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DEN DANSKE THULE OG ELLESMERE LAND
EKSPEDITION 1939—41
LEADER: JAMES VAN HAUEN

CONTRIBUTIONS TO THE GEOLOGY OF NORTHWEST GREENLAND, ELLESMERE ISLAND AND AXEL HEIBERG ISLAND

BY

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WITH 17 FIGURES IN THE TEXT AND 1 MAP

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Introduction and Acknowledgments.

The present paper proposes to give an account of the main geological results of the Danish Thule-Ellesmere Land Expedition 1939—1941. The first draft was finished already in 1943, but because of the war and other, more pressing work the publication of the report had to be postponed. At the present time, the collections of Cambrian and Ordovician fossils are under investigation, and the writer has, therefore, thought it desirable to publish a general account of the stratigraphy and structure of the regions visited by the Danish expedition.

As the work on the report progressed, it became necessary to compare and combine the writer's results with those of earlier investigators, and the report therefore contains numerous references to other papers on the same subject. The present report may thus be said to be an expansion of certain sections of the synopses by Kindle (1939) and Teichert (1939).

On the map accompanying the present paper, the writer has attempted to compile all available information, with the limitations that the scale of the map imposes. He has endeavored to leave blank those areas that should be shown in blank, and to indicate uncertainty as to the age of the formations where such uncertainty exists.

One of the difficulties in carrying on geological work in North Greenland and Ellesmere Island[1]) is the lack of adequate base maps, the available maps showing only the coast line and, in some cases, a few conspicuous points of elevation for some distance inland. In the field work the following maps were used:

1. Sverdrup's map of the western part of the area, 1:2,000,000. (Sverdrup, 1904).
2. British Admiralty Chart of Smith Sound, Kennedy and Robeson Channels, 1:1,000,000. 1931.
3. Lauge Koch: "Map of North Greenland, 1:300,000". 1932.

After the end of the war, the following maps have become available and have been used in the preparation of the report:

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[1]) On the latest maps, "Ellesmere Island" is the name for the whole island, while the part of the island south of Bay Fjord and Bache Peninsula is called "Ellesmere Land".

4. U.S.A.A.F. Aeronautical Chart, 1:1,000,000, Sheets 7, 8, 20, and 21. 1943.
5. "Glacial Map of North America, 1:4,555,000". Published by the Geological Society of America, 1945.

Finally, Mr. JAMES VAN HAUEN, the leader of the expedition, has been kind enough to place a sketch map of Otto and Hare Fjords at the writer's disposal.

Grateful acknowledgment is made to Mr. JAMES VAN HAUEN for the opportunity to participate in the expedition.

The writer is deeply indebted to Mr. HANS NIELSEN, former manager of the Thule District and Providence's lieutenant of many arctic expeditions, and to Mrs. NIELSEN, for boundless hospitality and much practical advice.

To the members of the committee of the expedition, Doctors M. DEGERBØL, CHR. POULSEN and O. HAGERUP, thanks are due for much help and advice.

Gratitude is expressed to the directors of the American Museum of Natural History in New York and the University Museum of Mineralogy and Geology in Copenhagen for placing the facilities of their institutes at the writer's disposal.

The writer is indebted to Dr. THOMAS E. SAVAGE, of the University of Illinois, for the loan of material collected by Dr. W. ELMER EKBLAW on the Crocker Land Expedition, and to Dr. A. HEINTZ, of Paleontologisk Museum, Oslo, Norway, for the permission to examine PER SCHEI'S collections from Ellesmere Island.

Dr. CHR. POULSEN, Dr. A. NOE-NYGAARD and Professor F. J. MATHIESEN kindly undertook the examination of various parts of the writer's collections. To Dr. W. ELMER EKBLAW, of Clark University, the writer owes thanks for valuable information on the geology of certain parts of Ellesmere Island.

Special thanks are due to Mr. GUDMUNDUR THORLAKSSON, who, though engaged by the expedition as a botanist, collected fossils and rock samples when time and opportunity permitted and later placed his notes and collections at the writer's disposal.

The illustrations accompanying the present report are by the writer. Mr. CHR. HALKIER, preparator at the University Museum of Geology in Copenhagen, has carried out the printing of the photographs.

Previous Work.

Since the beginning of the nineteenth century, numerous whalers and explorers have visited Smith Sound, some of the explorers even penetrating to the north coasts of Greenland and Ellesmere Island.

Among the expeditions in the nineteenth century, only a few added appreciably to our knowledge of the geology of those regions. HAYES (1867), on his expedition in 1860—1861, collected a few fossils along Kennedy Channel. Various members of NARES's expedition, which wintered in Lady Franklin Bay and at Cape Sheridan 1875—1876, made geological maps of North Greenland and northeastern Ellesmere Island (cfr. FEILDEN & DE RANCE, 1878). GREELY'S report (1888) contains a few scattered notes on the geology of the same regions. ROBERT E. PEARY, on some of his numerous expeditions to the Polar regions, brought home a few fossils from the coasts of Ellesmere Island (WHITFIELD, 1908).

Very important contributions to our knowledge of the geology of the western part of the map area are due to the investigations by PER SCHEI, who, as a member of the Second Norwegian Arctic Expedition in the "Fram", 1898—1902, examined the region around Bache Peninsula; the south and west coasts of Ellesmere Island; and the east coast of Axel Heiberg Island (SCHEI, 1903 a & b; 1904. HOLTEDAHL, 1917).

Equally important as SCHEI's work are the results of the expeditions in which LAUGE KOCH took part as a geologist. In 1916—1918, as a member of the Second Thule Expedition, and in 1920—1923, as the leader of the Danish Jubilee Expedition, KOCH collected a large amount of information about the geology of Northwest and North Greenland and published the first detailed geological map of the region (KOCH, 1920, a. o.).

W. ELMER EKBLAW (MACMILLAN, 1918) collected some fossils in central Ellesmere Island. ROBERT BENTHAM examined in 1935 and 1936—1938 the coast from Bache Peninsula to Scoresby Bay besides parts of southern Ellesmere Island (BENTHAM, 1936 & 1941; POULSEN, 1946). HAROLD DREVER, a member of one of WORDIE's expeditions, visited Bache Peninsula in 1937 (WORDIE, 1938).

Field Work of the Present Investigation.

During the years 1939—1941, the present writer, as a member of the Danish Thule-Ellesmere Land Expedition, studied the geology of various parts of Ellesmere Island and the north coast of Greenland. Of these two years, only a few months could be spent in actual field work, the long period of darkness in winter and the unfavorable traveling conditions in part of summer and fall forcing the party to stay near the base camp for several months at a time. Because of unfavorable ice conditions in the summer of 1939, the base camp had to be established at Neqe, som 80 kilometers from the nearest locality where fossiliferous sediments are exposed.

The best time for field work in those parts of the Arctic is the period from the middle of March till the beginning of June. After the first of June, traveling by dog sledge is generally impracticable because of the unsafe condition of the sea ice, the absence of snow on land, and the melting of the snow on the glaciers. Later in summer, when the sea ice breaks up, drift ice ordinarily prevents the navigation by small vessels of the sea north of Etah. In October it again becomes possible to go north by dog sledge, but then the rapid decline of daylight makes geological field work difficult.

The writer's field work in Inglefield Land, Washington Land and on Bache Peninsula may be characterized as a revision and continuation of Koch's and Bentham's investigations. Emphasis was placed on the collection of fossils *in situ* and on the examination of formation contacts.

The field work in Ellesmere Island outside of Bache Peninsula was strictly of the nature of a rapid reconnaissance, and the collections brought home from this region are very small. The circumstance that provisions for men and dogs for practically the whole journey of about 1800 kilometers (ca. 1100 miles) had to be carried on the sledges, forced the party to travel as fast as possible and prevented it from stopping at any place for more than a few hours. As the route encircled the central part of Ellesmere Island (fig. 1), no depots could be left for the return trip, and on the difficult overland trip from Greely Fjord to Archer Fjord it even became necessary to abandon part of the equipment. The writer's investigations in western and northern Ellesmere Island are, therefore, very far from being exhaustive, and a great many important problems still await their solution.

The more important of the journeys undertaken by the writer are listed below (cfr. fig. 1 and map):

August, 1939: a brief stay at Etah.

October 7—November 6, 1939: a sledge journey from the base at Neqe across the ice cap to Inglefield Land and back. Because of fog and declining daylight, only 11 days could be spent in actual field work.

March 13—May 28, 1940: a sledge journey from Neqe around the central part of Ellesmere Island and back along the north coast of Greenland. About a week was spent on Bache Peninsula, while short stops were made at numerous other points along the coast of Ellesmere Island. On the return journey, a couple of days were spent in northeastern Inglefield Land.

April 9—May 4, 1941: a sledge journey to the coast of Inglefield Land between Rensselaer Bugt and Kap Kent, and to Kap Clay and the coast between Kap Webster and Gonioceras Bugt on the south coast of Washington Land.

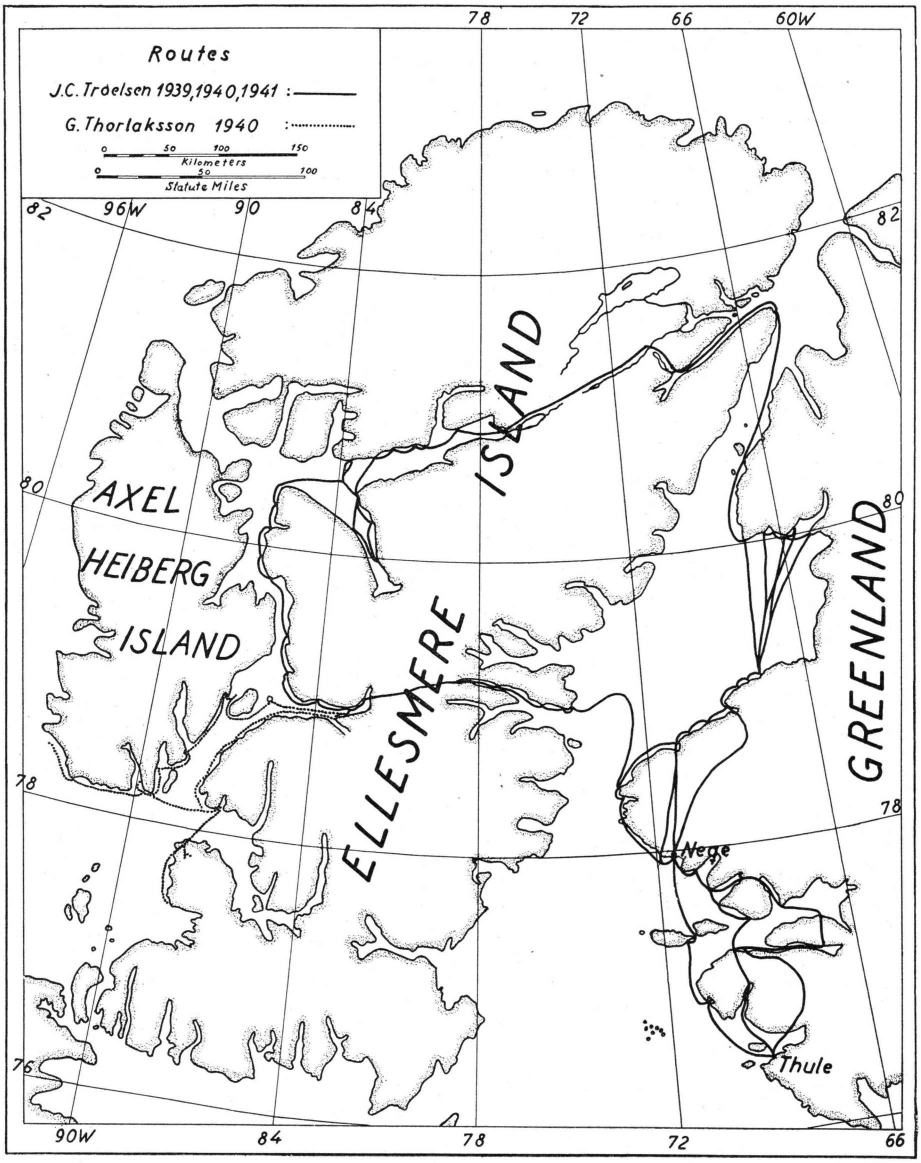

Fig. 1.

May 17—June 3, 1941: a sledge journey to various points on the coast of Inglefield Land and to Wright's Bugt and Nygaard's Bugt on the south coast of Washington Land.

In the spring of 1940, Mr. Gudmundur Thorlaksson, the botanist of the Danish expedition, undertook a sledge journey to southwestern Ellesmere Island and southeastern Axel Heiberg Island (fig. 1).

On this trip he collected fossils and rock specimens from a number of places on the south coast of Bay Fjord; the west coast of Raanes Peninsula; the peninsula on which Great Bear Cape is located; and the south and southeast coasts of Axel Heiberg Island. After the war, Mr. THORLAKSSON kindly placed these collections at the writer's disposal.

Remarks on the Map of Inglefield Land.

During the field work it proved to be somewhat difficult to locate the Cambrian type localities because of discrepancies between the various maps of Inglefield Land. In the following lines the newer maps of Inglefield Land will be compared and the locality names correlated.

The best of the available maps are based upon the survey by L. KOCH in 1922. The outline of the coast is identical in all three maps, mentioned below, but the distribution of the names differs somewhat.

The first of the maps was published by POULSEN (1927). The second one is L. KOCH's "Map of North Greenland, 1:300,000" (1932). The third map was published by L. KOCH in 1933. All of these maps show the coast line and the rivers in a fairly accurate way.

A comparison of the maps gives the following result:

POULSEN, 1927, & KOCH, 1933	KOCH, 1932	Eskimo Names
unnamed	Cape Frederik VII	—
Cape Frederik VII	Cape Wood	Uvingassok
Pemmican River	unnamed	—
Cape Wood	Cape Kent	—
Wulff River	Wulff River	Siorapaluk
Cape Kent	unnamed	—

The Eskimo names have been added for the benefit of future travelers who may be employing Eskimos as guides.

For the orientation in the field it is important to note that on KOCH's map of 1932, an Eskimo village is shown at the mouth of the river which, on KOCH's map of 1933, is called Pemmican River, although neither houses nor ruins seem to be present in this place. On the other hand, an old village, not marked in the maps, is located at the promontory called Cape Frederik VII by KOCH (1933).

The Cambrian localities, mentioned in the following chapters, refer to the maps by POULSEN (1927) and KOCH (1933).

The name Blomsterbækken has been used by the present writer for a watercourse which on POULSEN's map is the second one southwest of Cape Frederik VII, while on KOCH's map (1932) it is the third water-course southwest of Cape Wood. On KOCH's map of 1933, Blomsterbækken would be the third stream southwest of Cape Frederik VII.

Physiography.

Because of the lack of accurate and detailed topographic maps, the subject of physiography can only be treated in the most general terms. The following remarks may, however, serve to orient the reader as to the appearance of the landscape within the map area. A somewhat more detailed account of the Greenland portion of the area has been given by KOCH (1928).

Northwest Greenland is, in general, a dissected plateau of rolling relief, attaining elevations in excess of 1000 meters.

Southwest of the Humboldt Gletscher, the plateau varies in altitude between 1000 meters, attained in several places around Inglefield Bugt, and 300—400 meters, the latter being the most common elevation above present sea level. The plateau is modeled on pre-Cambrian gneisses and faulted and gently dipping eo-Cambrian sediments, the highest points being underlain by gneiss and resistant sandstones and conglomerates (cfr. KOCH, 1926). Careful mapping may show whether more than one erosion surface exist in the area, or whether the variations in altitude are due to the destruction of the plateau remnants in connection with lithologic control[1]). At least some of the valleys and fjords are determined by faults, and all of them bear striking testimony to the effects of glacial scour. Though the plateau surface evidently has been completely covered by the Pleistocene ice cap, glacial erosion seems to have played but a minor part in the modeling of the surface.

Also north of the Humboldt Gletscher the plateau remnants are much in evidence. Southern Washington Land attains elevations of close to 500 meters, while altitudes of nearly 800 meters have been measured in the northern part of Washington Land.

The folded mountain range along the north coast of Greenland (fig. 2) is chiefly built up of resistant metamorphic and intrusive rocks and reaches elevations of 1065 meters in Halls Land, 1250 meters in Nyboes Land, and even greater heights in Peary Land. According to KOCH (1920, p. 68), remnants of a plateau exist in certain parts of the range, but whether the mountains have ever been completely peneplaned is not known. South of the mountain range follows a broad depression,

[1]) BENTHAM (1936) observed two plateaux at Etah, one at about 300 meters, the other at about 550 meters above sea level.

determined by the occurrence of Silurian sediments of low resistance. Farther south, the surface rises again to a height of somewhat more than 1000 meters.

Raised beaches occur in several places in Northwest Greenland. Koch (1928, p. 517—518) states that in the Kap York district, that is, along the coast between Etah and Melville Bugt, "the most typical shore line is about 50—55 meters high". Schei (*vide* Holtedahl, 1917, p. 24) found two terraces at Etah, the lower at about 24 meters above sea level and the upper at 100—125 meters (estimated). In the same place, Bentham (1936) found terraces at 12 meters (40 feet), 27 meters (90 feet), 38 meters (125 feet), 61 meters (200 feet), 88 meters (290 feet), 107 meters (350 feet), and 122 meters (400 feet).

Near the east coast of Ellesmere Island, separated from each other by a depression in the vicinity of Bache Peninsula, two mountain ranges rise to considerable heights. The Prince of Wales Mountains south of the depression are composed of pre-Cambrian rocks and reach elevations of around 1300 meters. North of the depression, roughly speaking between Bache Peninsula and Archer Fjord, the Victoria and Albert Mountains form a conspicuous range that attains altitudes of some 2000 meters. The mountains consist of folded and faulted sediments and are dissected into peaks and serrated ridges. Whether a concordant summit level exists, is unknown.

A depression that extends from the head of Greely Fjord to Lady Franklin Bay separates the Victoria and Albert Mountains from the mountainous regions of the interior of Grant Land, where it is known that several high ranges exist. The available maps show the Garfield Range and the United States Range running in a northeast-southwesterly direction along the northwestern shore of Lake Hazen. The Challenger Mountains near the north coast may be arranged along a line parallel to the other ranges. A member of the Oxford University Ellesmere Land Expedition (Humphreys, 1936, p. 425) climbed a peak nearly 3000 meters high in the United States Range and sighted still higher mountains farther north.

South of Makinson Inlet and in western Ellesmere Island north to, and probably including part of, Grant Land, the hill tops are truncated by plateau remnants of somewhat varying elevation. The average height above sea level is somewhere around 600 meters, the greatest elevations being found to the east (Holtedahl, 1917. Bentham, 1941). Around Eureka Sound, faulting and weak folding and the varying resistance of the rocks have caused the dissection of the plateau through erosion into smaller units; "viewed from certain positions, the landscape there presents some of the rich modeling and variety of Alpine forms; whereas from other points of observation it has faithfully preserved the character of the tableland it really is. This same plateau type of formation, which is characteristic of Ellesmere Land [Schei here refers to southern Ellesmere Island] appears again west of Eureka Sound, the south, west, and north sides of Heiberg Land, as well as north-west of the folding strike in Grinnell Land" (Schei, 1904).

Along the above-mentioned depression that separates the Prince of Wales Mountains from the Victoria and Albert Mountains, the erosion surface of western Ellesmere Island is connected with that of Bache Peninsula. On Bache Peninsula the plateau attains an altitude of some 400—500 meters. It is tempting to assume that this erosion surface was once continuous with that of Inglefield Land, but no adequate support for such an inference exists.

The depression that connects Greely Fjord with Lady Franklin Bay may be characterized as a rolling, somewhat dissected plateau that truncates intensely folded sediments, and which attains altitudes in the neighborhood of 600 meters. The plateau includes the northern end of the peninsula between Archer Fjord and Kennedy Channel.

That more than one pre-glacial erosion surface exist in Ellesmere Island is indicated by the occurrence, south of Bay Fjord, of the socalled "Braskerudflya", which, according to Holtedahl (1917, p. 22), seems to be a wave-cut plain that has been somewhat modified by subsequent glacial scour. It is "situated not more than about 200 m. above sea level—that is not much above the highest marine late quaternary terraces .....—yet must be of quite another and greater age".

As to the present extent of ice caps and glaciers in Ellesmere Island, the reader is referred to the Glacial Map of North America (Geological Society of America, 1945) and to the papers by Bentham (1941) and Wright (*vide* Haig-Thomas, 1940). During the maximum extent of the Pleistocene glaciation, the western part of the island, where no glaciers now exist, must have been covered with ice, at least over large areas. At Blaamanden in Eureka Sound the writer thus found a couple of large ice-scratched boulders of Permian limestone, a formation that occurs in place at a distance of probably 40 kilometers to the east. At the head of Greely Fjord, glacial striae were observed on the cliffs at an altitude of 200 meters above present sea level. Also the valleys tributary to Archer Fjord show the effects of intense glacial scour.

Raised beaches occur here and there along the coasts of Ellesmere Island. A little south of Bache Peninsula, Schei (*vide* Holtedahl, 1917, pp. 23—24) measured terraces at 174, 171, 133.6, 122.3, 117, 95, and 22.5 meters above present sea level. At the head of Goose Fjord, on the north coast of Jones Sound, Schei found the uppermost raised beach at an elevation of 144.5 meters. Bentham (1941), working in southeastern Ellesmere Island, found a prominent beach terrace at around 18 meters (60 feet) and another at about 55 meters (180 feet).

The present writer observed a few raised beaches, at elevations of about 40 meters, along the north coast of Greely Fjord. Marine terraces have probably formerly existed at higher levels, but because of the steepness of the coast, the older beaches have been eroded away during the formation of the youngest preserved terrace.

The floor of the valley between the head of Greely Fjord and Lake Tuborg a couple of kilometers inland is underlain by marine clay and sand and reaches an altitude of around 40 meters. At the present time, the valley is nearly closed by a large glacier which through a tributary valley comes down from the highland south of the main valley. At a former, higher level of the sea, the front of the glacier has probably been located farther south because of the breaking-off of icebergs.

General Structure.

The dominant structural features of Northwest Greenland and Ellesmere Island (fig. 2) are (1) the foreland (corresponding to the Greenland and the Arctic Island Provinces of MORLEY E. WILSON (1939, fig. 1)), which along its edges is partly covered by gently dipping, somewhat faulted sediments of eo-Cambrian and Early Paleozoic age; (2) the intensely folded Franklinian geosyncline (SCHUCHERT, 1923, 1939) or, as KOCH (1929 a) calls it, the Smith Sound geosyncline, which is now exposed along the north coast of Greenland and in the northeastern and central parts of Ellesmere Island; (3) the belt of weakly folded sediments of Late Paleozoic and Mesozoic age, which is preserved in Axel Heiberg Island and the western and northwestern portions of Ellesmere Island; and (4) the hypothetical borderland "Pearya" (SCHUCHERT, 1923, 1939) along the north coast of Grant Land.

Figure 2 shows diagrammatically the major structural elements of the map area. The sketch is not intended to show the original extent of the basins of sedimentation. Shore lines were ever shifting, and later folding has greatly foreshortened the region and brought together elements that were originally far apart. Moreover, part of the belt of intense folding is probably hidden under the weakly folded younger sediments, and the width at the surface of the different belts is, therefore, to some degree dependent upon the amount of crustal warping and erosion subsequent to the last orogeny.

Marked diastrophism appears to have affected the area at least twice since pre-Cambrian time. These episodes include (1) close folding at the end of the Silurian or, more likely, some time during the Devonian

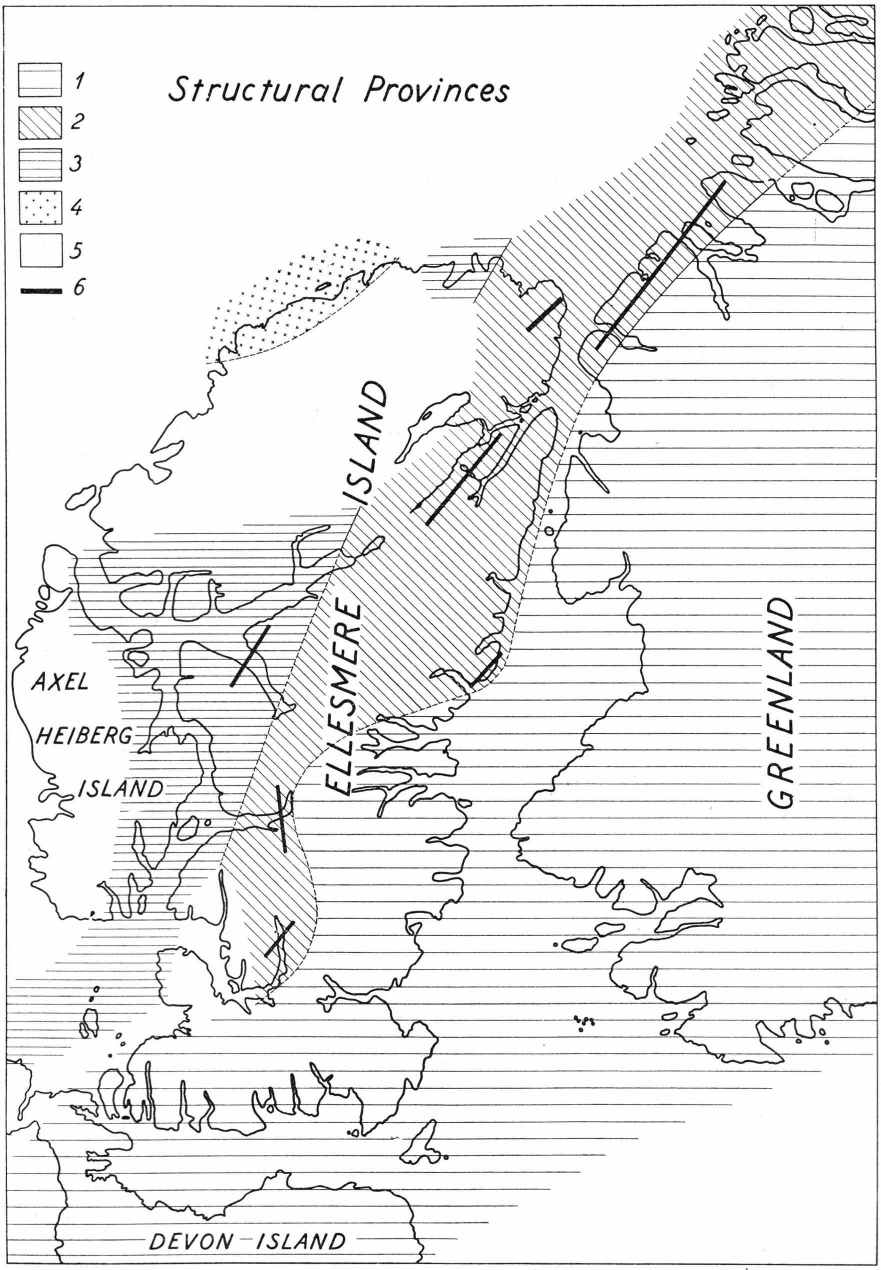

Fig. 2. Structural provinces of Northwest Greenland and adjoining islands. *1.* Pre-Cambrian basement partly covered by unfolded sediments of eo-Cambrian-Silurian (in Greenland) or eo-Cambrian-Devonian (in Ellesmere Island) age. *2.* Older folding (strongly folded sediments, probably ranging in age from eo-Cambrian to Devonian). *3.* Younger folding (slightly folded Pennsylvanian, Permian and Mesozoic sediments) *4.* Hypothetical borderland "Pearya". *5.* Unexplored. *6.* Main trend of the folding axes.

period (Caledonian-Acadian revolution), and (2) weak folding with local, small-scale overthrusting between the Early Jurassic (?) epoch and the time of the deposition of the Cretaceous or Cenozoic limnic beds. In the same interval, but after the folding, a number of apparently normal faults dissected the area. A few faults may be later than the deposition of the limnic beds.

Crustal warping accompanied by uplift of the regions of intense folding has undoubtedly occurred at least once in the history of the area.

Apart from pre-Cambrian events, intrusive activity was marked in (1) eo-Cambrian time and (2) in the interval between the deposition of the Mesozoic marine beds and the deposition of the limnic Eureka Sound group.

Historical Geology of Northwest Greenland and Ellesmere Island During Early Paleozoic Time.

On the following pages, the writer will attempt to give a brief outline of the geological history of the area as it is known at the present time.

While the stratigraphic sequence of the foreland is known in considerable detail, very little information is available concerning the belt of folding. Not only is the structure much simpler on the foreland than in the geosyncline proper, but while the coasts of Washington Land, Inglefield Land, Bache Peninsula and southern Ellesmere Island are relatively easily accessible by dog sledge or boat, the east coast of Ellesmere Island north of Bache Peninsula is ordinarily blocked by heavy drift ice in summer and by pressure ridges and hummocky ice in winter. The mountainous character of the folded geosyncline in connection with the shortness of the field season in those regions has also contributed toward making our knowledge of the geosyncline very unsatisfactory. Our conclusions regarding the orogenic episodes must, therefore, partly be drawn from circumstantial evidence from the stratigraphic sequence of the foreland.

Eo-Cambrian sediments are known from many areas in the western Arctic. Sediments of this age have been observed in all parts of the foreland of the Franklinian geosyncline from Peary Land in the east (Koch, 1929 a; Troelsen, 1949) to southern Ellesmere Island in the southwest (Bentham, 1941); and also from the East Greenland geosyncline (Koch, 1929 a), Baffin Land and the vicinity of Coronation Gulf (Teichert, 1937 b). The sediments rest on beveled pre-Cambrian rocks.

Within the map area, the eo-Cambrian sediments in most cases attain relatively inconsiderable thicknesses. On Inglefield Land and Bache Peninsula, the total thickness does not exceed 210 meters, and, as will be shown in the chapter on stratigraphy (p. 37), it is unlikely that erosion removed more than a few meters of sediment before the beginning of the Cambrian sedimentation. The lithology of the sediments suggests a progressive change in environment during sedimentation, the sequence starting at the bottom with an arkose and progressing through quartz sandstones to dolomites at the top. Cross-bedding of the sandstones and the occurrence of numerous diastems in the dolomites suggest shallow water during the deposition, while the change in lithology in the vertical direction indicates a decrease in the supply of detrital sediments. The direction of transportation has not been determined.

Southeast of Etah, a much greater variety of lithologic types exists, and the eo-Cambrian sediments attain greater thicknesses there than they do along the edges of the foreland. A short distance southeast of Neqe, the present writer thus measured a section through nearly 1000 meters of gently dipping sandstones and conglomerates without observing either the top or the bottom of the formation. In eo-Cambrian time the area between Etah and Thule may, therefore, have formed a region of local subsidence (cfr. KOCH, 1929 a, p. 271).

Around Smith Sound the eo-Cambrian sediments are shot through with sills and dikes of dolerite (CALLISEN, 1929; BUGGE, 1910; MUNCK, 1941). The relationship between the intrusives and the disconformity at the base of the Cambrian system has never been directly observed, but intrusives do not occur in the Cambrian strata and KOCH (1929 a; 1933) mentions the occurrence in the Lower Cambrian conglomerates of pebbles of diabase. It therefore seems reasonable to assume that the intrusions took place before the beginning of Cambrian time.

The base of the Cambrian system is, at least on the foreland, marked by an erosional disconformity, which probably indicates a rather short time interval (p. 37)[1]. The lowest Cambrian formations are typical shallow water deposits, such as sandstones, impure limestones, and conglomerates with pebbles of quartz and diabase. The conditions on Bache Peninsula and Inglefield Land suggest a progressive transgression coming from the west or northwest. The Police Post limestone in the former area belongs, though lithologically similar to the Wulff River formation in the latter, to a horizon that is slightly older than that of the Wulff River formation. Also, the latter formation contains pebbles of a fossiliferous sandstone which has at least

[1]) The Cambrian section on the south coast of Ellesmere Island has been examined by BENTHAM (1941), but no details have been published.

one species in common with the Police Post limestone (Poulsen, 1946). According to Poulsen (1927 & oral information), the fauna of the Wulff River formation indicates connections with the Atlantic coast province of North America, while that of the Police Post limestone is without known affinities.

Later in Early Cambrian time the sea withdrew from the foreland. The next submergence established connections with the Early Cambrian Cordilleran trough. During this submergence the Cape Kent limestone, a rather pure oolitic rock, was deposited on the foreland, indicating that the bordering lands were low and supplied but little detrital sediment to the sea.

The entire Lower Cambrian sequence is not more than 14–44 meters thick. It is topped by an erosional disconformity.

The succeeding Middle Cambrian deposits are generally calcareous sandstones and thin-bedded, more or less shaly limestones with some intraformational conglomerates of a combined thickness of 45–85 meters. The connection with the Cordilleran sea still existed (Poulsen, 1927).

Upper Cambrian strata are absent from Bache Peninsula and Inglefield Land. So far, no Cambrian formations have been discovered within the geosyncline proper.

In Early Canadian time the sea once more invaded the foreland. At least 400 meters of shaly limestone with numerous bands of edgewise conglomerates (Cass Fjord formation; Koch, 1929 b) were deposited in the course of a period of oscillatory subsidence during which the sea remained shallow. The lands to the southeast were evidently low and supplied no coarse detrital material to the epicontinental sea. About the condition within the geosyncline at this time we know nothing.

The Cass Fjord formation is preserved over large areas in Washington Land, Inglefield Land and Bache Peninsula. It seems to be absent in Peary Land (Troelsen, 1949) but reappears in Northeast Greenland (Poulsen, 1937). Schei's description of the sections in southern Ellesmere Island (Holtedahl, 1914) gives no definite information as to the presence or absence of the Cass Fjord formation in that area. Canadian strata may, however, be present in the 400—500 meters of limestone conglomerates in the lower part of Schei's Series A.

During the rest of Canadian time, the foreland was several times covered by shallow seas. In the section on Washington Land (fig. 6), which is comparatively well known, the strata are composed of more or less pure, thick-bedded limestones, alternating with shaly limestones and shales with intraformational conglomerates, totalling at least 250 meters. Though several erosional unconformities exist in the section, there are no signs of major uplifts from which detritus was spread over the foreland.

Throughout Canadian time, the seas of North Greenland and Ellesmere Island must have had connections with eastern North America and the Missouri-Arkansas region. The Cass Fjord formation also shows affinities to contemporaneous deposits in northwestern Europe and British Columbia (Poulsen, 1927 & 1937).

The Upper Canadian Nunatami formation passes without any major break in sedimentation into the overlying Cape Webster formation, a succession of 290 meters of interbedded shales, mudstones and flaggy limestones of doubtful Chazyan age. The environment must have been about the same as that which obtained during the deposition of the Cass Fjord formation.

Above a distinct erosional disconformity follows on Washington Land the Gonioceras Bay limestone, a sequence of some 100 meters of pure, massive limestone upwards grading into more flaggy limestone. The age of the strata appears to be Black River and/or Trenton. The overlying thin-bedded or massive Cape Calhoun limestone may be of Richmondian age, a hiatus probably separating it from the underlying strata. The two formations are known from North Greenland, the coast south of Scoresby Bay and the head of Bay Fjord. Massive limestone of supposed Trenton age is known from the unfolded sequence in southern Ellesmere Island (Holtedahl, 1914).

Within the belt of folding, a pure limestone of Middle or Late Ordovician age has been observed at the entrance to Archer Fjord (Cape Baird limestone, p. 59), and black shaly limestone of comparable age occurs at Bay Fjord (Thorup Fjord limestone, p. 59).

The faunas of the post-Canadian Ordovician formation in the map area show affinities to those of northern Canada (Teichert, 1937 a & b).

While the Cambrian and Ordovician periods were relatively quiet, the Silurian period was marked by the first signs of the diastrophism that seems to have culminated in Devonian time. The most nearly complete record of the history of the Silurian period may be found in North Greenland (Koch, 1929 a), while the sequence in southern Ellesmere Island appears to be interrupted by hiati of long duration.

At the bottom of the Silurian system, separated from the Ordovician beds by a simple disconformity, one finds in North Greenland a conglomerate with pebbles of Ordovician limestone, eo-Cambrian sandstone and pre-Cambrian gneiss (Koch, 1929 a, p. 237). The conglomerate passes upwards into limestone and shale of a maximum thickness of 200 meters (Cape Schuchert formation)[1]). The fauna, which is of Late Llandovery (Late Birkhill, Late Clinton) age, is "an Arctic fauna of

[1]) In 1925 (p. 281), Koch stated that "the final beds are sandstones, which become coarser toward the top". In 1929 (a, p. 237), however, no mention is made by Koch of any arenaceous beds. The present writer has not examined the formation.

hitherto unknown character" (Koch, 1929 a; Poulsen, 1934), though the graptolites are also known from northwestern Europe.

Above the Cape Schuchert formation follows in North Greenland the Offley Island formation, a sequence of arenaceous shale and limestone overlain by massive limestone of a total thickness of 500—800 meters[1]). The bottom layers are developed as conglomerates with large pebbles of limestone, signifying a period of intense erosion (Koch, 1925). The Offley Island formation, which Poulsen (1934) correlates with the Upper Birkhill (Upper Clinton), contains a fauna "typical of the Arctic Lower Silurian". It is distributed over a large part of the Greenland section of the foreland and also occurs at Scoresby Bay (Teichert, *vide* Kindle, 1939). Strata of the same age may be present in southern Ellesmere Island (Holtedahl, 1914, p. 6) and are known to occur in the East Greenland geosyncline (Nielsen, 1941, p. 25).

At the close of Late Birkhill time, an uplift with accompanying vigorous erosion affected the North Greenland portion of the foreland. According to Poulsen (1934), the uplift must have been of relatively short duration. It is unknown whether the movement included southern Ellesmere Island, but in Northeast Greenland the Offley Island formation is overlain by a coarse conglomerate (Nielsen, 1941, p. 24) that may mark a disturbance contemporaneous with the Late Birkhill uplift in North Greenland.

In the period following the uplift, some near-by land mass must have been supplying detrital sediments to the seas, while the North Greenland portion of the foreland was subsiding. The Cape Tyson formation, which in places was deposited in valleys, several hundred meters deep, in the underlying Offley Island formation, is locally developed as a very coarse conglomerate with limestone boulders, while elsewhere the strata consist of interbedded limestone and graptolite shale. In several places the formation becomes increasingly arenaceous toward the top: "in reality all transition forms to the overlying sandstone are represented . . .", but "along the north coast the upper part of the formation appears to have been developed as pure limestone at least 500 meters thick" (Koch, 1929 a, p. 240).

According to Koch, the formation may be traced across North Greenland. If the upper, massive limestone of supposed Niagaran age of Schei's Series A should turn out to be the equivalent of the Offley Island formation, the Cape Tyson formation and the Polaris Harbour sandstone of North Greenland may correspond to an hiatus in the section in southern Ellesmere Island. The Cape Tyson formation

[1]) This is how Koch described the formation in 1929 (a, p. 238). In 1925 (p. 281), Koch mentioned the occurrence in the formation of coarse sandstone. He added that "the upper portion of the [Offley Island formation] is very sandy . . .".

may, however, be represented among the folded strata at Bay Fjord (p. 61).

Like the other Silurian faunas of the region, that of the Cape Tyson formation is of an Arctic type with slight affinities to American faunas. The shales contain graptolites that are referable to English-Scandinavian species (POULSEN, 1934; KOCH, 1929 a, p. 241), and which indicate a Tarannon-Wenlock-Earliest Ludlow age of the formation.

In North Greenland, the Cape Tyson formation is overlain, possibly without a break, by the Polaris Harbour sandstone, which KOCH (1929 a) describes as a coarse, loose, partly micaceous sandstone with occasional bands of shale. The minimum thickness is stated to be 500 meters. The age of this interesting formation is somewhat uncertain. KOCH (ibid.) refers to the discovery of "an erratic boulder, containing doubtful Ludlow fossils, [which] possibly originates from this formation" and to the fact that "an increasing number of sandstone bands occur even in the graptolite shales of [the underlying Cape Tyson formation]", but the only conclusion he draws as to the age of the sandstone is "that there is no evidence of a Devonian age".

The Polaris Harbour sandstone is the youngest known pre-Pleistocene formation in Northwest Greenland. In Ellesmere Island Silurian strata occur that may be slightly younger than, or contemporaneous with, the Polaris Harbour sandstone. SCHEI's Series B, a sequence of some 300 meters of gently dipping black shales and dark, pure limestones occurring in the southern part of the island, must, according to HOLTEDAHL (1914), be correlated with the uppermost Silurian (Keyser group; uppermost Ludlow and Downtonian).

In the interior of Scoresby Bay, a crinoidal limestone is exposed that TEICHERT (*vide* KINDLE, 1939, pp. 185—186) suggests may be related to Series B. The detrital sediments that were spread over North Greenland in Late Silurian time may not have reached as far south as Scoresby Bay, or erosion may have been brought to a standstill before the deposition of the crinoidal limestone of Scoresby Bay and the limestone and shale of southern Ellesmere Island.

Thick deposits of Devonian age are known from southern Ellesmere Island, while none seems to occur in North Greenland.

The oldest Devonian deposit is Series C. According to SCHEI (1903, 1904), Series B is overlain by some 300 meters of unfossiliferous arenaceous shale, upwards grading into quartz sandstone and argillaceous sandstone, which must belong to the Lower Helderberg or at least to some stage of the Lower Devonian (p. 62). The source of the detritus is not known with certainty. It seems a reasonable assumption, however, that a diastrophism caused an uplift of the borderland or maybe even of the northeastern portion of the geosyncline itself, from where detrital sediments were carried to the subsiding southwestern part of the geosyncline and the adjoining foreland.

After the deposition of Series C, a period of relatively quiet conditions obtained, during which the still subsiding southwestern part of the geosyncline received some 400 meters of marine shales and limestones (lower part of Schei's Series D). Upwards, the calcareous and argillaceous sediments grade into a sequence of partly limnic sandstone, at least 700—800 meters thick (upper part of Series D and Series E). Lower Devonian marine strata, which Holtedahl (1914, p. 45) correlates with the lower part of Series D, may occur on the west coast of Kennedy Channel (p. 62). The age of Series D and E has been variously given as Middle Helderberg to Chemung; Helderberg to Hamilton-Late Devonian; and Middle to Late Devonian (p. 62).

Sandstone of doubtful Devonian age (Series E?) occurs at Bay Fjord and Trold Fjord. Part of the Cape Rawson beds (p. 63) may have been formed at the same time as Series E.

The Devonian faunas of Ellesmere Island show affinities to those of eastern North America.

To sum up, we have a record of repeated uplifts and subsidences of the North Greenland portion of the foreland in Silurian time, accompanied by a gradual spread of detritus from some land mass that was rising in the vicinity. In southern Ellesmere Island we have, from the same period, a sequence of marine calcareous and argillaceous sediments, possibly interrupted by long breaks in sedimentation. In the latter area, marine sedimentation continued till the end of Silurian time, a branch of the sea reaching as far north as Scoresby Bay, while North Greenland at that time may have been dry land.

An influx of detrital sediments in southern Ellesmere Island in the beginning of the Devonian period must signify the rejuvenation of the streams flowing from a land that may have been located in northern Ellesmere Island and/or north of Greenland.

After the end of this phase, the steadily subsiding southern part of Ellesmere Island was again covered with calcareous and argillaceous marine sediments, possibly as far north as the region of Kennedy Channel. In Middle Devonian time, however, coarse detrital material once more appeared among the deposits laid down in southern Ellesmere Island, the sedimentation continuing into Late Devonian time, and this time the sea was apparently crowded out of the geosyncline by the flow of coarse material.

The Paleozoic Folding.

The crustal movements, recorded in the disconformities and the deposition of detrital sediments, must represent various phases of the diastrophism that affected the Franklinian geosyncline in Early Paleozoic time.

The belt of folding includes the north coast of Greenland (fig. 2), and northeastern, central and south-central Ellesmere Island. How far the folding may be traced northwestward under the wedge of Upper Paleozoic and Mesozoic beds that occupies western Ellesmere Island and Axel Heiberg Island, is not known. The metamorphic rock on the north coast of Grant Land may as well belong to the belt of folding as to a borderland (p. 28).

The boundaries of the belt of folding cannot be accurately defined. In North Greenland, the course of the boundary against the foreland is a fairly straight line, running approximately northeast-southwest (Koch, 1920, 1925, 1928, a. o.). It then goes southwest through Kennedy Channel and reaches the coast of Grinnell Land somewhere south of Scoresby Bay. From here on, the boundary describes a large S-shaped figure, touching the head of Bay Fjord and turning around the mouth of Vendom Fjord.

The boundary against the sediments that are younger than the folding has been observed on Feilden Peninsula on the north coast of Grant Land (Feilden and de Rance, 1878) and at the head of Greely Fjord. Its further course is not known with certainty. It must cross Bay Fjord somewhere west of Thorup Fjord, but whether it goes east or west of Trold Fjord is still a problem. Schei (*vide* Bugge, 1910, pp. 24—25) found folded sediments at Trold Fjord, but as the age of these strata is variously given as Devonian and as Carboniferous (p. 62), the strata may as well have been folded during the younger orogeny as during the one that is under discussion in these paragraphs.

There is no conclusive evidence as to whether the southern part of the belt of folding turns west and continues under the Permian of Great Bear Cape, or whether the folding dies out southwest of Vendom Fjord. In view of the fact that the rather thick Silurian and Devonian strata in the southern part of the island are unfolded, the latter possibility seems the more probable. Bentham (1941, pp. 38—39), however, is more inclined to think that the folding continues under Great Bear Cape.

Erosion has gone deepest along the Greenland coast, where, according to Koch (1920), gneiss is exposed in the cores of some of the anticlines, while the strata nearer the original surface are said to consist of "more or less metamorphosed sandstone". Metamorphic rocks have not been observed in the folds of Ellesmere Island (still with the possible exception of the north coast of Grant Land), either because erosion has not gone very deep in this part of the area, or because the folding has been less intensive here.

Normal folding seems to be the predominant structural feature, while no overthrusting of any importance has been observed.

Intrusive rocks penetrate the folded rocks in the northeastern part of the geosyncline (KOCH, 1920, p. 74) but have not been observed in the central and southwestern sections.

As to the direction of movement during the deformation but little evidence is at hand. Some of the sections from North Greenland (KOCH, 1920, pl. 1) show features that suggest small-scale overthrusting and folding coming from the northwest, but in Ellesmere Island very few cross-sections of folds have been observed, none of them giving any reliable information as to the direction of dip of the axial planes of the folds. SCHUCHERT (1923, p. 193) quotes a statement by W. ELMER EKBLAW according to which folding and overthrusting in the United States Mountains[1]) is away from the Arctic Ocean and toward southeast. EKBLAW has, however, informed the present writer that his observations were made in regions which lie within the zone of the Mesozoic folding.

The trend of the folding axes is known in several places (fig. 2). In North Greenland, the trend of the folds is about east-northeast (KOCH, 1920, pl. 1). In northern Ellesmere Island, the present writer observed a trend parallel to Archer Fjord and Dodge River, the latter flowing in an anticlinal valley over a large portion of its course. FEILDEN and DE RANCE (1878) made similar observations north of Lady Franklin Bay. North of Bay Fjord, folded strata have been dissected by erosion into hogbacks running approximately north-south. THORLAKSSON's notes on the folded Ordovician and Silurian beds on the south coast of the fjord confirm this observation. South of Scoresby Bay, BENTHAM (1936, p. 431) noted a fold whose axis runs parallel to the coast, i. e., about northeast-southwest. Finally, the Silurian sediments around the head of Vendom Fjord have been thrown into folds trending northeast-southwest (BENTHAM, 1941).

As to the age of the diastrophism, several different opinions have been set forth. FEILDEN and DE RANCE (1878), in their section from Feilden Peninsula, show folded Cape Rawson beds unconformably overlain and beveled by what they took to be Devonian strata. In the accompanying text, however, they expressly state that "whether the boundary is a natural or a faulted one is doubtful; but the latter is the more probable . . .". PER SCHEI (*vide* HOLTEDAHL, 1917, p. 19) discovered

[1]) When SCHUCHERT uses the name United States Mountains, he refers to the whole system of montain ranges in North Greenland and Grant Land.

folded Triassic strata in southwestern Grant Land and, rising the question of whether the Cape Rawson beds (p. 63) might not be identical with the Mesozoic shales and sandstones in western Ellesmere Island, set forth the hypothesis that the folding axes in southwestern Grant Land may be the continuation of those that FEILDEN and DE RANCE observed in northeastern Grant Land. HOLTEDAHL (1924, p. 133) says about the Lower Devonian Series C that "it can scarcely be doubted that the occurrence of this sandstone indicates diastrophic movements in an area not too far away".

LAUGE KOCH has repeatedly commented on the age of the folding in North Greenland. In 1920 (pp. 71—74), he drew the conclusion that the folding happened in the "Devonian, presumably the first half of this period, perhaps beginning in the uppermost Silurian". In 1929 (a, pp. 280—285), he stated that the folding is of Caledonian age, as the folded strata include Silurian deposits and are overlain (in northern Grant Land) by Devonian and Carboniferous beds. Later on (1935, p. 619), KOCH realized that FEILDEN and DE RANCE's Dana Bay beds are not of Devonian but rather of Early Permian age. His views as to the age of the diastrophism are now expressed in the following words (ibid.): "In North Greenland there have been slight (in lowermost Ordovician) and strong (in lowermost Gotlandian) epeirogenic movements. The folding proper is younger than Wenlock and older than Schwagerina [Early Permian]". In the same paper, KOCH gives a map on which the belt of folding, described above, and another belt in northwestern Grant Land are shown with a convention that signifies "folded sediments, mostly Gotlandian [Silurian]".

SCHUCHERT (1923, pp. 193—194) does not accept KOCH's interpretion of the folding but thinks that "since at least the Pennsylvanian strata are involved in the folding, it is clear that the origin of these ranges can not be older than late Pennsylvanian time. On the other hand, the Triassic strata appear to be unfolded . . .". FREBOLD (1934) doubts the validity of the evidence for a Caledonian age of the orogeny and states that the folding may possibly be of Variscan or even younger age. BENTHAM (1941, pp. 38—39), on the basis of evidence from the southern part of Ellesmere Island, states that the folding is "definitely post-Silurian" and "since [the Devonian strata on the south coast] are comparatively undisturbed it is probable that the folding is pre-Devonian. This evidence is not . . . conclusive since it is possible that the folding does not cross Baumann Fjord".

Direct evidence as to the age of the folding is scarce. Folded Silurian beds were observed by KOCH (1929 a, p. 280) in Halls Land. Highly disturbed Ordovician and Silurian beds (including some of very late Silurian age) are known from the region of Scoresby Bay (TEICHERT, *vide* KINDLE, 1939). Folded Silurian deposits were discovered by BENTHAM (1941) at Vendom Fjord and by THORLAKSSON on the south coast of Bay Fjord. The present writer found folded Ordovician limestone at the entrance to Archer Fjord (p. 59). It further appears possible that the Lower Devonian marine strata in the region of Kennedy Channel (HAYES, 1867) have taken part in the folding as HAYES seems to have found his fossils near sea level in a region of very high folding mountains that must have undergone an uplift in comparatively recent time.

On the other hand, the folding probably took place before the deposition of the Middle Pennsylvanian and Permian beds. The contrast between the intensely folded Cape Rawson beds and the but slightly disturbed Upper Paleozoic strata is so great and the exposures of the two groups of sediments are found so close together that this conclusion seems permissible even if large scale overthrusting took place during the younger orogeny. As will be shown later, there is no evidence that the younger folding was accompanied by overthrusting of any importance.

By comparing the direct arguments for a post-Late Silurian but pre-Pennsylvanian age of the main phase of the folding with the circumstantial evidence derived from the history of sedimentation within the unfolded sections of the area, the writer arrives at the conclusion that the diastrophism began early in Silurian time, continued with several interruptions through the rest of the Silurian period, became marked toward the end of this period, and, after an interruption in Early Devonian time, probably reached its final expression during the Middle or Late Devonian epochs[1]).

The Borderland "Pearya".

The presence of detrital sediments in the Silurian and Devonian systems of the map area indicates the presence near the geosyncline of a land of considerable mobility. The compression of the geosyncline in Silurian-Devonian time points in the same direction. This, in connection with what is known about the Appalachian and Cordilleran geosynclines, led SCHUCHERT (1923 and 1939) to assume the presence of a borderland northwest of the Franklinian geosyncline. He states (1923, p. 193) that "northern Ellesmereland (Grant Land) and Peary Land are margined by Archean rocks, and they are to be interpreted

[1]) A preliminary report (TROELSEN, 1940), published during the writer's absence from Denmark, contains the erroneous statement that the only diastrophism recorded in Ellesmere Island took place between Mesozoic (Late Triassic?) and Cenozoic time.

as remnants of the borderland that furnished most of the detritals for the Franklinian geosyncline. This old land may be known as Pearya ..."

Though there can be little doubt that such a borderland must have existed in Early Paleozoic time, it is not certain that Archean rocks are exposed in the northern parts of the map area. The "Archean rocks" in the north of Peary Land are most probably gneisses and intrusive rocks belonging to the core of the folding mountains (Koch, 1920; 1929 a, p. 280), and the "mica schists and altered rocks" (Feilden and de Rance, 1878, pl. 24) from the north coast of Grant Land may possibly belong to the folded geosynclinal sequence. It is, therefore, only with much reservation that the present writer has marked a borderland in the latter area (fig. 2).

Historical Geology of Ellesmere Island and Axel Heiberg Island During Late Paleozoic Time.

In Middle Pennsylvanian (Des Moines) time, the sea once more invaded the site of the Franklinian geosyncline, submerging at least the region around Canyon Fjord. That a portion of the folded mountain system, which by now presumably was wholly or partly peneplaned, was inundated during the transgression seems reasonable but cannot be proved; neither is it possible to outline the seaway.

At Canyon Fjord at least 158 meters of impure limestone, sandstone and coquina were deposited in Des Moines time. The fauna is mainly composed of brachiopods, corals, and fusulines. Above the deposits of known Des Moines age follow cross-bedded sandstones and conglomerates with fragments of limestone from the underlying formation and of sandstone, chert and quartzite. The deposition of these detrital sediments must signify crustal movements, but not much can be deduced as to their age, except that they must be younger than the Middle Pennsylvanian Canyon Fjord formation and older than the younger (Mesozoic or Cenozoic) orogeny.

So far, no Upper Pennsylvanian deposits have been discovered within the map area. Possibly we have similar conditions in Ellesmere Island as in Holms Land and Amdrups Land in Northeast Greenland where a hiatus separates the deposits of the Des Moines from those of the Wolfcamp (Sakmarian) (unpublished report).

In Early Permian time, large portions of Axel Heiberg Island and Ellesmere Island must have been covered by the sea. Exposures of Lower Permian (Wolfcamp) or closely related beds are now found along a line running from Feilden Peninsula to Great Bear Cape and are also known from northern Axel Heiberg Island. How far east the sea spread over the site of the geosyncline cannot now be determined, but subsequent warping and erosion has probably caused the removal of considerable amounts of Permian rocks from central Ellesmere Island. Deposits of comparable age are known to exist in other parts of Artic Canada and in Northeast Greenland.

The Early Permian seaway must have been shallow and exposed to frequent changes in outline. The deposits are mostly impure limestones, alternating with shales; biostroms with brachiopods and bryozoans; cross-bedded sandstones; and conglomerates with fragments of chert, limestone, and sandstone. The faunas show considerable similarity to those of the Lower Permian beds of other parts of the Arctic and of Russia.

At Greely Fjord, the total thickness of the Permian sequence is about 700 meters, which indicates a progressive downwarping of the basin of deposition.

In northern Axel Heiberg Island, the Permian limestones are interbedded with lava sheets and volcanic tuffs (Bugge, 1910, p. 35—37).

Historical Geology of Northwest Greenland, Ellesmere Island, and Axel Heiberg Island During Early Mesozoic Time.

The contact between the Lower Permian and the Mesozoic deposits has only been observed at Canyon Fjord and around the eastern part of Greely Fjord, where Lower Jurassic (?) sandstones rest without measurable difference in dip upon the shaly sandstone of the Greely Fjord group. The field evidence thus points toward epeirogenic movements at the end of the Paleozoic or the beginning of the Mesozoic era, but no signs have been found so far of Appalachian orogeny within the map area (cfr. Schuchert, 1923, p. 193; this report p. 27).

Sediments of proved or assumed Mesozoic age occur over wide areas in western Ellesmere Island, Axel Heiberg Island, and the islands farther west. The deposits mostly consist of interbedded shale and sandstone with layers of impure marine limestone. A coal bed on the west coast of Raanes Peninsula may also be of Mesozoic age. In a number of places on both sides of Eureka Sound, Schei and Thorlaksson have collected marine fossils, mostly pelecypods, which Kittl (1907, pp. 42—44) compares with late Middle and early Late Triassic (Ladinian-Karnian) faunas of Bear Island, Spitzbergen, Germany and the Alps.

Also younger marine deposits may be present in the Mesozoic system of the map area. At Canyon Fjord and Greely Fjord the Lower Permian beds are overlain by sandstone, shale and coquina (Cape With formation), which may be of Karnian but more probably of Early Jurassic (Sinemurian) age. In Jurassic time the sea may have reached farther east than it did during the Triassic submergence, or an uplift with partial destruction of the Triassic beds may have preceded the Jurassic marine transgression.

As mentioned above, the Mesozoic sediments contain a large proportion of rather coarse detrital material. The source of this material is unknown, neither is anything known about the uplift that must have preceded or accompanied the deposition of the sand and shale. The uplift may have been the forerunner of the Mesozoic or Cenozoic (younger) orogeny.

The Mesozoic or Cenozoic Orogeny.

Schei (1903, a & b; 1904) observed that the deformation which has affected the region around Eureka Sound, must be younger than the Mesozoic (Triassic) strata but older than the limnic beds, which he referred to the Miocene. It is now known that also beds of probably Early Jurassic age were disturbed during the diastrophism, while, on the other hand, the limnic beds need not belong to the Miocene but may as well be of Early Cenozoic or even Cretaceous age (p. 79). Schei's determination of the age of the disturbance is not materially affected by this new evidence. All that can be said about the time of the orogeny is still that the disturbance must have happened during the Jurassic, Cretaceous or Cenozoic period.

The diastrophism caused gentle folding and small-scale overthrusting in the Upper Paleozoic and Mesozoic strata of the map area (fig. 10). How the Lower Paleozoic beds responded to the orogenic stresses cannot easily be determined as the younger diastrophism took place along almost the same lines as the older one.

Along the north coast of Greely Fjord and in Canyon Fjord it may be seen how the thrust planes and the axial planes of the folds dip toward the northwest. An overthrust with the same dip of the fault plane seems to occur on the south coast of Greely Fjord (fig. 11). The existence of a prominent monoclinal ridge with northwestward dipping beds, which in a northeasterly direction cuts across Canyon Fjord and the country south of Greely Fjord, further strengthens the impression of a movement from the northwest during the deformation.

The amount of displacement along the thrust planes has apparently been small, at the most a hundred meters or so. An especially incompetent layer of the Permian Greely Fjord group (p. 69) has been thrown into broad, gentle folds independently of the enclosing, more rigid strata, while the individual laminae of the incompetent layer have been intensely crumpled (fig. 12). One would expect to find a thrust plane in this layer, had major overthrusting taken place during the deformation. In the apparent absence of such a thrust plane, one is inclined to draw the conclusion that the orogeny has caused a rather weak deformation without any major horizontal displacements.

The United States Mountains on the northwestern side of Lake Hazen may form an exception to this rule. Feilden and de Rance (1878, p. 560) assumed that the mountains were composed of "Carboniferous" (probably Lower Permian) limestone, an assumption that gains support through our present knowledge of the distribution of the Permian beds, and it is, therefore, conceivable that the orogeny that affected the region northwest of Lake Hazen is identical with the one whose effects may be seen father to the southwest[1]). According to an oral communication from W. Elmer Ekblaw, the range consists of intensely disturbed sediments, which indicates that deformation has been much more thorough in this area than in the region around Greely Fjord and Canyon Fjord.

The Mesozoic and Permian beds are penetrated by sills and dikes of various kinds of basic rocks (p. 80). Already Schei noticed that the intrusive activity was concentrated around Eureka Sound. Toward the east, the dikes disappear from the sections and only sills penetrate the strata. In the central parts of Greely Fjord and Canyon Fjord, the easternmost sills may be seen in the coast cliffs. Whether the intrusive activity occurred before, during or after the deformation cannot easily be determined. It is conceivable, however, that the intrusions have some genetic connection with the diastrophism.

Faulting in Mesozoic or Cenozoic Time.

Several parts of the map area have been dissected by faulting. Bentham (1936) describes northeastward-trending faults on Bache Peninsula, and in another paper (1941) he mentions the occurrence around Makinson Inlet in southeastern Ellesmere Island of two fault systems striking northeast and northwest, respectively, the latter being the more prominent. He also thinks that a north-south line of weakness

[1]) Suess (1902, Vol. 3) referred the range to his édifice asiatique, while Kober (1928) assumed that the folding belonged to the Alpine orogeny. Koch, on the other hand, does not exclude the possibility that the range might belong to the belt of Caledonian folding (1929 a, p. 284; 1935, fig. 4). It should be stressed, however, that no substantial evidence has been found that would indicate the age of the disturbance that affected the United States Mountains.

is developed in the southwestern part of the island as indicated by the trend of the fjords. BENTHAM suggests a post-Miocene age of the northwesterly faulting since coal measures that he assumes to be of Miocene age are cut by a fault striking northwest-southeast. Though the age of the coal-bearing beds must be said to be uncertain (p. 79), BENTHAM's observation is interesting as it is the only known example of faulting that is later than the deposition of the beds, mentioned above. As for the other faults described by BENTHAM, the only thing we know with certainty is that they must be younger than the Lower Paleozoic beds which they cut. It seems natural, however, to group them with the faults described below.

Around Eureka Sound and Greely Fjord a great many faults occur, some of which may have been formed during the younger orogeny, while others definitely are younger than the folding (fig. 10). North-south trending faults were observed by the writer on the eastern shore of Eureka Sound, and the outline of the sound suggests that it was formed along such faults. A north-south and an east-northeasterly line of weakness are indicated by the trend of Greely Fjord and its northern tributaries (fig. 2 and pl. 1).

In Greenland, not a single fault has been observed between Etah and southern Halls Land, the only secondary structures in this area being jointing and very small variations in the dip of the strata. Southeast of Etah, the thick sequence of sediments of the Thule group has been cut by a great number of faults, the most important of which trend northwest-southeast, changing to north-south in the southern part of the Thule district[1]). KOCH (1926) stated with much reservation that the faulting might be of Cenozoic age, while later (1929 a, p. 285) he was more inclined to ascribe a Cretaceous age to the faulting. Though this theory may be correct, there is no direct evidence to prove it. Neither is it known which of the fault systems in Ellesmere Island, should there be more than one, that corresponds to the one in the Thule district.

Development of Northwest Greenland and Ellesmere Island after the Main Phase of Faulting.

Fairly late in the history of the map area, presumably after most of the faults had been formed, the area went through a period of prolonged erosion. Monadnocks may have been left in the regions which today are the most mountainous, but at least the greater part of western Ellesmere Island and of North Greenland must have been reduced to

[1]) The stretch of coast between Etah and the Melville Bugt.

a fairly smooth plain. The picture is somewhat complicated by the fact that more than one pre-glacial erosion surface exist within the map area (p. 13 and 15), but the general impression of a widespread peneplanation is not disturbed by this circumstance.

Later, an uplift happened and the plain was dissected by valleys that in the main correspond to the present fjord system. This is particularly obvious in western Ellesmere Island and around Lady Franklin Bay where remnants of the coal-bearing sequence are found here and there on the slopes that border the valleys and fjords. It is suggested that western Ellesmere Island was drained by two river systems, one debouching north of Axel Heiberg Island and the other, south of the island, Eureka Sound having been opened later on.

The next event must have been a raising of the baselevel of erosion and the filling of the valleys with deposits of sand, shale and lignite, presumably of limnic origin and aggregating several hundred meters (Eureka Sound group). This deposition must have happened in Cretaceous or Cenozoic time (p. 79).

After the valleys had been filled with sediments, baselevel of erosion was lowered again and the greater part of the loose deposits was swept out of the valley system. At the present time, only a few remnants of the coal-bearing sequence are preserved in protected places in the fjord system.

The mountainous regions of Ellesmere Island and North Greenland have undoubtedly undergone secondary uplift and warping. The Victoria and Albert Mountains on the west coast of Kennedy Channel, for example, which seem to have been the site of a Devonian diastrophism, are now around 2000 meters high. It is almost inconceivable that the range should have preserved this height through some 280 million years unless erosion has been counterbalanced by uplift or warping.

In the Victoria and Albert Mountains, no signs of a concordant summit level have been seen, but remnants of a plateau, which presumably has been arched and uplifted, are said to occur in the North Greenland range (Koch, 1920, p. 68). At the present time, we have no way of knowing at what time the arching and uplift took place or whether more than one uplift has affected the ranges.

The last geological event within the map area, the Pleistocene glaciation and the following develeling, has been treated elsewhere in this report (pp. 13—16).

Stratigraphy.

Pre-Cambrian Rocks.

Within the map area, pre-Cambrian rocks are exposed in Inglefield Land and in many localities southeast of Etah. Further, in southeastern Ellesmere Island from Bache Peninsula to the north coast of Jones Sound. Descriptions of these rocks have been given by BUGGE (1910), KOCH (1920, 1929 a, 1933) and BENTHAM (1936, 1941). The present writer wishes to add that gneisses are exposed in the eastern part of Sverdrup Valley[1]), at an altitude of about 100 meters above sea level, where the pre-Cambrian rocks are overlain by sandstone of the Thule group.

Eo-Cambrian Sediments.

Thule Group.

The group was first defined by KOCH, who describes it in the following words (1929 a, p. 220):

"Mainly coarse red sandstone and dolomite without lime. The formation is most clearly defined within the Cape York district. It begins, at the base, with coarse arkose, passing upward into purple sandstone, succeeded by red yellowish sandstone with several ripplemarks. These beds are overlain by cliff-forming dolomite, and this again by dark-grey, micaceous, hard sandstone or, locally, black shales with many ripple-marks. The lower purple sandstone, containing Cryptozoon reefs, appears again on Inglefield Land. Above come yellow, cross-bedded sandstone and fine conglomerates, overlain by yellow dolomite, locally containing Cryptozoon and chert . . .".

Further details have been published by SCHEI (1903, 1904), HOLTEDAHL (1913, 1917), BENTHAM (1936, 1941), MUNCK (1941) and KOCH (1920, 1925, 1926, 1933, o. a.).

The purple and the yellow sandstones, whose mutual contact is not well defined, occur within the map area along the north coast of Inglefield Land and the south coast of Bache Peninsula. For this portion of the Thule group, the name Rensselaer Bay sandstone is here proposed. The overlying yellow fine-grained dolomite, which is of equally universal distribution in Inglefield Land and along the south coast of Bache Peninsula, is here called the Cape Leiper dolomite.

The youngest part of the Thule group is of particularly great interest. In all localities where the Thule group is overlain by Cambrian strata, the yellowish-gray Cape Leiper dolomite, which has hitherto been considered the youngest formation of the group, is separated from the Lower Cambrian limestone by a layer of crystalline dolomite, which

[1]) This name was proposed by MACMILLAN (1918) for the valley that connects the head of Flagler Fjord with the head of Bay Fjord.

is here called the Cape Ingersoll dolomite (identical with the "Ophiomorph limestone" of TROELSEN, 1940). This bed seems to have passed unnoticed until 1939, although a study of the upper contact of the eo-Cambrian deposits furnishes information of some importance.

The Cape Ingersoll dolomite is a medium-grained hard gray rock, which weathers to a rusty red, while the underlying Cape Leiper dolomite is gray or yellow in all stages of weathering. In most places, the Cape Ingersoll dolomite contains small fillings of white crystalline dolomite, which form conspicuous branching figures on the weathered surface. The lower boundary of the dolomite is always perfectly sharp and well defined. The upper surface of the underlying Cape Leiper dolomite shows no trace of erosion, but one gets the impression that the uppermost layer was indurated or dried out before the deposition of the Cape Ingersoll dolomite. It is quite evident, however, that the upper surface of the Cape Ingersoll dolomite was subject to a certain amount of erosion before the beginning of the Cambrian transgression.

KOCH's observations (1933, p. 23) have thus been confirmed. On the other hand, KOCH's and the present writer's views are definitely at variance with those of WORDIE (1938, p. 399), who states about the section on the south coast of Bache Peninsula: "[the dolomites of the Thule group] are then succeeded without apparent break by limestone in which Drever without much difficulty found Cambrian trilobites in place".

In several places, as for instance at Blomsterbækken, in a ravine west of the mouth of Minturn Elv, and at Locality II at Marshall Bugt, the upper part of the Cape Ingersoll dolomite is strongly brecciated. In some cases, the original matrix in the breccia has been dissolved and replaced by a white crystalline cavernous dolomite. The brecciation is particularly conspicuous along the south coast of Bache Peninsula, where some of the fragments attain diameters of about 50 centimeters. The fragments show no signs of having been transported over any appreciable distance. That tectonic movements have not played a part in the formation of the breccia is clearly demonstrated by the undisturbed condition of the enclosing strata.

The Cape Ingersoll dolomite is present at all localities where the lower contact of the Cambrian system has been observed. It occurs at the following altitudes above the sea:

Kap Leiper, 150—160 meters,
Kap Taney, about 30 meters,
a ravine west of the mouth of Minturn Elv, 160—170 meters,
Locality I at Marshall Bugt, 185—195 meters,
Locality II at Marshall Bugt, 250—260 meters,
Blomsterbækken, 46—50 meters,

a ravine between Cape Camperdown and Cape Albert on Bache Peninsula, about 200 meters,
the ravine behind the Royal Canadian Mounted Police Post on Bache Peninsula, 195—205 meters.

It is a remarkable fact that although the thickness of the formation nowhere seems to exceed 10 meters, the erosion that preceded the Early Cambrian submergence apparently was insufficient to produce a perforation of this thin bed anywhere along a section that is more than 200 kilometers in length. This may be taken as an indication that the period of erosion has been of relatively short duration and that the surface of the eo-Cambrian wedge of sediments formed a flat and low-lying plain during that period.

The Cape Ingersoll dolomite appears to be entirely unfossiliferous. As it is separated from the underlying Cape Leiper dolomite by what seems to be an ordinary diastem, there is no reason for separating it from the Thule group.

The geological age of the Thule group has been the subject of much discussion (cfr. the reviews by Koch, 1920 and 1929 a) It is now generally agreed that the group belongs to the Lower Cambrian, the eo-Cambrian or the late pre-Cambrian. As it is a sequence of unfossiliferous (except for *Cryptozoon*?) sediments that is separated from the fossiliferous Cambrian deposits by a simple disconformity, the present writer prefers to place the group in the eo-Cambrian.

The geographical distribution of the Thule group has been described on pages 18—19 of the present report. It should be added here that light-gray quartzitic and coarse yellow sandstones which probably belong to the group, were discovered by the writer at the head of Flagler Fjord and in the eastern part of Sverdrup Valley. A light-grey flaggy quartzite with a westerly dip, which occurs at an altitude of about 300 meters just east of the glacier that nearly closes Sverdrup Valley, probably also belongs to the Thule group.

Cambrian System.

Within the map area, Cambrian sediments are known from Washington Land (?) and Inglefield Land (Koch, 1929 b, 1933) and from Bache Peninsula (Bentham, 1936; Poulsen, 1946) and the south coast of Ellesmere Island (Bentham, 1941). The writer spent much time examining the strata on Bache Peninsula and in Inglefield Land, and as a publication on the fossils is now under preparation, the present writer finds it necessary to give a detailed account of the Cambrian stratigraphy of the area, especially since previous descriptions have turned out to be misleading in many respects.

Lower Cambrian Series.

Police Post Limestone.

The formation was discovered by Bentham (1936) at the Royal Canadian Mounted Police Post on Bache Peninsula and was later described by Poulsen (1946) under the name of Bonniopsis horizon. Poulsen, who refers the formation to a horizon slightly below that of the Wulff River formation (see below), states (oral communication) that its fauna is almost without known affinities to the faunas of other regions. A single species from the Police Post limestone also occurs in sandstone pebbles in the Wulff River formation.

The Police Post limestone occurs in the section along the south coast of Bache Peninsula, while its absence from the section on Inglefield Land was definitely established. The formation is a dark gray or brownish, impure or even slightly arenaceous limestone with a few layers of rather pure limestone. Thin conglomeratic layers with very small pebbles of quartz occur at several levels.

In the sections, the formation was found to occur at the following altitudes above sea level:

the ravine at the R. C. M. Police Post: 205—209 meters;
the cliff east of the mouth of the ravine: 260—264 meters;
between Cape Albert and Cape Camperdown: about 200 meters.

The Police Post limestone shows considerable lithologic similarity to the Wulff River formation of Inglefield Land. Both rest disconformably upon the Thule group and are separated from the overlying Cape Kent limestone by another disconformity. As mentioned above, sandstone pebbles in the Wulff River formation contain a fossil that is also known from the Police Post limestone. It is, therefore, not excluded that we are here dealing with a case of what Wheeler and Beesley (1948) call a temporal transgression. As the physical continuity of the two formations has not been proved, the writer prefers to give them separate names.

Wulff River Formation.[1])

The formation was described by Poulsen (1927) on the basis of Koch's observations as a green, glauconitic sandstone with beds of

[1]) In the writer's preliminary report (Troelsen, 1940), a new formation, the so-called Marshall Bay formation, was proposed for a limestone bed that lies below the strata which the writer at that time considered the Wulff River formation proper. Poulsen (1946) includes the Marshall Bay formation in his correlation chart. The writer's investigations in 1941 indicated, however, that the Marshall Bay formation should be regarded as the lowest member of the Wulff River formation, and Poulsen's subsequent examination of the fossils has confirmed this view.

Fig. 3. Section at Blomsterbækken on Inglefield Land. *Th*: Cape Ingersoll dolomite of the Thule group. *WR*: Wulff River formation. *CK*: Cape Kent limestone. *CW*: Cape Wood formation. *CF*: Cass Fjord formation. The section is about 160 meters high.

limestone and conglomerate. The conglomerates contain pebbles of a dark brown sandstone with fossils of an older fauna (cfr. p. 38). KOCH (1929 a, 1933) adds to this description that also pebbles of quartz and diabase may be found in the conglomerates (p. 19).

The results of the writer's investigations are summarized below:

At Kap Frederik VII, where only the uppermost part of the formation is exposed, a grayish-green calcareous sandstone with thin bands of limestone may be seen. Very thin conglomeratic layers with small pebbles of quartz alternate with the sandstone beds.

At Blomsterbækken the following section was measured, the section being presented in descending order:

3. gray calcareous sandstone[1]) with thin layers of limestone. Conglomeratic layers are of minor importance. Cross-bedding occurs at several levels. Among the fossils may be mentioned *Kutorgina reticularis* POULSEN and *Salterella* sp. .... 15 meters
2. gray hard fossiliferous limestone.................................. 10 meters

[1]) The insoluble residue consists chiefly of poorly rounded quartz grains besides some feldspar, tourmaline and glauconite.

1. gray hard fossiliferous limestone, separated from the overlying bed by a very prominent diastem. The fauna is about the same as that of Bed 2 (according to Poulsen). The lower part of the layer is crowded with fragments of the underlying Cape Ingersoll dolomite .... 5 meters

Total... 30 meters

The lower contact of Bed 1 lies about 50 meters above sea level.

The section at Locality I[1]) in Marshall Bugt is essentially the same as that at Blomsterbækken. The sequence is presented in descending order:

6. gray hard limestone with a few fossils .... 8 meters
5. gray calcareous sandstone with limy nodules .... 1 meter
4. gray, highly fossiliferous limestone .... 1 meter
3. gray calcareous, fossiliferous sandstone with limy nodules .... 5 meters
2. gray hard limestone with small stringers of yellow sandstone. Fossils are rare .... 10 meters
1. gray or faintly reddish, compact limestone, which near the top contains a thin conglomerate layer with small, flat pebbles of limestone. Fossils are fairly common. This bed is evidently the equivalent of Bed 1 at Poulsens Elv .... 5 meters

Total... 30 meters

The lower contact of Bed 1 occurs at an altitude of 195 meters above sea level.

At Locality II[2]) in Marshall Bugt an identical section was examined, in which the upper and lower contacts of the formation occur at altitudes of 260 meters and 295 meters, respectively.

At Marshall Bugt, the conglomerates in the Wulff River formation are very poorly developed. They contain some very small pebbles of quartz and brown sandstone, but of the diabase pebbles that Koch (1929 a) reported from Kap Frederik VII, no trace was seen at Marshall Bugt.

In a little ravine west of the mouth of Minturn Elv, the lower contact of the formation occurs at an altitude of 170 meters above sea level. The lower part of the formation is composed of a dense, reddish-gray limestone with angular fragments of Cape Ingersoll dolomite at the base. The upper portion of the formation is inaccessible at this locality, but talus blocks of a highly fossiliferous, gray limestone probably originate from the upper strata.

At Kap Leiper, the formation occurs from an altitude of 160 meters to an altitude of about 180 meters above sea level. It here consists

[1]) Located on the north coast of the bay, about 2 kilometers from Kap Russell.
[2]) Located on the north coast of the bay, about 5 kilometers from Kap Russell.

of gray limestone with small pockets of yellow sandstone, interbedded with layers of gray sandstone, which are from 30—40 centimeters in thickness. No conglomerates have been observed at this locality. A detailed correlation based on lithologic characters between the members of the formation at Kap Leiper and those in the northeastern part of Inglefield Land is not possible, but no appreciable difference in faunas may be observed (Poulsen, oral communication).

Generally speaking, the basal portion of the Wulff River formation consists of rather pure limestones, while the upper portions are more arenaceous. The allochthonous conglomerates (as distinguished from the autochthonous breccia at the contact between the Wulff River formation and the Cape Ingersoll dolomite) occur exclusively in the upper part of the formation.

The brown sandstone that occurs as pebbles in the conglomerates has never been found in place. Although one might expect to find it in pockets in the eroded surface of the Cape Ingersoll dolomite, the writer has always in such places found the gray limestone of the Wulff River formation. The pebbles of the brown sandstone, collected by Koch at Wulffs Elv, are large enough to contain identifiable fossils, but farther to the southwest along the coast of Inglefield Land the pebbles are very small, and apparently they get smaller the farther one gets from Wulffs Elv. The most plausible conclusion is that the brown sandstone, or at any rate the last remnant of it, at one time occurred in place somewhere in northeastern Inglefield Land. The similarity in fauna between the brown sandstone and the Police Post limestone has been mentioned in the section on the latter formation.

Cape Kent Limestone.

The formation has previously been described by Poulsen (1927) and Koch (1929 a, 1933), and the present writer's observations confirm in the main the accounts given by Poulsen and Koch.

The formation consists of a rather pure, oolitic, cream-colored limestone of a very uniform character. The upper and lower boundaries are sharp, and no basal conglomerate is present. The lithologic character of the formation is the same throughout Inglefield Land, though it seems that fossils are particularly abundant in the northeast. The thickness varies between 10 and 20 meters.

In general, fossils are only visible on weathered surfaces. Nearly all existing collections from the Cape Kent limestone have, therefore, been secured from talus blocks, and, as a consequence, it has not been possible to determine whether more than one faunal zone is represented within the formation.

The description, given above, refers to Inglefield Land only. On Bache Peninsula, conditions are somewhat different. At the Royal Canadian Mounted Police Post, a gray or violet, compact limestone, which at some levels is somewhat oolitic, occurs between the Police Post limestone and the Middle Cambrian Cape Wood formation. Its thickness is about 16 meters. Although the limestone appears to be completely devoid of fossils, the present writer (*vide* Poulsen, 1946) is strongly inclined to refer it to the Cape Kent limestone because of its oolitic structure and its position in the stratigraphic column.

In Inglefield Land, the Cape Kent limestone occurs at the following altitudes above sea level:

Kap Leiper: 180—190 meters,
Kap Taney: about 60 meters,
Locality I at Marshall Bugt: 225—about 240 meters,
Locality II at Marshall Bugt: 295—315 meters,
Blomsterbækken: 80—90 meters.

On Bache Peninsula, the stratum that is here referred to the Cape Kent limestone attains the following altitudes above sea level:

the ravine behind the Police Post: 209—219 meters,
the cliff east of the ravine: about 264—about 280 meters.

Middle Cambrian Series.

Cape Wood Formation.

The formation, as defined by the present writer, includes the Cape Wood, the Cape Frederik VII, and the Pemmican River formations of Poulsen (1927) and Koch (1929 a, 1933). It further corresponds to the Cape Wood formation of Poulsen (1946). Poulsen (1946), who recognizes three faunal zones within the formation, viz., the *Glossopleura*, the *Elrathiella*, and the *Blainiopsis* zone, gives a brief review of the literature on the Cape Wood formation (*emend.*) and of the results of the present writer's field work.

When the Middle Cambrian faunas were first discovered in Northwest Greenland, very little was known about their affinities to other faunas, and much confusion prevailed as to where they belonged in the stratigraphic system (fig. 4). It is hoped that the investigation of the collections brought home by the Thule-Ellesmere Land Expedition will bring the final solution to these problems. In the meantime, the writer will give a fairly detailed account of the Middle Cambrian sections in order to provide a basis for the coming description of the faunas. This is the more necessary as the several accounts given by Koch (1929 a, 1933) and Poulsen (1927) are inconsistent and partly misleading.

The observations made in the field, combined with a preliminary investigation of the faunas, has given the writer the impression that the Middle Cambrian strata of Inglefield Land and Bache Peninsula should be regarded as only one formation with two members. For this formation the writer proposes to use the name Cape Wood formation as the formation described under that name by POULSEN (1927) and KOCH (1929 a, 1933) corresponds to the main part of the Cape Wood formation as it is defined in the present report.

The two members are (1) the Cape Russell member, which includes all the formations mentioned in the first paragraph of the present section except POULSEN's *Blainiopsis*-horizon, and (2) the Blomsterbæk limestone member, which is the equivalent of the *Blainiopsis*-horizon, and which is separated from the underlying Cape Russell member by a thin basal conglomerate.

The upper and lower contacts of the formation are well defined and marked by disconformities.

The sediments of the Cape Russell member vary in character, both in the vertical and in the horizontal direction. Evidently they are all of shallow-water origin.

At the Royal Canadian Mounted Police Post on Bache Peninsula, the member consists of alternating beds of (1) dense gray limestone which weathers yellow, and (2) cavernous dolomite that is gray in all stages of weathering. The combined thickness amounts to some 60 meters. The limestone bed that forms the basal stratum of the member contains fossils of the *Glossopleura* assemblage (POULSEN, 1927), while the remainder of the member appears to be unfossiliferous.

In the ravine behind the Police Post, the member occurs between altitudes 219 meters and 245 meters above sea level. In the cliff east of the ravine the corresponding altitudes are 280 meters and 320 meters, the top of the member having been removed by erosion.

At Kap Leiper on Inglefield Land, the Cape Kent limestone is overlain by more than 40 meters of apparently unfossiliferous, gray, massive limestone that presumably belongs to the Cape Russell member.

At Locality I in Marshall Bugt, where the strata, as in the rest of Inglefield Land, are almost horizontal, the upper and lower boundaries of the Cape Russell member are found at altitudes of 325 meters and 240 meters above sea level, respectively. The following section is presented in descending order:

7. Flaggy arenaceous gray, yellow-weathering limestone. At 325 meters, 310 meters, and 300 meters of altitude, fossils of the *Glossopleura* assemblage occur .... 40 meters
6. Covered .... 5 meters

5. Gray finely crystalline limestone with *Prosymphysurus* sp. of the *Clavaspidella* assemblage .... about 1 meter
4. Covered .... 5 meters
3. Flaggy gray limestone with trilobites of the *Glossopleura* assemblage 20 meters
2. Massive gray limestone with stringers of yellow sandstone. This stratum seems to pass gradually into the underlying and overlying layers.. 5 meters
1. Gray flaggy unfossiliferous sandstone .... 10 meters

Total... 86 meters

At Locality II in Marshall Bugt, the Cape Russell member occurs between about 315 meters and 395 meters of altitude. The section is presented in descending order:

5. Massive gray limestone with stringers of yellow sandstone ... about 1 meter
4. Covered .... 30 meters
3. Massive gray limestone with stringers of yellow sandstone. At an altitude of 365 meters above sea level, trilobites of the *Glossopleura* assemblage were collected. *Prosymphysurus* sp. of the *Clavaspidella* assemblage occurs at a height of 350 meters above sea level ..... 15 meters
2. Covered .... 5 meters
1. Thin-bedded gray conglomeratic sandstone with fragments of a harder sandstone. Trilobites of the *Glossopleura* assemblage occur in this layer .... 30 meters

Total... about 81 meters

It has thus been proved that in Northwest Greenland, the *Clavaspidella* assemblage occurs within the *Glossopleura*-zone (cfr. Resser, 1939) and that, consequently, the Cape Frederik VII formation, which according to Poulsen (1927) is characterized by the occurrence of *Clavaspidella*, *Prosymphysurus* and *Ptychoparella*, cannot be maintained as a separate formation (fig. 4).

At Blomsterbækken, where the beds are better exposed than in any other accessible section on Inglefield Land (fig. 3), the writer examined the following section, which is described in descending order:

4. (Blomsterbæk limestone member)
3. Flaggy or thin-bedded, commonly somewhat arenaceous, gray limestone, which weathers to an ocher-yellow. At altitudes of 115 meters, 120 meters, 125 meters and 134.5 meters above sea level the writer collected numerous trilobites, mostly belonging to the *Glossopleura* assemblage .... 25 meters
2. Gray or greenish sandstone with poorly preserved fossils. The sandstone passes gradually into the overlying limestone .... 20 meters
1. (Cape Kent limestone)

The lower contact of Bed 2 and the upper contact of Bed 3 occur at altitudes of 90 meters and 135 meters above sea level, respectively.

If the Cape Frederik VII and the Pemmican River formations were present in this section—and according to Koch's report they

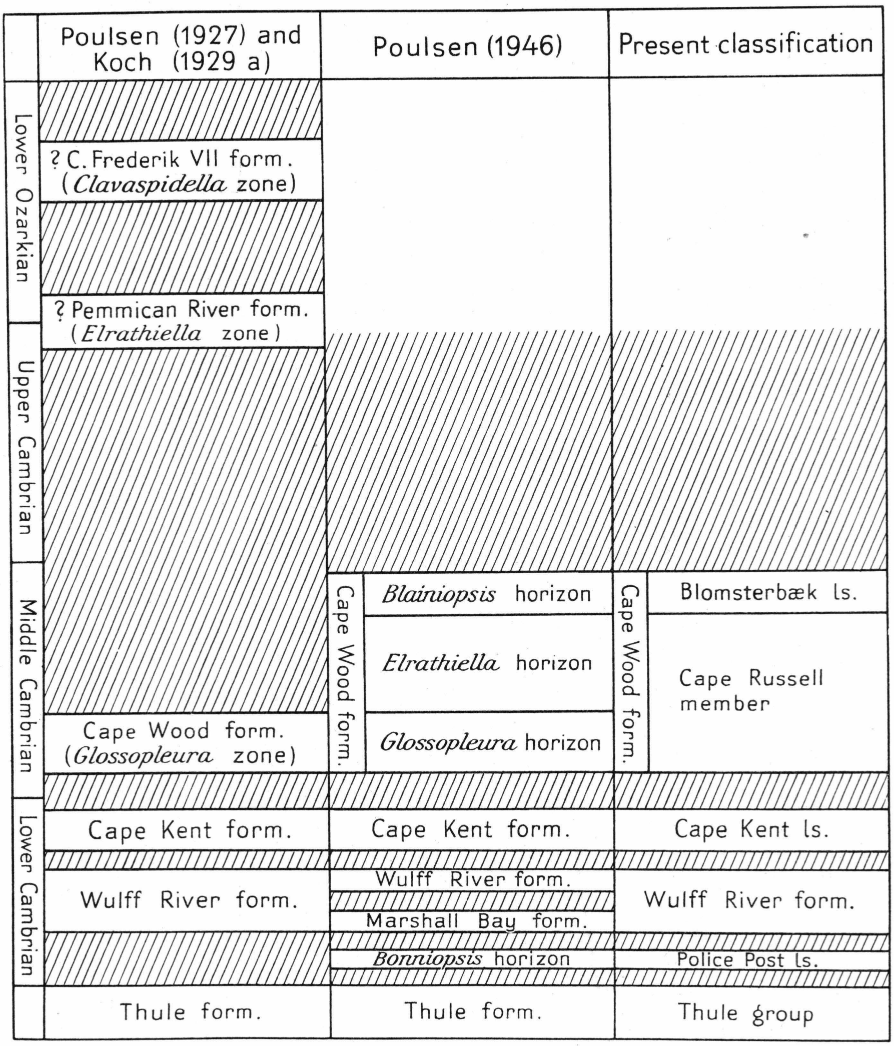

Fig. 4. Table of the past and present classifications of the Cambrian formations of Northwest Greenland and Ellesmere Island.

should be—they would have to be looked for somewhere between the Cape Kent limestone and the Blomsterbæk limestone member as there is no possibility of mistaking the two last-mentioned limestone beds for any other formation. It must be admitted that the talus that covers a few meters of the section between the Blomsterbæk member and the overlying Cass Fjord formation contains numerous blocks of a gray crystalline limestone of unknown affinities, but as these blocks seem to be unfossiliferous, there is no basis for comparing them to either the Cape Frederik VII or the Pemmican River formation. On the other hand, certain layers of Bed 3 of the section described above are indistinguishable from the Pemmican River formation and the Cape Frederik VII formation as we know them from the samples brought home by KOCH. Though the collections of fossils have not been completely worked up, we must draw the conclusion that there is no reason for maintaning the two formations, just mentioned, as independent units.

At Kap Frederik VII, the accessible part of the section is somewhat obscured by talus, and the Cape Wood formation could not be examined in details. The thickness of the Cape Russell member is here about 50 meters. Also in this locality, the upper part of the member corresponds lithologically rather closely to the Pemmican River formation as we know it from the samples in the University Museum.

The Blomsterbæk limestone member has only been observed in two localities, but as the thickness of the member is negligible, it may actually be present in several places where the contact between the Cape Wood formation and the Cass Fjord formation is obscured by talus.

At the Royal Canadian Mounted Police Post on Bache Peninsula, the Blomsterbæk limestone was first discovered by BENTHAM (1936; POULSEN, 1946) in the ravine behind the Police Post. In this place it was found again by the present writer, while on the southern edge of the plateau east of the ravine the stratum has been removed by erosion. In the ravine, at an altitude of 245 meters above sea level, the Cape Russell member is overlain by 5 meters of thin-bedded gray, yellow-weathering limestone with very thin layers of sandstone and limestone conglomerates. While it may be observed that the contact with the Cape Russell member is marked by a distinct diastem or disconformity, the contact with the overlying Cass Fjord formation is covered with talus. The fauna of the limestone corresponds closely to that of the *Blainiopsis*-horizon (Poulsen, 1946). Though this name has priority over that given by the present writer, viz., the Blomsterbæk limestone, the writer prefers the latter name because it is in better agreement with the rules of nomenclature than the name used by POULSEN.

At Blomsterbækken on Inglefield Land, from which the Blomsterbæk limestone derives its name, the member occurs between the altitudes of 135 meters and about 137 meters above sea level. It is developed as a massive gray limestone, and it starts at the bottom with a thin basal conglomerate with angular fragments of the underlying limestone. Between the Blomsterbæk limestone and the overlying Cass Fjord formation there is a covered interval of about 5 meters. As previously mentioned, this talus slope has yielded numerous blocks of a light gray or brownish-gray, unfossiliferous limestone.

Ordovician System.

Canadian Series.

Cass Fjord Formation.

The distribution of the formation has been described on page 20 of the present report. Koch (1929 b, 1933) and Poulsen (1927) describe the formation as a sequence, at least 400 meters thick, of coarse lime-

Fig. 5. Cass Fjord formation, Bache Peninsula. The conglomerate layer in the center of the picture is about 25 centimeters thick.

stone conglomerates alternating with thin-bedded or shaly, impure gray limestones. As may be seen on fig. 5, the fragments in the intra-formational conglomerates are slabs of shaly limestone.

On Inglefield Land, the upper part of the formation has been removed by erosion. The lower contact attains the following altitudes above sea level:

Kap Taney: about 150 meters,
Locality I in Marshall Bugt: 325 meters,
Blomsterbækken: about 142 meters,
Kap Frederik VII: about 170 meters.

Doubt has been expressed as to the presence of the Cass Fjord formation in Ellesmere Island, though Poulsen (1946) is inclined to think that the formation is exposed on Bache Peninsula. The present writer has had an opportunity for comparing the sections of Bache

Peninsula and Inglefield Land with those of Washington Land, and though no fossils were found in the interbedded limestones and conglomerates that rest upon the Middle Cambrian strata of the former areas, there can be no reasonable doubt about the identity of the limestone and conglomerates with the Cass Fjord formation of southern Washington Land (fig. 6).

In the ravine behind the Royal Canadian Mounted Police Post on Bache Peninsula, the lower contact of the formation occurs at an altitude of 250 meters above sea level.

In Sverdrup Valley, about half way between Flagler Fjord and Bay Fjord, at an altitude of about 200 meters above the sea, a thin-bedded, dark gray, unfossiliferous limestone with intraformational conglomerates is exposed. The deposit resembles the Cass Fjord formation to some degree, but the fragments in the conglomerates are smaller and better rounded than is ordinarily the case in the Cass Fjord formation, and the deposits of Sverdrup Valley are, therefore, only with doubt referred to this formation.

Fossils are exceedingly rare in the Cass Fjord formation except in a horizon a few meters below the top of the formation, in which also Koch (1929 b) found fossils. The best exposure of the upper contact of the formation may be seen at Kap Clay on Washington Land.

Cape Clay Limestone.

Poulsen (1927) described the formation in the following words: "... compact, yellowish gray limestone ... Some of the layers are limestone conglomerates, but the pebbles are so intimately fused with the matrix that the whole mass has the character of compact limestone ...". Age: Early Canadian.

The formation was examined only at Kap Clay on Washington Land, where the writer collected some fossils. As for the distribution of the Cape Clay limestone, the reader is referred to the section dealing with the Poulsen Cliff shale.

Poulsen Cliff Shale.

While Koch's geographic maps of Washington Land (1929 b, 1932) are fairly accurate, part of his geologic map must be said to be misleading. What is marked by Koch (1929 b, fig. 6 & pl. 3) as the Cass Fjord formation is, along the coast between Nygaards Bugt and Kap Webster, really two new formations, the Poulsen Cliff shale and the Nygaard Bay limestone, and what Koch mapped as the Cape Clay formation (1929 b, figs. 6 & 7, pl. 3) is, on the same part of the coast,

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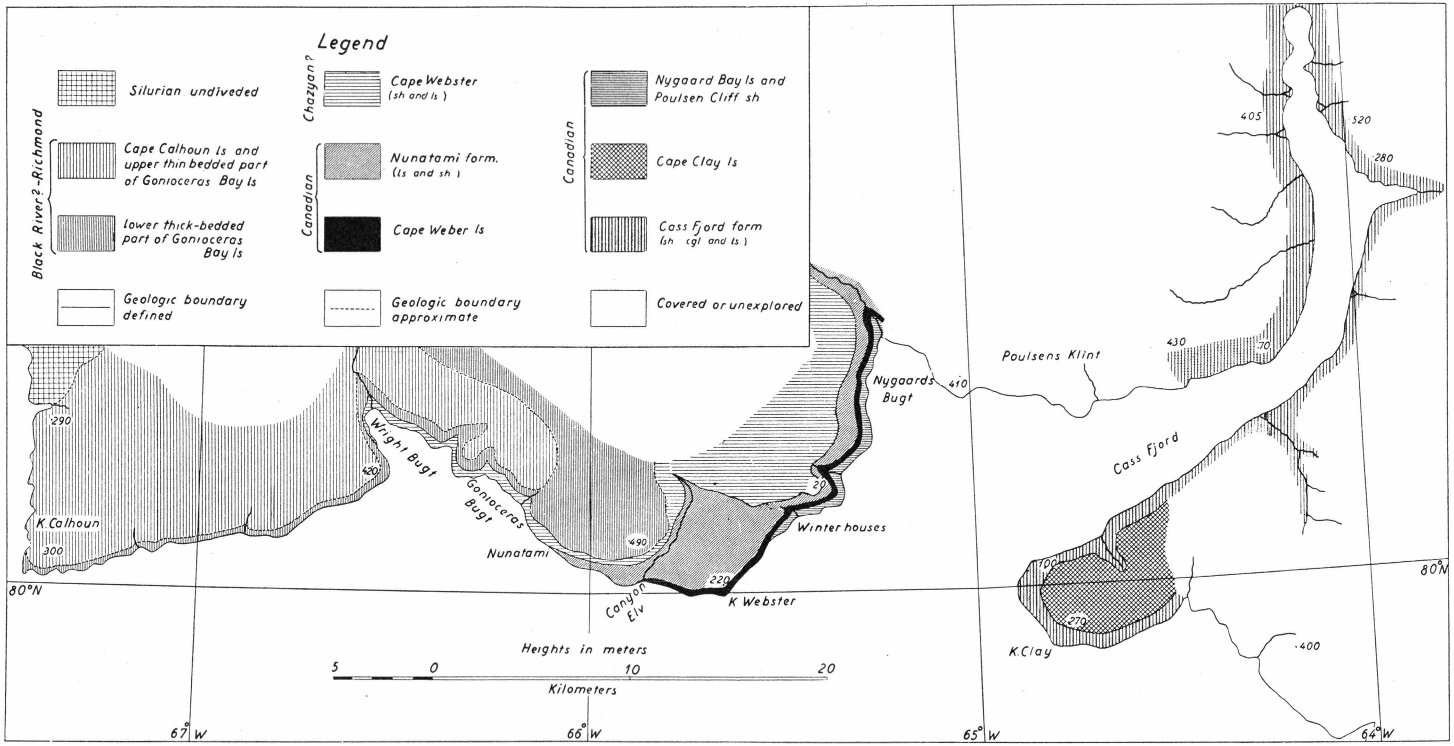

Fig. 6. Geological map of southern Washington Land. Based on the survey by Koch (1929 b) and the writer's observations.

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the Cape Weber limestone, which has not previously been found in Northwest Greenland. Koch's mistake is understandable because, seen from a distance, the new formations look very much like the Cass Fjord formation overlain by the Cape Clay limestone, but on closer examination the differences in lithology and fossil content become obvious.

Between Kap Webster and the head of Nygaards Bugt, the oldest exposed strata may be seen in the first small ravine northeast of the ruins of the old Eskimo winter houses (fig. 6). Talus here covers the slope to a height of 100 meters above sea level.

Between the altitudes of 100 meters and about 140 meters, a gray, unfossiliferous fissile shale is exposed. The shale, which contains a few layers of limestone conglomerate of an average thickness of 15 centimeters, passes gradually into the overlying Nygaard Bay limestone.

The lower contact of the shale is not exposed in the section, though the strata, because of the northwesterly regional dip, here reach higher altitudes than anywhere else along the west coast of Nygaards Bugt. The contact is probably exposed somewhere between Nygaards Bugt and the mouth of Cass Fjord, but exceptionally deep snow prevented the writer from examining the sections along this part of the coast.

As to the age of the Poulsen Cliff shale nothing is known except that it must be older than the Upper Canadian Cape Weber limestone, which occurs a little higher in the stratigraphic column, and younger than the Lower Canadian Cape Clay limestone.

The shale formation is named after Poulsens Klint, and it may be said with a high degree of probability that the Poulsen Cliff shales are exposed in that vicinity.

Nygaard Bay Limestone.

Above the Poulsen Cliff shales follows about 10 meters of dark gray dense limestone with layers of a more shaly limestone containing nodules of chert. A few layers of limestone conglomerate also occur.

Silicified gastropods and cephalopods are rather abundant but ordinarily very poorly preserved. The only form it has been possible to identify is *Protocycloceras* sp., a cephalopod that is common in the Canadian.

As mentioned in the section on the Poulsen Cliff shale, the lower boundary of the Nygaard Bay limestone is poorly defined. The contact of the limestone against the overlying Cape Weber formation is, however, distinct and well defined.

The formation is named after Nygaards Bugt, where one may expect to find good exposures. During the writer's visits to Washington Land, Nygaards Bugt was made inaccessible by very deep snow.

Cape Weber Limestone.

Above the Nygaard Bay limestone follows on Washington Land a hard, gray or brownish, thick-bedded limestone with nodules and lenses of white chalklike calcite and dolomite. The thickness of the stratum is about 10 meters. It is overlain by the Nunatami formation. The upper and lower contacts are distinct and marked by well-defined disconformities.

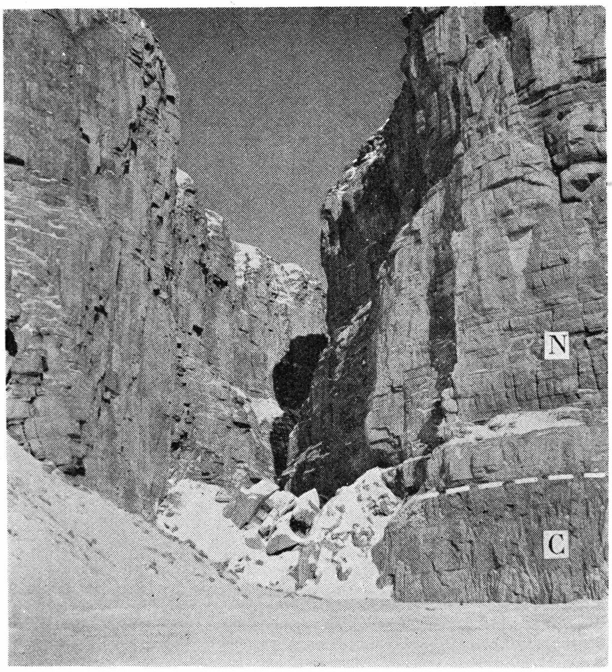

Fig. 7. The mouth of Canyon Elv, Washington Land. *C*: Cape Weber limestone. *N*: Nunatami formation. The exposure of the Cape Weber limestone is about 8 meters high.

The formation may be observed in the coast cliffs between the head of Nygaards Bugt and the mouth of Canyon Elv. In the latter locality it disappears below sea level (figs. 6 & 7). Because of the northwesterly regional dip, the formation also descends toward the head of Nygaards Bugt. In the first ravine northeast of the ruins of the old Eskimo winter houses, the lower contact of the formation occurs at an altitude of about 150 meters above sea level.

The formation is possibly identical with the layer described by Koch (1929 b, p. 21) in the following words: "Gastropod Sandstone [one of the members of the Nunatami formation] ... From Canyon River and the coast west thereof originates a brownish grey limestone which I have noticed in no other place, and in which several trilobites were imbedded". Elsewhere in Koch's paper (cfr. the section in the present report on the Poulsen Cliff shale), the present formation is referred to as the Cape Clay formation.

At the mouth of Canyon Elv a number of trilobites were collected. According to oral communication from Poulsen, the fauna is practically identical with that of the Cape Weber limestone of Northeast Greenland and eastern Ellesmere Island[1]).

The type locality of the Cape Weber limestone is located in Northeast Greenland, from where Poulsen (1937) has described a number of fossils. In 1935, the geologist of the Oxford University Ellesmere Land Expedition, R. Bentham, brought home a collection of fossils from the Canadian formations along the coast northeast of Bache Peninsula. Poulsen, who has examined these fossils, declares (1937, 1946) that some of them clearly belongs to the Cape Weber fauna. Poulsen further states that judged from the structural conditions at Bentham's localities, the Cape Weber limestone must be younger than the Nunatami formation. As both the Cape Weber fauna and the Nunatami fauna belong in the Late Canadian, he concludes that if the Cape Weber formation or its equivalent is present on Washington Land, it "is probably represented by the lowermost part of the Cape Webster series", which rests on top of the Nunatami formation (1937, p. 71). The discovery of the Cape Weber limestone below the Nunatami formation therefore came as a great surprise.

Poulsen, who has seen the collections from Washington Land as well as Bentham's fossils from Ellesmere Island, declares that lithologically there is no essential difference between the limestones of the Cape Weber formation of the two areas.

Nunatami Formation.

The formation was first discovered by Koch and later described by Poulsen (1927, 1946) and Koch (1929, a & b). Along the south coast of Washington Land—the only place where it was examined by the present writer—it is exposed in a vertical, perfectly smooth cliff

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[1]) Poulsen has kindly informed the writer that so far the following species have been identified:

Petigurus groenlandicum Poulsen (elsewhere known from the Cape Weber ls. of Northeast Greenland).

Bathyurellus teicherti Poulsen (elsewhere known from the Cape Weber ls. of Northeast Greenland and Ellesmere Island).

Pseudomera dactylifera (Poulsen) (previously known from the Nunatami formation of Washington Land).

Bolbocephalys seelyi Whitfield (also known from the Fort Cassin beds).

above a very steep and high talus slope (fig. 7). The thickness of the formation is about 140 meters.

POULSEN (1927) divided the formation into four members:

Ostracod limestone,
Gastropod limestone,
Angustifolius limestone,
Bifidus shale.

Of these members, only the Ostracod limestone was examined in detail by the writer (in connection with the search for the Cape Weber limestone; see the section on this formation). Because the Ostracod limestone is overlain by the easily eroded Cape Webster formation, it is accessible in places, and it was found that it passes gradually into the overlying formation, as already stated by KOCH (1929 b, p. 22).

The present writer did not succeed in locating the Gastropod limestone in the exposures along the coast, although a few loose-lying blocks of the limestone were found on the beach at Nunatami, and the writer is therefore inclined to believe that it merely forms lenses or thin layers in the Nunatami formation.

Champlainian and Cincinnatian Series.

Cape Webster Formation.

The character of the formation and its distribution in Washington Land has been adequately described by KOCH (1929 b). It may be characterized as a sequence of shallow-water deposits, composed of alternating layers of thin-bedded light-gray, yellow-weathering limestone and dark shale and mudstone. The total thickness is 290 meters. The lower contact has been described above. The upper contact is marked by a distinct disconformity.

Fossils are exceedingly rare. Apart from some ostracods and crinoid stem joints in the layers that form the transition to the underlying Nunatami formation, no fossils were found by the present writer. He has therefore nothing to add to TROEDSSON's (1926, p. 110; 1928, p. 147) and TEICHERT's discussions of the age of the formation. TROEDSSON found some arguments for referring the strata to the Chazyan, but the faunal evidence is too scanty for an exact age determination.

Gonioceras Bay Limestone (with Remarks on the Wright Bay Limestone and the Cape Calhoun Limestone).

The formation was discovered and examined by KOCH in 1920—1922. KOCH gave it the preliminary name of Receptaculites limestone, but Troedsson (1926) renamed it the Gonioceras Bay formation. It was defined by Koch (1929 b, p. 25) as a "very hard and reddish brown" limestone that tends to form steep cliffs and which rests upon the Cape Webster formation. According to Koch, its thickness is 50 (?) meters. Its lower contact is well defined (fig. 8). Its boundary toward the somewhat hypothetical Troedsson Cliff formation, which Koch

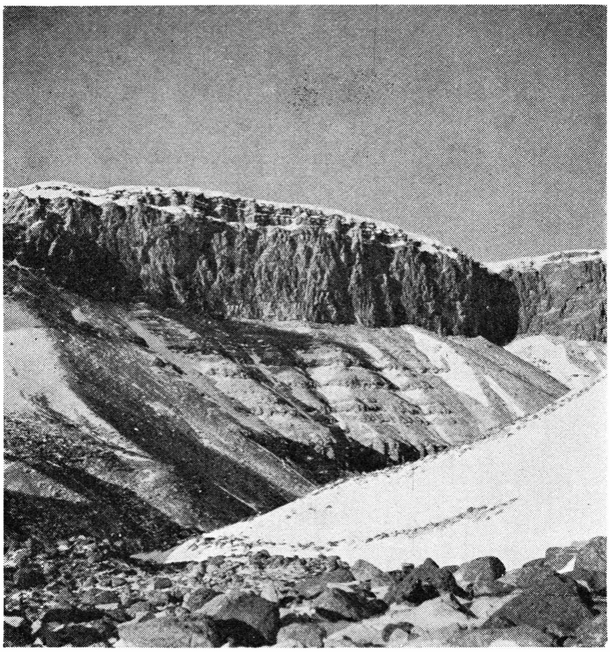

Fig. 8. Gully at Gonioceras Bugt, Washington Land, with exposures of the Cape Webster formation overlain by the Gonioceras Bay limestone. The thick-bedded portion of the latter formation is about 70 meters thick.

(1929 b) tentatively proposed for the overlying 60 (?) meters of limestone of supposed Trenton age, was said to be uncertain.

The age of the Gonioceras Bay limestone has been discussed by Troedsson and Teichert. Troedsson (1926, p. 111) concluded that the formation "hardly shows affinities to the Chazy, but is likely to have its place at the very base of the Black River (Lowville ?)". In 1928 (pp. 155—156), Troedsson wrote: "the Gonioceras Bay fauna, which is correlated with the Black River . . ., is very poor; its only leading fossils—except the cephalopods—are *Bumastus milleri*, which has been found in the Black River of Ontario, New York, and New Jersey, and *Batostoma magnopora*". Teichert (1937 a, p. 17), however, drew the following conclusion: "the evidence, however poor it may be, is . . . more in favour of the assumption of a low Trenton than of a Black River age of the Gonioceras Bay fauna".

The overlying Cape Calhoun formation was by Koch (1923 and 1929 b) divided into (1) brown unfossiliferous limestone (40 meters thick; the top of the formation), (2) *Leptaena* beds (20 meters thick), (3) *Halysites* limestone (130 meters thick), and (4) the upper part of the *Receptaculites* limestone (60? meters thick), the lower part being identical with the Gonioceras Bay limestone. Troedsson (1926) referred the formation to the Black River, the Trenton (Galena) and the Richmond, while in 1928 he arrived at the conclusion that the formation belongs to the Trenton (the upper part of the *Receptaculites* limestone) and the Richmond (*Leptaena* beds and *Halysites* limestone). Teichert (1937 a) thinks that the formation comprises strata of Trenton and Richmond age.

Previous investigations of the Gonioceras Bay—Cape Calhoun fauna have been greatly hampered by the fact that all the fossils hitherto known from these strata have been collected from talus boulders so that the fossils from the two or three faunal zones which Troedsson and Teichert recognize have become thoroughly mixed. Only the fossils from the lowermost part of the sequence, viz., Troedsson's Gonioceras Bay limestone, could, because of the reddish color of the rock matrix, be separated from the rest of the lot with a reasonable degree of certainty.

The question of the proper subdivision of the sequence did not become easier when Teichert (1937 a), on the basis of a few loose-lying pieces of dark-colored limestone, described a new formation from Washington Land, to which he attached the name Wright Bay formation. As to the relative age of this formation, Teichert (ibid.) set forth the following alternative hypotheses:

(1) The specimens of *Gonioceras holtedahli* from Gonioceras Bay may actually be from the Wright Bay formation, or
(2) the Gonioceras Bay limestone and the Wright Bay formation may be one and the same formation, or
(3) they may represent two different faunal zones which are closely related in age.

During his visits to Washington Land in 1941, the writer therefore endeavored to collect the greatest possible number of fossils *in situ.* Because of the difficulties encountered in scaling the steep cliffs, the collections brought home are not very extensive, but at least a beginning has been made towards bringing the stratigraphic subdivision of this part of the North Greenland sequence on a sounder basis. Unfortunately only the lower part of the Gonioceras Bay—Cape Calhoun sequence could be investigated during the writer's visits to Washington Land, but in summer when the snow has disappeared from the valleys it should be possible to measure a nearly complete section on the slopes of the ravine at the head of Wrights Bugt.

On the west slope of Wrights Bugt, the writer measured a section that starts at the bottom with 40 meters of sediments of the Cape Webster formation.

In the immediately overlying, reddish or brownish, dense limestone, some undetermined ostracods were collected.

40 meters above the top of the Cape Webster formation, the writer collected a *Leurorthoceras* sp., which is different from *L.* (?) *ruedemanni* TROEDSSON and *L. hanseni* (?) FOERSTE, both of which TROEDSSON lists as occurring in the Gonioceras Bay limestone.

50 meters above the top of the Cape Webster formation were collected *Sowerbyella "sericea"* (Sow.) and undetermined ostracods.

60 meters above the top of the Cape Webster formation the color of the limestone changes from reddish or brownish to dark- or medium-gray with only a very faint brownish cast. At this level the limestone is richly fossiliferous, and the following species have been identified:

Batostoma bassleri TROEDSSON**,
Labyrinthites (?) *monticuliporoides* TROEDSSON**,
Rafinesquina ? spp. indet.
Sowerbyella "sericea" (Sow.) (conspecific with TROEDSSON'S *S. sericea***),
Bumastus aff. *orbicaudatus* (BILLINGS) (aff. *B. milleri**),
Ceraurus cfr. *milleranus* SLOCOM,
Encrinurus sp.
Illaenus groenlandicus TROEDSSON**,
Isotelus spp. indet.,
Thaleops sp. (not *T. borealis* TEICHERT***),
Gonioceras holtedahli TROEDSSON*,
Endoceras cfr. *proteiforme* HALL,
Actinoceras n. sp.

5 meters higher in the section the limestone is still dense and thick-bedded, and its color is medium- to dark-gray. Of the fairly rich fauna the following species have been identified:

Labyrinthites (?) *monticuliporoides* var. *minor* TROEDSSON*,
Amplexograptus (?) sp.
Bumastus n. sp. (group of *B. indeterminatus* (WALCOTT); possibly conspecific with *B.* n. sp. TEICHERT***),
Goldillaenus peculiaris TEICHERT***,
Kochoceras (?) aff. *vetustum* TROEDSSON (K. (?) *vetustum**).

80 meters above the top of the Cape Webster formation, the limestone becomes flaggy or thin-bedded, and its color changes to a light- or medium-gray. The only fossil collected at this level was *Dawsonoceras* (?) cfr. *aquilonare* TROEDSSON (*D.* (?) *aquilonare***).

In the fauna lists given above, species that TROEDSSON reports from the Gonioceras Bay limestone are marked with an asterisc (*); species which TROEDSSON lists from the Cape Calhoun limestone, with **; and species which TEICHERT reports from the Wright Bay limestone, with ***.

As it will appear from the fauna lists, species which TROEDSSON refers to the Gonioceras Bay fauna occur together with species which he lists as occurring in the Cape Calhoun fauna. This fact is easily explained if one considers (1) that TROEDSSON's material came exclusively from talus blocks; (2) that none of the species that TROEDSSON regards as typical Richmond forms are represented in the strata described above but only species which he refers to the Black River and/or Trenton; (3) that no visible disconformities exist in the examined part of the section at Wright Bugt; and (4) that large numbers of TROEDSSON's specimens from what he calls the Cape Calhoun limestone (preserved in the University Museum of Geology in Copenhagen) are imbedded in a limestone that is indistinguishable from that of the upper 20 meters of the section described above.

Some of the specimens in TROEDSSON's collection that he regards as typical Richmond forms, are imbedded in a medium-gray limestone that on weathering assumes a faintly greenish tinge. The fossil remains in this type of limestone are generally black. On the other hand, specimens which TROEDSSON refers to Black River or Trenton forms and also some of his Richmond species are preserved in brown calcite and are imbedded in a dense, light-gray or light-brown limestone which is very similar to the one that predominates in the section described above. It thus seems possible that the Cape Calhoun limestone as TROEDSSON defines it should be divided into two parts, an upper division belonging to the Richmond and for which the name Cape Calhoun limestone might be retained; and a lower, Mohawkian division that cannot be separated from the underlying Gonioceras Bay limestone. However, the difference between the two types of limestone as they are represented in TROEDSSON's collection is not very conspicuous, and in many cases the smallness of the hand specimens prevents a definite determination of the lithologic type. Until a complete section has been measured somewhere between Wright's Bugt and Kap Calhoun (fig. 6), the question of the nature and position of the contact between the Cape Calhoun limestone (in its present restricted sense) and the Gonioceras Bay limestone can, therefore, not be finally settled. It is certain, however, that the lower part of TROEDSSON's Cape Calhoun limestone cannot be kept separate from the Gonioceras Bay limestone.

As for TEICHERT's Wright Bay limestone, there seems to be no reason for maintaining it as a separate formation as it, both lithologically and faunistically, is an integral part of the Gonioceras Bay limestone. Species that TEICHERT regarded as typical of the Wright Bay limestone occur in the same stratum as forms which already TROEDSSON listed as belonging to the Gonioceras Bay limestone.

In THORLAKSSON's collections there are a few fossils from the coast near the mouth of the river that flows into the head of Bay Fjord in central Ellesmere Island and from a valley that evidently is tributary to the lowermost part of the river. The only fossil taken *in situ* at the latter locality is a specimen of *Gonioceras groenlandicum* TROEDSSON[1]), which is imbedded in a dense light-brown limestone that resembles the Gonioceras Bay limestone. In the pores and cavities of a loose-lying fragment of *Receptaculites arcticus* ETHERIDGE from the same vicinity, a similar type of limestone has been observed. It may, therefore, be assumed with some reason that the Gonioceras Bay limestone, in its present extended sense, occurs near the head of Bay Fjord.

From the coast immediately south of the river mouth, THORLAKSSON brought home a few fragments of a dense medium-gray limestone that on weathering assumes a bluish-gray or faintly greenish cast. One specimen consists of a greenish-gray, strongly argillaceous limestone. The fossils are generally dark-colored or black. According to THORLAKSSON's notes, the limestone beds dip toward the west, while the specimen of *Gonioceras groenlandicum*, mentioned in the foregoing paragraph, is said to have come from slightly older strata. Unless the structure is complex, the bluish- or greenish-weathering limestone must then be younger than the limestone with *G. groenlandicum*. Lithologically, the former agrees fairly well with the Cape Calhoun limestone (restricted; = the upper part of TROEDSSON's Cape Calhoun limestone). The only identifiable fossil is, however, *Sowerbyella "sericea"* (Sow.) (not conspecific with the form that TROEDSSON described under that name from Washington Land), and the stratigraphic age of the greenish limestone from Bay Fjord, therefore, remains uncertain except for the fact that it must belong to the Middle or Upper Ordovician series.

It should also be mentioned that on the coast just south of the entrance to Scoresby Bay, BENTHAM (TEICHERT, *vide* KINDLE, 1939)

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[1]) TROEDSSON's specimens of *G. groenlandicum* from Washington Land, although referred to the Cape Calhoun limestone, are imbedded in a matrix that cannot be distinguished from the rocks of the typical Gonioceras Bay limestone. *G. groenlandicum* has also been reported from Boothia Felix and King William Land (*vide* TROEDSSON, 1926, p. 88).

found limestone beds with a fauna that has several species in common with the Gonioceras Bay limestone, as it is defined in the present report.

Cape Baird Limestone.

The type locality and only known occurrence of this formation is about 2 kilometers southeast of Cape Baird, south of the entrance to Archer Fjord in the northeast of Ellesmere Island. At an altitude of about 100 meters there is here an exposure of black fine-grained bituminous, somewhat brecciated limestone with gray spots. The strata dip about 45° southeast. As the surrounding area was covered with glacial till, the contacts of the black limestone with other formations could not be observed.

The known fauna consists of the following species:

Armenoceras n. sp.
Maclurites n. sp.
Bryozoan, gen. et sp. indet.
Single tetracoral
Halysites aff. *feildeni* TROEDSSON (not ETHERIDGE).

The fauna is evidently of Ordovician age, and the presence of *Halysites* indicates that it is not older than the Trenton. The faunal evidence is, however, too scanty to allow an exact correlation with the Ordovician sequence in Northwest Greenland.

Thorup Fjord Limestone.

This formation is only known from the small peninsula that separates Thorup Fjord[1]) from the eastern part of Bay Fjord.

According to THORLAKSSON, who in 1940 visited this locality, strongly folded quartzite and shale, overlain by unfolded sandstone of unknown age, are here exposed along the coast. Among the numerous specimens in THORLAKSSON's collection from the folded strata, two distinct types may be distinguished. One is a black shale with Silurian graptolites (see pag. 61). The other is a thin-bedded black argillaceous limestone replete with Ordovician trilobites and graptolites.

No other Ordovician formation of this lithologic and faunal type is known from Greenland or Ellesmere Island. Although so little is known about the stratigraphical conditions at the type locality, the writer, therefore, ventures to regard the black Ordovician limestone as

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[1]) Named in honor of the late Associate Justice of the Supreme Court of Denmark, VIGGO THORUP, who was one of the trustees of the Danish Thule-Ellesmere Island Expedition.

a distinct formation, for which he proposes the name Thorup Fjord limestone.

The known fauna is composed of *Isotelus* n. sp., represented by numerous cranidia and pygidia and a few loose cheeks and fragments of thoraces; and indeterminable biserial graptolites (*Diplograptus*?).

. An exact age determination is not possible on the basis of the faunal evidence. About 30 kilometers east-northeast of the type locality of the Thorup Fjord limestone, Thorlaksson found limestone beds that lithologically and faunistically show similarities to the Gonioceras Bay limestone and the Cape Calhoun limestone (p. 58) and which are quite distinct from the present formation. If the latter is the equivalent of one of the Ordovician formations we know from Northwest Greenland, the Cape Webster formation would then be the one that comes closest in lithologic respect. It must be pointed out, however, that such a correlation remains very uncertain until more is known about the section at Thorup Fjord. It is quite possible that the Thorup Fjord limestone represents an argillaceous facies of one of the limestone formations that are known from other parts of the map area, or that it is not represented at all in the Ordovician sequence of the foreland of the geosyncline.

Silurian System.

Within the map area, Silurian strata are known to occur in western Devon Island and southwestern Ellesmere Island, at Vendom Fjord and Bay Fjord, at various places along the coast northeast of Dobbin Bay, and in a broad belt across North Greenland.

A brief review of the geological history of Northwest Greenland in the Silurian period has been given in a previous chapter (p. 21). A few remarks on the geological age of some of the Silurian formations of Ellesmere Island will be added in this place.

In southwestern Ellesmere Island, the upper part of Schei's Series A, which consists of 1000—1200 meters of limestone conglomerates, limestones and shales, is regarded as being of Niagaran age (Holtedahl, 1914), while the overlying Series B, which is composed of about 300 meters of dark shales and limestones, has been referred to the uppermost Silurian (Decker, Manlius, Upper Kayser) (Holtedahl, ibid.; Swartz, *et al.*, 1942). A graptolite from the upper part of Series B has been compared to European Ludlow forms. In another paper, Holtedahl (1924, pp. 128—133) points out the close relationship between Series B and the Arctic *Lissatrypa phoca*-fauna.

Etheridge (1878) gives a list of Silurian and Ordovician fossils from Dobbin Bay, Cape Louis Napoleon, Cape Hilgard and Cape Frazer on the east coast of Ellesmere Island some 65 kilometers northeast of Bache Peninsula. As POULSEN (1946) has shown that the coast at Cape Frazer is composed of strata of Canadian age, the Silurian fossils in ETHERIDGE's list presumably have come from some other point on the coast. HOLTEDAHL (1924) compares ETHERIDGE's fauna to the *Lissatrypa phoca*-fauna.

BENTHAM (1941) reports the occurrence of folded Silurian beds at Vendom Fjord, without, however, giving any information as to the exact age. TEICHERT (*vide* KINDLE, 1939) refers to BENTHAM's discovery at Cape Norton Shaw of dolomite with a fauna that he (TEICHERT) correlates with the Upper Silurian (Upper Llandovery) Offley Island formation of North Greenland. It is further mentioned that in the interior of Scoresby Bay exposures have been found of a crinoidal limestone, which probably belongs to the youngest Silurian or the transition strata between the Silurian and the Devonian. TEICHERT suggests that the limestone should be correlated with Series B of southwestern Ellesmere Island and with the beds that contain the *Lissatrypa phoca*-fauna.

The present writer did not study the Silurian system of Northwest Greenland. In Ellesmere Island, the Danish Expedition encountered Silurian sediments in one locality only, viz., at the peninsula between Thorup Fjord and Bay Fjord. As described above (p. 59), the folded strata here includes Silurian graptolite shales.

The shales are hard, somewhat calcareous, black in the fresh state and light-bluish-gray on weathered surfaces. They split along rather widely spaced bedding planes (about 1 centimeter apart).

The only known fossils are indeterminable *Monograptus* spp. One of the species shows considerable resemblance to *M. priodon* (BRONN), but a reliable identification is not possible.

Lithologically, the shales are similar to the graptolite shale facies of the Cape Tyson formation (Tarannon-Wenlock) of North Greenland, the fauna of which includes *Monograptus priodon*. There is thus a possibility that the Silurian shales from Thorup Fjord belong to the Cape Tyson formation.

According to KOCH (1929 a), the deposition of the Cape Tyson formation was preceded by an uplift of at least 400 meters with accompanying vigorous erosion. If we assume that the shales at Thorup Fjord belong to the latter formation, such an uplift, extended to central Ellesmere Island, would explain why the Middle or Upper Silurian shales are found in close connection with the Ordovician Thorup Fjord limestone.

Devonian System.

Devonian strata were not recognized among the deposits examined by the present writer. A sequence of more than 1400 meters of unfolded Devonian sediments is present in southwestern Ellesmere Island, and marine Devonian beds may also occur on the west coast of Kennedy Channel.

A brief summary of the geological events within the map area during the Devonian period has been given on page 23 of the present report, and only a few remarks on the literature dealing with the stratigraphy of the Devonian system of Ellesmere Island need to be added.

Above the unfossiliferous Series C, which forms the lowermost part of the Devonian sequence, follows Series D, whose fauna according to Meyer (1913) ranges in age from Middle Helderberg (as Cooper, *et al.*, 1942, define that term) to Chemung. Loewe (1913) thinks that the corals indicate a range in age from Helderberg to Hamilton-Late Devonian, while Tolmachoff (1926) reaches the conclusion that only the Middle Devonian is represented in Series D. Kiær (1915) states that Division D-h, the next-highest division of Series D, cannot be referred to the Chemung but should probably be assigned to the lower part of the Upper Devonian or even to the transition strata between the Middle and the Upper Devonian.

Series E, which rests on top of Series D, contains fossil fishes and plants at several levels. The plants have been examined by Nathorst (1904), who refers them to the Late Devonian. Of the three horizons that have yielded fossil fishes, the oldest cannot be "paralleled with Chemung, but is of older Upper Devonian age", while the higher horizons give less definite indications as to their age (Kiær, 1915).

Around Trold Fjord and north and south of the central part of Bay Fjord, Schei (*vide* Bugge, 1910, p. 24; Kiær, 1915, p. 19) observed limestones, sandstones and shales with plant fossils which he tentatively referred to Series E. Meyer (1913, p. 10) mentions the occurrence in Schei's collections from Trold Fjord of a brachiopod which he (Meyer) compares to *Spirifer cameratus* Montfort. If this identification is correct, at least some of the beds at Trold Fjord must be younger than the Devonian.

The Devonian fossils from the west coast of Kennedy Channel have been described by Meek (1865; see also Hayes, 1867), who gives a list of Early Helderbergian fossils from "Capes Leidy, Frazer, and other points of the coast" between Bache Peninsula and Archer Fjord. The exact position of the exposures from which Hayes collected his fossils cannot now be determined. It is therefore with the greatest reservation that an occurrence of Devonian strata has been placed north of Scoresby Bay on the geological map.

It should finally be mentioned that the Dana Bay beds on the north coast of Grant Land, which Feilden and de Rance (1878) and Etheridge (1878) referred to the Devonian, have been shown by Whitfield (1908), Tschernyschew and Stepanow (1916, Vorwort), Holtedahl (1924, p. 146) and Koch (1935 b) to be of Late Carboniferous or Early Permian age.

Metamorphic and Sedimentary Rocks of Early Paleozoic(?) Age.

Across northeastern Ellesmere Island and North Greenland, intensely folded, more or less metamorphosed, unfossiliferous sedimentary rocks occupy a broad belt. The age of these rocks has been the subject of much discussion, but the weight of evidence seems now to be in favor of an Early Paleozoic age.

At the northeastern corner of Ellesmere Island (Cape Rawson and other points), Feilden and de Rance (1878) found strongly disturbed beds of jet-black slate and impure limestone. North of latitude 82°33′, "the above-mentioned rocks give place to a vast series of quartzites and grits". According to Feilden and de Rance, the southwestern boundary of the area of the Cape Rawson beds runs from the north side of Scoresby Bay across Kennedy Channel to Thank God Harbour on Halls Land and from there to the southern end of Newmans Bugt. The nature of the boundary was not determined. The northwestern boundary was observed on Feilden Peninsula, where the Cape Rawson beds are faulted against or unconformably overlain by Carboniferous or Lower Permian limestones (p. 26).

Subsequent work has shown that if one maintains the definition of the Cape Rawson beds as a group of folded unfossiliferous rocks, their southeastern boundary lies farther to the northwest than Feilden and de Rance assumed. Ordovician rocks are known north of Scoresby Bay; folded fossiliferous Silurian (?) strata at Cape Cracroft, some 18 kilometers south of Cape Baird (Greely, 1888, Vol. 1, p. 272); Ordovician limestones at Cape Baird; and "unfolded post-Silurian sandstone" (later called the Polaris Harbour formation) at Thank God Harbour.

Besides on Feilden Peninsula, the northwestern boundary of the area of the Cape Rawson beds has now been located with an accuracy of a few kilometers to a line near the head of Greely Fjord, where the Cape Rawson beds give place to Permian sediments (p. 67).

The Cape Rawson beds are now known to occupy a belt along the north coast of Greenland, where Koch (1920) found folded schists ("crystalline slates") with gneiss in the cores of the anticlines. In Ellesmere Island, the Cape Rawson beds have been observed from Feilden Peninsula in a broad belt along the coast southward to Archer Fjord and its tributary fjords, and from there along the valley of Dodge River to the head of Greely Fjord. Along the last-mentioned stretch the present writer found (1) dark-gray slate and phyllite, (2) dark-gray quartzitic sandstone, (3) dark-gray calcareous sandstone, and (4) dark-gray to black, rather pure limestone with dry-cracks. Neither gneiss nor intrusive rocks have been observed. As Dodge River runs in an anticlinal valley, the present writer has probably seen only a minor part of the section.

As to the age of the rather nondescript complex known as the Cape Rawson beds, widely differing opinions have been set forth. FEILDEN and DE RANCE (1878) and ETHERIDGE (1878) think that the group might be of Huronian age. DAWSON (1887) tentatively referred the group to the Cambrian. SCHEI (1903, 1904) suggests that the Cape Rawson beds may be the equivalent of the folded Mesozoic sandstones and shales on the coasts of Eureka Sound. LOW (1906) and WILLIS (1912) adopt SCHEI's theory by referring the Cape Rawson beds to the Triassic. KOCH (1920) correlates the group with his "post-Silurian, unfossiliferous sandstone" and with SCHEI's Series C, all of which he places in the Lower Devonian. In 1929, KOCH abandons this view without, however, substituting any new correlation. In 1935 (b), KOCH maps the belt of folding as "folded sediments, mostly Gotlandian".

As previously mentioned (p. 26), FEILDEN and DE RANCE (1878) figure a section which indicates that the Cape Rawson beds are older than the Carboniferous, but the nature of the contact could not be definitely determined. The present writer found somewhat similar conditions near the head of Greely Fjord (pp. 25, 28, 63). Regardless of the nature of the contact, the conclusion seems almost inescapable that the Cape Rawson beds are older than the Permian strata. The unmetamorphosed, slightly folded Pennsylvanian (Moscovian; Des Moines) sediments in Canyon Fjord are also so strikingly different from the Cape Rawson beds that one may be justified in assigning a pre-Pennsylvanian age to the latter.

As to the lower age limit of the Cape Rawson beds, nothing definite can be said. The beds may include the geosynclinal equivalents of all the pre-Pennsylvanian formations that are known from the foreland of the Franklinian geosyncline.

Mississippian System.

ETHERIDGE (1878) reports the occurrence in the limestone on Feilden Peninsula of a coral identified as *Lithostrotion junceum* (FLEMING) and a *Spirifer* species allied to *S. grimesi* HALL. According to WELLER, *et al.* (1948, p. 176), these species suggest the presence of Meramecian and Osagean strata. As the Dana Bay beds, which are said to be the oldest fossiliferous rocks occurring on Feilden Peninsula, are now referred to the Upper Carboniferous or the Lower Permian (p. 63), it seems doubtful whether Mississippian rocks are really present in the collection described by ETHERIDGE.

Pennsylvanian System.

Within the map area, beds of Pennsylvanian age are known only from a point on the east coast of Canyon Fjord immediately south of the eightieth parallel.

These beds, for which the writer proposes the name Canyon Fjord formation, are chiefly composed of gray impure, highly fossiliferous limestone overlain by gray sandstone.

A preliminary investigation of the fauna shows conclusively that the formation is of Middle Pennsylvanian age. The occurrence in Bed 1, described below, of *Fusulina* spp. shows that at least Bed 1 belongs to the Desmoinesian, which, according to DUNBAR (1940), should be correlated with the Moscovian series in Russia or the Middle Carboniferous of most European authors.

A section was measured along the right bank of a small brook at the type locality (fig. 9). The strata are listed below in descending order:

4. Gray limestone overlain by gray sandstone with poorly preserved Producti .... at least 15 meters
3. Soft violet limestone replete with *Fusulinella* n. sp. .... 0.20 meter
2. Grayish-white oolitic limestone with *Bellerophon* (?) sp. .... about 3 meters
1. Hard gray impure limestone alternating with beds of soft gray limestone. The rock is replete with partly silicified fossils, mainly corals, brachiopods and foraminifera. Among the latter are *Fusulina* n. spp., *Fusulinella* n. spp., *Wedekindellina* n. sp., *Ozawainella* sp., and *Staffella* sp. The brachiopods include *Spirifer* spp. and *Neospirifer* sp. indet. .... about 140 meters

Total... about 158 meters

In a creek bed in the vicinity, the writer's Eskimo companions collected a few loose-lying silicified fossils, among which are a *Neospirifer* sp. related to *N. triplicatus* (HALL); *Pugnax* (?) sp.; *Composita* spp.; and *Squamularia* sp.

A short distance south of the type locality (in the right middleground of fig. 9, at an altitude of about 160 meters above sea level), exposures, up to 2 meters high, of a white or light-gray limestone, which may be described as a coquina with numerous small foraminifera in its matrix, were examined by the writer. Its relations to the section described above are undetermined, but it shows lithologic similarity to Bed 2. The limestone contains but few determinable fossils, among which are a *Neospirifer* sp. of the *N. cameratus* (MORTON)-group; *Bakewellia* (?) sp.; and *Ozawainella* sp.

Above the coquina follow beds of yellowish-gray cross-bedded sandstone with conglomerate layers of varying thickness. The fragments

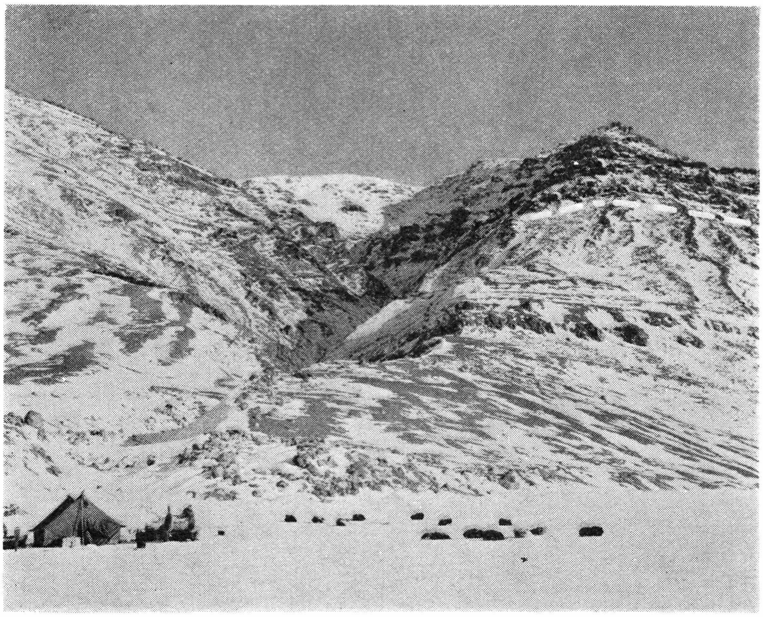

Fig. 9. Canyon Fjord formation overlain by sandstones and conglomerates of uncertain age. East coast of Canyon Fjord immediately south of the eightieth parallel.

in the conglomerates are ordinarily very small, but a few attain a diameter of about 10 centimeters. They consist of quartzite, reddish sandstone, chert, and gray limestone. The limestone pebbles, which contain large single corals, show great similarity to some of the rocks of Bed 1 of the section described above. Also the fact that the larger fragments in the conglomerates nearly always consist of gray limestone indicates that the limestone fragments are of local origin.

The cross-bedded sandstone with the conglomerate layers cannot be said to belong to the same lithologic unit as the Canyon Fjord formation, but as the sandstone is so imperfectly known that it will hardly be possible for the surveyor to recognize it in other localities, it does not merit a name of its own. About the geological age of the sandstone nothing is known except that it must be younger than the Canyon Fjord formation.

Permian System.

Permian beds are of widespread occurrence in the western Arctic. They are known from Northeast Greenland (cfr. Teichert, 1939) and from the Canadian Archipelago southwest of Ellesmere Island (cfr. Kindle, 1939). In Ellesmere Island and Axel Heiberg Island, Permian beds are known to occur on Feilden Peninsula (Feilden and de Rance, 1878), at Great Bear Cape (= Store Bjørnekap) and the northern tip of Axel Heiberg Island (Schei, *vide* Holtedahl, 1917) and around Canyon Fjord and Greely Fjord (W. Elmer Ekblaw, *vide* Koch, 1929 a, pp. 283—284; the present report, pp. 69 & 71).

Around the eastern part of Greely Fjord and the north central part of Canyon Fjord the writer examined extensive deposits of the Permian system of a total thickness of about 700 meters. The general name of Greely Fjord group is proposed for this sequence, but the writer finds that too little is known about the lateral extent of the divisions of the group and about the sedimentational history of the area to justify the giving of formation names to the several subdivisions.

Along the northern shore of Greely Fjord the strata dip gently toward the northwest, the only disturbances being local folding and occasional faults (fig. 10).

The lower contact of the group reaches sea level somewhere near the head of Greely Fjord. The place where one would expect to find the contact is covered with talus and drift, but apparently the Upper Paleozoic beds rest unconformably upon the intensely folded Cape Rawson beds (p. 63). In this vicinity, no trace was seen of the Pennsylvanian strata that are exposed in Canyon Fjord, but the possibility cannot be excluded that Pennsylvanian sediments may be present in Greely Fjord.

The oldest Permian strata examined are exposed some 10 kilometers east of the mouth of Tanquary Fjord. From an altitude of 160 meters to an altitude of 220 meters above sea level there are here beds of gray, reddish-weathering fossiliferous limestone (Division 1). A *Chaetetes* sp. is the only fossil brought home from this division.

Above Division 1 follows about 30 meters of yellow cross-bedded unfossiliferous sandstone with conglomerate layers (Division 2). The fragments in the conglomerates consist of reddish-yellow sandstone; black or multicolored chert; and gray limestone. Division 2 apparently reaches sea level somewhere in Tanquary Fjord.

Division 2 is overlain by at least 100 meters of gray massive, commonly arenaceous limestone with nodules of brown chert (Division 3). Stem joints of crinoids and poorly preserved single corals were the only fossils noticed in this division.

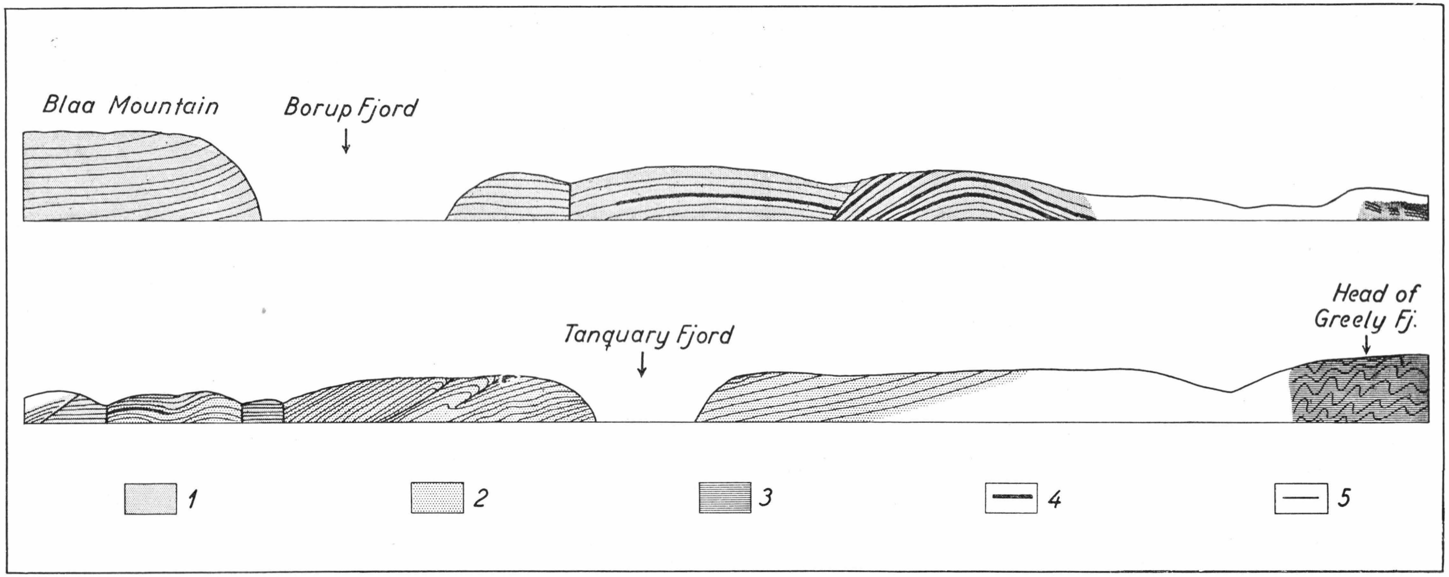

Fig. 10. Generalized section along the north coast of Greely Fjord. Vertical scale exaggerated around 6 times. *1.* Mesozoic sandstone, shale and limestone. *2.* Lower Permian limestone and sandstone. *3.* sandstone, shale and limestone of the Cape Rawson beds. *4.* sills. *5.* faults.

East of the mouth of Tanquary Fjord, the top of the section is formed by slightly metamorphosed and folded shales and limestones (Division 4). Division 4 may be studied immediately west of the mouth of the fjord, where it occurs from sea level up to an altitude of about 162 meters. The limestones of Division 4 have been transformed into white and gray, fine-grained marbles, certain layers of which are strongly brecciated, while others are locally folded because of differential movement between the enclosing, more competent beds (fig. 12). Sections through the shales exhibit some drag folds. In the uppermost part of Division 4, a poorly preserved trilobite pygidium and a few brachiopods of the group of *Spiriferella parryana* (TOULA) were collected.

Upwards, Division 4 passes gradually into a brown, commonly argillaceous or arenaceous limestone with large nodules of brown chert (Division 5). Division 5, which is at least 65 meters thick, has yielded the following species: *Dictyoclostus transversalis* (TSCHERN.), *Marginifera involuta* TSCHERN., *Marginifera* sp., *Camarophoria* sp. of the group of *C. mutabilis* TSCHERN., and *Fenestella* sp.

In 1917, the geologist of the Crocker Land Expedition, W. ELMER EKBLAW (MACMILLAN, 1918), collected a few fossils near the mouth of Tanquary Fjord[1]). These fossils are imbedded in a gray, occasionally arenaceous limestone that may well belong to Division 5. Among the fossils are *Syringopora* sp. indet., *Dictyoclostus* sp. indet., *Juresania* aff. *juresanensis* (TSCHERN.), *Linoproductus* aff. *koninckianus* (VERNEUIL), and *Linoproductus* sp. indet. Two of the samples contain a few specimens of fusulines, which is the more fortunate as not a single fusuline has been discovered in the very small collection brought home by the present writer. On sectioning the fusulines it is revealed that they belong to a small, primitive species of *Schwagerina* (*sensu strictu*) with chomata in the inner volutions.

The upper contact of Division 5 reaches the level of the sea some 10 kilometers west of the mouth of Tanquary Fjord. Upward it passes gradually into a greenish-white, somewhat silicified, unfossiliferous limestone, which is about 60 meters thick (Division 6).

Above Division 6 follows a yellow sandstone, about 40 meters thick, with large burrows or fillings of unknown origin (Division 7).

Division 7 is overlain by a red calcareous sandstone replete with brachiopods, among which the Producti are the most prominent (Division 8). The layer is from 5 to 10 meters thick.

Upward the red sandstone passes gradually into a sequence, about 100 meters thick, of calcareous glauconitic sandstone, which is greenish in the unweathered state but ochre-yellow on weathered surfaces (Divi-

[1]) Through the courtesy of Dr. THOMAS E. SAVAGE, University of Illinois, the collection has been made available to the present writer.

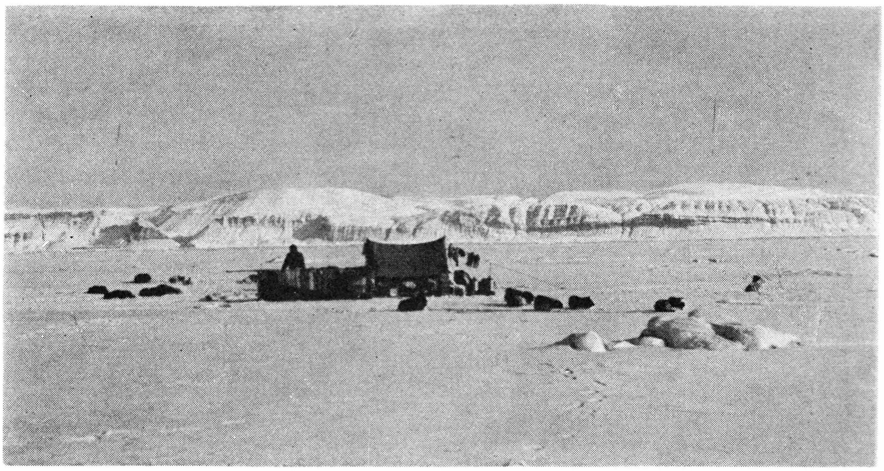

Fig. 11. Permian (?) beds along the south coast of Greely Fjord. The small unnamed bay may be seen to the left of the center.

sion 9). The upper part of this division is somewhat shaly. The more calcareous beds are developed as biostromes, crowded with brachiopods and bryozoans. The state of preservation of the fossils is generally poor. The only species known from Division 9 is *Linoproductus* n. sp. 1.

In the upthrown block in which the Permian beds are overlain by Mesozoic sandstone (fig. 10), Divisions 6 to 9 are present.

Division 9 is the youngest preserved member of the Greely Fjord group. Above a simple disconformity follow Mesozoic sandstones.

Exposures of the upper part of the Greely Fjord group may also be observed a little north of the central part of Canyon Fjord, i. e., at East Cape on the east coast and south of Cape With on the west coast (fig. 13). At East Cape one finds, below the Mesozoic sandstone, a green, sandy shale very similar to the upper portion of Division 9. Below the green shale there are at least 200 meters of interbedded strata of light-gray, dark-gray, dark-brown and black limestone and sandstone. Except for the green, sandy shale, the divisions of the Greely Fjord group, described above, cannot easily be recognized at this locality.

Many of the layers may be characterized as biostromes with innumerable brachiopods and bryozoans. The fossils are generally rather poorly preserved. In the small collection brought home from East Cape are the following species: *Linoproductus* n. sp. 1, *Horridonia* (?) cfr. *timanicus* (Tschern.), *Spiriferella* sp. of the group of *S. parryana* (Toula), *Dictyoclostus* sp., *Spirifer* sp. of the group of *S. ravana* Diener, *Spirifer* cfr. *fasciger* Keyserling, *Marginifera* aff. *involuta* Tschern., and *Fenestella* sp.

As to the age of the Greely Fjord group, the *Schwagerina* sp. mentioned in the description of Division 5, gives the best information. *Schwagerina* does not occur below the base of the Permian (DUNBAR, 1940), and the fact that the species from the Greely Fjord group possesses primitive characters suggests an Early Permian (Wolfcamp, Sakmarian) age of (at least part of) the group. *Schwagerina* species belonging to the

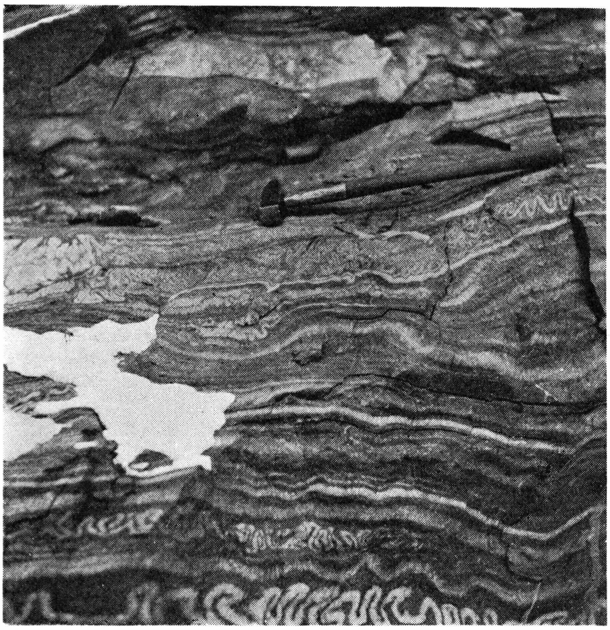

Fig. 12. Folded laminae of limestone of Division 4 of the Greely Fjord group. North coast of Greely Fjord, east of the entrance to Tanquary Fjord.

same evolutional stage as the one from Division 5 occur in the Upper Marine Sequence (zone of *Pseudoschwagerina*) of Northeast Greenland (unpublished report).

In the collections brought home by the Crocker Land Expedition there are a few pebbles from the beach at the head of Canyon Fjord. One of the pebbles consists of a medium-gray limestone crowded with specimens of a *Schwagerina* species. Although not conspecific with the *Schwagerina* species from the Greely Fjord group, it exhibits the same primitive characters and probably belongs to the same stratigraphic zone as the former. If the pebbles have been brought to their present place by fluvial or glacial activity, they must almost certainly have come from the region around the head of the fjord rather than from the north. The writer has, therefore, tentatively mapped as Permian an area southwest of the fjord, along the strike of the Upper Paleozoic beds farther to the northeast.

In 1940, G. THORLAKSSON collected a number of fossils at Great Bear Cape, which is one of the two places in which SCHEI discovered marine Permian deposits, the other being Svartevæg at the northern end of Axel Heiberg Island. THORLAKSSON's collection contains a. o. the following species: *Dictyoclostus* sp. conspecific with *D. inflatus* (TSCHERN., 1916; not McCHESNEY), *Horridonia timanicus* (STUCKENBERG), *Tschernyschewia* (?) *porrectus* (KUTORGA), *Linoproductus* (?) *weyprechti* (TOULA), *Marginifera typica* WAAGEN var. *septentrionalis* TSCHERN., *Camarophoria* aff. *mutabilis* TSCHERN., and *Spiriferella parryana* (TOULA).

The species, listed above, were identified by direct comparison with SCHEI's material (now in Oslo, Norway), which has been described by TSCHERNYSCHEW and STEPANOW (1916). The identifications are, therefore, in a certain sense, TSCHERNYSCHEW's.

As could be expected, the present fauna corresponds closely to the one previously described from Great Bear Cape. Unfortunately, not a single fusuline has been found in THORLAKSSON's collection. The brachiopods, however, indicate the possibility of a correlation with the Sakmarian series (zone of *Pseudoschwagerina*) of Russia. This was already stated by TSCHERNYSCHEW and STEPANOW (1916)[1]), but as pointed out by several authors (*vide* DUNBAR, 1940), a great deal of confusion exists in TSCHERNYSCHEW's interpretation of the Carboniferous and Permian sections of Russia. TSCHERNYSCHEW seems, however, to have interpreted his section from the Timan Arch correctly, and if the proper precautions are taken, a comparison between the fauna from Great Bear Cape and that of the Russian Permian, as described by TSCHERNYSCHEW (1902) may, therefore, be permissible. It seems that *Horridonia timanicus* occurs in the Omphalotrochus-, Cora- and "Schwagerina"-horizons; *Tschernyschewia* (?) *porrectus* in the "Schwagerina"-horizon; *Marginifera typica* var. *septentrionalis* in the Cora- and "Schwagerina"-horizons; and *Camarophoria mutabilis* in the "Schwagerina"-horizon of the Timan Arch. Although some of TSCHERNYSCHEW's identifications may need revision, the present writer is inclined to agree with TSCHERNYSCHEW and STEPANOW (1916) that the Great Bear Cape sequence should be referred to the zone of *Pseudoschwagerina*. If so, the sequence belongs to, or is the equivalent of, the Greely Fjord group.

The Permian faunas from the Feilden and Parry Peninsulas on the north coast of Grant Land were first described by ETHERIDGE (1878) and FEILDEN and DE RANCE (1878), who referred part of the species to the Devonian and the rest to the Carboniferous. TSCHERNYSCHEW (1902, pp. 693—695) is inclined to refer the whole fauna to the Late

[1]) Also the deposits on Axel Heiberg Island were referred to the "Schwagerina" zone.

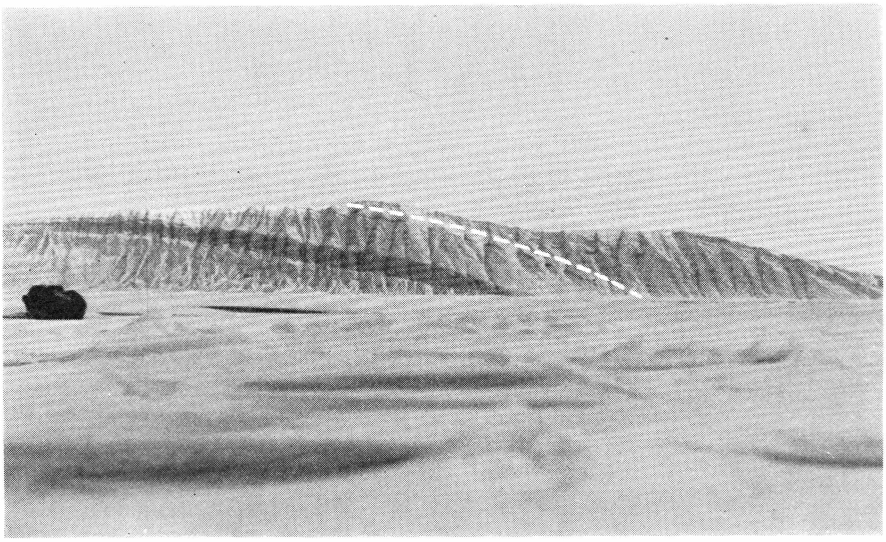

Fig. 13. Greely Fjord group overlain by sandstone of the Cape With formation. The black band is a quartz-dolerite sill. Cape With on the west coast of Canyon Fjord.

Carboniferous. WHITFIELD (1908) described some additional species and compared the fauna to that of the American Coal Measures.

TSCHERNYSCHEW and STEPANOW (1916, Vorwort) revise ETHERIDGE's identifications and point out (ibid., Vorwort, pp. 36, 41, 42, 43) that a number of species are common to the faunas of Feilden Peninsula and of Great Bear Cape and Svartevæg.

GRØNWALL (1917, pp. 601—604) and HOLTEDAHL (1924, pp. 145—147) review the literature on the fauna of Feilden Peninsula and give some information concerning the Permian deposits of the region southwest of Ellesmere Island. Finally, KOCH (1935 b, p. 619) states that he has examined FEILDEN's collections and found that they comprise "typical Schwagerina brachiopods".

Triassic and Jurasssic Systems.

Black shales and impure limestones interbedded with sandstones and containing pelecypods, especially *Halobia* and *Daonella*, and ammonites of Middle-Late Triassic (Ladinian-Karnian) age are known to occur at Goose Nose, Hat Island, Stor Island, and Blaa Mountain (SCHEI, 1903 & 1904; KITTL, 1907). THORLAKSSON's collections from Blind Fjord, Hare Nose, and a point on the coast of Raanes Peninsula southeast of Stor Island, contain samples of sandstone, black shale, and gray limestone very similar to those in SCHEI's collections and having some species in common with these, viz., *Pecten oscari* Kittl and *Halobia zitteli* Lindstr. (very abundant). Also indeterminable ammonites and *Discina* sp. occur in Thorlaksson's samples.

This sequence of interbedded black bituminous calcareous shales; gray limestones; and gray sandstones with a Ladinian-Karnian fauna dominated by *Halobia* and *Daonella* seems to form a lithologic and paleontologic unit. The upper and lower contacts have not been observed, and nothing is known about the thickness of the strata, except that it is probably of the order of magnitude of some hundreds of meters, but in the writer's opinion the sequence is sufficiently well characterized to be considered a distinct formation, for which the name Blaa Mountain formation is proposed. As type locality is designated Blaa Mountain (= the Blaafjeld of Schei and the Blauer Berg of Kittl) at the northern end of Eureka Sound, between Borup Fjord and Hare Fjord (figs. 10 and 15).

Mesozoic deposits of presumably younger age are exposed in Canyon Fjord and the eastern part of Greely Fjord. At Cape With on the west coast of Canyon Fjord, the Lower Permian Greely Fjord group is disconformably overlain by 300—400 meters of unfossiliferous yellow, reddish-weathering sandstone which, though not separated from the Permian by a basal conglomerate, shows much greater similarity to the overlying sandstone of known Mesozoic age than to the underlying green arenaceous shale of Permian age (fig. 13).

The yellow sandstone grades into a couple of hundred meters of gray fossiliferous sandstone with poorly preserved oysters and Rhynchonellids.

After a covered interval follows, some 500 meters north of the point where the upper contact of the Permian beds reaches sea level, the section that is shown in fig. 14. The section is described below in descending order:

5. Yellow unfossiliferous sandstones, the lower layers of which are soft and crumbling	about 80 meters
4. Dark crumbling unfossiliferous shales with scattered concretions	about 30 meters
3. Yellowish-gray sandstone with layers of coarse coquina. The fossils, which are rather poorly preserved, include *Gryphaea* aff. *incurva* Sow., Pectinids and other pelecypods	about 15 meters
2. Red or gray, unfossiliferous crumbling shales	about 22 meters
1. Gray or yellow sandstone with beds of coquina, which measure 1—2 meters in thickness. Besides fragments of fossils, the coquina contains carbonized plant remains, rounded quartz grains, and small pebbles of reddish-yellow sandstone. The known fauna consists of crinoid stems and poorly preserved gastropods and pelecypods	about 40 meters
Total...	about 187 meters

For the sequence of sediments that ranges from the upper contact of the Permian beds to the top of Bed 5 of the section, described above, the writer proposes the name Cape With formation. In the absence of ammonites, it is difficult to determine the age of the formation with any degree of accuracy. The occurrence of *Gryphaea* aff. *incurva* Sow. suggests an Early Jurassic (Sinemurian) age of the strata, but the species from the Cape With formation is much smaller than the oysters of the

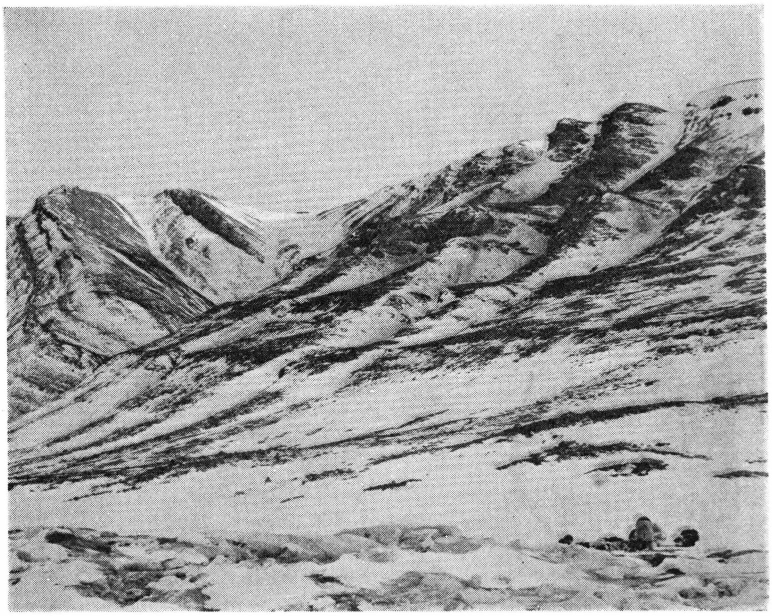

Fig. 14. Sandstone and shale of the Cape With formation. Immediately north of Cape With on the west coast of Canyon Fjord.

group of *Gryphaea incurva* that are so characteristic of the lowermost Jurassic formations of Europe. The small oysters from Canyon Fjord may be related to *Gryphaea arcuataeformis* Kiparisova, which has been described from deposits in eastern Siberia of doubtful Late Triassic (Karnian) age (Kiparisova, 1936). Considering, however, that the Triassic age of the Siberian deposits has not been definitely established and that *Gryphaea incurva* and related forms elsewhere are restricted to the earliest Jurassic, there is some basis for regarding the Cape With formation as being of Early Jurassic age.

There may be three different reasons for the absence (real or apparent) of the Triassic Blaa Mountain formation from the section in Canyon Fjord: (1) the Blaa Mountain formation may correspond to the unfossiliferous reddish-weathering sandstone at the base of the Cape With formation; or (2) a disconformity may separate the Blaa Mountain

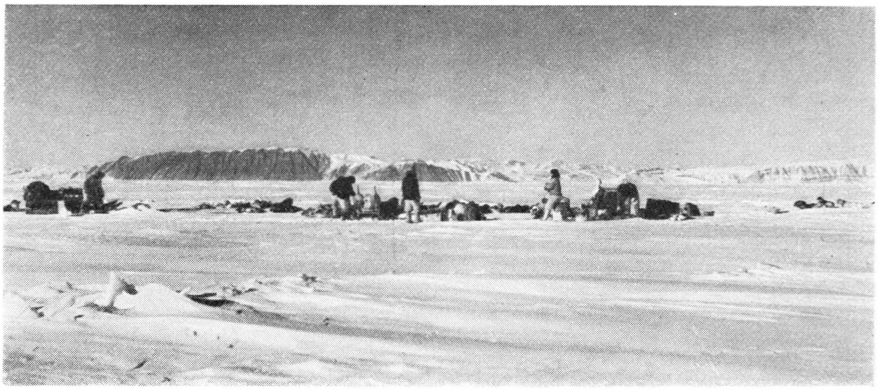

Fig. 15. The north coast of Greely Fjord seen from Iceberg Point. Blaa Mountain may be seen in the left background. The mouth of Borup Fjord is visible to the right of the center of the picture. In the cliffs, Mesozoic sandstone, shale, and limestone are exposed.

formation from the Cape With formation, the former having been removed by erosion from the Canyon Fjord region during the regression of the sea; or (3) the Early Jurassic (?) marine transgression may have reached farther east than did the Middle-Late Triassic one.

The Cape With formation is also exposed in the section at East Cape (cfr. the chapter on the Permian system) and along the north coast of Greely Fjord. In the latter place, the reddish-weathering sandstone that constitutes the lowermost part of the formation may be seen in a couple of down-faulted blocks 10—15 kilometers west of the mouth of Tanquary Fjord. The same layer may be seen resting upon

Fig. 16. Anticline in Mesozoic sandstone, shale, and limestone on the north coast of Greely Fjord (cfr. fig. 10). The black lines are sills of quartz-dolerite, dolerite, and olivine-diabase.

green shales of the Greely Fjord group in the westernmost exposure of the latter (fig. 10).

Besides the deposits of known Triassic and Jurassic (?) age, described above, sediments of supposed Mesozoic age have been observed on both shores of Eureka Sound by SCHEI, THORLAKSSON, and the present writer. These deposits are mostly composed of gray sandstones and dark-colored shales with carbonized plant remains (fig. 17).

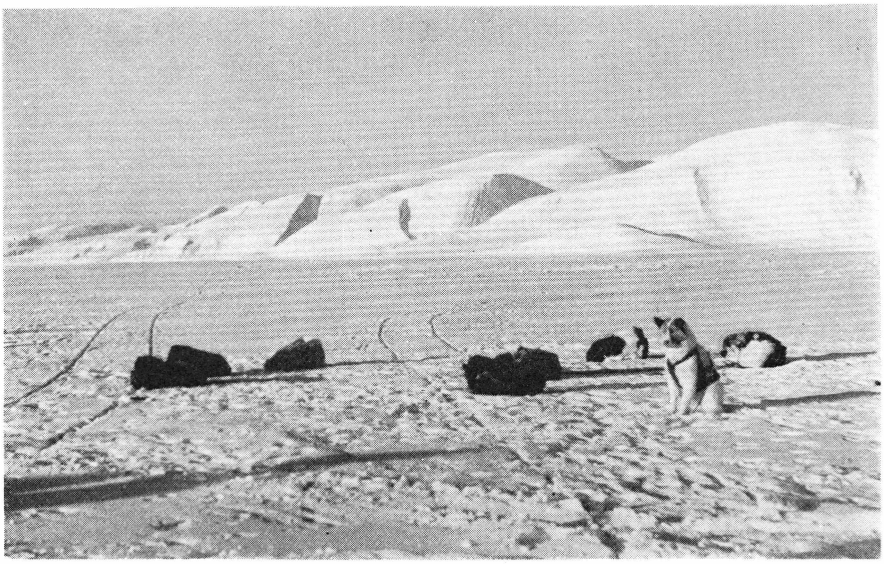

Fig. 17. Exposures of Mesozoic (?) sandstones and shales on the east coast of Eureka Sound, immediately north of Vesle Fjord.

A coal bed on the southwest coast of Raanes Peninsula may also belong to these deposits. The coal, which is hard, brittle, and lustrous and much more altered than the lignites ordinarily found in the Cretaceous or Cenozoic deposits, occurs, according to THORLAKSSON, in a sequence of shaly marl and dark shales and may well be of Early Mesozoic age.

In the large anticline on the north coast of Greely Fjord (fig. 16) the present writer investigated a section through gray sandstone and fissile arenaceous shale with a bed, about 50 centimeters thick, of dark-gray limestone. The limestone contains numerous small oysters and Rhynchonellids, all of which must be said to be indeterminable.

No basis for an exact determination of the age of the deposits, mentioned in the three foregoing paragraphs, has been found. It is reasonable to assume that the strata are younger than the Lower Permian Greely Fjord group, and they have all been affected by the younger (Mesozoic or Cenozoic) orogeny, but in the absence of determinable fossils no further age determination is possible.

Cretaceous or Cenozoic System.

Already on Nares's expedition (Feilden and de Rance, 1878), undisturbed beds of sandstone and shale with seams of lignite were discovered in a valley in the folded Cape Rawson beds at Discovery Bay at Lady Franklin Sound. Members of Greely's expedition (Greely, 1888, Vol. 1, p. 271) found large petrified tree trunks and impressions of leaves and twigs at Cape Baird. Elsewhere in Greely's report, mention is made of occurrences of lignite at Wrangel Bay (opposite Halls Land) and in various places around Lady Franklin Sound. While the fossil wood and the other plant remains at Cape Baird possibly occur in place, the samples of lignite from the other localities may have been collected from the drift. There is little doubt, however, that lignite-bearing strata are of rather widespread occurrence in the valley systems of northeastern Ellesmere Island. Though a correlation between these deposits and the lignite-bearing beds at Discovery Bay cannot be supported by direct evidence, it seems probable that all the plant-bearing beds of northeastern Ellesmere Island were deposited during the same general period of sedimentation.

In valleys and terraces around Eureka Sound and its tributaries, Schei found undisturbed and unconsolidated sandstones and shales with occasional seems of lignite. Schei (*vide* Nathorst, 1915) noticed such deposits at Stenkul Fjord; on the west coast of Skaare Fjord; east of Blaamanden; west of Blaa Mountain; and on Richard Island (= Graham Island).

Similar lignite-bearing beds were discovered by Thorlaksson at the entrance to Glacier Fjord. North of Bay Fjord and on the east coast of Eureka Sound, north of Vesle Fjord, the present writer observed extensive deposits of nearly horizontally bedded sandstone, gray arenaceous shale, black carbonaceous shale and clay ironstone with lignite, calcified wood, and impressions of leaves of conifers and deciduous trees. A similar sequence at the head of Bay Fjord appears to have been tilted a few degrees after deposition.

For all the above-mentioned deposits of sandstone, shale, and lignite that are younger than the last orogeny, the writer proposes the name Eureka Sound group. The history of deposition of the group has been discussed on page 34 of the present report.

Other occurrences of lignite that may belong to the Eureka Sound group have been reported from Møkka Fjord (James van Hauen; personal communication), the south coast of Bay Fjord (MacMillan, 1918, p. 343; 1927, p. 168), the south coast of Axel Heiberg Island (MacMillan, 1918, p. 238), and Amund Ringnes Island, which lies west of Axel Heiberg Island (Haig-Thomas, 1940, p. 273). On the beach north of Great Bear Cape, THORLAKSSON collected a large piece of crumbling lignite that probably came from an exposure of the Eureka Sound group in the nearest vicinity.

HUMPHREYS (1936, p. 403) reports the occurrence on the south coast of Bay Fjord of a coal bed which, "as far as could be seen, appeared to occur as a vertical seam about 2 yards wide". North of Trold Fjord, at a point on the south coast of Bay Fjord that apparently is located a little west of the exposure examined by HUMPHREYS, THORLAKSSON observed strongly disturbed beds of sandstone interbedded with crumbling carbonaceous shales. As the sediments of the Eureka Sound group normally are undisturbed except for secondary deleveling, it seems extremely doubtful whether the deposits discovered by HUMPHREYS and THORLAKSSON are of the same age as the former. A piece of silicified wood that THORLAKSSON collected at the exposure north of Trold Fjord resembles, according to F. J. MATHIESEN, samples of wood from the occurrence of the Eureka Sound group north of Bay Fjord and may have come from strata that are younger than the disturbed sequence.

As to the age of the Eureka Sound group, it has commonly been assumed that the group is of Cenozoic age. On the basis of leaves of deciduous trees, HEER (1878) referred the deposits at Discovery Bay to the Miocene. SCHEI (*vide* HOLTEDAHL, 1917, p. 20) regards, probably on the strength of HEER's opinion, the lignite-bearing strata around Eureka Sound as being of Miocene age, while NATHORST (1915), in his description of the sequence at Stenkul Fjord, merely refers them to the Cenozoic system without attempting any detailed correlation. KOCH (1929a, p. 285), for unstated reasons, considers the Eureka Sound group as being of Eocene age.

In the hope of gaining further information as to the age of the group, the writer had thin-sections made of samples of excellently preserved calcified wood from Bay Fjord and handed them over to Professor F. J. MATHIESEN, of the College of Pharmacology in Copenhagen, who kindly undertook the examination of the slides. According to Mr. MATHIESEN, all the samples from the exposure at the head of Bay Fjord belong to the type of *Cupressinoxylon*, while those from the north coast of the fjord may be classified as *Xenoxylon*. Both types of wood occur throughout the Jurassic, Cretaceous and Cenozoic periods, but the occurrence in the same strata of leaves of deciduous trees suggests that the deposits are not older than the Cretaceous. In the opinion of Mr. MATHIESEN, the plants referred by HEER (1878) and NATHORST (1915) to the Cenozoic may as well be of Cretaceous age. Until more evidence has been brought to light, one must therefore be content with regarding the Eureka Sound group as being of either Cretaceous or Cenozoic age.

Intrusive Rocks.

As mentioned elsewhere in the present report (pp. 19 and 32), post-Archean intrusive activity centers around Smith Sound and Eureka Sound.

In the former area, the eo-Cambrian sequence has been penetrated by sills and dikes of dolerite, which are especially abundant in the thick, faulted deposits in the area between Etah and Thule. These rocks have been examined by Bugge (1910), Callisen (1929), and Munck (1941).

The intrusives around Eureka Sound penetrate Permian and Mesozoic deposits but are older than the Eureka Sound group. Bugge (1910) has described some of these intrusives. Additional material, brought home by the Danish Thule-Ellesmere Land Expedition, has been examined by Dr. A. Noe-Nygaard, Director of the University Museum of Geology and Mineralogy in Copenhagen. Through the courtesy of Dr. Noe-Nygaard, the description, given below, has become available:

Sill in the large anticline on the north coast of Greely Fjord (fig. 16) (No. 251):

A medium-grained dolerite composed of plagioclase; clinopyroxene; ilmenite; micropegmatite with some quartz; and fairly large patches of chlorite. The plagioclase is strongly altered, and a very small quantity of secondary pleochroic biotite is present. The rock may be classified as a quartz-dolerite.

Sill in the large anticline on the north coast of Greely Fjord (fig. 16) (No. 252):

A rather coarse-grained dolerite consisting of plagioclase; clinopyroxene, which is probably titaniferous; iron-ore (whether magnetite or ilmenite is undetermined). Micropegmatite is absent. Reddish-brown biotite is rather abundant. The rock is a dolerite.

Sill in the large anticline on the north coast of Greely Fjord (fig. 16) (No. 253):

A rather coarse-grained dolerite consisting of olivine; clinopyroxene; ilmenite, possibly with some magnetite; plagioclase; and some light-muddy-green chlorite. Micropegmatite is absent. A very small quantity of biotite occurs in the iron-ore. The rock may be characterized as an olivine-diabase or olivine-bearing dolerite.

Sill in the Permian beds on the north coast of Greely Fjord (fig. 10) (No. 298):

A rather coarse-grained dolerite composed of plagioclase; clinopyroxene, which is somewhat titaniferous; iron-ore, probably predominantly ilmenite; rather coarse-grained apatite; muddy-brownish-green chlorite; rather abundant biotite; micropegmatite; and a little calcite. The rock should be classified as a quartz-dolerite.

Sill in the Permian beds at Cape With in Canyon Fjord (fig. 13) (No. 275):

A medium-grained dolerite composed of plagioclase; rather strongly altered clinopyroxene; ilmenite; quartz; some strongly pleochroic biotite; rather large patches of chlorite of light-green and bluish-green color; and apatite. A few pleochroic halos have been observed in chlorite-biotite (zircon?). The rock is a quartz-dolerite.

Dike in Mesozoic (?) sandstone 5—6 kilometers south of Iceberg Point (No. 247):

A coarse- to medium-grained basalt composed of plagioclase; clinopyroxene; a little partly altered olivine; iron-ore; and a partly opaque interstitial substance with yellow, originally glassy, isotropic grains. The rock is an olivine-bearing basalt.

Dike in Mesozoic (?) sandstone at Blaamanden in Eureka Sound (No. 244):

A rather coarse-grained dolerite composed of strongly altered plagioclase; clinopyroxene; iron-ore, predominantly ilmenite; large, irregular patches of light-green chlorite with a few pleochroic halos (zircon?); apatite; and some biotite. The rock may be classified as a dolerite.

Dike in Mesozoic (?) sandstone on the western part of the north coast of Bay Fjord (No. 242):

A fine-grained ophitic basalt composed of plagioclase; titaniferous clinopyroxene; iron-ore; a certain amount of partly opaque interstitial substance; and a few pseudomorphs (?) in muddy-brown chlorite after olivine (?). The rock is a basalt.

Sill (?) in Mesozoic sandstone on the west coast of Raanes Peninsula, at about 78°20′ N. lat. (collected by G. Thorlaksson):

A very strongly altered coarse-grained rock containing iron-ore, probably predominantly ilmenite; much apatite; some biotite; green chlorite; and completely opaque feldspar with sericite and other alteration products. A dark mineral that is a prominent component of the rock is probably a titanium-augite. If the feldspar originally was a labradorite, the rock should be interpreted as a gabbroid dolerite or a gabbro, but the identification is uncertain.

It will be noted that titaniferous minerals take part in the composition of nearly all the intrusive rocks described above.

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ADDENDUM

When the present report was in the galley proofs, a paper by H. Frebold, entitled "Die Arktis" (Geologische Jahresbericht, Band IV B, 1942), was brought to the writer's attention. On pages 24—29, Frebold gives an account of the (then) latest papers on the geology of North Greenland and the Canadian Arctic. Unfortunately, undue importance has here been attached to a statement by Troelsen (1940; cfr. the present paper, p. 28, footnote) to the effect that the only orogeny that has left a record in Ellesmere Island took place in Mesozoic-Cenozoic time.

Frebold further states that the present writer agrees with Wordie (1938) in that the sediments of the Thule group are succeeded without apparent break by Lower Cambrian strata. This is a misinterpretation caused by the circumstance that Troelsen (1940) separated the Cape Ingersoll dolomite (the "Ophiomorph limestone") from the Thule group (cfr. the present report, pp. 35—37).

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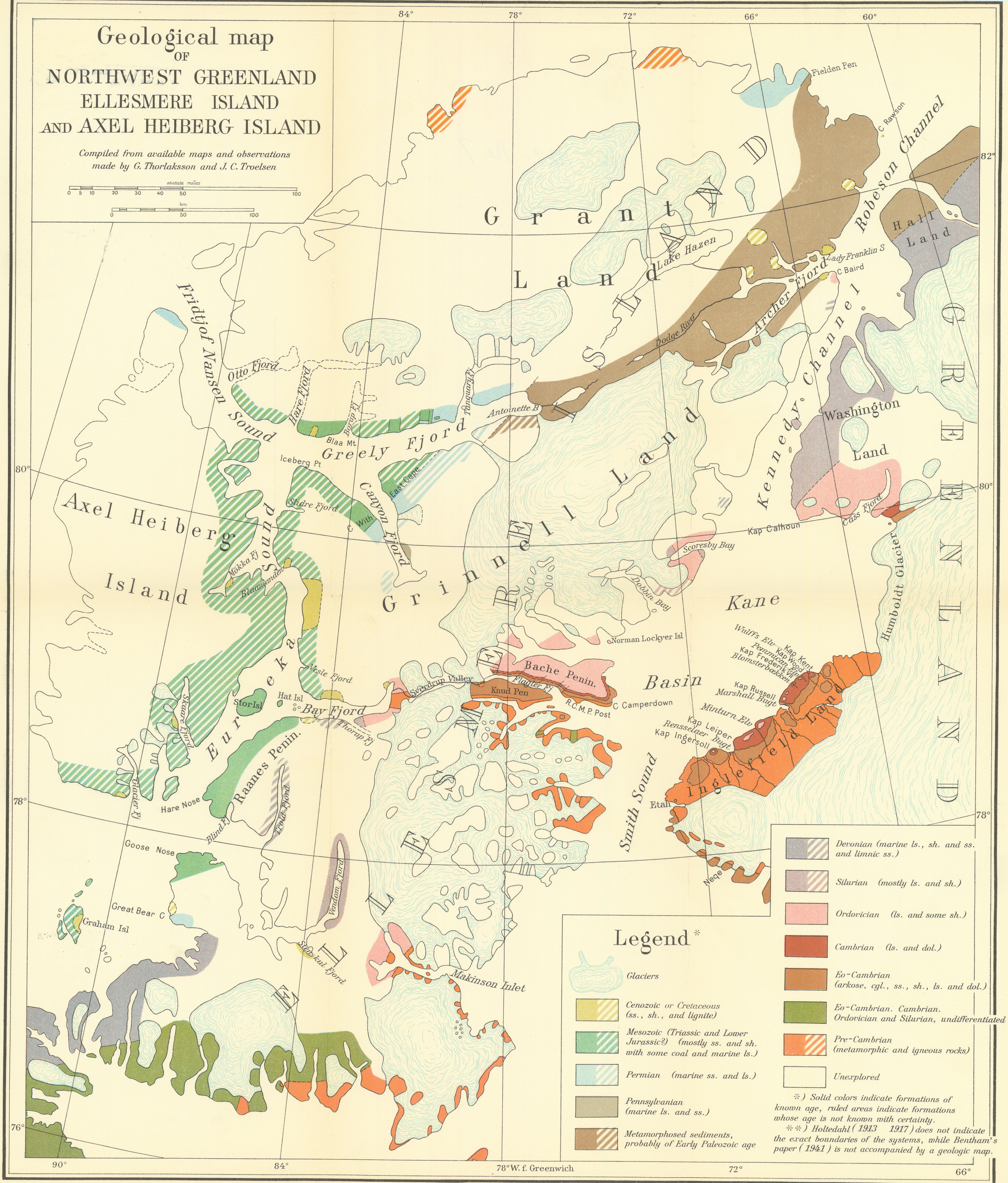

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