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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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PAPER 53-10

GEOLOGICAL RECONNAISSANCE NORTH COAST OF ELLESMERE ISLAND, ARCTIC ARCHIPELAGO, NORTHWEST TERRITORIES

By

R. G. Blackadar

OTTAWA

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Price, 50 cents

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(Report and Map)

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Map 53-10A, North Coast of Ellesmers Island, Northwest Territories ..... In pocket

GEOLOGICAL RECONNAISSANCE
NORTH COAST OF ELLESMERE ISLAND, ARCTIC ARCHIPELAGO, NORTHWEST TERRITORIES

INTRODUCTION

Location

Ellesmere Island is the northernmost and one of the largest of the islands of the Canadian Arctic Archipelago. For administration it is included in the District of Franklin, Northwest Territories. This report describes that part of the north coast of the island between longitudes 61°00' and 72°15' west, and part of the interior of the island south of the coast to latitude 82°15' north.

Present Investigation and Acknowledgments

The author made a reconnaissance survey of the geology of northeast Ellesmere Island from April to August 1953, while attached to a Defence Research Board field party led by G. Hattersley-Smith, the primary purpose of which was to study the Ice Shelf of northern Ellesmere Island. This was the first investigation by an officer of the Geological Survey of Canada at the northernmost point of Canada.

The weather station at Alert, Dumb-Bell Bay, was used as a main base. Geological observations at salient points of the north coast of the island were made during two trips west of Alert by sledge and dogs. One trip was to Markham Bay, the other to Point Moss. A short trip was taken to Cape Sheridan and vicinity. Overland walks were made from Alert and also a 350 mile back-packing trip was taken into the United States Mountain Range south-west of Alert.

Two Greenlanders from Thule, Rasmus Mjak Tatschera and Sigssuk Jensi Seemon, accompanied the party and capably performed their duties as dog drivers, and also gave assistance in the scientific work of the project. They were employed through the courteous intermediary of the Danish Greenland Administration.

Transportation to and from Alert was provided by the United States Air Force, whose personnel in every circumstance was most anxious to help. The Meteorological Division of the Department of Transport kindly gave permission to use the facilities of the weather station at Alert.

The author is grateful to the Defence Research Board, for the opportunity to participate in the Northern Ellesmere Ice Shelf project, 1953, and to G. Hattersley-Smith, leader of the project, who frequently co-operated in the geological work. Finally, the author thanks P. Harker and Wayne L. Fry, of the Geological Survey of Canada, who made a preliminary examination of the fossil collections cited in this report.

History of Discovery

In 1875-76 a British Naval Expedition, under the command of Captain Sir George Nares, wintered at Cape Sheridan. A man-hauled sledge party, under Lt. Pelham Aldrich, travelled along the north coast of Ellesmere Island west to a point in Yelverton Bay. Another party, headed by Commander Albert Markham, attempted to reach the Pole. The parties experienced many hardships. Their mapping was found to be reliable and useful. An American expedition, commanded by Lt. Adolphus Greely, passed the winter of 1882-83 at Fort Conger, Discovery Harbour. Sledging trips of this expedition reached Feilden Peninsula. Commander R. E. Peary, of the United States Navy, led two expeditions along the north coast of Ellesmere Island. In 1905-06 he explored the coast west to Axel Heiberg Island, that is beyond Alert Point, reached by Aldrich. In 1908-09 the coast west to Cape Columbia was traversed by sledge parties from Peary's ship S. S. Roosevelt, which wintered in 1905-06 and again in 1908-09 at Cape Sheridan.

In 1920, Commander Godfried Hansen of the Royal Danish Navy sledged from Thule in Greenland to Cape Columbia to establish caches for Captain Roald Amundsen. P. Bruggemann and S. Macdonald, conducted in 1951 a biological survey about Alert, and, travelling Wood Creek to near its source, sighted the ice-cap of the eastern United States Mountains.

Previous Geological Investigation

Extensive rock and fossil collections were made by Captain H. W. Feilden, naturalist with the British expedition of 1875-76. Over 2,000 specimens were brought back by this expedition. A study of these established the presence of rocks of Palaeozoic age along a part of the coast as well as extensive regions of metamorphic rocks.

Later parties to visit the area did little geological work, but papers by Feilden and De Rance (1878)[1] and Etheridge (1878)

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[1]Dates and names in parentheses are those of publications listed in the References on page 5 of this report.

have been the source of geological information on Ellesmere Island up to the present.

The age of folding in this area has been in doubt. Koch, Troelsen, and others consider it to be Caledonian whereas Schuchert has favoured a Variscan and Schei an early Mesozoic age. Frebold has considered the age of folding as not yet known and thought that there was some evidence of younger (post-Caledonian) folding, although not denying the possibility of many orogenies.

Accessibility and Method of Travel

The Alert Weather Station is accessible by air. It is also possible in some seasons to reach this station by sea, using vessels especially equipped to withstand the pressure of pack ice.

Travel within the area is best by dog team. From early April, when the sun rises above the horizon, until June travel conditions are good. The snow melts rapidly in June and by the end of the month the land is practically free of snow and the sea ice covered with water. Travel on foot is quite feasible during July and August. The ground is generally firm with few swampy regions. Mechanical land transport is not possible except locally because of the steep grade of the valleys and, west of Black Cliffs Bay, because the country is rugged.

Vegetation and Game

A relatively abundant and diverse flora grows along the valleys. All hilly and flat areas possessing soil are covered with purple-flowered saxifrage in bloom from early June until August. Sandy soils are dotted with brilliant yellow Arctic poppy. Grasses were noted. Willows, only a few inches in height, are common locally. Mosses grow especially at the margin of areas where the soil is in the form of polygons.

Ptarmigan, snow buntings, a snowy owl, hawks, geese, ducks, knots, and gulls were noted.

Some sixty musk-oxen were counted and were abundant in Wood Creek Valley. A few caribou were observed. Lemmings were abundant, their tracks being found on the pack ice 4 miles from land. A few wolves and foxes were seen. Seals were observed when the ice began to break up in the bays around Alert. One was seen crossing the ice on Clements Markham Inlet many miles from an opening in the ice.

A few mosquitoes appeared in June but did not sting. Common house flies were found as far west as Point Moss; caterpillars and butterflies were noted.

In view of the latitude and the shortness of the growing season, the flora and fauna are prolific and bright-coloured plants relieve the monotony of the treeless landscape.

Climate

The climate at Alert is not as severe as that much farther south in interior areas such as central Yukon. During the year August 1952 to August 1953, the weather station at Alert recorded a minimum temperature of -55° F. and a maximum of 60°F. In March 1876, the British Arctic Expedition recorded -73.7°F. at Cape Sheridan, some 8 miles east of Alert. Precipitation is low, averaging 2 inches a year, mostly in the form of snow. Some snow can be expected each month of the year. Many summer days are foggy, although in some years these are noticeably fewer than in others. The prevailing wind is from the southwest and the strongest gales are from this direction. In the summer of 1953 winds of 60 miles an hour were recorded. An unusual occurrence was noted in connection with the barometric pressure; high barometric pressure was usually accompanied by fog in the spring, and by violent winds, snow, and rain in the summer, whereas during periods of low barometric pressure the sky was clear and the winds moderate.

Topography and Drainage

The eastern part of northern Ellesmere Island is a dissected plateau. Cliffs rise almost vertically from the shores of Robeson Channel to a height of between 500 and 1,000 feet. Inland from the top of the cliffs, the surface levels off and assumes a rolling, plain-like appearance with a reported maximum elevation of 2,800 feet. This plateau extends westward to Lake Hazen and northward to the foothills of United States Mountain Range. The surface of the plateau has been modified by glaciation. A rocky mantle chiefly derived from the country rock is widespread. Glacial erratics, some as much as 6 feet high, are present. The rivers have cut the plateau deeply but, because of the low precipitation, none is large. The largest streams are those originating at the face of a glacier but their size is also controlled by the climate.

North of Wood Creek the character of the topography changes within a short distance. There the land becomes rugged and mountainous, and lobes of ice spread across the plateau. The mountains, known as the United States and British Empire Ranges, exceed 6,500 feet in height above sea-level east of Clements Markham Inlet, and, west of this inlet, Mount Oxford is reportedly 9,000 feet high, and other peaks there are reported to be higher. Ice-caps are widespread, with only high peaks rising above the ice. Even these peaks carry small glaciers. Most of the ice-free parts of the mountains are talus slopes.

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GENERAL GEOLOGY

General Statement

Sedimentary strata, mainly of marine origin, in part fossiliferous, unmetamorphosed to highly metamorphosed, gently undulating to highly folded, basic dyke-rocks, and gneisses with granitic and pegmatitic dykes occur in the region. The known fossils range in age from Silurian to Miocene or later. The results of the field studies of 1953 suggest that the consolidated rocks are from possibly Precambrian to Miocene or more recent in age, and that orogenic deformation probably occurred at three different periods, namely, Middle or pre-Middle Silurian, Late Carboniferous or Early Permian, and some time between Early Permian and Miocene. No evidence was found that the glaciers are retreating at the present time, but widespread glacial debris and land-forms beyond the present land ice prove that glaciation formerly was more extensive. Marine deposits and seashore features above present sea-level indicate a recent emergence of the land. Minor topographic features of permanently frozen ground are common locally.

Table of Formations

Period (mainly tentatively identified)	Formation	Lithology
Quaternary		Silts, clays, gravels
Disconformity		
Miocene or later	Eureka Sound group	Sand, silt, boulder beds, and lignite; fossils

Angular unconformity

Mesozoic?		Diabase sills and dykes
Intrusive contact		
Late Carboniferous or Early Permian	Feilden group	Limestone, minor sandstone, and conglomerate; fossils
	Guide Hill group	Red sandstone, conglomerate, minor shale and limestone; fossils
	Angular unconformity?	
	Dana Bay group	Limestone, shaly limestone; fossils
Permian or earlier	View Creek group	Sandstone, quartzite, greywacke, slate, conglomerate, red sandstone and conglomerate, limestone
	?	?
	Sail Harbour group	Shale, slate, and shaly limestone; fossils
?	?	?
Middle Silurian		Limestone and argillaceous limestone; fossils

Angular unconformity?

Middle Silurian or earlier	Cape Rawson group	Argillaceous limestone, shale, slate, greywacke, quartzite, limestone, chert, calcareous sandstone
?	?	?
Precambrian or Palaeozoic	Mount Disraeli group	Calcareous slate and phyllite; limestone, shaly limestone, calcarenite, granule conglomerate, quartzite, marble
	?	?
	Cape Columbia group	Biotite gneiss, garnet-biotite gneiss, augen gneiss, mixed biotite and granitic gneiss; granitic and pegmatitic dyke-rocks

The stratigraphic position of the Sail Harbour, Cape Rawson, Mount Disraeli, and Cape Columbia groups is not known except that the Cape Rawson group is older than the Silurian and the Feilden group, and that the Sail Harbour group is probably older than the Guide Hill group.

Precambrian or Palaeozoic

Cape Columbia group

Feilden and De Rance (1878, p. 556) mapped mica schists and other altered rocks in the region of Cape Columbia, but did not describe them. That map, and Peary's mention (1907, p. 213) of gneisses in this area, were the basis for Schuchert's (1923) inferred old borderland or "Pearya". To others, such as Troelsen (1950, p. 28), these observations suggested that northern Ellesmere was formerly part of a main geosynclinal or eugeosynclinal belt.

Metamorphic and granitic rocks outcrop between Cape Aldrich and Markham Bay and the assemblage is named after Cape Columbia, a name prominent in Arctic literature. The group is remote from other similar lithologic units and, as no fossils were found in it, its stratigraphic position is not known. It is the most metamorphosed unit found in northern Ellesmere and for this reason it is tentatively placed either in the Palaeozoic or in the Precambrian. The group includes biotite gneiss, garnet-biotite gneiss, augen gneiss, banded biotite and granitic gneisses, and granitic and pegmatitic dyke-rocks.

The biotite gneiss is composed of fine-grained biotite and feldspar, the former comprising 50 to 80 per cent by volume of the rock. Plates of biotite, up to 2 mm. across, are present.

The garnet-biotite gneiss is similar to the biotite gneiss except that grains of red garnet are developed, mostly in grains under 0.5 mm. in diameter. Garnet may form up to 15 per cent by volume of the rock.

Narrow bands of spectacular augen gneisses occur. These carry large, white or pink feldspar crystals in a matrix of biotite, sericite, fine-grained feldspar, and red garnet. Some of the mica grains bend around large feldspar crystals.

Banded biotite and granitic gneisses are represented. Biotite-rich bands, similar to the biotite gneiss, alternate with layers of intimately mixed quartz and feldspar. This rock is fine grained, only a few grains being over 2 mm. across, and only a few bands of this rock-type exceed 10 mm. in width.

Dykes of granitic and pegmatitic character cut the gneissic rocks. The granitic type is medium grained, with less than 5 per cent of biotite. The pegmatites are variable in texture and mineral content; coarse-grained, pink feldspar and quartz constitute many; others are made of coarse white feldspar with minor amounts of pale brown muscovite and garnet. Only a few pegmatite dykes exceed 10 feet in width and their lateral extent is unknown.

Pebbles and boulders of green slate and pyroxene gneiss in the recent moraine deposits about Cape Aldrich suggest that other types of metamorphic rocks are exposed inland.

Details of the folding of the Cape Columbia group is not known.

None of the above rocks are known elsewhere in the north and northwest periphery of the archipelago. Similar types, if found among debris within the "Ice Islands" floating in the Arctic Sea, would be a factor in correlating these islands with the Ice Shelf of northern Ellesmere, as part of the shelf lies against the Cape Columbia rocks.

Mount Disraeli group

Mount Disraeli is a prominent peak and its name is suggested for the sedimentary strata west of Clements Markham Inlet. The areal extent of these strata is unknown; they were studied along the coast from Cape Colan to Good Point, and for 20 miles along the west side of Clements Markham Inlet.

The contact of members of the Mount Disraeli group with other formations of the area was not found. It is, as in the case of the Cape Columbia group, placed in the Precambrian or Palaeozoic. The beds are slightly metamorphosed and no fossils were found. Two distinct assemblages are represented, the first is calcareous black slate and phyllite, and the second is grey limestone and shaly limestone. Minor amounts of marble, calcarenite, granule conglomerate, and quartzite occur in this second division. The two assemblages alternate and the members within each do the same. All contacts within the group are conformable.

Veins and irregular masses of quartz and calcite cut these rocks. At some localities narrow ferruginous bands occur in the limy rocks. Some of the limestone has been marblized, a feature well illustrated at Good Point. The beds of the Mount Disraeli group dip steeply and locally are folded closely.

Middle Silurian or earlier

Cape Rawson group

The name Cape Rawson was applied by Feilden and De Rance (1878, p. 556) to a series of rocks "occupying the country between Scoresby Bay and Cape Cresswell in lat. 82°40' N.". Jet-black slates, impure limestones, quartzites, and grits were included in this series. Many veins of quartz and chert were also observed by Feilden.

Troelsen (1950, p. 63) states that the north boundary of this group is near Antoinette Bay (Greely Fiord) and south of Feilden Peninsula. The south boundary is between Archer Fiord and Scoresby Bay. The total thickness is unknown, this being difficult to determine because of complex folding. The group is composed of argillaceous limestone, shale, slate, greywacke, quartzite, limestone, black chert, and calcareous sandstone. Cubes of pyrite are present at many localities in the black shale and slate.

Veins of milky quartz, yellow carbonate, and quartz and carbonate cut some beds.

The strata of the Cape Rawson group have been strongly deformed. In some areas they lie in a series of isoclinal

folds; in other areas in broad, more open folds. Slaty cleavage parallels the bedding except locally where the two cross. Some shearing follows the cleavage.

The age of the Cape Rawson group has not been determined precisely. Feilden and De Rance (1878) and Etheridge (1878) compared this assemblage to the Huronian of Nova Scotia. Dawson (1887) considered the strata possibly of Cambrian age. Schei (1903), Low (1906), and Willis (1912) placed the group in the Triassic. Koch, referred to by Troelsen (1950, p. 64), compared the members of the Cape Rawson group to Lower Devonian rocks but eventually left the age of the group undecided. Troelsen (1950, p. 64) considered the lithology of the group as an indication of its pre-Pennsylvanian age. As discussed below, the Cape Rawson group is considered overlain unconformably by the Guide Hill and Feilden groups (described on pages 12-15) of Permo-Carboniferous age and also by Middle Silurian limestone. Hence, the Cape Rawson group is Middle Silurian or older.

Members of the Cape Rawson group were not found in contact with the Cape Columbia, Mount Disraeli, Sail Harbour, View Creek, or Dana Bay groups.

Middle Silurian

Limestone

Beds of Silurian age are exposed over an area of some 2,000 square feet at the east side of the entrance to Colan Bay, some 4 miles west of Alert. Here, grey limestone and black argillaceous limestone outcrop. The dip and strike of the beds could not be determined as they had slumped. The outcrop is partly surrounded by members of the Cape Rawson group, which within 100 feet of the limestone dip vertically. The Silurian limestone strata appear to cross the strike of the Cape Rawson beds, suggesting an unconformity at the base of the limestone. Furthermore, metamorphism of the Cape Rawson rocks is in contrast with the relatively unaltered Silurian strata.

Fossils from the Middle Silurian limestone identified by P. Harker are:

Amplexus sp.
Favosites sp.
Virgiana sp.

Permian or earlier

Sail Harbour group

Feilden and De Rance (1878, p. 560) report exposures of Carboniferous limestone on Feilden and Parry Peninsulas, and west to Clements Markham Inlet. The lithology of the rocks on Parry Peninsula differs from that of the formations on Feilden Peninsula, and for that reason have been mapped separately and designated Sail Harbour group, after the name of the bay around which they are well exposed. Members of the group outcrop at points from James Ross River west to Clements Markham Inlet.

The group includes black shale, slate, and argillaceous limestone. Veins of white carbonate and milky quartz cut these strata. One small fossil, an unidentified pelecypod, was found.

The beds lie in open and closed folds. Inland on Parry Peninsula the folds are broad and open, whereas folds south of Parker Bay and on the coast along Clements Markham Inlet are closed and overturned. Axial planes of the latter dip northwesterly and many small folds occur in incompetent beds. The highest grade of metamorphism noted was that of a slate.

The Sail Harbour group is post-Precambrian, because of the pelecypod it contains, and the structure of its strata suggests that they lie beneath those of the Guide Hill group of Permo-Carboniferous age. The limestone of the Sail Harbour group is not known to be metamorphosed and folded to the same extent as strata of the Cape Rawson group, and for this reason may be younger than that group.

View Creek group

The name View Creek is suggested for a group of slightly metamorphosed beds exposed along View Creek in the south-eastern part of Feilden Peninsula. The strata outcrop over an area approximately 1 mile in width and 4 miles along strike.

A great diversity of prevailingly clastic rocks are represented, including light buff sandstone with numerous interbeds of granule and pebble conglomerate, red sandstone and conglomerate, black and green slate and phyllite, quartzite, grey and dark grey limestone, and greywacke. Veins of milky quartz cut across many beds.

The View Creek strata are folded closely. Feilden and De Rance (1878) concluded that at latitude 82°33' north, Cape Rawson slate and impure limestone change along the strike into a thick series of quartzite and grit similar in character to members

of the View Creek group. On Feilden Peninsula, however, typical beds of Cape Rawson argillaceous limestone and carbonate-bearing sandstone outcrop within a short distance along the projected strike southwest of beds of the View Creek group and without evidence of gradation northward into beds of the View Creek type.

View Creek beds have the same structural attitudes as the nearby Dana Bay strata, which are Late Carboniferous or Early Permian in age. For this reason the View Creek beds are thought to be Permian or earlier.

Late Carboniferous or early Permian

Dana Bay group

The name Dana Bay was applied by Feilden and De Rance (1878, p. 559) to a group of beds on Feilden Peninsula exposed along the north shore of Porter Bay. Beds of this group outcrop for less than a mile across their strike.

Grey limestone and black argillaceous limestone comprise this group. Veins of white carbonate cross the strata.

The beds are folded and many of the folds are closed. Strata dip vertically at many places.

The northernmost Dana Bay beds, outcropping along View Creek, strike north 55 degrees east and dip 55 degrees southeast. To the north of, and separated from these beds by a short drift-covered interval, is the following section: a 50-foot wide layer of biotite-bearing rock; a 50-foot wide band of grey limestone, in part changed to marble and carrying poorly preserved fossils, chiefly brachiopods; a 15-foot covered interval followed by the top beds of the View Creek group with a strike and dip parallel with the Dana Bay beds at the south end of the section. If the intervening formations covered by drift represent strata of either the Dana Bay or the View Creek groups the members of the two groups at this locality are conformable.

The fossils collected by Feilden from the Dana Bay beds were identified by Etheridge (1878) as of Devonian age. Holtedahl (1924, pp. 146, 147) gave the opinion that these fossils were of Carboniferous age and that the Dana Bay beds, which are overlain by limestone referable to the Schwagerina zone, could be considered younger than older Upper Carboniferous.

The fossils, collected in 1953, have been identified by P. Harker as follows:

Fenestella sp.
Linoproductus sp. cf. L. duplex Wiman
Neospirifer sp. cf. N. cameratus (Norton)
Productus pseudohorridus ? Wiman
Productus sp. cf. P. payeri Toula
Productus sp. ex. gp. P. uralicus Tschern
Productus uralicus Tschern
Spiriferella sp. cf. S. parryana Toula
Spiriferella sp.
Tabulipora ? sp.

Harker considers that the fossils have a distinct Lower Permian affinity although some may be late Carboniferous.

Guide Hill group

The strata of deep red colour exposed on Guide Hill, south of James Ross Bay, are named the Guide Hill group. This group comprises chocolate-red sandstone and conglomerate, brick-red sandstone, black and purple shale, and grey limestone. The conglomerate carries fragments of quartz, jasper, limestone, quartzite, red and black shale, and granitic rocks. Gradation in pebble size was noted. The matrix of the sandstone and conglomerate is calcareous. Minor disconformities at the base of conglomerate beds indicate their deposition in streams.

Members of this group outcrop in scattered areas both on Parry and Feildeh Peninsulas, on the top of the mountains between Clements Markham Inlet and Parker Bay, and at Cape Hecla.

The Guide Hill strata are folded and beds dip as steeply as 70 degrees. The rocks are fresh and unmetamorphosed. The Guide Hill group formations appear from a distance to cap the mountains southwest of Parker Bay, which in their lower part are made of Sail Harbour rocks. The latter rocks possibly underlie unconformably the Guide Hill group, but of this the author found no direct evidence.

A rubbly outcrop of metamorphic rocks of the Cape Rawson group lies 2 miles south of Guide Hill and there on the south these rocks are separated from beds of the Guide Hill group by an area of drift 2 feet across. The Guide Hill beds dip 20 degrees south. The metamorphism of the Cape Rawson rocks and their blocky, cleaved appearance are in marked contrast with the nearby, fresh-looking Guide Hill strata, which lack these deformational features. The occurrence suggests that the Cape Rawson group formations were folded before the Guide Hill beds were deposited.

No contacts were observed with either the Dana Bay or View Creek beds.

Fossils collected from beds of the Guide Hill group are identified by P. Harker as of Late Carboniferous or Early Permian age and include Caniniid corals.

Feilden group

The beds, dominantly limestone, on Feilden Peninsula are designated as Feilden group. The strata of this group are probably the same as most of the formation Feilden and De Rance (1878, p. 559) called "Carboniferous Limestone". The outcrop of the Feilden group extends west of Porter Bay for at least 12 miles. The group also occurs west of Rowan Bay.

The most important member of the group is a buff weathering grey to dark grey limestone. Some of the limestone beds are argillaceous and these carry many fossils. Sandstone is present in small amount, also beds of conglomerate with fragments of chert, black slate, and limestone, in a light grey calcareous matrix. Dark grey chert nodules occur locally in the limestone. The limestone was in part extensively carbonatized. The beds of this group lie in broad, open folds.

Etheridge (1878) identified as Carboniferous the fossils Feilden collected from this formation. Tschernyschew (1902, p. 694) and Grønwall (1917, pp. 601-604) concluded that these fossils were of Late Carboniferous age. Holtedahl (1924, p. 147) referred the limestone to the Schwagerina zone. Fossils collected by the author from beds of the Feilden group are identified by P. Harker as follows:

Caniniid corals
Fenestella
Lithrostrotion sp.
Linoproductus
Marginifera sp. cf. *N. involuta* Tschern
Productus uralicus Tschern
Productus orientalis? Tschern
Productus cf. *P. uralicus* Tschern
Tabulipora? sp.
Spiriferella sp.
Syringopora sp.

These fossils are of Early Permian or possibly Late Carboniferous age.

The brachiopods reported to have been collected at Cape Sheridan by one of Peary's men, are, according to Whitfield (1908), Late Carboniferous in age and similar to forms collected

by Feilden on Feilden Peninsula. The author observed no fossiliferous limestone in many visits to Cape Sheridan, but only metamorphosed Cape Rawson beds.

West of Rowan Bay, strata of the Feilden group outcrop over an area of 5 square miles and strike southeasterly. Nearby, to the south, is an extensive outcrop of Cape Rawson group strata striking northeasterly to easterly. Nearly half-way between Dana Bay and James Ross River, Guide Hill group conglomerate appears to be unconformably above Cape Rawson group beds, and the Feilden group strata to overlie conformably the Guide Hill rocks.

North of Porter and Dana Bays, two creeks have cut deep valleys exposing almost complete sections of Guide Hill and Dana Bay group strata. No Feilden group beds are exposed along these creeks, although members of this group outcrop patchedly near the top of nearby hills across the projected strike of members of both View Creek and Dana Bay groups exposed in the two valleys and in other interjacent hills. These outcrops of the Feilden beds are thus indicated to be erosion remnants of a former more extensive cover of Feilden rocks laid unconformably over both the View Creek and Dana Bay strata.

No contact between members of the Feilden and the Sail Harbour groups was observed, most probably because the non-marine Guide Hill group red-beds separates them. The Guide Hill group red-beds appear to lie exclusively below the Feilden limestone south of James Ross Bay, although red sandstone and conglomerate, minor purple and black shales of the Guide Hill group type on Feilden Peninsula, are interbedded with the Feilden group limestone west of Rowan Bay.

Mesozoic ?

Diorite Sills and Dykes

Sills and dykes of igneous rocks cut strata of the Mount Disraeli, Cape Rawson, View Creek, and Feilden groups. The intrusive rocks are dark green and fine grained (2 mm. or less). Some exhibit diabasic texture. In a few, feldspar phenocrysts are 10 mm. long.

Only one dyke was observed in the Mount Disraeli strata. It lies half-way between Good Point and Cape Colon and is porphyritic. The dyke trends northerly nearly at right angles to the strike of enclosing formations. The dip is steep and westerly. The rock is fractured and some fracture planes are slickensided. A thin section showed the following minerals: white mica, plagioclase, clinopyroxene, chlorite, quartz, titaniferous magnetite, pyrite, leucoxene, and red iron oxides. The groundmass is chiefly small

laths of plagioclase. Much of the clinopyroxene in the matrix is altered to chlorite and phenocrysts of clinopyroxene also have been altered in part to chlorite. Some of the phenocrysts of plagioclase are 10 mm. across and are altered almost completely to white mica.

Cape Rawson group strata are cut by sills of diabase north and northwest of Knot Harbour. These sills hold many inclusions of black slate, also veins of quartz and/or carbonate. The veins are in part vuggy with quartz crystals projecting from the walls of the vugs. Many veins in the sills do not extend into the adjacent strata. The specimen of diabase taken for study carries clinopyroxene, andesine (An_{48}), white mica, biotite, titaniferous magnetite, and pyrite. Phenocrysts of andesine and clinopyroxene constitute most of the section. Most of the intervening fine-grained material is altered plagioclase. Biotite is secondary after clinopyroxene. Pyrite replaces biotite and clinopyroxene.

Outcrops of a doleritic rock occur in areas underlain by members of the View Creek group, but it could not be determined whether these occurrences were dykes or sills. The study of two thin sections of specimens from outcrops of these rocks proves them to be dioritic in composition and diabasic in texture. One rock is fine grained and carries plagioclase, clinopyroxene, titaniferous magnetite, pyrite, apatite, uralite, white mica, biotite, and red iron oxide. Fine-grained plagioclase and white mica are interstitial to large crystals of clinopyroxene. Plagioclase also occurs in lath-shaped phenocrysts. The feldspar is much altered to white mica, whereas clinopyroxene is less intensely altered to uralite along cleavage planes and at the margins of the crystal. Biotite in small amount is also an alteration product of clinopyroxene. The second rock is a coarse-grained diabase, carrying white mica, labradorite (An_{57}), uralite, clinopyroxene, titaniferous magnetite, biotite, and red iron oxide. The matrix is fine-grained clinopyroxene and feldspar, both in large part altered respectively to uralite and white mica. The phenocrysts of labradorite and of clinopyroxene are fresh. The metallic minerals have a lattice-like pattern and appear to have formed late.

In the area west of Rowan Bay sills of diabase cut members of the Feilden group. A specimen from one of the sills carries: labradorite (An_{55}), clinopyroxene, white mica, titaniferous magnetite, biotite and its alteration products, and apatite. The diabasic texture is well defined. The plagioclase is in part altered to white mica and the clinopyroxene to biotite. The large grains of metallic minerals may be younger than the silicate minerals.

It is not known whether all the above dykes and sills are contemporaneous. The undeformed Miocene or younger strata are not known to be crossed by diorite. Schei (1903) and Troelsen (1950) described basic dykes and sills from the region about Eureka

Sound, Nansen Sound, and Greely Fiord. Troelsen observed them in folded Permian and Mesozoic strata but not in undisturbed Cretaceous and/or Tertiary limnic beds.

Miocene or later

Eureka Sound group

Two beds carrying lignitic or sub-bituminous coal occur at latitude 82°15' north and longitude 67°30' west. In one bed, fragments of partly coalified wood occur in sand and this sand bed grades upwards into silt, followed above by a bed of boulders. The second coal bed is in a section exposed a few hundred feet to the east of the first and at a slightly higher elevation. The base of the section is a bed of boulders that may be a part of the boulder bed of the first locality. The boulder bed at the second locality is overlain by a 6-foot thick layer of silt and this by a 2-foot thick bed of compact brown coal. The coal bed is followed upwards to the surface by an irregular thickness of silt. The strata dip very gently in various directions, as they presumedly were deposited on slightly sloping surfaces.

A sample of the compact coal was analysed by W. J. Montgomery of the Mines Branch and the results are:

Moisture condition	As rec'd	Dry
Proximate analysis		
Moisture ..... %	11.2	0.0
Ash ..... %	8.4	9.4
Volatile matter ..... %	44.9	50.5
Fixed carbon ..... % (by difference)	35.5	40.1
Ultimate analysis		
Sulphur ..... %	0.8	1.0
Calorific value		
B. T. U./lb. gross	9,365	10,545
Capacity moisture (100% Rel. humidity)	21.7	
A. S. T. M. rank	Sub-bituminous "C"	
(Moist mineral matter free B. T. U. = 9,221)		

As the small sample was not carried in an air tight container, it is possible that a loss of humidity in transit has resulted in a higher ranked coal, which in the outcrop may be a lignite.

The low-grade coal beds probably are a part of the widespread group of sedimentary strata designated Eureka Sound by Troelsen (1950, p. 78).

Plant and lignite remains are described from the east coast of Ellesmere Island (Heer, 1878, p. 66ff), from Axel Heiberg Island, Amund Rignes, and from western Ellesmere Island (Schei, 1903, p. 56ff) (Troelsen, 1950, p. 78). Heer (op. cit.) concluded that the coaliferous deposits are of Miocene age. Troelsen (1950, p. 78) presents evidence that the beds are post-Jurassic. G. Hattersley-Smith found, in silt beneath the brown coal described above, a well-preserved cone of a coniferous tree that Wayne L. Fry assigns either to Picea sp. or Larix sp. Fry suggests that the cone comes from strata not older than Miocene and possibly more recent.

Quaternary

Glacial Deposits and Land Forms

Unconsolidated deposits are widespread in northern Ellesmere Island and especially so over the plateau region. These deposits are variable in thickness and include clay and both rounded and angular fragments of rock. The ice may have advanced and retreated many times in this region, hence most of the unconsolidated material is probably reworked glacial till. Erratics are not abundant but are widespread, the most characteristic of which are jasper conglomerates and granite-gneiss. Outcrops of granite-gneiss are not known east of Cape Columbia. No other types of glacial deposits were found except in close proximity to present glaciers.

The low hills southeast of Alert have the form of large roches moutonées or rock bosses moulded by an advancing ice cover. The drainage has changed as the size of the ice-caps varied. Evidence of at least five former levels of Wood Creek were observed along its valley. Many valleys lack the "U" shape of a glaciated valley, and probably these are the result of erosion by glacial streams. The depth of the unglaciated valleys suggests that for many years the ice-caps have not extended eastward. Glacial striae are rare; the northeasterly trending roches moutonées are the best criteria of the direction of movement of the former ice cover.

Marine Deposits, Land Submergence and Emergence

Former beaches and marine shells were found by the author 300 feet above present sea-level. Delta deposits are widespread, as at the junction of Wood Creek and the sea, where deltas of two or more ages are represented.

Wave-cut cliffs were noted at several localities. The freshness of this feature despite the softness of the rock from which the cliffs were carved suggests that uplift was rapid.

Patterned Ground

The soil patterns noted on northern Ellesmere Island are non-sorted polygons and non-sorted stripes, according to the useful classification of patterned ground presented by Washburn (1950). With steepening ground slope, the polygons become elongated and eventually are rectangular, but polygonal outlines may persist on slopes as steep as 10 degrees. Circular forms were not seen. Most of the polygons about Alert are four to six sided. They are of the depressed margin type. The average diameter is less than 2 feet although some are larger. None is 40 feet across, the upper size range of these forms. Subangular to angular fragments of rock make up 5 to 20 per cent of the material in a polygon; the remainder is mainly grey-black clay. The rock fragments and clay are intermixed. The margin of most polygons is moss-filled and is not distinct at a depth of 3 feet or more. Few polygons are over 1 foot high, measured from the margin to the top of the centre. South of the present ice-cap some polygons are over 2 feet high. The high polygons resemble closely spaced, conical ant-hills. At Alert, trenches were cut through the polygons and they appear to be above the level of permafrost. Patches of permafrost were encountered at a depth of 18 inches. The black, clayey soil, derived from the slates of the Cape Rawson rocks, are drained poorly and permafrost is closer to the surface in such soil than in others.

STRUCTURAL GEOLOGY

All sedimentary strata are folded with the exception of the Eureka Sound beds. Members of the Guide Hill and Feilden groups lie in broad, open folds, whereas strata of the Mount Disraeli, Cape Rawson, View Creek, Dana Bay, and Sail Harbour groups have been deformed into tight folds. The type of folding in the Middle Silurian limestones is not known.

The Cape Rawson beds trend slightly north of east in the area south of latitude 82°45' north. The Feilden beds west of Rowan Bay strike southeasterly. All the strata between Porter Bay and Clements Markham Inlet strike northeasterly. West of the inlet to Giffard Peak, the Mount Disraeli strata are bent in a broad arc with an easterly to southeasterly strike. The Cape Columbia gneisses trend southeasterly between Cape Aldrich and Markham Bay.

Along the east shore of Clements Markham Inlet, beds of the Sail Harbour group are overturned and the axial planes of the folds dip northwesterly. The overturning of the beds in this area

may be related to a thrust fault, which may account for the site of Clements Markham Inlet. The movement along this assumed fault also could have produced the partial variation in trend of strata across the inlet. A transcurrent fault, crossing the north part of Parry Peninsula and through Sail Harbour, is suggested by the following facts: (1) a depression, less than 80 feet above sea-level with bordering hills rising to 1,000 feet in height; and (2) the axes of folds on the north of the depressions are farther east than those of assumed corresponding folds on the south side.

Field relations indicate that the Feilden group and, locally, the Guide Hill group sediments were deposited on the eroded surface of folded Cape Rawson, Dana Bay, View Creek, and Sail Harbour strata. The Middle Silurian rocks appear to have been deposited on the eroded surface of folded Cape Rawson rocks. The undeformed Miocene or later lignite-bearing beds were deposited after the last period of folding.

The age of the Dana Bay group, Guide Hill group, and Feilden group strata, based on their contained fossils, indicates that one orogeny took place in Late Carboniferous or Early Permian time, and that another orogeny followed the deposition of Permian strata but was before the formation of Miocene or later brown coal measures. The Cape Rawson group rocks were folded before the Middle Silurian limestone was deposited. Thus, at least three periods of folding are indicated: Middle or pre-Middle Silurian, Late Carboniferous or Early Permian, and post-Early Permian to Miocene or later. The more metamorphosed strata may owe their nature to earlier orogenies, and thus the Cape Columbia rocks might have been involved in Precambrian crustal upheavals. On the other hand, they may represent stratigraphic levels or zones more intensely affected than, but involved in the same orogeny as, the less metamorphosed formations; with the evidence at hand, the author is not ready to decide the point.

Koch (See Troelsen, 1950, p. 27) considered the folding in the northern Arctic to be Devonian in age. Koch (1935, p. 619) revised this opinion and stated "In North Greenland there have been slight (in lowermost Ordovician) and strong (in lowermost Silurian) epeirogenic movements. The folding proper is younger than Wenlock and older than Swagerina (Early Permian)". Schuchert (1923, p. 193) stated that "since Pennsylvanian rocks are involved in the folding the orogeny must be not older than late Pennsylvanian".

Troelsen (1950, p. 27) mentions a statement by Frebold, who doubted that a Caledonian age of the folding has been proved but who thought the folding possibly could be Variscan (Late Carboniferous). Again in 1950, Frebold (See Troelsen, 1952, p. 199) expressed the view that the age of the folding is unknown.

Troelsen (1952), in a preliminary statement of the results of his recent studies, reports that Middle Carboniferous sandstone and limestone (with Fusulina and Fusulinella) are folded gently along Canyon Fiord, west-central Ellesmere Island, where they lie unconformably over intensely folded Late Silurian strata. This, according to Troelsen, proves the essential correctness of Lauge Koch's theory of a Caledonian age for the folding. In northern Ellesmere Island the Dana Bay group of Late Carboniferous or Early Permian age is closely folded, whereas the Feilden group, also of Late Carboniferous or Early Permian age, has been only gently folded, and in this respect resembles Troelsen's Middle Carboniferous. A further study of the fossils from these two formations may establish either that the Feilden group of northern Ellesmere Island and the "Middle Carboniferous" of Canyon Fiord can be correlated or that the two regions had a different geological history.

The geology of northern Ellesmere Island thus appears more complex than was suggested by the preliminary work of Feilden in 1876.