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THE NATURAL HISTORY EXPEDITION TO NORTHWEST
GREENLAND 1936

LEADER: FINN SALOMONSEN

GEOLOGICAL OBSERVATIONS FROM THE
THULE DISTRICT IN THE SUMMER OF 1936

BY

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WITH 17 FIGURES IN THE TEXT

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INTRODUCTION

In June 1936 Mr. RUDOLF SAND, Copenhagen, the administrator of the Cape York District Thule station, kindly invited me to visit Thule, as a passenger onboard the chartered three-master schooner the "Dannebrog". The captain of the "Dannebrog" was to be KNUD RASMUSSEN's well-known skipper, PEDER MARCUS PEDERSEN, and the idea was that I should undertake such geological investigations as were reconcilable with the ordinary sailing route of the vessel.

I would like to take this opportunity to express my gratitude towards the then owner of the Thule station, Mrs. DAGMAR RASMUSSEN, and to Mr. RUDOLF SAND for the chance given me to visit Thule — the place from which so many famous expeditions have derived their name.

Further, I owe a debt of gratitude to Professor O. B. BØGGILD of the Mineralogical Museum, Copenhagen, for support given, both towards the journey itself and towards the subsequent working out of the results, and I also wish to thank Professor N. E. NØRLUND of the Geodetic Institute for the readiness with which he placed the necessary cartographic material at my disposal.

The journey took about three months, of which only eighteen days were spent in the Thule District. At Upernavik we took onboard "The Natural History Expedition to Northwest Greenland", the leader of which was Dr. FINN SALOMONSEN. Like myself, this expedition should follow the vessel round the coast, the result naturally being that I joined it, and this gave me certain advantages, for which I am very grateful to Dr. SALOMONSEN. Our route was: Thule—Robertson Bay—via Carey Islands back to Thule—Savigssivik in Melville Bugt—Thule—and then home. Owing to this rather complicated route and the consequent number of sailing days, our time for actual work was reduced to fourteen days, eleven of which were spent in Thule and its surroundings. I wish to express my warmest thanks to Captain PEDER MARCUS PEDERSEN, not only for his pleasant company and hospitality onboard the "Dannebrog", but also for his kind understanding and helpfulness

towards the carrying out of the geological work. A similar debt of gratitude I owe to Mr. HANS NIELSEN, the manager of the Thule station, for his very great hospitality to me ashore, as well as for valuable information regarding the country and place-names, and for his trouble to meet our wishes, when we wanted the use of a motor-boat, the craft of the station being sufficiently in request elsewhere at a time when the vessel of the year was in harbour.

Siorapaluk in Robertson Bay.

Our stay at Siorapaluk only lasted for about twenty-four hours, and the conditions for undertaking geological work were as bad as possible, a dense fog enveloping everything except the lower 50 m of the foot of the mountain. About 1 km northeast of the dwelling place a section was measured up to a height of 500 m (see fig. 5, p. 12). It started at sea level with a diabase sill, 15 m thick; then followed red sandstone screes up to a height of 200 m, here and there with small outcrops, also consisting of red sandstone.

200 m above sea level: outcrops of a red conglomerate with quartz pebbles of the size of a pea.

210 m above sea level: 50 m thick, bedded red sandstone with a southern dip of the strata.

340 m above sea level: a banded red sandstone. It was a rather fine grained rock of a light yellowish-red colour, with narrow dark-red streaks and scattered millimeter-large, rusty brown spots originating from weathering iron compounds.

380 m above sea level: a light yellowish-red, medium grained, ferruginous quartz sandstone, the iron compounds of which here and there formed centimeter-thick veins. The disintegrating surfaces of the sandstone as well as the weathering gravel in the screes had a striking, vividly bluish-green colour, originating from these iron compounds. Ripple-marks and sun-cracks were extremely common here.¹⁾

400 m above sea level: transition from red to yellow sandstone.

450 m above sea level: a yellowish, medium grained, mottled sandstone with centimeter-large, rusty brown spots.

480 m above sea level: a conglomerate layer, 10—15 m thick and overlying a coarse grained, yellow, cross-bedded sandstone (see fig. 1). The pebbles in the conglomerate mainly consisted of pegmatitic quartz,

¹⁾ R. BENTHAM describes a similar sandstone from a section at Cape Hatherton (lit: 1, p. 429).



Fig. 1. Intraformational conglomerate in yellow cross-bedded sandstone. Siorapaluk, 480 m above sea level.

but rolled fragments of other rocks of the archæan complex were not uncommon; in particular a light, reddish gneiss was frequently found here. Also the conglomerate was locally studded with the centimeter-large rusty brown spots.

Above the conglomerate the yellow sandstone continued up to the top of the mountain about 600 m above sea level.

Southwest of the dwelling place, in one of the typical "little auk cliffs", the succession of the strata corresponded with the one described above, but no diabase was found here.

The two following samples were examined microscopically:

1. **Banded sandstone, Siorapaluk, 340 m above sea level.**

The sizes of the grains are generally between 0.06—0.1 mm, and more rarely are seen grains from 0.1—0.2 mm. The rock consists almost entirely of quartz with a very few mica scales. The silica subsequently added is deposited in optical orientation with the grains of quartz. A thin film of rusty red iron compounds marks the original contours of the quartz grains in the present crystallized sandstone.



Fig. 2. Carey Islands. Above the light-coloured gneiss a dark "skull-cap" of diabase.

2. Yellow conglomerate, Siorapaluk, 480 m above sea level.

The grainsizes of the groundmass: 0.15—0.25 mm.

The sizes of the rolled pebbles: 2, 3, 4, 10, 15, 22 mm.

The rolled pebbles lie in a groundmass chiefly consisting of quartz, but with more zircon than was observed in the sediments of Wolstenholme Fjord; furthermore, the rock is more loosely cemented than the corresponding conglomerates from Uvdle.

Northumberland, Hakluyt and Carey Islands.

From Siorapaluk the M/S "Dannebrog" passed in a southern direction through the strait between Northumberland Island and Hakluyt Island. Both of these islands consist of yellow or, less frequently, red sandstone, traversed by dykes and sills of diabase; in a few places the sediments are capped by a cover of diabase.

Further, the vessel called at the small group of gneiss islands, the Carey Islands, the gneiss here being for the greater part intruded by horizontally running diabase sills. In some of the heights the diabase covered the red gneiss, like black "skull-caps" (see fig. 2). The islands were surveyed in 1937 by the expedition of J. M. WORDIE, who also

undertook measurements of certain parts of the skerry-filled waters between the islands. The results of this, up to the present the most accurate survey undertaken of this group of islands, have been published in "The Geographical Journal" 1938 (lit: 15), where there is also an excellent description of the topography of the islands. The individual islands in the group were named by the same expedition, the only one which before 1937 had already been given a name being Bjørlings Ø situated towards south-east. On the east side of North West Island were taken samples of diabase dykes, and on Middle Island of the diabase cover on top. (See description of the diabases p. 31). From Carey Islands we shaped our course towards Thule.

The south coast of Wolstenholme Fjord.

The topography of the country has already been described by KNUD RASMUSSEN (lit: 5), and consequently only a brief mention of it will be made here. The country is traversed by three huge valleys, viz. Narssârssuk towards west, Sioraq immediately west of the Thule station and Uvdle or Amitsuarsuk farthest in the fjord, west of Moltke Glacier; the two latter go right up to the inland ice. These three valleys are all of a broad U-shape and were at one time formed by the ice. The Pitugfik river runs through Sioraq; it drains Great Land Glacier (see the map p. 9) and is therefore very abounding with water. On the other hand, there is a striking disproportion between the valley at Uvdle which is several kilometers broad, and the insignificant river which runs through it and has excavated a small cañon in the shales at the bottom of the valley.

The geological structure of the coast stretch has been described by LAUGE KOCH in a series of treatises (e. g. lit: 6, 7, 8, 9). As was to be expected my short investigation there did not produce any great new discoveries, but the results of a few detailed investigations on the coast stretch may possibly offer points of interest for later works up there.

As indicated (e. g. lit: 6, 7) in several places by LAUGE KOCH the archæan rock is exposed farthest out in the fjord, viz. west of Narssârssuk, and at the head of the fjord east of Uvdle. The oldest parts of the overlying Thule formation: conglomerates and sandstone, are only poorly represented by a narrow, low shore section at Uvdle and by the western slope of Narssârssuk (lit: 6, p. 21). Unfortunately I did not myself have the opportunity to investigate the latter locality, whereas Uvdle was visited.

The Uvdle section which was measured along the sea shore at the eastern and southern sides of a small bay (fig. 4), was hardly 2 km

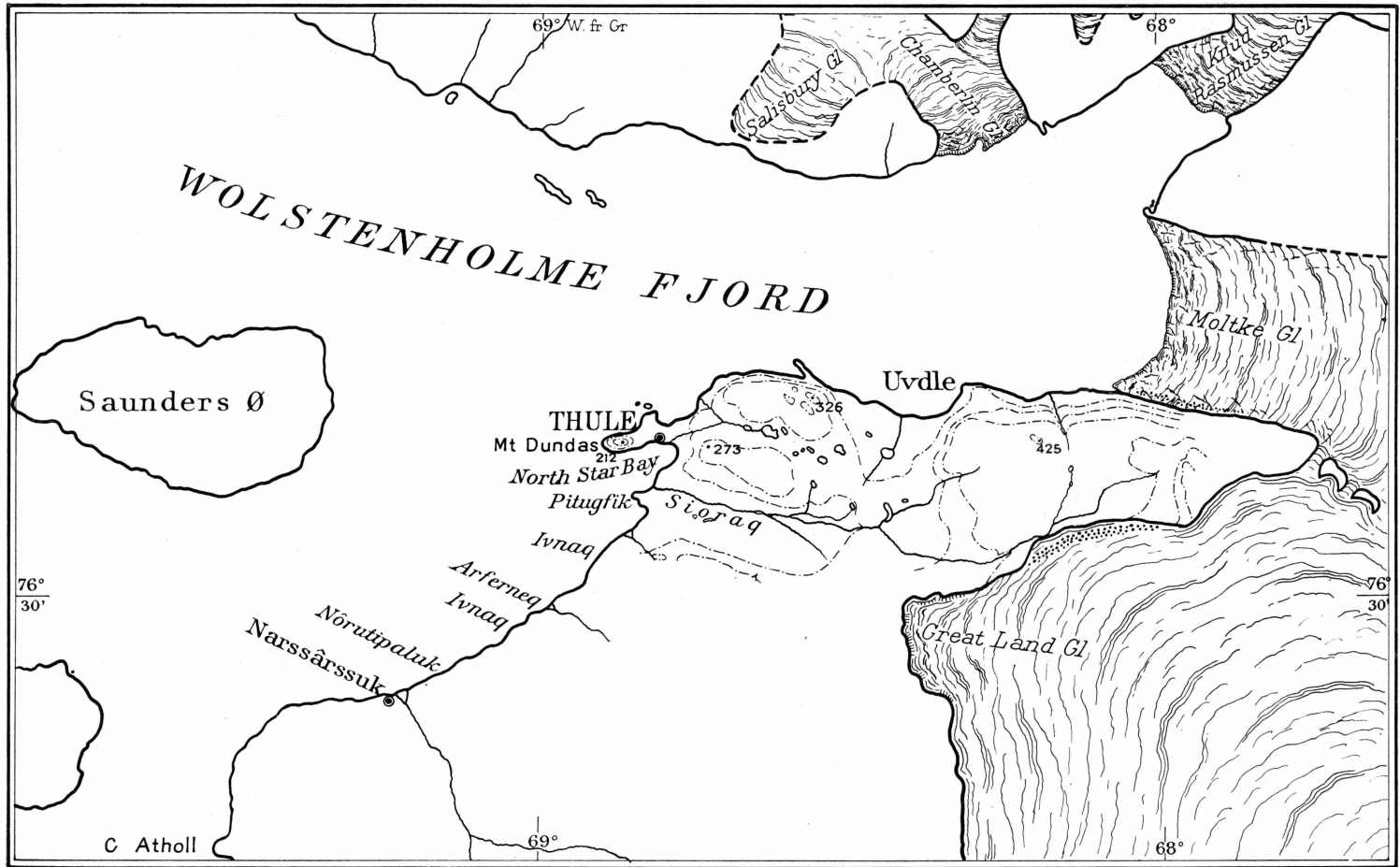


Fig. 3. Map-sketch of Wolstenholme Fjord after J. W. WRIGHT and L. KOCH. Designed by F. RÖHLING. Scale abt.: 1 : 300.000

long, and the dip of the layers was 10° — 15° in a southwesterly direction; it corresponds with an ideal section of 400 m, the average inclination being calculated at $12^{\circ}.5$.

The point of Uvdle consists of gneiss striking northeast; it is traversed by numerous pegmatite veins, the main direction of which is N. 70° E. Hornblende schists and a dark biotite gneiss are of common occurrence, as e.g. at the cairn about 200 m above sea level, where veins of pure quartz pegmatite were found in great quantities. The surface of the archæan rock is high towards the fjord, but inclines downwards farther inland, where it is overlain by the scree-covered sediments of the Thule formation, here chiefly consisting of shales with extensive diabase sheets (fig. 4).

The measuring which was undertaken by a counting of strides, started towards northeast with the oldest layers (x on fig. 4) and continued towards southwest—mainly following the dip of the strata—and so arriving up into still younger layers. In the description below, the corresponding heights of the ideal section has been given in parenthesis beside each coordinate of length. As mentioned above, the section is very low and narrow, and must rather be looked upon as a relict, which wind, weather and ice have not been quite able to remove. However, there are in two places total slips in the section, where small river courses debouch. In the ideal section (p. 12) these places are marked with scree signatures.

The Uvdle section begins towards northeast with a conglomerate, which only occurs over a very small area; it forms a kind of pavement on the beach and immediately disappears below the turf and the sea. A direct superimposition on the gneiss was not to be observed, and consequently the possibility exists that it may here be a question, not of the bottom conglomerate of the Thule formation but of an intraformational conglomerate, which also occurs within the red sandstone series (cf. Siorapaluk), and so the section does not give the exact thickness of the sandstone series. The conglomerate is here rather developed as a very coarse grained sandstone, with quartz pebbles of $\frac{1}{2}$ —1 cm irregularly scattered in the rock.

It is overlain by stratified red sandstone; the thickness of the strata is about 10 cm at the bottom, but decreases in an upward direction to 2 cm. Ripple-marks were seen 100 m from the starting point (a: 21 m in the ideal section).

At 150 m (a: 32 m) yellow sandstone begins to occur, being at first intermixed with the red rock.

A little less than 100 m farther on (a: 51 m) a yellow conglomerate begins to dominate; it lies evidently concordant upon the red sandstone and has a vertical extent of 4—5 m. It is overlain by a yellowish-grey,

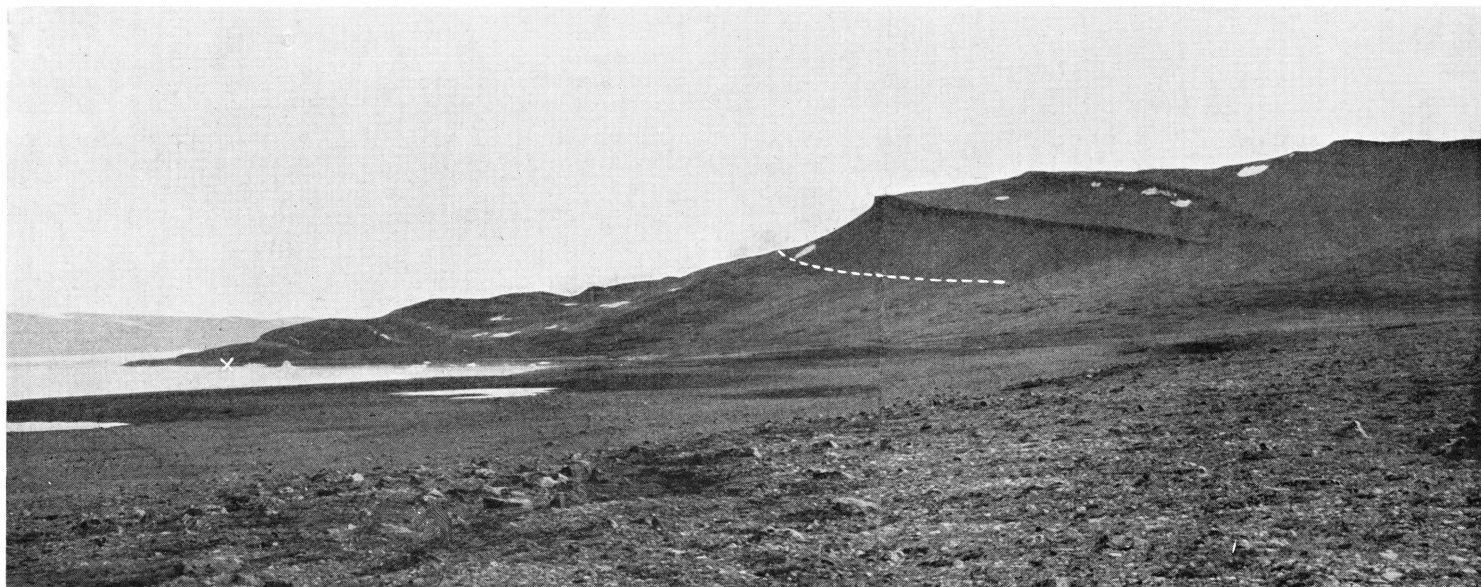


Fig. 4. The valley of Uvdle seen towards east. The dotted line marks the boundary between gneiss and Thule formation. Below the gneiss, along the shores of the little bay, the section mentioned in the text is to be seen, beginning with x. Behind the low gneiss point Moltke Glacier is just visible.

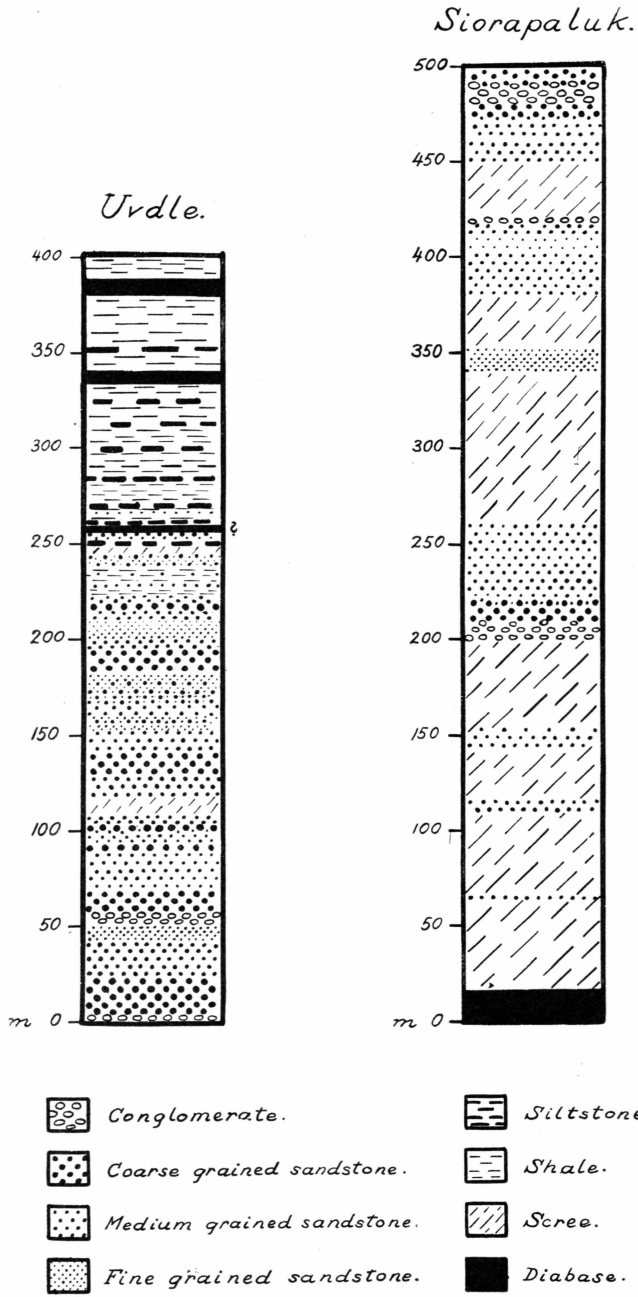


Fig. 5. Sediment sections from Uvdle and Siorapaluk.



Fig. 6. Columnar sandstone, Uvdle.

coarse grained sandstone of loose structure with 10 cm thick strata, frequently with ripple-marks on the bedding planes. The sandstone becomes more fine grained, the farther up one gets, and is arranged in thick beds; these beds interchange with thin layers of the coarse sandstone.

The yellow sandstone continues, and at about 600 m (ø: 130 m) it becomes particularly loose and coarse grained and is cross-bedded. Then again follows hard, yellow sandstone in beds 10—50 cm thick, and with a decreasing size of grains in an upward direction.

At 750 m (ø: 162 m) cross stratification again appears, followed by thick strata of medium to fine grained sandstone.

At 800 m (ø: 173 m) were seen thick strata of quartz sandstone with rusty brown spots, overlain by a grey, coarse, thinly laminated sandstone which becomes more fine grained, the farther up one gets. From now onwards the sandstone becomes still richer in iron compounds which at the beginning occur in irregularly scattered spots, but gradually impart a rusty brown tinge to the whole rock; in some places the iron compounds occur as flat, sandy concretions.

At 1000 m (ø: 216 m) the grey sandstone is overlain by a layer of particularly ferruginous sandstone 75 cm thick, with large, irregularly shaped ferruginous concretions, and above that follow the weathering

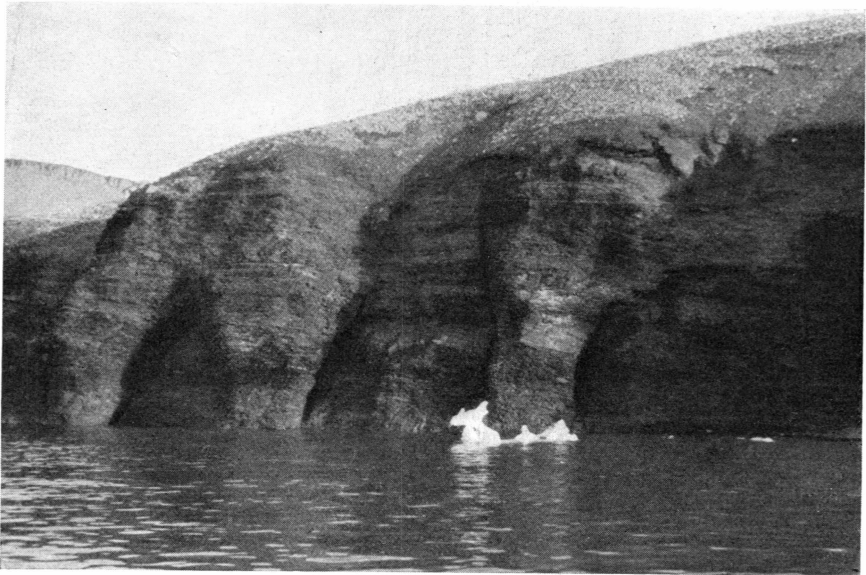


Fig. 7. Shale at the head of the bay, Uvdle.

layers of very thinly laminated shales which disintegrate with great facility into a soft talus of leaflets. These two rocks now occur in irregularly interchanging strata, until the shales, at about 1300—1400 m (o: 300 m), predominate entirely.

At 1175 m (o: 253 m) the grey, ferruginous sandstone appears in strata the total extent of which is barely a couple of meters. Its uppermost strata are very hard, and extend a little farther out into the beach as a sloping row of pillars (see fig. 6), supposed to be due to the thermal effect of a diabase sill, now entirely removed (marked “?” in fig. 5, p. 12). The sandstone is overlain by the thinly laminated mouldered shales with mud-cracks and a certain content of iron, which lends a yellowish red tinge to the weathering surfaces.

From 1350 m (o: 300 m) the thinly laminated shales predominate as mentioned above (see fig. 7). The strata interchange with 0.5—5 cm thick, hard bands of an extremely fine grained sandstone, which is ferruginous like the shale and furrowed with mud-cracks.

At 1550 m (o: 335 m) a diabase sill has intruded into the shale, and after some hundred meters another diabase sill occurs¹⁾.

The microscopical studies of the sediments from the Uvdle section gave the following information²⁾:

¹⁾ From 1400 m the investigation, owing to highwater, was undertaken from a motor-boat.

²⁾ The indications of heights, given in parenthesis, refer to the ideal section.

3. Coarse grained, red sandstone with larger rolled pebbles (0 m).

The grainsizes of the groundmass: 0.2—0.5 mm.

The centimeter-large pebbles practically exclusively consist of quartz from the pegmatite veins of the archæan rock; they are all well rounded. The groundmass also chiefly consists of quartz with a sprinkling of mica, zircon and, in rare cases, a little caolinized felspar, cemented with solutions rich in SiO_2 , the silica of which is optically continuous with the original quartz grains. The groundmass may in parts be granulated quartz or a sericitic mass.

4. Coarse grained, red sandstone without pebbles (0.5 m).

The grainsizes: 0.2—0.65 mm.

A hard, well-sorted, light-reddish sandstone with ripple-marks on the bedding planes. The colour of the strata changes from light yellowish-red to a dark tile-colour. The cement is also here secondary quartz in crystalline continuity with the detrital quartz grains. A few colourless mica scales and rounded grains of zircon occur. The quartz grains have an undulose extinction, and their original sutures are clearly visible under microscope, where they appear as dark lines (limonite?).

5. Fine grained, dark-striated, red sandstone (43 m).

The grainsizes: 0.1—0.3 mm.

A hard quartzitic rock of a light reddish colour with narrow dark-red, more or less parallel streaks. It greatly resembles the banded sandstone from Siorapaluk (no. 1), but is far harder and more quartzitic in character. The cement is SiO_2 ; a few zircon grains occur, as also a few mica scales and a light-green hornblende.

6. Yellowish-white, medium grained sandstone (140 m).

The grainsizes: 0.1—0.6 mm.

The light-coloured sandstone is studded with millimeter-large, brown spots, originating from weathering iron compounds. Under microscope a few zircon grains are to be seen, muscovite, biotite (pleocroic: brown—pale-green and with a small axial angle) and also a green hornblende. The quartz plays a predominant part, and here as in the above mentioned samples has grown out through the cement, without effacing the original boundary lines.

7. Coarse grained, grey sandstone (184 m).

The grainsizes: 0.3—1 mm.

A light-grey, coarse grained sandstone cemented with SiO_2 and in spots with CaCO_3 . Otherwise it rather resembles the preceding samples, thus being a crystal sandstone. 2—3 millimeter-large, rusty brown spots are to be seen everywhere, and also the bedding planes have a brown colour due to weathering iron compounds.

8. Grey columnar sandstone (253 m).

The grainsizes: 0.4—0.6 mm.

A grey, rather well-sorted, pure quartz sandstone. The quartz grains are completely rounded, as in the preceding samples, some of them containing fine rutile needles. The cement is in the main calcite, effervescing strongly with diluted HCl. The dense calcite attempts in spots to form fairly large crystallographic unities. Felspar has not been observed.

9. Dark-grey siltstone (347 m).

This rock occurs as hard 5 cm thick bands in the thinly laminated shale, extremely rich in mica. Under microscope: The predominating constituent is quartz with a large contingent of mica, and there is also a good deal of hornblende. Felspar and zircon only occur as a few grains. The sparse cement between the closely packed grains consists in spots of CaCO_3 , in other places of an indeterminable mass.

As appears from what is written above, the Uvdle section only includes conglomerates, sandstone (red, whitish-yellow and grey) and shales in the same succession as that mentioned by Chamberlin from Inglefield Gulf (lit: 2, pp. 172—173). No dolomites or limestone occur (cf. lit: 6, p. 23). The conformity of the sandstone-shale-series suggests that the superimposition, partly on gneiss (see fig. 4, p. 11), partly on sandstone (see the Uvdle section on p. 12) must be explained by original differences of levels in the gneiss substratum at the time of the deposition of the Thule sediments.

The valley bottom itself at Uvdle is, as mentioned above, built of laminated, black shales. It is a huge plain, covered by a thick layer of boulders and pebbles, mainly consisting of the different rocks of the archæan complex, such as gneiss, biotite- and hornblende-schists, phyllites, quartz pegmatites etc., but also of the rocks of the Thule formation, particularly the red and light-coloured sandstone, as well as of conglomerates, all of them with quartz pebbles of the size of walnuts. On the other hand, only few diabase blocks were to be seen.



Fig. 8. From the Uvdle valley towards west: coastal cliff with "steps" of diabase (cf. fig. 9).

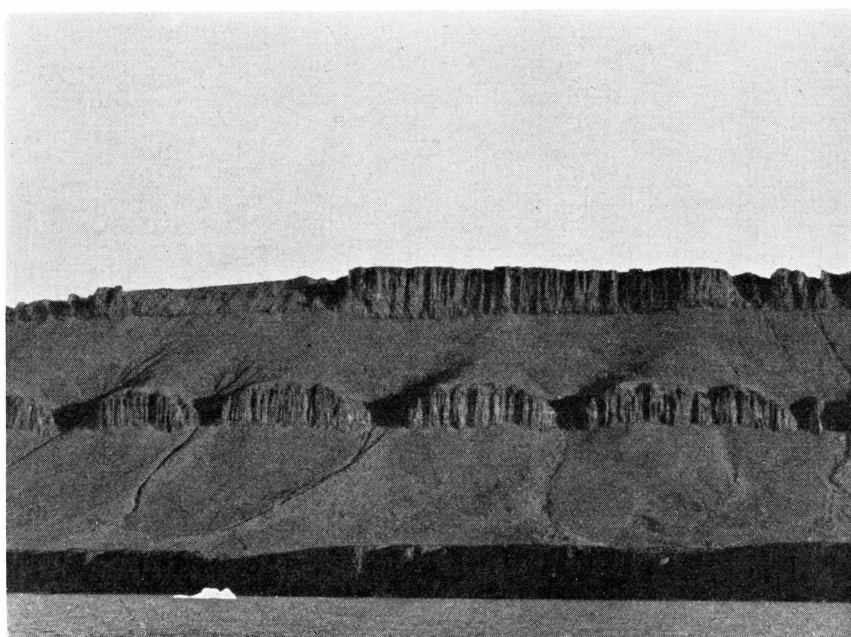


Fig. 9. Coastal cliff between Uvdle and Mt. Dundas. The lower diabase sill forms a land tongue with a northwesterly direction (cf. the map p. 9).

The northern side of North Star Bay, i.e. the level plain on which the Thule station is situated as well as the country east and north of it, is built up of dark micaceous shale, frequently calcareous and sandy, which is intruded by extensive diabase sills. The coastal cliffs between the Uvdle valley and Mt. Dundas are characteristic because of their stair-like shape (see fig. 8). They are completely covered with screes, and only the diabase "steps" stand out with their steep walls, varying in thickness between 5 and 25 m. The contact effect upon the sandy shales is not particularly great; however, hardening and smaller alterations have taken place within a short distance of the contact. Here and there in the coast section were seen broken ends of layers of shale in the diabase, e.g. immediately west of the small diabase land-tongue which extends in a northwesterly direction (see the map, p. 9).

The diabase sills are fairly parallel and run almost horizontally, though with a small dip out of the fjord; in the main, they follow the dip of the strata. The eastern part of the coast stretch have three "steps" (fig. 9), the western part nearer the station only two.

10. Dark-grey, calcareous siltstone

taken immediately under a diabase sill north of the station shows under microscope grainsizes between 0.06—0.1 mm. As contrasted with a similar kind of rock from Uvdle (no. 9) it exclusively consists of quartz grains with a groundmass of granulated quartz, of a green chloritic mineral with a faint refraction and double refraction, and of calcite which frequently within each interval forms a crystallographic unity. The cementing matrix of the sediments evidently becomes particularly rich in carbonate towards the diabase contacts.

Akinârssuk is the mountain which forms the eastern boundary of the low, habitated plain. It is built up of fine grained, micaceous sandstone with mud-planes, interchanging with shales. Here too the mountain slopes are covered with screes in which are seen large flags with mud-cracks; the dip of the strata is about 10° towards southwest. At the top there is diabase as on Mt. Dundas, which is situated vis-à-vis Akinârssuk (see fig. 17) and forms the northern boundary of North Star Bay.

The 200—300 m high plateau between the valleys Sioraq and Uvdle is covered with blocks consisting of shale, diabase, pegmatitic quartz, gneiss and a few large boulders of red conglomerate with the large, round quartz pebbles, whereas sandstone is only seen in small quantities. At the 326 m mark (see the map p. 9) the dip of the shale strata was measured to be 13° S 10° W. On the plateau a broad U-shaped valley, now filled with lakes, marks a former glacier bed,



Fig. 10. The plateau east of Thule. The photograph is taken in a westerly direction, with the flat, sloping roof of Mt. Dundas in the background. In the foreground a diabase sill.

the monotony of the landscape here only being broken by a few steep diabase walls (fig. 10). The contact effect of the diabase could be observed in a "fleckschiefer" which weathers with a strikingly reddish-yellow colour.

11. "Fleckschiefer" from the Akinârssuk plateau (220 m above sea level).

Under the microscope the "flecks" may, in certain cases, be determined as cordierite with the characteristic penetration twins parallel with (110), but for the greater part the small, round spots are only seen to consist of a local accumulation of dark pigment. The bedding planes are coated with a yellow, opaque mineral, presumably pyrite.

The characteristic and well-known rock of the settlement, Mt. Dundas, is 212 m high, being lately measured by J. W. WRIGHT (lit: 16). Like Akinârssuk it consists of fine grained sandstone or siltstone interchanging with strata of shales, and with its top covered by a "skull-cap" of diabase, about 20 meters thick (see fig. 11). The dolomites which dominate from Sioraq and westwards were neither seen *in situ*

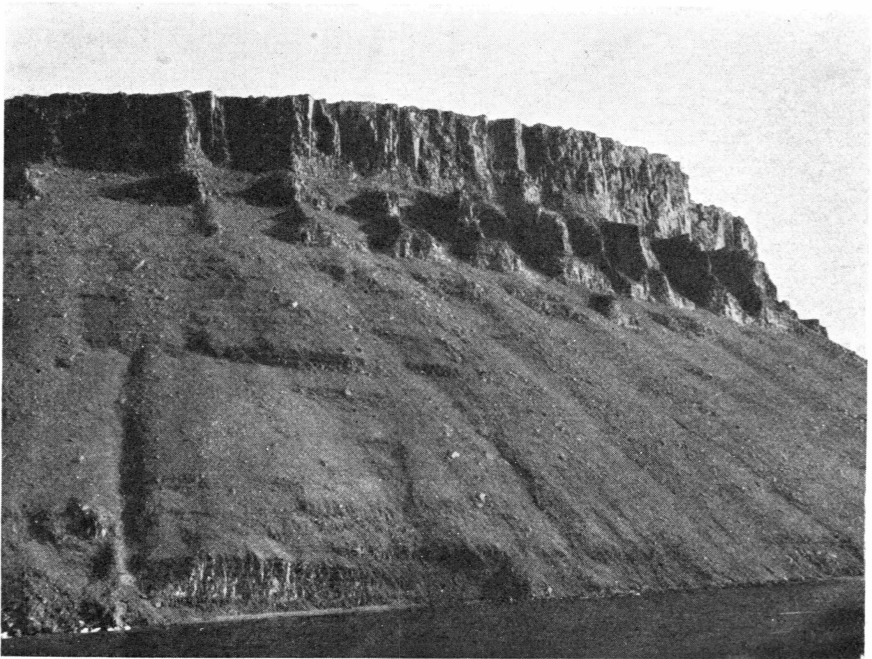


Fig. 11. The northern side of Mt. Dundas. At the top diabase, below which outcrops of sandy shales and fine grained sandstone.

nor in the screens on Mt. Dundas. The dip of the strata is barely 15° in a southwestern direction. The sandstone has varying colours: light greyish, yellowish, reddish. The shale, with the strata of which it interchanges, is black, micaceous, thinly laminated and easily disintegrates into thin slabs, except where it is impregnated with limonite in millimeter- to centimeter-thick layers. At the foot of the mountain the black bands of shale which mark the stratification are 80—90 cm thick. In these shale-bands appear thin layers of fine grained sandstone.

12. Light-grey siltstone from the foot of Mt. Dundas.

This kind of rock chiefly consists of small, angular quartz grains. The contents of mica are large (cf. no. 9) and the cementing matrix consists of the greenish, darkly pigmented chloritic mineral, whereas calcite is lacking (cf. no. 9). In spots there is an opaque, yellow mineral, presumably pyrite (cf. no. 11). In the hand specimen it occurs in 2—4 mm large grains. On the other hand, it is not to be seen on the bedding planes, which have a rusty brown colour, presumably due to the disintegration of the pyrite. The large contents of mica may also be seen megascopically.

13. **Fine grained, light-coloured, striated sandstone.**
The foot of Mt. Dundas.

The grainsizes: 0.06—0.2 mm.

An almost pure quartz sandstone, containing a very small amount of feldspar (microcline), some zircon and practically no mica. Secondary

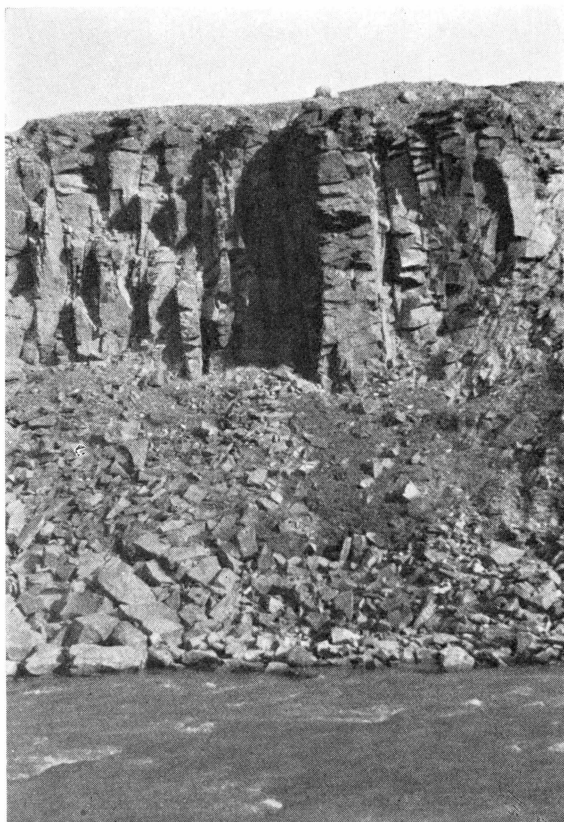


Fig. 12. The lower course of the Pitugfik river through a cañon of jointed diabase.

siderite occurs, traversed by veins and broad edges of brown limonite. The cementing matrix which can only be observed in a few places consists of a greenish, pigmentated mass, the refraction of which is greater than that of the quartz.

The Pitugfik river, as mentioned above, drains Great Land Glacier and is consequently rather rich in water. It has cut its bed into the flat plain, rich in lakes, between the glacier and the coast, and through a jointed diabase sill, 12—15 m thick, which forms steep banks in the lower part of the river course (see fig. 12).

On the coast stretch between Sioraq and Narssârssuk dolomites and varicoloured fine grained sandstones form coastal cliffs, the foot of which is covered by screes (see fig. 13). Only right out towards west near Narssârssuk the steep coastal cliffs pass into flat sloping coast land covered with screes, and according to L. KOCH (lit: 6, p. 21)

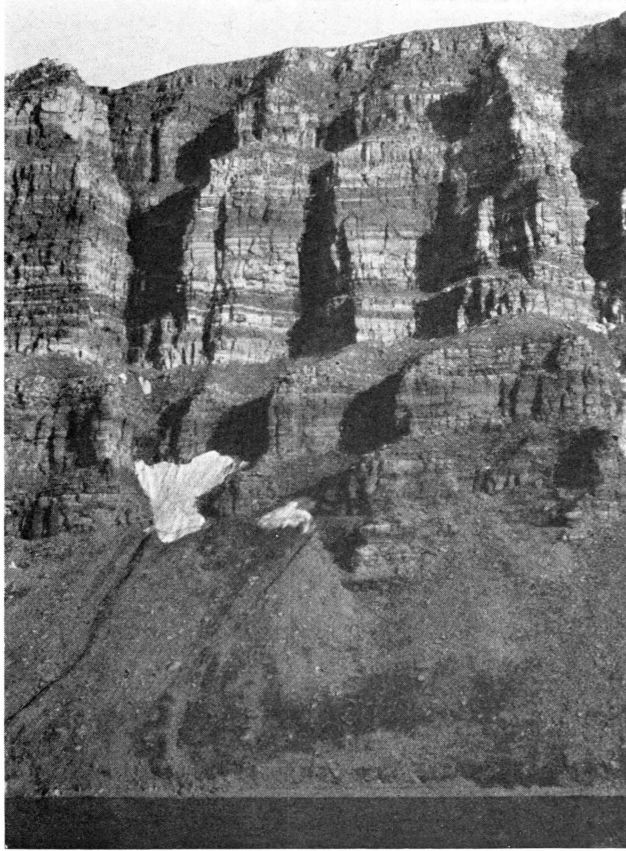


Fig. 13. Steep coastal cliff southwest of Thule, consisting of dolomites and fine grained sandstone.

it is here possible to find the lower links of the Thule formation overlying the gneiss at Narssârssuk.

The dip of the strata along the stretch is in the main northeasterly, but between Arferneq and Nôrutipaluk the layers have small, variable dips which at times are westerly. The steep coastal cliffs along this stretch consist of sandy, hard shales and of grey and white dolomites, which dominate more and more, the farther west one gets. Out here diabase occurs rarely in sills, more frequently in dykes cutting through the light yellowish-grey dolomites and standing out as vertical black

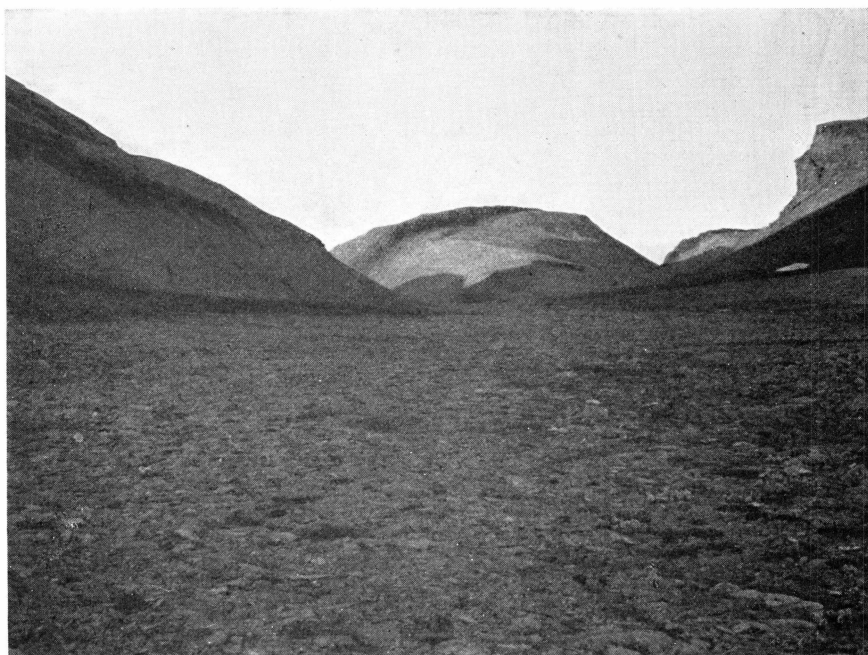


Fig. 14. The Arferneq valley seen towards southwest. A dark diabase dyke cuts through the light-coloured sediments of the distant mountains to the right and in the middle of the photo.

columns, which have also attracted the attention of the Eskimos. If I rightly understood the skipper of the motor boat, Ūmaq, they call such places Ivnaq or Ivnuk. East of the valley Arferneq and at Nôrutipaluk such huge dykes were seen.

Arferneq is an infertile, desert valley, excavated into the dolomitic limestone, which in this place has peculiarly rough and dentate disintegration surfaces. It has plenty of pores and may perhaps be called a "rauchwacke". The fresh unweathered dolomite is dark-grey, but becomes yellowish on the weathering surfaces. It is thick-bedded, but the beds vary greatly in thickness; the dip is about 10° towards east. A couple of kilometres farther in the valley an almost vertical 30—50 m broad diabase dyke cuts through the whole of the dolomite series in the direction $N 10^\circ W - S 10^\circ E$. The direction is easily followed, the dyke standing out very sharply in the topography as a dark hump on the flat-topped sediment mountains (see fig. 14); it is presumably the same dyke which forms the "Ivnaq" northeast of Arferneq. In the interior of the valley stromatolitic structure was seen in the dolomite.

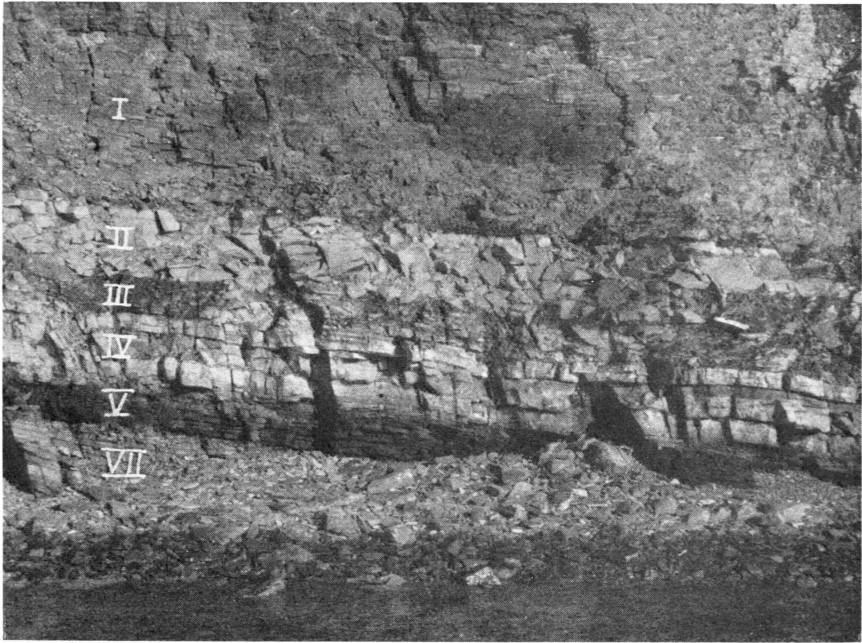


Fig. 15. Coast section between Arferneq and Nôrutipaluk, with a westerly dip of the layers.

14. Dolomite. Arferneq.

Under microscope the rock is a fine grained, impure dolomitic limestone. The impurities consist of quartz, felspar and mica, which are to be found irregularly scattered in the rock; on the bedding planes compounds of iron have been deposited, presumably consisting of limonite. The rock is porous, full of irregular angular cavities, elongated in the direction of the stratification; under microscope they seem to be of secondary origin, the grains along the cavities being partly dissolved.

Between Arferneq and Nôrutipaluk the strata, as mentioned above, have small, varying dips. About 1 km west of Arferneq samples were taken from 7 different strata, which in this place showed a 8° dip towards southwest (see fig. 15). The succession of strata (beginning from the top) was as follows:

- 30 m dense, dark-grey, banded dolomite (no. 33 I¹).
- 0.3 m dense, light-grey dolomite (no. 33 II).
- 0.25 m yellowish-grey, calcareous siltstone (no. 33 III).
- 0.4 m impure grey porous dolomite of the same kind as in the valley at Arferneq (no. 33 IV).

¹) The numbers I-VII correspond with those in the section above (fig. 15).

- 0.25 m reddish-brown, fine grained, micacious sandstone (no. 33 V).
0.1 m intraformational breccia. The upper strata of the yellowish-grey dolomite bed lies as flakes in a matrix of the overlying reddish-brown sandstone (no. 33 VI).
0.4 m dense, yellowish-grey dolomite with many cavities (no. 33 VII).

Chemical analyses were undertaken on the dolomites in the section (see p. 27). Thin sections were made of the following rocks:

15. (33.I) **Dark-banded, grey dolomite**

a dense rock with few impurities, consisting of quartz and mica, which show a tendency to gather in certain layers.

Megascopically the banding in this 30 m thick bed wears a certain resemblance to the varved mudstone from the Tillite Canyon formation, to which A. ROSENKRANTZ called my attention. Under microscope is really seen an interchange between and a transition from coarser to more fine grained strata (the coarser ones frequently have brownish bedding planes due to limonite). This "varved" bedding is of course not necessarily due to its being formed under glacial conditions, and in the Thule dolomite it is neither so regular nor so distinct as in the mudstone brought home by CHR. POULSEN¹) from Tillite Canyon in East Greenland.

16. (33.II) **Light-grey dolomite**

is a very fine grained rock with few impurities which mainly consist of quartz and a little mica. Microcline and a few grains of zircon were seen. As in the preceding rock the impurities are gathered in certain layers.

17. (33.III) **Light-grey, calcareous siltstone**

consists mainly of quartz, secondarily of mica and felspar. The grains are unequal in size and shape, and they are not so rounded as in the dark siltstone (no. 9) from Uvdle. The cementing matrix consists of granulated calcite, which nowhere forms larger crystallographic unities.

18. (33.V) **Red, calcareous, micacious siltstone.**

This rock consists chiefly of quartz, but the felspar contingency is here strikingly large, consisting of microcline and of an acid plagioclase; mica is common, and a few round zircon grains are visible. The cement is yellowish and doubly-refracting, and it may here and there be defined as calcite.

¹) See CHR. POULSEN 1930: Contributions to the Stratigraphy of the Cambro-Ordovician of East Greenland. (Medd. om Grøn. Bd. 74),

East of Nôrutipaluk a 30 m thick diabase dyke cuts through the whole of the dolomite series (see fig. 16) which along the contact is strongly cleaved in two directions at right angles to each other. West of this dyke samples of the dolomites were taken: no. 30 (which like nos. 15 and 16 has impurities concentrated in definite layers) at sea

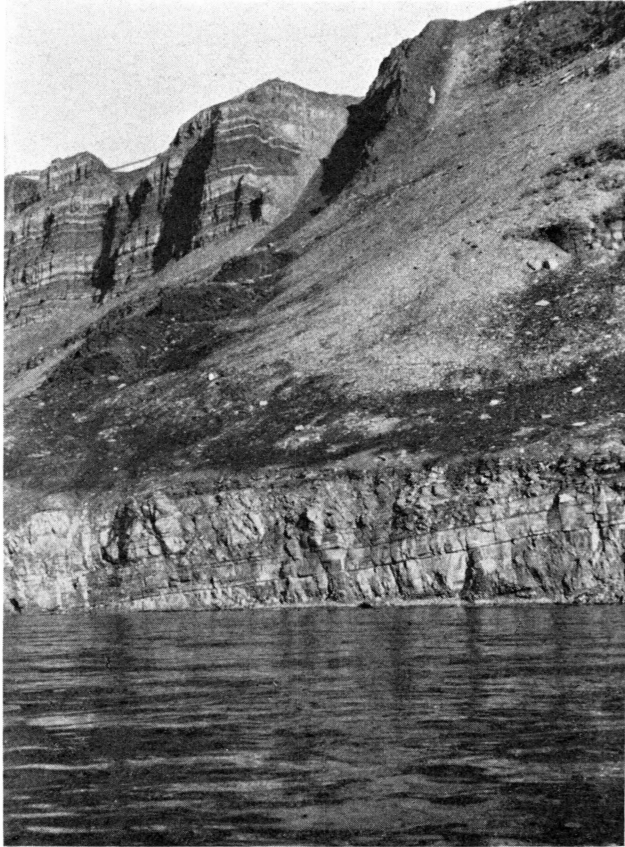


Fig. 16. Diabase dyke east of Nôrutipaluk.

level, no. 31 about 35 m above sea level. Their chemical composition is given below in table 1.

The analyses were undertaken by the chemist of "Danmarks Geologiske Undersøgelse", Mr. WERNER CHRISTENSEN, from whose report the extract given below has been taken:

"The samples were boiled with diluted hydrochloric acid, by which means carbonates (as well as possibly some soluble silicates) will be dissolved. The filtrate from this is vaporised and the remainder treated with hydrochloric acid and water and filtrated; in this filtrate the metals were determined. At the vaporising a small amount of silicic acid was

Table 1. Chemical analyses of six different dolomites.

No. of sample.....	30	31	33.I	33.II	33.IV	33.VII
Indissoluble residue ..	29.6	8.5	10.9	9.9	12.9	4.7
CaO.....	26.2	28.2	27.2	27.7	26.9	29.9
MgO.....	7.9	17.5	17.4	16.3	15.9	18.1
Fe ₂ O ₃	1.3	1.0	1.1	1.1	1.1	1.1
CO ₂	29.2	41.2	40.4	39.5	38.5	43.2
Total.....	94.2	96.4	97.0	94.5	95.3	97.0
Mol. %						
CaCO ₃	70.31 %	53.51 %	52.72 %	54.81 %	54.71 %	54.11 %
MgCO ₃	29.69 %	46.49 %	47.28 %	45.19 %	45.29 %	45.89 %

disengaged, and together with the indissoluble residue it was made red-glowing and weighed (the total of this is given as an indissoluble residue). The contents of CO₂ was determined by means of an analysis of the weight, after it had been absorbed in soda-lime. . . . The contents of iron are very small, and no distinction between ferro and ferri has been made, the total amount being given as Fe₂O₃."

A recalculation of the CaO + MgO + CO₂-contents to 100, and a division through the molecularweights in question showed that the CaO + MgO-contents corresponded with the CO₂-contents as 1:1, i. e. that all Ca and Mg is present as carbonate, and that the iron has not been present as carbonate, which corresponds very well with the microscopic data. If one calculates dolomite at 1 mol. CaCO₃ and 1 mol. MgCO₃ there is consequently a great surplus of lime in sample no. 30, whereas that in the other ones is quite insignificant.

As mentioned above, the sandstone-shale series between Uvdle and Sioraq has a southwestern dip of the strata (out of the fjord), whereas the layers of the sandstone-dolomite series between Narssârssuk and Sioraq in the main incline towards northeast (i. e. into the fjord). The valley Sioraq consequently "marks the bottom of a very flat synclinal", as written by L. KOCH (lit: 7, p. 336).

The position of the dolomite in the succession of strata is not satisfactorily elucidated. In "Ymer", 1925 (lit: 7, p. 332). L. KOCH has in accordance with CHAMBERLIN divided the Thule formation into the three following groups:

1. A lower sandstone series.
2. An upper sandstone series.
3. A series, consisting of dolomites, thinly laminated sandstone and black shales.

In other treatises (e. g. lit: 6, 9 and in "Geologie von Grönland" 1935, p. 6) KOCH places the shales as the youngest link, overlying the dolomites.

The Uvdle section proved that the sandstone series, at any rate in this place, was directly overlain by a huge shale series; but the relation of the latter to the dolomites towards west could not be identified in the localities visited. By means of a thorough investigation of the succession of strata from Narssârssuk (where according to L. KOCH (lit: 6, p. 21) the lower links of the Thule formation is represented) in a north-easterly direction it ought to be possible to decide whether the dolomite overlies the shale, or whether it is only a question of different facies within contemporaneous depositions.

Diabases.

Diabases from Siorapaluk, Carey Islands as well as from different localities on the southern side of Wolstenholme Fjord were examined. They are of a very uniform aspect. Megascopically they are medium grained, dark-grey kinds of rocks with tabular plagioclases which give them a characteristic appearance. Fine grained and porphyritic varieties occur in the chilled margins of the sills and dykes, and the colour here becomes bluish-grey. Coarse grained varieties occur in the central part of the more extensive dykes. The colour here becomes lighter, black-and-white spotted, frequently with a greenish tinge which is due to the beginning alteration of the large felspar laths. The diabase is frequently very strongly jointed, forming 5—6 sided pillars in steep walls (see fig. 12, p. 21). Outer surfaces are always covered by a thin rusty brown weathering crust.

Microscopically the diabases as a rule show a doleritic, rarely a sub-doleritic texture (the nomenclature is according to T. KROKSTRÖM, lit: 11, pp. 198—199); and the non-porphyritic, fine grained marginal zones show a hypidiomorphic texture.

Their main constituents are always plagioclase and pyroxene; as accessories and products of alteration are seen apatite, iron ore, amphibole, biotite, micropegmatite and pure quartz, epidote (?) as well as chloritic and sericitic masses in greatly interchanging proportions of quantity.

The plagioclase determinations were, in most cases, supplemented by measurements on the universal stage. The determinations of pyroxene are based upon measurements of $2V$, combined with measurements of c/γ according to the method indicated by BURRI (lit: 3). For investigations by means of the universal methods a FEDOROFF stage of LEITZ' construction was used.

The plagioclase which nearly always develops in long narrow laths, is a labrador with angles of extinction \perp M and P varying from 28° to 34° and corresponding with an An-content of 54—62 %. Twinning is common, the most usual laws being the albite-, the pericline- and the Karlsbader-laws. Zonary banding is generally developed.

The pyroxene fills the interspaces between the plagioclase laths; it does not show uniform extinction over larger areas, and it may be idiomorphic towards the surrounding plagioclase laths. It is most frequently developed in short prisms, gathered in heaps, but it also occurs in elongated crystals. It has a dull, brownish tinge and never shows pleocroism; twins parallel with (110) are common, and the directions of the cleavage planes are distinct. It is monocline and optically positive with c/γ varying from 41°—44°. The optic axial angle is generally about 44°, but in some cases it has been measured at 59°—60°. When comparing these optical data with T. TOMITA's diagram (lit: 12, p. 46) of the variations in composition and in the extinction-angles on (010) and 2V, it proves that the pyroxene of the Thule diabases is nearest to the diopside corner, but contains varying amounts of FeSiO₃ and MgSiO₃.

Accessories and alteration products will be mentioned below under the description of the individual thin sections.

By means of geometrical analyses an attempt was made to ascertain the approximate mineral composition of the diabases. The counting was made difficult by the often very radical alterations, which have taken place, and the results are only given with great reservation. In the pyroxene percentage the alteration products connected with the mineral have constantly been included, and so it is made to comprise all the femic constituents, except the iron ore. In every case the measurements have been extended over an indicatrix of a length of 35 cm, in the porphyritic rocks over one of 45 cm. The measurements were undertaken by means of a LEITZ' integration table, and the total of the results are included in the table given below:

Table 2. Geometrical analyses of the quartz diabases.

No. of sample.....	19	20	21	22	24	25	26	27
Plagioclase.....	43.3	..	43.8	41.1	47.4	42.7	45.1	..
Pyroxene	39.2	..	43.8	38.6	41.2	48.7	42.7	..
Ore	11.2	..	7.7	12.2	8.4	7.0	11.5	..
Micropegmatite	4.9	..	—	} 8.1	—	1.5	} 0.7	..
Quartz.....	1.4	..	—		3.0	0.1		..
Groundmass .....	..	89.2	..	..	..	..	..	90.9
Phenocrysts of plagioclase .	..	6.3	..	..	..	..	..	4.6
Phenocrysts of pyroxene ..	..	3.8	..	..	..	..	..	4.5
Accumulation of ore .....	..	0.7	..	..	..	..	..	..

19. **Diabase sill northeast of Siorapaluk (at sea level in the section p. 12).**

It is a medium grained, greyish black rock with a greenish tinge and conspicuous plagioclase laths, the length of which under microscope was measured at 2—3 mm. The texture is doleritic. The mineral constituents are: plagioclase, pyroxene, great quantities of ore, apatite, micropegmatite and pure quartz, hornblende and chlorite.

The felspar is a zonary labrador with 59 % An; it generally occurs as long, narrow laths, but also here and there as short and broad individuals, which are not always idiomorphic towards the pyroxene. It is clear and fresh except in the cleavage-lines where a greenish, doubly-refracting alteration product appears, evidently originating from the surrounding femic constituents.

The pyroxene is frequently accumulated in small heaps, consisting of several smaller individuals, but it is also developed in very large, elongated crystals of up to 3.5 mm in length, which show a striation parallel to the base. It is colourless or faintly brownish, without pleocroism with c/γ between 41° — 44° .

Ore is to be found in great quantities in more or less regularly confined, but sometimes cubic grains. The colour is in incident light bluish black, and the grains are almost exclusively concentrated in the heaps of pyroxene.

Quartz is common, partly in large grains with undulose extinction, which fill the interspaces between the plagioclase laths as well as between the pyroxene grains, partly in micropegmatitic intergrowth with felspar, which often show the same extinction as the surrounding laths of plagioclase.

Apatite is seen everywhere in colourless grains and six-sided prisms with bluish grey interference colours.

Biotite is very sparse, and is strongly pleocroic with α : light straw-yellow coloured, γ : dark red-brown and with a very small optic axial angle; it is presumably rather rich in iron.

Hornblende also occurs in small quantities, although more frequently than the biotite. It is green and strongly pleocroic with α : light brownish yellow, β : olive-brown and γ : mossgreen; c/γ is $16^\circ.5$ and $(\div)2V$ is rather large. It occurs partly as an alteration product of the pyroxene, and in that case it is seen together with mica and chloritic alteration products at the outer edges of the pyroxene individuals. In a few cases it has been observed in crystallographically well-defined individuals, which are idiomorphic towards surrounding quartz. In these cases it must be a primary constituent of the rock.

20. Porphyritic diabase from the chilled margin of a dyke on the eastern side of North West Island.

Megascopically it is a dense, black rock with easily distinguishable tabular plagioclase.

Under microscope the groundmass proves to be very fine grained. It constitutes about 90 % of the whole rock (cf. the planimetric analysis p. 29) and consists of small laths of felspar, which are partly altered. The interspaces between them are filled with a faintly greenish, strongly doubly-refracting mineral, which is presumably partly altered pyroxene. Further the groundmass is richly impregnated with a black dust of ore, which in a few places has gathered in larger heaps and forms phenocryst-like grains: 1.2×0.8 and 0.6×0.5 mm in size and of a bluish black colour.

The largest plagioclase phenocrysts are 1.6×0.1 and 1.3×0.1 mm, and consist of a very few albite twins, the An-contents of which vary from 54—58 %.

The pyroxene phenocrysts occur either singly or in larger heaps (most frequently about 0.5×0.5 mm large) consisting of several short-prismatic individuals. Some of these are entirely transformed into a green fibrous chloritic mineral; in others c/γ could be determined to be about 42° , and (+) 2V to 43° .

21. Diabase cover on Middle Island.

A medium grained, light greyish-black rock with numerous plagioclase laths; it is rather weathered, and the more light-coloured appearance is due to the thorough transformation of the plagioclase.

The plagioclase laths, the size of which is about 1×0.25 mm are turbid, from a very much advanced sericitizing and, near the dark minerals, from a chloritizing.

The pyroxene has the same appearance as in the sections of the other diabases; its c/γ is about 41° . It is to a large extent transformed into hornblende, which is frequently seen together with biotite. All the dark minerals are strongly chloritized. Great quantities of ore are present, as a rule in the shape of crystal skeletons. Besides there is a good deal of apatite, much quartz and calcite.

22. Central part of the dyke. Nôrutipaluk.

The rock is coarse grained of a rather light-coloured greenish appearance, which is due to the greenish tinge of the felspar. The texture is doleritic. The mineral constituents are as in no. 20: plagioclase,

pyroxene, great quantities of amphibole, biotite, apatite, ore, micropegmatite and pure quartz, and of secondary constituents: calcite, chlorite and sericite.

The felspar laths frequently attain a length of 4, the longest of 6 mm. They are more or less altered, sometimes zonary banded, and occur as in no. 20 either in long narrow laths or in short, broad irregular crystals, which fill the interspaces between the other minerals. The extinction \perp M and P is 30° , corresponding with an An-content of 57 %.

The pyroxene is, as is generally the case, faintly brownish without pleochroism. c/γ was found to be 41° — 43° , (+) 2V was 44° — 46° . The pyroxene is along the edges transformed into hornblende (more rarely into mica) and chlorite.

The ore occurs in automorphic, most frequently cubiform grains.

Micropegmatite is very widely distributed and occurs in large areas, in which the felspar shows the same extinction as the adjacent plagioclase laths. Quartz with inclusions and most frequently with undulose extinction is to be found everywhere, and forms an integrating part of the rock. Fresh, clear grains fill the interspaces between the laths of plagioclase or within the femic constituents.

Biotite with the usual absorption colours are more common than in no. 20. It is found either surrounding the greatly altered pyroxenes or in connection with ore and quartz.

Besides these apatite and calcite are found in small quantities.

23. The marginal zone of the dyke. Nōrutipaluk.

A grey, fine grained rock with many plagioclase laths and a hypidiomorphic texture. The mineral constituents are the same as in the preceding samples; no micropegmatite is, however, found in this sample but a large amount of pure quartz.

The plagioclase is strongly altered; the length of the laths is as a rule about 0.5 mm or less, but they may also be greater.

The diameters of the pyroxene individuals lie as a rule about 0.1 mm.

Hornblende occurs, but is not so common as in the preceding slides.

On the other hand, biotite is very common and shows the usual absorption colours. It is partly an alteration product of the pyroxene and occurs together with hornblende and a green, faintly refractory mineral, presumably chlorite, surrounding the pyroxene grains.

Ore is present in the thin section, most frequently in the shape of crystal skeletons.

The contingent of quartz is very large; even as compared with these diabases, so rich in quartz, the quartz percentage of the Nôruti-paluk dyke is unusually high (cf. the planimetric analyses of no. 22, p. 29). The quartz occurs in larger or smaller grains with an undulose extinction; on the other hand, it is not seen micropegmatitically intergrown with felspar.

No planimetric analyses were undertaken, the rock being too fine grained.

24. Diabase sheet from the 273-point on Akínârssuk

(see the map p. 9).

The rock is medium grained and of a light-grey colour. It is unusually fresh and under microscope shows a doleritic texture. The pyroxene lies in small heaps, filling out the intervals between the thick plagioclase laths, towards which they are now and then idiomorphic. The mineral constituents are: plagioclase, pyroxene, hornblende, biotite, ore, apatite and quartz.

The plagioclase is lath-shaped and is as a rule 1.5 mm or less, rarely longer. On the Fedoroff stage the An-content was found to be 61 % (an average of 6 measurements of different individuals).

The pyroxene is greatly altered. Along the edges of most of the individuals were seen hornblende, with the characteristic cleavage angle, biotite and the faintly doubly-refracting, greenish, chloritic mineral. In the middle of the individuals there is as a rule a kernel of pyroxene. Its c/γ was measured and found to be 41° — 42° , its (+) 2V was 59° and 60° , and according to TOMITA's diagram (lit: 12, p. 46) it is a diopside with 20 % hedenbergite. It has the usual light-brownish colour without pleochroism.

The hornblende is green and strongly pleochroic with α : light yellowish green, β : dark olive and γ : dark green.

Biotite occurs in comparatively large quantities and is possibly not always of a secondary origin. It occurs most frequently in connection with ore, but also together with quartz it occupies large, angular intervals between the plagioclase laths. It has the absorption colours α : pale yellow, γ : dark red-brown. Large amounts of biotite are, as mentioned, found together with hornblende and chlorite (?) along the edges of the large heaps of pyroxene.

Ore is found everywhere as long plumose branches with irregular contours and as cubic crystals.

Quartz is exclusively found as pure quartz in the intervals between the other constituents of the rock. Besides a good deal of apatite prisms are to be seen.

25. Diabase sill northeast of the station.

A medium grained, grey, not entirely fresh species of rock with a doleritic texture. The mineral constituents are: plagioclase, pyroxene, ore, quartz, micropegmatite, biotite in very small quantities, and a great amount of hornblende and chlorite.

The plagioclase is seen in laths at most 1.5 mm in length, more frequently smaller. On the FEDOROFF stage the An-contents were measured, the result being 58 % (an average of 5 measurements).

The pyroxene is greatly altered, the diameters of the individuals being about 0.6 mm.

Ore is hardly so common as in the preceding samples and is either distributed in fine particles in the chloritic masses or in cubic crystals.

Pure quartz grains are found, but quartz in micrographic intergrowth with felspar is more common.

Biotite is often observed connected with ore or chlorite and is evidently a stage in the alteration of the pyroxene.

The hornblende is more common in this slide than augite and may possibly in some cases be regarded as a primary constituent of this rock.

26. Diabase sill northeast of the station.

The sample originates from a sill, situated above the preceding one. It is a fine to medium grained, dark bluish grey rock with rather fresh plagioclase laths, which generally attain a length of 0.7 mm, but may attain twice that length. Texture and mineral constituents are the same as described under no. 25. However, the ore here frequently occurs in plume-shaped individuals, and both quartz and micropegmatite are rare (cf. the planimetric analysis p. 29).

27. Diabase from the chilled margin of a dyke northeast of the station.

It is a dark, bluish-grey porphyritic rock with a microcrystalline groundmass. The phenocrysts consist of plagioclase and pyroxene. The plagioclase laths rarely attain a length of 1 mm, the heaps of pyroxene a diameter of 0.6 mm, and a few larger equidimensional augite individuals have a diameter of 0.3 mm.

The greenish groundmass consists of light-coloured elongated laths of felspar, which are considerable fresher than in the corresponding diabase-porphyrity from North West Island (no. 20, p. 31). Between the plagioclase laths a greenish mass with a high double refraction and numerous small grains of ore are to be seen.

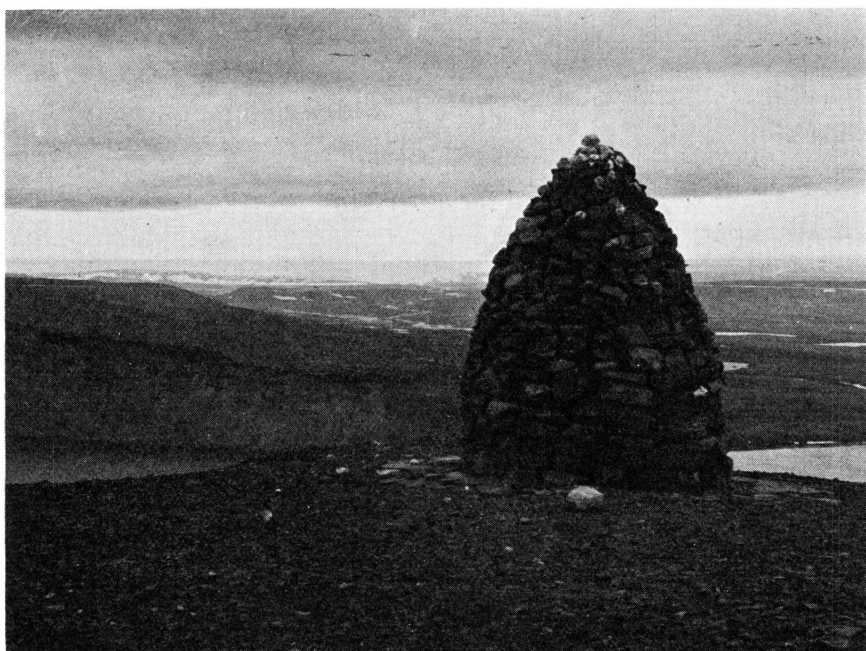


Fig. 17. KNUD RASMUSSEN'S cairn, erected by the Polar Eskimos on the top of Mt. Dundas. View in a southern direction over Sioraq towards Great Land Glacier. To the left Akinârssuk is visible

The phenocrysts of plagioclase which are fresh and un-altered, show \perp M and P 31° — 34° extinction, and this corresponds with an An-contents of 58—62 %.

The c/γ of the pyroxene phenocrysts lies about 44° .

The diabases described above show a conspicuous resemblance to the quartz diabases which were described by K. CALLISEN (lit: 4) under nos. 16, 22 and 31 from Etah, Kap Leiper and Kap Glacier, respectively, all of them stated to be intruded into red sandstone.

As to the age of the quartz diabases it is naturally a fact that they are younger than the Thule formation into which they have intruded. Their upward age limit is possibly Lower Cambrium, the following information being given by L. KOCH (lit: 8, p. 497) from Inglefield Land, viz. "... Lower Cambrian conglomerates¹⁾ contain among other things blocks of diabase averaging the size of a hand." The possibility, it is true, is not excluded that it is here a question of an older diabase connected with the archæan complex, but this possibility is greatly weakened by the fact that up to the present no one,

¹⁾ σ : The bottom conglomerate of the Wulff River formation.

in spite of eager search, has found diabase boulders from the archæan complex in the numerous conglomerates of the Thule formation.

The material brought home by L. KOCH from the bottom conglomerate of the Wulff River formation unfortunately only consists of a few, very small samples and as I have not succeeded in finding diabase fragments in any of them, the problem must remain unsolved for the present. An eruption of quartz diabase, narrowly limited in time, may, however, become of stratigraphic importance, and so a certain interest attaches to the solution of the problem.

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