# A Natural Resource Survey of Eastern Axel Heiberg Island, Northwest Territories.

by

S.C. Zoltai,
P.N. Boothroyd,
and G.W. Scotter

*Prepared for Parks Canada, Ottawa*
*1981.*

Environment Canada — Environnement Canada
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1545-4-1



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March 29, 1982

Mr. S.F. Kun, Director
National Parks Branch
Parks Canada
Ottawa, Ontario
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Dear Mr. Kun:

I am pleased to transmit herewith a report entitled "A Natural Resource Survey of Eastern Axel Heiberg Island, Northwest Territories", by S.C. Zoltai, P.N. Boothroyd and G.W. Scotter. Your comments on the report would be appreciated.

This project was a cooperative study between the Canadian Forestry Service and the Canadian Wildlife Service, with funding provided by Parks Canada.

Yours sincerely

Gordon H. Kerr
Regional Director

Encl.

# A NATURAL RESOURCE SURVEY OF EASTERN AXEL HEIBERG ISLAND, NORTHWEST TERRITORIES

by
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Prepared for Parks Canada

1981

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# 1. INTRODUCTION

## 1.1 Purpose of Study

Portions of northeastern Ellesmere Island and eastern Axel Heiberg Island were designated by Parks Canada as natural areas of Canadian significance that merit protection under the national parks system (Parks Canada 1978). In the original concept, the Ellesmere Island portion was to represent the glacier-covered highlands and the Axel Heiberg Island portion would represent the biologically more productive lowlands. In May 1980, Parks Canada requested the Canadian Wildlife Service and the Canadian Foresty Service to evaluate the natural resources of eastern Axel Heiberg Island.

The study area covers some 5400 km$^2$ on the east side of Axel Heiberg Island. It lies east of the Princess Margaret Range, the glacier-clad high mountain chain that forms the backbone of the island. The study area is within Natural Region 39, Eastern High Arctic Glacier Region (Parks Canada 1972), but it is located within a large depression surrounded by high mountains. The area, therefore, is representative of the lowland portions of the region.

The objectives of this study are:

1. To describe the geology, physical geography, flora, fauna, and human history of the study area.

2. To map and classify the vegetation types and ecological units of the study area.

3. To identify outstanding features that might be critical to the management of a national park that includes all or part of the study area.

4. To determine whether the study area would complement the main potential national park on northeastern Ellesmere Island.

5. To suggest alternative solutions to having a national park in two widely separated sections.

## 1.2 Scope of Study

This study is based primarily on a review of existing information, and on the interpretation of aerial photographs, supported by a brief period of field work.

### 1.2.1 Field Research

One of us (S.C.Z.) accompanied the field party based at Lake Hazen on northeastern Ellesmere Island during July 7-14, 1980. The main field research consisted of a helicopter supported survey of the study area on eastern Axel Heiberg Island during July 18-25, 1980. The itinerary included helicopter traverses of the study area and its vicinity. A total of 24 stops were made on Axel Heiberg Island and an additional 10 stops on the adjoining parts of Ellesmere Island to examine the vegetation, soil, wildlife, and physiography, and to collect plant and soil samples. Additional foot traverses were made in the vicinity of Eureka, on Fosheim Peninsula.

### 1.2.2 Office Studies

Office studies consisted of reviewing published literature and unpublished government files, and interviewing scientists who have extensive field experience in the study area. The collected plant specimens were identified, and soil analyses were performed.

Zoltai interpreted the aerial photographs, established ecological land units and broad vegetation types, and mapped the study area at a scale of 1:250,000. He also summarized the information on physiography, geology, and soils.

Boothroyd researched and summarized the literature on wildlife, hydrology, and climate. He also prepared the section on human history and considered economic and other claims on the study area.

Scotter prepared the species lists for bryophytes, lichens, and vascular plants, and prepared the discussions on the flora. He was responsible for field logistics. He also acted as liaison between the contracting services and Parks Canada.

## 1.3 Acknowledgements

We are grateful to the following people for providing access to their unpublished manuscripts, unpublished data and files: Don Thomas, Ken Ross, Dick Kerbes, and Dalton Muir of the Canadian Wildlife Service; Don McAllister of the National Museum of Natural Sciences; Doug Heyland of the Environmental Protection Service; J.G. Hunter of the Arctic Biological Station; Bruce Stephenson of the Northwest Territories Wildlife Service; Pat Sutherland of McMaster University; Don Kanik of the Department of Indian and Northern Affairs; Judith Marsh of the Archaeological Survey of Canada.

Knowledge of and access to published information used in the preparation of this report was greatly assisted by: Ming-ko Woo, McMaster University; Rick Riewe, University of Manitoba; Pat Kelsey, McGill University; Ian Stirling, Canadian Wildlife Service. Library support was well provided by June Martin at the Freshwater Institute library, and Linda Casagrande and Barbara Arnold of the Canadian Wildlife Service libraries in Ottawa and Edmonton respectively.

We wish to acknowledge the assistance of Mr. William J. Cody (Biosystematics Research Institute, Agriculture Canada, Ottawa), Dr. William C. Steere (The New York Botanical Garden, Bronx), and Dr. John W. Thomson (Department of Botany, University of Wisconsin, Madison) for assistance with the identification of vascular plants, bryophytes, and lichens, respectively.

Ian McNeil (Parks Canada) arranged for and supported the study and assisted with the field work.

## 2. CLIMATE

The location of the study area, east of the mountains of Axel Heiberg Island and south and west of the mountains of Ellesmere Island, is responsible for its "continental" type climate. This climate is shared with the Fosheim Peninsula area of adjacent Ellesmere Island and is therefore fairly well described by meteorological data collected by the Atmospheric Environment Service at Eureka. Factors affecting the climate of the Arctic Archipelago are described in detail by Maxwell (1980).

The high ice-capped mountain ranges on Ellesmere Island present a barrier to the entry of mild, moist air from the North Atlantic (Thompson 1967). Similarly, the mountains of Axel Heiberg Island provide an effective barrier to maritime influences from the west (Andrews 1964). The climate of most islands of the Arctic Archipelago is influenced by the marine channels lying between them. However, Eureka Sound, Nansen Sound and Greely Fiord are never completely free of ice and therefore have little influence on the climate of the study area.

Continental climates are characterized by warmer summers, colder winters and lower precipitation than experienced in maritime areas. Mean daily temperatures at Eureka range higher and lower than other locations in the northern Arctic Archipelago (Table 1). The warmer weather in the summer months accounts for the greater number of frost-free days at Eureka (66) compared to Alert (29) and Isachsen (27) (Table 1).

The drier climate of Eureka compared to other high arctic locations is evident in Table 2. Meteorological data collected at Expedition Fiord, Axel Heiberg Island (west of the Müller Icecap), show high precipitation values for summer months (Müller and Roskin-Sharlin 1967). A comparison with nearby weather stations shows that summer precipitation here is more than twice that at Eureka and Isachsen, and the estimated annual precipitation is more than three times higher than at Eureka (Nagel 1979). This indicates that the Princess Margaret Range intercepts much of the precipitation, creating a precipitation shadow effect in the study area east of the mountains.

A major factor influencing climate is the formation of a north-south oriented high pressure ridge in late winter. By April, this high pressure area spreads over the entire Arctic Archipelago and is associated with predominantly light winds and clear skies in April and May (Rae 1951). A drop in mean pressure occurs in June and July and low overcast stratus clouds are prevalent in the spring and summer months. Offsetting this is the fact that snowmelt is largely complete by this time throughout much of the archipelago and increased convection from solar heating of the ground surface results in a decrease in cloud cover (Rae 1951). Table 3 shows that the Eureka area receives less cloud

Table 1. Mean daily temperatures (°C) and mean days with frost for Eureka, Alert and Isachsen (1941-1970).

| Location | J | F | M | A | M | J | J | A | S | O | N | D | Average total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a) Mean daily temperatures | | | | | | | | | | | | | |
| Eureka | -36.6 | -37.2 | -36.7 | -27.6 | -10.1 | 2.3 | 5.5 | 3.6 | -7.7 | -21.8 | -35.7 | -34.8 | -19.3 |
| Alert | -32.1 | -33.3 | -33.0 | -23.6 | -24.4 | -0.6 | 3.9 | 0.8 | -10.1 | -19.7 | -26.1 | -29.8 | -18.0 |
| Isachsen | -35.1 | -36.4 | -34.4 | -25.6 | -11.7 | -0.8 | 3.1 | 1.1 | -8.8 | -19.4 | -28.2 | -32.5 | -19.1 |
| b) Mean days with frost | | | | | | | | | | | | | |
| Eureka | 31 | 28 | 31 | 30 | 31 | 13 | 2 | 11 | 30 | 31 | 30 | 31 | 299 |
| Alert | 31 | 28 | 31 | 30 | 31 | 25 | 15 | 23 | 30 | 31 | 30 | 31 | 336 |
| Isachsen | 31 | 28 | 31 | 30 | 31 | 26 | 17 | 22 | 30 | 31 | 30 | 31 | 338 |

Source: Atmospheric Environment Service (1975a).

Table 2. Mean monthly precipitation (mm) for Eureka, Alert and Isachsen (1941-1970).

| Location | J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a) Total precipitation | | | | | | | | | | | | | |
| Eureka | 2.8 | 2.3 | 1.5 | 2.0 | 2.8 | 3.8 | 13.0 | 9.2 | 10.2 | 6.1 | 2.8 | 2.0 | 58.4 |
| Alert | 7.6 | 5.1 | 7.1 | 5.3 | 10.2 | 13.5 | 18.0 | 27.4 | 27.9 | 15.8 | 8.1 | 8.1 | 156.2 |
| Isachsen | 2.3 | 2.3 | 2.3 | 3.8 | 9.1 | 7.6 | 21.1 | 21.8 | 15.5 | 9.9 | 4.3 | 2.3 | 102.4 |
| b) Precipitation falling as rain | | | | | | | | | | | | | |
| Eureka | 0.0 | 0.0 | 0.0 | 0.0 | T * | 2.3 | 12.5 | 7.6 | T * | 0.0 | 0.0 | 0.0 | 22.4 |
| Alert | T * | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 | 7.9 | 7.1 | 0.3 | 0.0 | 0.0 | 0.0 | 18.8 |
| Isachsen | 0.0 | 0.0 | 0.0 | 0.0 | T * | 2.3 | 15.2 | 15.2 | 1.5 | T * | 0.0 | 0.0 | 34.3 |

Source: Atmospheric Environment Service (1975b).

* T =trace amounts

Table 3. Incidence of cloud cover at Eureka, Alert and Isachsen (1941-1960).

| Location | J | F | M | A | M | J | J | A | S | O | N | D | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eureka | 3.8[1] | 3.8 | 3.5 | 3.9 | 4.7 | 5.7 | 6.5 | 6.6 | 7.4 | 5.4 | 4.2 | 3.2 | 4.9 |
| Alert | 4.2 | 3.8 | 4.3 | 4.4 | 5.6 | 6.2 | 6.8 | 7.7 | 7.5 | 6.2 | 4.9 | 3.7 | 5.4 |
| Isachsen | 4.2 | 4.4 | 3.7 | 4.9 | 6.8 | 7.7 | 7.5 | 8.2 | 7.9 | 7.3 | 4.9 | 4.5 | 6.0 |

Source: Atmospheric Environment Service (1968).
[1]Index related to fraction of time the sky is more or less covered with cloud.

cover than other locations in the archipelago, particularly in March, May and August.

Average wind speeds in the High Arctic appear to be somewhat less than at more exposed locations such as Sachs Harbour in the western Arctic and Resolution Island-Cape Warwick in the eastern Arctic (Table 4). Thompson (1967) noted the high incidence of calm conditions at high arctic locations during the period December to April. However, high winds can occur during periods of storms or passing cyclones. In addition, "foehn winds", characterized by relatively high temperature, low relative humidity and gustiness, occur as a result of prevailing winds passing over a mountain barrier (Andrews 1964). Sometimes associated with such foehn conditions is a phenomenon referred to as "anti-cyclone blocking". Members of the Jacobsen-McGill Arctic Research Expedition, who were located on the west side of Axel Heiberg Island, experienced the effects of this weather pattern in August 1961 when storm winds reached a strength of almost 100 kph. As a consequence, the expedition's Piper Super-Cub, which had been anchored down with 500 kg weights attached to each of its wings, was blown over onto its back and completely wrecked (Müller and Roskin-Sharlin 1967). Visitors to a park established in the study area should therefore be advised of the possible occurrence of such wind phenomena.

The frequency of fog and reduced visibility, due to blowing snow in the study area, was evaluated from a sample of five years of data collected at Eureka (Atmospheric Enviromnent Service 1959-63). Table 5 shows that fog and blowing snow occur considerably less often than at other high arctic locations. The summer months, when the area would receive the greatest number of visitors should a national park be established, are virtually free of fog and blowing snow, thus providing easy access by aircraft from points south and unimpeded movement within the park.

Table 4. Comparison of average wind speed (kph) at Eureka, Alert, Isachsen, Sachs Harbour and Resolution Island-Cape Warwick (1955-1972).

| Location | J | F | M | A | M | J | J | A | S | O | N | D | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eureka | 10.5 | 9.3 | 8.5 | 9.7 | 13.4 | 17.1 | 17.5 | 10.6 | 11.6 | 9.7 | 8.7 | 8.5 | 11.6 |
| Alert | 9.7 | 9.3 | 7.4 | 7.9 | 9.0 | 10.6 | 12.4 | 10.8 | 10.6 | 11.3 | 8.9 | 9.3 | 9.8 |
| Isachsen | 17.2 | 15.1 | 13.7 | 12.6 | 17.4 | 19.6 | 17.2 | 17.4 | 16.9 | 14.5 | 13.0 | 15.0 | 15.8 |
| Sachs Harbour | 18.7 | 18.0 | 18.7 | 20.9 | 20.8 | 20.9 | 21.1 | 21.7 | 23.5 | 24.3 | 20.3 | 20.0 | 20.8 |
| Resolution Island-Cape Warwick | 41.4 | 41.4 | 38.9 | 34.6 | 31.2 | 32.7 | 28.0 | 31.1 | 35.4 | 36.7 | 36.1 | 40.1 | 35.6 |

Source: Atmospheric Environment Service (1975c).

Table 5. Mean number of days with fog and blowing snow at Eureka, Alert and Isachsen (1959-63).

| Location | J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a) Days with fog | | | | | | | | | | | | | |
| Eureka | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 4 | 1 | 1 | 0 | 9 |
| Alert | 1 | 0 | 0 | 0 | 3 | 6 | 5 | 10 | 8 | 4 | 2 | 1 | 39 |
| Isachsen | 3 | 3 | 5 | 4 | 3 | 6 | 5 | 7 | 10 | 7 | 5 | 2 | 59 |
| b) Days with blowing snow | | | | | | | | | | | | | |
| Eureka | 4 | 7 | 1 | 3 | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 5 | 26 |
| Alert | 5 | 5 | 1 | 2 | 1 | 0 | 0 | 1 | 3 | 4 | 5 | 6 | 36 |
| Isachsen | 15 | 13 | 9 | 7 | 6 | 0 | 0 | 1 | 5 | 9 | 8 | 14 | 89 |

Source: Atmospheric Environment Service (1959-63).

# 3. PHYSIOGRAPHY

Axel Heiberg Island, the third largest of the Queen Elizabeth Islands, is physiographically and geologically closely related to Ellesmere Island, from which it is separated by Eureka and Nansen sounds[1]. The island is dominated by a central mountainous region that is nearly completely covered by icefields and glaciers. The highest peak is just over 2200 m. To the east, the mountains pass into a region of ill-defined low uplands, small plateaus, and lowlands, with several escarpments and isolated mountains that flank the shores of Eureka Sound. The study area lies in this complex uplands area, east of the main mountain chain. Roots (in Fortier et al. 1963) divided the area into two major subdivisions, the Ridged Uplands and the Eureka Sound Uplands. A third physiographic subdivision, Dissected Plateau, lies to the west, but outside the study area (Map 2).

## 3.1 Ridged Uplands

This area consists of a range of mountains extending in a north-south direction. The ridges are often broad, widening into upland surfaces of irregular extent. A well-developed trellis drainage pattern is evident, with short, but fast-flowing creeks originating on the ridges at regular intervals. The valley walls are often steep (Fig. 1), and the steep mountains rising from the sea form a spectacular scenery (Fig. 2). The mountain chain is cut by Buchanan Lake, but it continues to the northwest with about the same altitude, but generally lowering relief. The highest peaks reach about 1300 m above sea level, occurring both northwest and southeast of Buchanan Lake. A few small, isolated icecaps occur on the highest peaks, but the ice accumulation is not sufficient to sustain glacier flows.

## 3.2 Eureka Sound Uplands

This area consists of generally low, but varied topography, drained by a well-developed dendritic pattern of streams. The major streams originate in the glaciers reaching down from the mountains in the west. Three main physiographic elements can be recognized, occurring interspersed with one another: rolling uplands, low mountain ranges, and broad lowlands.

The main element in this physiographic unit is a rolling upland that occurs generally below the 300-m contour. The relief is generally less than 75 m, with broad valleys and low ridges (Fig. 3), although some streams may be incised to a greater depth.

The rolling uplands are interrupted by low mountains that have peak elevations between 550 m and 840 m. These areas may consist

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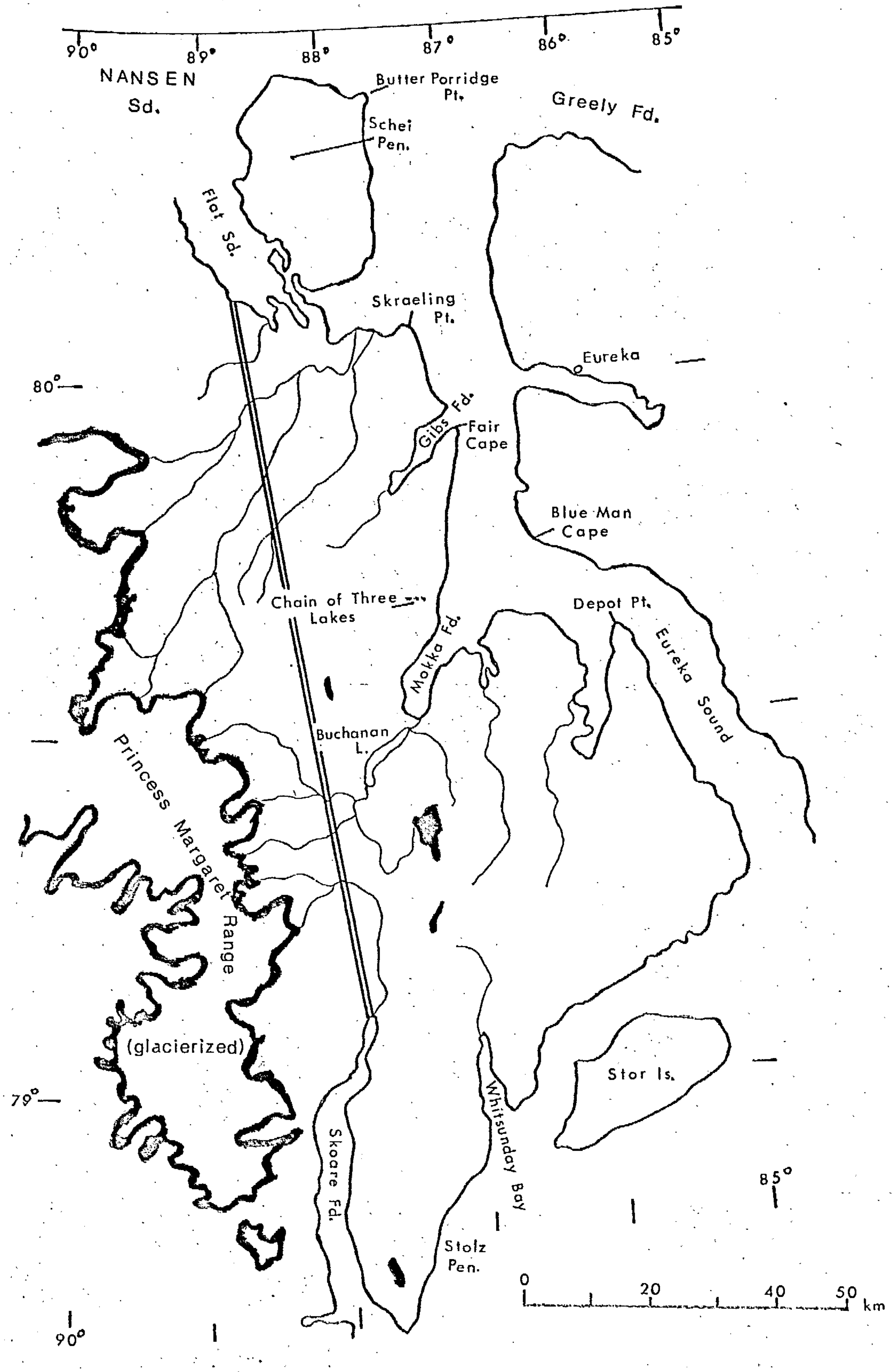
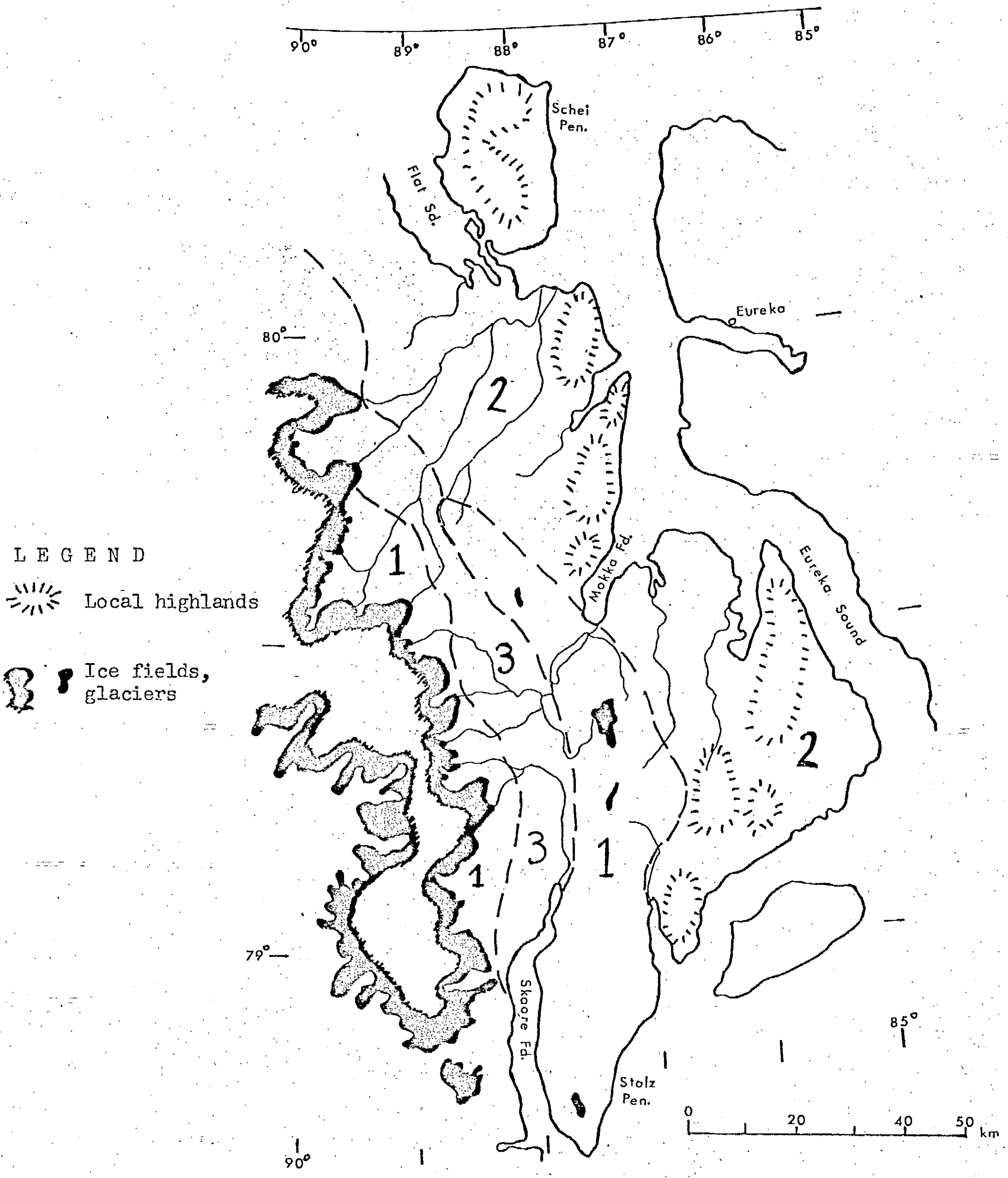
[1]Locations of places referred to in this report are shown in Map 1.




Map 1. The study area, showing named topographic features.




Map 2. Physiographic subdivisions of eastern Axel Heiberg Island.
1 - Ridged Uplands
2 - Eureka Sound Uplands
3 - Dissected Plateau

Figure 1. Deeply incised valley south of Buchanan Lake.

Figure 2. Mountainous coastline of Whitsunday Bay.

Figure 3. Gently rolling terrain with low sandstone scarps.

Figure 4. Steep highlands of Schei Peninsula.

of single peaks, or mountainous chains up to 25 km long. Although the elevations are not high, steep rocky cliffs are abundant (Fig. 4). A dramatic peak is a dome-shaped gypsum hill that rises some 400 m from the surrounding plain (Fig. 5). The regular shape and the strongly eroded slopes of this mountain form an unmistakable landmark.

The third element of this physiographic unit is characterized by low relief. Flat, featureless plains extend for long distances south of Schei Peninsula and in other low-lying areas. Poorly drained lowlands, some with small ponds are frequent.

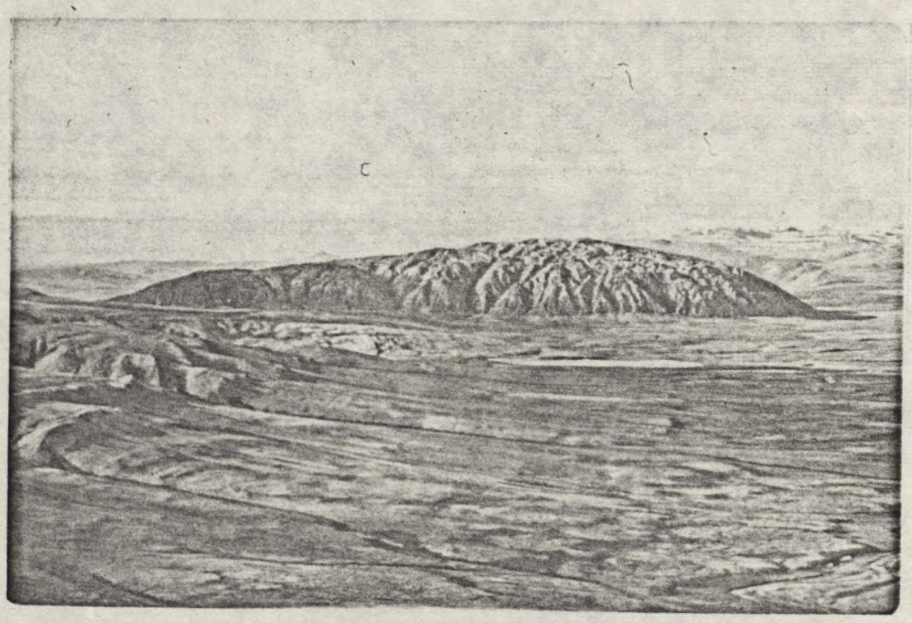


Figure 5. Dome-shaped gypsum hill west of Mokka Fiord.

Figure 6. Gypsum diapir with characteristic erosion pattern.

# 4. BEDROCK GEOLOGY

Most of Axel Heiberg Island and all of the study area are stratigraphically in the sedimentary Sverdrup Basin, and structurally within the Eureka Sound fold belt (Fortier et al. 1963). The stratigraphic units range from the Permo-Carboniferous, through the Mesozoic into the Tertiary and constitute a conformable sequence of marine and non-marine deposits. Volcanic basic flows are of Permo-Carboniferous and Cretaceous ages.

All formations were folded simultaneously and the orogeny took place in the Tertiary, as even the early Tertiary Eureka Sound formation was folded along with the older formations. Gypsum of Permo-Carboniferous age was deformed and intruded into younger rocks following the intense period of orogeny during the Tertiary.

The geology of Axel Heiberg Island was intensively studied in the 1950s and 60s. The following account is based on the reports (Fortier et al. 1963, Tozer 1963, Thorsteinsson 1974) and maps (Thorsteinsson 1971a, 1971b, Thorsteinsson and Trettin 1972) resulting from these studies (Map 3).

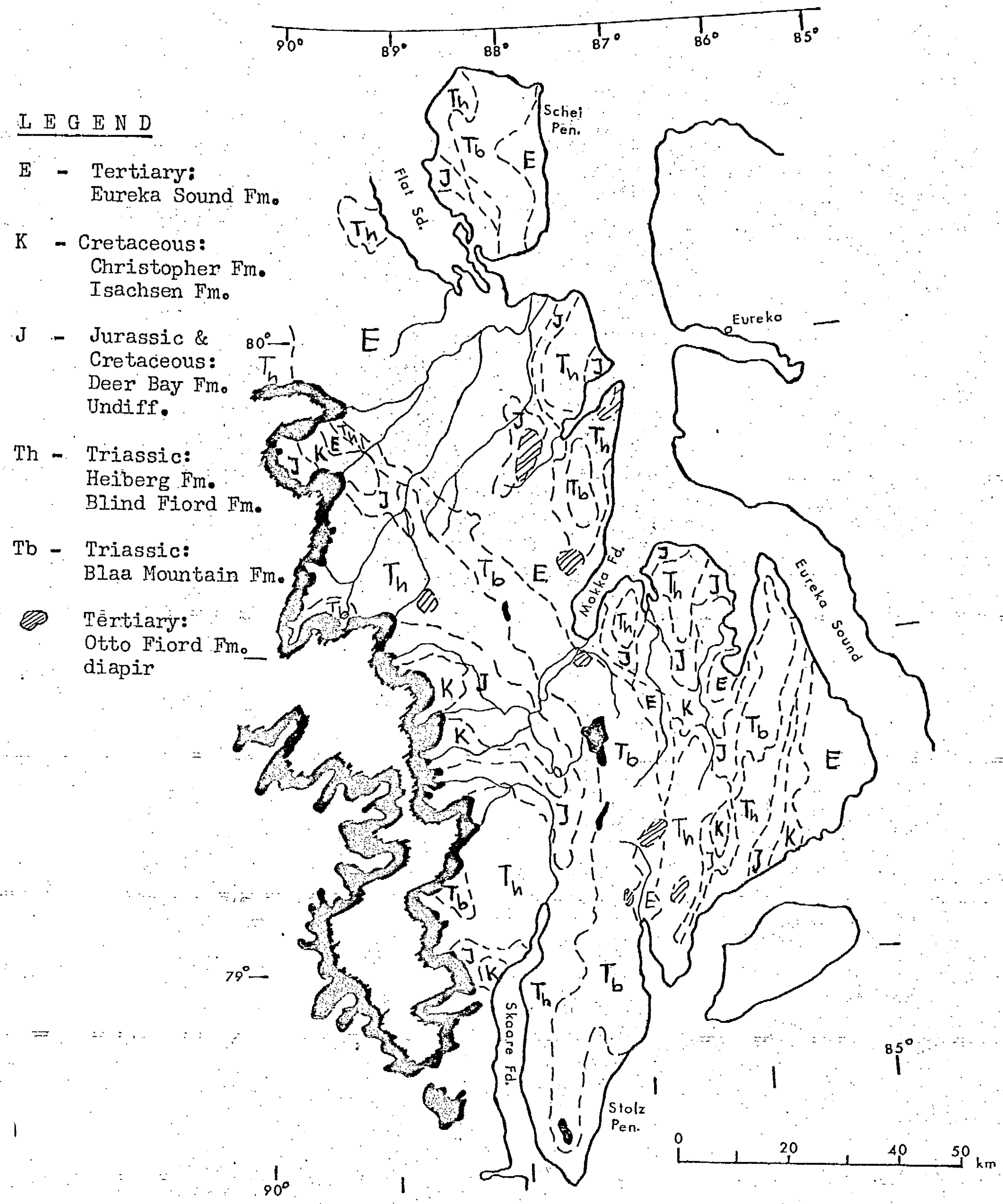
## 4.1 Stratigraphy

Most formations encountered in the study area on the surface or in sections are of sedimentary origin of Paleozoic, Mesozoic, and Cenozoic age. The following discussion lists the most common formations in order of age, beginning with the oldest.

### 4.1.1 Carboniferous and Permian

The Otto Fiord Formation consists of anhydrites and their alteration product, gypsum. It varies in thickness from 40-300 m. The striking white colour of this formation is a useful identification characteristic. This formation supplied the source materials for the diapirs that intruded the overlying younger formations during the Tertiary period. The relatively light and somewhat plastic anhydrite was squeezed by the weight of the overburden toward the surface following the mountain building episodes during the Tertiary. Later erosion removed much of the covering materials, exposing the intruded masses to the surface. The diapiric intrusions can be of huge proportions: most are 5-8 km in diameter and range up to 400 m in height. The regular dome of the Mokka Fiord diapir is a truly impressive sight (Figs. 5, 6). The material is gypsum, ranging in composition from fine crystals to large, translucent selenite crystals. Although readily dissolved by water, the gypsum bodies are tough and strong, especially the very compact alabaster.

The Hare Fiord Formation, while present in some sections, is exposed only in very limited areas on eastern Axel Heiberg Island. It ranges in thickness between 30 and 1250 m, consisting of siltstone,




Map 3. Bedrock geology of eastern Axel Heiberg Island

shale, and limestone. The Van Hauen Formation is similarly seldom exposed on the surface in the study area. In exposures its thickness is 70-400 m, consisting of non-calcareous siltstone, sandstone, and shale.

#### 4.1.2 Triassic

Triassic formations form the backbone of all highlands. The oldest Triassic formation, the Blind Fiord Formation ranges in thickness from 140 m to 1200 m. It is composed of light to dark grey siltstone, some fine-grained sandstone, and dark grey, fissile shale. Some shales and a few of the siltstones are slightly calcareous or dolomitic.

The Blaa Mountain Formation occurs in the highest parts of the mountain ranges. It may reach 2500 m in thickness, and it is composed of black shale, interbedded with sandy siltstone and intruded by numerous diabase sills.

The overlying formation, the Heiberg Formation, reaches a thickness of 1400 m and consists of light grey to reddish brown sandstone and minor dark grey shale. It frequently contains gabbro sills. These relatively hard rocks often form steep slopes, usually covered by frost-shattered rubble (Fig. 7).

#### 4.1.3 Jurassic

The Savik Formation is about 90 m thick at its type location. It consists of black pyritic shale that is soft, crumbly, and easily erodible (Fig. 8). The overlying Awingak Formation is some 300 m thick, consisting of shale and sandstone members of non-marine origin. The sandstone members are light brown, poorly consolidated fine- to medium-grained, grading into massive-bedded quartz sandstones. The fine-grained sandstone occasionally contains coalified plant remains.

The Deer Bay Formation was laid down in the Upper Jurassic and Lower Cretaceous periods in a marine environment. It varies in thickness from 260 m to 850 m, and is composed of shale, with minor siltstone, sandstone, and mudstone. The shale is dark grey, with small calcareous concretions and thin beds of ferruginous mudstone.

#### 4.1.4 Cretaceous

The sandstones of the Isachsen Formation are remarkably uniform throughout the area. They consist of soft, yellowish-grey, coarse-grained, quartzose sandstone, with lenses of pebble conglomerate. All Isachsen sands are loosely cemented with little or no evidence of compaction or fracturing. Despite their softness, the sandstones are prominent cliff-formers (Figs. 9, 10). A measured thickness of this formation was recorded at 210 m, but may reach 300 m locally. Carbonized plant remains and petrified wood is common, indicating deposition in a terrestrial environment. A 2-m thick seam of bituminous coal was found in an exposure west of Buchanan Lake.

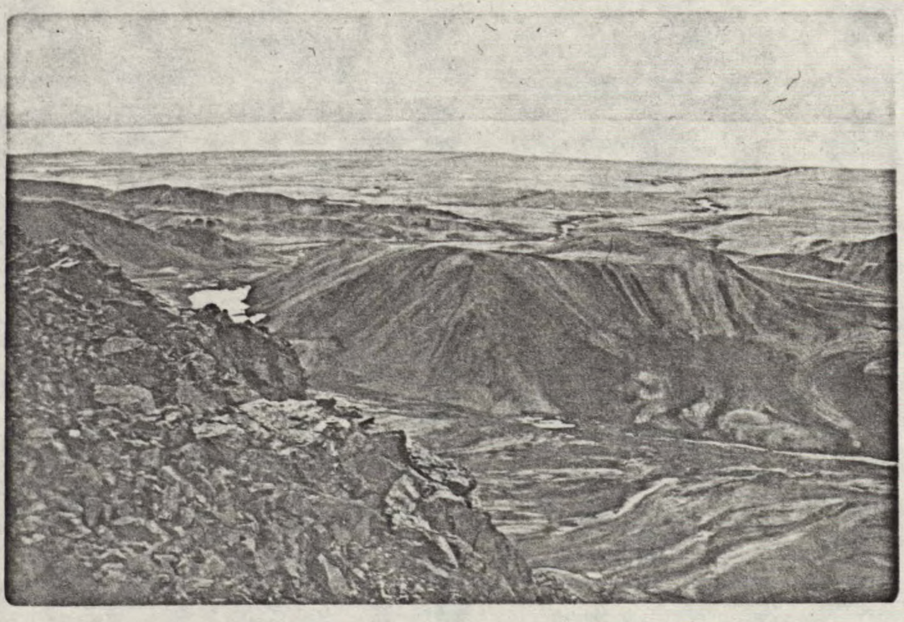


Figure 7. Frost-shattered sandstone on a peak, Schei Peninsula.

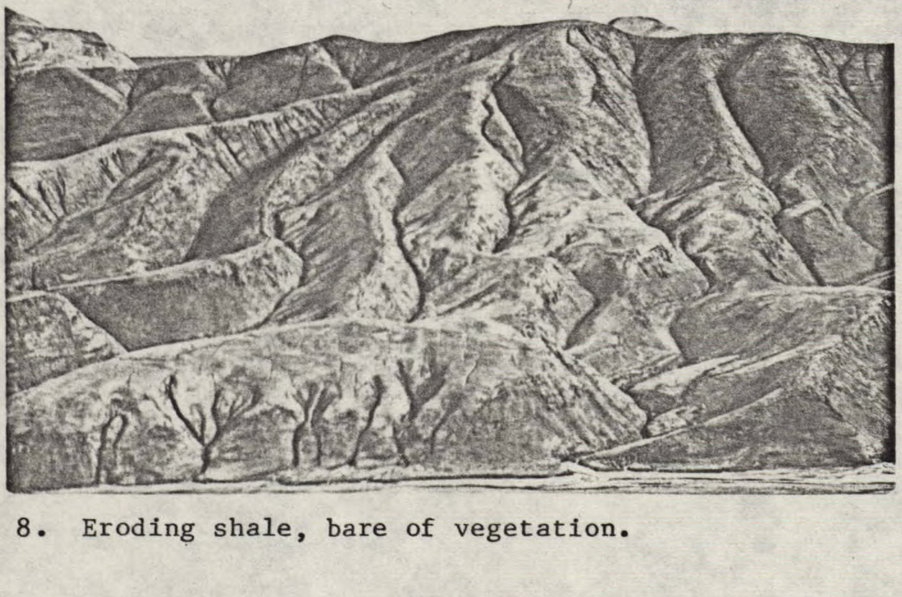


Figure 8. Eroding shale, bare of vegetation.

Figure 9. Highly sculptured cliffs of Isachsen sandstone.

Figure 10. Isachsen sandstone often forms picturesque cliffs.

The Christopher Formation is approximately 900 m thick, comprising dark grey, in part calcareous shale. Siltstone concretions are abundant, especially in the lower part of the strata. In some areas quartzose sandstone members are included. In general, these marine shales are poorly consolidated and erode readily.

The Hassel Formation is poorly indurated, fine-grained sandstone. In some locations there is an upper member, consisting of black shale. The thickness of the formation is variable between 300 to 450 m. Gabbro sills are often present. The sandstone is generally a dark grey color, but grades through light grey to light greyish green, resulting in colorful bands of exposed beds (Fig. 11).

The Kanguk Formation consists of up to 360 m thick beds of bentonitic shale. It is generally light grey, but locally red colours occur. It is not indurated, except for red calcareous concretions. Fossils found in the shale indicate a marine depositional environment.

#### 4.1.5 Tertiary

The Eureka Sound Formation is the youngest stratigraphic unit. Its measured thickness is 2500 m, consisting primarily of yellowish grey to yellowish brown sandstone and siltstone. Minor beds of shale, mudstone, and coal are common. The rock is a moderately well indurated, quartzose sandstone. Irregular bedding planes, crossbedding, and graded bedding indicate a fluvial depositional mode, but some marine strata have been identified on the basis of fossils (West et al. 1975). Carbonized debris and coal beds are common (Fig. 12).

#### 4.1.6 Intrusive Rocks

Sills and dykes of intrusive diabasic gabbro are widespread and locally abundant on the study area. Sills (intrusions between beds) and dykes (intrusions across beds) are known to be present in rocks of all ages, although they are not all of the same age. Some intrusions took place after the Eurekan orogeny and are hence of Tertiary age, but the majority are older. The most common intrusive rocks are the Strand Fiord Formation that overlies the Cretaceous Hassel Formation.

The rocks vary from crystalline, fine-grained basalt to coarse-grained gabbro. The total thickness of the sills is variable, they commonly range between 85-160 m. Well-developed dykes were noted at the north end of Stolz Peninsula, where several subparallel dykes extend for about 10 km. These dykes are about 50 m wide. Because they are more resistant to erosion than the sedimentary rock they cut, the dykes protrude up to 40 m above the surroundings, appearing as massive walls. Sills commonly form scarps (Fig. 13) or caps over more readily erodible sedimentary rocks (Fig. 14).

Figure 11. Alternating layers of sandstone in Cretaceous formations.

Figure 12. Coal beds in folded Eureka Sound Formation. Red color in foreground was caused by burning coal beds.

Figure 13. Diabase sills are marked by low scarps at the base and near the top of the slope.

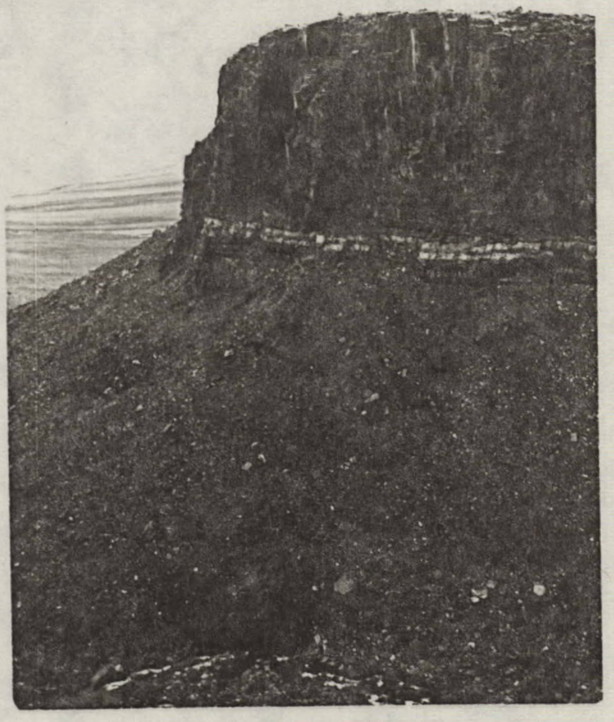


Figure 14. Erosion resistant gabbro forms a cap over softer sediments.

## 4.2 Economic Geology

No minerals have been identified on the study area. The abundant coal measures induced the exploration of natural gas and oil.

### 4.2.1 Coal

Coal seams were noted in the Isachsen Formation, but they are particularly abundant in the Eureka Sound Formation, outcropping over large portions of the study area (Map 3). The coal seams are generally less than one metre thick, but a few exceptionally thick seams reach 4-5 m (Bustin 1980). The coal often contains clay and sand, with ash content ranging as high as 30%. Bustin (1980) examined the quality of the coal. He found that the rank of the coal varies from sub-bituminous to highly volatile bituminous coal. It was found that the bituminous coal occurs near thrust faults and diapir bodies, where the heat generated by faulting or diapirism raised the rank of the coal (Bustin et al. 1977). It was estimated that eastern Axel Heiberg Island, including the Flat Sound area outside the study area, contains 4000 million tonnes of sub-bituminous coal, 5000 million tonnes of lignite, and 300 million tonnes of highly-volatile bituminous coal (Bustin 1980).

### 4.2.2 Oil and Gas

There are no known oil or gas reserves within the study area. However, favourable conditions exist within the Sverdrup Basin, where productive areas have been found. Within the study area, the Eurekan folds and associated piercement domes provide possible structural traps for petroleum. During the coalification of the Eureka Sound sediments, gas and oil may have been generated, but in the absence of suitable impervious capping material these probably escaped (Bustin et al. 1977).

### 4.2.3 Gypsum

Gypsum and anhydrite occur on the surface in massive quantities in diapiric piercement domes. The remoteness of these materials from markets makes their exploitation uneconomic at this time. The commercial potential of very compact alabaster that resembles porcelain (Roots in Fortier et al. 1963) has not been investigated.

# 5. QUATERNARY GEOLOGY

The Quaternary geology of Axel Heiberg Island has not been studied in a comprehensible manner. Localized information indicates the occurrence of at least two former glaciations, each accompanied by a marine transgression. Existing glaciers cover about a quarter of the island, but only a small portion of the study area.

Most information is derived from the expedition reports of McGill University which centered on Expedition Fiord on the western side of the island. In the following discussion much of this data is used, supplemented by other sources and by the data collected during our field survey.

## 5.1 Pleistocene History

Evidence of former glacierization is based mainly on erosional landforms and glacial erratics. In the High Arctic glaciers are often cold-based and hence the sediment load carried by them is minimal compared to temperate glaciers (Boesch 1963). Consequently, the deposition of glacier-transported debris (till) is usually discontinuous. Nevertheless, glacial transport can be demonstrated by the presence of rocks foreign to the area (erratics).

The highest peaks and uplands in the study area do not show any signs of glaciation. Frost-shattered and weathered rocks occur on these surfaces which are free of erratics. Tors (erosional bedrock remnants) are common on ridges and valley rims (Fig. 15), consisting of highly weathered diabase and gabbro (Rudberg 1963). Such fragile forms which represent great antiquity would certainly not survive erosion by moving glaciers. The absence of any glacial deposits and erosional features was particularly noted west of Buchanan Lake (Souther in Fortier et al. 1963), where the valleys are V-shaped, indicating the absence of glacial erosion.

Scarce till and subrounded erratics are found on the western part of the island at elevations up to 600 m ASL, and in one instance up to 800 m (Rudberg 1963), indicating an extensive glaciation that once covered the lowlands up to an elevation of 600 m above present sea level. A subrounded gabbro erratic was found during the field survey on the summit of the diapir dome west of Mokka Fiord at an elevation of about 640 m. This indicates that glaciation affected the eastern part of the island up to an elevation of at least 640 m. Granitic erratics were found at two locations, both at an elevation of 155 m and at the same elevation on Fosheim Peninsula (Map 4), just below the marine limit. Granitic erratics were also reported from Schei Peninsula (Rudberg 1963) and from south of Schei Peninsula (Prest 1970). The source area for these erratics was probably eastern Ellesmere Island, however, their mode of deposition is unknown since they occur at or below the marine limit which may indicate transport by floating icebergs or sea ice, rather than by glaciers.

Figure 15. Tors on a valley rim, composed of weathered diabase.

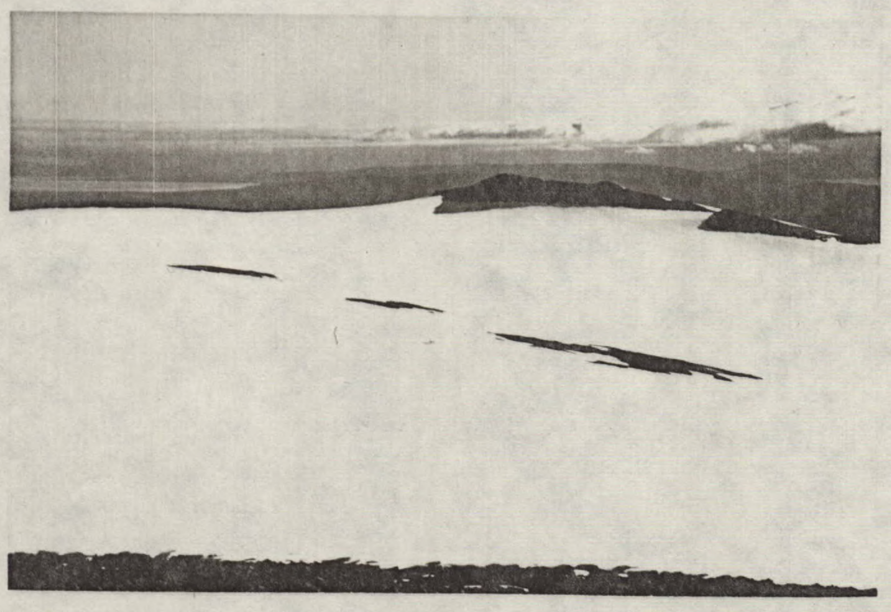
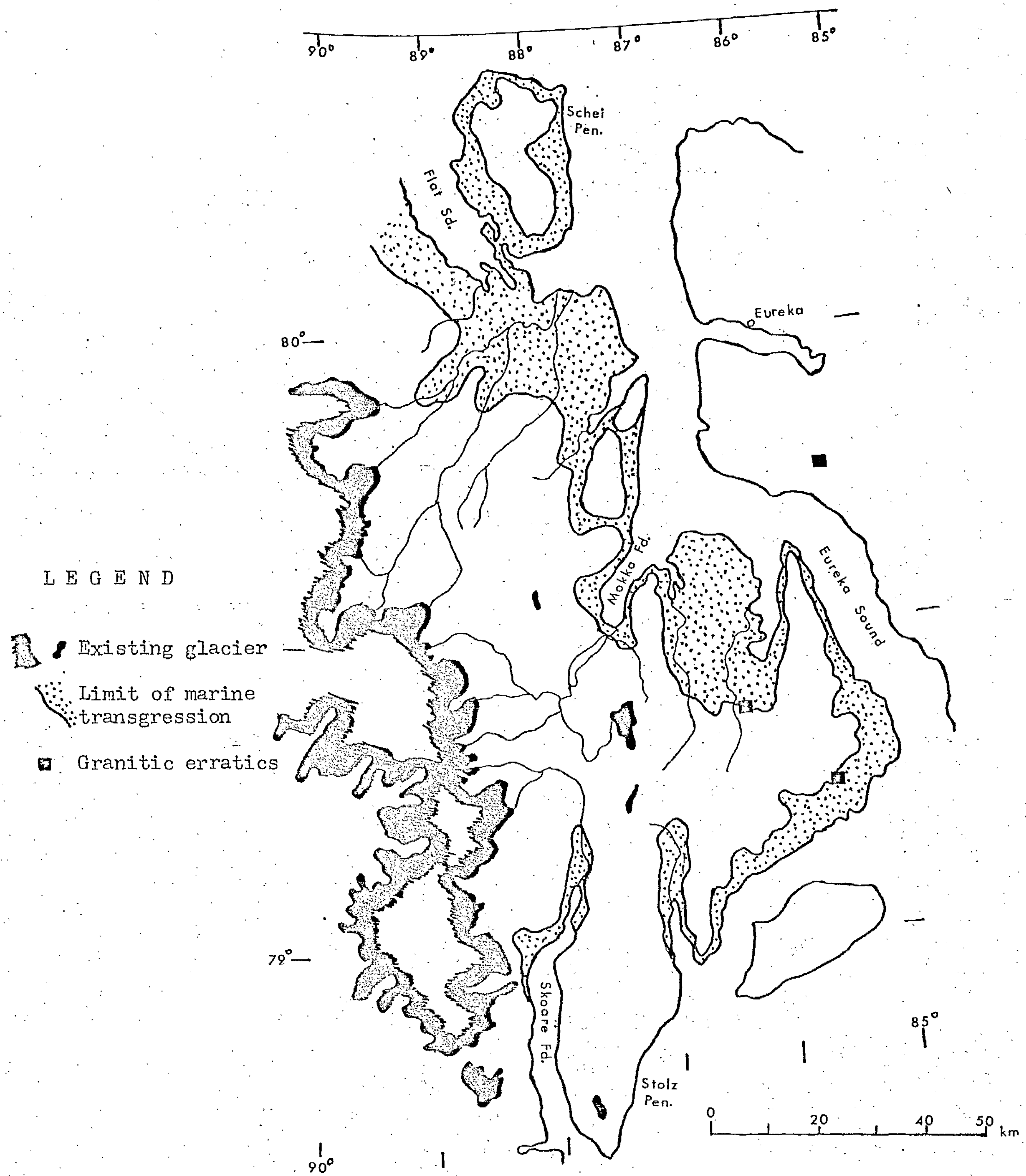


Figure 16. Ice field on the Princess Margaret Range, with snow-free nunataks.




Map 4. Limit of high level marine transgression on eastern Axel Heiberg Island.

Marine deposits were found on the eastern lowlands of Axel Heiberg Island, up to the 155 m level (Map 4). Marine shells were found at both the east and west end of the most westerly lake in a chain of lakes north of the Mokka Fiord diapir. Between these lakes and Flat Sound a large lowland occurs, composed of massive silt and sand, interpreted as near-shore marine deposits. Elsewhere, south of the fiord at Depot Point, and on the easternmost part of the island, marine deposits can be found up to an elevation of 150 m. A faint shoreline is also perceptible, indicated by a break in the erosion pattern at about 155 m. It is possible that this marine submergence was the product of the early, extensive glaciation. The age of the early glaciation is not known, but the maturity of the landscape covered by the early glaciation suggests a great age. Marine shells found at 115 m ASL in northern Axel Heiberg Island and at 120 m across Nansen Sound on northern Ellesmere Island were dated at 36,000 and 38,000 years BP (England 1976). These dates would place the high marine submergence in the early Wisconsinan or in an even earlier period.

Conflicting evidence to this perspective, however, is provided by the age of marine shells from the 150 m level on Schei Peninsula (8080 years) and from the 110 m level at Eureka (9550 years) (Müller 1963a). Acceptance of these dates would raise a question about the lack of corresponding marine features from the thoroughly studied western part of Axel Heiberg Island. If the Holocene dates (i.e. less than 10,000 BP) are dismissed as being anomalous and an early Wisconsinan (or older) age is accepted for the highest shorelines, then the lack of high-elevation marine features on western Axel Heiberg Island can be explained as being due to overriding by a later, late-Wisconsinan ice.

Signs of another, more recent glaciation were found in western Axel Heiberg Island. Well-preserved glacial striae (bedrock scored by moving ice) were found below an elevation of 250 m, indicating an advance from the central part of the island (Rudberg 1963). On the eastern part of the island no such evidence is present, but it is highly likely that a glacial advance took place toward the lowlands.

Faint beaches were noted on the east and west side of Schei Peninsula at an elevation of about 75 m ASL. In many cases a series of fresh-appearing beaches reaches down to the present sea level. Marine beaches were also found on the western side of the island. Mollusk shells were dated from various elevations; shells from the highest beach at 80 m yielded an age of 9000 years BP (Müller 1963a). This date indicates that this marine transgression followed the late-Wisconsinan glaciation.

## 5.2 Present Glaciation

About 27%, or 11 735 km$^2$ of Axel Heiberg Island, is presently covered by glacial ice, representing some 3221 km$^3$ of ice (Ommanney 1969). In the study area, however, only 12 small galciers occur, covering a total of 10.9 $km^2$, with a total volume of less than 0.2 $km^3$. All but one of these are remnants of earlier ice caps. Only the Buchanan Lake Ice Field has an appreciable accumulation zone. The accumulation area ratio, an indicator of the mass balance of glaciers, shows that ablation far exceeds accumulation for all 12 glaciers in the study area. Even in the most favourably situated glacier, the Buchanan Ice Field, the ratio is 57%, which is far short of a ratio of 75% necessary for the maintenance of glaciers (Ommanney 1969).

The highlands west of the study area are covered with ice fields (Fig. 16) from which mountain peaks protrude as nunataks. From these ice fields glaciers extend eastward along valleys, but fail to reach the study area. Extensive studies on the White and Thompson glaciers (Adams 1966, Müller 1963b) and on the Müller Ice Cap (Müller 1963c) showed that considerable variation exists in ablation rates in different years. Thus in 1960-61, the White Glacier showed a small gain of $1.9x10^6$ $m^3$, but large losses in 1959-60 ($15.4x10^6$ $m^3$) and very large losses in 1961-62 ($28.4x10^6$ $m^3$) resulted in a large net loss in three years. On the Müller Ice Cap, a mean annual mass gain of 37.1 g (of water equivalent) per $cm^2$ was obtained for a 41 year period (Müller 1963c).

The mass balance of glaciers is controlled by precipitation and summer melting. The equilibrium line divides a glacier into an accumulation and an ablation area. Over a long period of time the equilibrium line altitude approaches a steady-state value, if the climate remains stable. The equilibrium line altitude in eastern Axel Heiberg Island at 800-1000 m is high when compared to the western side of the island where it is 300-400 m (Miller et al. 1975). This disparity is partially due to the precipitation-shadow effect caused by the Princess Margaret Range (Miller et al. 1975) and to the long melt season (Bradley and England 1978).

Changes in the climatic pattern influence both the ablation rate and precipitation amounts. It has been found that the mean July temperature decreased in the Canadian Arctic by 1.1 to 2.7°C since 1964 (Bradley and England 1978). Although the precipitation decreased somewhat during this period at Eureka, these changes caused a reduction of the net losses of glaciers. However, such a change in the regimen of glaciers is not immediately manifested by an advance of the glaciers. Ice masses whose margins are sustained by the continous movement of ice from the accumulation zone down into the ablation zone have a time lag in response to climatic change. For large ice caps, 50 to 150 years may elapse before a climatic fluctuation becomes noticeable at the margin (Miller et al. 1975).

Aerial photos show that most glaciers are shrinking in the study area, as indicated by light-coloured, lichen-free areas adjacent to glaciers and perennial snowbeds. Similar lichen-free areas were noted around the glaciers reaching eastward from the highlands. In one case a lowering of ice level by about 25 m is indicated in a small ice lobe (Fig. 17). A similar lichen-free zone of about 50 m in width is apparent around the terminus of a large outlet glacier (Fig. 18). This shrinking of glaciers, however, is not marked by moraines, as the sediment load of the glaciers is very limited. Furthermore, vegetation and patterned terrain continue right up to the glacier ice, indicating a stable glacier front. This may suggest that although recent thinning of the icefields has occurred, the termini of the outlet glaciers may be as far advanced today as they have been during the postglacial period, as is the case in northern Ellesmere Island (England 1978). This conclusion is indicated by organic material which is emerging from sediments overridden by the Thompson Glacier (Müller 1963a). Willow bushes and graminoid rhizomes were radiocarbon dated at 6200 years before present. Driftwood from beneath the margin of Thompson Glacier was dated at 5480 and 5920 years old. This indicates that the climate was less favourable for glaciers about 6000 years ago than at the present and that a climatic deterioration after that led to their advance.

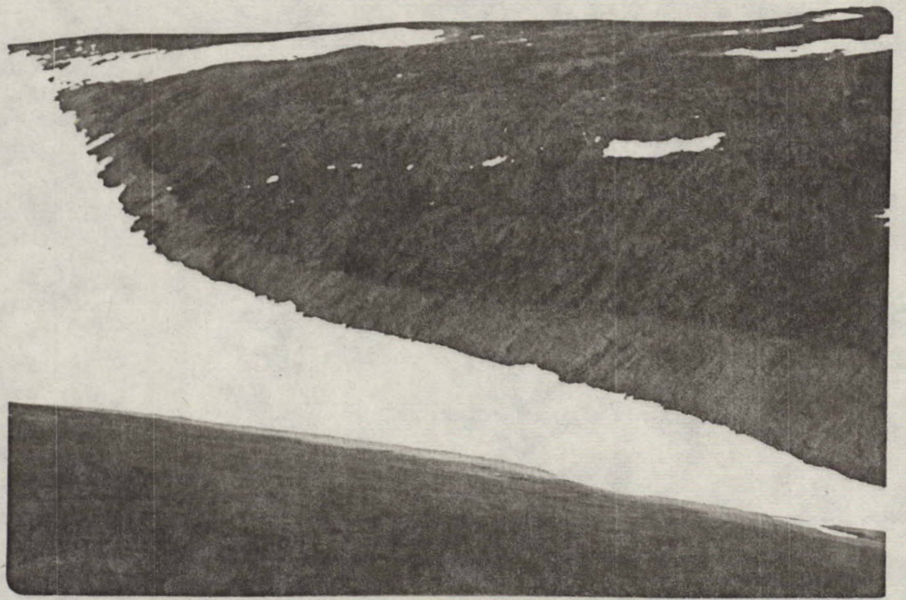


Figure 17. Thinning of a glacier is indicated by a light-colored, lichen-free zone.

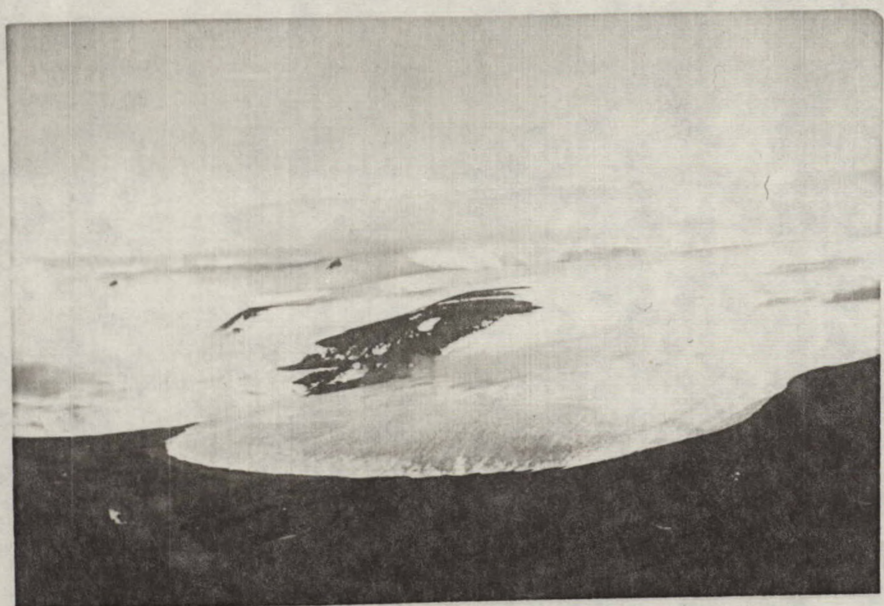


Figure 18. Lichen-free zone indicates recent retreat of the large outlet glacier.

# 6. PERMAFROST AND PERIGLACIAL PHENOMENA

The severe climate creates conditions peculiar to polar regions. The ground remains frozen throughout the year, forming permafrost. Frost action continuously affects the surface materials, forming various patterned gound.

## 6.1 Permafrost and Active Layer

Permafrost underlies all land surfaces. The thickness of the frozen layer is not known, but it certainly amounts to several hundreds of metres. The ice content of the permafrost is variable. Ice-rich permafrost is found near the surface in fine-grained soils having imperfect to poor drainage. Under such conditions the moisture content of the soil exceeds 100% by weight, showing that a large excess of moisture is stored in the soil. If exposed to thawing, such soil would turn into mud.

Ice accumulation is present in some soils in the form of ice wedges. These wedges are up to 1 m wide at the top, and extend two or more metres into the gound. They are commonly present in coarse to medium-grained soils and in wet depressions. In such areas 5-10% of the land surface is underlain by ice wedges.

The seasonally thawed surface layer, the active layer, varies in thickness at its maximum development according to different soil materials and vegetation cover. The thickest active layer is found in gravel at 95 cm. In well drained sand, the active layer varies between 60 and 80 cm, with the shallower thickness under better-vegetated moist patches. In the clay, loam, or fine sand materials, the thickness of the active layer is 50-65 cm, again varying with vegetative cover. Under a fully vegetated meadow turf, the permafrost table occurs within 45 cm of the surface.

## 6.2 Patterned Terrain

Intensive frost action and numerous freeze-thaw cycles initiate processes in the ground that result in frost heaving and churning of the soil (cryoturbation). Various surface forms are attributed to frost action, collectively known as patterned terrain.

### 6.2.1 Nonsorted Pattern

Patterned terrain developed by frost churning of the ground is not common in the study area, but locally it can be abundant. Three different kinds of nonsorted patterns were identified: earth hummocks, mudboils, and mini-mounds.

Earth hummocks (Tarnocai and Zoltai 1978) are nonsorted circles that develop on fine-grained soil materials. They are characterized by regularly-spaced mounds of about 1 m in diameter and 40 cm in height

(Fig. 19). Internally, they show signs of intensive cryoturbation in the form of smears of organic matter that appear to originate in the outer rim, extending inward. Earth hummocks always occur on clay to clay loam soils, in areas of poor drainage. They are fully vegetated, although the vegetative mat is often disrupted by cracks caused by frost heaving.

A second type of nonsorted circle is the mudboils (Zoltai and Tarnocai 1981). They are roughly circular, but may be elongated downslope (Fig. 20). They are 1-1.5 m in diameter, but their height is less than 20 cm. They occur in loamy sand materials that are imperfectly drained. A slight evidence of sorting may occur, as stones are often more prominent in the inter-boil depressions than on the mudboils. Internally, cryoturbation is indicated by the downward extension of soil horizons in the inter-boil depressions, and by the presence of unaltered parent material in the center of the mudboils.

A third kind of nonsorted pattern can be termed as mini-mounds. These are generally small (30-40 cm diameter), but high (20-30 cm) mounds developed on moderately steep slopes (Fig. 21). They occur in stone-free fine sands of aeolian, marine, or colluvial origin. Internally, they do not show signs of cryoturbation. They are believed to have originated as frost or desiccation cracks that were deepened by erosion on the slopes. Dense mats of Dryas usually cover them, helping them to preserve their shape by hindering further erosion.

6.2.2 Polygonal Pattern

Large polygonal pattern can be observed throughout the study area. The polygons have various shapes, but most have four to six sides. The average diameter is 15-20 metres. Polygons are formed when the intensely cold ground contracts during the winter, opening cracks that may be several metres deep. Condensation, melting snow accumulates in the cracks, freezing as the permafrost is reached. Eventually ice wedges develop in the cracks. Each side of a polygon is therefore underlain by an ice wedge.

Polygonal pattern has developed on two distinctly different terrain types: lowlands and uplands. In the lowlands, poorly drained depressions show polygonal pattern. Usually, there is a thin (25-40 cm) peat in these wet depressions. As the ice wedge grows, soil is displaced and pushed aside into ridges (Fig. 22). The ridges enclose small pools, or very wet fens.

In the uplands, the polygons are about the same size as those in the lowlands. They occur mainly in coarse-textured materials, such as gravel, sand, or sandy loam. The pattern consists of a network of polygonal trenches, enclosing somewhat elevated centers. The trenches are usually well-vegetated, but the centers may be bare (Fig. 23).

Figure 19. Well-vegetated earth hummocks.

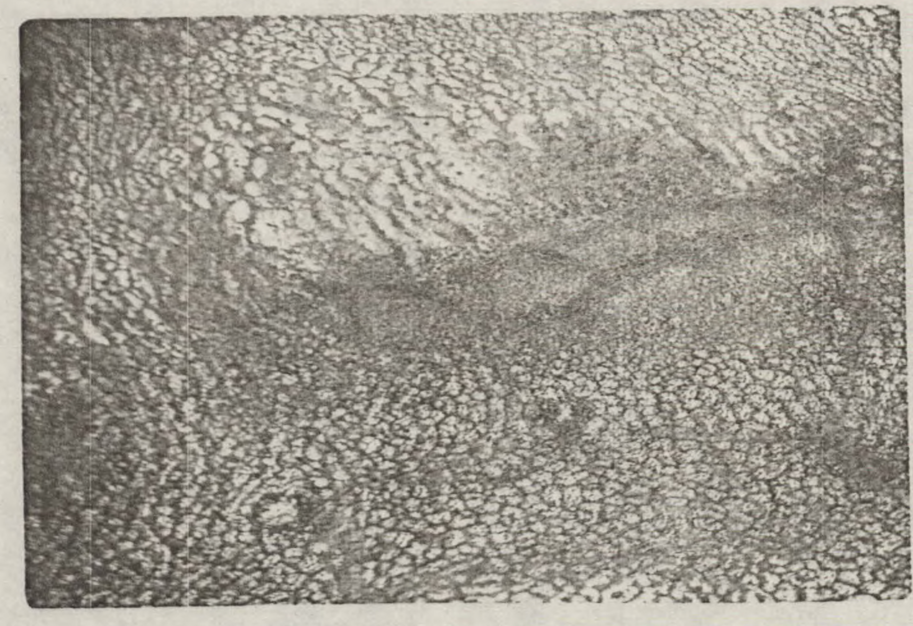


Figure 20. Aerial view of a field of mudboils.

Figure 21. Erosional mini-mounds in fine sand on a slope.

Figure 22. Lowland polygons.

Figure 23. Upland polygons developed in sandy loam.

Figure 24. Mass movement of soil is noticeable in the left foreground. Frost-shattered bedrock is transported downslope in the right foreground.

### 6.3 Mass Movement

The slow downslope movement of the active layer can occur even on gentle slopes. The active layer, often lubricated by water from a late-melting snowbank, slides downslope on the permafrost table (Fig. 24). The rate of movement is very slow, less than a metre per century. In some cases frost-shattered bedrock that has an ice core may also move downslope. The movement causes mixing of the materials and the resulting colluvial mix resembles glacial till in its composition.

# 7. SOILS

## 7.1 Parent Materials

Parent materials are the surficial unconsolidated materials on which soils develop. Within the eastern Axel Heiberg study area the main deposits are of colluvial, glacial, and marine origin. In most areas these materials were subsequently modified by periglacial action, such as cryoturbation and mass wastage.

The Quaternary history of Axel Heiberg Island determines the occurrence of the various materials. The Quaternary sequences appear to be complex and have not been worked out in detail. There appears to be an old glacial till at moderate elevations. This old till has the characteristics of locally-derived colluvium, except for a few erratic rocks. Although technically a till, the old till has been grouped with the colluvial deposits, as it has been exposed to colluvial action for tens or perhaps hundreds of thousands of years, acquiring colluvial characteristics. Fresh till, occurring near existing glaciers and on local highlands, present no such problems of classification.

### 7.1.1 Glacial Till

Till consists of materials that were incorporated into a glacier, transported for a distance, mixing it with new materials, and finally deposited as the glacier melted. The till, therefore, reflects the composition of the bedrock over which the glacier passed. In shale bedrock areas, the till is mainly clay to clay loam in texture (Table 6). In areas that have significant sandstone components, the till is sandy loam (Table 6). In general, the carbonate content of the till is low and the pH is between 6.5 and 7.5 (Table 6).

### 7.1.2 Colluvium

Colluvium is a material that was transported downslope by slope wash, mass movement, soil creep, or cryoturbation. The original material was locally derived from the bedrock, but often old till was added. As the material is mainly locally weathered bedrock, its composition reflects the properties of the bedrock. Shale gives rise to clay, shale with sandstone generates clay loam materials. Weathered sandstone results in loamy sand or fine sand materials. As in the case of till, the colluvium is low in carbonates. The pH is acid to neutral indicating a lack of mixing with carbonate-rich materials (Table 6).

### 7.1.3 Marine Deposits

Widespread marine deposits occur at elevations below the 155 m contour (Map 4). The texture of the material ranges from silt to sand (Table 6). Raised marine beaches are composed dominantly of gravel. The pH of the marine sediments is around 7 and the carbonate content is low. A notable exception occurs in marine silts near gypsum outcrops

Table 6. Chemical and physical properties of various parent materials.

| | pH | % $CaCO_3$ equiv. | % Sand | % Silt | % Clay | Textural Class |
|---|---|---|---|---|---|---|
| Clay till | 6.8 | 1.2 | 45.5 | 22.4 | 32.1 | Clay loam |
| Sandy till | 7.7 | 1.9 | 71.0 | 14.1 | 14.9 | Sandy loam |
| Colluvium | 3.9 | 0 | 20.0 | 35.1 | 44.9 | Clay |
| Marine silt | 7.2 | 0.8 | 20.7 | 57.6 | 21.7 | Silt loam |
| Marine sand | 7.1 | 0.8 | 94.7 | 2.8 | 2.5 | Sand |

where the soils are high in soluble salts and the soil is alkaline.

### 7.1.4 Alluvium

Alluvial deposits are formed within the floodplains of rivers, especially those originating in the glaciers of the Princess Margaret Range. The material consists mainly of sand and gravel, with local silt deposits. The material generally consists of rocks that are resistant to weathering, such as sandstone and diabase.

## 7.2 Soil Classification

Soil classification is based on the soil profile development, using the terminology developed by the Canadian Soil Survey Committee (1978). All soils belong to the Cryosolic Order, as permafrost occurs within 1 m of the surface everywhere. Turbic and Static Great Groups were encountered.

### 7.2.1 Static Cryosols

The most common soils belong to the Static Cryosol Great Group. These soils are characterized by the presence of permafrost within 1 m of the surface and by the lack of evidence of cryoturbation. This lack of cryoturbation can possibly be attributed to the generally low soil moisture status of all these soils.

Regosolic Static Cryosols are recognized by the lack of horizon development. Seemingly unaltered soil material occurs at the surface, down to the permafrost table that occurs within 65 cm of the surface. These soils are common on well drained situations and are associated with polar desert vegetation.

Orthic Static Cryosols display a thin (5-10 cm thick) B horizon that is somewhat different from the parent material in its colour or structure. These soils are common on well drained sites and are associated with polar desert and semi-desert vegetation.

Brunisolic Static Cryosols have a weakly developed colour B horizon that is 10-18 cm thick, with permafrost within 90 cm of the surface. These soils were found on moderately well drained gravelly sand deposits, associated with polar semi-desert vegetation.

Chemical analyses of these soils show (Table 7) that there is an adequate nutrient supply in the soil, including organic carbon. The moisture content of the soil, however, is very low. The organic carbon content of a soil, developed in aeolian fine sand, is high throughout the profile. This Cumulic Regosolic Static Cryosol was developed in the redeposited topsoil of the neighbouring areas, that was collected in the lee of a slope.

Table 7. Chemical properties of some Static Cryosolic soils.

| Soil | Horizon | Depth (cm) | pH | % org. C | Exchang. cations (m.e./100 g) Ca | Mg | K | Na | Moisture % by wt. | Textural class |
|---|---|---|---|---|---|---|---|---|---|---|
| Regosolic Static Cryosol | C | 3-8 | 6.7 | 1.53 | 11.55 | 2.42 | 0.37 | 0.09 | 12.9 | Sandy Clay Loam |
| | C | 20-25 | 6.6 | 1.99 | 21.00 | 4.73 | 0.54 | 0.10 | 20.7 | Clay |
| | C | 47-51 | 6.8 | 2.31 | 20.25 | 3.37 | 0.44 | 0.09 | 16.2 | Clay Loam |
| Brunisolic | Bm | 1-5 | 7.9 | 0.34 | 2.55 | 1.13 | 0.31 | 0.70 | 4.6 | Loamy Sand |
| Static Cryosol | C | 28-34 | 7.9 | 0.48 | 9.35 | 2.97 | 0.30 | 0.70 | 7.9 | Sandy Loam |
| | C | 79-83 | 7.7 | 1.11 | 11.95 | 5.14 | 0.32 | 0.80 | 12.4 | Sandy Loam |
| Cumulic Reg. | Bm | 3-8 | 4.3 | 3.38 | 11.65 | 2.87 | 0.33 | 0.08 | 33.4 | Loam |
| Static Cryosol | C | 28-33 | 4.8 | 3.66 | 15.37 | 3.14 | 0.26 | 0.13 | 34.1 | Loam |
| | C | 33-36 | 5.1 | 4.26 | 20.35 | 3.37 | 0.34 | 0.11 | 59.1 | Loam |
| | C | 46-48 | 4.9 | 3.94 | 14.90 | 3.08 | 0.29 | 0.11 | 53.8 | Loam |

### 7.2.2 Turbic Cryosols

Cryoturbation of the soil is manifested on the surface by the heaving of stones from the soil and by orienting of flat stones on edge, normal to the direction of pressure. Internally, displaced and disrupted soil horizons may be evident, occurring as streaks or distinct lumps of organic material or upper soil horizons. Sorting and orienting of flat stones is also often observed in the solum.

A common subgroup is the Regosolic Turbic Cryosol, where little horizon development is apparent. Cryoturbated parent material forms the entire profile, although in some cases a faint Bm horizon may be visible as a somewhat darker, 10-20-cm wide band beneath the surface. This soil is found on well to moderately drained till and colluvium, and is associated with semi-desert vegetation.

Orthic Turbic Regosol was recognized by the presence of a 10-15-cm thick structural Bm horizon under a 10-cm thick Ah horizon. This soil was found on marine silty clay, occuring in earth hummocks in poorly drained situation, associated with sedge meadow vegetation.

Gleisolic Turbic Cryosol occurs on most gentle slopes (less than 10%) where seepage water is present through the summer. It is also found in depressional lowlands where the drainage is poor. A thin organic layer (10-25 cm thick), consisting of somewhat decomposed organic materials, occurs on the surface. This is underlain by gleied parent material, without any B horizon development. Cryoturbation is manifested by convolutions in the upper horizon and by the orientation of stones. Permafrost is usually within 40 cm of the surface. The associated vegetation is sedge meadow.

### 7.2.3 Saline Soils

In some areas, especially on marine soils occuring near gypsum outcrops, salt efflorescenses were found. Chemical analyses of such soils (Table 8) clearly show that the greatest concentration of salts occur at the surface. This indicates that salts were moved upward from the soil, possibly by groundwater, and were precipitated at the surface as the water evaporated. Such soils are considered to be common in the polar regions (Tedrow 1977).

Table 8. Chemical properties of some saline soils on marine sediments.

| | | | | Conduct. | % | % | Soluble salts (m.e./L in sat. exctr.) | | | | | | | Textural |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil | Horiz. | Depth | pH | (mmhos/cm) | $CaCO_3$ | Organ. | Ca | Mg | Na | K | Cl | $SO_4$-S | $HCO_3$ | Class |
| Reg. Turb. Cryo. | Cy | 3-8 | 7.8 | 78.0 | 1.2 | 1.15 | 70.50 | 143.33 | 952.17 | 7.18 | 46.63 | 30.42 | 14.20 | Silt Loam |
| | Cy | 38-43 | 7.2 | 1.1 | 1.0 | 1.15 | 0.90 | 1.16 | 6.96 | 0.49 | 3.08 | 1.04 | 4.84 | Clay |
| | Cy | 45-47 | 7.2 | 1.6 | 0.8 | 0.54 | 1.15 | 1.54 | 12.17 | 0.69 | 7.64 | 1.82 | 9.68 | Silt Loam |
| Reg. Stat. Cryo. | C | 0-3 | 8.7 | 40.0 | 1.1 | 1.21 | 38.50 | 123.33 | 658.70 | 0.69 | 74.98 | 176.04 | 12.10 | Loam |
| | C | 45-50 | 7.4 | 1.0 | 0.5 | 1.42 | 4.43 | 2.12 | 5.7 | 0.18 | 2.22 | 2.50 | 9.68 | Sandy Loam |

## 8. HYDROLOGY

Streamflow information has not been systematically collected for any of the rivers and streams in the study area. This section will therefore only describe hydrologic phenomena typical of the High Arctic, and assumed to occur in the study area. The conditions which give rise to these phenomena and their implications to landscape features and visitor use of the area is discussed.

Runoff is derived from seasonal rainfall, snowmelt and glacial melt and occurs only during a short summer season (Maag 1969). After a rainfall, the bulk of the water cannot percolate because of the presence of continous permafrost in the ground. As a result, practically all of the rain water runs off almost immediately, collecting in stream channels and causing brief but sharp-peaked rises in the flow of rivers (Maag 1969). Adams (1966) showed that peak discharges of a glacier-fed river in western Axel Heiberg, after concentrated rainfall, exceeded the maximum flow recorded at times of most intensive ice melt. The force of floods resulting from rainfall is illustrated by the fact that a gabbro boulder weighing over 1000 kg was moved some 200 m downstream during two such floods (Maag 1969). Such events exert a powerful influence on riverbed and floodplain morphology.

Woo (1979a) estimated that over three-quarters of annual streamflows in high arctic basins are released during the snowmelt period. Rapid melting of the snowpack and release of substantial amounts of water to a thinly-thawed active layer often results in overland flow or standing water conditions (Woo 1976a). The flow of water along streambeds is often impeded by the presence of snow jams. Snow jams form in valleys where drifting causes accumulation of snow cover whose thickness exceeds those on hilltops and basin slopes (Woo and Marsh 1978). Snow jams pond meltwater, causing flooding upstream until seepage or overflow create channels in the snow jams. When this happens, large volumes of water are suddenly released downstream (Woo 1979b) which have greater capacities to erode valley sides and remove and transport streambed material than normal meltwater flow. Woo (1976b) demonstrated that streamflow will likely cease rapidly soon after the meltwater supply is depleted and the streambed will remain dry despite the occurrence of summer rainstorms. This is due to evaporation exceeding summer rainfall input.

Floods also result from the sudden emptying of ice-dammed lakes (Young 1977). Maag (1972) noted that Axel Heiberg Island has a concentration of ice-dammed lakes comparable to, if not higher than, that of subarctic Alaska and certainly much higher than that of temperate glacier regions such as the Swiss Alps. Typically, ice-dammed lakes may be formed on the surface of a glacier, between a glacier and a valley wall, at the junction of converging glacier lobes, or by damming of a tributary valley by a glacier (Maag 1969). An ice-dammed lake continues to fill to a critical level whereupon the dam fails and the water is catastrophically released. Thus, the already short runoff season can be concentrated even more to only a few days or weeks of high discharge. The effect of this flood discharge is much greater than if the same volume of water flowed along the streambed over the entire period during which it collected in the lake basin (Maag 1972). The geomorphological effects of such floods can be remarkable and are described by Maag (1969).

Should the study area be designated as a national park, the incidence of sudden floods resulting from concentrated rainfall, rapid snowmelt and glacial outburst floods should be investigated. Such events could influence visitor movement and access within the park and could endanger the safety of visitors.

## 9. VEGETATION

The vegetation was assessed by using existing literature, aerial photograph analysis, visits to selected sites and by extensive collections of plants. The vegetation of the study area is dominated by polar semi-desert community types, with local areas of arctic tundra. The composition of the flora reflects high arctic elements, with a representation of low arctic species.

### 9.1 Floristics

Large collections of bryophytes, lichens, and vascular plants were made during the field inventory. The non-vascular flora plays an important role in the polar desert vegetation of the study area and has a much greater diversity of species than the vascular flora. The results of those collections are indicated below.

#### 9.1.1 Bryophytes

Four species of Hepaticae and 81 species of Musci were collected from the study area (Appendix 1). The bryophyte flora of Axel Heiberg Island has been subjected to some previous study. Kuc (1969, 1973) reported on bryophytes from Good Friday Bay and the Expedition Fiord areas. According to Miller and Ireland (1978), a total of 131 species have been reported from the island. In addition, Holmen (1953) has reported 46 species from Eureka, Ellesmere Island, which is directly east of the study area.

#### 9.1.2 Lichens

The field inventory in the study area resulted in the collection of 144 taxa of lichens and three lichen parasites (Appendix 2). A number of those species are particularly interesting. For example:

- *Acarospora cartilaginea* - New to the flora of Canada.
- *Aspicilia contigua* - New to the flora of Canada.
- *Buellia nivalis* - New to the flora of Canada.
- *Caloplaca alcarum* - Possibly new to North America.
- *Collema bachmanianum* - A major northeastward range extension from previously known sites at Coppermine and Churchill.
- *Glypholecia scabra* - Previously known in the western Arctic from Alaska and Anderson River, N.W.T.
- *Peltigera occidentalis* - Previously known from Iceland, Greenland, and Bathurst Inlet, N.W.T.
- *Rhizocarpon pusillum* - New to the flora of Canada.

Except for Kuc (1969) there have been no major published reports on the lichens of Axel Heiberg Island, although Roland E. Beschel made numerous collections there in the early 1960s. Schuster *et al.*

(1959) and Powell (1967) have published papers on the lichen flora of northern Ellesmere Island.

### 9.1.3 Vascular Plants

The vascular plant flora of Axel Heiberg Island is relatively well known. Beschel (1963) reviewed the localities on Axel Heiberg Island and adjacent Ellesmere Island where collections have been made. Porsild (1957) and Porsild and Cody (1980) have published distribution maps of plants of the continental Northwest Territories and the arctic islands. Depending on one's species concept, about 130 species of vascular plants are known to be on Axel Heiberg Island. Our inventory in the study area resulted in the collection of 83 vascular plants (Appendix 3), over 60 percent of the vascular plants species present on the island. The phytogeographic affinities of those 83 species are: 52 circumpolar, 2 amphi-Beringian, 12 amphi-Atlantic, 8 North American, and 9 endemic to the Arctic Archipelago and Greenland.

## 9.2 Broad Vegetation Types

The dependence of the vegetation on soil moisture is well illustrated by the occurrence of vegetated areas in situations where extra moisture is available. Wet depressional areas and slopes watered by melting snowbanks invariably support a nearly complete vegetative cover (Fig. 25), while the drier uplands are nearly devoid of vegetation. This creates an intricate pattern in vegetation distribution, where bare areas alternate with luxuriously vegetated patches (Fig. 25).

During the brief reconnaissance survey broad vegetation types were identified and these were later used to map (in pocket) the vegetation of the study area at a scale of 1:250,000. The scale of mapping and the lack of field control dictated that the vegetation types be broad, recognizable on air photos, and mappable at the given scale. The resulting vegetation types are based on the physiognomy of the floral assemblages, rather than on floristics. This gave a workable tool, especially when combined with the estimated gound cover of the vegetation. Each broad type contains subtypes of vegetation, which are recognized by the dominant and characteristic species. Although no vegetation studies have been previously conducted in the study area, vegetation types found in the neighbouring regions (Beschel 1961, 1963, Savile 1964, Brassard and Longton 1970) occur in the study area.

A brief description of the mapped vegetation types and the common vegetation subtypes follows.

### 9.2.1 Dwarf Shrub (I on attached map)

This vegetation type is dominated by dwarf, ground-hugging woody plants. They seldom exceed 10 cm in height. Other herbaceous vegetation may be present but mosses are restricted to moist spots. The vegetation cover in the polar desert is generally less than 10%, but may

Figure 25. Vegetated slope watered by a melting snowbank.

Figure 26. Green patches of vegetated slopes watered by melting snowbanks alternate with barren uplands.

range as high as 50% in moist, protected areas. The common subtypes are Dryas Barren, and Barren Heath.

9.2.1.1 Dryas Barren Subtype

The main dwarf shrub component is Dryas integrifolia, with less frequent Salix arctica. Other commonly associated species are Carex misandra, C. nardina, Kobresia myosuroides, and Papaver radicatum. The ground cover varies from less than 5% in the Polar Desert (Figs. 27, 28) to about 50%. This is a common vegetation type on most dry and mesic uplands and slopes.

9.2.1.2 Barren Heath Subtype

The dominant vegetation is comprised of Saxifraga oppositifolia, Papaver radicatum and Draba alpina. Minor components are Dryas integrifolia and Salix arctica. Lichens, such as Alectoria nigricans, A. ochroleuca are frequent. This vegetation type occurs on exposed ridges and at high elevations below glaciers. The ground cover is generally less than 5%.

9.2.2 Dwarf Shrub-Sedge (II on attached map)

The dominant vegetation is composed of Salix arctica, Kobresia myosuroides, and Carex nardina var. atriceps. Other sedges, such as Carex membranacea and C. rupestris are also common. Dryas integrifolia is also widespread. This subtype is common on long mesic slopes, covering up to 50% of the ground (Fig. 29).

9.2.3 Sedge (III on attached map)

This vegetation type is dominated by sedges and other grassy species, growing in a carpet of moss. Abundant supply of moisture is present either in depressional lowlands, or on slopes watered by persistent snowbanks. The common subtypes are Sedge Meadow and Seepage Slope.

9.2.3.1 Sedge Meadow Subtype

This subtype is dominated by Carex aquatilis var. stans. Other sedges, such as Carex misandra and cottongrass (Eriophorum triste, E. scheuchzeri) are also common. Herbs, such as Pedicularis arctica and Saxifraga hirculus are also present. The mosses are dominated by Calliergon giganteum and Orthothecium chryseum, and by Drepanocladus intermedius, D. revolvens, and D. uncinatus in the wet areas. This vegetation type is common in depressional wetlands, often dissected by polygons (Fig. 30). The ground cover is usually complete.

9.2.3.2 Seepage Slope Subtype

This subtype is dominated by grassy species, such as Carex

Figure 27. Scant plant cover of the Dryas Barren Subtype.

Figure 28. Dryas Barren Subtype in the polar desert.

Figure 29. About 50% ground cover in the Dwarf Shrub-Sedge vegetation type.

Figure 30. A sedge meadow in a lowland polygon.

misandra, Eriophorum triste, Deschampsia brevifolia, and Luzula nivalis. Other vascular plants are Draba lactea, Polygonum viviparum, Ranunculus sulphureus, Saxifraga nivalis, and S. cernua; these are present in constant, but low numbers. This vegetation subtype is common on gentle slopes watered by perennial snowbanks (Figs. 31, 32).

9.2.4 Dry Steppe (IV on attached map)

This vegetation type is characterized by the occurrence of the grass, Puccinellia angustata. Other grasses, such as P. poacea and Agropyron latiglume also occur, along with Pedicularis arctica, Papaver radicatum, and Armeria maritima. This vegetation type is usually restricted to marine clay or silt deposits, where the ground cover is less than 5%, and frequently less than 1% (Fig. 33).

9.2.5 Upland Seepage (V on attached map)

The characteristic plants are Luzula nivalis, L. confusa, and Juncus biglumis, along with Cardamine bellidifolia, Saxifraga rivularis, S. flagellaris ssp. platysepala, and S. nivalis. On gravelly soils Epilobium latifolium is found (Fig. 34). Mosses are also abundant, Distichium capillaceum, Tortula ruralis, Orthothecium chryseum, and several Braya spp. being the most prominent. This vegetation type occurs on seepage areas on uplands, often having a 70-100% cover.

Figure 31. Sedge meadow on a seepage slope, watered by a melting snowbank.

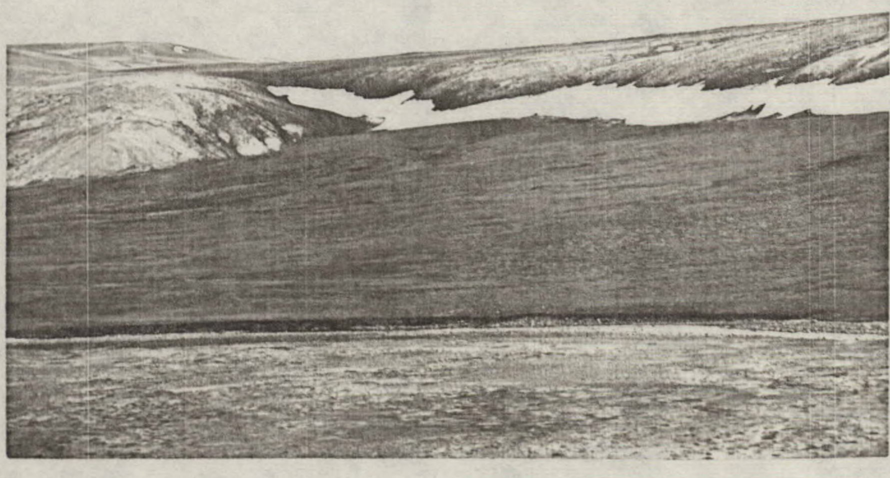


Figure 32. A seepage slope with sedge meadow.

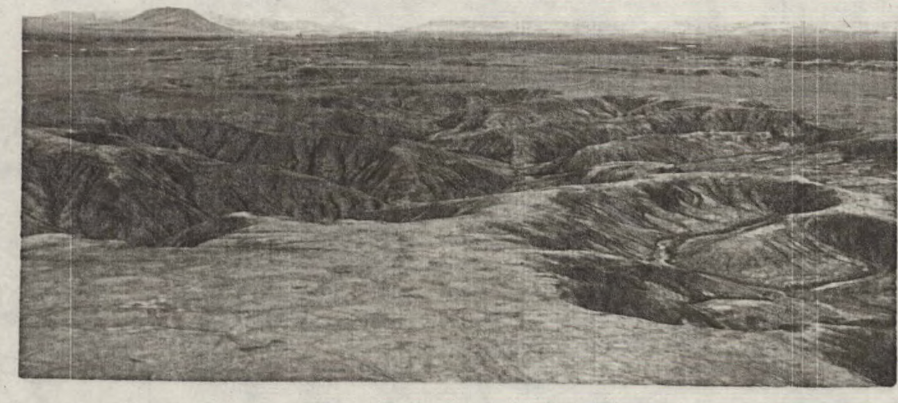


Figure 33. A nearly barren marine silt plain, with occasional clumps of grass.

Figure 34. A bright patch of Epilobium latifolium.

# 10. ECOLOGICAL LAND CLASSIFICATION

Ecological (bio-physical) land classification of the area was completed, using the principles outlined by Lacate (1969). The terminology of this approach has been revised by the Canada Committee on Ecological (Bio-physical) Land Classification. The new terminology will be used throughout, with the equivalents of the original terminology also indicated.

Ecological land classification is an evaluation of elements of the physical environment in terms of their importance to the biological components. Thus the various physical components, such as climate, soil texture, soil mineralogy, drainage, and slope are evaluated with regards to their influence on plant growth and distribution, and indirectly, on animal populations. During this process groups of physical factors that have similar influence on the living environment are grouped into classes. During the mapping process, areas that are alike are delineated.

In this process the ecoclimatic regions (land regions) are the broadest subdivisions, based mainly on the effect of climate on the biosphere. The next level is the ecodistrict (land district) occurring within each ecoregion, where the physiography and soil materials that influence vegetation growth and distribution are used as distinguishing criteria. At the next lower level, the mapping level at 1:250,000 scale, ecosections (land systems) are recognized on the basis of differences in soil and landform which affect the biological components.

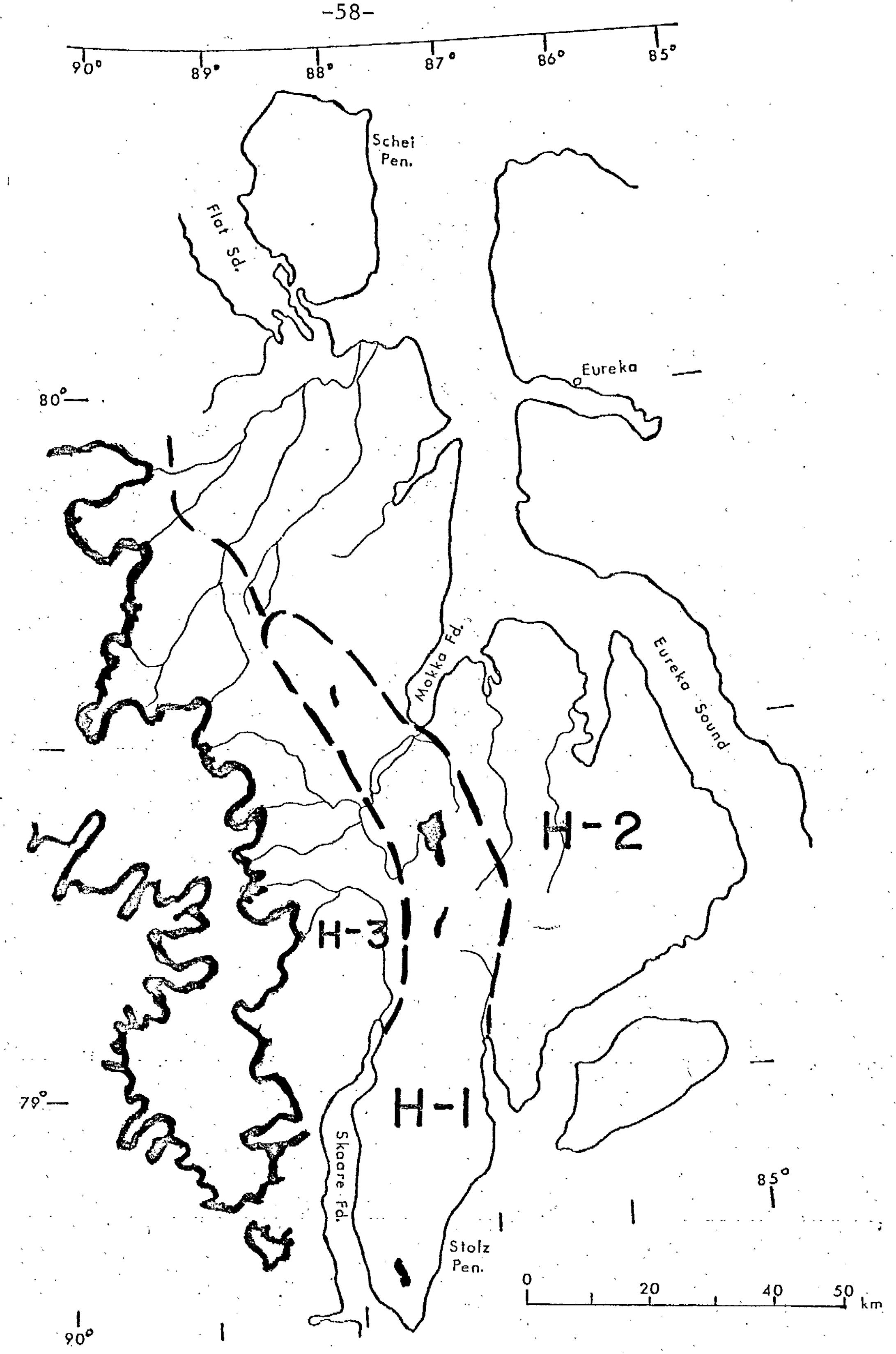
## 10.1 Ecoclimatic Regions and Ecodistricts

The study area is entirely within one ecoclimatic region, as determined by the growth and distribution of vegetation on similar soils. This is the High Arctic Ecoclimatic Region (Zoltai 1978). Portions of three ecodistricts were recognized in the study area, on the basis of physiography, soil and vegetation distribution.

### 10.1.1 High Arctic Ecoclimatic Region

In this region the normal sites (mesic sites with no toxic or deficient nutrient levels) are characterized by dwarf shrub barrens with a ground cover of less than 15%. On excessively drained sites the vegetation cover is often less than 1%. In local wet areas grassy species form a complete cover. The common soil is Regosolic Static Cryosol, with Turbic Cryosols in moist sites.

Three ecodistricts were recognized, the Buchanan Lake, the Eureka Sound, and the Foothills ecodisticts (Map 5).




Map 5. Ecodistricts of the eastern Axel Heiberg Island area

#### 10.1.1.1 Buchanan Lake Ecodistrict (H-1 on Map 5)

This ecodistrict occupies the Ridged Uplands physiographic subdivision. The mountain chain constituting the ecodistrict reaches an elevation of 1300 m above sea level, consisting of rugged, steep cliffs. They are composed of shale bedrock, with interbedded sandy siltstone, and intruded by diabase sills and dykes. The common soil material is rock rubble, with clay or clay loam colluvium in valleys. The common vegetation is a polar desert, composed mainly of Desert Shrub vegetation type. Large areas are without any vegetation, mainly due to the instability of the rubble slopes.

#### 10.1.1.2 Eureka Sound Ecodistrict (H-2 on Map 5)

This ecodistrict includes a variety of landscapes from lowlands to local highlands. Several discrete highland areas occur, the highest reaching an elevation of 825 m ASL. Broad lowlands, at elevations below the 155 m contour, were subject to marine inundation. The dominant soil material is a sandy loam derived from poorly consolidated sandstones, but silt and clay occur within the former marine limit. The vegetation is a polar semi-desert, with Dwarf Shrub and Dwarf Shrub-Sedge vegetation types. Well-vegetated areas of Sedge vegetation type are common in wet lowlands and on slopes watered by melting snowbanks.

#### 10.1.1.3 Foothills Ecodistrict (H-3 on Map 5)

This narrow, dissected plateau lies between the mountains of the Buchanan Lake Ecodistrict and the Princess Margaret Range. The material is derived mainly from Triassic sandstone, but shales also occur. The dominant soil material is a sandy loam colluvium or glacial till. The vegetation is a polar semi-desert on gentle slopes, with polar desert vegetation on broad hills and plateaus.

### 10.2 Ecosections

Ecosections were determined on the basis of broad relief and the texture of soil materials. The relief classes have significance in indicating the presence of anomalous local climates and moisture distribution. The textural classes have an important bearing on the moisture and nutrient availability to the plants, as well as on the thickness of the active layer. The broad vegetation types were also used as criteria for delineating the ecosections.

The scale of mapping dictates that few uniform ecosections will be delineated on the map. In fact, most are patterns of several soil and vegetation types. Even if different ecosections could be recognized in the field and on air photos, these could not always be mapped. As a general rule, if an included different material or vegetation was less than 20% of the area, it was not indicated in the symbol. In a complex symbol, the type in the first position is more prevalent than those in subsequent positions. The map of ecosections and broad vegetation types is enclosed with this report (in pocket).

Ecosections are intended to characterize an area in broad terms, showing the main relief, soil, and vegetation features. This level of detail is perhaps sufficient at a very broad scale of planning, but not at the detailed, management planning level. Planning for park development must be based on a more detailed map of the biophysical features of the area to take advantage of local features that could not be mapped at the broad scale. Such detailed mapping should be an integral part of the planning process.

### 10.3 Terrain Sensitivity

Terrain sensitivity refers to the susceptibility of the terrain to damage as a result of a disturbance. The most sensitive terrain will show much reaction to the impact (thermal collapse, slumping, erosion, etc.) even after relatively low levels of disturbances, whilst the least sensitive terrain will withstand severe disturbances.

Two interrelated kinds of sensitivity can be recognized. One refers to the terrain, where ice content of the soil, soil texture, and slope may predispose the terrain to damage. A second aspect is the ability of the vegetation to absorb the effects of disturbances and become re-established.

The susceptibility of the terrain to disturbance is rather low. This can be attributed to the cool thermal season which allows only limited thawing of exposed permafrost. Secondly, the ice content of the majority of the soils is low. Nevertheless, the following sensitive terrain types have been recognized:

| | |
|---|---|
| Wet marine silt | - ice-rich layers of the permafrost table predispose this soil to subsidence upon disturbance. |
| Dry marine silt | - material is readily erodible: erosion may be accelerated by disturbance. |
| Seepage slopes | - roads following the contour would intercept drainage, inducing eventual slope failure. |
| Polygonal terrain | - presence of ice wedges indicates potential for subsidence on disturbance. |
| Sedge vegetation type (III) | - wet areas are highly susceptible to rutting by vehicles, or by foot traffic. |

The sensitivity of vegetation to disturbance is high in all vegetation types. The cold, dry vegetative season makes the regeneration of the vegetation very uncertain, and the growth rate of the existing vegetation (and therefore its recuperative powers) is very slow. Even concentrated foot traffic would rapidly kill the vegetation, possibly inducing erosion. Recuperation rates measured in decades and centuries are indicated by the study of disturbed sites in the general area.

An abandoned hydrocarbon drilling site near May Point showed no sign of deterioration after the site was rehabilitated. Although vegetation has not reoccupied the disturbed areas, the site appears to be stable. Another drillsite near Romulus Lake on Fosheim Peninsula showed different vegetation patterns on the disturbed and undisturbed areas. The bed of the winter road had more vegetation that was more vigorous than the undisturbed soil, possibly due to increased moisture holding capacity of the compacted soil. A careful study of these sites would yield much valuable information on the effects of disturbances on the vegetation and terrain.

Management considerations

1. Building of facilities on susceptible terrain types must be avoided.
2. Concentrated foot traffic (such as near campsites) should be allowed only on gravelly soils with polar desert vegetation.
3. Trails should not be marked, as these would tend to concentrate traffic.
4. Traversing well-vegetated seepage slopes should be avoided, by steering traffic to the ridges.

# 11. WILDLIFE

## 11.1 Mammals

Due to its extreme northern location, the status of many mammal species within the study area is poorly known. However, distribution and habitat preferences of muskoxen and caribou in the study area are fairly well known. There are no native communities on Axel Heiberg Island; the closest community is Grise Fiord on the southern coast of Ellesmere Island more than 140 km away. Consequently, the study area is rarely visited by native people. Between 1951 and 1973, hunting parties of Grise Fiord Inuit travelled along Eureka Sound less than five times (Riewe 1977). Presently, a limited amount of hunting (for polar bear) occurs at the extreme southern end of Axel Heiberg Island (Kiliaan et al. 1978). Records of hunting and trapping by Grise Fiord Inuit do not, therefore, contribute to our knowledge of mammals occurring in the study area. Furthermore, the N.W.T. Wildlife Service has not conducted any wildlife surveys on either Ellesmere or Axel Heiberg Island (B. Stephenson, pers. comm.).

A provisional checklist of the mammals of Axel Heiberg Island, with additional comments on mammal distribution within the study area, is provided in Appendix 4. Only seven species of land mammals have been reported to occur on Axel Heiberg Island; all are found in the study area. The ringed seal is the only marine mammal which occurs regularly; the polar bear and the bearded seal appear to be occasional visitors to the study area.

### 11.1.1 Hares and Rodents

Arctic hares are abundant throughout the higher-elevation areas of the study area, favouring steep gravel slopes and ridges and upland barrens (Fig. 35) which provide abundant supplies of willow and grasses important to their diet (Bonnyman 1975, Parker 1977). Kerbes (1971) noted hares to be "extremely abundant" on the west side of Mokka Fiord and small herds of less than 12 individuals were seen on the high slopes in the Chain of Three Lakes area. Arctic hares were "very abundant" west of Mokka Fiord during the summer of 1973 (G.R. Parker, pers. comm.). Gauthier (1978) observed 421 hares south of Gibs Fiord in June 1977 and over 200 in the vicinity of Mokka Fiord in late August of the same year. Aerial surveys flown over Schei Peninsula in June 1976 provided an estimate of 500 hares for the entire peninsula (Gauthier 1977). The authors saw comparatively few hares on the study area, although scats were generally numerous in upland areas; the largest group of hares seen on Schei Peninsula numbered only five. However, we noted that the average size of the groups on Ellesmere Island was increasing during our last few days in the area. According to Gauthier (1977) and Parker (1977), adult and young hares do not congregate into large herds of 50 or more individuals until early to mid-August.

Figure 35. Arctic hare in a typical *Dryas* Barren habitat.

Figure 36. Skeletal remains of a muskox, gnawed by carnivores.

The status of the varying lemming population in the study area is poorly known. Macpherson (1963) noted that lemmings appeared to be "common throughout the area" (Axel Heiberg Island). No lemmings were observed by the authors; a winter nest containing a lemming skeleton was discovered west of Mokka Fiord. The lemming is an important prey item of the snowy owl. Only one sighting of a snowy owl was made in the study area. This may indicate that the lemming population was experiencing a "low" in 1980. Many authors refer to dramatic oscillations in lemming numbers from year to year, and to the fact that many predators are dependent on the lemming population cycle. In years when lemmings are scarce, snowy owls, jaegers, arctic foxes and ermine produce few young or may fail to breed.

### 11.1.2 Carnivores

#### 11.1.2.1 Arctic Fox and Arctic Wolf

No information has been collected on numbers of arctic foxes or wolves occurring on Axel Heiberg Island. The extent of present knowledge of their distributions is limited to a few reports made by investigators in the area. Tener (1963) observed neither foxes nor dens on Axel Heiberg Island, although two were seen on Fosheim Peninsula. Two pairs of wolves and one pack of four wolves were observed inland from Flat Sound in 1961 (D. Thomas pers. comm.). Macpherson (1963) reported foxes to be scarce on Axel Heiberg Island and observed a pack of nine wolves attacking a herd of muskoxen on the eastern coast of the island. An old fox den, showing no signs of recent use, was located on a slope near Chain of Three Lakes by Waterston and Waterston (1972). One fox was seen in the vicinity of their camp on several occasions. Many wolf scats were found around old muskox skeletons but wolves were not seen (Fig. 36). G.R. Parker (pers. comm.) found both foxes and wolves to be common west of Mokka Fiord; he believed the wolves were predators of arctic hare in the area (Parker 1977). Arctic foxes were often seen carrying young hares to a nearby den. The authors did not see either foxes or wolves, although wolf tracks and scats were found at many of the sites visited in the study area. Fox tracks and scats were not as common. Should the area be designated as a national park, an inventory of foxes and wolves should be undertaken to determine their numbers and distributions within the park.

#### 11.1.2.2 Polar Bear

Whether the polar bear occurs in the study area on a regular basis is not certain. Sverdrup (1904) reported seeing "bear tracks" north of Skraeling Point during his sled journey up Eureka Sound in May 1901. Only one recent sighting of a polar bear has been made in the area, about 2 km west of Butter Porridge Point on Schei Peninsula (Kerbes 1971). The authors observed the remains of two seal carcasses on the ice adjacent to breathing holes less than 1 km from the shore at Mokka Fiord. We suspected them to be polar bear kills. No polar bears were observed during an aerial survey of marine animals in Eureka Sound conducted by Smith et al. (1979) in 1978 even though low numbers of ringed seals, their major food source, were present. However, Smith et al. did observe polar bears on solid shorefast ice west of Axel Heiberg Island near Ellef Ringnes and Amund Ringnes islands. Kiliaan et al. (1978) tagged a bear in Eureka Sound south of the study area and three others in Norwegian Bay within 30 km of the southern coast of Axel Heiberg Island. Observations of tracks indicate that the southern coast of the island may be a maternity denning area. Kiliaan et al. (1978) noted that between 1974 and 1977 only three out of the 284 trips (3%) made by Grise Fiord Inuit to hunt polar bear were to the northern part of Norwegian Bay near Axel Heiberg Island. Between 1966 and 1977, the number of bears killed by hunters in the Norwegian Bay area as a whole was 60. This represents about 18% of the total number of bears killed by Grise Fiord Inuit during that period with most of these bears being taken to the east or west of Bjorne Peninsula, Ellesmere Island (Kiliaan et al. 1978). Polar bear hunting does not appear to take place north of Norwegian Bay presumably due to the distance involved and the lower probability of finding a bear.

#### 11.1.2.3 Ermine

Virtually nothing is known about the distribution of ermine on Axel Heiberg Island. Macpherson (1963) reports sightings of ermine on Schei Peninsula and near Buchanan Lake. No other records of the species have been made by other investigators and none were observed by the authors. Surveys should be conducted to determine the status and distribution of this furbearer species in the study area should the area receive national park designation.

### 11.1.3 Seals and Walrus

Ringed and bearded seals are the only seal species known to occur in the study area, the bearded seal being uncommon. Bruggeman (1954) reported seeing ringed seals frequently in Slidre Fiord near Eureka, hauled out on the ice and swimming near shore. He also observed three in Eureka Sound. During an aerial survey of Eureka Sound in mid-July 1978, Smith et al. (1979) counted 25 ringed seals from Eureka to the southern limit of our study area, a distance of approximately 220 km. Seal density in Eureka Sound and the northern part of Norwegian Bay is low compared to more southerly areas in the region such as Queens and Wellington channels west of Devon Island (Smith et al. 1979). Stirling et al. (1981) concluded that the low ringed seal density observed in Norwegian Bay and other areas north of 77°N was due to the presence of multi-year ice. Ringed seals showed a preference for annual ice areas further south.

From Butter Porridge Point on July 19, the authors observed six ringed seals hauled out on the ice where Eureka Sound meets Greely Fiord (Fig. 37). Other ringed seals were seen near Fair Cape. On July 21 as we crossed Eureka Sound from Ellesmere Island to the head of Mokka Fiord, a distance of 15 km, we counted nine ringed seals, which

Figure 37. Ringed seal near a breathing hole in sea ice.

Figure 38. A lone muskox bull in barrens near a well-vegetated seepage strip.

appeared to indicate a higher density than that reported by Smith et al. (1979). However, seals would not likely be distributed uniformly along Eureka Sound. Numbers observed at a given location would fluctuate seasonally and annually depending on factors such as ice type, snow cover, distribution of ice cracks and time of ice break-up. In addition, diurnal rhythms of the seals give rise to daily differences in distribution, and observability of the seals would be influenced by whether or not weather conditions were favourable for haul-out on the ice (Smith and Hammill 1981).

The bearded seal appears to be an infrequent inhabitant of the study area, although it is reasonably common in Norwegian Bay. This is probably due to its preference for areas of moving pack ice and pan ice (Burns 1970). Bruggeman (1954) observed a bearded seal on September 8 in the middle of Eureka Sound off Fair Cape. Another was observed at Slidre Fiord, Ellesmere Island (Macpherson 1963). Smith et al. (1979) did not note any bearded seals along Eureka Sound; those observed were associated with polynyas formed in the Hell Gate area between Devon and Ellesmere islands and in Penny Strait between Ellesmere and Bathurst islands. Bearded seals observed during surveys of Norwegian Bay by Stirling et al. (1981) were located in the Belcher Channel area and north of Hell Gate.

Ice conditions in Eureka Sound are unfavourable for walruses. For most of the year, walruses associate with pack ice or polynyas. During the open water season, they may haul out on land in large numbers at traditional sites (Mansfield 1967). During winter, walruses congregate to feed in shallow water areas which are either relatively ice free or in which they can maintain breathing holes in leads (Kiliaan and Stirling 1978). Important overwintering areas for walruses occur in the Hell Gate and Penny Strait areas (Stirling et al. 1981). Observations of walruses further north in northern Norwegian Bay or Eureka Sound would be unusual; Smith et al. (1979) did not see any walruses in these two areas. However, about four individuals were observed on one occasion in Slidre Fiord (C. Jonkel, pers. comm.). It is possible that during the summer an occasional sighting of a walrus in Eureka Sound may be made, hence the hypothetical status given to the species.

### 11.1.4 Ungulates

#### 11.1.4.1 Caribou

The caribou of Axel Heiberg Island belong to the subspecies *pearyi* (Banfield 1974). The present status of the Axel Heiberg population is not known since recent surveys of the population have not been conducted. The hunting range of Grise Fiord Inuit does not presently include Axel Heiberg Island, according to E. Land (pers. comm.), N.W.T. Wildlife Service. Between 1951 and 1973, the majority of the caribou taken were from southeast Ellesmere Island, the Bjorne Penninsula-Vendom Fiord region of Ellesmere Island and Graham Island in Norwegian Bay

(Riewe 1977). Therefore, there is no harvest data available for Axel Heiberg Island to shed light on caribou abundance and distribution. Similarly, wintering areas, calving areas and pre- and post-calving migratory movements are not known. This section will summarize results of the few aerial surveys that have been conducted and the observations of scientific investigators. Habitat use and food preferences of caribou on Axel Heiberg Island are compared to those of muskoxen in a later section (11.1.4.3).

Caribou observations on Axel Heiberg Island are summarized in Table 9. Hendrigan (in Macpherson 1963) estimated that there were 150 caribou on Axel Heiberg Island in 1960. The total caribou population for the island in 1961 was judged to be 300 animals (Tener 1963). This probably indicates an underestimate of the 1960 population rather than a doubling in population size. More than half of the caribou seen in 1960 were in the northern part of the island, south of Cape Stallworthy and along the coast of Nansen Sound. That area also accounted for the majority of caribou sighted in 1961 (D. Thomas, pers. comm.). No caribou were observed in the study area in 1961.

In 1971, Kerbes (1971) counted 108 animals in the Nansen Sound area but only four southwest of Butter Porridge Point, Schei Peninsula. A single individual was observed north of Hyperite Point at the extreme southeastern end of Axel Heiberg Island. No other sightings were made in the eastern part of the island. Five caribou were noted north of Hyperite Point in May 1971 (C. Jonkel, pers. comm.). Inglis and Jonkel (1972) did not record any caribou during aerial surveys of eastern Axel Heiberg Island, southeast of Mokka Fiord, conducted in July 1971. Waterston and Waterston (1972) noted four caribou southwest of the Chain of Three Lakes area. During an aerial survey of eastern Axel Heiberg Island, between Stang Bay, west of Flat Sound, to Whitsunday Bay in 1973, 32 caribou were observed (Ross 1975). Since some of these may have been located outside the study area near Stang Bay, this represents the maximum number observed in the study area. Seven of the caribou observed during the survey were located on the coastal plain at the northwest corner of Schei Peninsula. Riewe (1973) estimated the size of the population occurring in the Skaare Fiord-Wolf Fiord area in 1973 to 35. Most of these would have probably been located outside of the study area. More recent estimates of caribou population size on Axel Heiberg Island have not been made.

We did not observe any caribou in the study area or areas adjacent to it in 1980. Muskoxen in the study area were also observed in lower numbers than was expected. It is possible that populations of both muskoxen and caribou have suffered significant declines since 1973 due to harsh conditions experienced during one or more winters. Such declines in numbers have been documented for both species on Bathurst Island over the past decade (Miller _et al_. 1977). A crash of muskox and caribou populations on Bathurst and Melville islands during the 1973-74 winter was attributed to malnutrition caused by poor availability of forage (Parker _et at_. 1975). Inaccessibility of forage resulted from

Table 9. Caribou observations on Axel Heiberg Island.

| Year | Study area | NW Axel Heiberg[1] | SE Axel Heiberg | Axel Heiberg Island |
|---|---|---|---|---|
| 1960[2] | | | | 150 |
| 1961[3] | | 44 | | 300 |
| 1971[4] | 4 (Schei Peninsula) | 108 | 1 (N of Hyperite Point) | |
| 1971[5] | | | 5 (N of Hyperite Point) | |
| 1972[6] | 4 (Chain of Three Lakes area | | | |
| 1973[7] | 7 (Schei Peninsula) | | | |
| 1973[8] | | | 35 (Wolf and Skaare fiords area) | |

[1]North of Expedition Fiord, west of Flat Sound
[2]Macpherson (1963)
[3]Tener (1963)
[4]Kerbes (1971)
[5]C. Jonkel (pers. comm.)
[6]Waterston and Waterston (1972)
[7]Ross (1975)
[8]Riewe (1973)

extensive drifting of wet snow during early winter snow storms aggravated by the length of the winter, snow accumulation and late winter icing. However, caribou in the Mokka Fiord area of the study area apparently did not suffer a decline during the 1973-74 winter (Parker and Ross 1976). Therefore, any reduction in population would have occurred since 1974.

On the western Queen Elizabeth Islands generally, Peary caribou declined by about 90 percent from 24,320 animals in 1961 to 2676 in 1974 (Gunn et al. 1980-81). Concern for Peary caribou prompted the Committee on the Status of Endangered Wildlife in Canada to officially declare the subspecies to be "threatened" (COSEWIC 1978). Surveys of the western Queen Elizabeth Islands, conducted in 1980, tentatively revealed that the Peary caribou population have declined still further since 1974 to an estimated 634 animals (Thomas and Joly 1981). It is now felt that the Peary caribou maybe in danger of extinction on the western Queen Elizabeth Islands. Whether or not the caribou population of Axel Heiberg Island has paralleled this decline is not known.

In summary, the present size of the caribou population of Axel Heiberg Island is not known but probably does not exceed 300. Caribou appear to be most numerous in the northwestern corner of the island and along the Nansen Sound coast between Cape Stallworthy and Flat Sound. Less than 50 animals are estimated to occur within the study area between Schei Peninsula and Skaare Fiord. Small numbers of animals occur in the southwest and southeast corners of the island and along the west coast.

Management concerns:

1. Surveys of caribou on eastern Axel Heiberg Island should receive high priority should the area receive national park status. Such surveys would be designed to determine population status and seasonal abundance and to identify calving rutting and wintering areas, migration routes and extent of movements between Axel Heiberg, Ellesmere and other islands.

2. Calving, rutting and wintering areas should be considered critical areas and should be vigorously protected. Migration routes should be taken into account in the development of management plans for the park.

#### 11.1.4.2 Muskoxen

As with caribou, the extent of our knowledge of muskox distribution and abundance on Axel Heiberg Island is limited to the results of a few aerial surveys supplemented by miscellaneous observations made by early explorers to the area and scientific investigators. No population data is available from the N.W.T. Wildlife

Service and the island is beyond the hunting range of the Grise Fiord Inuit (Riewe 1977, A. Tagak, pers. comm.). It is not known whether muskoxen in the study area occupy separate winter and summer ranges with seasonal movements occurring between the two or whether suitable range is used year-round. On Fosheim Peninsula, Ellesmere Island, studies in 1951 indicated that some herds moved as much as 32 km between their winter and summer ranges (Tener 1954). At Lake Hazen, Ellesmere Island, winter and summer ranges in 1958 were within 1 km of each other and in a few instances were the same (Tener 1965). Zoltai et al. (1980a) considered muskoxen on Banks Island to utilize year-round ranges.

Observations of muskoxen on Axel Heiberg Island are summarized in Table 10. The first non-native to observe muskoxen on Axel Heiberg Island was Captain Otto Sverdrup in 1901 during his discovery and exploration of the island's coastline. Sverdrup (1904) provides detailed accounts of hunting these "polar oxen". Herds of as many as 50 head were reported near the northern end of the island in 1909 by Donald MacMillan and large herds were also found along the southern coast (Hone 1934). Sargeant A.H. Joy reported muskoxen to be abundant on the south coast in 1926 and Captain H.W. Stallworthy saw a total of 106 muskoxen between Stolz Peninsula (at south end of study area) and Schei Peninsula during a patrol of the eastern coast in 1932 (Hone 1934).

In 1960, muskoxen were common in the Expedition Fiord area and were frequently recorded in the northwestern part of the island, Schei Peninsula, Mokka Fiord and Buchanan Lake (Macpherson 1963). The total muskoxen population of Axel Heiberg Island was estimated that year to be 150 to 200 animals. In 1961, Tener (1963) estimated the total island population to be 1000. Presumably, the 1960 population was significantly underestimated. Muskoxen observed in 1971 were most numerous in the valley lying between Gibs and Mokka fiords and in the triangular-shaped area bounded by Mokka Fiord, May Point and Whitsunday Bay (Map 6).

Kerbes (1971) found 133 muskoxen between the base of Schei Peninsula and Mokka Fiord. Most of those were located north and west of Gibs Fiord. Other animals were sighted inland from Nansen Sound (49) and at Hyperite Point (3) in the extreme southeast part of the island. Inglis and Jonkel (1972) observed 184 muskoxen in 1972 in the triangular area southeast of Mokka Fiord. Twenty-four animals were noted in the same year in the Chain of Three Lakes area (Waterston and Waterson 1972). In 1973, 866 muskoxen were counted during an aerial survey of the area between Stang and Whitsunday bays, including Schei Peninsula (Ross 1975). Map 7 shows the approximate location of herds and lone bulls observed in the study area. Two hundred and seventy-five of the 866 animals were in the well-vegetated area between Gibs Fiord and Buchanan Lake (Parker and Ross 1976).

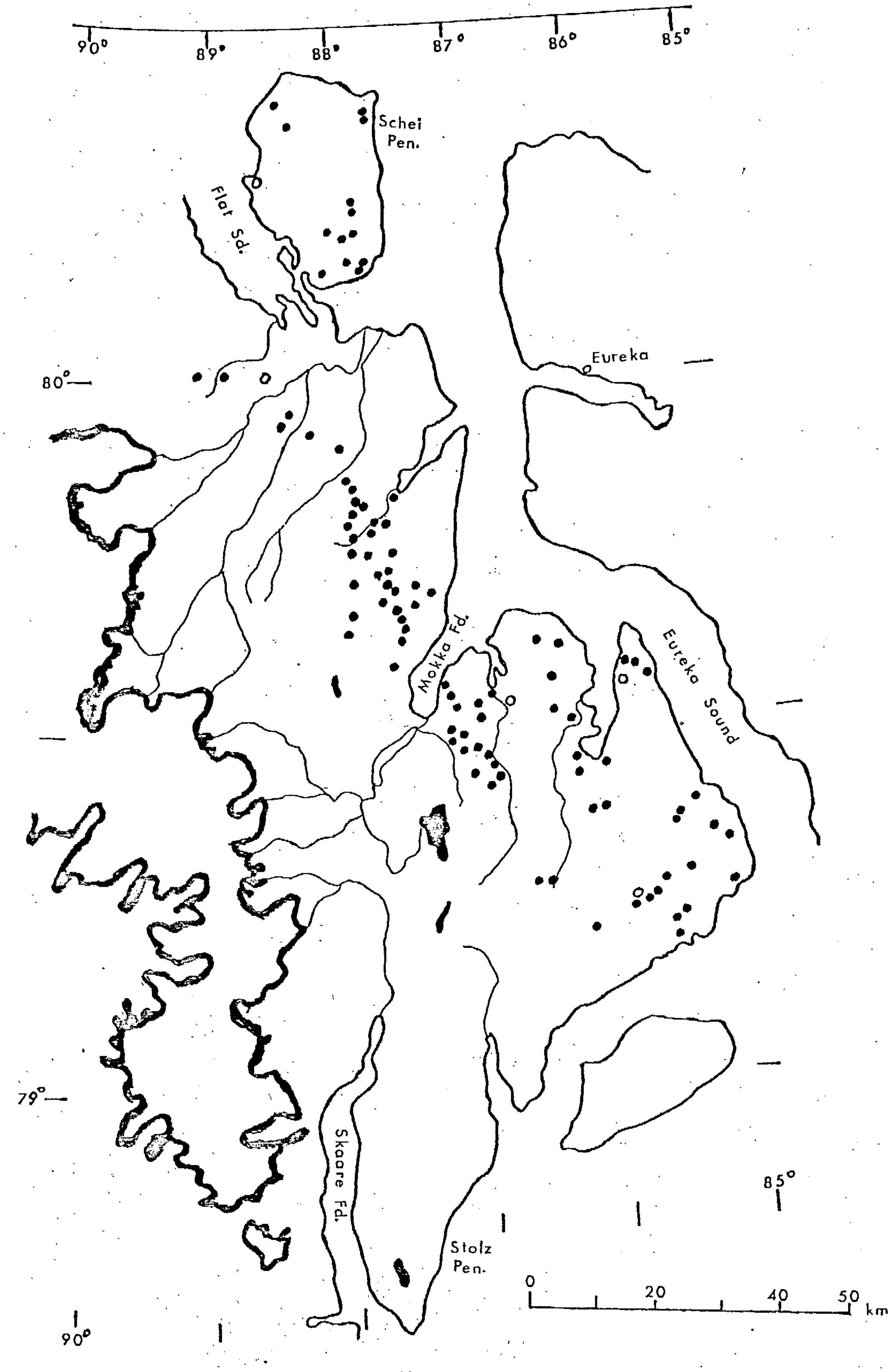
The authors observed a total of 180 muskoxen with in the study area. Forty-two animals were on Schei Peninsula, located mainly

Table 10. Muskoxen observations on Axel Heiberg Island.

| Year | Study area | NW Axel Heiberg[1] | SE Axel Heiberg | Axel Heiberg Island |
|---|---|---|---|---|
| 1932[2] | 106 (E.coast-Stolz Pen. to Schei Pen.) | | | |
| 1960[3] | | | | 150-200 |
| 1961[4] | | | | 1,000 |
| 1971[5] | 133 | 49 | 3 (Hyperite Point) | |
| 1972[6] | 184 (SE of Mokka Fiord) | | | |
| 1972[7] | 24 (Chain of Three Lakes area) | | | |
| 1973[8] | 866 | | | |
| 1980[9] | 180 | | | |

[1]North of Expedition Fiord, west of Flat Sound
[2]Hone (1934)
[3]Macpherson (1963)
[4]Tener (1963)
[5]Kerbes (1971)
[6]Inglis and Jonkel (1972)
[7]Waterston and Waterston (1972)
[8]Ross (1975)
[9]Present study


Map 6. Important areas for muskoxen in the study area




Map 7. Distribution of muskox herds (●) and lone bulls (○) in the study area in 1973 (Ross 1975)

on the eastern coastal plain. Sixty-five occurred in the valley between Gibs and Mokka fiords and 55 were located in the triangular-shaped area southeast of Mokka Fiord.

Muskox distribution within the study area observed in 1980 was similar to that observed in 1973 by Ross (1975). Numbers of muskoxen observed in the two years cannot be compared since the 1973 counts were made over a larger geographic area using aerial strip census techniques. The 1980 count was derived from a compilation of sightings made on the ground at various study sites and others made from the helicopter while travelling between sites (Fig. 38). The present population of muskoxen in the study area on Axel Heiberg Island is not known. However, Parker and Ross (1976) and Thomas et al. (1981) noted that the Mokka Fiord area is one of the highest density areas for muskoxen in the Canadian Arctic.

Management concerns:

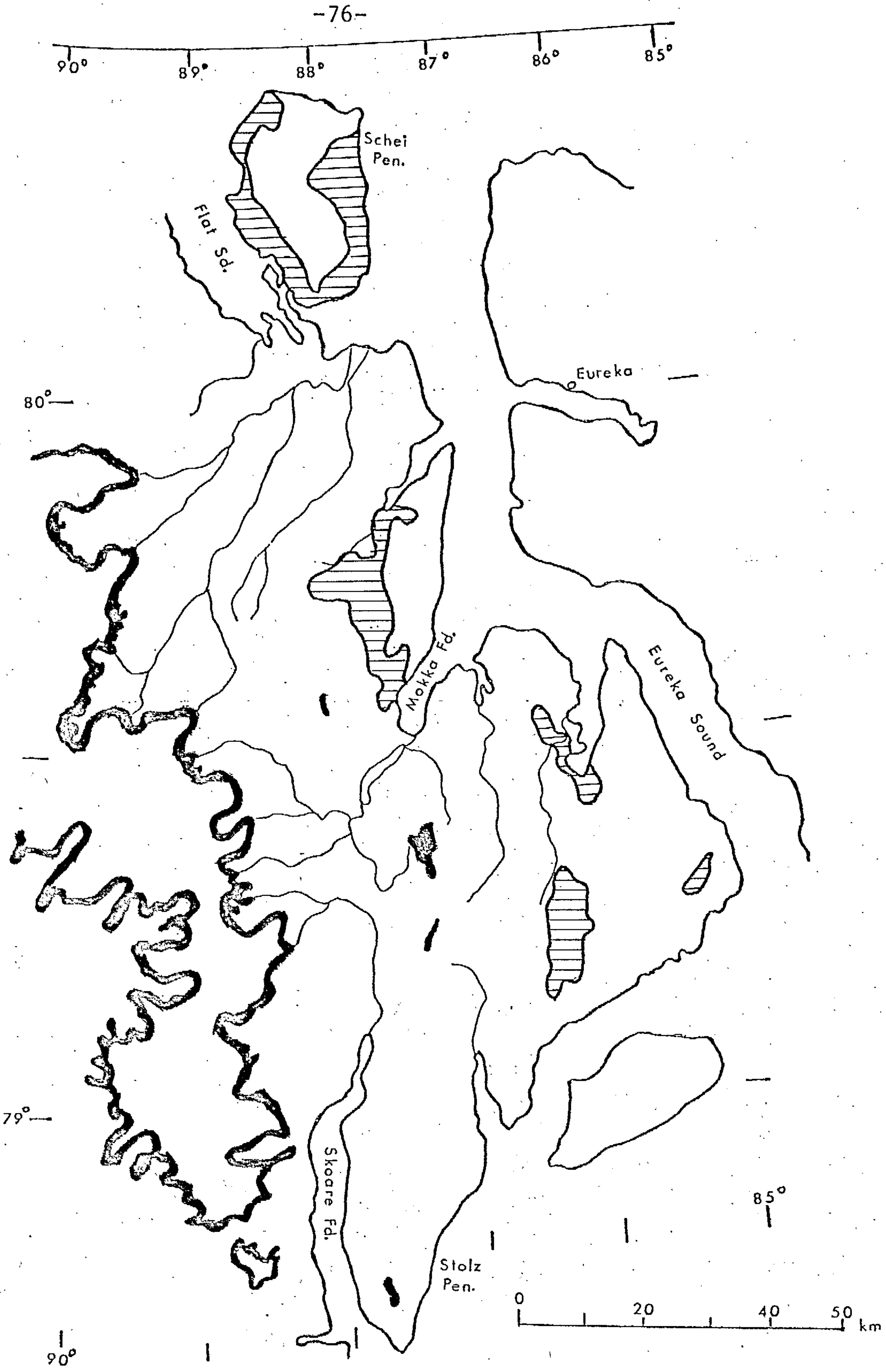
1. Should the study area be designated as a national park, surveys should be conducted to determine whether muskoxen in the study area use distinct summer and winter ranges or year-round ranges. Chronology of seasonal movements and migration routes should also be determined if distinct ranges are used. These studies should receive high priority.

2. All summer and winter ranges and habitat important for year-round muskox use should be considered as critical areas and receive adequate protection in managing the park.

#### 11.1.4.3 Habitat and Food Preferences of Muskoxen and Caribou

Studies conducted in the Mokka Fiord area (Parker and Ross 1976, Parker 1978) provide information on the habitat types utilized by muskoxen and caribou and their seasonal diets. The following summarizes the results of those studies and makes comparisons with habitat and food preferences of the two species in other geographic areas of the Canadian Arctic.

The high density of muskoxen in the Mokka Fiord area is attributed to the presence of highly-productive lowland meadows. Muskoxen showed a preference for those meadows which provided the sedges and grasses required for summer and winter forage. Meadow habitat is not restricted to the Gibs Fiord-Mokka Fiord valley but also occurs on eastern Schei Peninsula, southeast of Mokka Fiord and west of May Point (Map 8). In the winter, muskoxen searched for meadows with optimal snow conditions and remained in the same locality for several weeks or longer before moving to the next suitable meadow. In early summer, prior to the emergence of sedges in the meadows, muskoxen utilized the more elevated sites which were the first to produce new growth of willow, grasses and forbs. By early July, they were seeking out meadows supporting new sedge growth (Fig. 39). Muskoxen at Bailey Point on Melville Island exhibited




Map 8. Areas with high incidence of meadows (shaded)

Figure 39. Muskox skull in a heavily grazed sedge meadow.

Figure 40. A flock of geese (right middle) within a polygonal lowland.

a similar pattern but because sedge-producing meadows were more common and far more productive, they used less time and travelled shorter distances to secure their required forage.

In contrast, caribou were found to virtually avoid the meadow-type habitat used extensively by muskoxen in the summer. Caribou tended to use all vegetation types in much the same proportion to their occurrence. Upland barrens and mesic tundra types, intermediate between upland barrens and lowland meadows, were the most commonly used. The low productivity of these types was offset by the high mobility of the caribou. In winter, caribou favoured upland sites due to a lighter snow cover and easier access to forage.

Caribou and muskoxen were occasionally found together on the same vegetation type but direct competition for food did not occur. Caribou would move through an area occupied by muskoxen and feeding consisted of occasional bites of willow or flowers. Muskoxen would invariably be feeding on sedges and grasses. Tener (1963) found the distribution of caribou and muskoxen on Axel Heiberg Island to be mutually exclusive. Geographic separation of habitat use by the two species and the greater mobility of caribou were also noted in studies conducted on Banks Island (Wilkinson et al. 1976). Overlap in diets of muskoxen and caribou is minimal during the snow-free period. In the Mokka Fiord area, sedges (39.5%), particularly Carex aquatilis var. stans, were the most common forage selected by muskoxen, closely followed by willow (37.2%), although grasses (8.7%) and forbs (11.4%) were consumed also. Trends in the summer diet followed plant phenology. On Banks Island, sedges made up 77% of the diet and willow only 8.4% (Wilkinson et al. 1976). On Bathurst Island, willow was also a smaller component of the diet (16.8%) but grasses (41.3%) were more heavily consumed (Parker 1978).

Willow (Salix arctica) was the single most important component in the summer diet of caribou at Mokka Fiord accounting for 82%. Sedges and grasses only contributed about 3% to the diet and forbs 7%. Diet composition of caribou at Bailey Point was basically the same. However, Bathurst Island and Banks Island caribou consumed less willow.

In winter, when accessibility permits, muskox continue to feed on herbaceous vegetation (sedges and grasses) in the meadows but increase their intake of willow twigs and branches. Forbs play only a minor role in the overall winter diet. Unfavourable snow conditions force muskoxen from the preferred low-lying meadows to the slopes and ridges. This results in an increase in the intake of willow, grasses and forbs which are less abundant than sedges in the meadows. The winter diet of caribou in the Mokka Fiord area has not been studied. However, general preferences can be described from rumens collected from the western Queen Elizabeth Islands (Parker et al. 1975, Thomas et al. 1976). Willow is vital to caribou in winter; forbs, xeric sedges (e.g. Luzula nivalis, Kobresia myosuroides) and grasses are also important constituents of the winter diet. These components are obtained by foraging on exposed and snow-free ridges and upper slopes. In times of low forage availability, moss may be consumed in greater than usual quantities.

The conclusion drawn from the above studies is that competition between muskoxen and caribou for food and space is minimal. Competition is largely avoided by different food and habitat preferences and feeding strategies. In severe winters, when deep snows force muskoxen from the meadows to forage for willow, grasses and forbs on the exposed slopes and ridges, some inter-specific competition may occur.

There is some concern that the arctic hare may be an important competitor with muskoxen and caribou during the winter period when all three species feed on willow (Parker 1977). Willow may comprise as much as 95 percent of the winter diet of the arctic hare. An area used by a herd of several hundred hares in early winter can become virtually useless for hares, muskoxen or caribou due to severe compaction of the snow cover. However, muskoxen and caribou have a less restricted winter diet than hares and competition would become serious only where hares had reached extremely high densities and where severe winters made sedges in lowland meadows unavailable to muskoxen.

## 11.2 Birds

The avifauna of the study area has received only cursory examination. The main sources of information on birds occurring in the study area, or Axel Heiberg Island generally, are Parmalee and MacDonald (1960) and Macpherson (1963). Further information was obtained from Duvall and Handley (1948), Snyder (1957), Godfrey (1966), Kerbes (1971) Waterston and Waterston (1972), Ross (1974) and Muir (1975).

Only 22 species of birds have been reported with certainty to occur in the study area, although 30 species have been reported for Axel Heiberg Island as a whole (Appendix 5). A further seven species may be observed on Axel Heiberg Island in the future on an accidental basis (once in a decade). These seven species have all been reported for Ellesmere Island.

The bird fauna of the study area is not spectacular; bird-watching would be fairly unrewarding to most. Breeding bird densities are very low with the exception of ruddy turnstones and red knots. Isolated flocks of moulting snow geese in tundra ponds and low-centred polygon areas provide the greatest visual impact of all bird species. To the bird-watcher, the low density of birds is offset to some degree by the absence of nest records for 13 out of the 22 species reported for the study area and the opportunity for filling this information gap. Because there has been little ornithological investigation of the study area, an experienced bird-watcher has the opportunity for contributing significantly to our knowledge of the birds of the area.

### 11.2.1 Analysis of the Bird Fauna

The 22 species of the study area's bird fauna belong to the following orders: Charadriiformes 11 (50%); Anseriformes 5 (23%); Passeriformes 2 (9%); Gaviiformes 1 (5%); Falconiformes 1 (5%); Galliformes 1 (5%); and Strigiformes 1 (5%). As is typical of high arctic bird assemblages, shorebirds and gull-like birds dominate the fauna. The relatively high waterfowl component is however atypical and attests to the surprisingly good quality habitat present at this high arctic locality. The number of bird species recorded for Axel Heiberg Island (30) is considerably less than that recorded for Banks Island (70, Zoltai et al. 1980a), Bathurst Inlet (91, Zoltai et al. 1980b) and the Horton-Anderson rivers area (146, Zoltai et al. 1979) at the tundra-tree line transition.

An outstanding aspect of the avifauna of the study area is the likelihood that several of the species winter in Europe. Ruddy turnstones, red knots and brant banded on their breeding grounds in Ellesmere Island have been recovered in Europe (Maltby-Prevett et al. 1975, Morrison 1975). Wheatears, ringed plovers and sanderlings breeding on Ellesmere Island also winter in the Old World (Godfrey 1966, Wilson 1981). Populations of these species occurring in the study area presumably migrate with the Ellesmere Island populations.

Through interpretation of range maps published by Godfrey (1966) and Snyder (1957), the breeding distribution of birds can be characterized as High Arctic (breeding mainly in the Arctic Archipelago), Low Arctic (chiefly breeding on the Canadian mainland tundra), or wide-ranging (occurring in High and Low Arctic and south of the tree-line). Of the 13 species known to breed on Axel Heiberg Island, five (39%) are characteristic of the High Arctic; six (46%) are widespread in both the Low and High Arctic and two (15%) breed in several different biomes. The low numbers of breeding birds recorded for the area is again partly attributable to the small number of visitors to the area.

### 11.2.2 Waterfowl

Snow geese (Atlantica race) are the most abundant of the waterfowl species occurring in the study area. Table 11 summarizes snow goose population counts made on Axel Heiberg Island. Over 400 were counted in lakes and ponds of Schei Peninsula by Parmalee and MacDonald (1960) in 1955. Tener (1963) observed a total of 1047 flightless adult snow geese on the island in 1961. At least 542 of these occurred in the study area. Heyland and Boyd (1971) and D. Heyland (pers. comm.) have made a number of estimates of snow goose population size. Based on summer observations made between 1968 and 1974, D. Heyland (pers. comm.) calculated the Axel Heiberg Island population to number approximately 1000 individuals. Kerbes (1971) observed at least 30 breeding pairs and 560 non-breeders within the study area. We observed three breeding pairs, two of them with broods, and at least 250 moulting birds in flocks ranging

Table 11. Numbers of snow geese observed on Axel Heiberg Island, 1955–80.

| Year | | Study area | S. of Schei Peninsula to Stang Bay | Eastern Axel Heiberg Island | Axel Heiberg Island |
|---|---|---|---|---|---|
| 1955[1] | moulting adults | 400+ | | | |
| 1961[2] | moulting adults | 542 | 405 | | 1047 |
| 1968[3] | non-breeders | | 80 | 10 | |
| 1969[4] | breeding pairs | | 20 | 10 | |
| | non-breeders | | 480 | 131 | |
| 1971[3] | breeding pairs | | | 30 | |
| | non-breeders | | 192 | 443 | |
| 1971[5] | breeding pairs | 30 | 18 | | |
| | non-breeders | 560 | 50 | | |
| 1972[6] | moulting adults | 137 | | | |
| 1973[3] | breeding pairs | - | 12 | 22 | |
| | non-breeders | | 252 | 249 | |
| 1980[7] | breeding pairs | 3 | | | |
| | non-breeders | 252 | | | |

[1]Parmalee and MacDonald (1960); Schei Peninsula only
[2]Tener (1963)
[3]D. Heyland (pers. comm.)
[4]Heyland and Boyd (1971)
[5]Kerbes (1971)
[6]Waterston and Waterston (1972); Chain of Three Lakes only
[7]Present study

six to 55 birds in size. From the above information, the total Axel Heiberg Island population probably numbers about 1000 individuals or approximately 3% of the total greater snow goose population (D. Heyland, pers. comm.). Of this total, between 300 and 600 geese occur in the study area.

Most of the geese observed in 1980 occurred in:

(a) tundra lakes and ponds on the eastern coastal plain of Schei Peninsula;

(b) tundra lakes and low-centered polygon areas south of the ridge of mountains extending south from Depot Point (Fig. 40); and

(c) tundra lakes and low-centered polygon areas in the valley lying between Gibs and Mokka fiords, including the Chain of Three Lakes IBP site (Map 9).

These observations concur with those of Kerbes (1971). The study area appears to be of minor importance to other waterfowl species such as brant, oldsquaw and eiders. Macpherson (1963) observed a pair of brant with young on Schei Peninsula and 40 were seen southeast of the peninsula by Heyland and Boyd (1971). The occurrence of brant in the study area is made significant by the fact that high arctic populations of the species are known to winter in Europe (Maltby-Prevett et al. 1975). One male and three female common eiders were identified together on Schei Peninsula (Macpherson 1963) and a single female king eider was observed inland on the peninsula by Parmalee and MacDonald (1960). Oldsquaw have also been recorded on the peninsula (Parmalee and MacDonald 1960, Macpherson 1963). The authors did not see any brant or eiders but oldsquaw were seen on Schei Peninsula (one pair), at Mokka Fiord (six males) and in the coastal plain area south of Depot Point (10 males).

### 11.2.3 Birds of Prey

The arctic race (tundrius) of the peregrine falcon is considered to be an endangered species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 1978). North American peregrine falcons, including the arctic race, continue to decline as a result of sublethal effects of pesticides (Fyfe et al. 1976). Any recent records of peregrine occurrence in the study area are therefore significant. A single peregrine was seen on two occasions by Ross (1974) just north of Mokka Fiord. However, there was no evidence of breeding activity. Whether the species breeds in the study area, or other parts of Axel Heiberg Island, or occurs only as an occasional visitor is not known. Fyfe et al. (1976) does not include Axel Heiberg Island or Ellesmere Island in the known breeding range of the species. The nearest known breeding locality is the Cape Sparbo area of northern Devon Island (Ross 1974).


Map 9. Important areas for snow geese in the study area

Suitable cliff nesting habitat exists at Buchanan Lake, a few kilometres southwest of Mokka Fiord. If a national park was created in the study area, Buchanan Lake should be investigated further for peregrine falcon nest sites. All sites found should be rigorously protected as critical areas and their location kept confidential. Access to nest sites by boat or on foot should be strictly controlled, especially during incubation or when small young are in the nest. Low level aircraft flights should not be permitted within a 1.6 km radius of the nests. Fyfe and Olendorff (1976) and Goodman (1977) provide further guidelines for human activity near nest sites of raptors.

Gyrfalcons have been observed at the extreme northern tip of Axel Heiberg Island near Cape Stallworthy (Renewable Resources Consulting Services 1972). Breeding is suspected to occur on the ridges east of the cape. Muir (1975) reported a pair nesting in 1971 on a sandstone outcrop about 10 km east of Blue Man Cape on Fosheim Peninsula (Fig. 41). In subsequent years, the nest site appears to have been abandoned. However, the significance of this is questionable since there is evidence to suggest that gyrfalcons use alternate nest sites in different years (D. Muir, pers. comm.). The authors examined the area where the nest site was reported but no evidence of recent nesting was found. Suitable nesting habitat probably exists in the study area but we did not find any evidence of either resident or transient gyrfalcons.

Only one snowy owl was observed in the study area by the authors on a high ridge on Schei Peninsula. Macpherson (1963) noted that snowy owls appeared to be scarce on Axel Heiberg Island during the summer of 1960 and 1961. Parmalee and MacDonald (1960) considered the species to be rare on Fosheim Peninsula and related this to the extreme scarcity of lemmings during the 1953-55 period. Lemming is an important prey item of the snowy owl and when lemming numbers are low, lemming predators such as the snowy owl will fail to breed (Maher 1964). No lemmings were observed in the study area in 1980. However, a lemming winter nest containing a lemming skeleton was found by the authors in a ravine a few kilometres northwest of Mokka Fiord. It is possible that a series of severe winters had reduced lemming numbers on Axel Heiberg Island causing a reduction in the snowy owl population. A systematic study of the lemming population would need to be conducted to determine its current status in the study area.

### 11.2.4 Shorebirds, Gulls and Allies

Ruddy turnstones and red knots were the most common charadriiform species observed in 1980. No nests of either species were found although at least one pair of turnstones exhibited distraction displays as if to lead intruders away from the nest. Macpherson (1963) saw many turnstones on Schei Peninsula and several red knot adults accompanying broods near Buchanan Lake. Up to 400 turnstones were observed by Waterston and Waterston (1972) at one of the three lakes comprising the Chain of Three Lakes and one or two behaved "as though with young". The same authors also noted lesser numbers of knots

Figure 41. Gyrfalcon nesting area on Isachsen sandstone cliffs.

Figure 42. A long-tailed jaeger in flight.

feeding at the same lake and one was obviously with young. Both species occurred at most locations visited in the study area in 1980. However, low- elevation moist meadow and tundra habitat types seemed to be preferred. Morrison (1975) documented movements of turnstones and knots between their European wintering grounds and breeding grounds in the Canadian Arctic. Wilson (1981) reported that ringed plovers and sanderlings breeding on Ellesmere Island also winter in the Old World. Iceland is an important stopover for all four species. Of particular interest are the turnstones and knots which were banded in Europe and recovered on Ellesmere Island. Although not documented by Morrison (1975) or Wilson (1981), it is most likely that Axel Heiberg Island populations of the four species similarly spend the winter in the Old World. This migratory pattern reflects the former origin of the species and provides an interesting element to the avifauna of the study area.

Long-tailed jaegers are quite abundant in the study area, (Fig. 42) occurring mainly in habitat associated with low-elevation plains and valleys. The parasitic jaeger has been observed at Buchanan Lake (Macpherson 1963).

Glaucous gulls and arctic terns are quite common in the study area. Most commonly, they are associated with coastal plain lakes or coastal areas. One record of ivory gull on the Schei Peninsula exists (Macpherson 1963). A colony of gulls, believed to be Thayer's gulls, was discovered at Buchanan Lake by the authors. Eight individuals were counted on nests constructed on ledges of the steep south-facing cliffs. Parmalee and MacDonald (1960) report observations of the 1953 Axel Heiberg Expedition to Mokka Fiord whose members saw "as many as 15 Thayer's gulls nesting on cliffs near Buchanan Lake". We cannot be certain that this is the same colony as the one observed in 1980; however, it seems likely. It should be noted that the Arctic Ecology Map Series (Renewable Resources Consulting Services 1972) refers this breeding colony to be one of glaucous gulls. The colony should be given full protection should the area be included in a national park and access to the colony strictly controlled. The identity of the gulls should be resolved.

### 11.2.5 Perching Birds

Snow buntings are the most common of the passerine species occurring in the study area. They were observed mostly on rocky slopes and ridges in high-elevation areas in 1980. Also fairly common and occurring in similar habitats as the snow buntings were wheatears. This species had not been recorded for Axel Heiberg Island prior to our investigation. Although pairs were observed, no definite evidence of nesting was found. The presence of the wheatear in the study area is particularly interesting since its wintering grounds are in the Old World (Godfrey 1966).

## 11.3 Fishes

The occurrence and distribution of fish species in the Canadian High Arctic is poorly known. What little information there is comes from isolated collections of specimens. Information on seasonal movements, spawning areas and areas of important fish habitat is not available for the study area.

Appendix 6 is a preliminary checklist of marine and freshwater fishes of the Axel Heiberg Island area. It should be noted that strictly freshwater fish have not been reported for Axel Heiberg Island, although they are known to occur on adjacent islands. Fish species listed have been collected from either marine waters adjacent to the study area or other high arctic locations. The following sources were used to compile the checklist: Hildebrand (1948), Walters (1953), D. E. McAllister (pers. comm.) and J. G. Hunter (pers. comm.). Hildebrand (1948) lists fishes of the high arctic region which he describes as including the "Parry and Sverdrup Archipelago, Ellesmere Island and Northwest Greenland". Walters (1953) provides notes on fishes collected from Prince Patrick and Ellesmere islands. The marine waters of Slidre Fiord, adjacent to Eureka Sound, were sampled for species and abundance of fish in the summer of 1962. Results of the sampling were made available to the authors by J. G. Hunter (pers. comm.). National Museum of Canada maintains a computerized inventory of fish species by geographic location. A search of this inventory resulted in the addition of several species to the preliminary checklist (D.E. McAllister, pers. comm.).

The 20 species known to, or considered likely to, occur in marine waters adjacent to the study area belong to the following families: Salmonidae 1 (5%); Gadidae 3 (15%); Zoarcidae 5 (25%); Stichaiidae 1 (5%); Pholidae 1 (5%); Cottidae 5 (25%); Agonidae 1 (5%); and Cyclopteridae 3 (15%). Arctic char, a freshwater fish which runs to the sea, was the only species identified during extensive collections of fish from Lake Hazen, Ellesmere Island, during the summer of 1958 (J.G. Hunter, pers. comm.). Arctic grayling, also a freshwater species, have been reported for Victoria Lake, Ellesmere Island. While neither of these two species have been reported for Axel Heiberg Island, their occurrence there is possible.

The preponderance of bottom-dwelling sculpins (family Cottidae) and snailfishes (family Cyclopteridae) in the preliminary checklist is typical of arctic marine fish assemblages (McAllister 1977). J.G. Hunter (pers. comm.) reported that 1632 of the 1660 fish caught at Slidre Fiord were fourhorn sculpins, indicating the abundance of this species near the study area. McAllister (1977) briefly gives the habitat preferences of these and other species included on the checklist. These habitats are assumed to occur in the Axel Heiberg Island area. Fourhorn and shorthorn sculpins are found in the depauperate intertidal and immediate subtidal zones while the arctic staghorn sculpin prefers sandy bottom habitat. On muddy bottoms are found the Canadian eelpout and in the laminarian zone from 6 to 10 m depth live the fish doctor and Greenland seasnail. There are no arctic fishes whose survival depends on dwelling near the water surface, such as herring, although cryopelagic fishes such as arctic and polar cod live in close association with ice, feeding on diatom-consuming crustaceans. Greenland cod are commonly found swimming near rocky outcrops.

Arctic fishes are adapted to important limiting factors of the arctic environment which include reduced light, seasonal darkness, prolonged low temperatures and ice-cover periods, depauperate fauna and flora, and low seasonal productivity (McAllister 1977). Depauperate fauna and flora and harsh climate conditions are among the factors responsible for the lack of specialization among arctic fish assemblages. In many respects, the arctic environment parallels the deepsea environment with consequent similarities in fishes dwelling in these two habitats (McAllister 1977).

Management concerns:

1. Because of the paucity of information on species composition, abundance and distribution of fish in the study area, an inventory of fish and important fish habitat should be an early research priority should the area receive national park status. Such information is required in order to consider possible restrictions on fishing and boating activities in the park which may be necessary for preservation of the fish resource.

# 12. HUMAN HISTORY

## 12.1 Inuit Prehistory

The history of Inuit settlement on Axel Heiberg Island is just beginning to be investigated. At the time this report was being written, only one publication on archaeological material collected from Axel Heiberg Island existed (Schledermann 1975). Other authors have referred to the presence of archaeological sites at certain locations in the study area (Sverdrup 1904, Waterston and Waterston 1972, Nettleship and Smith 1975). Intensive archaeological investigations of sites on Axel Heiberg Island began in 1977 (Sutherland 1977).

McGhee (1978) and Taylor (1976) provide good accounts of how different Inuit cultures are believed to have developed through the dispersal and settlement of their ancestors of Alaskan origin. The following description is based on the work of these two authorities unless otherwise indicated.

### 12.1.1 Independence I: 2000-1700 B.C.

The first people to occupy the tundra lands of Alaska, arctic Canada and Greenland left archaeolocical remains known to archaeologists as the Arctic Small Tool Tradition (ASTt), named for the remarkably small size of their chipped-stone tools and weapons. Considered by most archaeologists to be the "first Eskimos". these people were the first to develop a way of life adapted to the non-forested arctic environment, expanding eastward and northward from Alaska about 4000 years ago. The variant of the early ASTt which populated the high arctic region is referred to as "Independence I", named after Independence Fiord on the northern Greenland coast where Eigil Knuth first discovered the remains of this culture. The Independence I culture lasted from about 2000 to 1700 B.C.

Steensby (1917) postulated a northeasterly migration of "paleo-eskimos" along a route referred to as the "Musk-Ox Way". The northern portion of the route took these people up Eureka Sound, Greely Fiord and Tanquary Fiord to Lake Hazen and Lady Franklin Bay, Ellesmere Island. Steensby's theory was supported by excavations of sites in northern Ellesmere undertaken by Knuth (1965). To date, no Independence I sites have been identified on Axel Heiberg Island (Sutherland 1977). However, assuming that Eureka Sound was indeed part of the migration route, the presence of yet undiscovered sites on Axel Heiberg would appear likely.

Characteristic of Independence I camp sites is their scattered distribution, contrasting with the clustered configuration of most camps of arctic hunters. The small number of bones and artifacts scattered about most camps suggests that they were usually occupied for only a few days or weeks. The Independence I people were apparently muskox hunters. Although they also depended heavily on small game, such as fox, hare and waterfowl, caribou seem to have been rarely hunted.

Northern Greenland and the Canadian High Arctic appear to have been abandoned by the Independence I people, for reasons not precisely understood, by about 1700 B.C.

12.1.2 Independence II: 1000-500 B.C.

There are few traces of habitation in the region until about 1000 B.C. when a second culture, referred to as "Independence II" emerged. Remains of this culture were discovered by Eigil Knuth. Certain characteristics suggest a close link between this and the Independence I culture. The most visible similarities are found in the settlement pattern (long, dispersed strings of camps) and the dwelling structure: rectangular to oval in outline, with a central box-hearth flanked by two lines of vertical slabs, forming a mid-passage, with gravel sleeping areas on either side. Distinct differences, however, are found in the style of the artifacts. Styles of artifacts continued to change and lead to the development of the Dorset culture.

12.1.3 Dorset: 800 B.C. - A.D. 1000

Characteristic of this period (named after Cape Dorset, Baffin Island where remains of this culture were first discovered) were soapstone pots and lamps, ivory snow knives and sled shoes (suggesting a new adaptation to winter hunting on the sea ice) and a rectangular semi-subterranean winter house. The winter house consisted of raised sleeping platforms along either side of a central passage or hearth area, and apparently had walls of either sod or snow (McGhee 1975). Dorset people may have spent spring and summer on the coast, hunting walrus at haulout areas and harpooning seals and walrus from the edge of shorefast ice. Later in the summer, larger groups may have gathered at fishing spots where char could be speared and at places where caribou could be hunted. The autumn may have been spent in the semi-subterranean houses on the coast until the winter ice formed. Some groups may have spent the winter in these houses, living on stored food or hunting in nearby areas of open water, but most Dorset people probably passed the winter in snow-house communities, hunting seals at their breathing holes.

In the High Arctic, the only Dorset sites known are those of the later phases which have been roughly dated to between A.D. 500 and 1000. One Dorset site has been found in the Buchanan Lake area of Axel Heiberg Island (Schledermann 1975).

Within a short period of time around 1000 A.D., the Dorset culture disappeared. The cause for extinction of the culture is not exactly known. The period around 1000 A.D. was one of rapidly warming climate, and this probably caused marked changes in sea-ice conditions and animal distributions throughout arctic Canada. Some Dorset groups may have been unprepared for such changes in hunting conditions and starved.

Shortly after A.D. 1000, a new migration from Alaska brough the immediate ancestors of the present day Inuit to arctic Canada. They may have killed some Dorset people and forced others into areas where they could not support themselves. Legend has it that the Dorset people were driven from the country.

12.1.4 Thule: A.D. 1000-1600

The Alaskan people, from whom the Thule culture originated, developed the float-harpoon and skin-covered boats (the kayak and the larger umiak) which allowed them to hunt larger sea mammals in open water. It has been postulated that the warm climatic period encouraged the Thule people to expand eastward and northward into the relatively ice-free waters of the Canadian Arctic, which at that time supported populations of bowhead whales and other sea mammals well beyond the present range of these species (McGhee 1978). It should be noted, however, that the importance of bowhead whales to Thule subsistence has recently come under debate (McCartney 1980).

The Thule people (obtaining their name from Thule, Greenland, where remains were first discovered) also developed a number of other specialized tools, including: probes to detect the shape of seal breathing holes, indicators to show when a seal had arrived at the hole, stools for the sealers to sit on, snow goggles to prevent snow blindness and special toggles for pulling the dead animal home across the ice. Winter hunting was also made easier by the use of dogsleds which seem to have originated with the early Thule people.

Thule hunters also depended on land animals for food and clothing. Caribou and muskoxen were shot with a sinew-backed bow or were killed with spears thrown from kayaks. Waterfowl were killed with blunt arrows, special bird spears with three sided prongs, or with bolas, a group of bone weights tied together with thongs and flung at low-flying birds. Fish were speared with tridents or caught with gorges and jigging hooks.

Characteristic of the remains of the Thule people are their winter houses. A typical dwelling was irregularly oval in outline, with an entrance tunnel built of stone slabs or boulders. The interior of the house was divided into two sections: a floor area in the front paved with flagstones with one or two cooking areas in the corners and, at the back, a raised flagstone platform where family members slept. The roof of the house was dome-shaped, held up by rafters of whale jaws and ribs set in the stones of the outer wall and tied together at the top. This frame was covered with skins, then with a thick layer of turf and moss and finally probably packed with snow. Early summer probably saw a move to skin tents pitched on beaches.

After about 1200 A.D., the climate of arctic Canada began to cool, reaching a cold peak known as the Little Ice Age between roughly 1600 and 1850 A.D. Glaciers advanced on the islands of the eastern Arctic, sea ice increased in area and duration and populations and ranges of many animal species probably changed markedly. Perhaps the most significant change was the disappearance of the bowhead and Greenland whales from many areas. The range of smaller whales, walrus and migratory seals may also have been limited. The Thule response to the Little Ice Age resulted in a series of local cultures, the forerunners of present day Inuit "tribes", each adapted to the resources of a specific area. The High Arctic did not offer the alternative resources that enabled the Inuit of the Central Arctic to adapt to the Little Ice Age and populations were forced to withdraw from the northernmost islands probably in the 1600's. Europeans visiting the eastern High Arctic in the nineteenth century found the area uninhabited except for some Greenland Inuit who made occasional hunting trips to Ellesmere Island.

A number of sites believed to be of Thule origin, and comprised of tent rings, caches and fox traps, have been located in the Buchanan Lake area by P. Sutherland (pers. comm.). Nummerous tent ring and other features are conspicuous on the west side of Mokka Fiord (J. Marsh, pers. comm., authors) and other such features were noted by the authors on the eastern coastline of Schei Peninsula. Tent rings and fox traps near Butter Porridge Point (Fig. 43) and Skraeling Point were first noted by Sverdrup (1904). Two Thule autumn houses built into the hillside and tent rings have been identified in the Chain of Three Lakes area (Sutherland 1977). Thule people probably found this site well placed for hunting muskoxen and waterfowl moulting at the lakes. From the archaeological evidence obtained so far, Thule occupation of eastern Axel Heiberg Island dates to the early to middle Thule period (Sutherland 1977). It is apparent from the number of discovered sites that certain localities within the study area received heavy use by Thule people. No doubt many more sites will be discovered in the study area during future archaeological investigations. It is vitally important that all archaeological sites on Axel Heiberg Island remain undisturbed prior to examination and analysis by qualified archaeologists so that the history of occupation by Inuit ancestral groups can be elucidated.

In summary, occupation of the High Arctic by the Inuit and their ancestors is marked by successive cultures increasingly sophisticated in their adaptations to changing environmental conditions. Habitation of the region was terminated by worsening climatic conditions which resulted in starvation of some groups and forced others to withdraw to more southerly regions.

## 12.2 Early European Contact

Around the time that the Thule people were becoming established in the eastern Arctic (about 1000 A.D.), a Norse expansion

Figure 43. A tent ring of stones near Butter Porridge Point.

Figure 44. A fiord crowded by icebergs (Otto Fiord).

to Greenland and eastern Canada occurred (McGhee 1978). Norse exploration and trading voyages along the west coast of Greenland are known to have taken place at least as far north as 72° latitude (Schledermann 1980). In the last few years, artifacts of Norse origin have been identified from Thule culture winter house ruins at several high arctic locations. Schledermann (1978) discovered a number of such artifacts (e.g. chain mail sections, knife blades, woolen cloth) in the Bache Peninsula region on the east coast of Ellesmere Island. At a Thule site at Slidre Fiord not far from the study area, a bronze folding balance was discovered by Sutherland (1977). Presently, it is not clear whether the Norse finds ended up on Ellesmere Island as a result of direct trade between the resident Inuit and Norse explorers or trade between Inuit groups along the west coast of Greenland and across Smith Sound. On the basis of present evidence, it seems possible that both events took place (Schledermann 1980).

### 12.3 Historical Exploration

The first explorer to come closest to discovering Axel Heiberg Island was Lieutenant Adolphus Greely of the U.S. Army who set out in 1881 to "establish a station north of the eighty-first degree of north latitude, at or near Lady Franklin Bay [Ellesmere Island], for the purposes of scientific observation" (Greely 1886). On April 24, 1883, Lieutenant J.B. Lockwood was ordered to explore the area of Grinnell Land (the name given to that region of Ellesmere Island in those days) lying to the southwest of Lady Franklin Bay. On May 12, Greely Fiord was discovered and named after the commander of the expedition. Lockwood travelled several miles out into the fiord and examined the country to the west with a telescope. He made the following observations:

> "Sergeant Brainard and I examined the mouth of the fiord carefully...which after some time brought out very faintly a cape [Lockwood] still farther to the west... Between Cape Lockwood and land's end [Cape Brainard] repeated scrutiny revealed nothing but the horizon".
>
> (Greely 1886, pp. 37-38)

Discovery of Axel Heiberg Island was "reserved" for the Norwegian explorer Otto Sverdrup. Otto Sverdrup was asked to lead a discovery expedition to the High Arctic, known as the Second Fram Expedition (named after the vessel they used, called the Fram), by Dr. Fridthof Nansen who was a seasoned arctic explorer himself. Sponsors of the expedition were Norwegian Consul Axel Heiberg and two wealthy brewers, the Ringnes brothers. With Sverdrup went fifteen of his countrymen, including: Lieutenant Baumann, second in command; Sverre Hassel, ship's mate; Gunerius Isachsen, cartographer; Herman Simmons, Herman Simmons, botanist, Edvard Bay, zoologist; Per Schei, geologist; and Ivar Fosheim. The following account of Sverdrup's expedition is abstracted from Sverdrup (1904).

Their route was to take them along the west coast of Greenland as far north up Smith Sound as the Fram could go. However, heavy ice conditions forced the expedition to put ashore at Cape Sabine, Ellesmere Island on August 22, 1898, where they stayed for the winter. In the spring of 1899, two parties left the Fram to cross Ellesmere Island and on April 29 discovered a fiord on the west side of the island which they called "Bays Fjord" (now called Bay Fiord). The following summer, another attempt was made to steam northward but Sverdrup could not drive his way through. He then altered his plans and headed south for Jones Sound. The winter of 1899-1900 was spent at "Havnefjord" (Harbour Fiord) on the south coast of Ellesmere Island. In the spring of 1900, nine men set out on extended sledging trips to search for new land to the north and explore the unknown western coastline of Ellesmere Island. They followed the coast of King Oscar Land (as that region of Ellesmere was called then) to Bjorne Peninsula. Sverdrup believed that, in the vicinity of where they were camped on Bjorne Peninsula, there must be a sound cutting northward "through the land in the direction of Greely Fiord" and that this sound was connected to the fiords they had seen the previous spring. They continued northwest across Norwegian Bay heading for a "black wall of rock" which was Axel Heiberg Island. They arrived at "Cape South-West" on April 11. On Easter Monday, Sverdrup climbed a huge ice pressure ridge and caught sight of "new land" to the west. The decision was made for Isachsen and Hassel to visit this new land (Amund and Ellef Ringnes islands) while Sverdrup and Fosheim would continue northward to explore the western coastline of Axel Heiberg Island, eventually reaching a point just north of 80°55' on May 5. They then proceeded homeward and returned to the Fram to find that the vessel had almost been destroyed by fire!

Another winter passed by and in the summer of 1900, Sverdrup attempted without success to move the Fram through Cardigan Strait. He returned to Jones Sound and sought harbour at "Gaasefjord" (Goose Fiord). Another winter passed and in the spring of 1901 sledging parties set off once more, determined to find the waterway which they believed connected Norwegian Bay to Greely Fiord. After getting sidetracked down Baumann and Vendom (meaning "turn back") fiords, they finally sighted "a beautiful, large sound extending northward as far as the eye could reach". The sound was named "Heureka Sound" (Eureka Sound), using the word exclaimed by the famous Greek scientist Archimedes when he made his famous discovery.

With renewed excitement, they continued northward up Eureka Sound reaching a point of land which they christened "Maiodden" (May Point) after the date of their arrival. Still travelling along the sound, they set their course for "Blaamanden" (Blue Man Cape). At this point the explorers split into two parties: Fosheim and Hassel were to follow the east side of the sound northwards and Sverdrup and Schei the west side of the sound as far as they could go. The parties confirmed that Eureka Sound was in fact connected to Greely Fiord.

Sverdrup and Schei rounded the northeastern tip of the peninsula named after the latter member of the party and camped somewhere on the peninsula's northern coast. Having been weatherbound for several days, they headed back to the point of land which they had passed several days earlier. This point was named "Smörgrautberget" or "Butter Porridge Mountain" (now Butter Porridge Point) after the meal they prepared to celebrate their farthest point north. The "smörgröd", made from flour and "best Danish butter", apparently went down well!

On May 13, they started back down Eureka Sound, stopping at "Skraellingodden" (Skraeling Point), "Vakkerkap" (Fair Cape), past "Mökkafjord" (Mokka Fiord) to "Depotodden" (Depot Point), May Point, "Storöen" (Stor Island) and "Whitsunfjord" (Whitsunday Bay, named after the date of discovery). They also discovered and named "Skaarefjord" (Skaare Fiord), after the young glaucous gulls ("skaarers") observed there, "Ulvefjord" (Wolf Fiord), "Hyperitodden" (Hyperite Point) and "Gletcherfjord" (Glacier Fiord) before heading across Norwegian Bay to the Bjorne Peninsula. This concluded exploration of Axel Heiberg Island in 1901.

In the following spring, Schei and Sverdrup set out once more to map the "tracts west of Greely Fiord". When they reached Greely Fiord they crossed over it to the mountainous land north of the fiord. They moved west along the coast and discovered "a large waterway, which cut through the land for a great distance in a northerly direction". They named the fiord "Harefjord" (Hare Fiord) because of the large number of arctic hare in the vicinity. Sverdrup comments in his book:

> "Almost everywhere we looked we saw hares scampering in all directions. The place was teeming with them. They ran about as if they had taken leave of their senses".

These observations are interesting in light of the authors' similar impressions of this locality made on a side-trip during our field investigations.

The party continued west along Nansen Sound until the land ran in a northward direction at "Lands Lokk" (situated at the tip of the Kleybolte Peninsula), the furthest north reached by the Second Fram Expedition (81°40' latitude). From there they crossed Nansen Sound to Cape Thomas Hubbard (or Cape Stallworthy as it now known), the northernmost point of Axel Heiberg Island. Heading east, they resolved "to find out for certain ... whether "Schei Ö" (Schei Island) was really an island or only a long peninsula":

"We drove south through a waterway west of the island and ascertained it for certain to be an island. The sound between Heiberg Land and Schei Island has been named Flatsund".

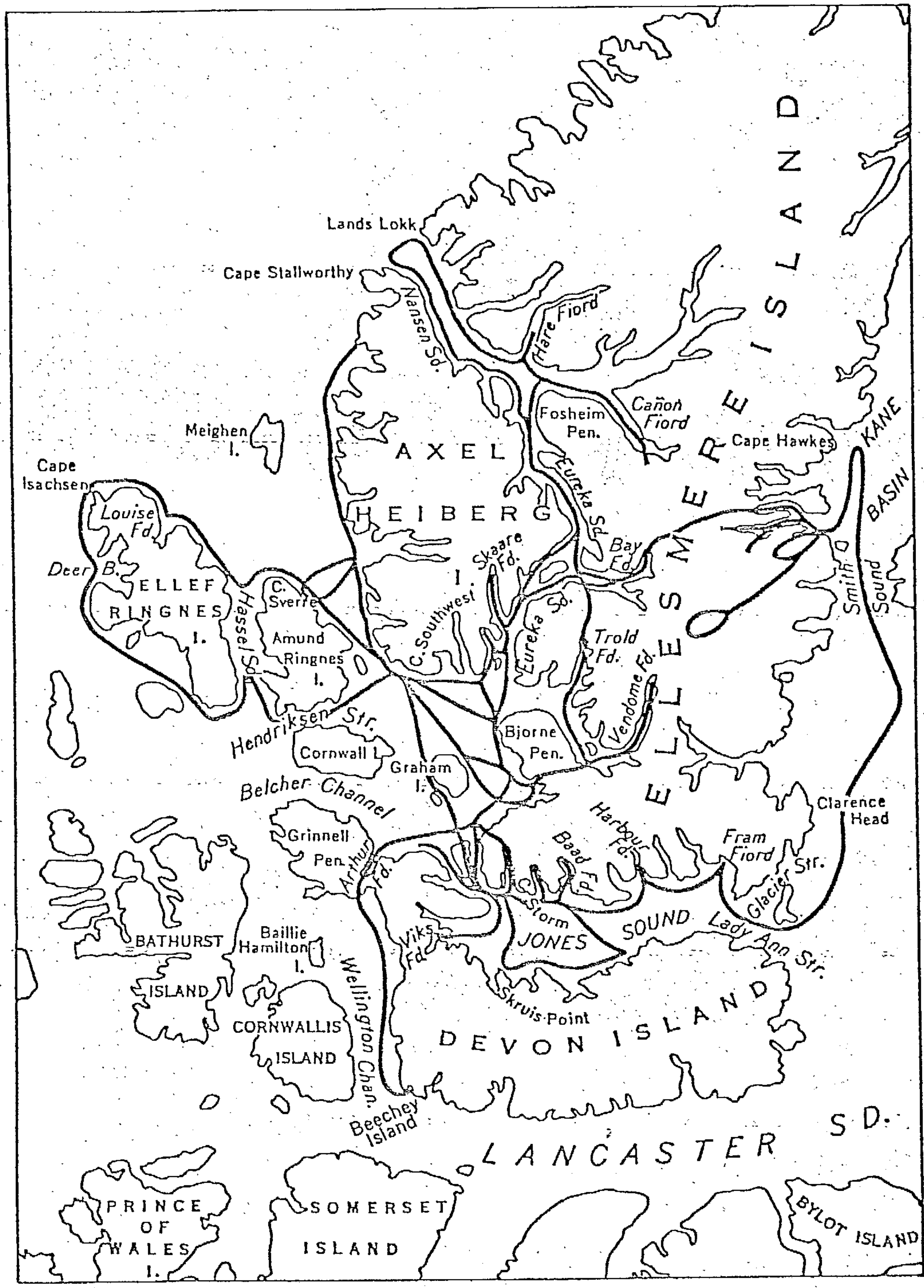
As it turns out, their judgment was incorrect and today the land mass bears the name "Schei Peninsula". The rationale behind their next move is somewhat hard to understand. Since they had "gone considerably out of [their] way" down Flat Sound to resolve the "Schei Island" question, and Sverdrup implies that they had to hastily continue their return journey south, it would seem logical for them to have taken a route along the waterway which supposedly existed between "Schei Island" and the mainland. This route would have lead them directly to Skraeling Point where they had camped the previous spring. Instead, they went the long way round, stopping at their old camping spot at Butter Porridge Point before returning south down Eureka Sound and concluding the first chapter in the exploration of Axel Heiberg Island. Map 10 summarizes the routes taken by Sverdrup and his parties between 1898 and 1902.

Axel Heiberg Island did not receive further attention until 1908. In the winter of 1905-1906, a gallant attempt was made by Commander Robert Peary to reach the North Pole. He managed to reach 87°00' latitude before turning back. Following his return to Cape Sheridan (east of Alert on Ellesmere Island), an expedition set out to fill in the detail of the northwest coast of Ellesmere Island, closing the knowledge between the farthest point west, reached by the expedition led by Captain Sir George Nares in 1876 (Alert Point), and Sverdrup's farthest north (Cape Stallworthy) (Taylor 1964). On the summit of Cape Stallworthy, Peary remarked:

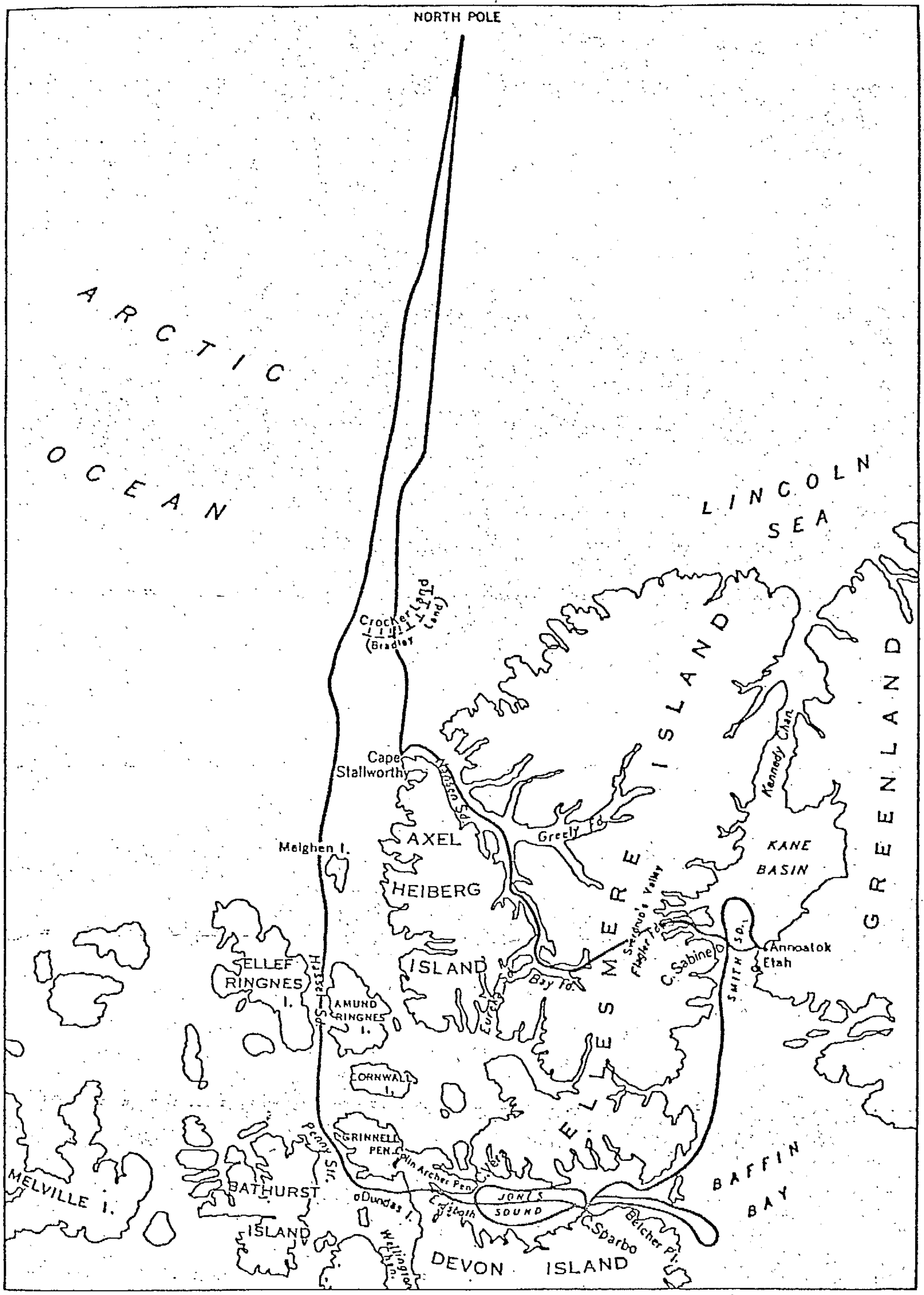
"I could make out apparently a little more distinctly, the snow-clad summits of the distant land in the northwest, above the ice horizon".

This "distant land", named Crocker Land by Peary (1907), was apparently also noted by Dr. Frederick Cook as he made his "dash for the Pole" in 1908 (Cook 1911). Prior to leaving Cape Stallworthy for the Pole, Cook's journey had taken him along Bay Fiord, Eureka Sound and Nansen Sound. Map 11 shows the route that Cook claims to have followed during his expedition to the North Pole and his eventual return to Annoatok, Greenland. It should be pointed out, however, that there is great doubt as to whether Cook did indeed reach the Pole (see, for example, Hall 1917, Stefansson 1939).

In 1914, Donald MacMillan set out from Etah, Greenland to solve the "last great geographical problem of the north": did Crocker Land really exist (MacMillan 1918). His route took him and his party along the same waterways Cook had followed: Bay Fiord, Eureka Sound and Nansen Sound, stopping at "Schei Island" for four days en route. After travelling more than 160 km from Axel Heiberg Island, they finally




Map 10. Areas explored by Second Fram Expedition lead by Captain Otto Sverdrup, 1898-1902 (Taylor 1964)




Map 11. Alleged route followed by Dr. Frederick Cook to and from the North Pole, 1907-1909 (Taylor 1964)

caught sight of "hills, valleys, snow-capped peaks extending through at least one hundred and twenty degrees of horizon". An Eskimo member of the party concluded that it was "poo-jok" (mist). MacMillan (1918) wrote:

> "As we proceeded the landscape gradually changed its appearance and varied in extent with the swinging around of the sun; finally at night it disappeared altogether... Could Peary with all his experience be mistaken? Was this mirage which had deceived us the very thing which had deceived him eight years before?"

To his great disappointment, MacMillan had to finally conclude that Crocker Land was just a grand illusion.

In the late 1920's, a number of arduous R.C.M.P. patrols were made in the Arctic Archipelago. The most outstanding of them all was made by Staff-Sergeant A.H. Joy in 1929 (Taylor 1964). Three years previously, Joy had made a journey of nearly 1600 km in 40 days from Craig Harbour, Ellesmere Island to Axel Heiberg Island and later in the same year travelled from Bache Peninsula, Ellesmere Island on a 2120 km, six-day journey to Axel Heiberg, King Christian, Cornwall and Graham islands. In 1929, he journeyed from Dundas Harbour, Devon Island along Lancaster and Viscount Melville sounds, across Melville Island and northeast to Eureka Sound passing the Ringnes islands, before crossing Ellesmere Island to Bache Peninsula. While Joy was travelling, Corporal E. Anstead left Bache Peninsula and "explored parts of Axel Heiberg Island which were almost completely unknown, and, after covering [1680 km] in forty-seven days, returned in safety to Bache Peninsula" (Fetherstonhaugh 1938).

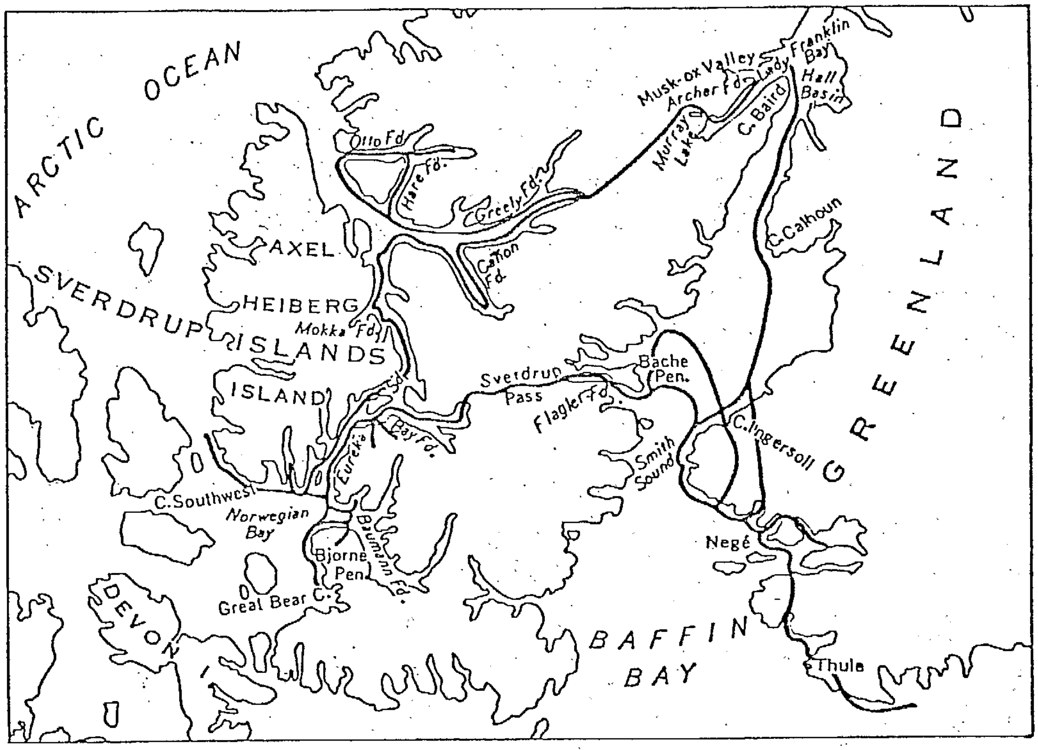
The next explorer that Axel Heiberg Island was to host was Dr. H.K.E. Krueger (an island in the vicinity of "Lands Lokk" is named after him). Krueger's objective was to relate the geology of Greenland with that of Ellesmere Island. However, there is some indication that he had a more ambitious purpose, namely, to make a further attempt to discover Crocker Land. He crossed the Ellesmere Island ice-cap to Eureka Sound in 1930 and, after cacheing some supplies at Depot Point, sent two of his Eskimos back. No further word was heard of him, although a search made in 1932 by the R.C.M.P. turned up a paper signed by Krueger and others (together with a record made by MacMillan) in a cairn built by Peary on Cape Stallworthy (Taylor 1964). The paper indicated that the Krueger party had decided not to continue any further north but to strike out in a southwest direction for Meighen Island (Map 10). No traces were ever found of the party.

A number of other expeditions subsequently passed through the study area. D. Haig Thomas led an expedition in 1938 which developed out of the Oxford University Ellesmere Land Expeditions of 1934-35. His route took him across Ellesmere Island to Eureka Sound from where he travelled to Amund Ringnes Island discovering an island en route, estimated to be 520 $km^2$ in area (Taylor 1964). As no surveying was done its location could not be mapped.

In 1938, Clifford MacGregor set out to, among other things, "explore the Polar Basin northwest of Ellesmereland, Canada, in order to clear up the question of Crocker Land". A flight was made by Commander I. Schlossback out of Etah, Greenland, touching down at Schei Peninsula and Cape Stallworthy, and heading northward in search of Crocker Land. Needless to say, he didn't find it.

Two sledging parties, comprising the Danish Thule and Ellesmere Land Expeditions of 1939-40, explored parts of Ellesmere and Axel Heiberg islands in 1940 (Map 12). Mokka Fiord and the southern coast of Axel Heiberg Island were among the areas examined during this expedition. More recently, a series of scientific expeditions to Axel Heiberg Island was initiated by McGill University, Montreal in 1959. Between 1959 and 1962, the Jacobsen-McGill Arctic Research Expedition, based at Expedition Fiord on the west side of Axel Heiberg Island, conducted numerous studies in disciplines which included glaciology, geophysics, meteorology, geomorphology, botany and zoology. Since then, Axel Heiberg Island has served as a study area for various other scientific investigations of the high arctic environment.

The preceding account of early exploration of Axel Heiberg Island shows that Eureka Sound has been fairly well-travelled through the ages. It is possible that evidence of these travels, such as remains of food caches, lost possessions and other expedition supplies may still be present at certain locations on Axel Heiberg Island (e.g. Depot Point, Butter Porridge Point). Such items may be recovered during the course of future archaeological investigations of the island.




Map 12. Areas explored by the Danish Thule and Ellesmere Land Expedition, 1939-1940 (Taylor 1964)

## 13. CONCLUSIONS AND RECOMMENDATIONS

Eastern Axel Heiberg Island contains a wide variety of landforms and natural settings ranging from elevated, barren outcrops of bedrock to low-lying, well-vegetated meadows. Although animal diversity is low, snow geese, muskoxen and arctic hare are seasonally or locally abundant. The relatively mild summer weather conditions typifying this high arctic locale accomodates the enjoyment of its scenic beauty. Evaluation of the potential of this area as a possible national park is complicated by the fact that consideration of eastern Axel Heiberg Island was initially based on the premise that it could form part of a two component park; a portion of Ellesmere Island would constitute the other component.

The general conclusion of the authors is that natural resource features contained in the study area are unusual for the extent of well-vegetated areas for a region of such high latitude. Such concentration of primary productivity sustains a relatively large number of animals. Although there are productive areas on northern Ellesmere Island, these are far more extensive on eastern Axel Heiberg Island. The scenic values of the study area are not comparable to those of northern Ellesmere Island, as the glacierized areas were purposely excluded from this study. There are reports of scenic excellence on the glacierized western Axel Heiberg Island that would match those of northern Ellesmere Island.

The primary recommendation of England et al. (1981), who conducted a natural resource inventory of the Ellesmere Island area, was that the area should receive protection as an ecological reserve rather than be established as a national park. In view of this recommendation, we have evaluated the feasibility or appropriateness of setting aside an area of Axel Heiberg Island, enlarged from our study area, which would satisfactorily represent the natural resource features of Natural Region 39.

The following sections address the potential of the study area and an enlarged area of Axel Heiberg Island as a national park.

### 13.1 National Significance of the Eastern Axel Heiberg Island Study Area

In spite of its relatively small area, the eastern Axel Heiberg Island study area contains a diverse assemblage of landscapes. Segments of the area exist as arctic oases within an otherwise harsh environment and are associated with a relatively rich flora and concentrated use by animal species such as muskoxen, snow geese and arctic hare. Other portions of the study area exhibit the harsh beauty and scenic qualities of the landscape. The ice fields, glaciers, and iceberg-choked fiords of western Axel Heiberg Island are as awesome as any in the high arctic region (Fig. 44).

The archaeological importance of the area is only beginning to be investigated. While to date there have been no discoveries of campsite or other remains of early historical investigations of the area, there are numerous pre-Inuit sites and the eastern margin of the study area (Eureka Sound) was travelled by the first explorers, such as Sverdrup, Cook and MacMillan.

### 13.1.1 Representativeness of the Area

Eastern Axel Heiberg Island falls within Natural Region 39, the Eastern High Arctic Glacier Region, which comprises Axel Heiberg Island, most of Ellesmere Island and a portion of Devon Island (Parks Canada 1972). The region is characterized by mountain ranges, rolling uplands and broad lowlands interspersed with one another. Glaciers and ice caps occur and coastlines are indented by fiords. For the most part, the fauna of the study area represents Region 39 satisfactorily. Typical of high arctic animal assemblages, the region supports relatively few species of mammals, birds and fishes. Certain species, notably muskoxen, snow geese, ruddy turnstones and arctic hares, are abundant in the study area during the summer months. In contrast, marine mammals are poorly represented in the study area. They are considerably more abundant in the Jones Sound portion of Region 39 — between Ellesmere and Devon islands.

### 13.1.2 Outstanding and Unique Features

Lush sedge polygon areas occuring in the broad valley between Gibs and Mokka fiords and west of May Point are outstanding and are in sharp contrast to the adjacent rocky and relatively bare upland areas. Muskoxen, snow geese and other birds are attracted to and extensively use these areas. Of these areas, the Chain of Three Lakes site is probably the most outstanding, featuring striking scenery, a number of Thule Eskimo sites as well as rich flora and fauna. Moulting snow geese were present in the two westernmost lakes at the time of our visit to the area and arctic hares were numerous on the surrounding rocky slopes. The European origin of several bird species (brant, ruddy turnstone, red knot and wheatear) occurring in the study area is an interesting and significant element of the area's fauna.

Buchanan Lake is probably one of the most spectacular sites in the study area. Dramatic scenery and harsh beauty are exhibited by the steep cliffs and towering rugged mountains which surround the lake. A gull colony located on a series of ledges overlooking the lake and several archaeological sites contribute further to this outstanding site. Although the status of the endangered peregrine falcon in the study area is uncertain, the potential of Buchanan Lake and nearby Mokka Fiord area for providing the habitat needs of this raptor exists.

Mokka Fiord, particularly the western half, is also a beautiful area, again because of its striking harshness. The conspicuous coal seams, the colourful rocks resulting from heat generated by burning coal and the occurrence of petrified wood add significantly to the area's interest. The huge dome of gypsum west of Mokka Fiord is a unique feature of the area. Many archaeological sites are present along the western shoreline of the fiord.

The occurrence of numerous archaeological sites, such as summer campsites, winter houses and food caches, within the eastern portion of the study area is significant in the light of the "Musk-Ox Way" theory. The sites remind the visitor that the region was once occupied several thousand years ago by pre-Inuit as they made their way slowly towards Greenland. The original discovery of the land by Sverdrup and his dogsled parties and the passing through the region of explorers, such as Cook and MacMillan intent on reaching the North Pole or discovering the elusive Crocker Land, provide further colour to the historical backdrop of the study area.

The outstanding features of the western Axel Heiberg Island cannot be evaluated at this time, as we did not visit this area. However, reports from the Expedition Fiord area (Müller 1963d) abound with descriptions of scenic beauty and unusual features, such as sulfur springs. Should western Axel Heiberg Island be actively considered for a national park, a survey of the area will no doubt reveal these outstanding features.

## 13.2 Evaluation of Geographic Segments of the Study Area

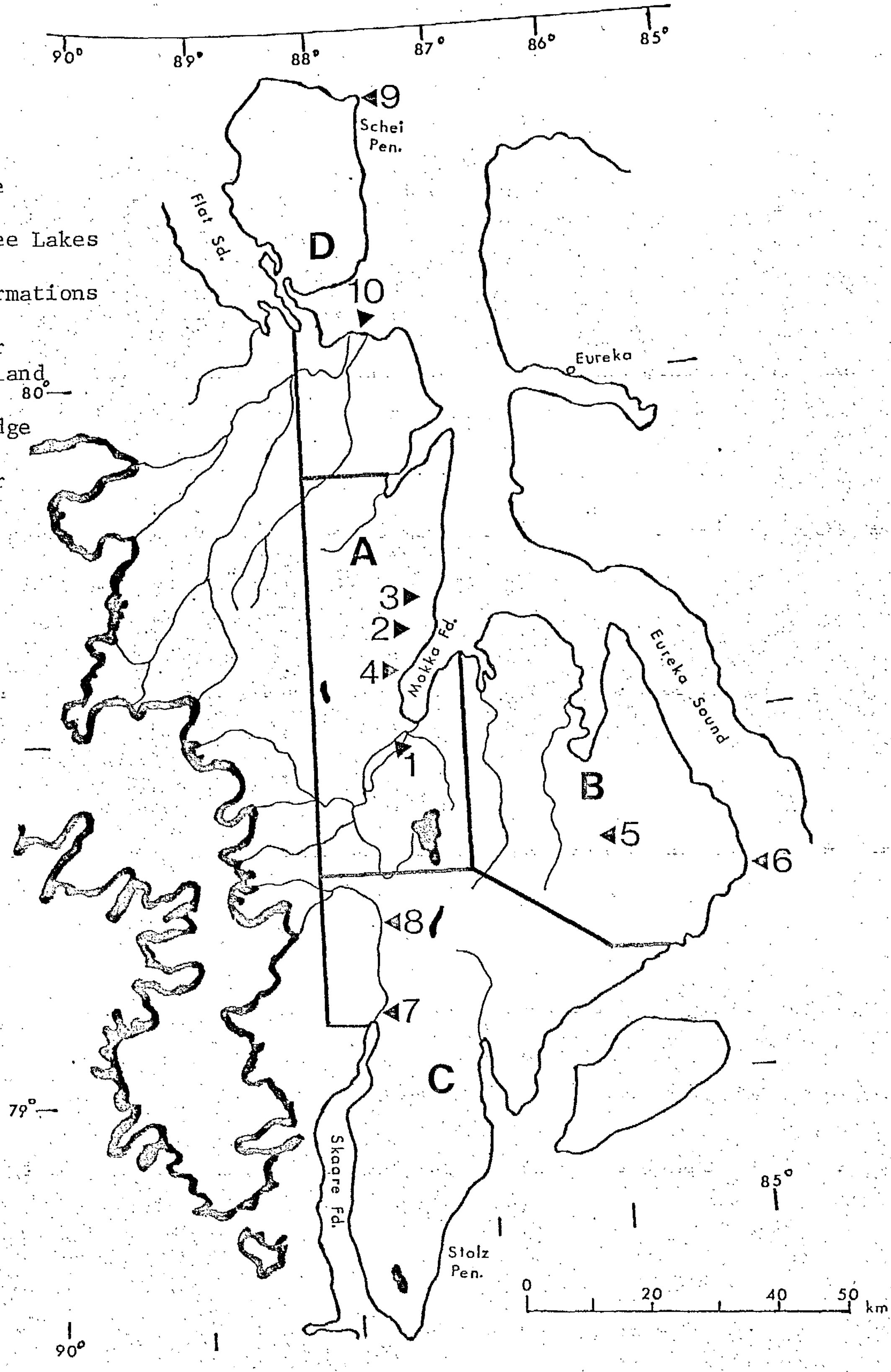
The most outstanding features of the study area are the variety of landforms, which in certain places are quite spectacular, and the diversity of plant life which is quite high considering the latitude where it occurs. Abundance of wildlife species is low although muskoxen and snow geese are conspicuous in the summer months. Opportunities for viewing muskoxen are probably not as good as in the proposed national park area on Banks Island. However, this is offset by the more varied and dramatic scenery of Axel Heiberg Island. The harsh nature of the landscape provides the visitor to the area with the opportunity of a total wilderness experience. Activities that would be suitable in a wilderness-oriented park would include: photography; viewing of scenic landscapes, flora and fauna; hiking; and possibly mountaineering. Opportunities for boating are limited to Buchanan Lake and the extreme south end of Mokka Fiord. Due to prolonged ice cover in Eureka Sound, access to the study area by boat from Eureka, Ellesmere Island, would not be possible.

The study area was divided into relatively homogeneous segments to permit their evaluation as potential park areas (Map 13).

<u>Block A</u> contains the most important elements of the study area: important muskox range; important snow goose nesting and moulting habitat; good arctic hare and caribou upland habitat; the Chain of Three Lakes I.B.P. site; spectacular and archaeologically important Mokka Fiord and Buchanan Lake; and geologically significant features such as

LEGEND

1 Buchanan Lake
2 Gypsum dome
3 Chain of Three Lakes
4 Coal seams
5 Sandstone formations
6 May Point
7 Braided river
8 Canyon & badland formations
9 Butter Porridge Point
10 Braided river




Map 13. Suggested boundaries and component areas of a national park on eastern Axel Heiberg Island, with points of interest

the gypsum dome and coal seams west of Mokka Fiord. The ridged upland and Eureka Sound upland physiographic unit are represented and a small icefield is included.

Block A is the most crucial area to be included and receive protection in a national park established in eastern Axel Heiberg Island. Consequently, management concerns are most numerous in this area.

Management concerns:

(1) Direct access to this remote area is poor, except by helicopter. Helicopter movements within the study area may disturb and place undue stress on wildlife such as muskoxen and snow geese. More information is required on seasonal habitat use and movements by muskoxen, and snow geese nesting areas must be identified, before measures for controlling visitor access can be established.

(2) A minimum wildlife viewing distance of 1 km should be established and the importance of this measure stressed through visitor orientation sessions.

(3) All archaeological sites should be strictly off-limits to all visitors, except archaeologists authorized to conduct investigations, and should receive protection from distrubance. Location of all sites should be kept confidential.

(4) A systematic survey of Buchanan Lake should be conducted to determine whether peregrine falcon nesting occurs here. Location of any nest sites found should be kept confidential. In addition, the size of the gull colony and identity of the gulls should be determined. Protection of the gull colony and any peregrine falcon nest sites must be considered a priority for the Buchanan Lake area.

(5) Should it be concluded that peregrine falcons do not make use of Buchanan Lake for nesting, non-motorized boating could be permitted and could contribute to a visitor's appreciation of the lake. Boating activity should not occur within 1 km of the cliffs on the north side of the lake where the gull colony is located.

<u>Block B</u> takes in an area of predominately lower relief and less varied scenery than Block A. Lowland plains are extensive and in the eastern part of the block, low-centered polygons occur which are frequented by snow geese during brood-rearing and moulting.

Important rangeland for muskoxen is contained in the area. Therefore, Block B would be an essential part of a national park established in the area. Also, there are interesting sandstone formations which do not occur in Block A. The existing airstrip presently maintained by Kenn Borek Air Ltd. could possibly be used to provide fixed-wing access to the park. A visitor orientation facility could also be located at this site.

Management concerns:

(1) The desirability of using the existing airstrip to provide access to the park should receive detailed study. The effect that aircraft activity and operation of a visitor orientation centre might have on muskoxen using the area needs to be carefully assessed.

(2) Seasonal movements and habitat use of muskoxen and caribou need to be studied to identify areas of critical importance to these species. Critical areas should receive full protection.

(3) Snow goose nesting areas should be identified and receive protection from visitor disturbance during the nesting period.

(4) The May Point and surrounding area should be investigated to locate any artifact remains of Sverdrup's expedition.

Block C is at the southern end of the study area and is comprised mainly of mountainous topography incised with canyons formed by drainages entering either Skaare Fiord or Whitsunday Bay. The steep-walled canyon and badland scenery is unique to this block within the study area. The braided river system entering Skaare Fiord is quite spectacular. Inclusion of this block in a national park is not essential but would contribute significatly to the park's overall character and content.

Block D contains a variety of different landscapes from lowland coastal plains to the more rugged uplands of Schei Peninsula. The area includes an extensive braided river system which enters Eureka Sound near the base of Schei Peninsula. The coastal plain along the east side of Schei Peninsula provides good habitat for muskoxen and snow geese. The rugged slopes further inland attract arctic hare. The part played by the peninsula during Sverdrup's expedition makes this probably the most historically important region of the study area. Because of its historical importance, this block would be a worthy addition to the park. However, its inclusion is not essential.

Management concerns:

(1) Sverdrup's campsite area at Butter Porridge Point and various pre-Inuit remains located along the eastern coastline of

Schei Peninsula should remain undisturbed to permit proper archaeological investigation.

(2) Studies should be conducted to determine the extent of movements by muskoxen between their range on Schei Peninsula and that situated between Gibs and Mokka fiords.

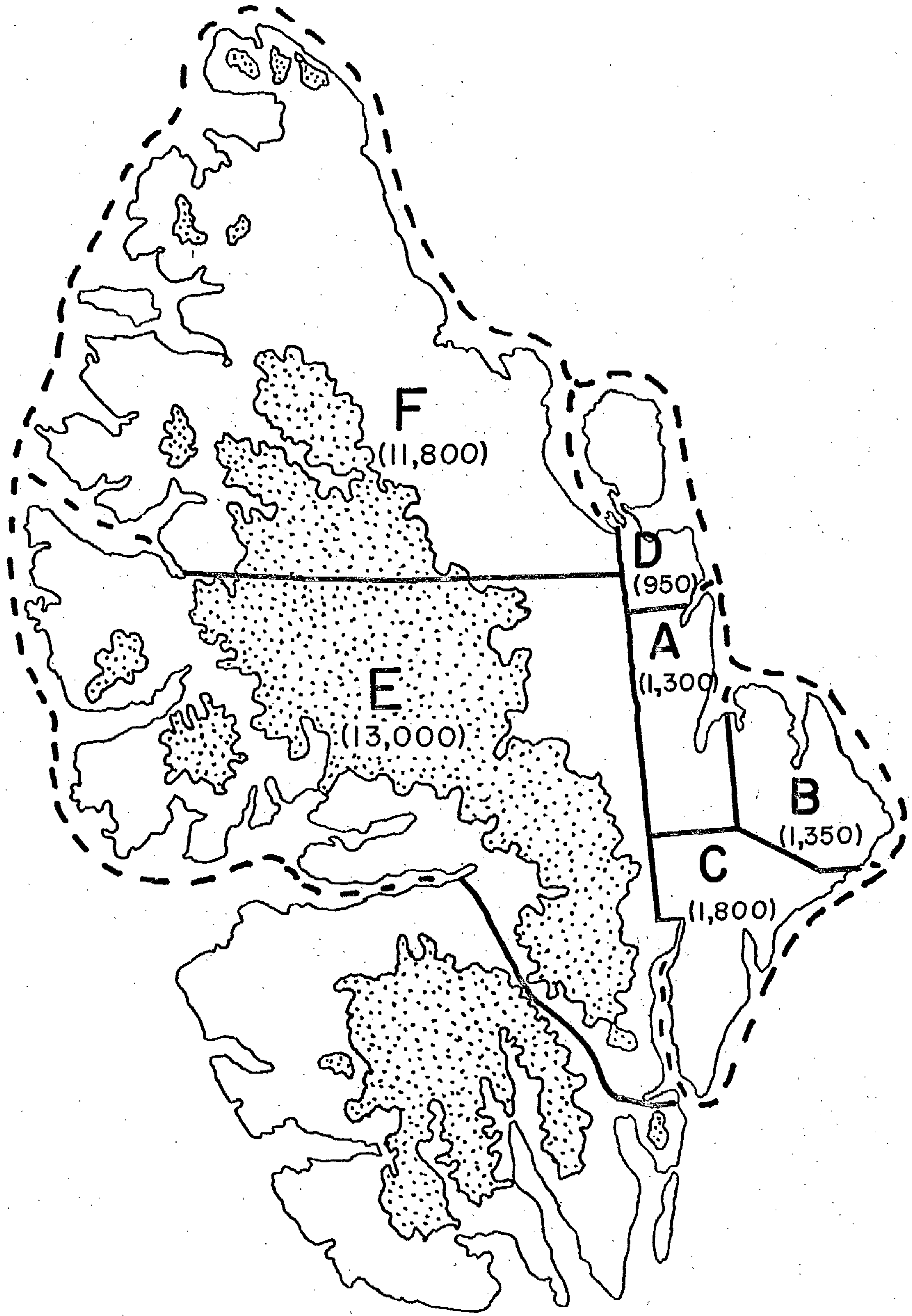
13.3 Evaluation of an Enlarged Area

Most of the natural resource features of the Ellesmere Island study area are also represented in the Axel Heiberg Island study area. Mammal diversity is slightly greater for Ellesmere (14 species) than for Axel Heiberg (11 species), reflecting the richer marine mamal fauna. Bird diversity in the two areas is approximately equal; 37 species are listed for Axel Heiberg, 35 for Ellesmere. Larger areas of comparatively lush, sedge meadow habitat occur on Axel Heiberg, while Ellesmere is more important historically. Physiographically, the area we considered on Axel Heiberg Island lacked two major features represented in the Ellesmere Island area, namely the large mass of landfast sea ice, known as the Ward Hunt Ice Shelf, and extensive ice caps and glaciers.

While the Ward Hunt Ice Shelf is unique to Ellesmere Island, glacier- and ice cap-dominated landforms could be represented by extending the western boundary of the Axel Heiberg study area to include most of the Müller Ice Cap. Should the decision be made not to establish a national park on Ellesmere Island, we recommend that Parks Canada consider the alternative of incorporating all of Axel Heiberg Island, except the southwestern segment, as a park (Map 14).

Block E is predominantly mountainous. It includes the area west of the study area south of 80° latitude to the south arm of Li Fiord, and north of a line from Skaare Fiord to Strand Fiord. This area contains a substantial portion of the Müller Ice Cap situated on the Princess Margaret Range. It also includes the Kanguk Peninsula with its scenic bedrock formations. The scientifically important Expedition Fiord area, which was identified as an ecological site during the International Biological Programme, lies within this area. The base camp area of the expedition could serve as a second point of access into the park.

Block F is also mountainous, but glaciers are not frequent. This block would contain an important Peary caribou range along the coast south and southeast of Cape Stallworthy where caribou have been observed in the hundreds (RRCS 1972). There is a suspected gyrfalcon nesting area at Cape Stallworthy. The Cape is also historically important. It marks Sverdrup's farthest northerly penetration, and it is the location of a cairn built by Peary in which a record made by MacMillan and the last message of Dr. Krueger were placed.




Map 14. The enlarged study area, with the approximate land area of component blocks ($km^2$).

## 13.4 Economic and Other Claims Upon the Study Area

### 13.4.1 Native Land Claims

The study area is beyond the hunting range of Inuit at Grise Fiord, the closest Inuit settlement (Riewe 1976, 1977). Therefore, establishment of a national park in the study area should not conflict with Inuit hunting activities. The presence of Dorset and Thule dwelling remains in the study area is evidence of former pre-Inuit use and provides a basis for Inuit claims to the land based on aboriginal title. Aboriginal title is established by use and occupation since time immemorial (Inuit Tapirisat of Canada 1980).

Following announcement by Parks Canada in 1978 of its identification of six "natural areas of Canadian significance" in the Arctic, the Inuit Tapirisat of Canada (ITC) initiated a study which dealt with how national wilderness parks should be planned and managed to reflect Inuit interests in the conservation of land which they occupy and use (Inuit Tapirisat of Canada 1979a). Shortly after the project commenced, the Board of Directors passed a motion rejecting all national wilderness parks until a land claim settlement had been reached for all Inuit lands. This motion received wide acceptance amongst other Inuit organizations and amongst the communities visited during the course of the ITC study. Broad consent was received by most Inuit on the conclusions of the study which reflected the ITC Board of Directors' motion.

The study revealed a number of opinion differences between Inuit and non-Inuit people over the role of conservation areas and the uses to which they may be put. Inuit consider their uses to be compatible with the main objective of conservation, the maintenance of natural systems. Some Inuit consider their land use practices to be an inseparable element of the natural system and consequently feel that these practices are in as much need of protection as animal populations and their habitat. Traditional hunting is considered to be part of the "cultural value" of the landscape and, as such, must take precedence over visitor use of areas where hunting occurs. Because of the gradual evolution of control over land management which is presently occurring, such as the control of local game populations by Hunters and Trappers Associations, the Inuit feel that local control over management of wilderness parks should be enshrined in an amended National Parks Act (Inuit Tapirisat of Canada 1979a).

It is evident from the above, that a perceived threat to continuation of traditional hunting, and other uses important to their culture, is the main basis for Inuit objection to establishment of wilderness parks in the Arctic. The fact that there is no significant occupancy or use made of the study area at present makes agreement of the Inuit to establishment of a national park in the study area more possible than for other park proposals in the Arctic. There may still be resistance, however, due to Inuit claim to land in the study area based on aboriginal title.

A further, and probably larger, impediment to national park establishment in the study area is the desire of the Inuit to achieve self-government through political development of Nunavut, the area of the Northwest Territories north of the treeline (Inuit Tapirisat of Canada 1979b, 1980).

The new Nunavut Territory would have powers roughly equivalent to the powers of the existing Government of the N.W.T. and, as proposed, would acquire provincial-type powers over a 15-year transition period. At the end of the 15-year period, Nunavut Territory would become Nunavut Province. The Nunavut Land Claims Project of the ITC is convinced that the interests of Inuit will be best served by a synchronous land claims settlement dealing with property matters and creation of a new Nunavut Territory. While the Nunavut Land Claims Project is optimistic that an early decision will be made by the Government of Canada in favour of a new Nunavut Territory, it is clear that negotiations on the subject of national park establishment would be premature prior to the Government of Canada decision.

### 13.4.2 Mineral Claims

According to Mr. B. Mercer, Mining Recorder for the Arctic and Hudson Bay and Nahanni Mining Districts, there were no mineral claims or prospecting permits in good standing in the study area as of December 11, 1980. Geological Survey of Canada (1980a) rated the mineral potential of the area as generally low, with some potential for uranium and zinc or lead-zinc.

Coal resources occur in the study area (Bustin 1980) and have been described in section 4.2.1 Geological Survey of Canada (1980b) considered them to be of poor quality and suitable for local use only. Mineral claims in the enlarged area defined in section 13.3 were not investigated.

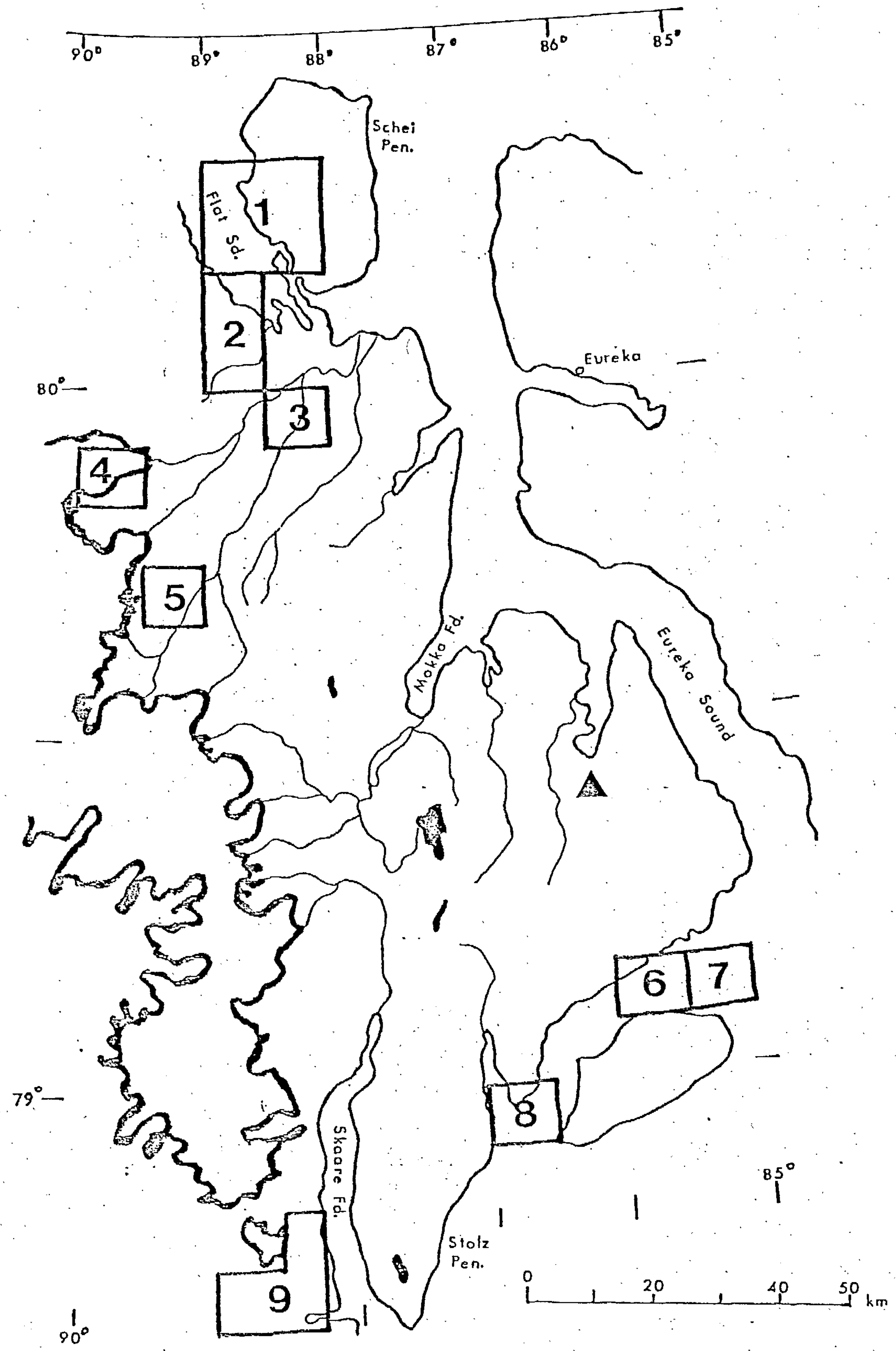
### 13.4.3 Oil and Gas Exploratory Permits

Oil and gas permits and leases are issued by the Minister of Indian and Northern Affairs and administered under the <u>Canada Oil and Gas Land Regulations</u>. The existence of permits or leases in the study area was first confirmed by the authors on January 8, 1981 (Northern Non-Renewable Resources Branch, Department of Indian and Northern Affairs, pers. comm.). Because of the rapid turnover of permittees and locations of areas for which permits or leases have been issued, the situation was reviewed a second time on July 31, 1981. Oil and gas permits and leases in effect at that time are listed in Table 12 and their locations shown on Map 15. Permits in the study area were originally issued for a period of eight years but were subsequently renewed annually for an additional six years (S. Kanik, pers. comm.).

Table 12. Oil and gas permits and leases in the study area. Block numbers correspond to Map 15.

| Block number | Number of permit[1] or lease | Registration | Issue date | Term |
|---|---|---|---|---|
| 1 | A2061-2062 | Dome Petroleum | 10 Aug 67 | 14 yrs |
| 2 | 10462-10463 | Gulf Canada Resources | 26 Aug 80 | 21 yrs |
| 3 | 10461 | Gulf Canada Resources | 26 Aug 80 | 21 yrs |
| 4 | Pending | Canada Geothermal, Yukon Geothermal, Amoco Petroleums, Bow Valley Explorations | Jan 81 | 21 yrs |
| 5 | See block 4 | | | |
| 6 | A2056 | Dome Petroleum | 10 Aug 67 | 14 yrs |
| 7 | A2096 | Dome Petroleum | 10 Aug 67 | 14 yrs |
| 8 | A2055 | Dome Petroleum | 10 Aug 67 | 14 yrs |
| 9 | 10165-10167 | Canadian Homestead Oil, Inter-City Gas | 7 Jan 80 | 21 yrs |

[1]A permit is denoted by the prefix "A".




Map 15. Oil and gas permits and leases, and land use permits in the study area. See Table 12 for registration details.

1 oil and gas permit or lease

▲ land use permit

Leases issued in blocks 2, 3 and 9 are all in effect for 21 years from the date of issue. In blocks 4 and 5, leases were still pending on September 1, 1981. When issued, the date of issue will be back-dated to sometime in January 1981 (S. Kanik, pers. comm.).

The pattern of ownership of oil and gas rights in the study area may change dramatically following the passage of new legislation to regulate oil and gas interests in Canada lands and to amend the Oil and Gas Production and Conservation Act. This new legislation, which was passed by Parliament on December 9, 1981 as Bill C-48, is to be called the Canada Oil and Gas Act. The Act is expected to receive Royal Assent in early 1982 and at that time existing permits and leases must be surrendered and new "exploration agreements" applied for.

While the pattern of permittees and lessees illustrated in Table 12 is therefore a temporary situation, it does indicate that there is limited interest in possible hydrocarbon formations in the study area. Records maintained by the Department of Indian and Northern Affairs, Yellowknife, show that exploratory drilling in this area has not resulted in significant discoveries of oil or gas (M.J. Morison, pers. comm.). Geological Survey of Canada (1980b) considered the area to have low to moderate oil and gas potential.

Information on the disposition of oil and gas rights in the study area under the new legislation would have to be obtained from the Oil and Gas Lands Division, Department of Indian and Northern Affairs, Ottawa. Before the national park could be established in the study area, Parks Canada would have to negotiate with those companies who entered into exploratory agreements under the Canada Oil and Gas Act. Oil and gas interests in the enlarged area were not investigated.

### 13.4.4 Land Use Permits and Leases

Land use permits and leases are issued under the Territorial Land Use Regulations by the Minister of Indian and Northern Affairs. Only one land use permit was in effect in the study area as of December 12, 1980, according to Mr. A.E. Ganske, Regional Manager, Land Resources, Department of Indian and Northern Affairs, Yellowknife. This permit (N79J055) allowed Kenn Borek Air Ltd. to maintain a fuel storage area and airstrip south of Depot Point, at 79°24'N, 86°07'W (Map 15). The expiry date of this permit was May 1, 1981. However, a recent check of the records indicated that the fuel storage facility continues to be operated under a new permit issued April 30, 1981 and expiring April 30, 1982. This activity will probably continue until all fuel has been consumed and the remaining empty drums, fuel bladders and other debris have been removed from the site. Alternatively, it may be desirable to keep the airstrip serviceable to allow fixed-wing aircraft access to the area, should it become a national park. Land use permits and leases in the enlarged area were not investigated.

### 13.4.5 Federal Reservations

There are no migratory bird sanctuaries or national wildlife areas established either in the study area or the enlarged area.

### 13.4.6 International Biological Programme

The Canadian Committee for the International Biological Programme Conservation Terrestrial-Panel 9 (CCIBP-CT) identified the area between Gibs and Mokka fiords as a potential ecological site because of the important grazing habitat for muskoxen, caribou, arctic hare and snow geese contained therein (Nettleship and Smith 1975). The site includes the Chain of Three Lakes area (name of the site) and Buchanan Lake.

As yet, the site has no legal protection and none has been proposed. Because the objectives of the International Biological Programme and Parks Canada are similar, establishment of a national park in the area would not result in conflicts with CCIPB-CT.

The enlarged area would also include another ecological site encompassing the Expedition Fiord area. The site is important for the extensive work done on post-glacial history of landforms, glaciers and vegetation and is invaluable to continuing research and as a record for further arctic investigations (Nettleship and Smith 1975).

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Appendix 1. Bryophytes from Schei Peninsula and Buchanan Lake regions of Axel Heiberg Island.

## HEPATICAE

Jungermanniineae
    Gymnocolea inflata (Huds.) Dumort

Gymnomitriaceae
    Gymnomitrion corallioides Nees

Aneuraceae
    Aneura pinguis (L.) Dumort

Cleveaceae
    Athalamia hyalina (Sommert.) Hattori

## MUSCI

Ditrichaceae
    Ceratodon purpureus (Hedw.) Brid.
    Distichium capillaceum (Hedw.) B.S.G.
    D. inclinatum (Hedw.) B.S.G.
    Ditrichum flexicaule (Schwaegr.) Hampe

Seligeriaceae
    Blindia acuta (Hedw.) B.S.G.

Dicranaceae
    Dicranella crispa (Hedw.) Schimp.

Encalyptaceae
    Encalypta rhaptocarpa Schwaegr.

Pottiaceae
    Bryoerythrophyllum recurvirostrum (Hedw.) Chen
    Desmatodon laureri (Schultz) B.S.G.
    D. leucostoma (R. Br.) Berggr.
    Didymodon asperifolius (Mitt.) Crum, Steere & Anders.
    Pottia heimii Hedw. = Desmatodon heimii (Hedw.) Mitt.
    Tortella arctica (H. Arnell) Crundw. & Nyh.
    T. tortuosa (Hedw.) Limpr.
    Tortula mucronifolia Schwaegr.
    T. ruralis (Hedw.) Gaertn., Meyer, & Scherb.

Grimmiaceae
    Rhacomitrium canescens (Hedw.) Brid.
    R. lanuginosum (Hedw.) Brid.

Appendix 1. Continued.

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Schistidium apocarpum (Hedw.) B.S.G. = Grimmia apocarpa Hedw.
S. gracile (Röhl.) Limpr. = Grimmia apocarpa Hedw. var. stricta (Turn.) Hook. & Tayl.
S. holmenianum Steere & Brass.
S. platyphyllum (Mitt.) Kindb. = Grimmia alpicola Hedw. var. latifolia (Zett.) Möll.
S. tenerum (Zett.) Nyh. = Grimmia tenera Zett.

Funariaceae

Funaria arctica (Berggr.) Lindb.
F. Hygrometria Hedw.

Splachnaceae

Aplodon wormskjoldii (Hornem.) R. Br.
Splachnum sphaericum Hedw.
Tayloria splachnoides (Schleich. ex Schwaegr.) Hook.
Tetraplodon mniodes (Hedw.) B.S.G.
T. pallidus Hag.

Bryaceae

Bryum argenteum Hedw.
B. cryophilum Mårt.
B. lacustre (Web. & Mohr) Bland. = B. knowltonii Barnes
Leptobryum pyriforme (Hedw.) Wils.
Pohlia cruda (Hedw.) Lindb.

Mniaceae

Cinclidium arcticum (B.S.G.) Schimp.
C. latifolium Lindb.
C. stygium Sw.
Mnium hymenophyllum B.S.G. = Cyrtomnium hymenophylloides (Hub.) Nyholm.
M. rugicum Laur. = Plagiomnium ellipticum (Brid.) Kop.

Aulacomniaceae

Aulacomnium turgidum (Wahlenb.) Schwaegr.

Meesiaceae

Meesia triquetra (Richt.) Ångstr.
M. uliginosa Hedw.

Catoscopiaceae

Catoscopium nigritum (Hedw.) Brid.

Bartramiaceae

Bartramia ithyphylla Brid.
Philonotis tomentella Mol. = P. fontana var. pumila (Turn.) Brid.
Plagiopus oederiana (Sw.) Limpr.

Appendix 1. Continued.

Timmiaceae

Timmia austriaca Hedw.
T. norvegica Zett.

Orthotrichaceae

Amphidium lapponicum (Hedw.) Schimp.
Orthotrichum speciosum Nees ex Sturm

Theliaceae

Myurella julacea (Schwaegr.) B.S.G.
M. tenerrima (Brid.) Lindb.

Amblystegiaceae

Calliergon giganteum (Schimp.) Kindb.
C. richardsonii (Mitt.) Kindb. ex Warnst.
C. sarmentosum (Wahlenb.) Kindb.
Campylium stellatum (Hedw.) C. Jens.
Cratoneuron filicinum (Hedw.) Spruce
Drepanocladus aduncus (Hedw.) Warnst.
D. badius (C.J. Hartm.) Roth
D. brevifolius (Lindb.) Warnst. = D. lycopodioides (Brid.) Warnst. var. brevifolius (Lindb.) Monk.
D. intermedius (Lindb. ex C. Hartm.) Warnst. = D. revolvens (Sw.) Warnst. var. intermedius (Lindb. ex C. Hartm.) Grout
D. revolvens (Sw.) Warnst.
D. uncinatus (Hedw.) Warnst.
Scorpidium turgescens (T. Jens.) Loeske

Brachytheciaceae

Brachythecium turgidum (C.J. Hartm.) Kindb.
Cirriphyllum cirrosum (Schwaegr. ex Schultes) Grout
Tomenthypnum nitens (Hedw.) Loeske

Entodontaceae

Orthothecium chryseum (Schwaegr. ex Schultes) B.S.G.
O. rufescens (Brid.) B.S.G.

Hypnaceae

Hypnum bambergeri Schimp.
H. procerrimum Mol.
H. revolutum (Mitt.) Lindb.
H. vaucheri Lesq.

Hylocomiaceae

Hylocomium splendens (Hedw.) B.S.G.

Appendix 1. Continued.

Polytrichaceae

Polytrichum alpinum Hedw. = Pogonatum alpinum (Hedw.) Rohl.

P. alpinum var. septentrionale (Sw.) Lindb. = Pogonatum alpinum (Hedw.) Rohl. var. septentrionale (Brid.) Brid.

P. hyperboreum R. Br.

P. juniperinum Hedw.

P. piliferum Hedw.

Psilopilum cavifolium (Wils.) Hag.

Appendix 2. Lichens and lichen parasites from Schei Peninsula and Buchanan Lake regions of Axel Heiberg Island.

Collemataceae

- Collema bachmanianum (Fink) Degel.
- C. tenax (Sw.) Ach.
- Leciophysma finmarkicum Th. Fr.
- Leptogium arcticum Jørg.
- L. cf. tenuissimum (Dicks.) Fr.

Placynthiaceae

- Psoroma hypnorum (Vahl) S. Gray.

Coccocarpiaceae

- Spilonema revertens Nyl.

Peltigeraceae

- Peltigera aphthosa (L.) Willd.
- P. canina (L.) Willd.
- P. canina (L.) Willd. var rufescens (Weis.) Mudd
- P. occidentalis (Dahl) Krist.
- P. polydactyla (Neck.) Hoffm.
- Solorina bispora Nyl.

Lecideaceae

- Lecidea arctogena Th. Fr.
- L. armeniaca (DC.) Fr.
- L. assimilata Nyl.
- L. auriculata Th. Fr.
- L. brachyspora (Th. Fr.) Erichs.
- L. confluens (G. Web.) Ach.
- L. cuprea Sommerf.
- L. glaucophaea Körb.
- L. lapicida (Ach.) Ach.
- L. limosa Ach.
- L. lulensis Hellb.
- L. marginata Schaer.
- L. picea Lynge
- L. ramulosa Th. Fr.
- L. rubiformis (Wahlenb. ex Ach.) Wahlenb.
- L. tenuissima Lynge
- L. tessellata (Ach.) Flörke
- L. umbonata (Hepp) Mudd
- L. vorticosa (Flörke) Körb.
- Lecidella stigmatea (Ach.) Hertel & Leuck.
- L. wulfenii (Hepp) Körb.

Appendix 2. Continued.

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Rhizocarpon badioatrum (Flörke ex Spreng.) Th. Fr.
R. disporum (Naeg. ex Hepp.) Müll. Arg.
R. geographicum (L.) DC.
R. paryum Runem.
R. pusillum Runem.
R. superficiale (Schaer.) Vain.
Toninia caerulconigricans (Lightf.) Th. Fr.
T. cumulata (Sommerf.) Th. Fr.
T. tristis (Th. Fr.) Th. Fr.
Trapelia coarctata (Turn. ex Sm.) Choisy
Tremolecia atrata (Ach.) Hertel

Stereocaulaceae

Stereocaulon alpinum Laur.
S. glareosum (Sav.) Magn.
S. groenlandicum (Dahl) Lamb
S. rivulorum Magn.

Cladoniaceae

Cladonia amaurocraea (Flörke) Schaer.
C. cariosa (Ach.) Spreng.
C. coccifera (L.) Willd.
C. macrophylla (Schaer.) Stenh.
C. pocillum (Ach.) O. Rich
C. pyxidata (L.) Hoffm.

Umbilicariaceae

Omphalodiscus decussatus (Vill.) Schol.
O. virginis (Schaer.) Schol.
Umbilicaria cylindrica (L.) Del.
U. havaasii Llano
U. hyperborea (Ach.) Ach.

Pertusariaceae

Pertusaria coriacea (Th. Fr.) Th. Fr.
P. dactylina (Ach.) Nyl.

Acarosporaceae

Acarospora cartilaginea Magn.
A. chlorophana (Wahlenb. ex Ach.) Mass.
A. fuscata (Schrad.) Arn.
A. peliocypha (Wallr.) Arn.
A. scabrida (Hedl.) Magn.
A. veronensis Mass.
Glypholecia scabra (Pers.) Müll. Arg.
Sarcogyne simplex (Dav.) Nyl.
Sporastatia testudinea (Ach.) Mass.

Appendix 2. Continued.

Lecanoraceae

Aspicilia anseris (Lynge) Thoms.
A. arctica (Lynge) Thoms. comb. nov.
A. contigua (Lynge) Thoms. comb. nov.
A. lesleyana Darb.
A. perradiata (Nyl.) Thoms.
A. plicigera (Zahlbr.) Räs.
A. supertegens Arn.
Lecanora badia (Hoffm.) Ach.
L. cenisia Ach.
L. congesta Lynge
L. crenulata (Dicks.) Nyl.
L. dispersa (Pers.) Somm.
L. epibryon (Ach.) Ach.
L. melanophthalma (Ram.) Ram.
L. occidentalis (Lynge) Lynge
L. palanderi Vain.
L. polytropa (Ehrh.) Rabenh.
L. rupicola (L.) Zahlbr.
L. superfluens Magn.
Ochrolechia frigida (Sw.) Lynge
O. upsaliensis (L.) Mass.
Pachyospora verrucosa (Ach.) Mass.
Placopsis gelida (L.) Lindsey

Candelariaceae

Candelariella aurella (Hoffm.) Zahlbr.
C. terrigena Räs.

Parmeliaceae

Cetraria cucullata (Bell.) Ach.
C. delisei (Bory ex Schaer.) Th. Fr.
C. fastigiata (Del. ex Nyl. in Norrl.) Kärnef.
C. nivalis (L.) Ach.
Hypogymnia subobscura (Vain.) Poelt
Parmelia elegantula (Zahlbr.) Szat.
P. infumata Nyl.
P. omphalodes (L.) Ach.
Xanthoparmelia centrifuga (L.) Hale
X. separata (Th. Fr.) Hale

Appendix 2. Continued.

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Usneaceae
- Alectoria nigricans (Ach.) Nyl.
- A. ochroleuca (Hoffm.) Mass.
- Bryoria chalybeiformis (L.) Brodo & Hawksw.
- B. nitidula (Th. Fr.) Brodo & Hawksw.
- Cornicularia divergens Ach.
- C. muricata (Ach.) Ach.
- Dactylina ramulosa (Hook.) Tuck.
- Evernia perfragilis Llano
- Pseudephebe minuscula (Nyl. ex Arn.) Brodo & Hawksw.
- P. pubescens (L.) Choisy
- Thamnolia subuliformis (Ehrh.) W. Culb.
- T. vermicularis (Sw.) Ach. ex Schaer.

Buelliaceae
- Buellia leptocline (Flot.) Körb.
- B. nivalis (Bagl. & Carest) Hertel
- B. papillata (Sommerf.) Tuck.
- B. stigmatea Körb.
- Rinodina nimbosa (Fr.) Th. Fr.
- R. occidentalis Lynge
- R. roscida (Sommerf.) Arn.
- R. turfacea (Wahlenb.) Körb.

Physciaceae
- Physcia caesia (Hoffm.) Hampe
- P. dubia (Hoffm.) Lettau
- Physconia muscigena (Ach.) Poelt.

Teloschistaceae
- Caloplaca alcarum Poelt
- C. cinnamomea (Th. Fr.) Oliv.
- C. festiva (Ach.) Zwack.
- C. stillicidiorum (Vahl) Lynge
- C. tetraspora (Nyl.) Oliv.
- C. tiroliensis Zahlbr.
- Fulgensia bracteata (Hoffm.) Räs.
- Xanthoria candelaria (L.) Th. Fr.
- X. elegans (Link.) Th. Fr.
- X. elegans ssp. splendens (Darb.)
- X. sorediata (Vain.) Poelt

Verrucariaceae
- Dermatocarpon lachneum (Ach.) A.L. Smith
- Staurothele clopima (Wahlenb. ex Ach.) Th. Fr.
- Verrucaria arctica Lynge

Appendix 2. Continued.

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Fungi Imperfecti
    Lepraria arctica (Lynge) Wetm.
Lichen Parasites
    Discothecium gemmiferum Vouax
    Rhabdospora lecanorae Bouly de Lesd.
    Tichothecium pygmaeum Korb.

Appendix 3. Vascular plants from Schei Peninsula and Buchanan Lake regions of Axel Heiberg Island.

Equisetaceae
- Equisetum arvense L.
- E. variegatum Schleich.

Gramineae
- Agropyron violaceum (Hornem.) Lange var. hyperarcticum Polunin
- Alopecurus alpinus J.E. Smith
- Arctagrostis latifolia (R.Br.) Griseb.
- Deschampsia brevifolia R.Br.
- Festuca baffinensis Polunin
- F. brachyphylla Schultes
- Hierochloe alpina (Sw.) R. & S.
- Pleuropogon sabinei R.Br.
- Poa abbreviata R.Br.
- P. alpigena (Fr.) Lindm.
- P. alpigena (Fr.) Lindm. var. calpodea (Fr.) Schol.
- P. alpina L.
- P. glauca M. Vahl
- Puccinellia angustata (R.Br.) Rand. & Redf.
- P. poacea Th. Sør.
- Trisetum spicatum (L.) Richt.

Cyperaceae
- Carex aquatilis Wahlenb. var. stans (Drej.) Boott
- C. misandra R.Br.
- C. nardina Fr. var. atriceps Kük.
- Eriophorum scheuchzeri Hoppe
- E. triste (Th. Fr.) Hadac & Löve
- Kobresia myosuroides (Vill.) Fiori & Paol.

Juncaceae
- Juncus biglumis L.
- Luzula confusa Lindebl.
- L. nivalis (Laest.) Beurl.

Salicaceae
- Salix arctica Pall.

Caryophyllaceae
- Minuartia rubella (Wahlenb.) Hiern.
- Silene acaulis L. ssp. acaulis
- Stellaria edwardsii R.Br.
- S. laeta Richards.
- S. monantha Hult.

Ranunculaceae
- Ranunculus hyperboreus Rottb.
- R. nivalis L.
- R. pedatifidus Sm. var. leiocarpus (Trautv.) Fern.
- R. sulphureus Sol.

Appendix 3. Continued.

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Papaveraceae

Papaver radicatum Rottb.

Cruciferae

Braya thorild-wulffii Ostenf.
Cardamine bellidifolia L.
C. pratensis L.
Cochlearia officinalis L.
Draba adamsii Ledeb.
D. alpina L.
D. cinerea Adams
D. corymbosa R.Br. ex DC.
D. lactea Adams
D. nivalis Liljebl.
D. oblongata R.Br. ex DC.
D. subcapitata Simm.
Erysimum pallasii (Pursh) Fern.
Eutrema edwardsii R.Br.
Lesquerella arctica (Wormskj.) S. Wats.

Saxifragaceae

Saxifraga caespitosa L.
S. cernua L.
S. flagellaris Willd. ssp. platysepala (Trautv.) Porsild
S. foliolosa R.Br.
S. hieracifolia Waldst. & Kit.
S. hirculus L.
S. nivalis L.
S. oppositifolia L.
S. tenuis (Wahlenb.) H. Sm.
S. tricuspidata Rottb.

Rosaceae

Dryas integrifolia M. Vahl
Geum rossii (R.Br.) Ser.
Potentilla hyparctica Malte
P. nivea L.
P. nivea L. ssp. chamissonis (Hult.) Hiit
P. rubricaulis Lehm.

Onagraceae

Epilobium latifolium L.

Ericaceae

Cassiope tetragona (L.) D. Don.

Appendix 3. Continued.

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Primulaceae
    Androsace septentrionalis L.

Plumbaginaceae
    Armeria maritima (Mill.) Willd. ssp. labradorica (Wallr.) Hult.

Scrophulariaceae
    Pedicularis arctica R.Br.
    P. capitata Adams
    P. hirsuta L.
    P. sudetica Willd.

Compositae
    Antennaria compacta Malte
    Arnica alpina (L.) Olin ssp. angustifolia (J. Vahl) Maguire
    Erigeron compositus Pursh
    Taraxacum lacerum Greene
    T. phymatocarpum Dahlst.
    T. pumilum Dahlst.

Appendix 4. Provisional checklist of the mammals of Axel Heiberg Island.

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This appendix summarizes both published and unpublished information on mammals of the Axel Heiberg Island study area. Since only muskoxen, caribou and marine mammals have been surveyed to any extent in the area, comments on the status of other species are speculative.

The assignment of common (C), uncommon (U), or rare (R), status to a species is subjective. A species is considered common where Banfield (1974) shows that the species has a geographic range that covers more than one-third of the study area, or if authorities that have worked in the study area explicitly state that the species is "common" or "occurs in fair numbers". A species is considered uncommon if its geographic distribution is restricted to a few localities, or if authorities state that the species is "scarce" or "distributed sparingly" in the study area. Rare species are those which are unlikely to be recorded in the study area more than once or twice in a decade. A hypothetical species (H) is one which has not been recorded in the study area but has been observed on Ellesmere Island.

Appendix 4. Provisional checklist of the mammals of Axel Heiberg Island.

| Species | Provisional status Canada | Region | Study area | Preferred habitat | Sources of information | Remarks |
|---|---|---|---|---|---|---|
| Arctic hare *Lepus arcticus* | C | U | C | Gravel slopes and ridges | Macpherson (1963), Waterston & Waterston (1972), Parker (1977), Gauthier (1977, 1978) | |
| Varying lemming *Dicrostonyx groenlandicus* | C | C | C | Well-drained tundra | Macpherson (1963) | Status in study area poorly known |
| Gray wolf *Canis lupus* | C | C | C | Wide-ranging | Macpherson (1963), G.R. Parker (pers. comm.), D. Heyland (pers. comm.) | |
| Arctic fox *Alopex lagopus* | C | C | C | Wide-ranging | Macpherson (1963), Waterston & Waterston (1972), G.R. Parker (pers. comm.) | |
| Polar bear *Ursus maritimus* | C | U | U | Solid fast ice | Kerbes (1971), Kiliaan *et al.* (1978), Smith *et al.* (1979) | Status in study area poorly known |

Appendix 4. Continued.

| Species | Provisional status: Canada | Region | Study area | Preferred habitat | Sources of information | Remarks |
|---|---|---|---|---|---|---|
| Ermine *Mustela erminea* | C | U | U | Wide-ranging | Macpherson (1963) | Status in study area poorly known |
| Walrus *Odobenus rosmarus* | C | C | H | Shallow marine waters having open leads through winter | C. Jonkel (pers. comm.) | Possible occurrence in Eureka Sound |
| Bearded seal *Erignathus barbatus* | C | C | U | Shallow marine waters with actively moving ice | Bruggemann (1954). Stirling *et al.* (1981) | |
| Ringed seal *Phoca hispida* | C | C | C | Stable shorefast ice | Smith *et al.* (1979) Stirling *et al.* (1981) | |
| Caribou *Rangifer tarandus pearyi* | C | C | U | Upland barrens | Tener (1963), Ross (1975), Parker and Ross (1976), D. Thomas (pers. comm.) | |
| Muskox *Ovibos moschatus* | U | C | C | Sedge meadows | Tener (1963), Inglis and Jonkel (1972), Ross (1975), Parker and Ross (1976) | |

Appendix 5. Provisional checklist of the birds of Axel Heiberg Island and study area.

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This appendix summarizes published information on the avifauna of Axel Heiberg Island and the study area and incorporates the results of the 1980 field work. The main sources of information are as follows: PM = Parmalee and MacDonald (1960); M = Macpherson (1963); ZBS = this study.

The assignment of common (C), uncommon (U), or rare (R) status is subjective. Species that are common will be seen many times per year in suitable habitats. Uncommon species are unlikely to be recorded more than 25 times per year. A rare species is unlikely to be recorded more than once or twice per year. Accidental (A) species are unlikely to be observed more than once in a decade. Hypothetical (H) denotes species which have not been recorded on Axel Heiberg Island but have been recorded on Ellesmere Island. Future records of hypothetical species on Axel Heiberg Island are considered possible. The designation "breeder" (B) refers to species for which there are records of nests or broods. Summer residents (SR) are species which occur in summer, but for which breeding has not been documented. Permanent residents (PR) occur throughout the year.

Information for all of Axel Heiberg Island is included since the study area has not received extensive investigation. Under "sources of information", the following symbols occur:

S = recorded in the study area;
S*= breeding record in the study area;
AH = recorded on Axel Heiberg Island; and
AH*= breeding record on Axel Heiberg Island.

Appendix 5. Provisional checklist of the birds of Axel Heiberg Island.

| Species | Provisional status: Canada | Region | Study area | Preferred habitat | Sources of information: PM | M | ZBS | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| GAVIIFORMES | | | | | | | | | |
| Arctic loon *Gavia arctica* | G-B | U-B | H | Tundra lakes and ponds | | AH | | | One record at South Fiord |
| Red-throated loon *Gavia stellata* | G-B | G-B | U-B | Tundra lakes and ponds | S* | | S | | |
| PROCELLARIIFORMES | | | | | | | | | |
| Northern fulmar *Fulmaris glacialis* | G-B | A | H | Marine cliffs | | | | AH | One record south of Stor Island (Duvall and Handley 1948) |
| ANSERIFORMES | | | | | | | | | |
| Brant *Branta bernicla* | G-B | G-B | U-B | Coastal tundra | S* | | | | |
| Snow goose *Chen caerulescens atlantica* | G-B | G-B | G-B | Low coastal plateaus and plains | S* | S* | S* | | |

Appendix 5. Continued.

| Species | Provisional status: Canada | Region | Study area | Preferred habitat | Sources of information: PM | M | ZBS | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Northern pintail *Anas acuta* | C-B | R-B | H | Tundra lakes and ponds | | | | | Breeding recorded at Lake Hazen, Ellesmere Island (Maher and Nettleship 1968) |
| Oldsquaw *Claugula hyemalis* | C-B | C-B | U-B | Tundra lakes and ponds | S* | | S* | | |
| Common eider *Somateria mollissima* | C-B | C-B | U-SR | Rocky marine shores | | S | | | |
| King eider *Somateria spectabilis* | C-B | C-B | U-SR | Marine areas, tundra lakes and ponds | S | | | | May breed in study area. Breeds on Fosheim Peninsula, Ellesmere Island (Parmalee and MacDonald 1960) |
| FALCONIFORMES | | | | | | | | | |
| Gyrfalcon *Falcon rusticolus* | U-B | U-B | H | Ridges and cliffs | | | | AH | Observed E of Cape Stallworthy on northern tip of Axel Heiberg Island. Breeding suspected (RRCS 1972) |

Appendix 5. Continued.

| Species | Provisional status: Canada | Region | Study area | Preferred habitat | Sources of information: PM | M | ZBS | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Peregrine falcon *Falco peregrinus* | R-B | R-B | A | Cliffs | | | | S | Endangered species. Sight record, Mokka Fiord (Ross 1974) |
| GALLIFORMES | | | | | | | | | |
| Rock ptarmigan *Lagopus mutus* | G-B | G-B | G-B | Mesic tundra | S | S* | S | | |
| CHARADRIIFORMES | | | | | | | | | |
| Ringed plover *Charadrius hiaticula* | G-B | U-B | U-SR | Mesic tundra | | | S | S | Sight record, Chain of Three Lakes (Waterston, and Waterston 1972) |
| Black-bellied plover *Pluvialis squatarola* | G-B | U-B | H | Mesic tundra | | AH* | | | May breed in study area |
| Ruddy turnstone *Arenaria interpres* | G-B | G-B | G-B | Moist tundra | | S | S*? | | No nest records but evidence of breeding in study area |

Appendix 5. Continued.

| Species | Provisional status Canada | Region | Study area | Preferred habitat | Sources of information PM | M | ZBS | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Red knot <br> Calidris canutus | C-B | C-B | C-B | Moist tundra | S | S* | S | | |
| Purple sandpiper <br> Calidris maritima | C-B | U-B | H | Rocky coastal shores | | | | | Summer range includes southern coast Ellesmere Is. (Snyder 1957) |
| White-rumped sandpiper <br> Calidris fuscicollis | C-B | U-B | A | Wet or moist tundra | | | | S | Sight record, Mokka Fiord (Ross 1974) |
| Baird's sandpiper <br> Calidris bairdii | C-B | C-B | U-SR | Moist tundra | AH* | S? | | | |
| Sanderling <br> Calidris alba | C-B | C-B | U-SR | Mesic to moist tundra | | AH | S | | |
| Red phalarope <br> Phalaropus fulicarius | C-B | C-B | H | Wet tundra | | AH | | | May breed in study area. Indications of breeding on Fosheim Peninsula (Parmalee and MacDonald 1960) |
| Parasitic jaeger <br> Stercorarius parasiticus | C-B | C-B | U-SR | Mesic tundra | | S | | | May breed in study area |
| Long-tailed jaeger <br> Stercorarius longicaudus | C-B | C-B | C-B | Mesic tundra | S | S* | S | | |

Appendix 5. Continued.

| Species | Provisional status: Canada | Region | Study area | Preferred habitat | Sources of information: PM | M | ZBS | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Glaucous gull <br> _Larus hyperboreus_ | C-B | C-B | C-SR | Rugged marine shores | | S | | | |
| Thayer's gull <br> _Larus thayeri_ | C-B | C-B | U-B | Marine cliffs | S* | AH | S* | | Sighted at Buchanan L. |
| Ivory gull <br> _Pagophila evurnea_ | U-B | U-B | R-SR | Rugged marine shores | | S | | | |
| Sabine's gull <br> _Xena sabini_ | C-B | U-B | H | Wet tundra | | | | | Hypothetical. Breeds on Ellesmere Island (Snyder 1957) |
| Arctic tern <br> _Sterna paradisaea_ | C-B | C-B | U-SR | Lakes, coasts, rivers | | S | S | | May breed in study area |
| Thick-billed murre <br> _Uria lomvia_ | C-B | U-B | H | Marine cliffs and coasts | | | | | Hypothetical. Sight record on Fosheim Peninsula (Macpherson 1963) |
| Dovekie <br> _Alle alle_ | U-SR | A | H | Marine cliffs | | AH | | | Not known to breed in Canada. Flock observed at South Fiord (Macpherson 1963) |

Appendix 5. Continued.

| Species | Provisional status: Canada | Region | Study area | Preferred habitat | Sources of information: PM | M | ZBS | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Black guillemot *Cepphus grylle* | C-B | C-B | H | Marine cliffs and coasts | | | | | Hypothetical. Breeds on Ellesmere Island (Godfrey 1966) |
| STRIGIFORMES | | | | | | | | | |
| Snowy owl *Nyctea scandiaca* | C-B | C-B | R-PR | Mesic tundra | | AH | S | | |
| PASSERIFORMES | | | | | | | | | |
| Common raven *Corvus corax* | C-PR | C-PR | H | Wide ranging | | | | | Pair observed flying towards Axel Heiberg Island from Ellesmere Island (Parmalee and MacDonald 1960) |
| Wheatear *Oenanthe oenanthe* | C-B | C-B | U-SR | Rock barrens | | | S | | May breed in study area |
| Hoary redpoll *Carduelis hornemanni* | C-B | C-B | H | Rock barrens | AH* | AH | | | No sight records in study area |
| Lapland longspur *Calcarius lapponicus* | C-B | C-B | H | Mesic tundra | | | | | Nest record on Fosheim Peninsula (Parmalee and MacDonald 1960) |
| Snow bunting *Plectrophenax nivalis* | C-B | C-B | C-B | Rock barrens | AH* | S* | S | | |

Appendix 6. Preliminary checklist of the fishes of Axel Heiberg Island and adjacent marine waters.

Nomenclature used follows, in most cases, Robins *et al.* (1980). Common names of species not listed in this reference were supplied by D. E. McAllister (pers. comm.). Notes on habitat are from McPhail and Lindsey (1970) and Leim and Scott (1966).

Sources of information for the checklist are: Hi = Hildebrand (1948); Wa = Walters (1953): NMC = D. E. McAllister (pers. comm.) (printouts from computerized inventory of fish collections); Hu = J. G. Hunter (pers. comm.) (letter to Boothroyd, dated December 17, 1980). The presence of each species in the study area (including adjacent marine waters) is designated as either certain (S), likely (L) or possible (P). Species considered to be definitely present in the study area have been collected either from Eureka or Nansen sounds. "Likely" species are those which have been collected from either Slidre Fiord and Romulus Lake, Ellesmere Island, or from marine waters adjacent to Axel Heiberg Island other than Eureka and Nansen sounds. "Possible" species are those which have been collected from other areas of Ellesmere Island or are known from the High Arctic in general. Except for species listed by Hildebrand (1948), the location of fish collections made closest to the study area, and corresponding source of information, is given for each species. Where a species could not be identified with certainty by the source, a "(?)" is placed after the common name.

Appendix 6. Preliminary checklist of the fishes of Axel Heiberg Island and adjacent marine waters.

| Species | Presence in study area | Nearest location of collected specimens to study area | Source of information | | | | Remarks on habitat |
|---|---|---|---|---|---|---|---|
| | | | Wa | Hi | Hu | NMC | |
| SALMONIDAE<br>Trouts | | | | | | | |
| Arctic char<br>*Salvelinus alpinus* | L | South Fd., Axel Heiberg Island | | | | X | anadramous |
| Arctic grayling<br>*Thymallus arcticus* | P | Victoria L., Ellesmere Island | | | | X | freshwater, large cold lakes and rivers |
| OSMERIDAE<br>Smelts | | | | | | | |
| Capelin<br>*Mallotus villosus* | P | High Arctic - specific location not reported | | X | | | deep water marine fish |
| GADIDAE<br>Codfishes | | | | | | | |
| Toothed cod<br>*Arctogadus borisovi* | P | Disraeli Fd., N. Ellesmere Island | | | | X | predacious marine fish |

Appendix 6. Continued.

| Species | Presence in study area | Nearest location of collected specimens to study area | Source of information Wa | Hi | Hu | NMC | Remarks on habitat |
|---|---|---|---|---|---|---|---|
| Polar cod *Arctogadus glacialis* | S | Eureka Sd. | | | | X | predacious marine fish |
| Arctic cod *Boreogadus saida* | L | Slidre Fd., Ellesmere Island | | | X | | predacious marine fish, northernmost fish species (Leim and Scott 1966) |
| Greenland cod *Gadus ogac* | P | High Arctic - specific location not reported | | X | | | predacious marine fish |
| ZOARCIDAE Eelpouts | | | | | | | |
| Fish doctor *Gymnelis viridis* | L | Slidre Fd., Ellesmere Island | | | | | marine bottom dweller |
| Saddled eelpout *Lycodes mucosus* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom dweller |
| Pale eelpout *Lycodes pallidus* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom dweller |
| Canadian eelpout *Lycodes polaris* | L | Romulus L., Ellesmere Island | | | | X | marine bottom dweller |
| Arctic eelpout *Lycodes reticulatus* | P | Robeson Channel, Ellesmere Island | | | | X | marine bottom dweller |
| Longear eelpout *Lycodes seminudus* | P | N. Baffin Bay, off S.E. Ellesmere Island | | | | X | marine bottom dweller |

Appendix 6. Continued.

| Species | Presence in study area | Nearest location of collected specimens to study area | Source of information: Wa | Hi | Hu | NMC | Remarks on habitat |
|---|---|---|---|---|---|---|---|
| GASTEROSTEIDAE<br>Sticklebacks | | | | | | | |
| Three-spine stickleback<br>*Gasterosteus aculeatus* | P | High Arctic - specific location not reported | | X | | | bottom feeder, salt or freshwater |
| STICHAIIDAE<br>Pricklebacks | | | | | | | |
| Slender eelblenny<br>*Lumpenus fabricii* | L | Slidre Fd., Ellesmere Island | | | X | | shallow water marine fish |
| PHOLIDAE<br>Gunnels | | | | | | | |
| Banded gunnel<br>*Pholis fasciata* | L | Slidre Fd., Ellesmere Island | | | X | | inshore marine fish |
| ANARHICHADIDAE<br>Wolffishes | | | | | | | |
| Northern wolffish<br>*Anarhichas denticulatus* | P | Mould Bay, Prince Patrick island | X | | | | marine bottom feeder |

Appendix 6. Continued.

| Species | Presence in study area | Nearest location of collected specimens to study area | Source of information Wa | Hi | Hu | NMC | Remarks on habitat |
|---|---|---|---|---|---|---|---|
| COTTIDAE<br>Sculpins | | | | | | | |
| Arctic staghorn sculpin<br>*Gymnocanthus tricuspis* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom feeder |
| Twohorn sculpin<br>*Icelus bicornis* | S | Nansen Sd., w. of Schei Pen., Axel Heiberg Island | | | | X | marine bottom feeder |
| Spatulate sculpin<br>*Icelus spatula* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom feeder |
| Fourhorn sculpin<br>*Myoxocephalus quadricornus* | P | Alert, Ellesmere Island | X | | | | marine bottom feeder |
| Shorthorn sculpin<br>*Myoxocephalus scorpius* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom feeder |
| Mailed sculpin<br>*Triglops nybelini* | P | High Arctic - specific location not reported | | | X | | marine bottom feeder |
| Ribbed sculpin<br>*Triglops pingeli* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom feeder |

Appendix 6. Continued.

| Species | Presence in study area | Nearest location of collected specimens to study area | Source of information: Wa | Hi | Hu | NMC | Remarks on habitat |
|---|---|---|---|---|---|---|---|
| AGONIDAE<br>Poachers | | | | | | | |
| Arctic alligatorfish<br>*Aspidophoroides olriki* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom dweller |
| Atlantic poacher<br>*Leptagonus decagonus* | P | High Arctic - specific location not reported | | X | | | marine bottom dweller |
| CYCLOPTERIDAE<br>Snailfishes | | | | | | | |
| Arctic lumpsucker<br>*Cyclopteropsis macalpini* | P | High Arctic - specific location not reported | | X | | | marine bottom dweller |
| Atlantic spiny lumpsucker<br>*Eumicrotremus spinosus* | L | Expedition Fd., Axel Heiberg Island | | | | X | marine bottom dweller |
| Gelatinous seasnail<br>*Liparis koefoedi* | L | Slidre Fd., Ellesmere Island | | | | X | marine bottom dweller |
| Striped seasnail<br>*Liparis liparis* | P | Alert, Ellesmere Island | X | | | | marine bottom dweller |
| Greenland seasnail<br>*Liparis tunicatus* | L | Slidre Fd., Ellesmere Island | | | X | | marine bottom dweller |

| DATE | ISSUED TO |
|---|---|
| Apr. 4/12 | P. Woodard |

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CANADA

1:250,000


# LEGEND

## RELIEF CLASSES

- V very low
- L low
- M moderate
- H high

## GENETIC MATERIAL

- m morainic till
- f fluvial
- s marine
- a alluvial
- c colluvial
- o organic

## TEXTURE

- G granular
- F fine sand, sandy loam
- L loam
- S silt
- C clay
- P peat
- R bedrock

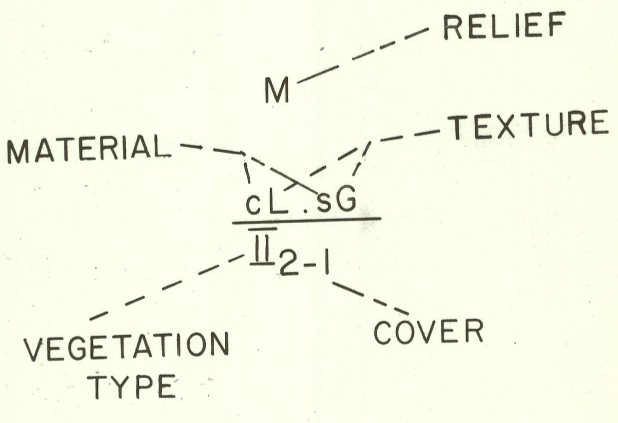
## VEGETATION TYPES

- I Dwarf Shrub
- II Dwarf Shrub - Sedge
- III Sedge
- IV Dry Steppe
- V Upland Seepage

## GROUND COVER CLASSES

| | | |
|---|---|---|
| 1 | 0-10% | bare |
| 2 | 10-40% | sparse |
| 3 | 40-70% | moderate |
| 4 | 70-95% | abundant |
| 5 | 95-100% | complete |

## MAP SYMBOL




To accompany:
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by
S.C. Zoltai, P.N. Boothroyd and G.W. Scotter

1981

Produced, 1965, by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF MINES AND TECHNICAL SURVEYS. Field surveys 1961. Printed 1966.

The daily change of the North Magnetic Pole renders the magnetic compass unreliable in this area. Magnetic declination 1966 varies from 114°14′ westerly at centre of west edge to 106°26′ westerly at centre of east edge.

# LANDFORM - VEGETATION MAP

Scale 1:250,000 Échelle

Transverse Mercator Projection
North American Datum 1927
Contour Interval 500 feet
Elevations in feet above Mean Sea Level

Projection Transverse de Mercator
Niveau de référence nord-américain, 1927
Équidistance des courbes: 500 pieds
Élévations en pieds au-dessus du niveau moyen de la mer