95.

A PRELIMINARY ACCOUNT OF SURFICIAL MATERIALS, GEOMORPHOLOGICAL PROCESSES, TERRAIN SENSITIVITY, AND QUATERNARY HISTORY OF KING CHRISTIAN AND SOUTHERN ELLEF RINGNES ISLANDS, DISTRICT OF FRANKLIN

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Introduction

This report outlines some of the basic data necessary for land management in the study area. The impetus has been provided by discoveries of natural gas at a number of sites on King Christian Island and both onshore and offshore of southwest Ellef Ringnes Island.

Dominant material-genetic units and landforms (Hodgson, 1975) are described and are displayed in Figure 95.1. The small scale of presentation requires much generalization of units, particularly in the case of Holocene coastal plain sediments. The descriptive units, together with observations on active geomorphological processes, form a basis for a discussion on the susceptibility of the terrain to man-induced disturbance. Finally, some observations on the Quaternary history are reported.

Field work for 1976 was intended to be based on traverses up to 50 km long, to be run by Honda A.T.C. 90's towing trailers carrying a shallow drill and fly camp equipment. Extensive snow cover until mid-July and subsequent slow drying-out of the active layer under generally overcast and cool conditions, however, restricted ground traverses to within 10 km of three camp locations (Fig. 95.1). Thirty hours of helicopter time used in the field area partially overcame transport difficulties. Field observations were made of: (a) landforms, materials, processes, and vegetation at surface sites, with pits being dug to the frost table; (b) stratigraphy, and particularly ice content of cores obtained by drilling to a maximum 2.5 m depth with a CRREL-type auger; and (c) natural stream cuts – of which a surprising number were present in coastal plain sediments.

Material-Genetic Units

A division of the landscape into areas exposed to Quaternary marine processes and areas at higher elevations that were not affected is evident. The boundary roughly follows the upper limit of Holocene marine deposition. This limit subsequently has been uplifted to ca. 40 to 50 m above present sea level on King Christian Island and the Meterologist Peninsula of Ellef Ringnes Island, declining northwards to ca. 30 m at Dome Bay.

In this section two items should be noted: 1) colluvium is not identified because slope processes do not significantly change the material-genetic units and 2) morainal material (including till) was not identified anywhere in the study area.

Above the Marine Limit

The landscape is controlled by the bedrock – a succession of Mesozoic and Cenozoic clastic strata, generally deformed into northwest trending broad folds, with major anticlines commonly cored by diapirs. The surface is formed of scarplands, rolling plains, and low plateaus, slightly to moderately dissected by drainage lines which are essentially normal to the coasts. Slopes are less than 5 degrees other than on scarps, immediately adjacent to drainage lines, or where diapirs are present. Surficial material is composed of residual weathered bedrock; rare outcrops of resistant strata occur.

The following map-units are based on rock-stratigraphic units, which in general have a fairly uniform lithology. Boundaries follow the stratigraphic unit boundaries established by Stott (1969) for Ellef Ringnes, with the exception of the Hassel-Christopher contact which follows the revision suggested by Balkwill (1973), and by Balkwill (1974) for King Christian Island. A further description of landforms and processes on Ellef Ringnes Island is given by St-Onge (1965).

Diapirs (Co): independent, commonly dome shaped massifs, visually prominent because of relief of 50 to 200 m and a high albedo. The cores are formed by gypsum, anhydrite, and (at depth) halite, with the Carboniferous Otto Fiord Formation as the probable source (Davies, 1975). Also present are minor intercalated limestones and gabbro and basalt intrusions. The strata of peripheral formations are steeply inclined on the margins of the dome.

Where diapiric rocks are exposed, the surface materials are chiefly large crystals to grains of gypsum, solution-pitted outcrop, and minor limestone and intrusive rock rubble. The surface is commonly highly dissected by fluvial processes and solution, with slopes greater than 10 degrees. Peripheral formations are included in the diapir unit where slopes are steep and partially overrun by talus of diapiric rocks. Hoodoo Dome is exceptional in that it still has a cover of Isachsen sandstone.

Deer Bay Formation (JKd): a dark grey to black papery silty shale, which contains increasing amounts of fine grained sand towards the top of the unit. It is only present at the surface on King Christian Island, and there it is largely reworked or covered by marine

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NOICE PENINSULA
Mocklin Point
Dome Bay
Thor Island
Cape Thorstein
Campbell Pt
Isachsen Dome
Elve Pt
Malloch Dome
Malloch River
Transection R
Divergent River
Hoodoo Dome
Jackson Bay
Danish Strait
METEOROLOGIST PENINSULA
ELLEF RINGNES ISLAND
Cape Allison
Cape Nathorst
KING CHRISTIAN ISLAND
Scallon Pt
Bordin Point
Cape Abernethy
Sutherland Point
675
575
425
325
540
Kilometres 10 0 20
N

LEGEND

Fd	Deltaic-marine sediments
Fp	Fluvial sediments
W	Marine sediments, undifferentiated
Wb	Beach sediments
$\frac{W}{R}$	Marine sediments, thin or discontinuous over rock
TQ	Late Tertiary or Quaternary gravels
	TQ_1 or * Flat lying or knobby
	xxxx Ridged
⊗	Camp site

R	Rock, residual weathered bedrock
RW	Marine-washed bedrock
Superscripts:	
Ke_1	Eureka Sound Formation — upper member
Ke_2	Eureka Sound Formation — lower member
Kk	Kanguk Formation
Kh	Hassel Formation
Kc	Christopher Formation
Ki	Isachsen Formation
JKd	Deer Bay Formation
Co	Diapir (source in Otto Fiord Formation)

Where the areas of two or more map-units are too small to be delineated separately at the map scale, compound units are used. Components of compound units are listed in order of decreasing area.

Figure 95.1. Surficial material-genetic map-units, King Christian and southern Ellef Ringnes islands.

sediments. The surficial material above the marine limit is an impermeable clayey silt, which is commonly poorly drained, with fine sandstone beds near the contact with the Isachsen Formation.

Isachsen Formation (Ki): mainly fining upwards cycles of poorly to noncemented fine to coarse grained sandstone, with minor siltstone, shale, and coal. The lower part of the formation is massive quartzose sandstone, locally well cemented. Surficial material is dominantly loose sand with strike-aligned bands of silty sand, silt, and clayey silt where cyclic successions of inclined sediments are exposed. Although generally noncemented (weathered?) to at least a depth of 2 m, a discontinuous cover of cemented sandstone fragments, probably of lag origin, is present.

The landscape is rolling, fluvially dissected, with a succession of minor scarps. Scarps and steep slopes in well cemented sandstone are locally 50 m high. Mesas, buttes, and hoodoos are common where flat lying to gently inclined sandstone is exposed on valley sides or coastal slopes. Stream channels are broad and are composed chiefly of sand. The unit is generally well drained.

Christopher Formation (Kc): chiefly shale, divided by Balkwill (1974) into two informal members, the lower being more silty than the upper, separated by an interval of glauconitic sandstone. Surficial material is silty clay, which has a fine granular to blocky structure to a 50 cm to 2 m depth, and is underlain by platy shale fragments. There are small areas of sandstone and mudstone lag cover, and local concentrations of shattered mudstone and ironstone nodules occur in stream courses.

The landscape is rolling, with the slightly more resistant intervals coring strike-aligned ridges; it is more rounded, though not topographically lower, than adjacent sandstone formations. Drainage is generally poor, with some wet sedge/moss areas. The thixotropic clay forming the active layer over much of the unit did not dry out in the summer of 1976.

Hassel Formation (Kh): a succession of generally poorly cemented, brightly coloured, fine to coarse grained sandstones, with minor siltstone, shale, and coal beds. The surficial material is chiefly sand, over poorly or noncemented bedrock; there are minor outcrops of well cemented sandstone or siltstone and narrow strike-aligned bands of finer material. The landscape is composed of gentle slopes and a succession of minor scarps, with some local dissection. It is more subdued than the Isachsen Formation as there are proportionately fewer resistant beds. Drainage is generally good.

Kanguk Formation (Kk): black silty shale, with minor beds of light weathering bentonite near the base of the formation. Surface material is partially weathered bedrock composed of silt, clay, and platy fragments of shale. A discontinuous lag cover of shattered brown ironstone nodules and siltstone and sandstone fragments is conspicuous on level areas. The shale is highly acidic, and the one core for which pH values are available provided a reading of 3.6 at both 20 cm and 150 cm depths, i.e. above and below the 25 cm-deep frost table (*see* also Balkwill and Hopkins, 1976).

The dominant relief feature is an almost continuous escarpment, controlled by siltstone beds which divide the formation into upper and lower members. The scarp cliff is commonly 20 m and locally 50 m high and is broken only by water gaps. A second scarp developed near the base of the formation is discontinuous, but where present it is just as prominent as the first. Most of the unit varies from overall gentle slopes to extensive level areas where beds are flat lying. Fluvial dissection is locally significant, with steep sided gullies advancing headwards along the rectilinear pattern ice-wedge troughs which are so distinctive on this formation. The active layer is moderately well drained except on the bentonite (cf. Christopher shale).

Eureka Sound Formation (Ke):

Ke$_1$ informal lower member: sandstone, well to noncemented, and shaly mudstone. Surficial material is dominantly sand, silt, and minor clay, with bands of outcrop or lag cover of sandstone and mudstone. The map-unit is chiefly one of long gentle slopes and some low scarps. Areas of moist, well vegetated fines have a 'horse tail' drainage pattern. The distinctive ice-wedge trough pattern, subdued landforms, and finer surficial material differentiate the lower member from the upper.

Ke$_2$ informal upper member: sandstone, poorly to noncemented, with minor beds of gravel, lignite, and carbonized wood. Surficial material is composed of unconsolidated fine to medium grained sand, with a discontinuous lag gravel cover, and local gravel deposits. The surface is rolling, with a succession of minor scarps and some steep slopes where drainage is incised. The unit is well drained.

Late Tertiary or Quaternary Gravel (TQ): Scattered unconsolidated gravelly deposits unconformably overlie Mesozoic sediments and commonly are capping rocks. Two units are recognized – but only on the basis of morphology as no good exposures were observed. Test pits or cores are needed to assess the composition, structure, and volume of granular materials. It is difficult to assign the smaller deposits to either unit on the basis of airphoto interpretation, therefore they are identified on Figure 95.1 by the same symbol (*). The ridges which form unit TQ$_2$ are shown by the symbol xxxx. Precise limits of deposits are difficult to define from superficial inspection or airphoto analysis as mass movement processes transport gravel downslope over underlying bedrock units. St-Onge (1965) also has described these deposits.

TQ$_1$: flat lying, locally knobby, gravelly sediments up to 2 km^2 in area, though generally much smaller. The gravel is round to subangular, granule to boulder size material, predominantly quartzose sandstone, but includes limestone, intrusive rocks, granite, and rare noncarbonized wood. The matrix of fine sand to clay normally makes up more than half of the deposit; thickness is possibly greater than 5 km where knobs occur, otherwise it is much thinner. Deposits occur on regional topographic highs, preferentially on the primary divides of the Meteorologist Peninsula, and in the centre of King Christian Island. The largest deposit is at 230 m and overlies and protects Kanguk shale, which in adjacent areas is 100 m lower in elevation. Drainage is good at the margins of deposits (note little fluvial dissection) but may be poor on level areas.

Deposits are possibly residuals from extensive fluvially deposited sediments of Quaternary or older age. Similar though far more extensive deposits in western Ellesmere and eastern Axel Heiberg islands are possibly coeval. Stott (1969) noted gravels overlying and thus postdating the Beaufort Formation in northern Ellef Ringnes.

TQ$_2$: linear, in places winding, ridges of gravelly material up to 15 km in length, though commonly broken by several water gaps in this distance. Orientation is between west and southwest. Where observed, surface material is granular to boulder size, round to angular quartzites, siltstone, mudstone, gabbro, rare limestone, and granite. The matrix of silty sand comprises less than half the deposit near the surface but is possibly the dominant material below the frost table. No sense of direction of sediment transport was determined. Gravel covered portions of ridges appear to be 50 to 200 m wide and 5 to 20 m high. This could be a gross overestimate of cross-sectional area if, as is likely, considerable erosion has taken place subsequent to emplacement of the deposit and gravel has slumped downslope.

Deposits occur on local topographic highs and minor divides down to, but not below, the marine limit. It is unlikely that deposition occurred preferentially on the highs, and thus a measure of subsequent erosion is available. For example, the gravel ridge northwest of Hoodoo Dome intersects the main scarp of the Kanguk shale. The scarp, which is 50 m high, has retreated at least 1 km (by lateral river erosion) since gravel deposition.

Below the Marine Limit:
Sedimentary Environments of the Coastal Plain

A coastal plain, commonly 5 to 15 km wide with a typically flat to gently concave profile of less than one degree, lies between the present shoreline and the marine limit. Development required one or more lengthy marine inundations to plane the variety of underlying bedrock lithologies. Closely spaced subparallel drainage lines have been extended seawards as the plain emerged during the Holocene, and channels are now commonly incised 2 to 15 m.

In addition to washed bedrock, there are fluvial, deltaic, beach, and undifferentiated marine sediments. Each of these units is described, however they are commonly not mapped separately in Figure 95.1 both for reasons of scale and because of the difficulty of defining boundaries between the sedimentary environments.

Sediments vary in thickness from discontinuous veneers to deltaic beds more than 15 m thick. Composition is greatly influenced by underlying bedrock lithologies, and for fluvial and deltaic sediments by the materials in the drainage basin. The dominant surface material below the marine limit is fine sand or silt.

Marine-Washed Bedrock (RW): a morphologically subdued form of the bedrock units previously described. KTe_2 sediments are locally reworked into sand and gravel beach ridges at elevations close to the marine limit.

Marine Sediments - Undifferentiated (W, $\frac{W}{R}$): generally featureless sediments, excluding mappable deltaic, fluvial, or beach landforms, and including nearshore sediments, marine reworked underlying material (chiefly bedrock), possibly thin beach deposits left by the regressing shoreline, some deltaic sediments from minor drainage lines, and windblown and ice-rafted sediments.

Littoral currents appear to be weak or nonexistent. There is no evidence of longshore drift at the modern shoreline, and where bedrock contacts under the coastal plain make an acute angle with the shoreline and are not covered by deltaic sediments, the lithological boundary is commonly reflected by overlying marine sediments. This is exemplified by the sharp Ki/JKd contacts on Thor Island, the adjacent area of Ellef Ringnes, and the south shore of King Christian Island. Where contacts parallel the shore (e.g., west side of Meteorologist Peninsula), the underlying lithologies may not be apparent from the composition of overlying sediments as contacts have been blurred by the retreating shoreline.

Sediment composition varies from medium sand to silty clay in massive to finely laminated deposits. Sediments are generally more than 1 m thick, with a transitional contact to underlying bedrock, and feather out towards or at the upper marine limit.

Drainage varies from good to poor, depending on slope and materials. Some wet sedge/moss areas are present, and ponding may occur in ice-wedge troughs.

Beach Sediments (Wb): Ridge and swale development is limited by short fetches in ice-infested waters and by deflation of the available material, which is commonly coarse silt and sand size. Areas of closely spaced ridges can be identified on airphotos to ca. 10 m above present sea level and to 3 km inland; but ground inspection shows that the ridges, developed in sandy material, have only a slight morphological expression.

The modern shoreline zone is narrow — 5 to 15 m, other than on modern deltas. This is a function of the small (ca. 25 cm) mean tidal range. Surface material is dominantly sand for all coasts, although where underlying material is fine grained, the beach sand may be only a veneer 15 cm thick. A few ice-push ridges were found on all coasts; ridges were up to 50 cm high and extended to several metres inland from the high-water mark.

There are exceptions to the above observations. The modern beach at the foot of Malloch Dome is gravel, with ice-push ridges to 1 m high, and flights of gravel beaches rise to 30 m above sea level. Gravel beach ridges also are developed on hills underlain by the upper member of the Eureka Sound Formation, close to the marine limit, inland from Jackson Bay, Ellef Ringnes Island. At Cape Abernethy, King Christian Island, a gravel ridge (spit?) extends 3 km inland.

Deltaic-Marine Sediments (Fd): Deltas of larger rivers have prograded as much as 10 km, each within a 1 to 2 km-wide zone, in the course of Holocene uplift. Modern arcuate deltas thrust up to 2 km beyond the adjacent coastline, indicating little wave or current erosion or lateral deflection of the channels. The generally planar raised delta surfaces show that these quiet conditions have existed throughout much of the Holocene.

A topographic profile of the coastal plain parallel to the shoreline shows the delta surfaces rising above adjacent marine sediments. The rise is commonly less than the thickness of the deltaic sediments, indicating that some rivers occupy valleys cut in bedrock.

The modern channel is commonly incised 5 to 15 m into older deltaic sediments underlain by bedrock. Channel widths of 10 m are common on minor tributary streams, and channels on the largest rivers are up to 1 km wide. The inclination of channel banks varies from 3 to 90 degrees.

Channel bank exposures typically show stratified sand and silty sand, sometimes with minor interbedded silt, clay, or organic material. This sequence is underlain by massive deltaic-marine clay or clay-silt. The sandy topset beds vary from a thin veneer over thick basal clay, to a thick unit overlying thick or thin basal clay. Successions of clay over sand, thick interbedded sand and clay, or sediments composed entirely of shaly fragments also have been noted. Source materials within the drainage basin determine the deltaic sediment composition and the fine/coarse sediment ratio. Where overlain by deltas, the upper metre of Eureka Sound Formation poorly or noncemented sandstone on the west side of the Meteorologist Peninsula appears to have been reworked and incorporated into a basal sandy bed prior to being overlain by the clay deltaic-marine sediments.

In general, raised delta surfaces are well drained because of their elevation above adjacent sediments and their relative coarse composition. Ponding, however, may occur in ice-wedge troughs on extensive level areas.

Fluvial Sediments (Fp): Active channel zone fluvial sediments cover 10 per cent of the coastal plain. Peak stream discharge, which occurs during snowmelt, is contained within a single well defined channel, which as previously noted may be up to 1 km wide. At lower water stages flow is restricted to one or more much narrower channels, 0.5 to 1 m deep. As with deltaic and undifferentiated marine sediments, sediment composition is controlled by underlying and upstream materials.

The only area of fluvial sediment large enough to be identified as a simple unit in Figure 95.1 is east of Cape Allison, Ellef Ringnes Island. At this locality unconfined and braided channel flow occurs over ca. 20 km^2 of sand.

Permafrost

Ground ice in the upper 1 to 2 m of the permafrost was examined in cores from the 63 holes drilled. A preliminary inspection of core logs shows no clear relationship between ground-ice content and materials or vegetation. Similar results have been obtained from programs conducted elsewhere in the Arctic Islands. Excess ice content can be highly variable within a single core of the same material. Values range from 0% excess ice (pore ice, or nonfrozen water which is not uncommon) to bands of ice 50 cm thick. No massive ground ice was encountered, other than in ice wedges.

Ice wedges to 5 m wide and 10 m deep are assumed to lie under all polygonal and rectilinear pattern troughs. No relationship has been established between the dimensions of a trough and the size of the underlying wedge. Wedges also may have no surface minifestation if for example the active layer is greatly disturbed by mass movement or deflation. Trough networks are present over much of the map-area.

An active layer develops between snowmelt in late June-early July and freezeup in late August. Maximum depth of the frost table ranges from 20 to 45 cm for most units. In sand or gravel, which is either well drained or saturated by subsurface water flow in a stream channel zone, the active layer may be 1 m thick.

Vegetation and Wildlife

Vascular plants were collected, and percentage cover was estimated at a number of sites on most of the material-genetic units. Both above and below the marine limit, much of the sandstone and the Kanguk shale were nearly devoid of vegetation. Elsewhere the cover was generally sparse. Certain localized areas have a moderate cover of vascular plants and a continuous vegetation cover including mosses and lichens.

Two areas in particular are botanically diverse and also support the only *Salix arctica* observed. These are the southern and western coastal margins of Malloch Dome and the deltaic sediments at the head of Dome Bay. At the latter area at least one muskox, two wolves, and a variety of wildfowl were observed.

Geomorphic Processes

Active geomorphic processes include weathering by physical disintegration, mass wasting, fluvial, eolian, and coastal processes, as well as nivation. No attempt will be made here to weigh the relative efficacy of processes; instead, some of the more interesting processes and resultant landforms will be described.

Weathering

Bedrock, whether or not disturbed by mass erosion, is commonly physically disintegrated to at least a 1 to 2 m depth. This depth greatly exceeds the present maximum thaw depth; however, it does not necessarily imply a formerly thicker active layer. Breakdown could have been accomplished during accretion of ground ice, as well as by frost shattering.

The weathered residual material and rock surface is normally smooth; however, irregularities can develop. Hoodoos are common where certain better cemented units of the Isachsen Formation are flat lying. Development is assumed to result from nivation and fluvial erosion along joints, possibly aided by eolian abrasion. Near the base of the Christopher Formation in east-central King Christian Island, a row of strike-aligned mounds to 1.5 m high and 5 m in diameter (Fig. 95.2) can be traced across the island down to about 35 m elevation on both northern and southern coastal plains.

Figure 95.2

Concretions uncovered by weathering and erosion of surrounding Christopher Formation shale, King Christian Island.

Figures 95. 3 and 95. 4

Earthflows in marine-deltaic sediments, subsequent to rainfall of July 30-August 1, 1976, north of Jackson Bay, Ellef Ringnes Island. The basal shear zone is at the frost table.

The mounds are diagenetic concretions (H. R. Balkwill, pers. comm.) surrounded by shale. Their presence below the Holocene marine limit indicates either that they have been uncovered by weathering and mass erosion of surrounding shale in the course of the Holocene or, less likely, that the marine inundation and later regression of the shoreline was sufficiently rapid that the concretions were not planed off.

Mass Movement

Solifluction is undoubtedly an active process; however, lobes were rarely observed, possibly because of the generally low inclination of slopes and the sparse vegetation cover. Both sorted and vegetated stripes are common.

The earthflow is the most striking type of mass movement. It occurs preferentially on fine grained materials, on slopes from less than 1 to 10 degrees with or without vegetation, and most commonly occurs below the marine limit although numerous earthflows were noted above the marine limit on the Christopher Formation. The basal shear zone is at the frost table and usually is in clay or silty clay, but in places failure may occur in fine sand. The thickness of the sliding material is thus rarely greater than 50 cm although the area of material that moves may be as great as 500 m^2. On river banks, undercutting of the toe of the slope is also a factor, although earthflow failures rarely occur on steeply undercut banks. Saturation of the active layer takes place during snowmelt; however, the layer is probably too thin for earthflows to be initiated at this time. They occur later in the summer, provided unusually heavy or extended rainfall saturates the active layer which is then at maximum thickness. It is likely that in summers with only light rain no failures occur.

In 1976 many earthflows occurred north of Jackson Bay during a period of intermittent rain (ca. 10 mm recorded at Isachsen, 100 km to the northwest) from July 30 to August 1, approximately two weeks after the end of snowmelt. Some slides reoccupied scars from earlier years. Figures 95. 3 and 95. 4 show a few of the many hundreds of earthflows activated in these two days on river banks cut in marine-deltaic sediments. No retrogressive thaw flowslides were observed, possibly indicating a general absence of massive ground ice.

Terrain Sensitivity

Although parts of the study area are highly susceptible to terrain disturbance, the net effect on the sparse vegetation and low density of wildlife probably would be slight. The few botanically diverse areas, however, should not be disturbed. The rivers seem an unlikely habitat for fish because of the short flow period, high sediment loads, and the acidic water where Kanguk shale is drained. Coastal waters were not considered in this study.

Of greater concern is the effect of a number of the geomorphologic processes on roads or pipelines. Some potential problems are: scouring of channel beds in the numerous water courses; initiation of gullies by concentrating runoff; failure of river banks; failure, particularly by earthflow, of any slope on the Christopher Formation or on fine grained coastal plain sediments; abrasion by windblown sand; corrosion, due to high acidity, on or downstream from the Kanguk Formation.

Quaternary History

No direct evidence of Pleistocene glacial erosion or deposition was found in the study area; topography appears to be chiefly a product of fluvial processes, mass wasting, and marine planation. A thick cover of weathered residual bedrock is present (though the rate of weathering is unknown); no morainal deposits have been found on the surface, incorporated in residual material, or underlying marine, deltaic, or fluvial sediments.

The flat lying gravel deposits (TQ_1), if remnants of widespread fluvial sediments, explain the presence of any exotic lithologies in lag deposits. These gravel caps also appear undisturbed by glaciation. A glacial origin for the gravel ridges (TQ_2) has yet to be proven, despite their esker-like form. If they are fluvioglacial sediments, the degree of erosion subsequent to emplacement makes a late Quaternary age unlikely.

Nevertheless, there is strong indirect evidence of glaciation. Some adjacent interisland channels have a trough-like form, and Balkwill *et al.* (1974) describe striations and striated erratics on adjacent Amund Ringnes Island, although the age of these features is unknown. The amount of uplift of King Christian and southern Ellef Ringnes Islands during the Holocene, however, seems only explainable by isostatic rebound from an ice cover of late Quaternary age.

England (1976) has suggested that much of this uplift is recovery from isostatic depression peripheral to the late Quaternary margins of the Greenland Ice Cap and enlarged Ellesmere and Axel Heiberg Island ice caps. On the basis of Walcott (1970), England considered the limit of the peripheral depression to be 180 km. King Christian Island, however, is 600 km beyond the suggested margin of Greenland ice, 200 km from the nearest coast of Axel Heiberg Island, and at least 400 km beyond the northern limit of Laurentide ice. Thus the 30 to 50 m or more of emergence in the Holocene is best explained by rebound from an ice cover over the islands and intervening channels, as in the concept of the Innuitian Ice Sheet proposed by Blake (1970), rather than by the influence of distant ice sheets. The lack of glacial landforms may be a consequence of the ice sheet being cold based (i.e. frozen to the underlying material), perhaps due to a low mean annual temperature. Another possibility is that locally thicker ice centres developed over higher land (the present islands) and there was little ice flow at these locations.

Radiocarbon age determinations are available for four surface samples collected by D.A. St-Onge on Ellef Ringnes Island. *Astarte borealis* valves from the southwest corner of the Noice Peninsula, at 22 m, are 7350 ± 200 years old (L-643B; St-Onge, 1965); *Astarte borealis* and *Hiatella arctica* from the south end of the Meteorologist Peninsula, at 33 m, are 8500 ± 200 years old (L-643A; St-Onge, 1965); a further determination on *Astarte borealis* shells, collected near the preceding sample L-643A, provided a date of 8370 ± 200 years (GSC-1846; Lowdon and Blake, in press); and driftwood in the same vicinity at 25 ± 5 m is 8320 ± 140 years old (GSC-999; Blake, 1970).

Two shell samples collected in 1976 have been dated. A *Mya truncata* valve on the surface at 42 m in south-central King Christian Island (77°45.25'N, 101°37.25'W) is 8900 ± 140 years old (GSC-2386). The sample dated was taken from one of a number of valve clusters and fragments, each representing one or two paired valves, surrounded by silty clay. The sediment, of marine or deltaic origin, extends to 48 m in elevation at this location. This age determination provides a minimum age and elevation for the highest Holocene sea level.

Mya truncata valves taken 8 m below the top of an exposure in deltaic sediments with the surface at 33 m, 12 km north of Jackson Bay, Ellef Ringnes Island (78°12.25'N, 100°46.75'W) are 7640 ± 120 years old (GSC-2383). In the exposure, which is typical of deltas on the coastal plain, interbedded silt, sand, and minor clay overlie massive dark grey clay with shells, which in turn unconformably overlies Eureka Sound Formation sediments. The shells were taken from the lower metre of clay. The age determination shows that the basal clay in at least this deltaic sequence is Holocene in age. It also provides a maximum age for sea level at 33 m at this location. The shells are surprisingly young in comparison with the three samples from a similar elevation at the south end of Meteorologist Peninsula – particularly the driftwood, which is usually contemporaneous with the shoreline on which it is deposited.

On southeast King Christian Island, shells and possible beach ridges are evidence of marine overlap to at least an 80 m elevation. Above ca. 45 m, however, shells tend to be notably thicker and more incrusted and pitted than those at lower elevations. Although no age determinations are available yet, the shells at higher elevations do appear similar to those collected elsewhere in the Arctic Islands which have provided infinite ages. The local abundance on the surface and the presence of pairs make glacial transport unlikely;

but with an ice cover and no basal ice movement, preservation of shells *in situ* is possible.

In the event of such an ice cover, then the late Quaternary high sea level would initially overlap the ice, and the only marine sediments to be expected would be in subsequent offlap deposits. On the other hand if no ice cover was present, some evidence of onlap would be expected in the form of sediments and anomalously old dates underlying Holocene offlap deposits. No such evidence has been found, and even if regressive shoreline processes eroded much of the onlap sediments, some should be preserved where deltaic offlap deposits were built beyond the (shallow) wave base – and it is in such deltaic deposits that many of the best exposures are cut.

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