. If Kidluit Formation was eroded from a more extensive ancestral Caribou Hills, it implies some antiquity in that the basins hosting Mackenzie Delta and the Campbell-Sitidgi Lowland must have formed subsequent to large scale erosion of the Caribou Hills and deposition of Kidluit Formation. An age of less than 730 ka for Kidluit Formation can be argued if Hooper clay, which underlies Kidluit Formation, equates to the basal clay member of the Stanton Sediments and Baillie Clay, both of which have normal polarity.

Kittigazuit Formation

Kittigazuit Formation has a distribution similar to that of Kidluit Formation, although it appears to be generally absent between Richards Island and the eastern end of Eskimo Lakes (perhaps it was never deposited in that area or was eroded). Its presence east of site 119V on the south side of Liverpool Bay (Fig. 35) is also questionable. The thinly bedded clays and silts overlying the presumed Kidluit Formation in the deformed sequence at Nicholson Peninsula (Fig. 34) may represent a deep water facies of Kittigazuit Formation.

Kittigazuit Formation, with its large foresets, represents deltaic deposition to a relative sea level well above that of today, probably to an elevation of near 50 m as evidenced by its presence to near this elevation over much of the area where it is exposed (Fig. 38). Deposition and progradation of the delta front into the sea was likely rapid (Mackay, 1963a) as Kidluit Formation underlying Kittigazuit Formation, and Kittigazuit Formation itself, shows little sign of wave reworking. For example, ice wedges in Kidluit Formation at Hooper Island were preserved during deposition of Kittigazuit Formation. Mackay and Matthews (1983) found macrofossil remains in Kittigazuit Formation at Hooper Island that suggested deposition under marine or brackish conditions. An abundance of disseminated fine organic material throughout the sands is suggested by the fact that these sands are dark grey and have a fetid smell when freshly exposed, but turn brown rapidly upon exposure to air. Their colour and smell suggest deposition under reducing conditions, probably marine. Marine fossils are absent from the upper part of Kidluit Formation and are sparse within Kittigazuit Formation, which indicates rapid influx and deposition of terrestrial material. Indicators of marine environment were noted to be absent by J.V. Matthews, Jr. (Tables 11, 12) in a sample of organic detritus within Kittigazuit Formation on the south side of Liverpool Bay at site VH-83-044 (Fig. 35). Others have suggested an eolian origin for these sands (J-S. Vincent, personal communication, 1985), and the high percentage of frosted grains in one sample examined under binocular microscope gives some credence to this suggestion (Appendix 3).

Kittigazuit Formation was likely deposited from glacial meltwater into a cold sea as ice wedges were preserved in the underlying Kidluit Formation at Hooper Island during its deposition. Oxygen isotope ratios of pore ice within Kittigazuit Formation also favour a glacier source for the depositing water (Mackay and Matthews, 1983), assuming syngenetic growth of permafrost. J.V. Matthews, Jr. (unpublished GSC Fossil Arthropod Report No. 84-13 and Plant Macrofossil Report No. 84-14) indicated that the fossil assemblage in an organic detrital layer from a site along the south side of Liverpool Bay (site VH-83-044) was indicative of cold and dry conditions. Spruce, alder, shrub birch, and Ericales macrofossils were absent, and arthropod fossils, such as Leptopiini, **Vitavitus thulius**, and **Morychus** sp., indicating cold and dry conditions, were present. However, the presence of seeds of **Corispermum hypsopifolium**, a plant presently limited to the area south of Inuvik, is suggestive of warm conditions. The detrital nature of the organic layers in Kittigazuit Formation attests to erosion and transportion from a number of sources and limits the paleoecological value of this assemblage.

Kittigazuit Formation predates the Early Wisconsinan because it is overlain by Toker Point Stade sediments (Fig. 53). If Kittigazuit Formation was deposited from glacial meltwater on a landscape isostatically depressed by a nearby ice sheet, it could possibly have been deposited during the Mason River Glaciation of Middle Pleistocene (Illinoian?) age.

Upper Eskimo Lakes and East Channel

In upper Eskimo Lakes, two fluvial units are present that both contain abundant organic detritus. The upper unit contains silty and peaty beds at selected localities such as a VH-83-033 and VH-83-037 (Table 15). The lower unit, namely a crossbedded sand with much organic detritus, was likely deposited in a braided channel environment as no associated floodplain sediments were noted. The upper unit, which is a mixture of sandy and silty sediments with peat beds, likely represents deposition on an alluvial plain characterized in part by meandering streams and floodplains.

Wood in the peat, with D-aspartic/L-aspartic ratios varying between 0.16 to 0.22, clearly has a different age than wood from the lower unit with ratios of 0.30 to 0.31 (Table 16), and suggests a significant age difference between the two units. Wood in peat from the upper unit has been dated at >50 900 BP (GSC-329, Appendix 4). Pollen analysis of the peat indicates that it was deposited under climatic conditions similar to those of today (Ritchie, 1984). Both the upper and lower units are considered to have been deposited during an interglaciation. The amino acid ratios from the wood in the peat would suggest a correlation with the interglacial Cape Collison Formation of Banks Island (Vincent, 1982, 1983), which is probably Sangamonian in age.

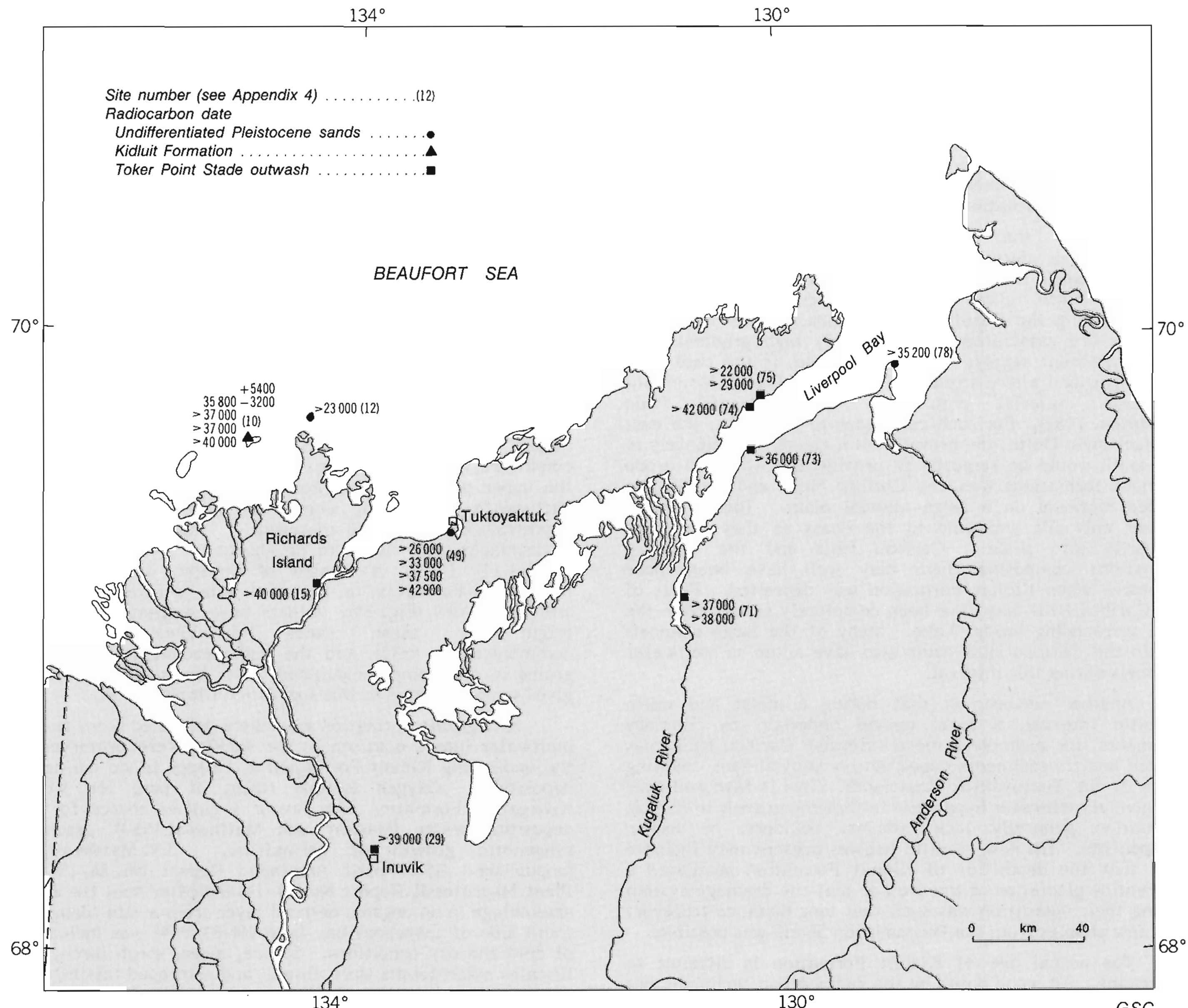


Figure 54. Radiocarbon dates on wood from Kidluit Formation, Toker Point Stade outwash, and undifferentiated Pleistocene sands (see Appendix 4 for details).

The lower unit in Eskimo Lakes may be the equivalent of the interglacial Morgan Bluffs Formation of Banks Island as the amino acid ratios of contained woods are similar – Morgan Bluffs, 0.32 to 0.35 (Vincent 1982, 1983) and lower unit in Eskimo Lakes, 0.30 to 0.31 (Table 16). Morgan Bluffs Formation represents an interglaciation predating the Sangamon, but falling within the last 730 ka (Vincent et al., 1984).

Along East Channel of Mackenzie River, just north of Caribou Hills and in the immediate area, grey fluvial crossbedded sands containing much organic detritus underlie brownish sands and silts, which at one locality contain a peat bed (site 67V, Fig. 40). In some places greyish sands, also rich in organic detritus, overlie the brownish sands. The grey sands are interpreted to have been deposited within a braided channel complex, whereas the brownish sands with the silt beds are interpreted to have been deposited on a fluvial plain characterized by meandering streams. L.D. Delorme (personal communication, 1970) has suggested that ostracods in the brown sediments are indicative of not only fluvial environments, but also lacustrine environments. This interpretation supports a lake-dotted alluvial plain, perhaps even a delta plain. Paleoecological studies on the peat bed present in the brown sediments indicate that a boreal forest or low arctic shrub tundra was present during its formation (Ritchie, 1984). This would suggest a climate similar to that of today, although **Larix laricina**, fragments of which were identified by Terasmae (1959) in the peat bed, is presently restricted to near Inuvik, some 70 km to the south.

The brown sediments along East Channel, and the grey sediments underlying them, are all beyond the limit of radiocarbon dating as the peat has been dated at >42 000 BP (L-552, Appendix 4). They must have been deposited during the Sangamon or an earlier interglaciation, as the brownish sediments contain a biota characteristic of interglacial climatic conditions. Normal polarity of silts in the brownish sequence limit their deposition to the Bruhnes Epoch. The upper grey sands along East Channel were deposited either during the early part of the Toker Point Stade or prior to it.

Correlation of Middle Pleistocene and Sangamonian events

The lack of absolute dates, known guide fossils, and good marker beds inhibits confident correlation of the many Quaternary stratigraphic units previously described. Nevertheless, the events they represent all predate the Early Wisconsinan and most likely lie within the Bruhnes normal polarity epoch.

Figure 19 gives a possible correlation of all pre-Wisconsinan units identified. Correlations are based on a number of assumptions: (1) that all major clay units observed throughout the region were deposited during one period of time; (2) that Kidluit Formation, characterized by woody detritus, is representative of a warm interglacial time interval; (3) that brownish sediments, which contain peats, in upper Eskimo Lakes and East Channel exposures are representative of warm interglacial intervals; (4) that Kittigazuit Formation was deposited from glacial meltwater when the region was isostatically depressed; and 5) that the thinly bedded member of the Stanton Sediments was deposited during an interval when the area was isostatically depressed.

The lower grey sands in either the upper Eskimo Lakes or the East Channel exposures could be correlatives of Kidluit Formation rather than Kendall sediments (Fig. 19). This is based on the fact that all these units were deposited under relatively warm climatic conditions, that the grey sands along East Channel and upper Eskimo Lakes underlie sediments attributed to the Sangamonian, and that Kidluit Formation underlies Kittigazuit Formation attributed to the Illinoian. This correlation would also result in the brownish unit in the upper Eskimo Lakes and East Channel exposures being the equivalent of the Ikpisugyuk Formation in the Cape Bathurst peninsula area.

The grey sands containing organic detritus in the Nicholson Peninsula deformed sequence also may be incorrectly correlated in Figure 19. These sands may correlate with Kendall sediments, rather than with Kidluit Formation. Alternatively, sands at Nicholson Peninsula that are the equivalent of Kidluit Formation and Kendall sediments may not be separately identified due to the deformation of the sequence there. If the grey sands at Nicholson Peninsula do correlate with Kendall sediments, the bedded clays and silts would then become possible stratigraphic correlatives of Hooper and Baillie clays; the lower clay at Nicholson Peninsula would then predate Hooper and Baillie clays.

Correlation of the strata from west of Nicholson Peninsula with those east of Nicholson Peninsula is extremely tenuous. The correlation in Figure 19 relies mainly on the thinly bedded member of the Stanton Sediments and Kittigazuit Formation being deposited in a sea whose extent and relative level was due to glacial loading of the region. The possibility exists that Kittigazuit Formation was deposited during a glacial interval preceeding or postdating that during which the thinly bedded member was deposited. If Kittigazuit Formation predates the thinly bedded member, it would be a shallow water equivalent of the Baillie Clay and the basal clay member of the Stanton Sediments.

Mason River Glaciation likely occurred just prior to deposition of the thinly bedded member (Fig. 19) as the thinly bedded member is not overlain by Mason River drift within the Mason River glacial limit east of Mason River, for example, at locality 19Z (Fig. 22); this presumes that the till was not deposited and subsequently eroded in the examined exposures. Also the thinly bedded member appears to overlie Mason River outwash at locality VH-83-038 east of Maitland Point (Fig. 24, 25). Indeed Mason River Glaciation may be responsible for the isostatic depression of the crust that allowed for deposition of the thinly bedded member. Alternatively, Mason River Glaciation may have caused depression of the landscape leading to deposition of the sandy or gravelly facies of the upper sandy member of the Stanton Sediments (Fig. 19). Driftwood within the gravelly facies, however, is more indicative of interglacial deposition (of at least the gravelly facies).

Grey sand and gravel overlying sediments of the Ikpisugyuk Formation have been correlated with Toker Point Stade outwash (e.g., Cape Dalhouse Sands). Both these grey sand and gravel and Toker Point outwash appear to grade to sea level (Maitland Sea) slightly above that of today. This correlation may only be valid if the sediments of Ikpisugyuk Formation were deposited during the Sangamon. If Ikpisugyuk Formation predates the Sangamon Interglaciation, the sand and gravel capping sediments of Ikpisugyuk Formation may well predate the Early Wisconsinan to which the Toker Point Stade has been assigned.

Horton Sea, which predates Mason River Glaciation, has been associated with the deposition of the major clay units (lower clay member of the Stanton Sediments, Baillie Clay, and possibly Hooper clay) in the region. Possibly it predates the clay units (Fig. 19). Harrowby Sea postdates Mason River Glaciation as shorelines representative of this submergence are developed on sediments deposited by the Mason River glacier; thus it is a Middle Pleistocene (Illinoian?) phenomena. Harrowby Sea is possibly correlative with Big Sea of Middle Pleistocene (Late Illinoian?) age on Banks Island. The Big Sea marine limit falls from more than 200 m elevation on eastern Banks Island to below 60 m elevation on

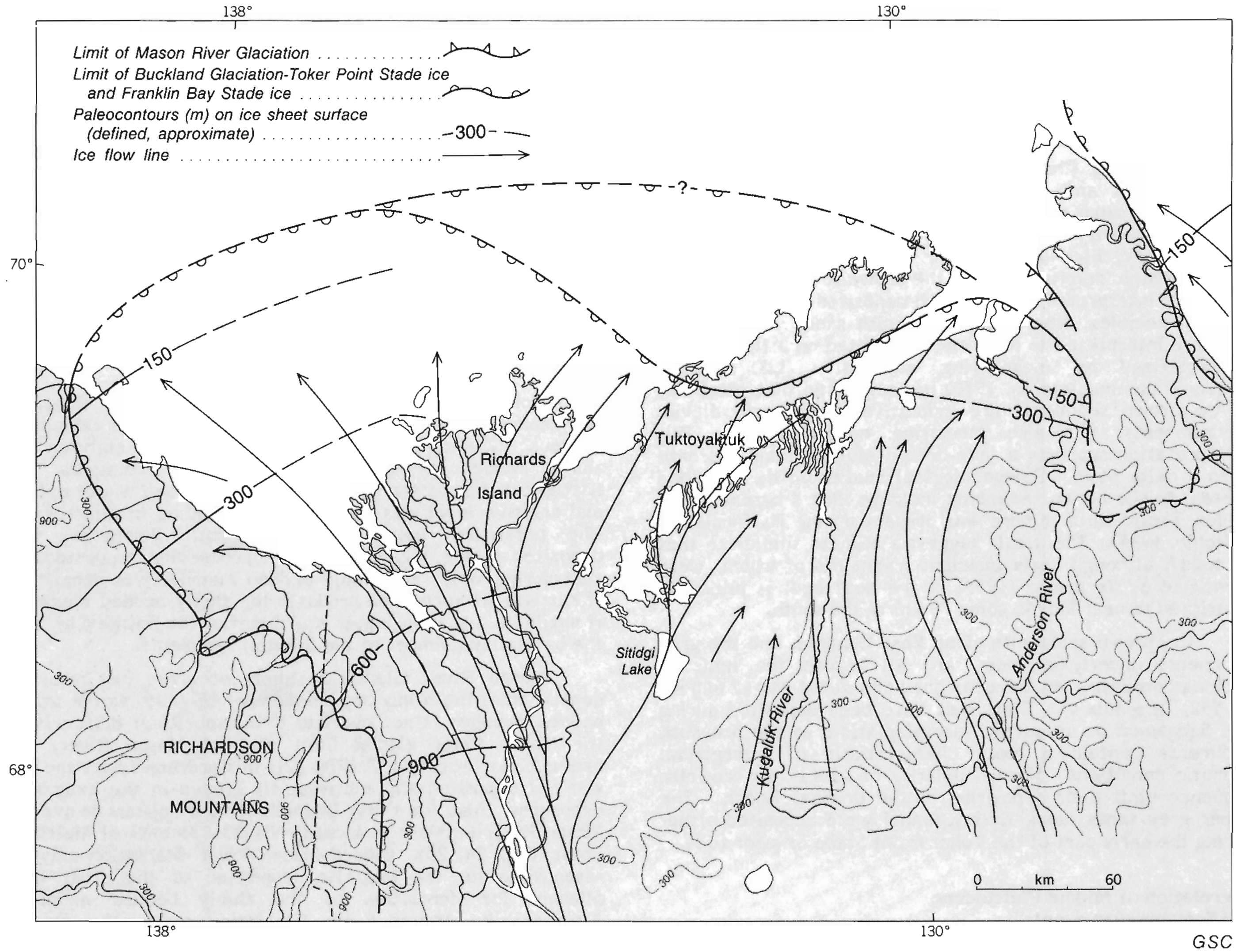


Figure 55. Ice flow and glacial limits during the Middle Pleistocene Mason River Glaciation, and the Early Wisconsinan Toker Point (Buckland Glaciation) and Franklin Bay stades.

the western coast of Banks Island (Vincent, 1982, 1983). Northeast of Mason River, the Harrowby Sea marine limit is at 30 to 50 m.

Early Wisconsinan

Early Wisconsinan events consist mainly of the regional glaciation assigned to the Toker Point Stade and Franklin Bay Stade and the associated effects upon sea levels and the ground thermal regime. The area was affected by both northerly flowing continental ice from Great Slave Lake (Toker Point Stade) and westwardly flowing continental ice from eastern Amundsen Gulf (Franklin Bay Stade). Thick accumulations of ice probably caused degradation of subglacial permafrost, and its melting resulted in much meltwater flow, both subglacially and proglacially. Following deglaciation permafrost re-established itself in the newly deglaciated terrain. Glaciation also caused significant eustatic and isostatic changes in relative sea level.

Glacial maximum

During the Early Wisconsinan, Toker Point Stade ice advanced northward into Tuktoyaktuk Coastlands, generally from Great Slave Lake, following a route paralleling Mackenzie River. Much of this ice flowed directly northwards over the hills east of Sitidgi Lake and was then channelled in a lobe that flowed north-northwest towards the junction of Kugaluk and Miner rivers. It then swung north-northeast towards Nicholson Peninsula as is evidenced by streamlined fluting in this area (Mackay, 1963a). This flow pattern seems to be the result of interference from the upland west of Anderson River and other sublobes to the west (Fig. 55). The Toker Point Stade ice stopped short of the Mason River glacial limit along the east shore of Liverpool Bay. Another major lobe of Toker Point Stade ice was funnelled down the broad trough paralleling Mackenzie River to the apex of Mackenzie Delta. This ice then continued down the trough, which underlies Mackenzie Delta, towards its western limit in Yukon Territory near Herschel Island

(Rampton, 1982). This event in Yukon Territory is termed the Buckland Glaciation. Some of the ice from this lobe flowed northward and northeastward forming a large lobe of ice north of the Caribou Hills. A major lobe of ice also likely flowed through the Campbell-Sitidgi Lowland and down Eskimo Lakes to where it abutted against ice flowing more directly from the south.

During the Early Wisconsinan Franklin Bay Stade ice also flowed westward down Amundsen Gulf (Amundsen Gulf Ice Lobe of Mackay, 1958a) and abutted against the Malloch Hill Upland on eastern Cape Bathurst peninsula. Ice from this lobe must have interacted with ice flowing northward from Great Slave Lake to the south of the Malloch Hill Upland.

Reconstruction of the extent of Early Wisconsinan ice on the Tuktoyaktuk Coastlands and adjacent areas is based on the distribution of erratics, glacial drift, and meltwater channels. Based on these data, paleocontours were also determined for Buckland Glaciation ice to the west of Mackenzie Delta (Rampton, 1982) and for Early Wisconsinan ice east of Anderson River (Fig. 55). These paleocontours and the intercepts of the Early Wisconsinan glacial limit with sea level on the Tuktoyaktuk Coastlands indicate an ice sheet with a relatively steep profile between Sitidgi Lake and the glacial limit north of Tuktoyaktuk. Topographic highs, such as the Caribou Hills and Hyndman Lake Hills, may be the cause of the rapid steepening of the ice front in this area. Alternatively, the ice sheet may have had a gentler profile extending some distance to the north of Tuktoyaktuk (Fig. 55). The till and erratics in that area may have been buried by outwash and marine deposits. Also, the high elevations of the Early Wisconsinan ice surface immediately to the west of Aklavik may be due to subsequent tectonic uplift along the northeast edge of Richardson Mountains.

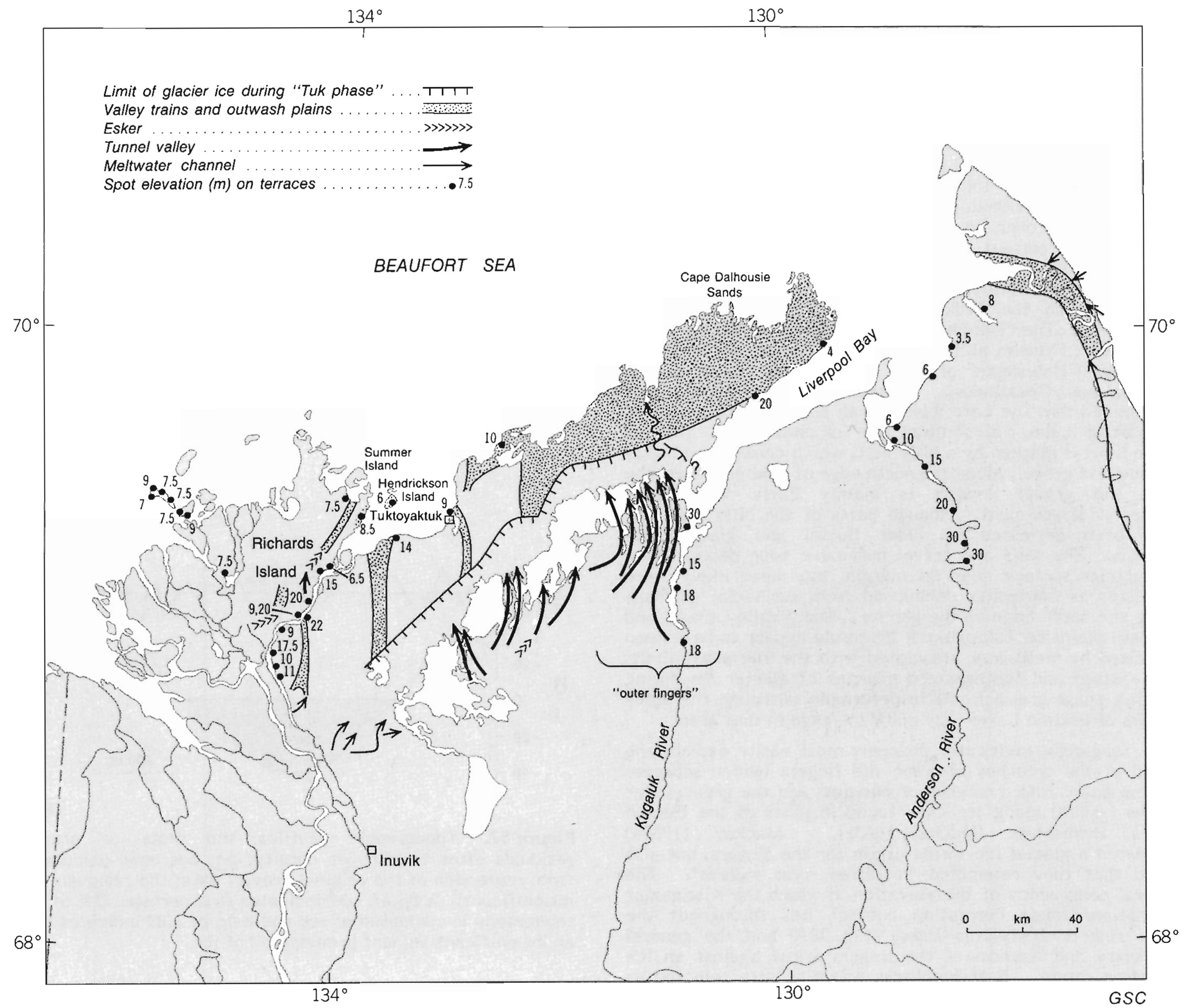


Figure 56. Glaciofluvial and glaciomarine features of Early Wisconsinan Toker Point and Franklin Bay stades.

Significant deformation of unconsolidated sediments by ice thrusting occurred near the margins of the Early Wisconsinan ice sheet and resulted in elevated land features such as islands in Mackenzie Bay, parts of Summer Island, high ground north of the outer fingers of Eskimo Lakes, and Nicholson Peninsula (Mackay 1963a, Mackay et al., 1972). Regions of elevated, deformed strata appear limited to areas where the Early Wisconsinan ice had a steep surface profile and was underlain by a moderate thickness of permafrost, conditions that favour disturbance of frozen unconsolidated sediments by ice thrusting (Mathews and Mackay, 1960; Mackay and Stager, 1966a).

When Early Wisconsinan ice stood at its maximum extent, meltwater undoubtedly flowed northward into Beaufort Sea and deposited large volumes of outwash. The outwash fan forming the northern edge of Tuktoyaktuk Peninsula to the northeast of Tuktoyaktuk (assigned to the Cape Dalhousie Sands) is likely part of this proglacial outwash system (Fig. 56). Some of this outwash may also have been deposited during a stillstand of the retreating ice. During the Early Wisconsinan, Horton River valley channelled meltwater from glaciers standing in its upper basin and in Franklin Bay. This proglacial valley train graded to below present day sea level west of Harrowby Bay.

Deglaciation

Early deglaciation of the eastern part of the Eskimo Lakes area and Liverpool Bay area likely consisted mainly of ice stagnation and thinning. The position of the glacier margin probably remained along the mapped maximum ice extent of the Toker Point Stade near Tuktoyaktuk, although some glacier retreat may have occurred to the east of Eskimo Lakes. The mapped maximum ice extent of the Toker Point Stade on Tuktoyaktuk Peninsula east of Tuktoyaktuk coincides with the "Tuk phase" limit there (Fig. 56 and Map 1647A). The "Tuk phase" was proposed by Mackay et al. (1972) and Fyles et al. (1972) as an alternative limit for "Classical Wisconsinan" or Late Wisconsinan glacier ice on Tuktoyaktuk Coastlands. Later work, however, has determined that the Late Wisconsinan glacial limit is located near Sitittgi Lake, well south of the Tuk phase limit. The Tuk phase limit is marked by a hilly belt, which consists primarily of sand and gravel, along the north edge of Eskimo Lakes; the sand and gravel deposit is mainly Early Wisconsinan glaciofluvial sediment, although parts of the hilly belt may have been deposited by older fluvial and glaciofluvial systems. The sand and gravel may have been deposited on the glacier surface near its margin, but more likely were deposited as meltwater debouched from subglacial channels along the north edge of the glacier. Many valley trains and outwash plains on Tuktoyaktuk Peninsula appear to have been deposited by meltwater associated with the Tuk phase limit. The eastern and southeastern margins of glacier ice during the Tuk phase are difficult to determine, although the outer fingers of Eskimo Lakes may mark the edge in that area.

Subglacial meltwater channels most easily explain the origin of the trenches between the fingers (which separate Eskimo Lakes into a number of entities) and the great water depths (>60 m) along trenches found in parts of the Eskimo Lakes themselves (Mackay, 1963a). Mackay (1963a) suggested a glacial ice-thrust origin for the fingers, but also noted that they resembled "modified river valleys". The general congruency of the elevation at which the Kittigazuit Formation/Kidluit Formation contact lies throughout the outer fingers of Eskimo Lakes (Fig. 38A) and the general symmetry and flatness of the fingers argue against an ice thrusting origin. A thermokarst origin is also rejected as gravity profiling indicates that the relief is not due to the "fingers" being ice cored (Fig. 57). Thus basal meltwaters driven by the hydraulic gradient of the overlying glacier ice

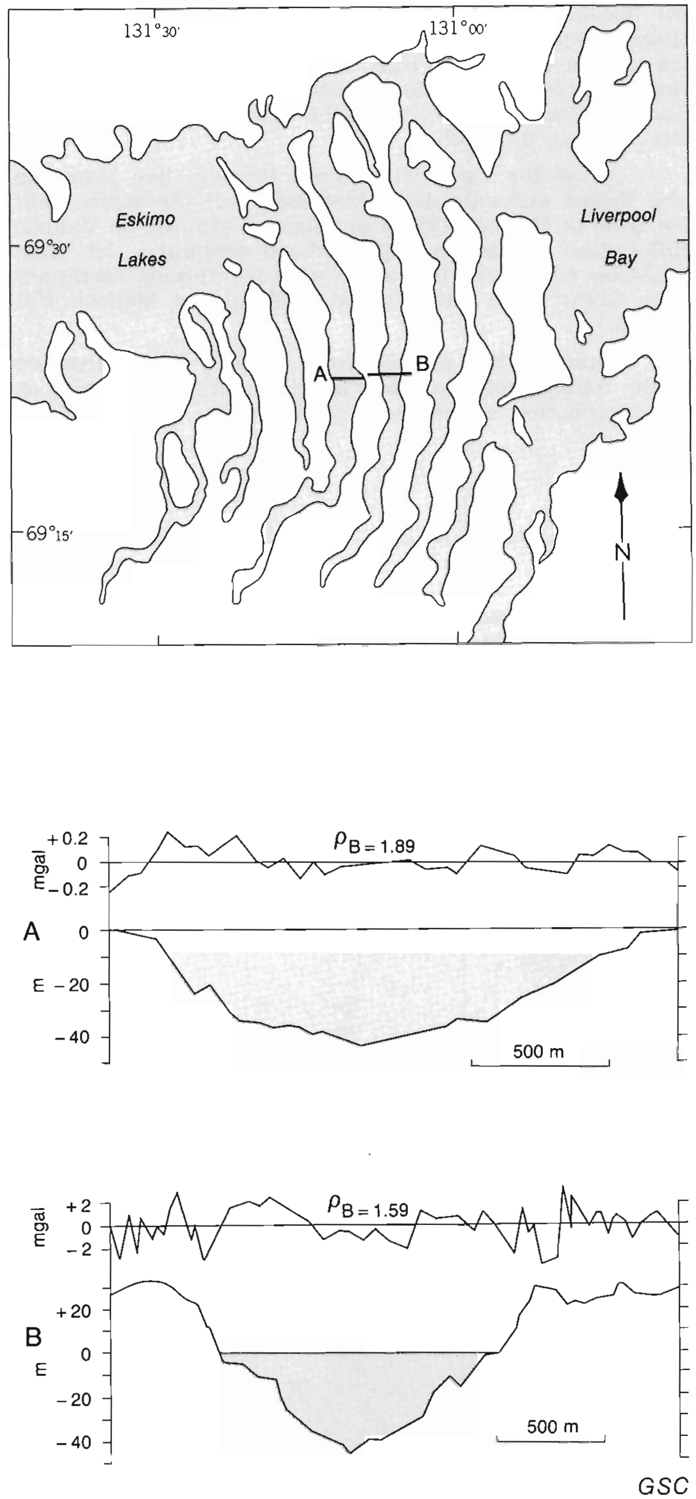


Figure 57. Topographic profiles and plots of gravity residuals after the Bouger density, ρ_B, has been calculated from regression of the original gravity data; the residuals are insignificant. A ρ_B of 1.59 indicates that perhaps 33% of the topography is composed of ice and a ρ_B of 1.89 indicates that an insignificant amount is composed of ice.

is the most likely agent responsible for carving the trenches. The fine to medium sands that underlie the area are easily eroded by subglacial meltwater, especially if the sediments were unfrozen (as they might be if the base of the glacier was at its basal melting point). The subglacial streams appear to have been localized along the juncture of a northeast flowing lobe along Eskimo Lakes and a north flowing lobe along Kugaluk River (Fig. 55). Undoubtedly, the subglacial streams, although driven primarily by the hydraulic gradient, were localized at a point of crevassing and fracturing related to the interaction of the two lobes. The river-like nature of the "upstream" part of these trenches as noted by Mackay (1963a) and their intergration with an esker west of Old Man Lake point to a glaciofluvial origin. The subsea level of the trenches at their northern downstream end requires erosion by water under hydrostatic pressure as would be the case in subglacial meltwater streams; the trenches have no obvious outlet to the sea. The sand and gravel north of the Eskimo Lakes was deposited at the edge of the glacier where the hydraulic gradient stopped functioning. During at least the latter part of the formation of the outer fingers, meltwater issuing from one of the subglacial meltwater systems eroded a meandering channel north toward McKinley Bay (Fig. 56). This channel appears to have graded to a sea level below present sea level.

Along the western part of Tuktoyaktuk Peninsula, sutures developed in the ice sheet and resulted in glaciofluvial systems that extend north from the axis of Tuktoyaktuk Peninsula to Kittigazuit and Tuktoyaktuk (Fig. 56). The high levels of valley trains where they presently intercept the coast is due in part to postglacial erosion; originally they probably graded to sea level at lower elevations some distance seaward of the present coastline. On Richards Island a system of eskers and tunnel valleys, paralleling East Channel, were formed during early deglaciation. These features merge into a large valley train, which grades towards the bay south of Summer Island, where the train surface stands 7.5 m above present sea level. Further southwestward development of this suture resulted in the formation of the large esker complex at Yaya Lake, which likely formed in an open channel as evidenced by its meandering pattern (Fig. 42). At the same time interlobate kame terraces or a valley train developed along East Channel downstream from Tununuk (Fig. 56). A meltwater system also developed along the western edge of the Caribou Hills, eventually joining with the East Channel meltwater system. The terraces may have developed as either englacial or proglacial glaciofluvial valley trains, and the present elevations of their remnants (as noted in Fig. 56) probably were dictated by glacial constraints rather than relative sea level at the time of their deposition.

Following complete deglaciation of Richards Island, a glacier lobe seems to have occupied the Mackenzie Delta trench for a significant interval. During this interval, meltwater flowed northward parallel to Mackenzie Delta south of Tununuk and thence down East Channel. Terraces, whose remnants are to elevations of 11 m south of Tununuk and to 6.5 m along East Channel, likely were formed during this interval (Fig. 56). Hendrickson Island may have been formed as part of the East Channel valley train at this time. Meltwater also formed a large terrace system in the Mackenzie Bay islands; these sands and gravels have been assigned to the Garry Island Member. This terrace system likely graded to a sea – the Garry Sea – with a relative sea level of about 7.5 m (no elevations have been corrected for frost heave caused by the formation of permafrost, which is a significant factor even if only the pore water freezes), as marine shells are abundant in the terrace sands (many shells were noted to have intact periostracum; Kerfoot, 1969). This terrace system is undoubtedly a glaciomarine system rather than a simple marine system; Kerfoot (1969) has indicated that erosion of the Mackenzie Bay Islands during a high sea stand would not produce enough sand or gravel to produce these extensive terraces. Shells with intact periostracum, as is the case in the Garry Island Member, are not common to the deformed sediments composing the Mackenzie Bay islands. Thus the Garry Island Member was more likely deposited in the sea from glacial meltwater.

Kerfoot (1969) believed that all of Garry Island was submerged following its deglaciation and interpreted faint breaks in slopes to over 46 m elevation as strandlines; however he did not find good beach deposits or marine fossils assoicated with his strandlines. They are more probably periglacial features or the surficial expression of ice-thrust Quaternary units of varying erodibility. In addition, no other marine features have been reported to these elevations by any other investigators throughout the area.

Evidence of relative sea levels comparable to those on Richards Island and the Mackenzie Bay islands is also present east of Tuktoyaktuk where Mackay (1963a) believed that some modification occurred of the downstream end of a meltwater channel leading to McKinley Bay. The lower parts of northern Tuktoyaktuk Peninsula may have been submerged but have been so modified by subsequent thermokarst and eolian activity that marine beaches and other deposits are difficult to identify.

Terraces are present along Kugaluk and Anderson rivers that could be related to high sea levels (Fig. 56). These terraces end at about 15 m elevation along Kugaluk River, suggesting possibly that their downstream extent has been removed by erosion. On Anderson River the high terraces appear to grade to a bench on the south side of Wood Bay at 6 m elevation. Whether this terrace correlates with a terrace at 8 m east of Maitland Point is not clear. However, together they suggest that the maximum elevation of the Garry (Early Wisconsinan) Sea appears to have been around 7 m near the west edge of Liverpool Bay.

Deglaciation of the crest of the Caribou Hills, which undoubtedly occurred prior to complete deglaciation of Richards Island, appears to have occurred from east to west as evidenced by large east-flowing meltwater channels across the hills (Fig. 56; Map 1647A). The meltwater may have in part occupied preglacial stream channels (Mackay, 1963a) or older meltwater channels.

Following deglaciation of the Eskimo Lakes basin, a short-lived glacial lake may have occupied the lakes. Some glaciolacustrine clays in the Eskimo Lakes basin have been assigned to an Early Wisconsinan lake (Map 1647A) as they stand well above clays assigned to the Sitidgi Stade of Late Wisconsinan age. This lake, which would have been confined by the high ground forming the axis of Tuktoyaktuk Peninsula and the outer fingers of Eskimo Lakes, likely drained when the outer fingers were breached.

Permafrost

Permafrost was present when Early Wisconsinan ice advanced into the area as evidenced by the glacial deformation of Quaternary ice sediments and massive ice in areas near the periphery of the ice sheet (Mackay and Stager, 1966a; Mackay, 1971; Mackay et al., 1972). Throughout much of the area, however, permafrost may have completely degraded during the Early Wisconsinan. Much of the massive ice and permafrost within the limit of the Early Wisconsinan glaciation has a postglacial origin since it is developed within the base of the Early Wisconsinan till (Rampton, 1974a). Thus during glaciation the base of the glacier must have been at its pressure melting point, allowing permafrost to degrade well below its base, if not completely. Permafrost aggradation and ground ice formation then proceeded rapidly during deglaciation (Fig. 58). Minor deformation of some frozen beds may have occurred during this interval due to small readvances of ice over terrain where permafrost had began to aggrade as is indicated by folding of icy sediments at Tuktoyaktuk (Rampton and Bonchard, 1975).

This hypothesis of permafrost aggradation during or following deglaciation also best explains the large volumes of ice in the frozen sediments within the region. Water expelled from freezing sediments does not sufficiently explain the large ice volumes (Rampton, 1974a). A more likely explanation is that water from basal melting was driven by the hydraulic gradient, created by the glacier ice overburden pressure, to the glacier terminus and was incorporated into the permafrost that was aggrading there (Fig. 58). The absence or at least partial absence of permafrost under the glacier and flow of subglacial meltwater towards its terminus also explains the formation of the fingers and intervening trenches along Eskimo Lakes. Oxygen isotope values from much of the ground ice in the Tuktoyaktuk region require a cold water source such as glacier meltwater (Mackay, 1983). On Hooper Island oxygen isotope values that indicate a warmer water source (Mackay, 1983; Mackay and Matthews, 1983) suggest that subglacial permafrost degradation was not complete in the peripheral areas, as do the major deformed beds located there.

Chronology

The Toker Point Stade (and related Buckland Glaciation and Franklin Bay Stade) is likely no older than Early Wisconsinan as no interglacial-like organic deposits (apart from Late Wisconsinan and Holocene organic deposits) or weathering profiles have been found overlying materials deposited during or after the Toker Point Stade. This is also true for areas in Yukon Territory covered by the Buckland Glaciation (Rampton, 1982). (Details of ^{14}C dates discussed here are given in Appendix 4).

A minimum age is difficult to assign to the Toker Point Stade. It seems to predate 35 ka as fresh-looking shells, some with intact periostracum, were dated at >35 000 BP (GSC-562, site 4; Appendix 4) and >37 000 BP (GSC-690, site 9) from the Garry Island Member in glaciomarine terraces assigned to the Toker Point Stade in the Mackenzie Bay Islands. Wood in Toker Point outwash and lacustrine deposits commonly gives nonfinite radiocarbon dates. Mackay et al. (1972) suggested that these dates indicated that the glaciation of the area covered during the Toker Point Stade was not Late Wisconsinan in age, but most likely was Early Wisconsinan. This argument suffers from the fact that much or most of the dated wood may be eroded from older strata and redeposited during the Toker Point Stade. Much of the wood is spruce, and it is difficult to imagine its presence in the immediate vicinity during glaciation. Amino acid ratios on wood from Toker Point outwash (Table 16) were generally higher than those on wood from the underlying Kidluit Formation. At face value, this suggests reworking of much older wood, but more probably it indicates different histories of diagenesis for the wood.

A date of 33 800 ± 880 BP (GSC-1974, site 86; Appendix 4)) obtained on twigs (some with bark) from Cy Peck Inlet on the west coast of Cape Bathurst peninsula was originally thought to be from a terrace related to glaciofluvial terraces along Old Horton Channel (Lowdon and Blake, 1978), but subsequent study has indicated that it is related either to a shoreline or to a pond event (Map 1647A). The date is also likely a result of the mixing of young wood and older reworked wood (wood in the sample was noted to be a mixture of **Salix** and **Picea**).

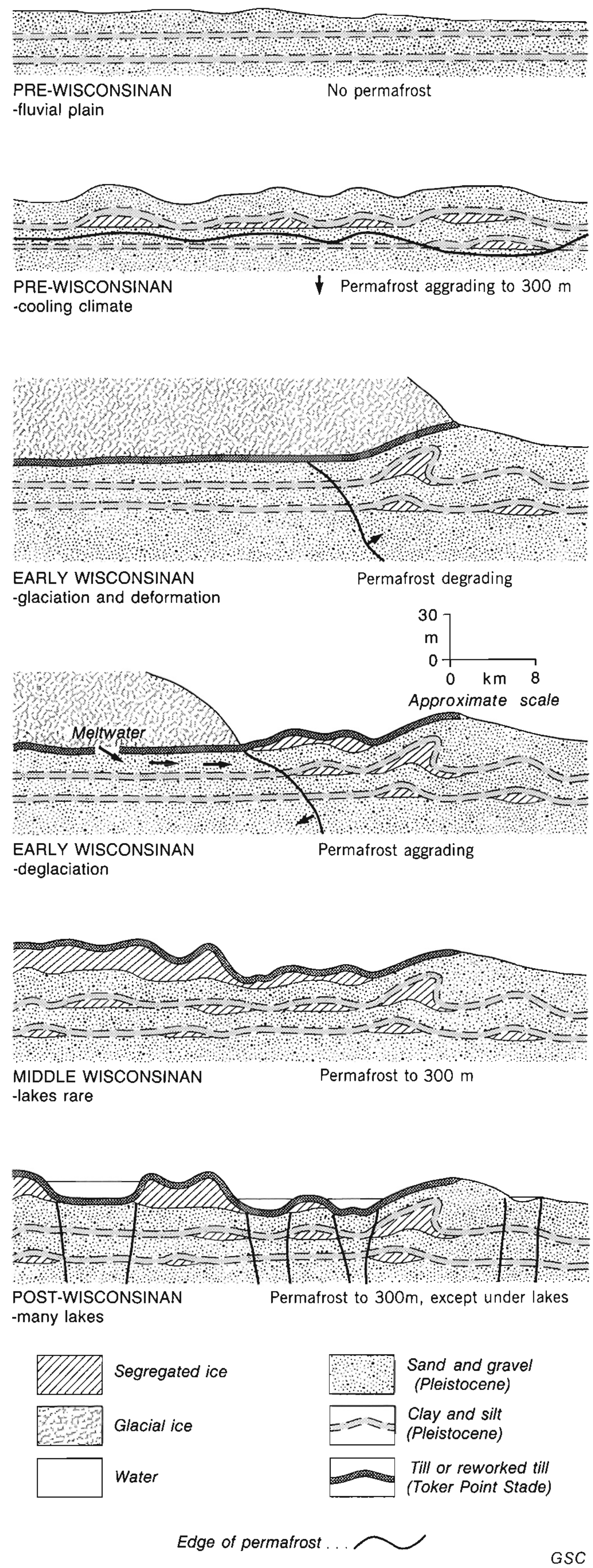


Figure 58. Schematic representation of the development of ice-cored topography in the Tuktoyaktuk Coastlands (from Rampton, 1974a).

Dates of 17 860 ± 250 (GSC-481, site 49; Appendix 4) and 14 130 ± 440 BP (GSC-512, site 49) from mudflow debris, whose deposition postdates glaciation of the area, at Ibyuk Pingo near Tuktoyaktuk have been cited as evidence that local glaciation clearly predates the Late Wisconsinan (Mackay et al., 1972). The argument is that these dates are older than the supposed age of the Late Wisconsinan glaciation in the Mackenzie Delta are (approximately 13 ka). Dates of 17 530 ± 540 (WAT-740) and 19 630 ± 1600 (WAT-742) on organic material from stony clay in Illisarvik Lake on northwestern Richards Island (site 99) also indicate deglaciation prior to 13 ka. However a date of 2320 ± 70 (WAT-746) on surface sediments in this lake suggests that some older carbon is being recycled in this lake. Indeed the antiquity of GSC-481 and GSC-512 at Ibyuk Pingo must be assessed with caution as the dated organic material may in part be reworked.

Late Wisconsinan

Sitidgi Stade

During the Late Wisconsinan continental glacier ice again invaded the area, but only the southernmost part. A glacier flowing down Mackenzie River valley trough flowed northward into the southern end of Mackenzie Delta (Fig. 59). The eastern part of this lobe extended into Campbell-Sitidgi Lowland where at its margin it formed a terminal moraine consisting of morainic and glaciofluvial deposits. East of Sitidgi Lake the limit is sharply delineated by morainal ridges, flanked by outwash leading to meltwater channels (Fig. 59, 60). The limit on South Caribou Hills and on Yukon Coastal Plain is marked primarily by lateral meltwater channels and, more rarely, sharp limits of hummocky topography. Small valleys in the upland east of Sitidgi Lake were blocked by morainic ridges and drainage was diverted east into the Miner River drainage system or northward towards Eskimo Lakes. Meltwater flowing parallel to the eastern flank of the glacial lobe occupying Campbell-Sitidgi Lowland eventually deposited its sediment load in a large outwash plain (Portage Point Sands) grading into the Eskimo Lakes basin where it merged with outwash which had been deposited directly by meltwater debouching into the Eskimo Lakes basin from the large terminal moraine north of Sitidgi Lake. Meltwater, which flowed towards Eskimo Lakes off South Caribou Hills via a major channel now occupied by Jimmy Lake just north of Noell Lake, also contributed to this large outwash plain. Along the west edge of Caribou Hills meltwater channels were formed by streams paralleling the edge of the glacier and flowing into the trench now occupied by Mackenzie Delta. On the west side of Mackenzie Delta,

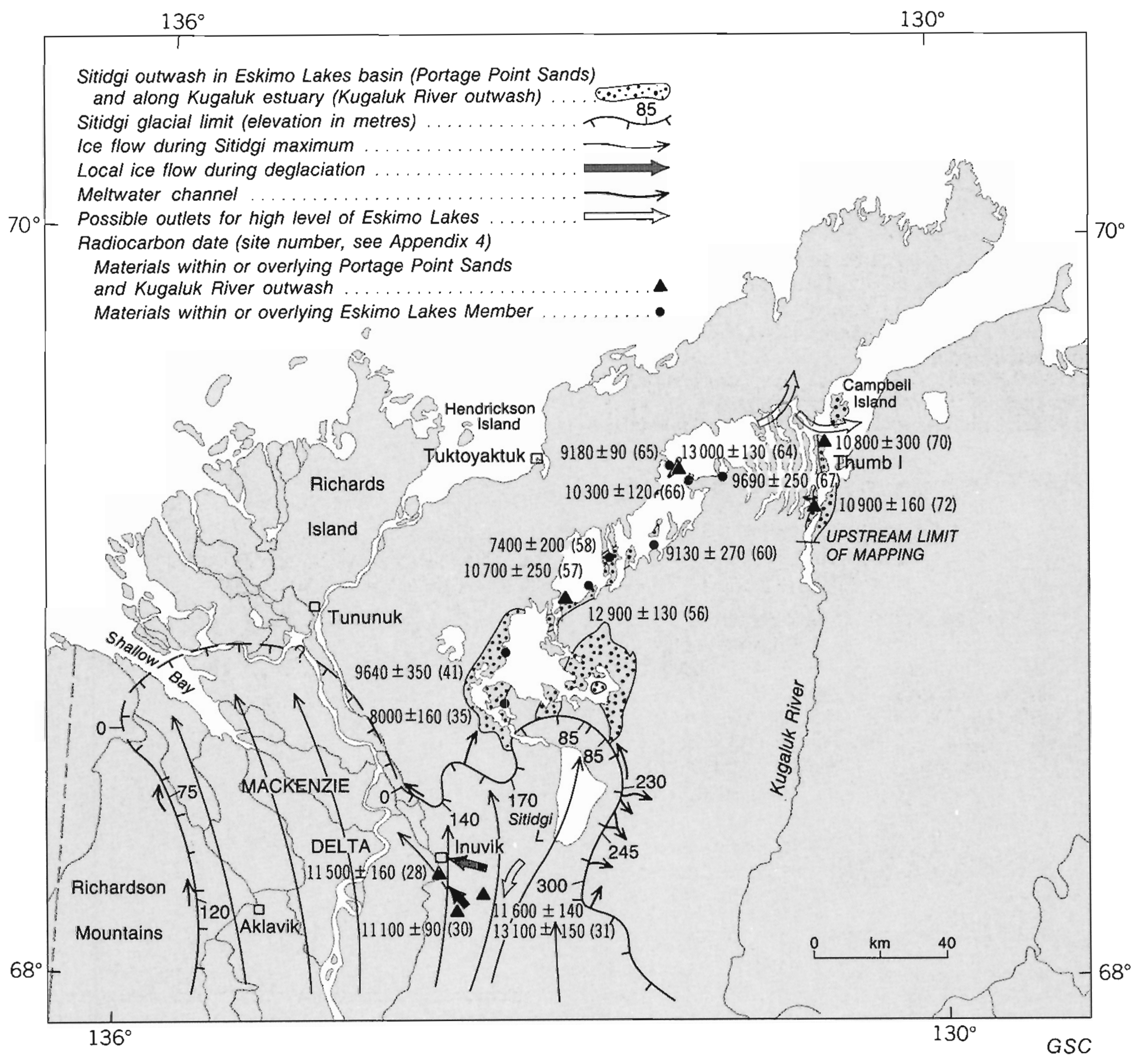


Figure 59. Glacial features and radiocarbon dates (Appendix 4) related to the Late Wisconsinan Sitidgi Stade.

meltwater also flowed northward paralleling the west edge of the lobe. Some major streams, such as Willow River, were diverted northward through the meltwater network along the west edge of the delta.

A flat thermokarst-pitted outwash plain or valley train can be traced in the Eskimo Lake basin from the large moraine north of Sitidgi Lake to near 132°W (Fig. 59). Its surface is flat or gently sloping and interrupted by numerous thermokarst basins (Fig. 5, 14B). In general, it is characterized by coarse sand and gravel at its southern (proximal to source) end and by fine sand and silt at its northern end. This valley train probably extended over much of the upper Eskimo Lakes basin west of 132°W. In part, it appears to have covered older glacial deposits overlying either glacier ice or segregated ground ice, for in many localities sand and gravel overlie till and clay, which in turn overlie massive ice (cf. Fig. 44). A few north-south trenches, probably tunnel valleys, are present west of 132°W in the Eskimo Lakes (J. Shearer, personal communication, 1974), although they are not nearly as common east of this longitude. These trenches must have been filled with glacier ice covered by glacial drift upon deposition of the Sitidgi valley train otherwise they would have filled with sediment during deposition of the outwash. The massive ice, which underlies most or all of the outwash plain (Portage Point Sands), is either buried glacier ice or segregated ground ice formed during the Toker Point Stade deglaciation, especially where the ice underlies till or lacustrine deposits beyond the

Figure 60. Glacial and lacustrine features along east side of Sitidgi Lake. NAPL A12902-21

limit of Sitidgi Stade ice (cf. Fig. 44), or is segregated ground ice formed during deglaciation following the Sitidgi Stade (this is possible where the ice directly underlies outwash deposited during this stade).

The valley train appears to have terminated in the eastern part of Eskimo Lakes. The actual elevation of Eskimo Lakes at this time is difficult to evaluate; however, if the lower terrace along Kugaluk estuary east of Thumb Island was formed during the Sitidgi Stade, the elevation of Eskimo Lakes was likely near 4 m – the same as the terrace. This terrace most likely controlled the elevation of any drainage channel leading from Eskimo Lakes to Liverpool Bay at this time. Alternatively, if drainage to Liverpool Bay was not yet established through the outer fingers of Eskimo Lakes, flow may have been north along the abandoned channel leading to McKinley Bay (Fig. 56); this would probably have resulted in the Eskimo Lakes being at a somewhat higher elevation.

Low terraces along Kugaluk and Anderson rivers were probably deposited during the Sitidgi Stade. The Kugaluk terrace can be traced on topographic maps and airphotos from south of the map area to Campbell Island; the Anderson terrace merges with low terraces and the floodplain near Liverpool Bay. Some low terraces along Old Horton Channel may also be of Sitidgi Stade vintage. During the Sitidgi Stade, glaciers occupied only the headwaters of these streams and most of the material within these terraces is likely eroded and redeposited older glaciofluvial and alluvial sediments rather than true outwash.

During the waning stages of the Sitidgi Stade, ice movement in the area between Inuvik and Sitidgi Lake was complex (Mackay, 1963a). Although most drumlins in the region have a north-northeast trend, drumlinoid topography east of Inuvik in a saddle between Mackenzie Delta and north end of Campbell Lake has an east-west orientation and fluting on the north end of Dolomite Lake Upland has a northwestward orientation (Fig. 59). This suggests that deglaciation of Mackenzie Delta may have proceeded more rapidly than deglaciation of adjacent terrain to the east and resulted in a drawdown of ice from the east towards the delta.

Concurrent with and immediately following the Sitidgi glacial maximum, a large lake undoubtedly existed in the Eskimo Lakes basin and Campbell-Sitidgi Lowland (Map 1647A). Its eastern extent was limited by the low terrace along the Kugaluk River estuary and its western extent marked by the retreating glacier front. Most of the extensive lacustrine benches (Eskimo Lakes Member), at 6 to 9 m elevation, were probably formed at this time. Rapid expansion of the lake through thermokarst probably obliterated much of the Sitidgi valley train (underlain by massive ice) in the Eskimo Lakes basin. Thermokarst was probably especially rapid during the later parts of the Sitidgi Stade just prior to the Holocene when climatic warming was rapid (Ritchie and Hare, 1971; Ritchie, 1972, 1977). Thermokarst may have also exceeded modern rates due to the high level of the Eskimo Lakes at this time.

Upon deglaciation of the Campbell Lake area, the large continuous lake occupying the Eskimo Lakes basin and Campbell-Sitidgi Lowland (Fig. 60) apparently drained through Campbell Lake towards Mackenzie Delta (Mackay, 1963a). The eventual lowering of the Eskimo Lakes and the drainage of the lake to Liverpool Bay was probably due to the isostatic adjustment of the area around Sitidgi Lake and the downcutting of an outlet to Liverpool Bay through the low Kugaluk River terrace at Thumb Island. Sea level was undoubtedly still low at this time and, in combination with a relatively sediment- and water-starved Kugaluk River, would have allowed this downcutting to proceed.

Sea levels

Many of the drowned valleys along the Yukon coast and throughout the Mackenzie Delta area (cf. Fig. 40, 42) have been cited as evidence of low relative sea levels (Mackay, 1963a; Forbes, 1980). These valleys were probably eroded during Late Wisconsinan time as they are all positioned beyond the limit of Late Wisconsinan ice and within the limit of Early Wisconsinan ice (Toker Point Stade, Franklin Bay Stade, Buckland Glaciation). Submarine valleys north of Kugmallit Bay, Hutchinson Bay, and a bulge in the submarine contours between 30 and 60 m (suggestive of a delta) off Liverpool Bay have also been attributed to Wisconsinan marine regression (Mackay, 1963a; Forbes, 1980). Again, the exact time of their formation within the Wisconsinan is not known. Submarine permafrost and ground ice on the Beaufort Sea shelf (Mackay, 1972d) have also been cited as evidence of an emergent environment and low sea levels over at least 50 ka (Forbes, 1980), most likely ending during the Late Wisconsinan (Mackay, 1972a).

Dense silty clay with high porewater salinity has been reported from 55 m to 67 m below the present surface of Mackenzie Delta (Johnston and Brown, 1965) within the confines of Mackenzie Delta covered by Late Wisconsinan ice. The relative inactive nature of the clays suggests that they may have been deposited in a glaciomarine environment, rather than a marine environment. This implies that relative sea level was at least within 55 m of its present level during retreat of Sitidgi ice from Mackenzie Delta.

Broad terraces at 3 to 4 m elevation along the Kugaluk River estuary have been dated at 10 800 ± 300 and 10 900 ± 160 BP (I-483 and GSC-1303, respectively; Fig. 59, Appendix 4). Mackay (1963a) believed that these terraces were deposited relatively close to sea level because of their broad extent (5 to 8 m wide). They may, however, grade to below present sea level with the downstream extension of the terrace system well to the east under Liverpool Bay.

Chronology

No absolute age determinations have been obtained that would date the beginning of the Sitidgi Stade; however, a number of radiocarbon ages are available that date the maximum extent of the Sitidgi Stade ice and that give a minimum age for regional deglaciation (see Appendix 4).

Ice during the Sitidgi Stade appears to have reached its maximum around 13 ka; grass from troughs in outwash in the Eskimo Lakes related to the large moraine north of Sitidgi Lake has been dated at 12 900 + 130 (GSC-1784-2, Fig. 59) and 13 000 + 130 (GSC-1995). GSC-1784-2 is believed to be particularily accurate as the dated grass, containing well preserved chlorophyll grains (unpublished GSC Bryological Report No. 202 by M. Kuc), was separated from charcoal, wood fragments, and other plant remains present within the sample. The dated portion of GSC-1995 was also hand picked to separate older wood and charcoal from sedge and grass fragments. These dates would appear to relate to the maximum position of Sitidgi ice because the source of sediment-loaded meltwater would be restricted as soon as glacier ice retreated south of the large moraine north of Sitidgi Lake, which marks the maximum extent of the Sitidgi Stade ice.

Numerous dates on organic materials from depressions and lake bottoms, mainly of thermokarst origin, give minimum ages for deglaciation of the terrain covered by Sitidgi Stade ice. The most relevant are dates of 13 100 ± 150 BP (GSC-3387, Fig. 59), 11 600 ± 140 BP (GSC-3346), and 11 100 ± 90 BP (GSC-2075), from basal lacustrine sediments in lakes on the Dolomite Lake Upland and 11 500 ± 160 BP (GSC-1514) from the base of a peat deposit near Inuvik. These age determinations must be considered with some caution as the hard-water effect and the common presence of reworked detrital coal, charcoal, and organic fragments in most sediments in the area is known to result in radiocarbon dates predating the actual time of deposition of the dated sediments. Nevertheless, the combined dates from the Portage Point Sands (Sitidgi outwash) and basal sediments in lakes within the Sitidgi Stade glacial limit indicate that deglaciation occured between 13 ka and 11 ka.

Dates on glaciofluvial terraces along the Kugaluk River estuary of 10 800 ± 300 BP (I-483, Fig. 59) and 10 900 ± 160 B.P. (GSC-1303) also indicate that entrenchment of these terraces had not began until after 11 ka. This suggests that glaciers were still present at the head of the Miner and Kugaluk River drainage systems and were affecting their downstream regimes until this time. The initiation of the Sitidgi Stade phase in the Eskimo Lakes basin, during which the Eskimo Lakes Member was deposited, was probably concurrent with development of the Sitidgi valley train and deposition of the Portage Point Sands in the Eskimo Lakes area around 13 ka. Twigs from beds that lie in a low broad terrace in the Eskimo Lakes basin and appear related to the presence of a large lake in the Eskimo Lakes basin have been dated at 10 700 ± 250 BP (GSC-1710, Fig. 59). Twigs from another bench, which also appears to relate to a high lake level of Eskimo Lakes, date at 9130 ± 270 (GSC-1653). Both dates indicate that a high lake level of the Eskimo Lakes persisted throughout the Late Wisconsinan into the Holocene. Both GSC-1653 and GSC-1710 may, of course, relate to local thermokarst development of ponds and lakes. Indeed other dates between 8 and 9.7 ka from benches in the Eskimo Lakes basin (shown in Fig. 59) appear to relate to local thermokarst basin development in the Sitidgi valley train.

In summary, glacier ice during the Sitidgi Stade appears to have reached its maximum extent around 13 ka and began to retreat shortly thereafter. Outwash continued to be supplied to the Kugaluk River estuary until at least 11 ka, and a high lake persisted within the Eskimo Lakes basin until the end of the stade at 10 ka.

Holocene

The Holocene (10 ka to present) on the Tuktoyaktuk Coastlands was marked by high sea level, extensive alluvial deposition, and thermokarst development. Rapid coastal recession also became common due, probably in part, to high Holocene sea level. Pingo growth and frost heave have been common to most infreezing drainage depressions. Solifluction and surface creep have been continuous on most slopes, and organic materials have accumulated on poorly drained flat areas. Sandy deposits have been subject to deflation and reworking by wind.

Sea levels

A major transgression has occurred during the Holocene which has resulted in the drowning of the downstream segments of most stream valleys. Some of these valleys have been filled with alluvium (cf. Fig. 40, 42). The amplitude and timing of sea level rise are not well documented. Wood fragments in postglacial alluvium from a depth of 38 m in Mackenzie Delta (Johnston and Brown, 1965) have been dated at 6900 ± 110 BP (GSC-54, Appendix 4). This wood only gives a minimum elevation for sea level at this time as it may be detrital wood incorporated into sediment infilling a channel (Forbes, 1980) or in prodelta deposits; both environments would allow for its deposition well below sea level at that time.

Lines of driftwood throughout the region mark strandlines formed during storm surges (Fig. 61). It is not known whether these strandlines have been inundated periodically during recent times or whether they mark a local sea level maximum in the not too distant past. A piece of driftwood from one of those strandlines near Tununuk on Devil Lake (Fig. 40) was dated at 150 ± 130 BP (GSC-1401, Appendix 4). This indicates that the highest strandlines are periodically inundated during modern storm surges.

Coastal retreat and advance are occurring throughout the area with coastal retreat generally dominant. The front of the Mackenzie Delta has for the most part advanced during the Holocene, but some areas such as south of Shallow Bay may be in retreat due to the small amounts of sediment being delivered there during recent time. On Tuktoyaktuk Coastlands extremely rapid retreat is occurring where the sea is eroding into steep slopes, especially where they are composed of ice material or underlain by ground ice (Fig. 62). Rampton and Bouchard (1975) have documented average retreat of 4 to 7.5 m per year over 22 years for exposed headlands underlain by ground ice and icy sediment near Tuktoyaktuk, and Mackay (1972a) has documented an average retreat of about 4 m per year over 38 years for a portion of the coastland south of Kugmallit Bay. Generally this erosion appears to be episodic with rapid erosion occurring during storm tides – 13.5 m in one day at Tuktoyaktuk during a violent storm in 1970 (Rampton and Bouchard, 1975). Even in areas where bedrock is present in the eroding cliffs, such as near Maitland Point, rapid coastal retreat is occurring. Rapid coastal retreat generally involves thermal niching, block slumping, and wave erosion of these broken-up blocks. Gentle slopes and minor scarps, especially those protected by gravel beaches or bars, have relatively slow rates of retreat, generally less than 1 m per year. In protected bays and lagoons retreat is negligible.

The evolution of large spits is probably more complex. Those attached to retreating headlands change their positions rapidly; one spit west of Tuktoyaktuk was noted to retreat about 14.5 m per year in 22 years (Rampton and Bouchard, 1975). The large spits and bars bordering the northern edge of Tuktoyaktuk Peninsula to the east of Tuktoyaktuk are also retreating as sediment moves eastward through them into a sediment sink in Liverpool Bay (Lewis and Forbes, 1975).

Alluvial events

Major drowned valleys have been filled with alluvium during the Holocene by the streams draining into them. This includes, most particularly, the Mason, Anderson, Smoke,

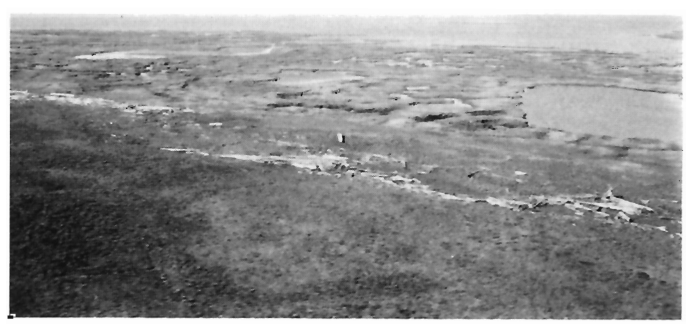


Figure 61. Strandline composed of driftwood on low tundra-covered glaciofluvial plain near Atkinson Point on Tuktoyaktuk Peninsula. Tundra in background is being thawed and eroded due to modern marine transgression. (GSC 159038)

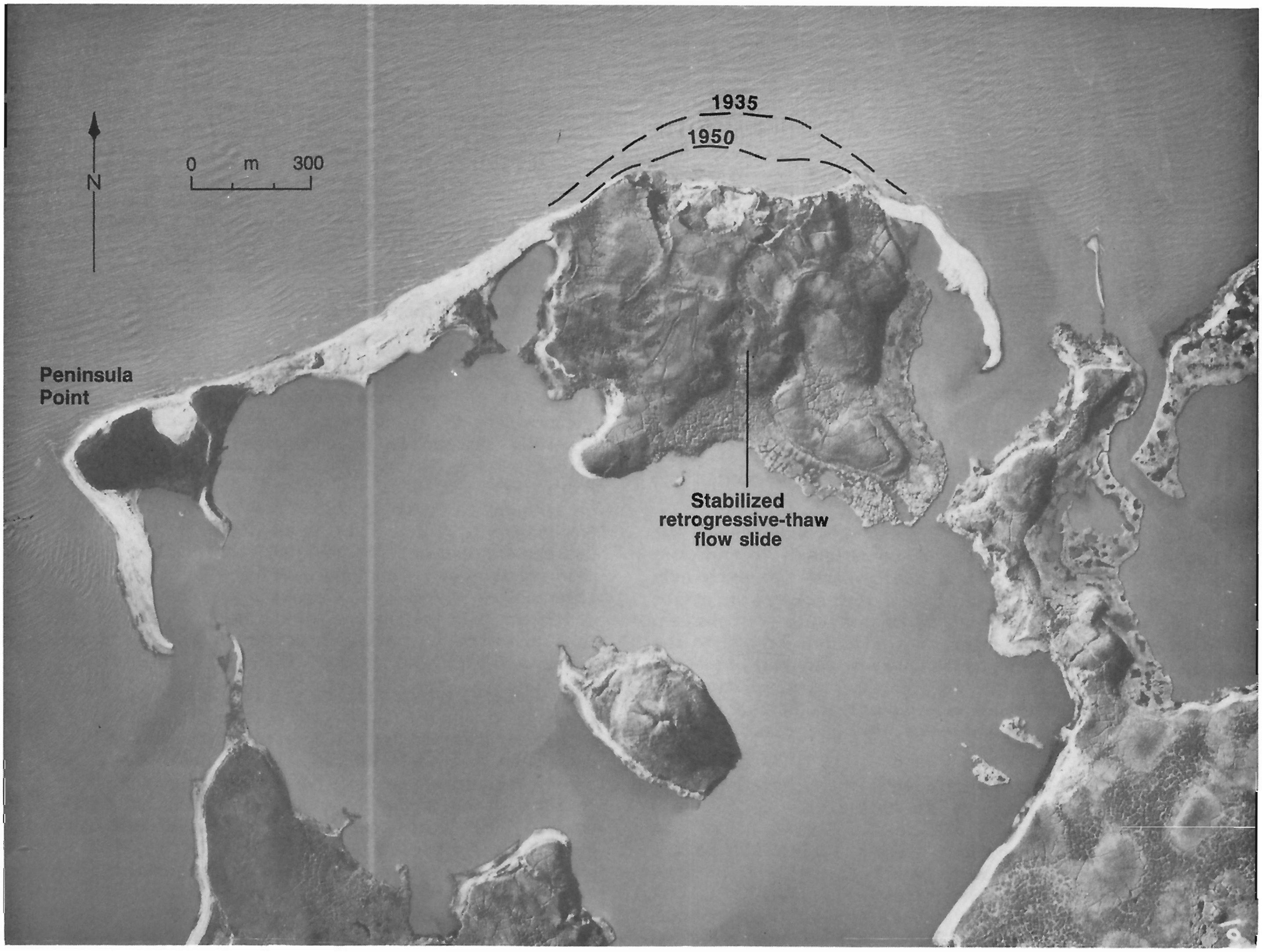


Figure 62. Coastal retreat of ice-cored hill west of Tuktoyaktuk. Retreat is through continued wave erosion of the base of the slope and polycyclic development of retrogressive-thaw flow slides as in Figure 14A (from Rampton and Mackay, 1971). NAPL A22535-101 was taken in 1967.

and Mackenzie river estuaries where large deltas have been constructed. The Mackenzie has infilled a number of small tributary valleys, such as the one occupied by Campbell Lake (Map 1647A); little data are available on the rate of this alluviation. An age of 6900 ± 110 BP (GSC-54, see Appendix 4 for ^{14}C dates) on wood from a depth of about 38 m in Mackenzie Delta near Inuvik (Johnston and Brown, 1965) suggests that much of the alluviation has occurred during the last 7 ka. This assumes that the wood was not incorporated into sediment infilling a channel in older alluvium. Dates of 1470 ± 175 BP (I-1154) and 2700 ± 200 BP (I-1155) on twigs in an eroded pingo near the front of Mackenzie Delta suggest that much of the present delta was formed by 2 ka ago. Present progradation of the subaerially exposed portion into Mackenzie Bay is relatively slow (Lewis and Forbes 1975).

Large alluvial fans have also been constructed along the east edge of the Richardson Mountains and the west edge of the Caribou Hills (Fig. 63). The rates of their formation is not known, but, they appear to be actively aggrading (cf. Legget et al., 1966). A date of 1840 ± 130 BP (GSC-1316) was obtained on a peat layer from below 1 m-thick alluvial fan deposits just north of Inuvik, indicating relatively recent alluviation there.

Horton River abandoned its course along Old Horton Channel (Fig. 64) around A.D. 1800 with a dramatic break through of the river into Franklin Bay about 100 km above its former mouth (Mackay, 1981b). "Since break-through, fan-deltas from tributary creeks have segmented the abandoned channel into several large oxbow lakes; permafrost and ice-wedge polygons have grown along parts of the abandoned channel; gelifluction lobes have enroached onto the abandoned channel; lower Horton River and its tributaries have rejuvenated and Horton River has built at 30 km delta into the relatively deep water of Franklin Bay" (Mackay, 1981b, p. 129).

Thermokarst, frost heave, and pingo growth

Thermokarst, which is the process of ground ice melting and the accompanying collapse of the ground surface to form depressions (Czudek and Demek, 1970), has been an active process in the area during the Holocene and the latter part of the Late Wisconsinan. "The nature and thickness of the sediments – colluvium overlain by lacustrine deposits – in the thermokarst basins indicate that initiation of the basins probably resulted from a small pond developing on the landscape, but that expansion of the basin was mainly through ground ice slumping. In this process, massive ground ice or ice-rich sediments exposed on a slope melt back rapidly with the overlying and enclosed sediments sliding to the base of the steep slope; the supersatured sediments at the base of the steep slope are supersaturated and flow further downslope; and wave action erodes the mud-flow debris and redistributes the material over the lake floor. As the lake expands the permafrost table degrades below the lake and further thermokarst subsidence may occur due to the melting of ice at depth." (Rampton, 1973, p. 299; see also Fig. 65). Melting slopes are generally retreating between 1.5 and 4.5 m per year in the area at present (Mackay, 1966a; Kerfoot, 1969; Kerfoot and Mackay, 1972; Rampton, 1974a).

As can be seen from Figure 66, which shows the radiocarbon dates related to the initiation of thermokarst activity in a number of basins, thermokarst was extremely intense between 10 and 9 ka. Earlier thermokarst did occur, however, especially near the end of the Late Wisconsinan. The paucity of dates younger than 9 ka may be due to the fact that the thick thermokarst lacustrine and peat sequences were generally sampled, although no obvious correlation was noted between the thickness of sediments in the thermokarst depressions and the antiquity of the age determinations presented in Figure 66.

Comparison of these data with the vegetational and climatic history of the area as outlined by Ritchie and Hare (1971) and Ritchie (1972) explains the cause and chronology of the thermokarst. From 12.9 to 11.6 ka the climate and vegetation seem to have been similar to those of today – presumably immediately preceding 12.9 ka it was cooler. This climate would therefore have allowed a similar level of thermokarst activity to that occurring today. Between 11.6 and 8.5 ka part of the area now north of the present treeline was invaded by spruce (poplar was present near Maitland Point around 9 ka). By about 10 ka climatic warming had resulted in a thickening of the active layer in the region to a depth where icy sediments and massive ice were melted and the landscape was vulnerable to active layer sliding. Thick active layers in the area (Fig. 66, Appendix 4) have been dated at between 10 and 7.5 ka. A thickening active layer can intercept icy layers and produce superficial slides along the base of the active layer or lead to the development of retrogressive-thaw flow slides as the icy layers melt. Thus, all slopes with thin covers of sediment over massive ice or icy sediments would be subject to extensive thermokarst and deterioration of the underlying ice during intervals when the active layer thickness increased. During the regional climatic optimum between 8.5 and 4 ka thermokarst appears to have continued, but with little initiation of further thermokarst depressions. The pollen record indicates that after 4 ka climate cooled to near present-day conditions. The active layer thinned and the number of sites vulnerable to ground ice slumping decreased. In essence, the landscape was partly stabilized. Today, only slopes where the ocean, a lake, or a stream is eroding are generally susceptible to thermokarst. In the vicinity of Inuvik, a large fire during the summer of 1968 changed the thermal properties of the ground and caused active layer detachment to occur on some steeper slopes (Mackay, 1970; Heginbottom, 1972; Fyles et al., 1972). Where such detachment exposed icy sediments or massive ground ice, retrogressive-thaw flow slides developed. The frequency of tundra fires in the area, however, is low under present conditions, and the surface is relatively stable except where it is disturbed by natural processes (e.g., wave erosion) or human activities (e.g., construction).

Recent stabilization of the landscape has allowed the drainage of many basins, as outlets that were formerly frequently blocked by retrogressive-thaw flow slides were re-opened. In addition, some lakes have probably drained simply because enough time has elapsed since their formation to allow an outlet to develop and drain them (cf. Fig. 47). In drained lake basins, permafrost re-establishes itself and ground ice forms; for example, near Tuktoyaktuk massive ground ice is known to underlie lacustrine deposits (Rampton and Bouchard, 1975). Many recently drained basins show tension cracks indicative of heaving due to ground ice formation. In many old drained thermokarst basins new lakes have developed due to the melting of ice in the sediments deposited in these depressions – in other words, polycyclic thermokarst has occurred.

Significant heave of the ground surface may occur following subaerial exposure of taliks, as has been demonstrated on northern Richards Island where up to 7.5 cm of heave was recorded during the second year of exposure of a lake bottom (Mackay, 1981a). Heave is a

Figure 63. Intense gullying and formation of alluvial fan at west edge of Caribou Hills. (GSC 158984)

Figure 64. Old Horton Channel. A number of alluvial fans have formed in the channel from eroding Cretaceous shales; the high terraces are glaciofluvial in origin and were formed during the Franklin Bay Stade. (GSC 159049)

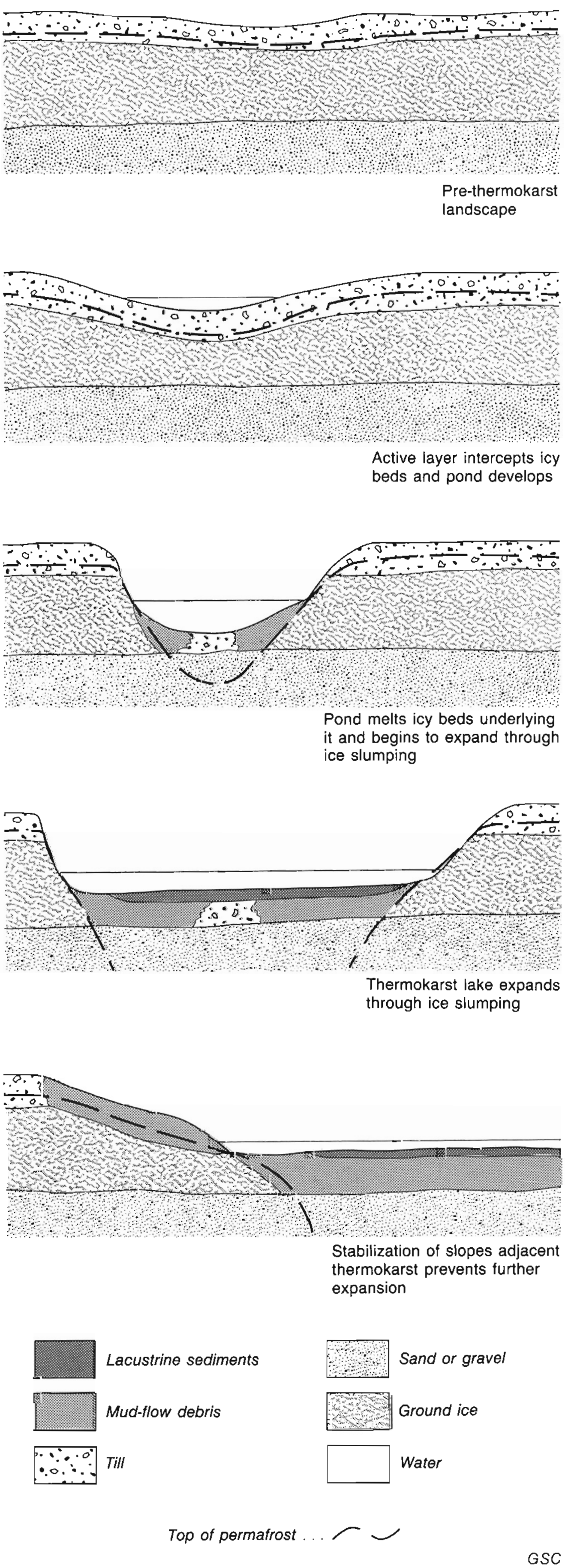


Figure 65. Schematic development of thermokarst basin on Tuktoyaktuk Coastlands.

function of the movement and freezing of pore water contained in the unfrozen sediments below the aggrading permafrost table (Mackay, 1979a). Where pore water is expelled from the sediments and moves to a local area under thin permafrost to freeze, a pingo will develop (Fig. 67). In the Tuktoyaktuk area pingos have probably been forming throughout the Holocene. Initiation of pingo growth continues today as lakes drain; Mackay (1973) reported that at least five pingos have commenced growth since 1935 on Tuktoyaktuk Coastlands. Generally their initial growth is rapid, up to 1.5 cm per year, and deceases rapidly with time (Mackay, 1973). Pingos may grow for a long period of time; for example, Ibyuk Pingo near Tuktoyaktuk is believed to have been growing for at least 1000 years (Mackay, 1973, 1976a). The final stage in the evolution of pingos is marked by their collapse and at least partial destruction through thermokarst if their ice core is exposed (Fig. 68).

Mass wasting

In addition to retrogressive-thaw flow slides, mass wasting in the form of surface creep, solifluction, and active layer detachment failures has occurred throughout the Holocene. Active layer detachment failures have been generally restricted to moderately steep slopes, where they still occur (Rampton and Dugal, 1974). In the Richardson Mountains, solifluction appears to be restricted to the base of moderately steep slopes. Annual movements of 3.8 to 9 cm on the surface of a solifluction lobe have been measured in this environment (Rampton, 1982). Radiocarbon dates on buried organic matter from beneath the same lobes indicate that they had only advanced 1.5 m during the last 1200 years. This suggests that the downslope movement of solifluction lobes may be sporadic. An average of 2.5 cm per year of frost creep on steep, bare slopes in the Richardson Mountains has also been measured, but no data are available for turf-covered slopes. On Garry Island, Kerfoot and Mackay (1972) and Mackay (1981a) found that solifluction and frost creep were proceeding at an average rate of up to 1 cm per year on slopes. The movement was found to be plug-like with some sliding along a thawing ice-rich layer at the base of the active layer (Mackay, 1981a). This results in hummocks maintaining their form over hundreds of years in spite of the downslope movement and burial of inter-hummock peat.

Subsurface organic layers, common throughout Tuktoyaktuk Coastlands, are likely due to downslope movement of the active layer and burial of organic material in depressions within patterned ground or between hummocks (Mackay, 1958b). Tarnocai and Zoltai (1978) have proposed that the organic layer is buried through the upward flow of unfrozen mineral material in the earth hummocks during freeze-back of the active layer (due to the development of high cryostatic pressures), and the subsequent lateral flow of these materials out over the organic material at the edge of the earth hummocks when it thaws. Mackay (1980b), however, believed that earth hummocks form through a cell type of circulation under bare areas that possess deeper active layers than surrounding areas. This bowl-shaped depression in the base of the active layer allows material to flow downward and inward along the sides of the depression and upwards in the centre because of frost heave during freeze-back and gravity flow during thawing. Radiocarbon dates from a number of organic layers indicate that the formation of hummocks and the buried organic layer began at least 11 ka, and was most active after 4.5 ka (Tarnocai and Zoltai, 1978; Zoltai et al, 1978). Dates related to frost creep, solifluction, and the origin of earth hummocks are shown in Figure 69 and are detailed in Appendix 4.

In swales, surface movement of soils up to 2 cm per year have been measured (Mackay, 1981a). This movement is thought to be caused primarily by the frictional drag of water

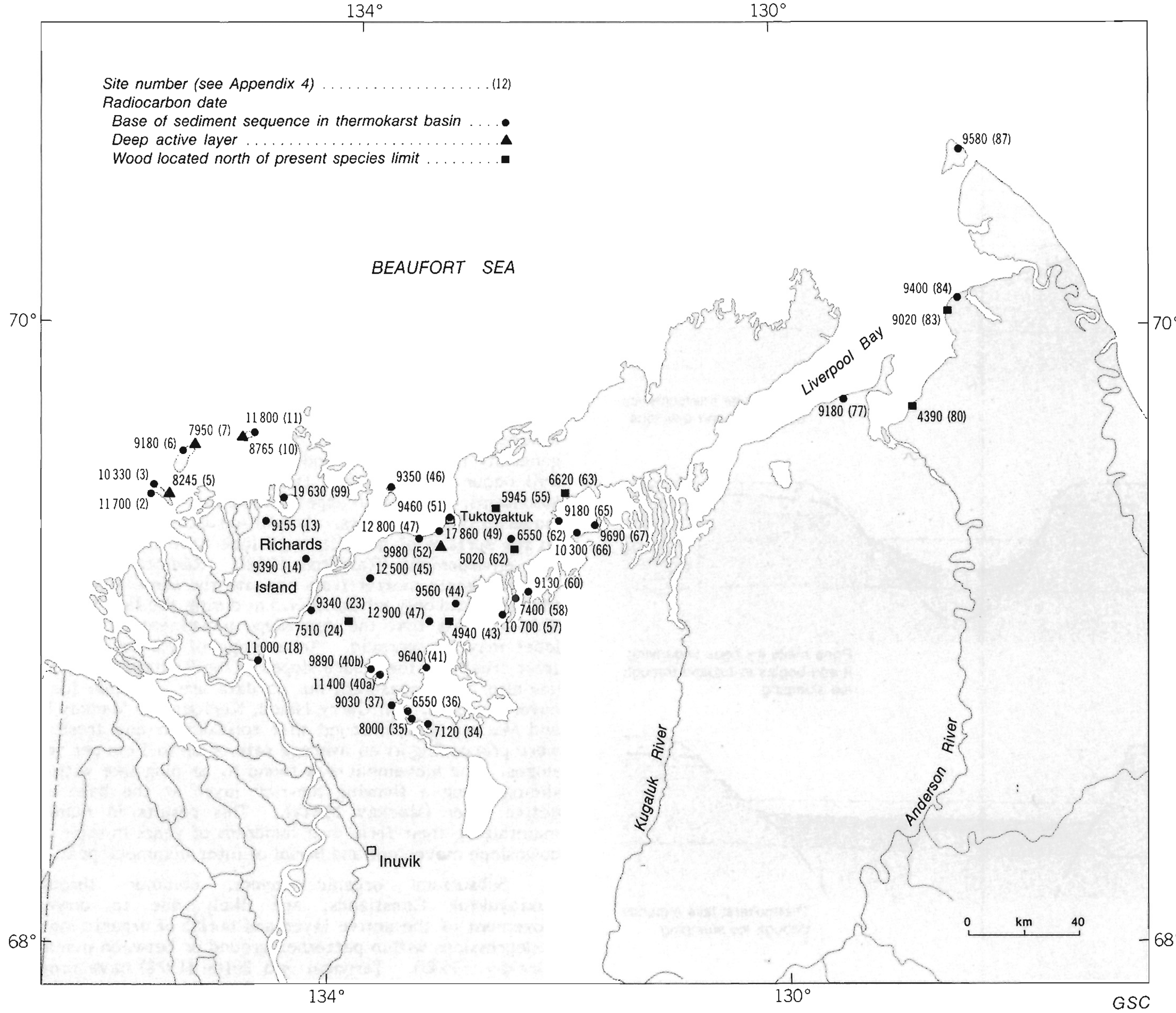


Figure 66. Radiocarbon dates (Appendix 4) related to Late Wisconsinan and Holocene thermokarst activity, active layer thickening, and northern extent of treeline.

flowing over these surfaces following snowmelt rather than by frost creep. In areas underlain by ice wedges, up to 0.2 cm per year of surface movement towards the ice wedge trough has been recorded (Mackay, 1981a).

Peat development

Organic sediments and peat have accumulated in poorly drained flats and on depressions, such as drained lakes and abandoned fluvial channels, during the very Late Wisconsinan and Holocene. Peat accumulation appears to have begun in this area around 11 to 12 ka. Basal peat in a bog near Inuvik was dated at 11 500 ± 160 BP (GSC-1514, Appendix 4) and near Tununuk at 11 000 ± 160 BP (GSC-1286). At Garry Island it appears to predate 11.7 ka (wood from 2.3 m in 3.3 m of peat dated at 11 700 ± 250 BP (S-277). Zoltai and

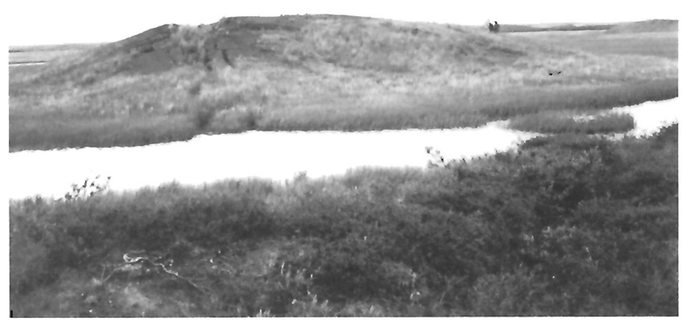


Figure 67. Pingo with extension crack forming in drained lake basin west of Tuktoyaktuk. (GSC 159016)

Figure 68. Melting ice core in pingo south of Tuktoyaktuk. Note the former shoreline of a large lake in this area. (GSC 159063)

Tarnocai (1975) believed that peat accumulation was greatest during the period between 8 and 4 ka ago when the climate was warmer than at present.

Peat accumulation has led to the development of patterned ground. Peatlands in Tuktoyaktuk Coastlands show well developed low centre and high centre peat polygons (cf. Fig. 45). The contrast between the two types of polygons may be partly due to the age of the peatland and to the local hydrology.

Sand dunes and oriented lakes

The sandy Pleistocene deposits on the northern end of Tuktoyaktuk Peninsula and along the lower Kugaluk River estuary (Map 1647A) have been reworked by easterly winds since their deposition. This reworking has resulted in the formation of parabolic and linear dunes on their surface (Mackay, 1963a; see also Fig. 4). Most of this activity probably occurred during the Holocene, although few direct dates are available to support this assumption. One date of 3280 ± 130 BP (GSC-1268) was obtained from the base of eolian deposits overlying glaciofluvial sand near the northeast tip of Tuktoyaktuk Peninsula.

Presently, blowouts are active along cliffs and scarps bordering rivers, lakes, and the sea and result in cliff-top dune formation (Fig. 46, 47). Blowouts are most common where Kittigazuit Formation or fine grained glaciofluvial sediments are exposed in scarps. If coarser pebbly sand is present, a lag of wind-polished pebbles (ventifacts) forms on the bottom of the blowout. Some modern dune activity is also occurring along the large sandy spits flanking the northern edge of Tuktoyaktuk Peninsula. A spectacular yardang has developed in an area of thick Holocene eolian sands along Old Horton Channel (Fig. 48). Sand removed from this yardang is being deposited at its western end and is leading to a westward migration of this landform.

Many lakes on the northern part of Tuktoyaktuk Peninsula (Fig. 4) and on Cape Bathurst peninsula are oriented perpendicular to the easterly winds which have probably persisted throughout the Holocene (Mackay, 1956b). Most of the lakes appear to have originated by thermokarst with further basin expansion occurring as a result of thermokarst processes, wave erosion, and differential transport and deposition of sediment. These processes are strongly affected by the wind regime during open water periods in a manner that produces an oriented lake form. The homogeneity of the sandy materials in which the lakes are formed undoubtedly contributes to their uniform shape and orientation.

ENGINEERING GEOLOGY

Intensive exploration by the petroleum industry of Tuktoyaktuk Coastlands and adjacent offshore waters, and the construction of support and transportation facilities since 1960, have resulted in an assessment of the terrain sensitivity, foundation conditions, hazards, and available construction materials throughout Tuktoyaktuk Coastlands.

Terrain sensitivity, foundation conditions, and harzards

Terrain susceptibility to a number of hazardous phenomena, such as thermokarst, slope failures, gully erosion, frost heave, flooding, and coastal erosion, are the overriding factors in determining the sensitivity of a terrain unit and its limitations in providing suitable foundation conditions for construction throughout Tuktoyaktuk Coastlands and adjacent areas. For many terrain units, the ground ice content, both in volume and location, is the most important factor governing terrain sensitivity and foundation conditions because of the subsidence and loss of bearing strength that occur upon its melting. Table 21 gives the susceptibility of the main units on Map 1647A to a number of relevent phenomena; this table is primarily a synthesis of a more detailed table in Rampton (1972d).

Thermokarst

Thermokarst subsidence and erosion are ever-present hazards in areas of ice-rich permafrost (Rampton, 1974b). Major subsidence can result from the thawing of materials having uniform ice contents, from the thawing of large bodies of massive ground ice, or from thawing of icy sediments found within other sediments having low ice contents (Fig. 70). The higher-than-average ice content that is common just below the base of the active layer (Mackay, 1970) will also lead to significant subsidence if that zone is thawed. Thawing of ice wedges, which are ubiquitous in most deposits, will result in a polygonal pattern of trenches (Fig. 71); on slopes runoff may further deepen these trenches.

Units composed of peat and fine grained sediments commonly have moderate to high ice contents and thawing of significant thicknesses of these materials may result in substantial subsidence. Units composed of coarse sand, gravel, or bedrock generally have low ice contents, and the resulting subsidence from their thaw is thus minor. Exceptions do occur in that ground ice may be associated with fine grained beds within the sand and gravel or may be in materials underlying the sand and gravel (Fig. 70). In general thaw must proceed to a greater depth from the ground surface in coarse grained sediments before any permafrost or ice will begin to thaw and affect subsidence. This is in part because the active layer thickness in coarse grained sediments is greater than in fine grained sediments (Mackay, 1970).

Table 21. Susceptibility of map units to thermokarst, frost heave, flooding, and poor drainage; and their potential as sources of construction material

Unit	Comments re susceptibility and sensitivity: Thermokarst and frost heave	Mass wastage	Flooding and drainage	Potential as construction material
Wr-beaches, bars, spits	Minor	Erosion and movement during major storms	Frequent inundation during high tides and storms	Granular material available, but limited by thickness and effects removal might have on coastal retreat
Wp-intertidal plains, salt marshes	Negligible thermokarst subsidence; significant frost heave upon freezing	Nil	Frequent inundation during high tides and storms	Nil
Ap-floodplains, deltas	Moderate to major thermokarst subsidence where permafrost is thick, minor elsewhere; significant frost heave upon freezing	Erosion by stream channels during high water	Common during highwater stages as caused by storms, ice jamming, and storm tides	Nil
At-alluvial terraces	Moderate thermokarst according to thickness of fines in unit	Nil	Ponding on flat areas marked by low centre polygons	Gravel and sand commonly available; limited by overburden thicknesses
Af-alluvial fans	Variable thermokarst; heaving during freezing of taliks may be extreme	Potential erosion of apex	Avulsion can lead to flooding of any segment	Materials generally too fine grained for use as granular material
C-colluvium	Moderate to major thermokarst possible at base of slopes if colluvium is thick	Solifluction and creep significant processes on specific slope segments; active layer detachment failures occur in mountains	Nil	Bedrock scree and underlying bedrock possible construction materials where bedrock is competent
Er-eolian deposits	Nil, but underlying materials may be susceptible to thermokarst	Blowouts common	Depressions between dunes may contain ponded water	Limited use as fill; too fine for good quality granular material
L-lacustrine deposits (Holocene)	Moderate subsidence in older basins; significant frost heave upon freezing	Nil	Much ponding especially in areas of low centre polygons	Nil, except in the upper Eskimo Lakes where deposits are reworked fluvial and glaciofluvial gravels
O-organic deposits	Major subsidence, but limited by thickness of deposits	Nil	Ponding common in areas of low centre polygons	Nil
L^S,L^T-lacustrine deposits (Wisconsinan)	Major subsidence possible as often underlain by massive ice	Retrogressive-thaw flow slides common along slopes	Minimum ponding on surface	Nil
Mm-rolling and hummocky moraine	Major subsidence possible under most hills and ridges, where they are underlain by massive ice of icy sediment	Retrogressive-thaw flow slides common along slopes	Nil	Nil, except for isolated patches of gravel or sand
Mb-morainal blanket	Minor to moderate subsidence possible on flatter areas	Active layer detachment failures and solifluction occur on some slope segments in mountains	Nil	Nil, except for isolated patches of gravel or sand
Mv-morainal veneer	Major subsidence possible under some hills and ridges, where they are underlain by massive ice or icy sediment	Retrogressive-thaw flow slides occur in areas underlain by massive ice	Nil	Sand and gravel common under veneer; locally some gravel and sand may be good quality granular material
Gp-outwash	Major subsidence possible along Eskimo Lakes where massive ice underlies outwash; moderate to major between Mackenzie Delta and Mason River; minor west of Mackenzie Delta and east of Mason River	Retrogressive-thaw flow slides common in areas underlain by massive ice	Ponding common on flat areas, especially if low centre polygons present	Good granular material available along Old Horton Channel, west of Mackenzie Delta and in upper Eskimo Lakes; gravel locally present in other areas; fine sand and silt contents may be significant especially in middle Eskimo Lakes and on northern Tuktoyaktuk Peninsula; extraction often restricted by ice contents
Gx-ice-contact deposits	Moderate to major subsidence probable under most hills and ridges	Retrogressive-thaw flow slides common in areas underlain by icy sediments	Nil	Sand most common material; gravel present in upper Eskimo Lakes, adjacent Caribou Hills and in other isolated areas, especially along axis of Tuktoyaktuk Peninsula; high silt contents south of Sitidgi Lake
A.W^L-perimarine deposits	Minor to moderate thermokarst where sediments are icy	Nil	Ponding common in areas of low centre polygons	Few isolated areas of gravel and sand
R-rock	Nil	Rock falls on steep scarps	Nil	Shales adequate for poor quality fill; certain sandstones, conglomerates, carbonates, and slates suitable for riprap and crushed rock

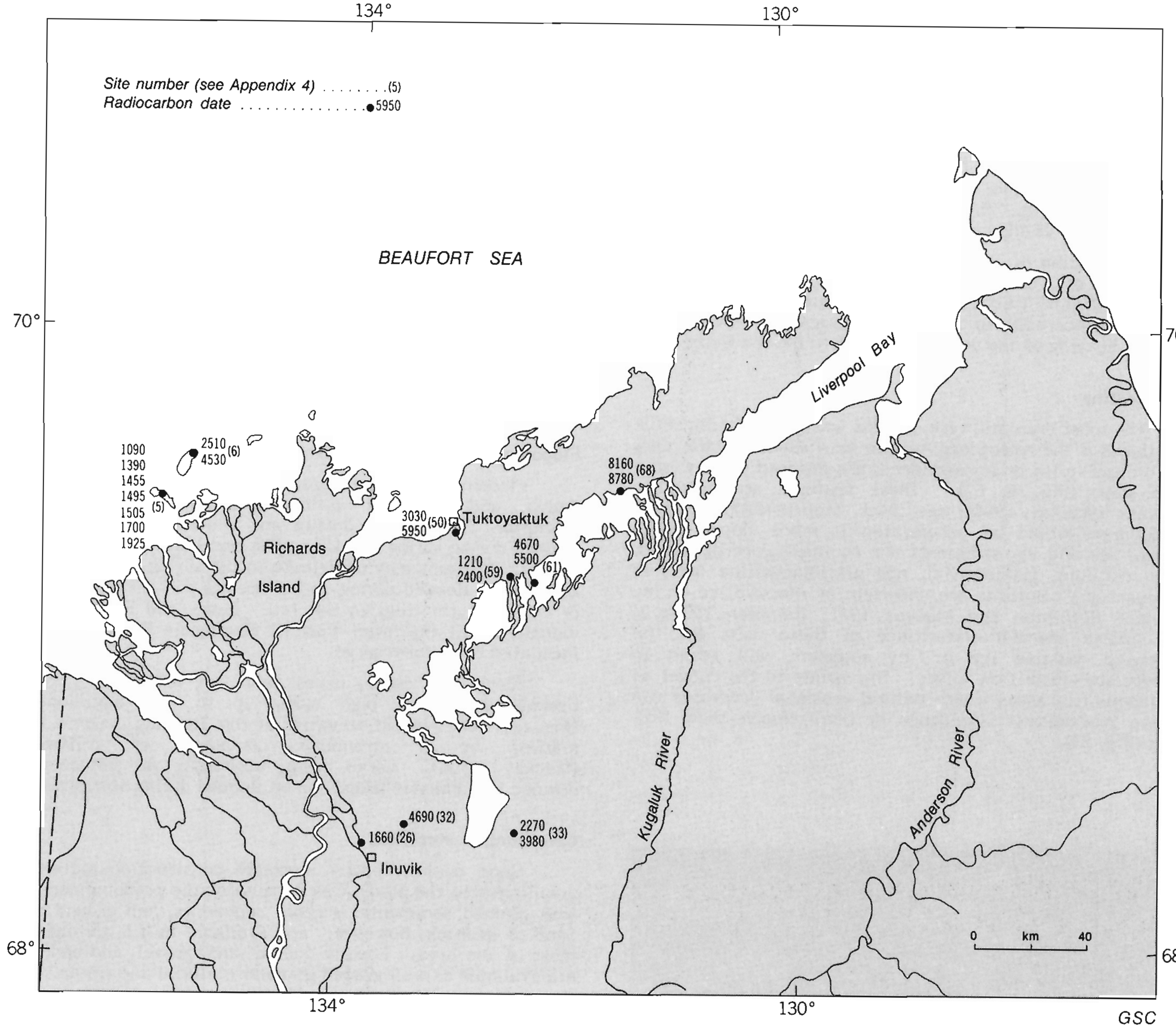


Figure 69. Radiocarbon dates (Appendix 4) related to Holocene mass movement and earth hummocks.

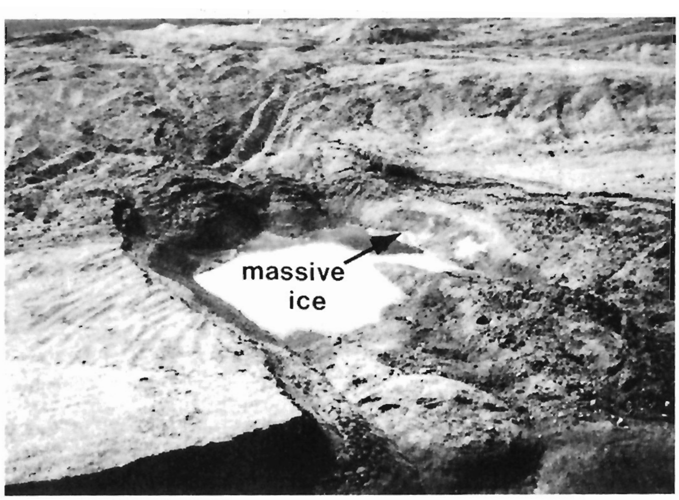


Figure 70. Thaw subsidence occurring under gravel pit on south end of Richards Island. Ground ice apparently is present in sediments under extracted sandy gravels. (GSC 201831-P)

Disturbance of the ground surface, specifically removal of the surface organic layer, or the addition of a heat source to the ground will result in thermal subsidence or thermal erosion (gulleying resulting from thaw of sediments and their erosion by the running water). Both thermal subsidence and thermal erosion have occurred where surface deposits have been stripped or the surface compacted along seismic lines (Fig. 72), winter roads and fire breaks (Heginbottom, 1972; Mackay, 1970; Kerfoot, 1972b). "Prediction of the amount of subsidence can be made by measuring the ice content at the top of permafrost and estimating the equilibrium thickness of the active layer following a surface disturbance." (Mackay, 1970, p. 431).

If large masses of ground ice or icy sediments are thawed, large thermokarst depressions may result (cf. Rampton and Walcott, 1974). Commonly, these large masses of ground ice and icy sediments have some thickness of sediment with low ice contents overlying them, in which case thaw and subsidence may be limited or avoided, if thermal disturbance to the ground surface is minimal.

Frost heave and related phenomena

Frost heave is a factor where permafrost is aggrading in unfrozen sediment, mainly in areas of alluvial or deltaic deposition and on drained lacustrine basins (Mackay, 1981a). Frost heave is greatest where in-freezing of lacustrine basins occurs under a closed system. Groundwater migration and its freezing can result in differential heave. The ultimate reflection of maximum heave in an in-freezing basin is, of course, a pingo (Fig. 67). The rate of heave and pingo growth slows with time as the basin in-freezes.

Contraction of the ground in the winter results in the formation of cracks and growth of ice wedges (Mackay, 1974a). This leads to an increase in ground volume through the accretion of the ice-wedge ice and results in an eventual heaving of the ground adjacent to the ice wedge.

Mass wasting

The most dramatic type of mass wasting in Tuktoyaktuk Coastlands is the retrogressive-thaw flow slide, which occurs where massive ice or icy sediments are exposed to thaw on a steep slope (Fig. 14, 62). These features are presently abundant (Mackay, 1966a; see inset, Map 1647A) and their development would be accelerated if more slopes where massive ice and icy sediments are common were disturbed. Many morainic, glaciofluvial, and glaciolacustrine units in Tuktoyaktuk Coastlands are underlain by massive ice or icy sediment (Rampton and Mackay, 1971; Rampton, 1974a, b) and positive thermal disturbance of these units and the underlying massive ice or icy sediment will result in retrogressive-thaw flow slides. This points to the danger of development in areas where natural erosional processes can initiate thermokarst subsidence or retrogressive-thaw flow slides (Fig. 73).

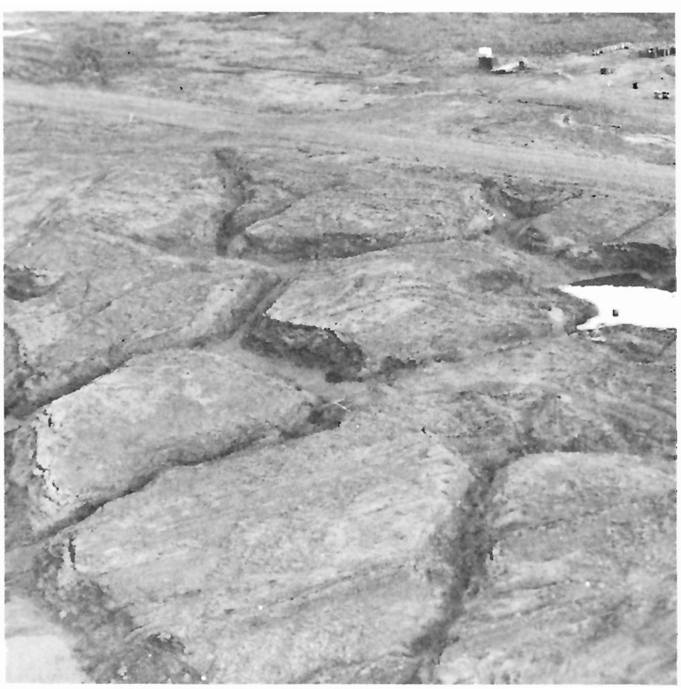


Figure 71. Polygonal network of trenches formed from the thaw of ice wedges following disturbance of the ground surface at Nicholson Peninsula. (GSC 5-8-73)

In mountainous and hilly areas, where slopes are moderate and the thickness of icy sediments are limited, thaw generally results in active layer detachment failures or simple slumps. Other hazards to development in areas of moderate slope are downslope movement through surface creep and solifluction. The latter is prevalent near the base of slopes where adequate moisture is present. On steep bedrock slopes rock falls are an ever-present danger.

Coastal retreat

As indicated in the previous section on Holocene sea level, rapid coastal erosion is taking place, especially in areas where icy sediments and massive ice are exposed periodically to high wave energy (Fig. 73, 74). Coastal retreat in areas protected from high wave energy is much slower. Spits may be vulnerable to rapid retreat if the spits are connected to headlands underlain by massive ice or icy sediments (cf. Rampton and Bouchard, 1975).

Flooding and drainage problems

Flooding is a major hazard on floodplains, alluvial fans, deltas, and in areas within 2 or 3 m of sea level (Rampton, 1974b). Floodplains and alluvial fans are usually flooded during spring break-up or during periods of extensive storms. Ice jams may contribute to the spring flood. Deltas are usually flooded during spring break-up if ice jams occur or during storm tides in the fall. Lewis and Forbes (1975) indicated that the lower third of Mackenzie Delta could be inundated by a storm surge.

Along the coast, areas near sea level are flooded periodically during high tides – up to 3 m occasionally (Fig. 61). The highest elevation of this flooding is commonly marked by a strandline composed of driftwood (Mackay, 1963a). Large areas, especially the bottoms of drained thermokarst lakes, can be flooded during storm tides.

Construction materials

Good quality, easily workable construction materials are limited in the study area because of the predominance of fine grained sediments, organic sediments, and ground ice. Sand or bedrock, however, are available as fill throughout most of the area. Locally coarse sand, gravel, and bedrock are available as well graded granular material and riprap.

Figure 72. Trenches along seismic line on Tuktoyaktuk Peninsula east of Tuktoyaktuk. The trench is mainly due to thaw subsidence, although a minor amount of material may have been mechanically pushed aside. Note gulley formed on slope in background. (GSC 159041)

Fill

Many of the glaciofluvial and fluvial sands, both in surficial and subsurface units, throughout Tuktoyaktuk Coastlands are suitable for general fill (cf. R.M. Hardy and Associates Ltd., 1977) however, they are commonly poorly graded, fine to medium grained, and contain significant contents of silt (Table 21). Organic silt and peat may cover their surface and add to development costs. Ice contents of these sands are generally low to medium, but are significant enough to require their thawing and draining prior to their utilization. Locally large masses of icy sediment or ground ice may be present within or under the sands (Fig. 70). Planning for the development of depressions and thermokarst ponds must be considered where these conditions are present.

To the south of Inuvik, shale is commonly used as fill, even in highway construction (Anderson et al., 1978). Shale is preferable to unconsolidated materials in this area because, once quarried below the near surface, it is relatively free of ice and easily worked after extraction. Other bedrock types present south and west of Inuvik (e.g., quartz, sandstones, conglomerates, carbonates) have limited use as fill, because of the expense of crushing, even though they are more competent and durable than shale.

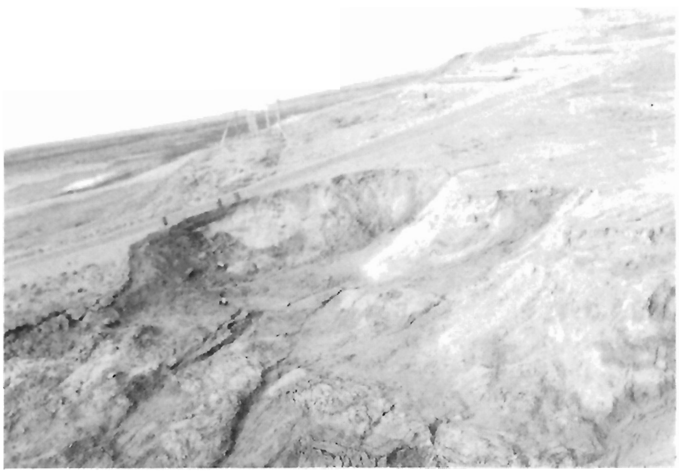


Figure 73. Retrogressive-thaw flow slide initiated through coastal erosion on the north coast of Nicholson Peninsula. Flow slide is infringing on the road between the air strip and DEW-line site. (GSC 5-7-73)

Well graded granular materials

Well graded granular materials are only locally available in the area. A number of surveys have been completed to evaluate deposits containing granular material in the southwest sector of the area (cf. Northern Engineering Services Company Limited, 1976; R.M. Hardy and Associates Ltd. and Terrain Analysis and Mapping Services Ltd., 1976; Terrain Analysis and Mapping Services Ltd. 1976; R.M. Hardy and Associates Ltd., 1977; BBT Geotechnical Consultants Ltd. et al., 1983). To date, large volumes of granular materials have been extracted from spits near Tuktoyaktuk (R.M. Hardy and Associates Ltd. and Terrain Analysis and Mapping Services Ltd. 1976), from the Yaya Lake esker complex (Terrain Analysis and Mapping Services Ltd. 1976), and from glaciofluvial deposits near Inuvik (Anderson et al., 1978). Development of these deposits has illustrated a number of problems that can be encountered during and following extraction. Extraction of granular material in spits may lead to an increase in the rate of coastal retreat if their removal affects longshore drift and susceptibility of the coastal line to erosion; it should only be considered where this is not a factor. Extraction of glaciofluvial deposits requires thaw and drainage of the extracted materials. Consideration must also be given to the effect upon the landscape of the thaw of massive ice within or under the extracted granular materials (Terrain Analysis and Mapping Services, 1976).

The largest deposits of gravel available for extraction are along Old Horton Channel east of Liverpool Bay and north of the mouth of Willow River west of Mackenzie Delta (Map 1647A). Glaciofluvial deposits and adjacent lacustrine benches within and just north of the large terminal moraine north of Sitidgi Lake (cf. Fig. 59) are largely gravel and coarse sand and probably contain large volumes of good quality granular material. The large glaciofluvial system beginning near Five Hundred Lake and extending north past Urquhart Lake also appears to contain a high proportion of gravel. Glaciofluvial deposits and colluvium derived from the Tertiary gravels of the Caribou Hills are excellent sources of

Figure 74. Piles to prevent coastal retreat; rapid coastal retreat is occurring along Kugmallit Bay at Tuktoyaktuk where massive ice occurs in Pleistocene sands. (GSC 3-20-72)

Figure 75. Stock piles of gravel extracted from the large esker north of Tununuk on Richards Island; note thaw subsidence occurring in foreground. (GSC 201831-O)

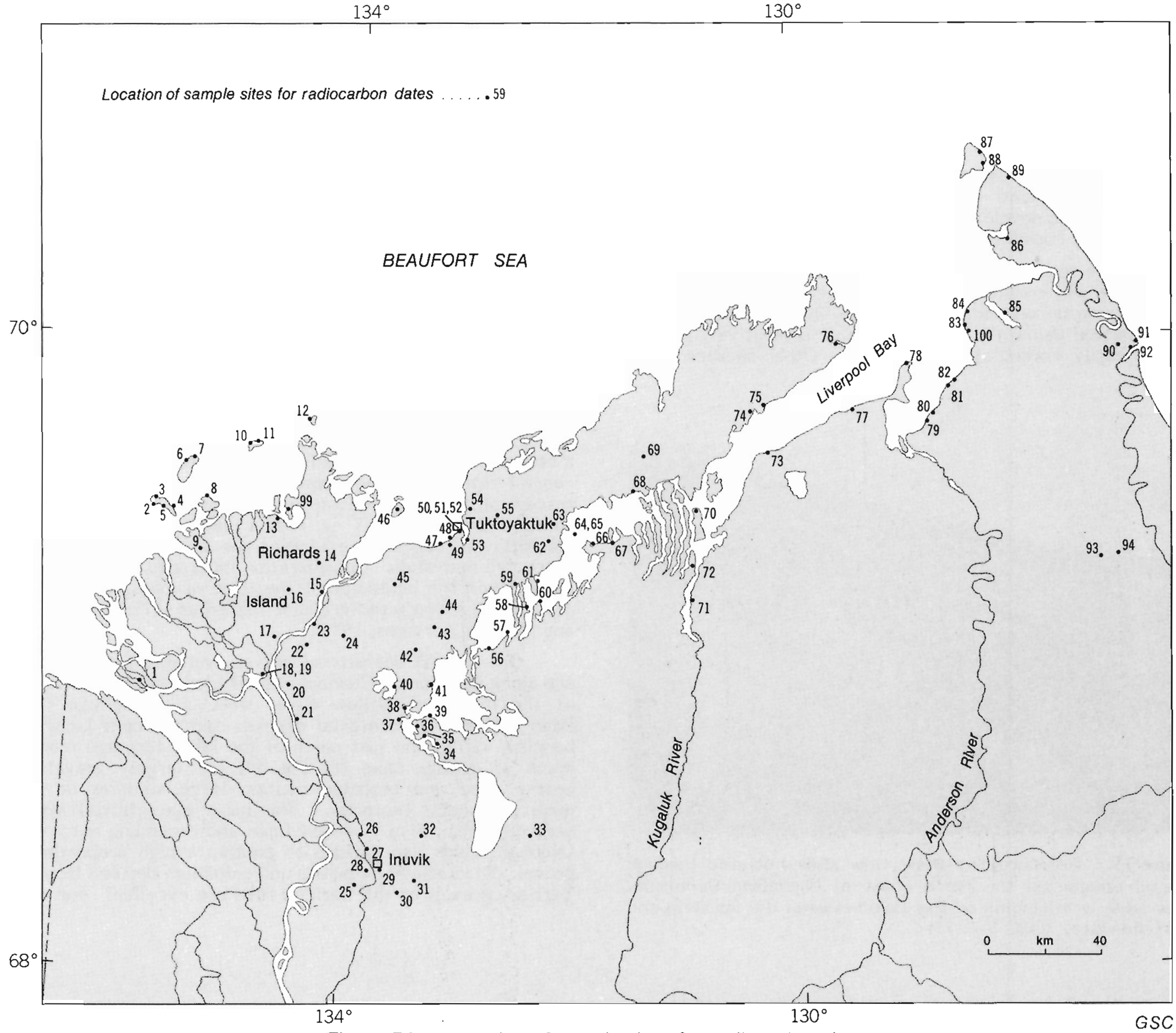


Figure 76. Location of sample sites for radiocarbon dates.

coarse granular material. Indeed, the Tertiary gravels themselves constitute good quality granular material (Northern Engineering Services Company Limited, 1976). High chert contents would restrict their use as concrete aggregate.

Good quality gravel and sand may be locally present within areas characterized by poor quality sand or silty sand. Segments of the large esker north of Tununuk Point (Fig. 42, 75), isolated hills and groups of hills in the extensive complex of glaciofluvial deposits forming the axis of Tuktoyaktuk Peninsula, and channel deposits (Turnabout Member) within Kittigazuit Formation in lower Eskimo Lakes-upper Liverpool Bay area all contain significant amounts of coarse sand and gravel (cf. Terrain Analysis and Mapping Services Ltd., 1976; R.M. Hardy and Associates Ltd., 1977; BBT Geotechnical Consultants Ltd. et al., 1983).

South of Sitidgi Lake a number of small and medium-size sources of granular material are present (Northern Engineering Services Company Limited, 1976). Their use is limited by high silt contents and the high proportion of shale constituting the clasts. Massive ice and icy sediments are generally not present in these sources.

Small deposits of good quality gravel and sand are scattered throughout the area. This is especially true when one includes the pebbly sand and gravel lenses interbedded throughout most glaciofluvial units. The latter would be limited as use for concrete aggregate even locally because they commonly contain a high content of coal and wood fragments.

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APPENDIX 1

Gravel content and sand/silt/clay percentages of selected samples

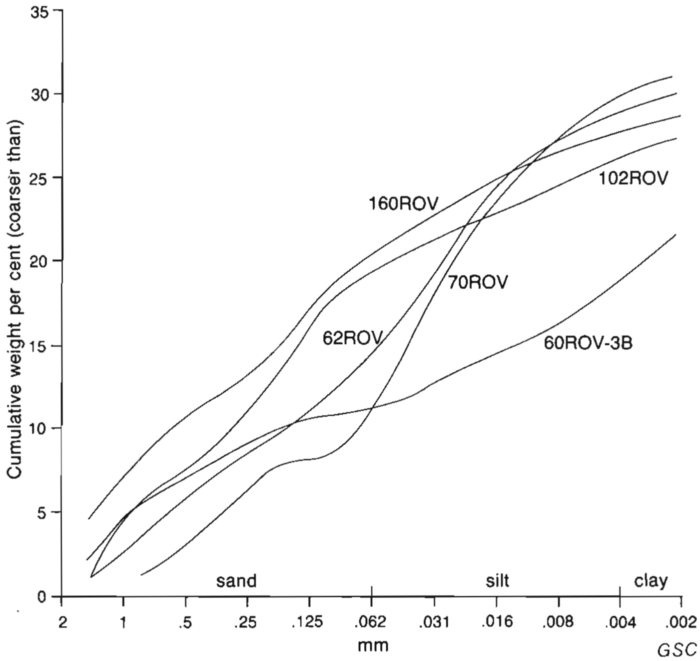
Sample No.	%>2 m	% sand	% silt	% clay	Description	Location Lat.° N	Location Long.° W
DIAMICTONS (WISCONSINAN AND HOLOCENE)							
25BGA	79	51	21	28	Gravelly diamicton near Tuktoyaktuk	69°25'	132°58'
65ROV12	16	61	27	12	Till over gravel along East Channel	68°56'	134°35'
68ROV1	44	72	17	11	Gravelly till along East Channel	68°55'	134°33'
81ROV6	70	63	22	15	Reworked till(?) north of Tununuk Point	69°05'	134°45'
90ROV4	5	51	29	20	Till-like material at Yaya Lake	69°08'	134°40'
110ROV4	9	17	35	48	Till-like colluvium near Stanton	69°47'	128°42'
121ROV2	16	23	26	51	Till(?) along south edge of Liverpool Bay	69°49'	129°32'
126ROV2	8	30	30	40	Till to west of Nicholson Peninsula	69°51'	129°08'
131ROV3	5	32	20	48	Thin till(?) east of Turnabout Point, Liverpool Bay	69°43'	130°03'
133ROV3	10	12	30	58	Till(?) from east of Turnabout Point	69°43'	130°01'
18ROW7	52	74	16	10	Till(?) on Holmes Creek	69°06'	134°21'
25ROW2	9	66	17	17	Till(?) on East Channel	69°24'	133°57'
49ROW1	5	17	42	41	Till-like material on northeastern Richards Island	69°33'	134°04'
49ROW2	3	20	36	44	Debris-flow on northeastern Richards Island	69°33'	134°04'
61ROW	-	39	32	29	Clayey till at north edge of Richards Island	69°42'	134°15'
67ROW7	36	40	43	17	Till near Tuktoyaktuk	69°26'	133°01'
75ROW	1	38	31	31	Diamicton from debris-flow west of Harry Channel	69°17'	135°00'
78ROW4	1	48	27	25	Reworked till on northwest side of Richards Island	69°31'	134°42'
106ROW2	7	21	38	41	Till(?) south of Tuktoyaktuk	69°18'	133°17'
112ROW2	2	38	29	33	Till along Eskimo Lakes	69°18'	132°05'
113ROW3	4	28	20	52	Till(?) on south side of Eskimo Lakes	69°14'	131°19'
121ROW1	2	15	37	48	Till(?) south of Tuktoyaktuk	69°17'	133°03'
140ROW	2	39	31	30	Clayey till east of Tuktoyaktuk on Eskimo Lakes	69°32'	132°02'
141ROW3	2	23	32	45	Till-like material from debris flow near east end of Eskimo Lakes	69°33'	131°28'
142ROW1	4	55	13	32	Reworked till from west of Campbell Island	69°35'	130°56'
142ROW2	2	37	22	41	Till from west of Campbell Island	69°35'	130°56'
169ROW	43	19	29	52	Till at Malloch Hill	70°02'	126°57'
170ROW1	9	14	21	65	Till south of Mason River	69°41'	128°28'
197ROW	9	18	33	49	Till-like material at Urquhart Lake	69°06'	132°11'
5ROX1	4	20	43	37	Diamicton in drillhole near Tuktoyaktuk	69°26'	133°01'
5ROX3	5	27	43	30	Diamicton in drillhole near Tuktoyaktuk	69°26'	133°01'
5ROX4	5	21	36	43	Diamicton in drillhole near Tuktoyaktuk	69°26'	133°01'
6ROX1	7	41	27	32	Diamicton from drillhole east of Tuk Harbour	69°25'	132°57'
7ROX5	1	14	56	30	Diamicton from drillhole east of Tuk Harbour	69°25'	132°57'
8ROX1	25	13	38	49	Diamicton from drillhole near Tuktoyaktuk	69°26'	133°01'
8ROX2	9	27	47	26	Diamicton from drillhole near Tuktoyaktuk	69°26'	133°01'
8ROX3	17	65	20	15	Sandy diamicton from drillhole near Tuktoyaktuk	69°26'	133°01'
9ROX1	16	23	35	42	Diamicton at Tuktoyaktuk	69°26'	133°01'
9ROX2	19	23	33	44	Diamicton at Tuktoyaktuk	69°26'	133°01'
9ROX3	14	22	42	36	Diamicton at Tuktoyaktuk	69°26'	133°01'
9ROX4	26	33	32	35	Diamicton at Tuktoyaktuk	69°26'	133°01'
278ROX	2	10	35	55	Clayey diamicton	69°26'	131°23'
284ROX1	3	27	29	44	Till(?)along south edge of Eskimo Lakes	69°26'	131°41'
294ROX3	3	20	33	47	Till under clay and outwash in Eskimo Lakes	69°13'	132°14'
312ROX1	7	17	38	45	Till(?) in middle of Eskimo Lakes	69°18'	132°18'
346ROX	3	13	43	44	Till from south end of Eskimo Lakes	68°50'	132°57'
94ROW5	24	19	40	41	Diamicton at Peninsula Point	69°24'	133°09'
95ROW3	11	14	35	51	Diamicton near Peninsula Point	69°25'	133°07'
1ROY3	5	22	36	42	Diamicton near Tuktoyaktuk	69°26'	133°01'
1ROY5	6	19	36	45	Diamicton near Tuktoyaktuk	69°26'	133°01'
LACUSTRINE SEDIMENTS (HOLOCENE AND WISCONSINAN)							
63BGA	-	54	32	14	Sandy lacustrine sediment near Tuktoyaktuk	69°27'	132°57'
113ROV3	-	6	70	24	From west of Nicholson Point	69°50'	129°27'
67ROW2	-	5	72	23	From pingo at Tuktoyaktuk	69°26'	133°01'
67ROW3	-	6	72	22	From pingo at Tuktoyaktuk	69°26'	133°01'
67ROW4	-	4	73	23	From pingo at Tuktoyaktuk	69°26'	133°01'
67ROW5	-	3	71	26	From pingo at Tuktoyaktuk	69°26'	133°01'
67ROW6	3	4	74	22	From pingo at Tuktoyaktuk	69°26'	133°01'
87ROW3D	-	13	63	24	From pingo at Tuktoyaktuk	69°27'	133°02'
87ROW3K	-	21	57	22	From pingo at Tuktoyaktuk	69°27'	133°02'
87ROW5	2	36	46	18	From pingo at Tuktoyaktuk	69°27'	133°02'
105ROW2	-	1	78	21	Glaciolacustrine(?) sediment on north side of Eskimo Lakes	69°04'	133°05'
116ROW	1	30	49	21	Silty organic sand near Atkinson Point	69°37'	132°09'
139ROW	-	-	4	96	Clay in depression on north side Eskimo Lakes	69°28'	132°04'
188ROW3	1	27	45	28	On Nicholson Peninsula	69°46'	129°05'
7ROX2	-	8	45	47	Near Tuktoyaktuk	69°26'	132°57'
7ROX3	-	6	44	50	Near Tuktoyaktuk	69°26'	132°57'
7ROX4	-	9	30	61	Near Tuktoyaktuk	69°26'	132°57'
287ROX3	-	12	49	29	From bench on south side of Eskimo Lakes	69°25'	131°53'
292ROX2	-	2	30	68	Glaciolacustrine(?) clay under outwash in Eskimo Lakes	69°15'	132°14'
312ROX2	-	2	4	94	Glaciolacustrine(?) clay under outwash in Eskimo Lakes	69°18'	132°18'
336ROX	-	58	28	14	Bench adjacent to Five Hundred Lake	68°56'	132°38'
339ROX2	-	28	46	26	Thermokarst basin adjacent southern Eskimo Lakes	68°51'	133°16'
ALLUVIAL AND DELTAIC SEDIMENTS (HOLOCENE)							
60ROV3B	-	3	22	75	Alluvial fan to north of Inuvik	68°23'	133°45'
62ROV	-	7	74	19	Delta near Inuvik	68°30'	133°50'
70ROV	-	2	78	21	Delta near Tununuk Point	68°53'	134°31'
101ROV1	70	93	4	3	Low terrace on Anderson River	69°35'	128°33'
102ROV	-	26	41	33	Floodplain of Anderson River	69°35'	128°33'
160ROV	-	29	44	27	Floodplain of Kugaluk River	69°07'	130°53'
13ROW	-	3	81	16	Floodplain along East Channel	69°02'	134°38'
71ROW2	-	-	78	22	Delta east of Harry Channel	69°24'	134°48'
144ROW	-	21	36	43	Floodplain of Smoke River	69°24'	130°17'
149ROW	-	10	64	26	Floodplain of Mason River	69°57'	128°18'
157ROW	-	77	9	14	Low terrace on Old Horton Channel	70°13'	127°18'
805ROW	-	7	81	12	Delta near Harry Channel	69°24'	134°52'
MARINE SEDIMENTS - INTERTIDAL (HOLOCENE)							
205ROW	-	3	87	10	Intertidal flats west of Richards Island	69°36'	134°29'
806ROW-X	-	26	68	6	Intertidal deposits near mouth of Harry Channel	69°30'	134°54'
806ROW-Z	-	33	60	7	Intertidal deposits near mouth of Harry Channel	69°29'	134°54'
MARINE SEDIMENTS - BEACH (HOLOCENE)							
84BGA1	76	97	1	2	Near Tuktoyaktuk	69°26'	133°03'
84BGA2	66	96	1	3	Near Tuktoyaktuk	69°26'	133°03'
95BGA	35	62	20	18	Near Tuktoyaktuk	69°26'	133°02'

Sample No.	%>2 m	% sand	% silt	% clay	Description	Location Lat.° N	Long.° W
GLACIOFLUVIAL SEDIMENTS (INCLUDING TURNABOUT MEMBER)							
34BGA	54	55	25	20	Gravel near Tuktoyaktuk	69°25'	132°57'
80BGA	33	97	1	2	Sandy gravel near Tuktoyaktuk	69°28'	132°57'
86BGA	55	62	22	16	Gravel near Tuktoyaktuk	69°26'	133°02'
93BGA	26	80	8	12	Gravel near Tuktoyaktuk	69°26'	133°02'
193BGA	24	34	35	31	Gravel(?) near Tuktoyaktuk	69°23'	132°59'
41BGA	68	78	13	9	Gravel near Tuktoyaktuk	69°26'	132°58'
55ROV	48	96	4	-	Gravel at north end of Caribou Hills	68°52'	134°28'
60 ROV2	52	94	3	3	Terrace north of Inuvik	68°23'	133°45'
68ROV3	-	39	42	19	Upper grey sand on East Channel	65°55'	134°33'
77ROV2	48	88	7	5	Subtill gravels at Tununuk Point	68°58'	134°37'
98ROV2	3	86	3	11	Outwash along Anderson River	69°42'	128°58'
113ROV2	1	89	4	7	Outwash(?) west of Nicholson Point	69°50'	129°27'
130ROV4	-	97	3	-	Upper grey sand near Turnabout Point, Liverpool Bay	69°42'	130°17'
141ROV5	64	74	3	3	From channel in Kittigazuit member near Turnabout Point	69°42'	130°15'
163ROV	1	96	4	-	Outwash along Kugaluk River	69°13'	131°00'
1ROW	71	89	7	4	Terrace on Old Horton Channel	70°01'	127°04'
16ROW3	53	88	7	5	Outwash along East Channel	69°05'	134°33'
20ROW3	-	92	6	2	On East Channel near Holmes Creek	69°06'	134°21'
29ROW2	-	87	7	6	Outwash adjacent to Kidluit Bay	69°31'	133°46'
52ROW3	2	93	3	4	Terrace on northeastern Richards Island	69°32'	133°58'
76ROW2	3	96	2	2	Glaciofluvial or glaciomarine terrace at north edge of Mackenzie Delta	69°16'	135°06'
84ROW2	-	93	4	3	Glaciofluvial or glaciomarine terrace east of Garry Island	69°25'	135°30'
89ROW2	-	95	3	2	Near Tuktoyaktuk	69°28'	133°03'
89ROW3	81	86	7	6	Near Tuktoyaktuk	69°28'	133°03'
94ROW4	-	98	1	1	Upper grey sand at Peninsula Point	69°24'	133°09'
102ROW	75	94	4	2	Ice-contact gravels near Parsons Lake	68°59'	133°33'
112ROW5	-	24	57	33	Silty sand (outwash?) in Eskimo Lake valley train	69°18'	132°05'
117ROW4	-	97	1	2	Cape Dalhousie Sands north of Liverpool Bay	69°52'	130°07'
123ROW2	73	95	3	2	Outwash along Holmes Creek	69°03'	134°15'
124ROW	77	91	6	3	Outwash at north end of Caribou Hills	68°58'	134°10'
128ROW5	-	80	9	11	Valley train in Eskimo Lakes	68°58'	133°13'
141ROW2	-	95	3	2	Upper grey sand at east end of Eskimo Lakes	69°33'	131°28'
146ROW	51	87	7	6	Gravel at Rufus Lake	69°32'	129°57'
252ROW2	11	95	3	2	Glaciofluvial or glaciomarine terrace at Garry Island	69°30'	135°43'
322ROX	-	92	4	4	At Urquhart Lake	69°02'	133°00'
342ROX7	1	94	4	2	Outwash near south end of Eskimo Lakes	68°51'	133°12'
359ROX11	29	94	2	3	Near Portage Point, Eskimo Lakes	68°45'	133°16'
294ROX5	-	73	16	11	Outwash valley train in Eskimo Lakes	69°13'	132°14'
KITTIGAZUIT FORMATION (MIDDLE QUATERNARY)							
128ROV	-	91	4	5	Near Turnabout Point, Eskimo Lakes	69°42'	130°19'
149ROV2	-	93	4	3	Southwest of Turnabout Point	69°33'	130°29'
152ROV3	-	90	6	4	Southwest of Thumb Island	69°21'	131°00'
18ROW4	-	83	12	5	Near Holmes Creek	69°06'	134°21'
30ROW2	-	96	1	3	Northwest Richards Island	69°29'	133°47'
37ROW2	-	93	2	5	Near mouth of East Channel	69°15'	134°06'
46ROW1	-	81	12	7	Northeast Richards Island	69°33'	133°47'
53ROW1	-	78	10	12	Northeast Richards Island	69°33'	133°57'
62ROW	-	92	3	5	North end of Richards Island	69°42'	134°16'
94ROW3	-	64	28	8	Brown sand at Peninsula Point – Kittigazuit Formation?	69°24'	133°09'
117ROW2	-	87	9	4	North edge of Liverpool Bay	69°52'	130°07'
141ROW1	-	74	19	7	East end of Eskimo Lakes	69°33'	131°28'
270ROX2	-	77	17	6	East end of Eskimo Lakes	69°28'	131°14'
KIDLUIT FORMATION (MIDDLE QUATERNARY)							
149ROV1	-	95	5	-	Southwest of Turnabout Point	69°33'	130°29'
152ROV2	-	97	2	-	Southwest of Thumb Island	69°21'	131°00'
37ROW1	-	70	25	5	Near mouth of East Channel	69°15'	134°06'
46ROW2	-	95	2	3	Northeast Richards Island	69°33'	133°47'
46ROW3	-	89	7	4	Northeast Richards Island	69°33'	133°47'
94Row2	-	99	1	-	At Peninsula Point	69°24'	133°09'
26ROW2	2	98	1	1	On East Channel	69°24'	133°55'
270ROX1	-	97	2	1	East end of Eskimo Lakes	69°28'	131°14'
PLEISTOCENE SANDS							
89ROV2	-	68	24	8	Vicinity of Yaya Lake	69°08'	134°40'
119ROV3	-	91	4	5	Brownish sand near Nicholson Point	69°49'	129°34'
68ROW1	-	85	9	6	Near Tuktoyaktuk	69°27'	133°08'
68ROW2	2	93	4	3	Near Tuktoyaktuk	69°27'	133°08'
68ROW3	-	89	8	3	Near Tuktoyaktuk	69°27'	133°08'
68ROW4	1	90	6	4	Near Tuktoyaktuk	69°27'	133°08'
85ROW2	-	98	1	1	From cellar at Tuktoyaktuk	69°28'	133°02'
85ROW3	1	90	4	6	From cellar at Tuktoyaktuk	69°28'	133°02'
85ROW3	1	90	4	6	From cellar at Tuktoyaktuk	69°28'	133°02'
85ROW4	-	95	2	3	From cellar at Tuktoyaktuk	69°28'	133°02'
87ROW6	-	98	1	1	From cellar at Tuktoyaktuk	69°28'	133°02'
87ROW7	-	93	3	4	From cellar at Tuktoyaktuk	69°28'	133°02'
137ROW	-	98	1	1	East of Tuktoyaktuk	69°28'	132°13'
192ROW5	-	89	7	4	At Nicholson Peninsula	69°47'	128°56'
201ROW	27	95	2	3	Central Richards Island – outwash?	69°36'	134°25'
5ROX5-19	0-5	93-99	1-4	1-3	15 samples in drillhole near Tuktoyaktuk above 12 m depth	69°26'	133°01'
5ROX20-30	0-3	85-95	4-10	2-5	11 samples in drillhole near Tuktoyaktuk, between 12 and 45 m depth	69°26'	133°01'
6ROX2	1	74	11	15	Near Tuktoyaktuk	69°25'	132°57'
6ROX3-9	0-3	86-93	3-8	3-9	7 samples in drillhole near Tuk from above 27 m depth	69°25'	132°57'
6ROX10-15	0-2	77-93	5-16	2-9	6 samples in drillhole near Tuk between 27 and 45 m depth	69°25'	132°57'
7ROX6	12	67	14	19	East of Tuk Harbour	69°26'	132°57'
7ROX7-9	0-1	88-95	2-4	3-8	3 samples in drillhole east of Tuk Harbour from above 8 m depth	69°26'	132°57'
7ROX10	1	79	9	12	East of Tuk Harbour from 8 m depth	69°26	132°57'
7ROX11-18	0-2	92-98	1-5	1-3	8 samples in drillhole east of Tuk Harbour from 12 to 20 m depth	69°26'	132°57'
8ROX4-13	0-2	95-99	0-4	1-3	10 samples in drillhole near Tuktoyaktuk from above 3 m depth	69°26'	133°01'
8ROX14	-	76	19	5	Near Tuktoyaktuk from 5 m depth	69°26'	133°01'
8ROX15-30	0-5	96-97	1-3	1-2	16 samples in drillhole near Tuktoyaktuk from 5 to 7 m depth	69°26'	133°01'
9ROX5-80	0-2	91-99	1-6	1-6	76 samples in drillhole near Tuktoyaktuk from 1 to 13 m depth	69°26'	133°01'
9ROX81	0	43	39	18	Silty sand in drillhole near Tuktoyaktuk from 13 m depth	69°26	133°01'
9ROX82-105	0-7	76-96	2-15	2-9	24 samples in drillhole near Tuktoyaktuk from 13 to 56 m depth	69°26'	133°01'
273ROX1	-	77	10	13	East end of Eskimo Lakes	69°28'	131°18'
284ROX2	-	96	2	2	Southeast Eskimo Lakes	69°26'	131°41'
STANTON SEDIMENTS (MIDDLE QUATERNARY)							
148ROW2	-	-	87	13	Silts in bluffs south of Nicholson Peninsula	69°52'	128°35'
162ROW5	67	97	1	2	Gravels at crest of cliff west of Maitland Point	70°04'	128°24'
MISCELLANEOUS							
68ROV2	-	80	14	6	Brown sand on East Channel	68°55'	134°33'
68ROV4	-	91	4	5	Lower greyish sand on East Channel	68°55'	134°33'
167ROW	9	98	1	1	Brown sands in cliffs south of Trail Point	70°16'	127°17'
155ROW	63	96	2	2	"Beaufort Formation"	69°58'	127°08'

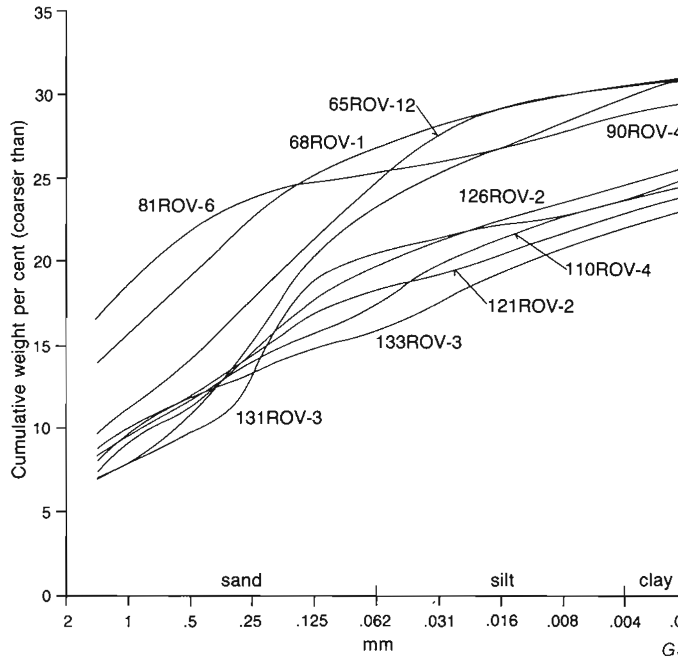
APPENDIX 2

Typical Grain-Size Distribution Curves For Sediment Types (see Appendix 1 for locations)

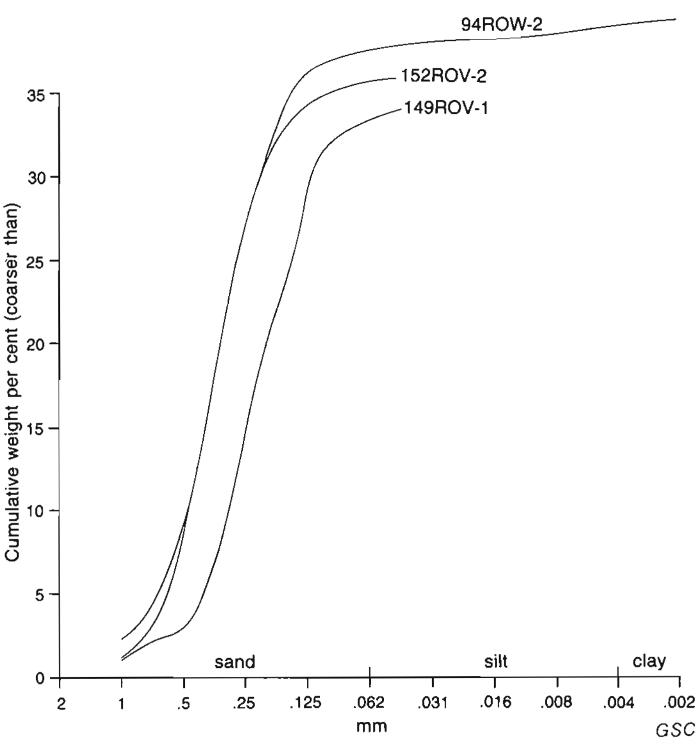
LOGARITHMIC – PROBABILITY GRAPH OF GRAIN-SIZE DISTRIBUTION



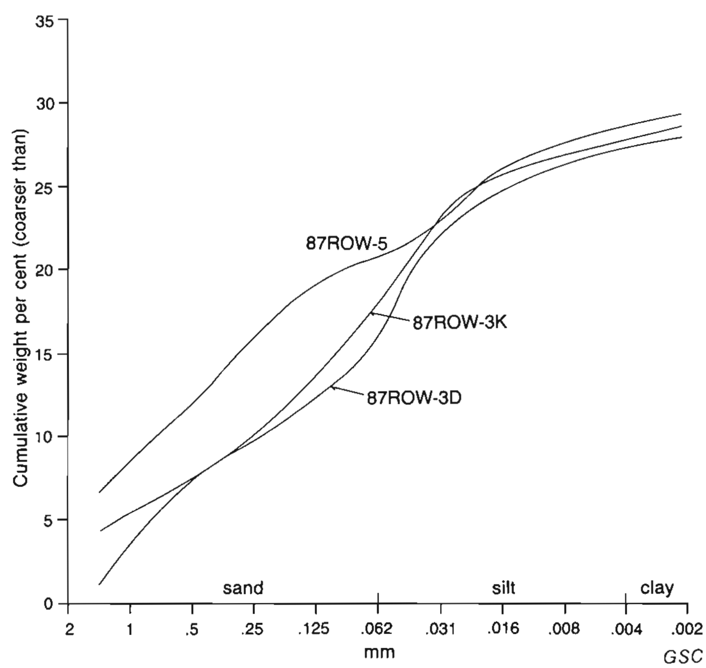
Floodplain and Deltaic Alluvium (Holocene)



Diamictons (Wisconsinan and Holocene)

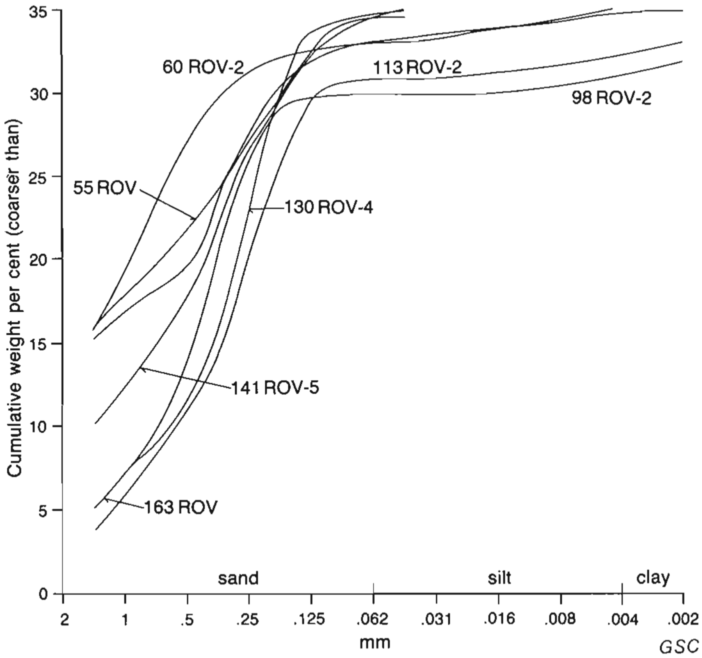


Kidluit Formation (Middle Quaternary)

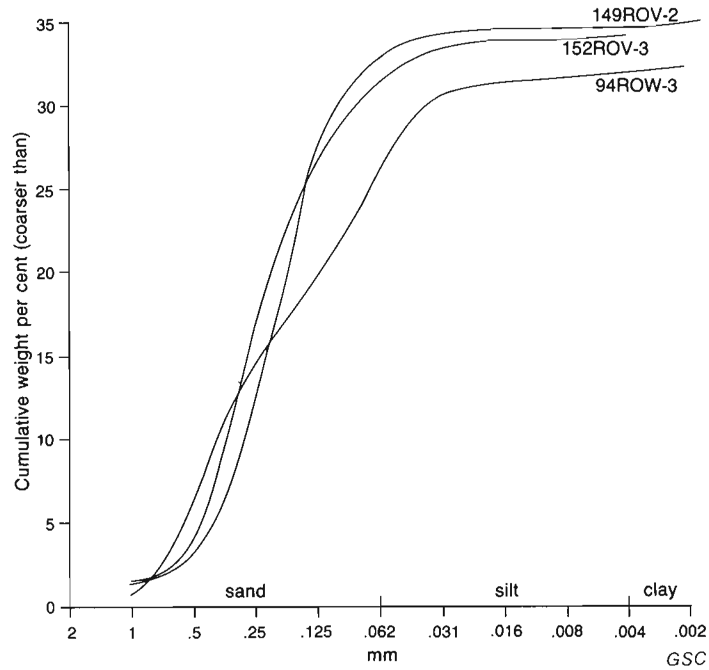


Lacustrine Sediments (Holocene)

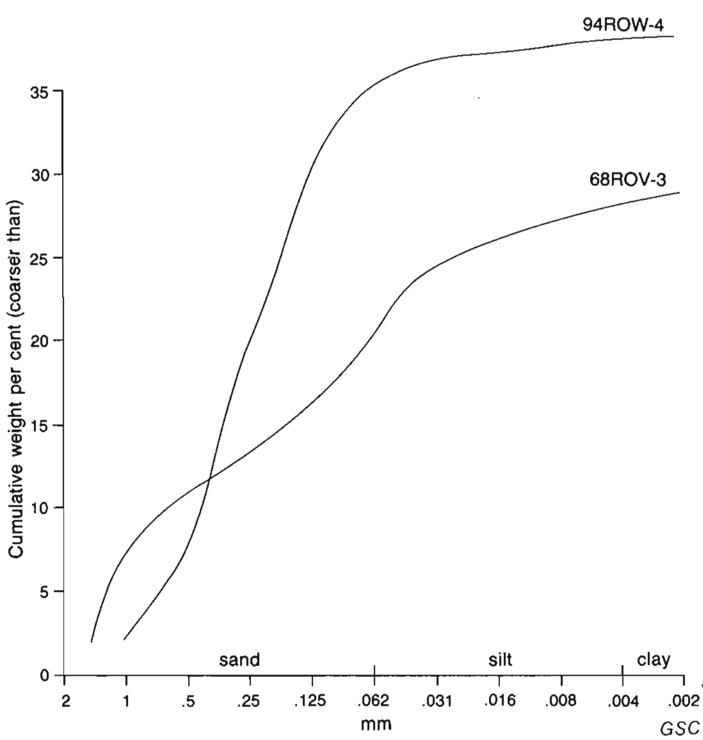
LOGARITHMIC – PROBABILITY GRAPH OF GRAIN-SIZE DISTRIBUTION



Glaciofluvial Sediments (Wisconsinan)



Kittigazuit Formation (Middle Quaternary)



Turnabout Member (Wisconsinan)

APPENDIX 3

Mineralogy of selected sand samples

Sample number	Minerals (abundance, percent of total sample, Tc-Trace)																		Quartz character*			
	amphibole	apatite	aragonite	biotite	calcite	chlorite	garnet	geochite	limonite	ilmenite	magnetite	muscovite	plagioclase	pyroxene	quartz	sericite	titanite	K-feldspar	Quartz rounding	Quartz frosting (%)	Quartz colour	Unit description
342ROX7	10	Tc			10	Tc	Tc	-Tc-			Tc			5	70	Tc		5	SR	50	brown	Outwash (unit 2, Table 14B)
353ROX	10	Tc		Tc	10	Tc	Tc	-Tc-			Tc			5	70	Tc	Tc	5	SA	10	clear	Silty outwash of Sitidgi Stade
225ROX1	10	Tc	Tc		10	Tc		-1-			Tc		Tc	1	76			2	SA	60	brown	Kittigazuit Formation
225ROX2	20	Tc		2	7	Tc	Tc		Tc	Tc	Tc			8	63	Tc		Tc	SA	few	clear	Kidluit Formation
249ROX2	20	Tc		Tc	10	3	Tc	2			Tc	Tc		5	60	Tc	Tc	1	SA-SR	10	clear	Kidluit Formation
341ROX3	10	Tc		18	7	Tc	Tc				Tc			4	60	Tc		1	SA-SR	10	clear	Brown upper unit in upper Eskimo Lakes (unit 3, Table 14A)
359ROX6	13	Tc		Tc	5	2	Tc	-15-			Tc			Tc	65				SA	some	clear	Sand from upper unit in upper Eskimo Lakes (unit 7, Table 15B)

*NOTE: SR-subrounded, SA-semiangular

APPENDIX 4

Radiocarbon dates, Tuktoyaktuk Coastlands and adjacent areas

Site No. (Fig. 76)	Lab No.	Date (years BP)	Location	Elevation (m)	Description	References
1	I-1154	1470 ± 175	68°55'N, 135°57'W	1	Twigs from truncated pingo on Mackenzie Delta	Mackay and Stager, 1966b; Forbes, 1980
1	I-1155	2700 ± 200	68°55'N, 135°57'W	1	Twigs from truncated pingo on Mackenzie Delta	Mackay and Stager, 1966b; Forbes, 1980
2	S-276	9500 ± 150	69°31'N, 135°47'W	30	Wood from 1.9 m depth in 3.3 m thick peat secton on Garry Island	McCallum and Wittenburg, 1968
2	S-277	11 700 ± 250	69°31'N, 135°47'W	30	Wood from 2.3 m depth in 3.3 m thick peat on section Garry Island	McCallum and Wittenburg, 1968
2	S-278	11 300 ± 190	69°31'N, 135°47'W	30	Wood from 3.7 m depth in lake silts on Garry Island	McCallum and Wittenburg, 1968
3	GSC-513	4140 ± 140	69°30'N, 135°47.5'W	3.4	Peat from 1.5 m depth in 1.7 m thick peat section on Garry Island	Lowdon et al., 1971
3	GSC-516	10 330 ± 150	69°30'N, 135°47.5'W	13	Peat from thin peat bed overlain by marl, gravel, and peat; lacustrine shoreline sequence on Garry Island	Lowdon et al., 1971
3	GSC-517	4120 ± 130	69°30'N, 135°47.5'W	3.8	Peat from 1.1 m depth in 1.7 m thick peat section on Garry Island	Lowdon et al., 1971
3	GSC-575	9730 ± 140	69°30'N, 135°47.5'W	10.7	Twigs and wood fragments from base of gravel overlying marl in lacustrine sequence on Garry Island	Lowdon et al., 1971
4	GSC-562	>35 000	69°30'N, 135°40'W	9	Shells (**Astarte borealis, A. montagui, Mya truncata**) from sands in glaciomarine terrace in Garry Island area	Lowdon et al., 1971
5	GX-4540	8245 ± 230	Garry Island	–	Organic matter from just above	Mackay, 1978d
5	GX-5053	2010 ± 140	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-5054	1925 ± 130	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-5055	1700 ± 125	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-5056	1390 ± 115	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-6818	1455 ± 130	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-6819	1505 ± 135	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-6820	1495 ± 130	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
5	GX-6821	1090 ± 130	Garry Island	–	Peat; buried interhummock peat on slopes	Mackay, 1981a
6	GSC-2197	9180 ± 110	90°37.5'N, 135°30.5'W	6.5	Wood (**Salix** sp.) near base of lacustrine silts and colluvium in thermokarst sequence on Pelly Island	Lowdon and Blake, 1979
6	GSC-2291	2570 ± 90	90°37.5'N, 135°30.5'W	10	Peat from below active layer in area of rapid downslope movement on Pelly Island	Lowdon and Blake, 1979
6	GX-4353	345 ± 125	69°37.5'N, 135°30.5'W	10	Peat; buried interhummock material on Pelly Island	Lowdon and Blake, 1979
6	GX-4354	4530 ± 145	69°37.5'N, 135°30.5'W	10	Peat; buried interhummock material on Pelly Island	Lowdon and Blake, 1979
7	GSC-2305	7950 ± 280	69°38'N, 135°30'W	15	Roots from above thaw unconformity on Pelly Island	Lowdon and Blake, 1979
8	I-1151	7800 ± 30	Kendall Island	–	Poplar wood from beaver house	Mackay, 1971
9	GSC-690	>37 000	69°21'N, 135°22'W	7	Shells (**Astarte borealis**) from glaciomarine (?) terrace in Garry Island area	Lowdon et al., 1971
10	GX-4352	8765 ± 230	Hooper Island	–	Organic matter from near base of former active layer	Mackay, 1983
10	GX-4579	35 800 $^{+5400}_{-3200}$	69°47'N, 134°56'W	–	Wood, rounded; from Kidluit Formation on Hooper Island	Mackay and Matthews, 1983
10	GX-4580	>37 000	69°47'N, 134°56'W	–	Wood, rounded; from Kidluit Formation on Hooper Island	Mackay and Matthews, 1983
10	GX-4581	>37 000	69°47'N, 134°56'W	–	Wood, rounded; from Kidluit Formation on Hooper Island	Mackay and Matthews, 1983
10	VQM-463	>40 000	69°47'N, 134°56'W	–	Wood, rounded; from Kidluit Formation on Hooper Island	Mackay and Matthews, 1983
11	GSC-1029	3700 ± 30	69°42'N, 134°55'W	20	Willow (?) twigs from pond sediments on Hooper Island	Ritchie, 1972
11	GSC-1056	11 800 ± 170	69°42'N, 134°55'W	20	Organic silt from base of pond sediments on Hooper Island	Ritchie, 1972
12	GSC-1877	>23 000	69°41'N, 134°24'W	3	Shells (**Macoma** sp.) in gravel cutting older sands on Pullen Island	Lowdon and Blake, 1976
13	I-1152	9155 ± 500	69°25'N, 134°41'W	2	Organic matter from near base of lacustrine sediments exposed in pingo, northwest Richards Island	Mackay and Stager, 1966b; Forbes, 1980
13	I-1153	3210 ± 400	69°25'N, 134°41'W	7	Organic matter from lacustrine sediments exposed in pingo on northwest Richards Island	Mackay and Stager, 1966b; Forbes, 1980
14	GSC-1031	9390 ± 150	69°18'N, 134°19'W	30	Peat gives approximate date for rise in **Picea** sp. curve at Cabin Creek	Ritchie, 1972
15	GSC-709	>40 000	69°14'N, 134°13'W	10	Wood (**Picea** or **Larix** sp.) associated with spruce cones in glaciofluvial (?) terrace along East Channel	Lowdon and Blake, 1973
16	G8-1373	>31 000	69°13'N, 134°34'W	2	Twigs in sand in small pingo on lacustrine (?) bench on east side Yaya Lake	Lowdon and Blake, 1973
17	GSC-549	>40 400	69°06'N, 145°37'W	–	Wood (**Picea** sp.) from depth of about 150 m in oil well	Lowdon et al., 1971
18	GSC-1286	11 000 ± 160	69°00'N, 134°40'W	14	Peat from base of 3 m peat and sand sequence overlying gravel at Tununuk	Lowdon and Blake, 1973
19	I-8578	19 440 ± 290	Tununuk	–	Bone (**Mammuthus** sp.) from Pleistocene deposits	Harington, 1978

Appendix 4 (cont.)

Site No. (Fig. 76)	Lab No.	Date (years BP)	Location	Elevation (m)	Description	References
20	GSC-1401	150 ± 130	68°55'N, 134°31'W	3.3	Wood (**Betula** sp.) from strandline approximately 3.3 m above summer level of Devil Lake	Lowdon and Blake, 1978
21	L522A	>44 000	68°51'N, 134°28'W	5	Peat from Pleistocene sediments along East Channel at north end of Caribou Hills	Mackay, 1963a
22	GSC-1797	6730 ± 80	69°04'N, 134°19'W	60	Peat from depth of 1 m on a 30 m high pingo on Tuktoyaktuk Peninsula	Lowdon and Blake, 1979
23	GSC-1495	9340 ± 260	69°08'N, 134°18'W	3	Peat (mainly sedge fragments) from base of 0.8 m of gravel containing peaty layers, which overlies more than 1 m of oxidized gravel near Holmes Creek (21ROW)	Lowdon and Blake, 1978
24	BGS-472	7510 ± 140	69°05'N, 133°52'W	40	Wood (**Larix**) from base of peat exposure	Zoltai and Zalasky, 1979; Spear, 1983
25	GSC-54	6900 ± 110	68°18'N, 133°50'W	-34	Wood from depth of 38 m in bore-hole in Mackenzie Delta	Dyck and Fyles, 1963
26	BGS-32	1660 ± 90	68°22'N, 133°45'W	–	Peat; dates origin of earth hummocks near Inuvik	Zoltai et al., 1978
27	GSC-1316	1840 ± 130	68°23'N, 133°45'W	7	Peat from peaty layer underlying about 1 m of silty clay and overlying more than 2 m of gravel, 6 m above summer river level on East Channel (site 60ROV)	Lowdon and Blake, 1978
28	GSC-25	8200 ± 300	68°22'N, 133°44'W	6	Wood at base of bog as exposed on shore of Twin Lakes near Inuvik	Dyck and Fyles, 1963
28	GSC-1514	11 500 ± 160	68°22'N, 133°44.5'W	15	Peat; basal layer of bog at Twin Lakes near Inuvik	Lowdon and Blake, 1973
28	GSC-1574	7700 ± 140	68°22'N, 133°44.5'W	15	Peat layer separating terrestrial part of profile from underlying lake deposits at Twin Lake bog near Inuvik	Lowdon and Blake, 1973
28	WIS-279	5420 ± 70	68°22'N, 133°44.5'W	15	Peat from Twin Lake peat exposure near Inuvik	Fyles et al., 1972
28	WIS-291	5840 ± 65	68°22'N, 133°44.5'W	15	Peat from Twin Lake peat exposure near Inuvik	Fyles et al., 1972
28	WIS-310	7220 ± 80	68°22'N, 133°44.5'W	15	Peat from Twin Lake peat exposure near Inuvik	Fyles et al., 1972
29	GSC-29	>39 000	68°21'N, 133°41'W	–	Wood from kame complex containing much ground ice near Inuvik	Dyck and Fyles, 1963
30	GSC-2075	11 100 ± 90	68°16'N, 133°28'W	75	Silty organic mud; dates rise of dwarf birch pollen at M Lake south of Inuvik	Ritchie, 1977; Lowdon and Blake, 1981
30	GSC-2087	2860 ± 80	68°16'N, 133°28'W	75	Gyttja from spruce-tree-alder zone at M Lake	Ritchie, 1977; Lowdon and Blake, 1981
30	GSC-2172	10 000 ± 110	68°16'N, 133°28'W	75	Silty organic mud; dates appearance of poplar pollen in M Lake sequence	Ritchie, 1977; Lowdon and Blake, 1981
30	GSC-2187	8590 ± 80	68°16'N, 133°28'W	75	Gyttja; dates rise of spruce pollen curve at M Lake	Ritchie, 1977; Lowdon and Blake, 1981
30	GSC-2221	6410 ± 90	68°16'N, 133°28'W	75	Gyttja; dates rise of alder pollen curve at M Lake	Ritchie, 1977; Lowdon and Blake, 1981
31	GSC-3346	11 600 ± 140	68°18'N, 133°25'W	20	Organic silt, much carbonate; dates rise in **Betula** pollen curve at "Twin Tamarack" site south of Inuvik	Blake, 1983; Ritchie, 1984
31	GSC-3347	7810 ± 100	68°18'N, 133°25'W	20	Organic mud; dates rise in **Picea** pollen curve at "Twin Tamarack" site	Blake, 1983; Ritchie, 1984
31	GSC-3377	3640 ± 90	68°18'N, 133°25'W	20	Organic mud from upper metre of sediment at "Twin Tamarack" site	Blake, 1983; Ritchie, 1984
31	GSC-3384	5830 ± 90	68°18'N, 133°25'W	20	Organic mud; dates rise in **Alnus** pollen curve at "Twin Tamerack" site	Blake, 1983; Ritchie, 1984
31	GSC-3387	13 100 ± 150	68°18'N, 133°25'W	20	Organic silt, much marl; from near base of lacustrine sediment at "Twin Tamarack" site south of Inuvik	Blake, 1983; Ritchie, 1984
32	BGS-320	4690 ± 100	68°26'N, 133°27'W	–	Peat; dates origin of earth hummocks northeast of Inuvik	Zoltai et al., 1978
33a	BGS-190	2270 ± 80	68°27'N, 132°27'W	–	Peat; dates origin of earth hummocks, east of Sitidgi Lake	Zoltai et al., 1978
33b	BGS-191	3980 ± 90	68°27'N, 132°27'W	–	Peat; dates origin of earth hummocks, east of Sitidgi Lake	Zoltai et al., 1978
34	GSC-329	>50 900	68°45'N, 133°16'W	19	Peat 3 m below top of interglacial silts and gravels, which underlie Sitidgi outwash on Eskimo Lakes	Dyck et al., 1966
34	GSC-371	7120 ± 140	68°45'N, 133°16'W	45	Peat; basal peat overlying outwash along south Eskimo Lakes	Dyck et al., 1966
35	GSC-671	8000 ± 160	68°56'N, 133°22'W	1	Twigs from near base of sand and gravel forming 5.5 m bench along Eskimo Lakes	this report
36	GSC-806	6550 ± 140	68°49'N, 133°23'W	21	Wood (**Picea** or **Larix** sp.) from gravels on bench at 23 m above Eskimo Lakes; dates thermokarst activity	this report
37	GSC-3344	9030 ± 80	68°50'N, 133°31'W	35	Lake sediment; basal date on small tundra pond southeast of Parsons Lake	Blake, 1983
38	GSC-1685	4640 ± 140	68°52'N, 133°28'W	2	Wood (**Picea** sp.) from sand in low bench north of Bonnieville Point (site 364ROX)	Blake, in press
39	GSC-491	>39 600	68°51'N, 133°11'W	6	Wood (**Picea** or **Larix** sp.) from sand with much wood in 32 m high scarp on Eskimo Lakes	Fyles, 1967
40a	GSC-1160	11 400 ± 160	68°56'N, 133°38'W	40	Twigs and peat near base of 5.5 m exposure of peat and lacustrine sediments at Parsons Lake	Lowdon and Blake, 1973
40b	BGS-240	9890 ± 130	68°57'N, 133°45'W	–	Marl from eroded beds on side of pingo near Parsons Lake	Delorme et al., 1977

Appendix 4 (cont.)

Site No. (Fig. 76)	Lab No.	Date (years BP)	Location	Elevation (m)	Description	References
41	GSC-1469	9140 ± 170	68°57.5'N, 133°13.5'W	5	Marl from the basal 5 cm of a 4.6 m thick peat layer overlying 70 cm of pond silts in thermokarst basin at Zed Lake, eastern Eskimo Lake (site 131ROW)	Lowdon and Blake, 1976
41	GSC-1469-2	9790 ± 180	68°57.5'N, 133°13.5'W	5	Peat from the basal 5 cm of a 4.6 m thick peat layer overlying 70 cm of pond silts in thermokarst basin at Zed Lake (site 131ROW)	Lowdon and Blake, 1976
41	GSC-1469-3	9640 ± 350	68°57.5'N, 133°13.5'W	5	Wood from the basal 5 cm of a 4.6 m thick peat layer overlying 70 cm of pond silts in thermokarst basin at Zed Lake (site 131ROW)	Lowdon and Blake, 1976
42	GSC-1237	11 500 ± 220	69°03'N, 133°27'W	50	Lake sediment; dates start of **Picea** rise at MK-5, Tuktoyaktuk Peninsula	Ritchie and Hare, 1971; Lowdon and Blake, 1973
42	GSC-1269	5440 ± 140	69°03'N, 133°27'W	50	Lake sediment at top of **Picea** dominated stratigraphic interval at MK-5	Ritchie and Hare, 1971; Lowdon and Blake, 1973
42	GSC-1321	12 900 ± 170	69°03'N, 133°27'W	50	Lake sediment; lowermost layer with pollen spectra at MK-5 on Tuktoyaktuk Peninsula	Ritchie and Hare, 1971; Lowdon and Blake, 1973
42	GSC-1338	3630 ± 140	69°03'N, 133°27'W	50	Lake sediment near base of birch-alder assemblage at MK-5 on Tuktoyaktuk Peninsula	Ritchie and Hare, 1971; Lowdon and Blake, 1973
43	GSC-1354	8690 ± 180	69°03'N, 133°27'W	50	Lake sediments; base of **Picea**-dominated stratigraphic interval at MK-5	Ritchie and Hare, 1971; Lowdon and Blake, 1973
43	GSC-1265	4940 ± 120	69°07'N, 133°16'W	30	Wood (**Picea glauca**); stump exposed in situ on gravel bank of small lake SSW of Tuktoyaktuk	Lowdon and Blake, 1973; Spear, 1983
44	GSC-1169	9560 ± 150	69°10'N, 133°12'W	40	Willow (?) twigs and peat from 3 m thick clayey mudflow-debris layer in exposure near small lake on Tuktoyaktuk Peninsula	Lowdon and Blake, 1973
45	GSC-3302	12 500 ± 110	69°15'N, 133°36'W	35	Silty gyttja; basal date from lacustrine sediments at "Sleet Lake", near Kittigazuit	Blake, 1983; Spear, 1983
45	GSC-3307	10 400 ± 110	69°15'N, 133°36'W	35	Silty gyttja; dates rise of spruce pollen at in sediments of "Sleet Lake"	Blake, 1983; Spear, 1983
45	GSC-3311	6210 ± 60	69°15'N, 133°36'W	35	Lake sediment; dates rise in alder pollen curve at "Sleet Lake"	Blake, 1983; Spear, 1983
45	GSC-3323	5270 ± 80	69°15'N, 133°36'W	35	Gyttja from core in "Sleet Lake"	Blake, 1983; Spear, 1983
45	GSC-3330	1970 ± 60	69°15'N, 133°36'W	35	Gyttja near top of core in "Sleet Lake" near Kittigazuit	Blake, 1983; Spear, 1983
46	GSC-1896	9060 ± 100	69°32'N, 133°35'W	6	Shells (freshwater) from near top of **Betula** zone in exposed pingo on Hendrickson Island	Hyvarinen and Ritchie, 1975; Lowdon et al., 1977
46	GSC-1896-2	9340 ± 80	69°32'N, 133°35'W	6	Lake mud; basal date on lake sediments on Hendrickson Island	Hyvarinen and Ritchie, 1975; Lowdon et al., 1977
46	GSC-1905	3140 ± 60	69°32'N, 133°35'W	6	Lake mud; dates birch-alder-spruce assemblage on Hendrickson Island	Hyvarinen and Ritchie, 1975; Lowdon et al., 1977
46	GSC-1960	6820 ± 80	69°32'N, 133°35'W	6	Lake mud; dates beginning of birch-alder-spruce assemblage on Hendrickson Island	Hyvarinen and Ritchie, 1975; Lowdon et al., 1977
46	GSC-1970	3160 ± 60	69°32'N, 133°35'W	6	Lake mud from exposed pingo on Hendrickson Island	Hyvarinen and Ritchie, 1975; Lowdon et al., 1977
47	GSC-1214	12 800 ± 180	69°24.5'N, 133°09'W	–	Peat near base of 1.5 m thick mudflow colluvium overlying sand at Peninsula Point	Lowdon et al., 1971
48	GSC-1582	3430 ± 140	69°24.5'N, 133°08'W	15	Organic detritus from fossil soil layer in outer, older part of ice wedge exposed west of Tuktoyaktuk	Lowdon and Blake, 1973
49	Be-49	>26 000	69°24'N, 133°04'W	30	Wood, 4 m below top of Pleistocene sands forming core of Ibyuk Pingo	Müller, 1962; Mackay et al., 1972
49	GSC-481	17 860 ± 260	69°24'N, 133°04'W	30	Peat, 0.3 m above base clayey silt (colluvium) underlying lacustrine silts and overlying Pleistocene in Ibyuk Pingo	Lowdon and Blake, 1973
49	GSC-485	>42 900	69°24'N, 133°04'W	30	Wood in top of Pleistocene sands forming core of Ibyuk Pingo	Lowdon and Blake, 1973
49	GSC-486	>37 500	69°24'N, 133°04'W	30	Wood, 2 m below top of Pleistocene sands forming core of Ibyuk Pingo	Lowdon and Blake, 1973
49	GSC-512	14 130 ± 440	69°24'N, 133°04'W	30	Organic silt 5 cm above base of clayey silt (colluvium) underlying lacustrine silts and overlying Pleistocene sands in Ibyuk Pingo	Lowdon and Blake, 1973 Blake, 1973
49	L-300A	>33 000	69°24'N, 133°04'W	30	Wood about 7 m below top of Pleistocene sands forming core of Ibyuk Pingo	Müller, 1962
49	S-69	12 000 ± 300	69°24'N, 133°04'W	30	Wood and shells from lacustrine sediments exposed on Ibyuk pingo	Müller, 1962
50	BGS-317	3030 ± 90	69°26'N, 133°01'W	–	Organic matter; dates origin of earth hummocks near Tuktoyaktuk	Zoltai et al., 1978
50	BGS-318	5950 ± 100	69°26'N, 133°01'W	–	Organic matter; dates origin of earth hummocks near Tuktoyaktuk	Zoltai et al., 1978
51	GSC-1458	9460 ± 140	69°27'N, 133°01'W	3.7	Woody peat from icy lacustrine silt overlying gravel and pingo ice at Tuktoyaktuk	Lowdon and Blake, 1973
52a	BGS-339	8800 ± 130	Tuktoyaktuk	–	Wood (willow); beaver chewed	Delorme et al., 1977
52b	GAK-5433	9980 ± 140	Tuktoyaktuk	–	Wood at depth of 4 m above a thaw unconformity	Mackay, 1978d
53	GSC-1676	8160 ± 140	69°23'N, 132°59.5'W	3	Peat overlies beach gravel and underlies 0.7 m of clayey colluvium on east side of Tuktoyaktuk Harbour (site 189BGA)	Lowdon and Blake, 1976 Blake, 1976
54	S-57	6800 ± 200	69°30'N, 132°55'W	10	Wood and shells from lacustrine sediment in Sitiyak Pingo	Müller, 1962
55	–	5945 ± 100	69°28'N, 132°35'W	–	Spruce twigs in frozen peat and peaty sand	Spear, 1983
56	GSC-1784	14 100 ± 170	69°04'N, 132°43'W	13.5	Fibrous organic material from large crossbed in outwash sand along Eskimo Lakes (site 320ROX)	Blake, in press

Appendix 4 (cont.)

Site No. (Fig. 76)	Lab No.	Date (years BP)	Location	Elevation (m)	Description	References
56	GSC-1784-2	12 900 ± 130	69°04'N, 132°43'W	13.5	Plant fragments (Gramineae) from large crossbed in outwash sands along Eskimo Lakes (site 320ROX)	Blake, in press
57	GSC-1710	10 700 ± 250	69°07.5'N, 132°32.5'W	13.5	Twigs (**Salix** sp.) from crossbedded sands developed by thermokarst or fluvial activity in Eskimo Lakes (site 318ROX)	Blake, in press
58	GSC-16	7400 ± 200	69°12'N, 132°27'W	1	Wood 15 cm above base of bog deposit exposed in banks along channel between Eskimo Lakes	Dyck and Fyles, 1963
59	BGS-202	2400 ± 80	69°16'N, 132°30'W	–	Peat; cryoturbated matter from earth hummocks north of Eskimo Lakes	Zoltai et al., 1978
59	BGS-203	1210 ± 80	69°16'N, 132°30'W	–	Peat; cryoturbated matter from earth hummocks north of Eskimo Lakes	Zoltai et al., 1978
60	GSC-1653	9130 ± 270	69°13'N, 132°18'W	3.5	Twig (**Salix** sp.) from lacustrine sand and gravels over clayey colluvium in middle of Eskimo Lakes (site 316ROX)	Blake, in press
61	BGS-213	4670 ± 90	69°16'N, 132°20'W	–	Wood; cryoturbated matter from earth hummocks on Eskimo Lakes	Tarnocai and Zoltai, 1978; Zoltai et al., 1978
61	BGS-214	5500 ± 100	69°16'N, 132°20'W	–	Spruce wood buried by debris-flow west of Eskimo Lakes	Tarnocai and Zoltai, 1978; Zoltai, et al., 1978; Spear, 1983
62	GSC-3335	6550 ± 90	69°25'N, 132°10'W	30	Organic clay; basal date on lacustrine sediments at "Black Ice Lake" east of Tuktoyaktuk	Blake, 1983; Spear, 1983
62	GSC-3341	5020 ± 60	69°25'N, 132°10'W	30	Lake mud – gives minimum age to spruce macrofossils in "Black Ice Lake" core	Blake, 1983; Spear, 1983
63	GSC-3239	6620 ± 70	69°27'N, 132°10'W	20	Wood (**Picea** sp.) located in depression well north of modern tree line on north side of Eskimo Lakes	Blake, 1983
63	GSC-3243	6370 ± 70	69°27'N, 132°10'W	20	Wood (**Picea** sp.) – log buried in soil on north side of Eskimo Lakes	Blake, 1983
64	GSC-1682	34 500 ± 690	69°24.5'N, 131°59.5'W	9	Organic detritus and plant fragments from crossbedded sands in glaciofluvial bench with crest at 17 m on island in Eskimo Lakes (site 288ROX); detritus eroded from older strata	Blake, in press
64	GSC-1995	13 000 ± 130	69°24.5'N, 131°59.5'W	6	Plant fragments (Gramineae) from mid-point of bench exposing outwash sands on island in Eskimo Lakes (site 2ROZ)	Blake, in press
65	GSC-2023	9180 ± 90	69°25'N, 131°58.5'W	3	Wood (**Salix** sp.), beaver gnawed; in peat-filled thermokarst basin on island in Eskimo Lake (site 1ROZ)	Blake, in press
66	GSC-1936	10 300 ± 120	60°25'N, 131°53'W	3.5	Twig from sand and silt overlying clayey diamicton in low bench along south shore of Eskimo Lakes (site 287ROX)	Blake, in press
67	GSC-1669	2920 ± 130	69°25'N, 131°40'W	6	Terrestrial peat, 15 cm below surface of eroded pingo on south side of Eskimo Lakes	Hyvarinen and Ritchie, 1975; Lowdon and Blake, 1981
67	GSC-1671	9690 ± 250	69°25'N, 131°40'W	6	Pond clay, base of exposed truncated pingo on south side of Eskimo Lakes; clay contains freshwater fauna	Hyvarinen and Ritchie, 1975; Lowdon and Blake, 1981
67	GSC-1717	9500 ± 170	69°25'N, 131°40'W	6	Gyttja with freshwater shells from near beginning of **Picea** pollen rise in truncated pingo on south side of Eskimo Lakes	Hyvarinen and Ritchie, 1975; Lowdon and Blake, 1981
67	GSC-1724	4530 ± 140	69°25'N, 131°40'W	6	Mossy detritus near rise of **Alnus** pollen in truncated pingo on south side of Eskimo Lakes	Hyvarinen and Ritchie, 1975; Lowdon and Blake, 1981
67	GSC-1737	6770 ± 140	69°25'N, 131°40'W	6	Mossy detritus; dates rise of **Alnus** curve in truncated pingo on south side of Eskimo Lakes; contains freshwater fauna	Hyvarinen and Ritchie, 1975; Lowdon and Blake, 1981
68	BGS-200	8160 ± 110	69°33'N, 131°35'W	–	Organic matter; cryoturbated matter from earth hummocks near east end of Eskimo Lakes	Zoltai et al., 1978
68	BGS-201	8780 ± 130	69°33'N, 131°35'W	–	Organic matter; cryoturbated matter from earth hummocks near east end of Eskimo Lakes	Taroncai and Zoltai, 1978; Zoltai, et al., 1978
69	GSC-1860	2280 ± 50	69°40'N, 131°26'W	12	Peat, frost-heaved to surface from a depth greater than 1 m and exposed on the bottom of a drained lake on Tuktoyaktuk Peninsula	Lowdon and Blake, 1979 Blake, 1979
70	I-483	10 800 ± 300	69°32'N, 130°55'W	5	Wood from 5 m below crest of eroded pingo	Mackay, 1963a
71	GX-5247	>37 000	Kugaluk River	9	Wood (waterworn) from 12 m terrace adjacent to east side of Kugaluk River	Mackay, 1963a; Mackay and Matthews, 1983
71	I-482	>37 000	Kugaluk River	9	Wood (waterworn) from 12 m terrace adjacent to east side of Kugaluk River	Mackay, 1963a
72	GSC-1303	10 900 ± 160	69°20'N, 130°55'W	3	Peat from a peat and organic silt unit that underlies more than 2.5 m of gravel and sand and overlies more than 2.2 m of sand (Kugaluk River Outwash in terrace on Kugaluk River estuary (site 166ROV))	Lowdon and Blake, 1978
73	GSC-1281	>36 000	69°41.5'N, 130°18'W	8	Wood near base of 8 m of grey sand and gravel (Turnabout Member) overlying more than 5 m of brown sand (Kittigazuit Member) near Turnabout Point (site 130ROV)	Lowdon and Blake, 1978
74	GSC-1650	>42 000	69°51'N, 130°14'W	13.5	Wood (**Picea** sp.) from near midpoint of 7.6 m of grey sand (Turnabout Member) overlying fine brown sand (Kittigazuit Member) on north side of Liverpool Bay Bay (site 188ROX)	Lowdon and Blake, 1978
75	GSC-1637-2	>29 000	69°52'N, 130°08'W	12	Wood from base of a 1 m thick sand layer (with wood and plant fragments and shale chips) that forms the upper part of a 4.2 m thick grey sand unit (Cape Dalhousie Sands) on north side of Liverpool Bay (site 186ROX)	Lowdon and Blake, 1978
76	GSC-1268	3280 ± 130	70°01'N, 129°29'W	3	Organic detritus from near base of eolian sand in exposure on south side of Johnson Bay	Lowdon and Blake, 1978

Appendix 4 (cont.)

Site No. (Fig. 76)	Lab No.	Date (years BP)	Location	Elevation (m)	Description	References
77	GSC-1327	9180 ± 150	69°48'N, 129°32'W	5	Peat from 4 m thick pebbly silt containing pods of peat and twigs in shore bluff on south side of Liverpool Bay	Lowdon and Blake, 1973
78	GSC-34	>35 200	69°56'N, 128°55'W	30	Wood from deformed sands at north end of Nicholson Peninsula	Dyck and Fyles, 1963
79	GSC-1282	8640 ± 150	69°47'N, 128°47'W	20	Peat from 1 m above base of 3 m thick peat and clay unit overlying 1 m sand, 12 m pebbly clay and 6.5 m bedrock at Castle Bluff	Lowdon and Blake, 1973
80	GSC-1050	4390 ± 130	69°47.5'N, 128°48'W	12	Wood (**Picea** or **Larix** sp.) from near base of 3 m colluvium, sea cliff exposure of drained thaw pond on Wood Bay	Lowdon et al., 1971
81	GSC-3759	>38 000	69°54'N, 128°31'W	2	Wood (**Picea** sp.) from driftwood mat under glaciofluvial (?) sands (Toker Point Stade) in 7 m high bench west of Mason River (site VH-83-050)	this report
82	GSC-2019	200 ± 70	69°55'N, 128°26'W	1	Plant fragments and small twigs with bark near midpoint of 2 m gravel unit (Toker Point Stade outwash?) in 2.6 m terrace west of Mason River (site 11ROZ); contains lemming-like droppings	Lowdon and Blake, 1978
82	GSC-2029	8650 ± 80	69°55'N, 128°26'W	2	Peat and woody fragments from the midpoint of the silty sand overlying 2 m of crossbedded sandy gravel (Toker Point Stade outwash?) in low terrace west of Mason River (site 11ROZ)	Lowdon and Blake, 1978
83	GSC-1989	9020 ± 80	70°05'N, 128°24'W	18	Wood (**Populus** sp.) from base of 1 m of peat in coastal cliff near Cape Monte Casino (site 20ROZ)	Lowdon and Blake, 1978
84	GSC-3763	9400 ± 80	70°07'N, 128°20'W	18	Peat and twigs from base of fine sands with peaty layers in coastal scarp west of Maitland Point	this report
85	GSC-3722	>39 000	70°06.5'N, 127°56'W	3.5	Wood (**Salix** sp.) from 5 m thick pond sequence (Ikpisugyuk Formation) underlying 3.5 m of marine, fluvial, or glaciofluvial sands in 7 m bench east of Maitland Point (site VH-83-040)	this report
86	GSC-1974	33 800 ± 880	70°20'N, 127°57'W	1	Wood (**Salix** sp., one fragment of **Picea** sp.) in 4 m bench of crossbedded sand along Cy Peck Inlet	Lowdon and Blake, 1978
87	GSC-2030	9580 ± 170	70°37'N, 128°10'W	7	Twigs (**Salix** sp.) from base of lacustrine sequence on Baillie Island (site 44ROZ)	Lowdon and Blake, 1978
89	I-5407	1810 ± 90	70°35'N, 128°04'W	0.5	Bone (**Bison** sp.) on beach on Baillie Island	Harington, 1980
89	GSC-478	>32 800	70°31'N, 127°48'W	3	Shells (**Yoldia arctica**) from 3 m of clay (Baillie Clay) at sea level southeast of Cape Bathurst	Lowden et al., 1971
89	GSC-545	>41 000	70°31'N, 127°48'W	3	Wood (**Picea** sp.) from 3 m of clay at sea level to southeast of Cape Bathurst	Lowdon et al., 1971
90	GSX-5248	150 ± 125	69°57'N, 127°05'W	10	Driftwood abandoned along Old Horton Channel	Mackay, 1981b
90	UQ-187	135 ± 50	69°57'N, 127°05'W	10	Driftwood abandoned along Old Horton Channel	Mackay, 1981b
90	UQ-190	160 ± 70	69°57'N, 127°05'W	10	Driftwood abandoned along Old Horton Channel	Mackay, 1981b
90	UQ-191	160 ± 60	69°57'N, 127°05'W	10	Driftwood abandoned along Old Horton Channel	Mackay, 1981b
91	GX-6817	3465 ± 140	69°57'N, 126°43'W	5	Twigs, water-worn, from channel gravels of abandoned Old Horton Channel	Mackay, 1981b
91	GX-6822	4635 ± 170	69°57'N, 126°43'W	8	Twigs, water-worn, from channel gravels of abandoned Old Horton Channel	Mackay, 1981b
92	GX-7011	8595 ± 230	69°57'N, 126°43'W	13	Peat from base of ice-wedge polygon near mouth of Horton River	Mackay, 1981b
92	GX-7012	5490 ± 165	69°57'N, 126°43'W	15	Peat from ice-wedge polygon near mouth of Horton River	Mackay, 1981b
93	GSC-576	>38 100	69°12'N, 127°05'W	205	Wood (**Picea** or **Larix** sp.) within interbedded cross-laminated sand silt, beneath 18 m clay on tributary of Horton on distal side of Franklin Bay glacial limit (east side of Bathurst Peninsula)	Lowdon et al., 1971
94	GSC-1100	>41 000	69°13'N, 127°03'W	205	Peat beneath 12 m of till and overlying 2 till units on west tributary of Horton River on distal side of Franklin Bay glacial limit (east side of Bathurst Peninsula)	Lowdon et al., 1971
99	WAT-739	4880 ± 80	69°28'N, 134°43'W	4	Organic lake silt in core from drained Illisarvik Lake	Michel and Fritz, 1982
99	WAT-740	17 530 ± 540	69°28'N, 134°43'W	5	Organic matter (?) from stony clay unit in core from drained Illisarvik Lake	Michel and Fritz, 1982
99	WAT-741	8720 ± 540	69°28'N, 134°43'W	3	Organic lake silt from base of lacustrine sediments at Illisarvik Lake	Michel and Fritz, 1982
99	WAT-742	19 630 ± 1600	69°28'N, 134°43'W	2	Organic matter (?) from stony clay unit in core from drained Illisarvik Lake	Michel and Fritz, 1982
99	WAT-746	2320 ± 70	69°28'N, 134°43'W	2	Organic lake silt from near surface of lacustrine sediments at Illisarvik Lake	Michel and Fritz, 1982
100	GSC-4075	>36 000	70°01'N, 128°24'W	7	Wood from driftwood layer in 2 m of sand overlying 6 m of organic sand and silt(?) and underlying 3 m of organic sand and silt channel deposit, overlain by 7 m of sandy gravel (beach deposit?), at site VH-83-048	this report

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