MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 149 · Nr. 2

DANSK PEARYLAND-EKSPEDITION 1947–50
Leader: Eigil Knuth

CONTRIBUTIONS TO THE GEOLOGY

OF THE AREA ROUND JØRGEN BRØNLUNDS FJORD, PEARY LAND, NORTH GREENLAND

BY

J. C. TROELSEN

WITH 12 FIGURES IN THE TEXT
AND 1 MAP

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI
1949

CONTENTS

Introduction and Acknowledgments.

As a member of the preliminary expedition of the Danish Peary Land Expedition, the present writer spent the time between July 30 and August 15, 1947, at Jørgen Brønlunds Fjord in Peary Land in the north of Greenland. During this period, the geologic mapping of the surrounding area was completed (although the uncertainty as to the time of the arrival of the relief plane forced the field party to spend much time in the vicinity of the camp), and though the fossil collections have not been completely worked up, the present writer feels that the publication of a paper dealing with the general geology of the Jørgen Brønlunds Fjord area is justified.

Grateful acknowledgement is made to Count EIGIL KNUTH and Mr. EBBE MUNCK for the opportunity to participate in the expedition.

To the writer's companions on the expedition thanks are due for friendship and good co-operation during the stay in the field.

The writer is indebted to Professor O. B. BØGGILD, of the University of Copenhagen, for the determination of a number of minerals from the solfataras at the mouth of Jørgen Brønlunds Fjord.

Gratitude is expressed to the Director of the University Museum of Mineralogy and Geology, Dr. A. NOE-NYGAARD, for placing the facilities of the museum at the writer's disposal and for examining a sample of dolerite.

Miss ME MOURITZEN, of the University Museum, kindly undertook the analysis of a sample of salt.

The geological map has been drawn on the basis of a topographical map by L. KOCH and a sketch by EIGIL KNUTH.

Some of the illustrations have been carried out by Mr. CHR. HALKIER, of the University Museum.

Previous Work.

Peary Land has previously been visited by ROBERT E. PEARY on several of his expeditions; by several members of the Danmark Expedition in 1907; by KNUD RASMUSSEN and PETER FREUCHEN on the Second

Thule Expedition in 1912; and by LAUGE KOCK on the Danish Bicentenary Expedition in 1921. Further, parts of Peary Land were overflown by LAUGE KOCH in 1933 and 1938.

Although all of these expeditions have added to our knowledge of the geography of the region, it is only in the papers by LAUGE KOCH that any mention is made of the geological conditions in the part of Peary Land with which we are here concerned. As KOCH's views with regard to the geological history of the region have undergone certain changes in the years that have passed since his expedition in 1921, the present writer finds it necessary to give a brief review of the literature on the subject.

In 1923 (a), LAUGE KOCH mentions the occurrence in the southern part of Heilprin Land (see Pl. 1) of red and gray sandstones with diabase dikes, forming a series more than 900 meters thick. Upwards, the coarse red sandstones are said to be interbedded with more fine-grained layers, and "finally the sandstone disappers entirely and a series of limestones and dolomites with thin layers of siliceous slates follows. The thickness of this series is about 400 m. (1300 ft.) ..... In the ... limestones well developed *Cryptozoon* structures are very common. The limestone series is especially well developed on both shores of Jørgen Brønlunds Fjord ..... The geologic age of the entire sandstone and limestone series appears to be uppermost Cambrian or lowermost Ordovician, since [KOCH has] not been able to find a discordance between the red sandstone and the Cryptozoon limestone ..... On the Cryptozoon limestone follows [north of Brønlund Fjord] a series of white limestone 100 m. thick, devoid of fossils, then 400—500 m. of grayish blue limestones with badly preserved fossils, followed by about 100 m. of gray limestone in which *Maclurea* is common....."

Another paper by KOCH (1923, b) contains the statement that although no unconformity was observed between the red sandstone and the limestone, a break in sedimentation is probably present here.

In 1925, KOCH expresses a slightly different view with regard to the age of the formations and the nature of their contacts. The red sandstone, which previously had been regarded as being of Cambrian age, is here referred to the Algonkian, while the formation which on the map of 1923 was named "Cryptozoon limestone" is here shown as Cambrian. On the older map, the Cryptozoon limestone is indicated on both sides of the fjord, while on the later one the Cambrian formations are restricted to the south side of the fjord. That the limestones and dolomites with *Cryptozoon* have now been separated from the red sandstone, is also shown by the following passage, found under the heading of Algonkian Rocks (ibid., p. 278): "..... nothing of dolomites and shale was met with here in the northeast". KOCH further states: "[The

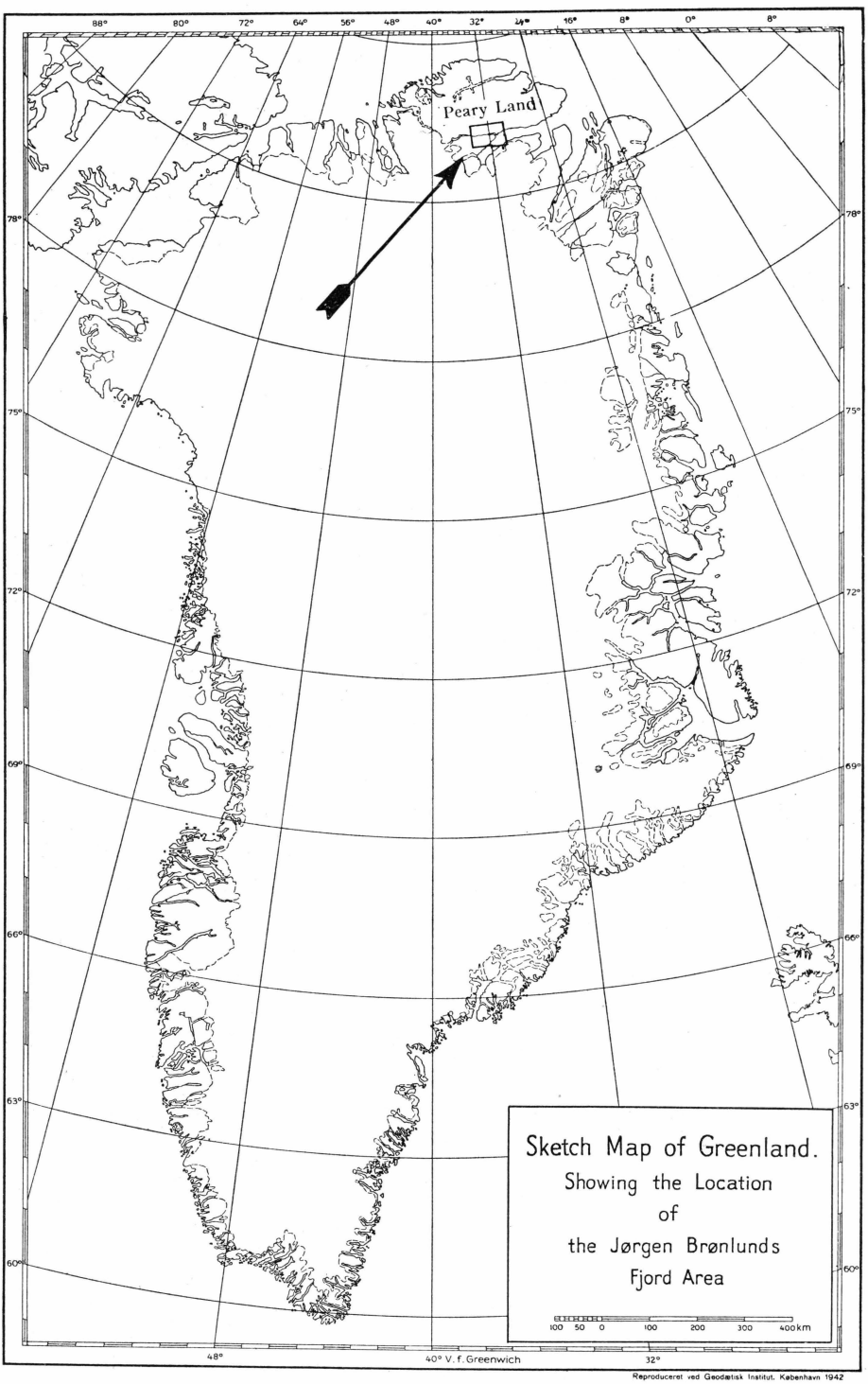


Fig. 1. Map of Greenland, showing the location of the Jørgen Brønlunds Fjord area.

discovery of Cambrian strata near the Humboldt Glacier in the northwest of Greenland] makes it certain that Cambrian is also present in East Greenland, although fossils of that age have not yet been found there". In another paragraph he says: "After the Algonkian eruptions had ceased, the surface of the old land was again peneplained, since the Cambrian sea transgressed over a rather level plain".

In 1929, KOCH uses the term Thule formation for the red and yellow sandstones overlain by dolomite which form the substratum for the Cambrian beds in Northwest Greenland. The Thule formation, which KOCH refers to the Late Algonkian, is also said to occur on Heilprin Land, and KOCH mentions the occurrence of a break in the sedimentation between the Algonkian and the Cambrian strata. KOCH assumes (ibid., pp. 273 and 274) that the Cambrian coastline ran across Heilprin Land, and he adds: "South of Brønlund Fjord the land surface has become denuded, and the [Cambrian and Ordovician] sediments are seen resting disconformably upon the base-levelled beds of the Thule formation and the associated eruptives". Concerning the development of the Cambro-Ordovician section, KOCH says (ibid., p. 274): "These beds I have studied very carefully round Kane Basin [in Northwest Greenland], but my observations show that the same series have developed on Peary Land in exactly the same manner". He goes on to say (ibid., p. 275): "On Peary Land conglomerates with terrigenous material are present, especially in the Cambrian beds, end this is quite natural if we suppose the existence of a steep coast here in Cambrian time".

In 1935 (a), KOCH states briefly that southern Heilprin Land consists of red sandstone and dolomite of the Thule formation (p. 10) and that in 1921 he found Cambrian sediments south of Peary Land (p. 24). About the development of the post-Cambrian section in our area he says (ibid., p. 31): "In Nordostgrønland scheinen diese Schichten [Ozarkium] auch vorzukommen, nämlich an der Nordküste des Brönlund-Fjordes. Versteinerungen wurden hier jedoch nicht gefunden". The intrusives in the Thule group are referred to in the following words (ibid., p. 122): "1921 bemerkte KOCH im südlichen Teil von Peary Land am Brönlund-Fjord, dass in einem bestimmten Niveau alle die Ergussteine, die die grönländischen Schichten [the Thule group] durchsetzen, wegerodiert worden sind und von Konglomeraten und Kalken, die, obwohl keine Versteinerungen in den untersten Schichten gefunden wurden, von KOCH zum Kambrium gestellt wurden, überlagert wurden".

In another paper published the same year (1935, b), KOCH gives a geological map of the Jørgen Brønlunds Fjord region which in the main corresponds to his map of 1925.

To recapitulate, KOCH, who visited Jørgen Brønlunds Fjord in 1921, regards the sandstone with diabase intrusions on Heilprin Land as the equivalent of the Eo-Cambrian or Late Algonkian Thule group of Northwest Greenland, while the limestones and dolomites with *Cryptozoon* which overlie the sandstone apparently correspond to the Cambrian strata of which he speaks in his later papers. At any rate, the formation that on his earliest map of the region is called "Cryptozoon limestone", agrees in its distribution almost exactly with the area that on his later maps is shown as Cambrian. This interpretation of KOCH's views is supported by the express statement (KOCH, 1929) that the Cambrian coastline ran across Heilprin Land. As to the nature of the lower contact of the Cambrian, KOCH has expressed differing opinions. In 1923 (a), he stated that he has "not been able to find a discordance between the red sandstone and the Cryptozoon limestone". In his later papers, however, he makes the equally clear statement that the Cambrian and Ordovician sediments "are seen resting disconformably upon the base-levelled beds of the Thule formation and the associated eruptives". (KOCH, 1929; 1935, a).

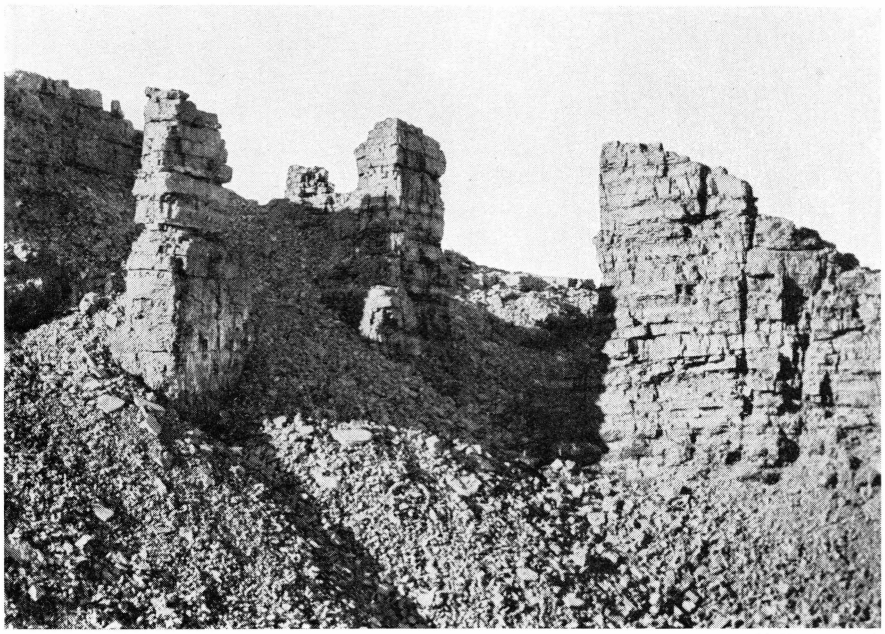
Stratigraphy.

Eo-Cambrian System.

Thule Group.

The Thule group was named in 1929 by LAUGE KOCH, who referred it to the Late Algonkian. Wherever the group has been examined, from the Arctic Archipelago of Canada to Peary Land, it is separated from the overlying Lower Paleozoic strata by a simple erosional unconformity, and the present writer has therefore preferred to place the group in the Eo-Cambrian.

As pointed out by KOCH in his earliest papers on the Jørgen Brønlunds Fjord area (1923, a & b), the oldest exposed strata consist of red and gray feldspathic sandstone, above which follow limestones, dolomites, shales, and some sandstone. Of the erosional unconformity on top of the basal sandstone of which KOCH speaks in his later papers on the subject (but of whose existence he expresses doubt in his paper of 1923 (a), written shortly after his return from his expedition to Peary Land), the present writer has found no signs. It must be admitted, however, that the sections are rather incompletely exposed so that a disconformity may have been overlooked, even if it is actually present in the sections. When, nevertheless, the whole sequence is here regarded as representing but one stratigraphic unit, it is because of the close similarity in lithology to the Thule group as it is developed in the



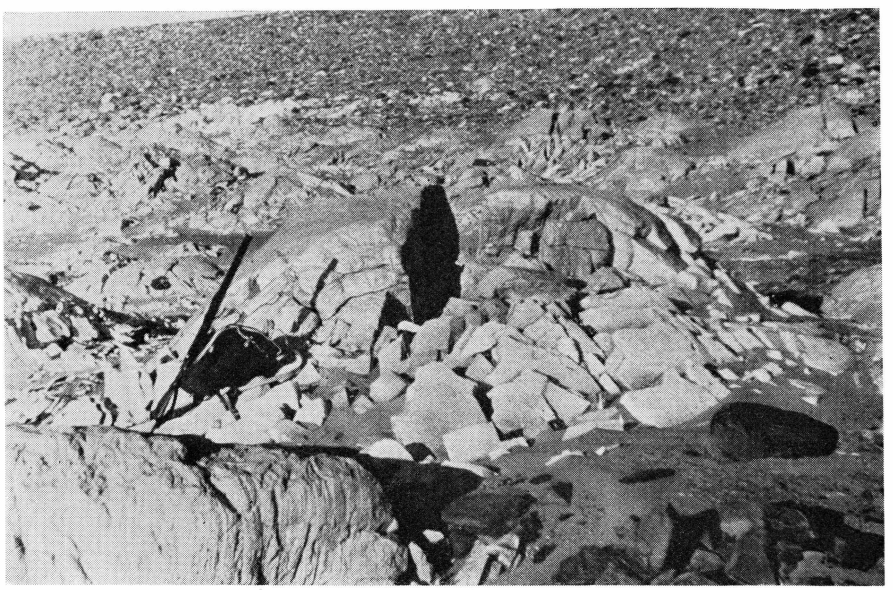
E. KNUTH phot.

Fig. 2. Dolomites of the Thule group. The scarp is about 15 meters high. South coast of Jørgen Brønlunds Fjord.

region round Kane Basin, which the present writer knows thoroughly from a long stay in Northwest Greenland and Ellesmere Island. There is not one type of sediment in the present sequence which does not have its exact counterpart in the Thule group of the region round Smith Sound and Kane Basin. Neither does the succession of strata—coarse, red, feldspathic sandstone at the bottom and partly calcareous sediments above—disprove the correctness of such a correlation. On the other hand, KOCH's theory (1925; 1929; 1935, a) of a similarity between the upper (post-Thule) part of the sequence at Jørgen Brønlund's Fjord and the Cambrian series on Inglefield Land in Northwest Greenland is not supported by any resemblance in lithology or fauna.

It is not known at the present time whether the various divisions into which the Thule group at Jørgen Brønlunds Fjord has been divided, are recognizable outside our area, and the present writer has, therefore, refrained from attaching names to them.

Only one diabase intrusion was observed in the whole Jørgen Brønlunds Fjord area, namely at a place on the south coast near the head of the bay. The intrusion does not reach the upper part of the basal red sandstone. It is, therefore, not clear what KOCH had in mind when he wrote about "the base-levelled beds of the Thule formation and the associated eruptives" (1929, p. 273; see also 1935, a, p. 122).



J. TROELSEN phot.

Fig. 3. *Cryptozoon* (?) reef in dolomites of the Thule group. The shotgun indicates the size of the reefs. South coast of Jørgen Brønlunds Fjord.

There are no indications in our area of any Pre-Cambrian or Cambrian erosion scarp that might have formed the landward limit of the calcareous part of the sequence. KOCH's suggestion (1929, p. 275) that "a steep coast [existed] here in Cambrian time" is thus not supported by evidence in the field (it must be remembered that KOCH regarded the upper part of the Thule group as being of Cambrian age).

Because of the regional dip, which is 2°—3° N. E., the oldest exposed strata are found on the southern shore, near the head of the fjord. There are here exposures of a coarse red sandstone with imperfectly rounded pebbles and boulders up to 50 centimeters in diameter. The sandstone is very poorly sorted and contains numerous grains of feldspar so that the rock in places has the characteristics of an arkose. The pebbles and boulders consist of red and gray sandstone and a deeply weathered igneous or metamorphic rock, which may be either granite or gneiss. It is in this arkose that the diabase intrusion, mentioned above, occurs.

A little higher in the sequence follows a fairly well-sorted, thin-bedded, red or gray quartzose sandstone with ripple marks. Also this sandstone has only been observed in the southwestern part of our area.

The next-younger beds are particularly well exposed in a ravine on the south side of Jørgen Brønlunds Fjord, opposite the small island

J. TROELSEN phot.

Fig. 4. *Cryptozoon* (?) reef in dolomites of the Thule group, showing the concentric layers of the reef. South coast of Jørgen Brønlunds Fjord. Scale furnished by shotgun.

in the neck of the fjord. The section contains the following strata, which are listed below in descending order:

8.	Gray, yellow-weathering dolomite, which is crowded with small *Collenia*-structures of the type that is shown in fig. 5	ca. 10 meters
7.	Light gray, yellow- to brown-weathering thin-bedded dolomite, which at certain levels shows disturbances of the stratification that suggest submarine slumping	ca. 30 meters
6.	Medium-gray, gray-weathering thin-bedded limestone, which passes into the overlying dolomite	ca. 20 meters
5.	Dark brownish-red thin-bedded laminated dolomite	ca. 6 meters
4.	Yellowish-white, strongly silicified, rather massive dolomite	ca. 9 meters
3.	Black, dark-gray-weathering banded dolomite with thin layers of black chert	ca. 50 meters
2.	Light gray, fine-grained thick-bedded sandstone	ca. 10 meters
1.	Dark gray, thin-bedded fine-grained sandstone	at least 5 meters
	Total:	ca. 140 meters

A few kilometers west of the ravine, one or more of the dolomite beds contain large hemispherical *Cryptozoon*(?) structures, which are up to 1.5 meters high and about 3 meters in diameter (figs. 3 & 4).

Another good section through beds of the Thule group is found in the cliffs on the north side of the fjord (figs. 6 & 7). As these beds are separated from the overlying Brønlund Fjord dolomite by a simple erosional disconformity, they must be considered the youngest preserved part af the group. Because the amount of novement on the faults that cut the area is unknown, it cannot be computed how many meters of unexposed beds there are between Bed 8 of the section described above and the lowermost exposed stratum on the north coast of Jørgen Brønlunds Fjord.

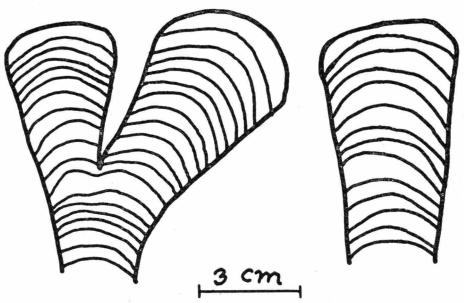


Fig. 5. Vertical sections through *Collenia* structures from the dolomites of the Thule group on the south coast of Jørgen Brønlunds Fjord. Copied from a notebook sketch by J. TROELSEN.

Immediately west of the mouth of Børglum Elv, the following section was measured (the strata being listed in descending order):

(Brønlund Fjord dolomite)

3. Black shale and thin-bedded dark gray sandstone with ripple marks and worm trakcs (?). Near the top, the sand stone becomes dominant over the shale ..... 112 meters
2. Talus ..... 104 meters
1. Shaly to thin-bedded sandstone of gray, brown or black color. Some of the gray-colored beds contain chips of black sandstone. Indistinct worm tracks (?) were observed on some af the bedding planes ..... 47 meters

(Sea level)

Total: 263 meters

Cambrian System.

Brønlund Fjord Dolomite.

This formation may be identical with the "white limestone 100 m thick, devoid of fossils" which according to LAUGE KOCH (1923, a) rests upon what he called the Cryptozoon limestone. It is true that a large proportion of the Brønlund Fjord dolomite is of a brown color, but on

weathering it assumes a lighter color, and, seen from a distance, the exposures appear yellowish-white. The Brønlunds Fjord dolomite does not rest upon KOCH's Cryptozoon limestone but on sandstone and shale, but as it is the only prominent light-colored calcare« ous formation near Jørgen Brønlunds Fjord it is difficult to escape the conclusion that it corresponds to what KOCH called the "white limestone".

As the Brønlunds Fjord dolomite appears to be entirely unfossiliferous, it is only with doubt that it is here referred to the Cambrian. It may as well be the uppermost member of the underlying Eo-Cambrian Thule group or, as the overlying formation belongs to the Middle or Upper Canadian, it may be of Early Canadian age.

The formation is named after Jørgen Brønlunds Fjord, where it is particularly well exposed.

No basal conglomerate is present in the formation, but the change in the character of the sediments from the arenaceous Thule group to the Brønlund Fjord dolomite is very abrupt. Also the upper boundary is sharp, although at first glance the difference between the sediments of the Brønlund Fjord formation and those of the lower part of the Wandel Valley formation seems very small.

In the cliff west of the mouth of Børglum Elv, where the formation was examined in details, the lower 10 meters of the formation are made up of a very massive, dark brown dolomite, which, seen from a distance, appears banded or layered. On closer examination it is seen that the dolomite is crowded with angular fragments of light gray or white dolomite. The fragments, which commonly show lamination, are from 2 to 45 centimeters in diameter.

Above follow about 56 meters of dark gray to brown dolomite interlaminated with light gray dolomite, the laminae being from 1 to 5 millimeters thick. In other respects this stratum resembles the underlying brecciated dolomite.

Upward, the laminated dolomite gradually changes into a rather massive rock of a uniform brownish-gray color. Still higher in the section, the dolomite becomes light gray and distinctly crystalline. The combined thickness of the two last-mentioned members of the formation is about 60 meters.

In the section, described above, the formation occurs from an altitude of 263 meters to an an altitude of 419 meters above sea level, and its total thickness is thus 156 meters.

On the east side of the valley of Børglum Elv, at a point about 6 kilometers from the mouth of the river, a scree-covered slope was examined, in which loose-lying blocks of the Brønlund Fjord dolomite occurred from an altitude of 207 meters to an altitude of 323 meters

B. FRISTRUP phot.

Fig. 6. The cliff along the north coast of Jørgen Brønlunds Fjord, seen from the camp on the south coast.

B: Brønlunds Fjord dolomite.
T: Sandstone and shale of the Thule group.

above sea level, suggesting a thickness of the formation of somewhat more than 100 meters.

The formation is prominently exposed along the north side of Jørgen Brønlunds Fjord and Wandels Dal (fig. 6) and may also be observed along Børglum Elv and for some distance east of the mouth of Jørgen Brønlunds Fjord, along the north shore of Independence Fjord. Further to the north and east, the gentle regional dip carries it below younger formations.

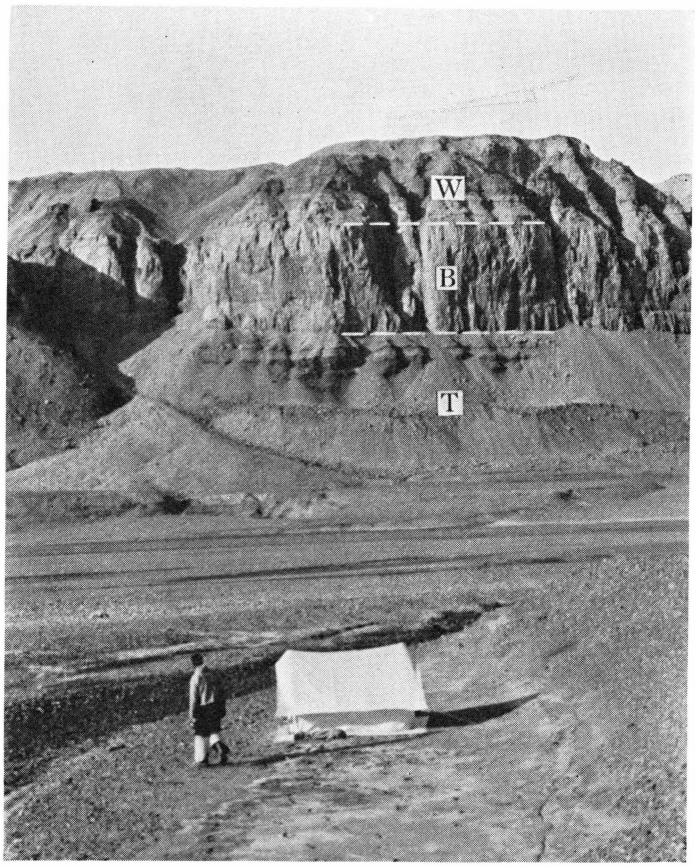
Ordovician System.

Canadian Series.

Wandel Valley Limestone.

This formation probably corresponds to the stratum which KOCH describes as "400—500 m. of grayish blue limestones with badly preserved fossils", and which is said to rest upon "white limestone 100 m. thick, devoid of fossils" (KOCH, 1923, a). The formation is named after Wandels Dal.

As mentioned in the description of the foregoing formation, the lower contact of the Wandel Valley limestone is sharp and well defined. The upper contact has not been examined in detail, but there is a striking difference between the light-coloured dolomitic limestone of the



K. RODAHL phot.

Fig. 7. The section west of the mouth of Børglum Elv.
W: Wandel Valley limestone.
B: Brønlunds Fjord dolomite.
T: Sandstone and shale of the Thule group.

present formation and the overlying dark-coloured Børglum River limestone.

The lower part of the formation was examined immediately west of the mouth of Børglum Elv, where a steep ravine affords an opportunity for scaling the upper part of the cliff (fig. 7). From an altitude of 419 meters to an altitude of 425 meters above sea level the formation is made up of thin-bedded, gray dolomitic limestone with occa-

sional laminae of a darker color. On weathering the rock assumes a grayish-white colour.

At an altitude of 425 meters layers of flat-pebble conglomerates with fragments of dark-gray dolomitic limestone and, also, bands of a dark grayish-brown dolomitic limestone begin to appear. Upward, the grayish-brown bands increase in number and thickness until at an altitude of about 473 meters the light-gray limestone has completely disappeared. The grayish-brown dolomitic limestone contains bands and nodules of black, white-rimmed chert; on weathering, the limestone assumes a yellowish-brown colour.

The top of the section is found at an altitude of 494 meters above sea level. Of the Wandel Valley limestone, the lower 75 meters are thus present here.

On the east side of the valley of Børglum Elv, at a point about 6 kilometers from the coast, the formation seems to be present in its full thickness. From an altitude of 323 meters to an altitude of about 462 meters above sea level the slope is covered with numerous large blocks of the same type of grayish-brown dolomitic limestone that forms the upper portion of the section west of the mouth of the river.

From an altitude of 462 meters to an altitude of 681 meters the slope is covered with blocks of a dark-gray to black, yellow-weathering laminated dolomite or dolomitic limestone with scattered nodules of black flint. Dry-cracks are commonly seen on the bedding planes. Although the last mentioned rock type has not been seen in place, it is here included in the Wandel Valley limestone (of which it is considered the uppermost part) because of its similarity to the lower, grayish-white-weathering portion of the formation.

The measurements given above suggest a total thickness of the formation of about 350 meters.

The Wandel Valley limestone forms the top of the cliff for a short distance west of the mouth of Børglum Elv and on the north side of Wandels Dal just west of the head of Jørgen Brønlunds Fjord. Between these two places the formation recedes from the top of the cliff, which is here formed by the Brønlund Fjord dolomite (fig. 6). It may also be seen in the cliffs in the lower part of the valley of Børglum Elv and along the coast of Independence Fjord for some distance east of the mouth of Jørgen Brønlunds Fjord.

Silicified fossils were collected at several horizons. Although the state of preservation ordinarily leaves something to be desired, it has been possible to recognize the following forms:

a. *Ostracods*, a few unidentifiable specimens.

b. *Cystoids*, represented by calyx plates and by arm and stem joints.

c. *Pelecypods*, several poorly preserved specimens, all of which apparently belong to the same species.

d. *Gastropods*, among which the following forms have been identified:

In the light gray limestone in the lower part of the formation: *Maclurites* spp. (represented by numerous opercula); *Raphistomina* sp.; *Trochonema* aff. *umbilicatum* (Hall); *Pagodispira* sp.

In the brownish-gray limestone in the middle part of the formation: *Ceratopaea* sp. (abundant); *Maclurina* sp. (represented by opercula); *Raphistomina* (?) sp; *Hormotoma* (?) spp.

Several other unidentified or unidentifiable gastropods occur in the formation.

e. *Cephalopods*, represented by *Protocycloceras* sp.

The occurrence of *Ceratopaea* indicates a Late or possibly Middle Canadian age of the formation[1]).

Champlainian or Cincinnatian Series.

Børglum River Limestone.

In 1923 (a), LAUGE KOCH mentioned the occurrence near Jørgen Brønlunds Fjord of "about 100 m. of gray limestone in which *Maclurea* is common", resting upon the "400—500 m. of grayish blue limestone with badly preserved fossils" which the present writer believes is identical with the Wandel Valley limestone. If this identification is correct, the "gray limestone in which *Maclurea* is common" must be identical with the strata which in the present paper are called the Børglum River limestone.

The formation is named after Børglum Elv, near which it was examined by the present writer.

Within our map area the formation has only been observed at a point on the east side of the valley of Børglum Elv, about 6 kilometers from the mouth of the river. In this locality, it occurs from an altitude of 681 meters to an altitude of 715 meters above sea level. As the latter altitude marks the top of the section, the total thickness of the formation could not be measured in this locality. As mentioned above, however, KOCH estimated the thickness as being about 100 meters.

The lower contact of the formation has not been observed, but the difference in lithology between the underlying Wandel Valley formation and the present formation suggests that the contact is well defined.

[1]) It has commonly been assumed that *Ceratopaea* in its distribution is limited to Newfoundland and the North American continent. Its occurrence in Northeast Greenland was, therefore, unexpected. It should be mentioned that Holtedahl (1920, p. 129) describes and figures a Canadian fossil from Bear Island (= Bjørnøya; between Norway and Spitsbergen) which evidently belongs to the genus *Ceratopaea*.

The Børglum River limestone is a black, strongly silicified limestone with stringers of brown dolomite. The known fauna consists of *Maclurites*, bryozoans and cephalopods. Of these froms, only a large, rather poorly preserved *Maclurites* has been brought home.

As to the age of the formation, not much can be said exept that the occurrence of *Maclurites* proves that the formation belongs to the Ordovician, while the presence of bryozoans suggests an age younger than the Canadian.

Pleistocene Series.

Signs of glacial activity may be seen everywhere in our map area. It can be said with certainty that the whole area has at one time or another been glaciated.

Of glacial abrasion there are but few recognizable traces in the landscape. The surface of a dolerite sill, exposed on the south coast of Jørgen Brønlunds Fjord, exhibits glacial striations, which run in the general direction of the fjord, but apart from this case no polished surfaces, striations or grooves have been observed. It is difficult to determine the extent of glacial abrasion, but presumably a certain amount of quarrying has taken place in the sedimentary areas. This process must have been aided to a large extent by the jointed and shattered condition of the bedrock.

Erratic boulders occur in many places, but only on the high plateaux is the surface blanketed with a layer of till. The till is generally of a very coarse and loose texture. North of Jørgen Brønlunds Fjord the till contains fragments of the underlying calcareous rocks besides numerous boulders of red sandstone, dolerite and gneiss, rocks that form the bedrock southwest of the fjord but which, as far as we know, are not exposed north of the fjord. This indicates that the ice sheet that covered the southern part of Peary Land, had its center west or southwest of Peary Land and not, for instance, at Mt. Nordkronen in the central part of Peary Land.

The glacial striations which run parallel to the valley of Jørgen Brønlunds Fjord have probably been formed during the retreat of the ice sheet at a time when the plateaux north of the fjord had become icefree, although the possibility cannot be overlooked that the striations may have been produced by the bottom layer of the ice sheet which has been deflected by the local topographic irregularities.

The post-glacial sediments are chiefly alluvium and marine deposits, while wind deposits are of minor importance.

Marine terraces, consisting chiefly of clay, are very conspicuous along the gently sloping south coast of Jørgen Brønlunds Fjord, while on the steep north coast they are generally poorly developed. The

height of the terraces above the present level of the sea was measured in two localities on the south coast, both of which are near the head of the fjord.

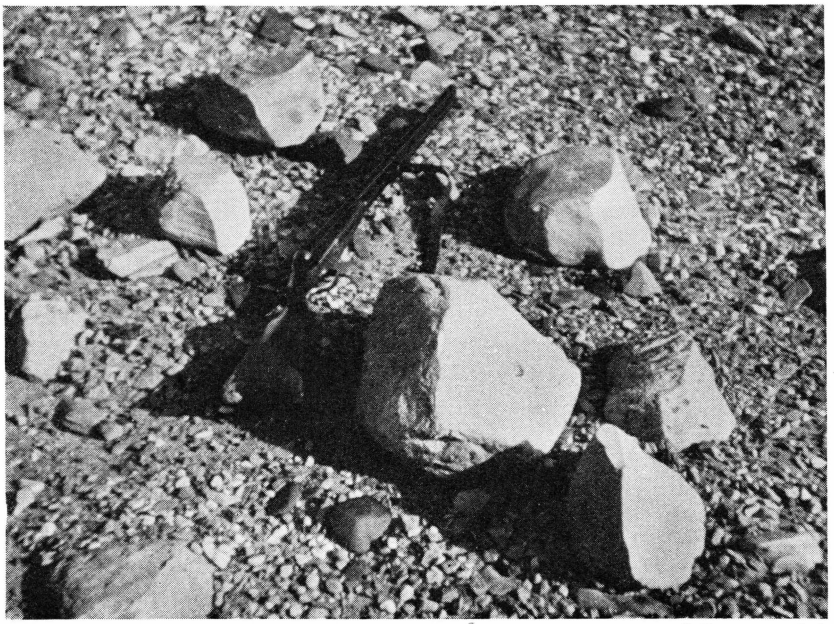
Another series of measurements was made south of the present delta of Børglum Elv. The fact that these terraces lie outside the valley of the river, i. e., in that part of the old delta which has been exposed to the activity of the sea, lends support to the writer's opinion that the terraces reflect abrupt changes in the emergence of the land rather than changes within the stream system.

As far as possible, points close to the landward edge of the terraces were chosen for the observations of altitude. The measurements were made with a large Paulin Aneroid. The time of the observations was noted, and by comparison with the records of a barograph at the base camp, about 20 kilometers from the head of the fjord, it was possible to get a fairly accurate idea of the actual height of the terraces. The fact that the atmospheric conditions were remarkably stable during the writer's stay at Jørgen Brønlunds Fjord serves to strengthen the confidence in the accuracy of the figures given below:

Height of the post-glacial marine terraces above present sea level.

At the head of Jørgen Brønlunds Fjord	About 5 kilometers from the head of Jørgen Brønlunds Fjord	South of the mouth of Børglum Elv
		113 meters
81 meters	73—82.5 meters	
		69 meters
	several narrow terraces	64 meters
		62 meters
		61 meters
	48.4 meters	49 meters
44 meters	42.5 meters	
		28 meters
		21 meters
		16 meters

Between the terraces near the head of the fjord there are several poorly developed beach lines, which were not measured. The difference in width between the conspicuous terraces south of the mouth of Børglum Elv and those at the head of the fjord may be due to an unequal supply of material. While Børglum Elv is able to furnish relatively



J. TROELSEN phot.

Fig. 8. Wind-worn boulders on the south coast of Jørgen Brønlund's Fjord. The boulders are lying in the position in which they were found. Scale furnished by shotgun.

large amounts of coarse material, the streams which flow through the large lakes in Wandels Dal drop part of their load before reaching the sea.

Why the terraces at 42.5, 44, 48.4, 81, and 73—82.5 meters are better developed than the rest of the beaches at and near the head of the fjord, is still an open question. It may be that the wider terraces mark comparatively long periods during which the shore line remained at the same level, or the amount of material supplied by the large river in Wandels Dal may, for unknown reasons, have varied.

How far into Wandels Dal the marine deposits can be traced, could not be investigated during the writer's short stay on Peary Land, but KOCH (1928, fig. 12) indicates "raised postglacial marine layers" along a narrow belt from Jørgen Brønlunds Fjord through Wandels Dal to the head of I. P. Koch's Fjord on the north coast of Greenland.

According to KOCH (1928), the maximum post-glacial deleveling amounted in North Greenland to 210 meters, compared to the present sea level. In eastern Peary Land, driftwood is said to occur up to an altitude of 165 meters above the present sea level, while in the large fjords in North Greenland shells may be found, according to KOCH, up to a height of 135 meters. KOCH states further that along the north

coast of Greenland two distinct former shore lines may be seen, one at 65 meters and another at 105 meters above the present sea level. Further investigations are needed before these shore lines can be correlated with those at Jørgen Brønlunds Fjord.

The valley of Børglum Elv is filled with alluvium, and well-developed stream terraces may be observed along the sides of the valley.

CHR. HALKIER phot.

Fig. 9. Wind-worn cobble of limestone with lenses of chert (nat. size). From the delta of Børglum Elv.

A detailed survey of these terraces was given up as being too time-consuming to be fit into the present investigation.

As mentioned above, wind deposits are of minor importance within our area. On the other hand, signs of wind erosion are extremely conspicuous in Wandels Dal and on the south side of Jørgen Brønlunds Fjord. Practically all pebbles and boulders are polished and worn on the side that is exposed to the wind that blows from Wandels Dal toward Independence Fjord. The softer pebbles are commonly grooved or furrowed, while those which consists of harder materials in most cases have flat, smooth facets on their western sides (figs. 8 & 9).

It is a remarkable fact that very few pebbles have more than one facet. Evidently even the smallest stones retain their position through

very long periods of time. This may indicate that the greater part of the wind erosion takes place at a season when the pebbels are frozen to the substratum.

Whether the tools of the wind are exclusively sand and silt, or whether drifting snow plays a part in the process of erosion, has yet to be investigated. Wind erosion by drifting sand is naturally favored by the dry climate that prevails in Peary Land. Another effect of the aridity is the formation of salt crusts on the surface of the ground around ephemeral lakes and creeks. In July and August, the salt crusts were so prominent that the ground looked as if it were covered with hoarfrost. According to information kindly furnished by Miss ME MOURITSEN, analyst in the University Museum, the chief soluble components of the salts are chloride and sulphate of magnesium and calcium.

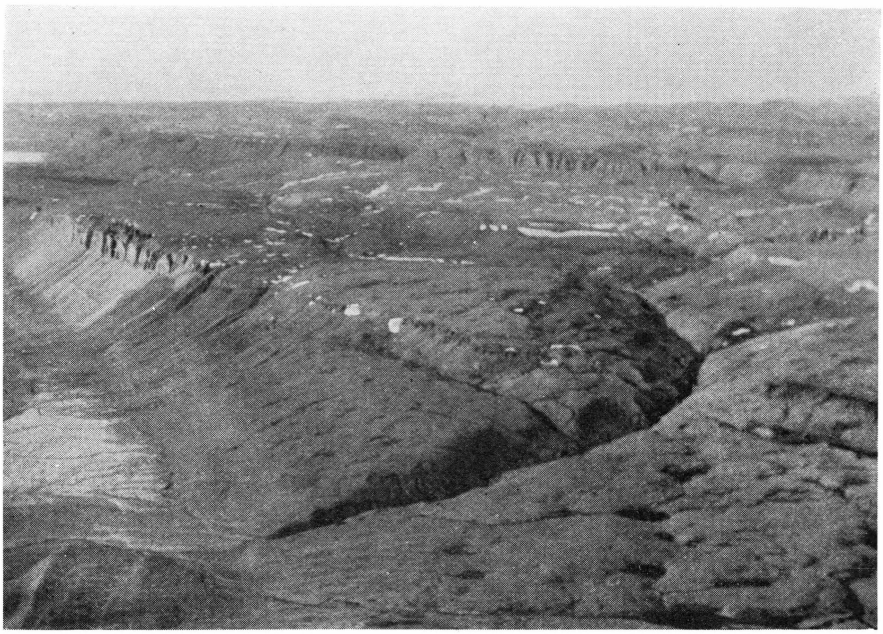
Structure.

As previously mentioned, the regional dip is 2°—3° N. E. Although small local variations in the dip may be observed, the attitude of the sedimentary beds is generally extremely regular. The Jørgen Brønlunds Fjord region is, in other words, outside the zone of folding which occupies the northern part of Peary Land. It can hardly be disputed that the Jørgen Brønlunds Fjord region belongs to the foreland south of the folded Franklinian geosyncline, which today is preserved in North Greenland and the central part of Ellesmere Island (KOCH, 1925 & 1935b; SCHUCHERT, 1939, fig. 2). The fact that the regional dip is directed toward the northeast instead of toward the north suggests that Jørgen Brønlunds Fjord lies near the point where the Franklinian and the East Greenland geosynclines unite.

Parallel to Wandel's Dal and Jørgen Brønlund's Fjord occurs a fault system, which on aerial photographs may be traced for some distance south and north of the fjord (fig. 10). Also the courses of the stream beds in the vicinity of the fjord suggest the presence of faults running parallel to the fjord (Pl.). Some of the minor faults, the directions of which could be directly observed, strike about N. 86° W. (on the south side of the mouth of the fjord) and about N. 83° E. (west of the mouth of Børglum Elv).[1])

As far as could be observed, all the faults are vertical or nearly so. On those on the south side of the fjord, the northern block went down,

[1]) As the magnetic deviation was unknown and the available map contained too few details to permit the taking of bearings by which the deviation could be computed, it became necessary to measure the deviation in the following way: A bearing to the sun was taken with the Brunton compass, and the reading was



K. RODAHL phot.

Fig. 10. Aerial view of the north side of Wandels Dal, near the head of Jørgen Brønlunds Fjord. A fault may be seen crossing the deep gully in the fore-ground.

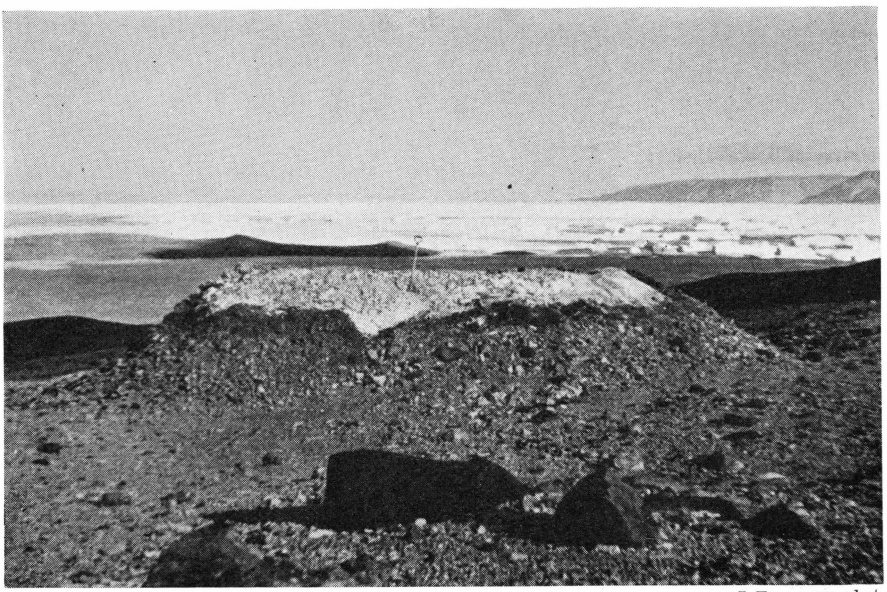
while on the faults on the northern shore the downthrow is on the southern side of the faults. The observed dip slips do not exceed some 60 meters. If the observations from the few and small faults that have been examined can be extended to the whole fault system, Jørgen Brønlunds Fjord and Wandels Dal must form a graben. Future investigations in Wandels Dal and its tributary valleys will probably give a more definite result as to the larger structural relations.

As to the age of the faulting, nothing is known except that it is younger than the Ordovician. The fact that the glacial striae in Jørgen

recorded. The time of the observation, measured in Greenwich Mean Time, was noted, and the geographis longitude and latitude were computed as accurately as possible from the availabale map. The true azimuth of the sun could then be computed by means of the following formulas:

$$\sin h = \sin d \sin B \cos d \cos B \cos Tv$$
$$\cos h \sin a = \cos d \sin Tv,$$

in which "h" is the altitude of the sun, "d" the declination of the sun, "a" the azimuth of the sun, "Tv" the hour angle of the sun on the given geographis longitude at the time of the observation, and "B" the given geographic latitude. When the true azimuth and the magnetic azimuth of the sun are known, the magnetic deviation may be computed. The accuracy is low, however, because the horizontal component of the magnetic force is so small that the compass may be influenced by even minor bodies of basic rocks in the vicinity.



J. TROELSEN phot.

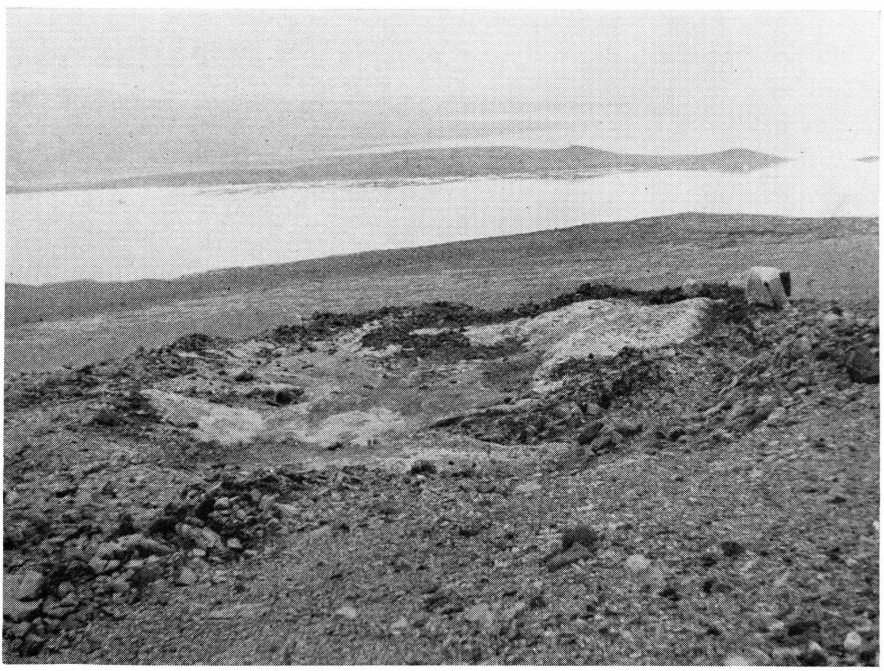
Fig. 11. Solfatara on the south coast of Jørgen Brønlunds Fjord, opposite the mouth of Børglum Elv. The ice-filled Independence Fjord may be seen in the background. The light-coloured crusts on the rim of the crater consist of gypsum, copiatite, and sulphur. The spade on top of the cone indicates the ize of the structure.

Brønlunds Fjord run parallel to the fjord indicates that the fjord, and therefore probably also the fault system, existed before the beginning of the Pleistocene epoch, but, on the other hand, unmistakable signs of recent volcanic activity along some of the faults suggest relatively recent movements along the fault surfaces.

Volcanic Activity.

As signs of active volcanism are otherwise unknown from Greenland, the writer was quite unprepared to find volcanoes in the vicinity of Jørgen Brønlunds Fjord. Solfataras may, indeed, be a better name for these features than volcanoes as lava or pyroclastics do not occur in connection with the craters.

The solfataras were chiefly found on the southern shore of the fjord. On the northern shore only one very small solfatara was observed. Most of the solfataras, among which are the largest that were found, are located south of the fjord, at a point opposite the mouth of Børglum Elv, at an altitude of about 200 meters above sea level. Their arrangement suggests that they are connected with the faults that occur in the vicinity.



J. TROELSEN phot.

Fig. 12. The crater of one of the solfataras on the south coast of Jørgen Brønlunds Fjord. A rucksack covered with a sweater (to the right in the picture) indicates the size of the crater.

The best developed solfataras appear as truncated cones, up to 2 meters in height and from 10 to 20 meters in diameter (fig. 11). The cones consist of sand and gravel mixed with larger erratic boulders and fragments of dolomite and limestone from the underlying Thule group. On top of the cones there are commonly well-developed craters, the rims of which are covered with thick crusts of gypsum and copiapite mixed with sulphur (fig. 12). Loose aggregates of copiapite; gypsum; pyrite mixed with sulphur; and fibroferrite mixed with an undetermined brown iron compound commonly occur in large quantities under the crusts and on the bottom of the craters.[1]) No traces of lava or pyroclastic rocks were found in or near the cones. On the lee side of the cones (i. e., east of the cones, as the prevailing wind evidently blows from the west), the pebbles on the ground up to a distance of some 50 meters from the solfataras are coated with a glaze or varnish of brown iron compounds.

[1]) For the determination of these minerals the writer is indebted to Mr. O. B. BØGGILD, Professor of Mineralogy (retired) in the University of Copenhagen.

The craters were cold at the time of observation (the beginning of August, 1947), and no emission of gases or vapors could be seen. At a time when the temperature of the air was from + 9° to + 10° C., the temperature in the center of the craters of three different solfataras, measured at depths of 0.5—0.75 meters below the surface, was + 1° C., + 4.5° C., and — 0.9° C., respectively. The solfataras must, nevertheless, have been in activity shortly before the writer's visit as the soft crusts of copiapite and gypsum on the rims of the craters were in no way affected by the violent wind erosion the effects of which are so much in evidence around Jørgen Brønlunds Fjord.

Solfataras are usually regarded as being characteristic of that period of the declining life of a volcano when its activity is confined to the emission of steam and gases. As mentioned above, however, there are no signs of previous eruptions of lavas or pyroclastics in the region around Jørgen Brønlunds Fjord, and the present solfataras may, therefore, mark the initiation of a period of volcanism, rather than one of the last stages of such a period.

The exact cause of the emission of steam and gases which evidently so recently has taken place in our area, is not known. It is beyond reasonable doubt, however, thar the solfataras are not the result of a "dry distillation" of bituminous shales. The rocks underlying the soltataras are limestones, dolomites and sandstones of the Eo-Cambrian Thule group, below probably follows Pre-Cambrian metamorphic and igneous rocks, none of which can be expected to to contain bitumen or other organic materials in appreciable amounts. The possibility should be taken into consideration that frictional heat generated along the fault surfaces may have been responsible for the formation of the solfataras. This problem is tied up with the question of the age of the faulting, a question which at the present time cannot be answered except in the vaguest terms.

Remarks on the Geomorphology.

In the section on the Pleistocene deposits a few remarks were made on the glacial and post-glacial features of our area. The topography of the region has apparently been but sligthly modified by glacial activity, and it may therefore be assumed that the major features of the present land forms were modelled in pre-glacial time.

In the vicinity of Jørgen Brønlunds Fjord a plateau exists, which reaches an altitude above the present level of the sea of between 600 and 700 meters. A few kilometers north of the fjord another, somewhat higher plateau was observed, which was separated from the lower one by a well-defined scarp. This scarp could not be examined in detail, but the following modes of formation are possible:

1) Differential erosion with lithologic control.
2) Faulting.
3) Stream erosion or marine denudation.

The small, northeasterly regional dip of the sedimentary beds would favor the type of erosion mentioned under 1), but two or more of the processes mentioned above may have combined to form the scarp.

Intrusive Rocks.

As mentioned in the section on the Thule group, a dike was observed on the south coast of Jørgen Brønlunds Fjord, near the head of the fjord, where it penetrates the red sandstone. According to information kindly furnished by Dr. A. Noe-Nygaard, the dike consists of a quartz dolerite which is very similar to the dolerites from Etah and Kap Leiper in Northwest Greenland and from Kap Glacier in Independence Fjord that were described by KAREN CALLISEN (1929, pp. 233, 238, 249). In all three localities, the quartz dolerite has been intruded into red sandstone of the Thule group.

BIBLIOGRAPHY

CALLISEN, KAREN (1929), "Petrografische Untersuchung einiger Gesteine von Nordgrönland", Meddelelser om Grønland, Vol. 71 (4); 1929.

HOLTEDAHL, OLAF (1920), "On the Paleozoic Series of Bear Island, Especially on the Heclahook System", Norsk Geologisk Tidsskrift, Vol. 5 (Aargangene 1918 & 1919); pp. 121—148, pls. 12—15; 1920.

KOCH, LAUGE (1923, a), "Preliminary Report on the Geology of Peary Land, Arctic Greenland", American Journal of Science, Vol. 5, pp, 189—199; 1923.

— (1923, b), "Resultaterne af Jubilæumsekspeditionen Nord om Grønland i 1921", Naturens Verden, Febr. 1923.

— (1925), "The Geology of North Greenland", American Journal Science, Vol. 9, pp. 271—285; 1925.

— (1928), "The Physiography of North Greenland"; in "Greenland", Vol. 1, pp. 491—518; Copenhagen, 1928 (See also: Geographical Review, Vol. 16 (1), 1926).

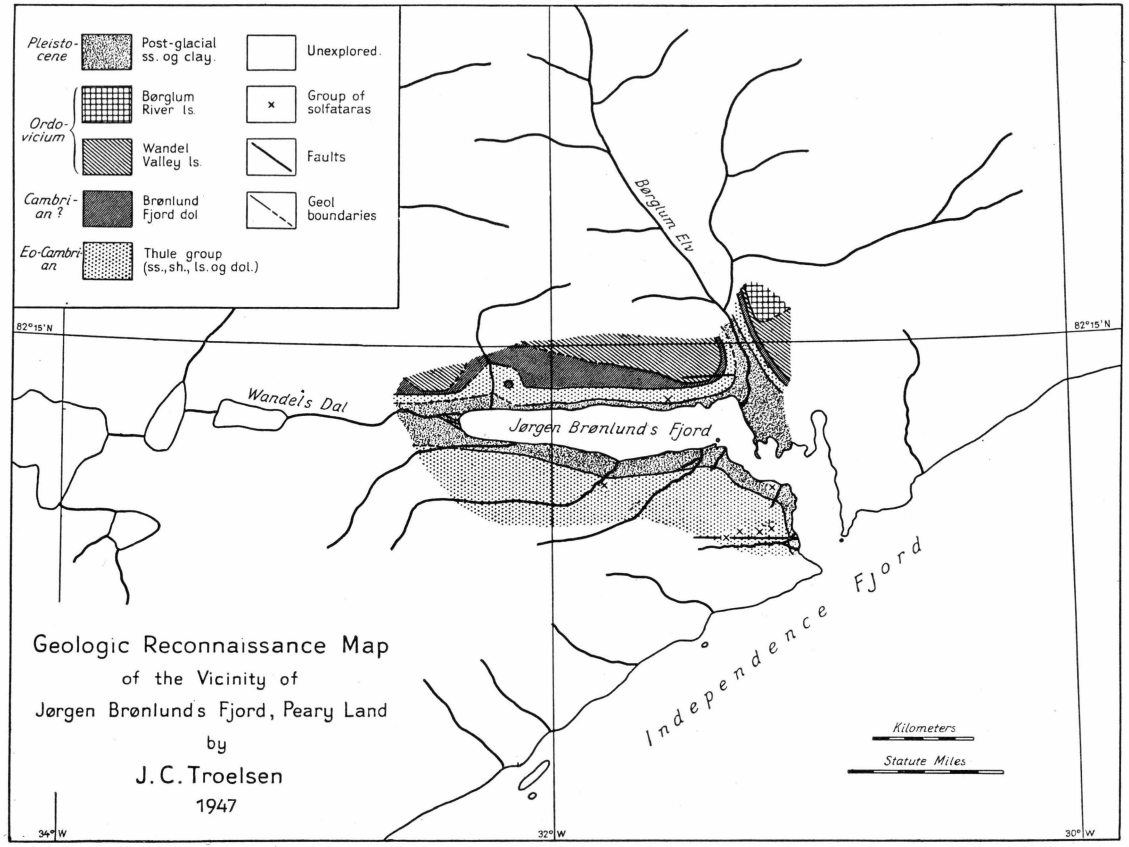
— (1929), "Stratigraphy of Greenland", Meddelelser om Grønland, Vol. 73, Part 2; 1929.

KOCH, LAUGE (1935, a), "Geologi von Grönland"; in "Geologie der Erde"; Berlin 1935.

— (1935, b), "A Day in North Greenland", Geografiska Annaler 1935, pp. 609—620; Stockholm, 1935.

SCHUCHERT, CHARLES (1939), "The Greater Structural Features of North America: The Geosynclines, Borderlands, and Geanticlines"; in "Geologie der Erde. Geology of North America", Vol. 1, pp. 56—71; Berlin, 1939.

Færdig fra trykkeriet den 18. juli 1949.



Geological map of the vicinity of Jørgen Brønlunds Fjord.