

A NEW FAULT ZONE IN NORTHWEST GREENLAND.

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During the autumn of 1920, I made several sledge journeys in the Cape York district, which led through regions only slightly known. Most of the journeys were made after the dark time had set in, nevertheless I got the impression that the faults in this district were much larger than I had assumed during my stay in North Greenland in 1916-18.¹

During my stay in the Cape York district in 1921 and 1922 I had abundant opportunity for studying the large faults. Experience soon showed me, however, that it would be quite impossible to get a general idea of the real extent of the fault-system as long as no good topographic map of the district existed. In the spring of 1922 I had the opportunity of measuring the region around my station and the coast northward as far as Etah at $78^{\circ}20'$ N. lat., and in the spring of 1923 I mapped the whole Cape York district and thus finished my mapping of the northern fourth of Greenland.

While mapping I especially examined the faults and entered a great many points on the map which were of importance for understanding the structure. My topographic and geologic survey of the Cape York district in the spring of 1923 was favored by an excellent surface and generally fine weather, and, moreover, I now knew almost the whole district and could get all the help I needed from the various Eskimo settlements.

FORMER OBSERVATIONS.

The first to mention the geological conditions in the Cape York district was Sutherland,² who traveled through these regions in 1852. In consideration of the fact that Sutherland, a ship's surgeon, only saw the district from the deck, it must be noted that his remarks as to the disposition of the strata are extraordinarily clear and exact. He first mentions that Saunter's Island consists of sediments that are lying hori-

*Translation of *Et nyt Forkastningsomraade i Nordvestgrönland*; by Lauge Koch. Translation made by Dr. Koch and checked by C. E. Resser.

¹Koch, Lauge, *Stratigraphy of North Greenland*. Meddel. fra Dansk Geol. Foren., 1920.

²Sutherland, P. C., *A few Remarks on the Physical Geography, 147-192*, in: E. A. Inglefield: *A summer Search for Sir John Franklin*. London, 1853.

zontal, in contrast to the beds somewhat east of Cape Atholl which, in his opinion, dip to the southwest. At the settlement Omenak (now Thule) he reported calcareous sandstone with strata of greenstone (diabase), dipping 15° to the west-southwest. In the interior of Wolstenholme Fiord Sutherland discovered strata dipping 10° to 30° to the southwest. From Granville Bay he mentions strata, the dips of which vary very much; in some places they are almost horizontal, in others dipping as much as 45° in various directions. From Cape Parry to Bardin Bay the strata descend towards the west, and in several places they are slightly flexured. Farther eastward Sutherland observed strata dipping up to 30° towards the southwest, and from the eastern shore of Bardin Bay he mentions the same calcareous sandstone as at Omenak. The layers, which are here also slightly folded, dip 15° towards the west-southwest.

At several places on Northumberland Island, Herbert Island, and Milne "Island" he observed altogether horizontal strata: "At C. Saumarez the same strata can be traced from one cleft to another, in conformable and horizontal lines over many miles."³ Finally he observed slightly folded strata at Cape Atholl, in contrast to the sediments in Crystal Palace Cliff, which are quite horizontal.

Sutherland has given a complete description of the structure of the strata along the route that his ship followed through the district. His angles of dip are, however, too large, probably not having been measured but only estimated, and he did not always note the fact that owing to erosion, level or sloping strata may appear folded. Altogether, Sutherland's observations are, however, excellent for his time, at any rate they are the most complete description of the structure of the district.

In 1894 T. C. Chamberlin participated in the Peary Auxiliary Expedition under Henry G. Bryant.⁴ He describes the geological conditions in Inglefield Gulf, mentioning crystalline rocks, sandstone, and shales of various ages. He is of opinion that even if the sediments in several places extend toward the interior underneath the ice cap, they form only a narrow zone along the coast, since in many places they are traversed by fiords and valleys reaching the gneiss farther inland. Further, Chamberlin mentions that on Redcliff Peninsula, which is

³Op. cit., 156.

⁴The Peary Auxiliary Expedition of 1894 by Henry G. Bryant. Geology by T. C. Chamberlin. Philadelphia, June 1895.

covered by a local firn detached from the ice cap, are often found blocks of gneiss in the young moraines, though the whole peninsula seems to be composed of sediments; underneath the firn there must consequently be gneiss, which, however, is not visible on the coast.

In 1920 I published my geological observations of the Second Thule Expedition of 1916 to 1918,⁵ and on pages 22-23 I discussed the tectonics of the Cape York district. I mentioned that in most places the strata are horizontal, but that dislocations have taken place, since in some places the sediments are considerably inclined. My opinion, which was chiefly based on journeys in the outermost part of the district, was that as a rule the sediments are horizontal and the dislocations are not very prominent. Not until 1920, during my journeys in the interior of the fiords, did I observe that the structure of the Cape York district was much more complicated than I had assumed at first.

THE STRATIGRAPHY OF THE CAPE YORK DISTRICT.

It is not quite clear from Ross' description⁶ that sediments occur in the Cape York district. Sutherland was the first who mentioned the red sandstone and the basalt which he knew from Disko. Feilden⁷ also compares a red sandstone in Foulke Fiord with the stratum in Disko Bay, especially after a piece of coal had been found on the shore. Chamberlin, though with some question, refers the sediments in the Cape York district to the Tertiary on account of their resemblance to the Disko strata. Kane⁸ mentions red sandstone and Silurian limestone from Inglefield Land without, however, mentioning the occurrence of fossils. Haughton⁹ correlates the red sandstone in the Cape York district with the red sandstone in Lancaster Sound, where it occurs together with Silurian strata. In accord with Haughton, Feilden refers the sandstone in Wolstenholme Fiord to Silurian. Schei¹⁰ puts

⁵ Op. cit.

⁶ Ross, J. A., *Voyage of Discovery in His Majesty's Ships Isabella and Alexander*. London, 1819.

⁷ Feilden, H. V., and DeRange, C. D., *Geology of the Coasts of the Arctic Lands visited by the late British Expedition under Capt. Sir George Nares*. *The Geological Journal*, 34. London, 1878.

⁸ Kane, E. K., *Arctic Explorations*. Philadelphia, 1856.

⁹ Haughton, *Geological Account of the Arctic Archipelago*. App. No. 4 in *M'Clintock: Fate of Franklin and his Discoveries*. London, 1859.

¹⁰ Schei, P., *Vorläufiger Bericht über die geologischen Beobachtungen auf der zweiten norwegischen Polarexpedition*. Leipzig, 1903.

Pre-Cambrian strata on his geological map in the places where Feilden put Miocene, and north of this Cambro-Silurian. Low,¹¹ who knew the Pre-Cambrian red sandstone from Canada, refers the sediments in the Cape York district to Huronian, in accord with Willis,¹² who, however, made an exception with regard to the strata north of Cape Alexander which he, evidently under the influence of Feilden, refers to Tertiary. Holtedahl,¹³ who studied Schei's material from Bache Peninsula, refers the sediments in Foulke Fiord to Cambrian. In my work of 1920 I almost agreed with Holtedahl's opinion in regard to the age of the sediments, since I could hardly think that there existed so large a series of strata from the Tertiary without the slightest indications of fossils, which were never found in the Cape York district. The age of the series of strata, as is evident from what is mentioned above, remained uncertain until July 1922 when I found the series of sandstone on Inglefield Land overlain by Lower Cambrian conglomerates and limestone containing a well-preserved *Olenellus* fauna and separated from the sandstone by a distinct unconformity. Thus it was proven that the sandstone series in the Cape York district is Pre-Cambrian.

Chamberlin gave the first rather complete stratigraphic description of the strata. According to him the gneiss is overlain by red sandstone and shales of a dark red-brown color. In several places, as already mentioned by Sutherland, younger and more basal eruptives occur. According to my observations the classification proposed by Chamberlin may be fully maintained. The lower sandstone series is dark-red or brown; it commences with a basal conglomerate, and thin conglomeratic beds occur through the whole series. *Cryptozoon* reefs are not uncommon in the deep-red sandstone. The yellow sandstone seems to have been deposited in very shallow water, possibly even on land. The cross-bedding and ripple-marks are very distinct, and the uppermost series of strata, which are composed of dolomites, slaty sandstone, and black slates, show ripple-marks, rain-drop impressions, and salt-pseudomorphs.

¹¹ Low, A. P., Rapport de l'expédition du Gouvernement du Canada à la Baie d'Hudson et aux Iles Arctiques à Bord du Navire du Gouvernement du Canada "Le Neptune." Ottawa, 1912.

¹² Willis, B., Index to the Stratigraphy of North America. U. S. Geol. Survey, Professional Paper 71. Geological Map. Washington, 1912.

¹³ Holtedahl, O., The Cambro-Ordovician Beds of Bache Peninsula. Report of the Second Norwegian Arctic Expedition in the "Fram," 1898-1902. Report No. 28, Kristiania, 1913.

The contrast in colors between the deep-red and the yellow sandstone renders it quite easy to point out the faults. On the other hand it is sometimes difficult to distinguish the middle yellow sandstone from the overlying slates and dolomites, and, on the whole, the limits between these two series of strata are not easily found.

THE VARIOUS FAULTS.

Looking at the map in Fig. 1 it will be seen at once that a distinct fault runs from Cape Alexander to the interior of Inglefield Gulf, and this fault may also be traced in the interior of the fiords. North of this fault the gneiss forms a plateau at an altitude of about 800 meters. The ice cap extends almost to the boundary of this plateau, which is traversed by steep valleys from which several glaciers pour out.

South of the fault we find sediments, and it may be stated with certainty that the throw of the fault along this line (see Fig. 2, A-A) is about 800 meters. The fault appears again at the settlement Kangerdluaksuak south of Inglefield Gulf, and may be traced to Olrik Bay and, following the direction of the fault, I have, although with some doubt, linked it with the fault in Dead Men's Fiord north of Cape York. East and north of this large fault no sediments occur.

On Prudhoe Land, especially to the west, and parallel with this fault, is another fault, bounding an area of syenite that originally covered the gneiss and may be traced into the interior of MacCormick Bay, where the syenite still covers the gneiss without being separated from it by faults (see Fig. 2). With regard to Prudhoe Land it may quite naturally be assumed that there is a second line of faults along the coast. The numerous small fiords extending to fault A and beyond as glacier-filled valleys into the gneiss area have, I think, been formed by faults, but I have no definite information. In Fig. 2 I have also tried to show the structure of Prudhoe Land by the aid of a series of profiles.

The elements of the land between Inglefield Gulf and Olrik Fiord are easily determined. The faults in this region run southeast-northwest, the highest portions (in two places even gneiss) occurring to the northeast, and the strata dip southwestward as on Prudhoe Land. An exception, however, is formed by a small fault zone extending parallel to the north coast, where the gneiss reaches an altitude of 500 meters and

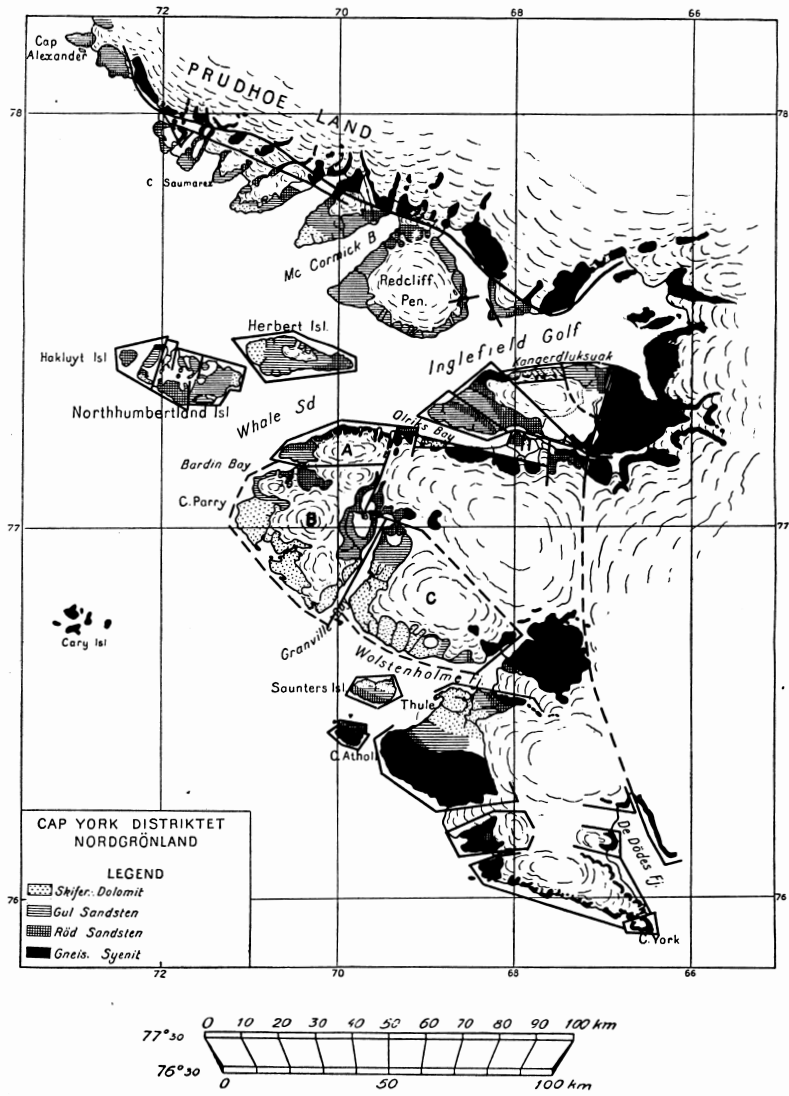


Fig. 1. Cape York district, North Greenland.

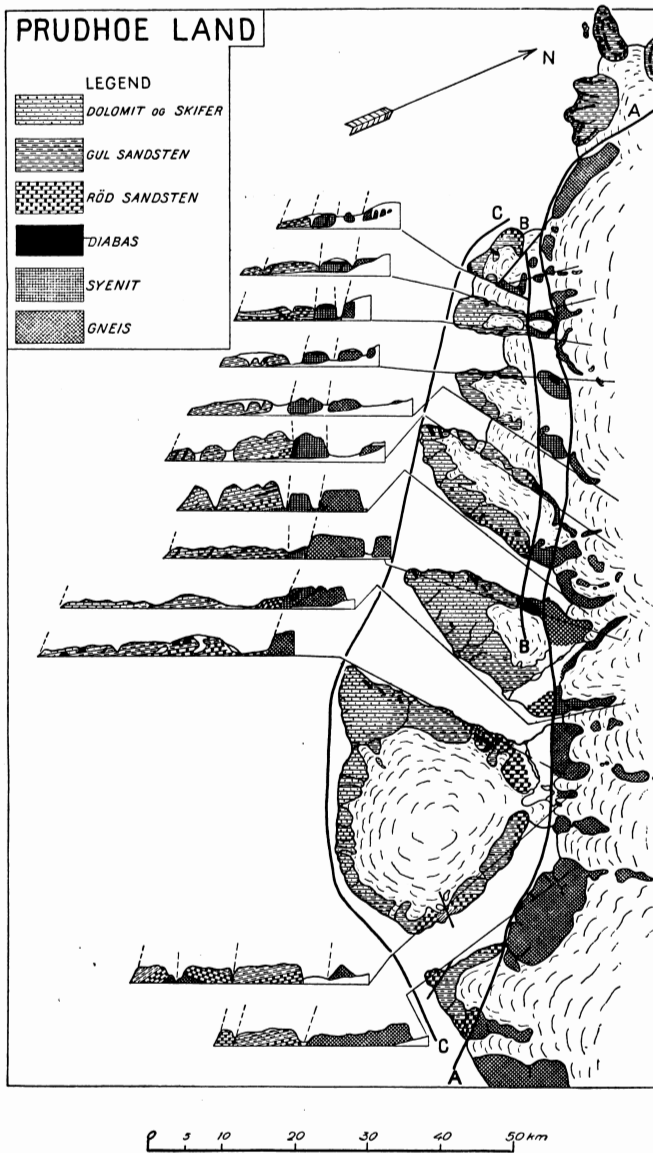


Fig. 2. The tectonic conditions in Prudhoe Land.

a small area of black slates, i.e., the upper part of the sedimentary series, is separated from this by a fault of a considerable throw.

The same is the case along the south coast of Olrik Fiord. In this place faults also occur south of and parallel to the coast, and from the map will be seen the great influence this has had on the shape of Olrik Fiord, which is due to faults.

A large system of faults extends northward from Granville Bay, which most likely has also been formed by faults, and farther on parallel with the fiord to Inglefield Gulf. Between Inglefield Gulf and Granville Bay this fault is marked by a valley which is very much used by the Eskimos as a sledge route, when in autumn and spring there is no ice around Cape Parry. From this glacier-filled valley, a valley runs to Bardin Bay, and the geological conditions near the coast show that this valley also has been formed by faults.

The whole peninsula between Whale Sound and Olrik Fiord and Wolstenholme Fiord consists of at least three blocks, A, B, and C, which all slope towards the southwest (see Fig. 1). The same is the case with regard to Herbert Island, whose eastern headland is made up of the lower strata of the dark-red series of sandstone. When travelling westward along the coast one encounters successively younger strata.

Northumberland Island and Hakluyt Island are considerably more complicated. Northumberland Island like Herbert Island must, I think, be considered as a horst which, however, is traversed by several faults running north-south. On the northern coast of this island the gneiss is again visible and in continuation of this there is shallow water towards Hakluyt Island, which seems to indicate that the sea bottom consists of gneiss. The western portion of Northumberland Island and Hakluyt Island together form a fault area dipping to the southwest. The central part of the island is traversed by numerous smaller faults which, however, cannot be entered upon this map, but as a whole the strata dip toward the south. The eastern area lies almost horizontal, inclining slightly to the east.

The shores at the head of Wolstenholme Fiord are made up of gneiss below, then follow thin layers of dark-red and yellow sandstone, overlain by dark slates dipping upwards of 12° southwestward. The same is true of the strata at Thule. South of the settlement a low valley leads in to the ice cap and indicates the bottom of a flat syncline, which can also be traced on Saunter's Island.

Cape Atholl and the land east of this cape consist of gneiss, which continues into Wolstenholme Fiord and possibly farther on up to Cary Island. While the whole series of sediments in the Cape York district thus dips towards the southwest, i.e. almost parallel to the coast, there is a flat syncline in the southern part of Wolstenholme Fiord and south of this a gneiss horst. In the vicinity of Cape York no sediments occur, but it must be assumed that the peninsula west of Dead Men's Fiord is traversed by faults, since the gneiss plateau at this place is composed of a system of blocks traversed by glacier-filled valleys.

THE MORPHOLOGY OF THE CAPE YORK DISTRICT.

In Fig. 1 is shown the extension of the Cape York district which, compared with other well-known areas, comprises about two-thirds of West Spitzbergen. The morphology of this region is, naturally, dependent to a very great extent on the various local fracture-lines. Above I have mentioned that fiords such as Olrik Fiord, Granville Bay, and maybe also the fiords on Prudhoe Land have been formed by faults. The coasts may also be referred to various classes or types such as precipitous coasts composed of elevated gneiss or the dark-red sandstone, or sloping coast mountains that, as a rule, are composed of yellow sandstone, or again flat shores with low land behind, composed of dark slates. In early literature the close resemblance of Saunter's Island to Herbert Island, which consists of flat plateaus with steep walls, is already mentioned. Further, Northumberland Island resembles Wolstenholme Island to some extent, since these islands are traversed by faults, and Alpine scenery with local glaciers occurs. I never observed foldings in connection with faults, whereas flexures are of common occurrence.

In Fig. 2 it will be seen that the sediments in several places are penetrated by diabase dikes, and in several places there are large sills. It has been impossible to ascertain a direct correlation between the diabase and the faults. The diabase seems without exception to be older than the tectonic dislocations.

THE AGE OF THE FAULTS AND A COMPARISON WITH OTHER REGIONS.

In spite of zealous investigations I did not succeed in finding Cambrian strata in the Cape York district. On the whole,

there were only a few Pre-Cambrian sediments in connection with the faults. The strata themselves thus give no information as to the age of the faults. When comparing this region with others it will be seen that Schei¹⁴ found faults along Heureka Sound west of Ellesmere Land. According to the slight information on this matter it may be expected that a closer examination will show a large fault area in the regions west of the Cape York district. Holtedahl,¹⁵ who has worked up Schei's material and has given a short summary of his geological results, is of the opinion that these faults are younger than Trias and older than Tertiary.

When looking at the map of Ellesmere Land it will be seen that in the western portion of this land numerous small fiords running northwards and southwards occur, and on superficial view it looks as if these have been formed by faults, which, however, must have had a different strike from that of the faults in the Cape York district. Dr. Therkel Mathiesen, who as a participator in the Fifth Thule Expedition in 1923 made observations in the vicinity of Ponds Bay, has told me that in this region several faults occurred that seemed to run north-south, i.e. in the same direction as the faults west of Ellesmere Land, but that they did not run parallel to the shore in Baffin Bay. Thus for the time being it cannot be ascertained whether the two fault areas in the Cape York district and west of Ellesmere Land may be correlated.

It may also be assumed that the faults in the Cape York district are of Tertiary age. Disko Bay and Umanak in West Greenland represent such a Tertiary fault area. Also in East Greenland, in Spitzbergen, on the west coast of Norway (And Island), and on Iceland as is well known, fault areas occur, where the strata have subsided towards the depths of the sea between Greenland and Norway (De Geer's Skandik). So long as we have no further detailed information, especially from Ellesmere Land, it will, I think, be most natural to assume that the fault area of the Cape York district was formed simultaneously with the faults at Disko Bay-Umanak Fiord, i.e. in the Tertiary epoch, and has subsided towards the depths of Baffin Bay. Later I hope to have an opportunity to give a complete description of the fault zones in Greenland together with a summary of other Arctic fault areas.

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¹⁴ Op. cit.

¹⁵ Op. cit.