GRØNLANDS GEOLOGISKE UNDERSØGELSE
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CONTRIBUTION TO THE STRATIGRAPHY OF THE NON-MARINE TERTIARY DEPOSITS

ON THE SOUTH COAST OF THE NÛGSSUAQ PENINSULA NORTHWEST GREENLAND

BY

B. ESKE KOCH

WITH REMARKS ON THE FOSSIL FLORA

WITH 37 FIGURES IN THE TEXT
AND 7 PLATES

Reprinted from
Meddelelser om Grønland, Bd. 162, Nr. 1

KØBENHAVN
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CONTENTS

ABSTRACT

The Tertiary, sedimentary sequence on the south coast of the Nûgssuaq peninsula, North Greenland (THE UPPER ATANIKERDLUK FORMATION) is described. The type area on the south-eastern part of the peninsula (the Atanikerdluk area) shows the *Upper Atanikerdluk formation* divided into 5 members:

Plateau basalts

5. *Point 976 member*
4. *Aussivik member*
3. *Umiussat member*
2. *Naujât member*
1. *Quikavsak member*

Cretaceous (Atane formation)

The Plateau basalts rest upon the *Upper Atanikerdluk formation* which again rests unconformably upon the *Atane formation* (*Cretaceous*). The first occurrence of subaeric lavas is found in Aussivik member.

West of the type area (Pautût and more westerly) the basalt volcanism began earlier, and here the number of sedimentary members of the type area substituted by products of the volcanism (basalt breccia and Plateau basalts) is increasing the more westerly one comes.

The basal Quikavsak member is only visible locally owing to its origin as an infilling of a river-valley in connection with the Paleocene transgression. This fossil river-valley can be traced from Atanikerdluk (purely fluviatile) by Pautût to Nûk kitdleq, where a marine intercalation has yielded a minor fossil fauna making the Paleocene age probable by its accordance with an occurrence of marine, fixed *Lower Paleocene* fauna in a delta deposit at Angmârtussut (the Agatdalen valley), whose stratigraphic equivalence to Quikavsak member is proved. With 1) this fixed point in the Agatdalen valley, 2) the faunal agreement between this occurrence and Nûk kitdleq, 3) the agreement between the fossil flora of

the fixed occurrence at Angmârtussut and Quikavsak member at Atanikerdluk and the other occurrences of this member at the south coast of the Nûgssuaq peninsula as well as 4) the same position in the geological course of events, all these occurrences of Quikavsak member and the litho-stratigraphically equivalent occurrences at Angmârtussut are linked together as *Lower Paleocene* deposits. This dating thus applies to the known fossil floras "Upper Atanikerdluk A" and "Upper Atanikerdluk B" of O. Heer. A short survey of the fossil floras from the localities described is given. Finally *Macclintockia Kanei* (Hr.) Sew. & Conw. is stated zone fossil of the *Lower Paleocene* of West Greenland.

PREFACE

After the finding of the *Lower Paleocene* deposits in the area of the Agatdalen valley (ROSENKRANTZ et. al 1940, ROSENKRANTZ 1951) which beyond the comprehensive marine fauna contain a fossil flora, a long awaited possibility opened up of aquiring a reliable dating of the non-marine, Tertiary sediments in the southeastern part of the Nûgssuaq peninsula where so far no marine intercalations had been found. These sediments have yielded the major part of the well-known fossil Tertiary floras from Northwest Greenland, among which the Atanikerdluk floras should be pointed out. A preliminary investigation (B. E. KOCH 1951) soon showed that there is a promising agreement between the *Lower Paleocene* Agatdalen flora and the one described by O. Heer, the "Upper Atanikerdluk A" flora (HEER 1883a, b) from Atanikerdluk.

The further investigation of the *Lower Paleocene* flora in the Agatdalen valley, not yet published (ref. pag. 94—97), have shown that the fossil floras from the two localities belong to the same type. They are thus contemporaries within the time interval in which this floral community lingered in the extreme North. Similarities of details make us assume that the "Upper Atanikerdluk A" flora belongs to *Paleocene*, but without a final proof.

To go one step further and try to prove or refute the full identity of age and to create a geological basis of a further investigation of the West Greenland Tertiary fossil floras with its possibilities of further datings, it became necessary to obtain a geological survey of the Tertiary in the area. For this purpose it was practical to investigate the whole south coast of the Nûgssuaq peninsula and start to the east in the Atanikerdluk area following the individual members of the formation eastwards towards the Paleocene coast line which was assumed to traverse the south coast of the Nûgssuaq peninsula somewhere. Thus, marine *Paleocene* fossils are known from Nûk kitdleq and Pautût. The result of such an investigation is presented in this paper and gives a positive support to the floristic correlation. It is published as the first part of a work of the dating of the non-marine Tertiary deposits in the southeastern part of the Nûgssuaq peninsula, which will later be followed by a publication of the floristic correlation.

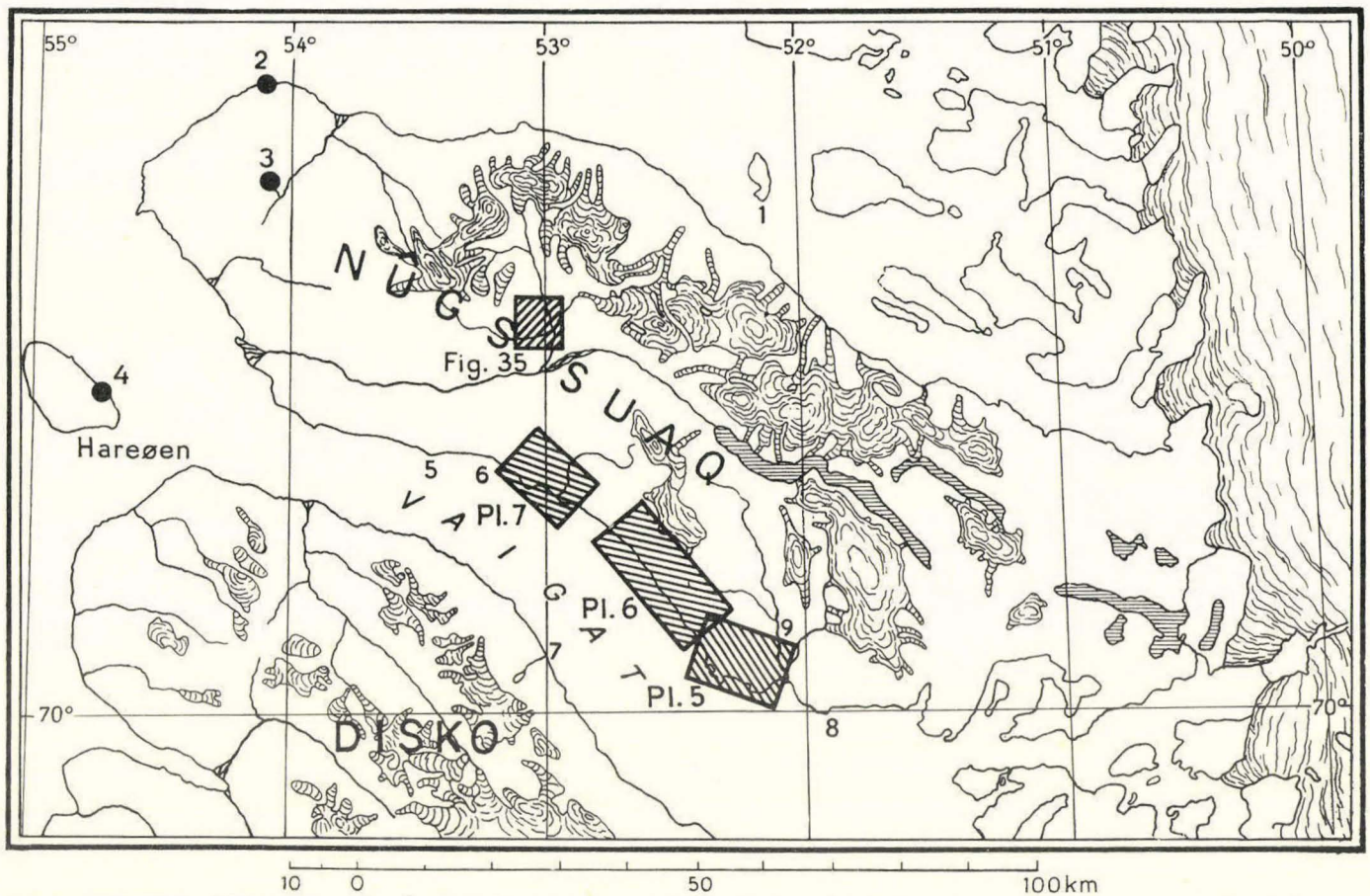


Fig. 1. Map of the Nûgssuaq peninsula showing names used in the text, and areas reproduced on a larger scale in plates and figures. Black spot: Intrabasaltic sedimentary occurrence. Numbers referring to localities: 1: Umanak, 2: Qernertuarssuit, 3: Qissugssarigsup qôrua (Kulelv), 4: Aumarûtigssâ, 5: Nûk kitdleq, 6: Nûk qiterdleq, 7: Qutdligssat, 8: Sarqaq, 9: Sarqaqdalen.

The area round Atanikerdluk was previously described by the author (B. E. KOCH 1955). New observations have been made since then, partly improving and partly revising the former ones. For this reason the description, which on certain aspects is rather detailed, is repeated of the profile of Atanikerdluk. On account of the agreement with the international nomenclature for the litho-stratigraphy, different designations have been used for the single members of the Tertiary sequence which are designated members and named after the type locality. These members are subdivisions of THE UPPER ATANIKERDLUK FORMATION (ref. TROELSEN 1956). In (B. E. KOCH 1955) they are incorrectly designated as series by means of main facies.

The field work on which this paper is based, was carried out in 1951, 1952, 1954, and 1956, and is part of the geological mapping of the Greenland Geological Survey being undertaken in Northwest Greenland under the leadership of Professor A. Rosenkrantz. Stud. mag. K. Raunsgaard Pedersen, stud. mag. A. Dinesen, stud. mag. Ragna Larsen, and the Greenlanders Johs. Tobiassen and Kristian Tobiassen participated in the field work.

Translation: (Miss) Esther Jacobsen
Drawings: F. H. Røhling and (Mrs.) Ragna Larsen
Photography: Chr. Halkier, A. Kiilerich (figs. 34, 36, 37).

When nothing else has been stated below the illustrations, the photos are taken by the author.

Pl. 7 has been compared with and aided by a geological sketch-map which was kindly placed at our disposal by Dr. phil. K. Gry, stategeologist. For some summer seasons Dr. Gry has carried out geological field work on the stretch of coast described in this paper and among other objects studied the Tertiary deposits. He has i. e. recognized the deposits, described in this paper as Quikavsak member, as fluviatile ones. The comprehensive collection of samples to illustrate the petrography of the sediments made by Dr. H. Gry is not yet published.

DESCRIPTION OF PROFILES

The South Coast of the Nûgssuaq Peninsula.

In the following a description is given of the Tertiary sequence within the areas shown on the maps pl. 5, 6, and 7, the position of which appears from the map fig. 1. These maps are not final geological maps, as only a number of profiles through the Tertiary sequence with intercalated observations were necessary for this investigation which, nevertheless, comprises as wide areas as possible. The maps comprise only areas directly observed; nothing has been constructed on the basis of this.

The Outlet of the Sarqaqdalen Valley.

In this chapter is described a profile in the western slope of the Sarqaqdalen valley where it joins the Vaigat strait. In *Flora Fossilis Groenlandica* 1883 O. Heer described plant fossils from this locality near Naujât, a small bay on the coast immediately west of the outlet of the Sarqaqdalen valley (pl. 5).

The profile is measured from the bottom of the Sarqaqdalen and up to the foot of the basalts which constitute the peak with point 970, based on outcrops on the valley slope below point 970 and south of this; and on outcrops in the uppermost tributaries of Aussiviup kûa, the blind valley which from the deserted village of Tartunaq stretches upwards towards point 970.

Quikavsak member: As mentioned in (B. E. Koch 1955) pag. 37ff there is an outcrop in the western slope of the Sarqaqdalen valley near Naujât from alt. abt. 200 m to alt. abt. 520 m (fig. 2). The lowermost sequence consists mainly of almost white coarse-grained quartz sandstone with few subordinate shale and fine-grained sandstone beds. No fossils are known from this sequence, but its continuity with the corresponding sequence at the basis of the profile at Atanikerdluk makes it natural to refer it to the *Atane formation* from where fossils are known belonging to Upper Cretaceous (Heer: Cenomanian). Again the sequence shows the regional dip of this formation (10°—15° NE), which in the out-

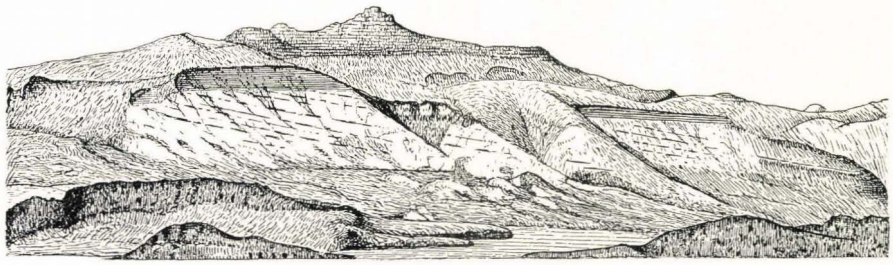


Fig. 2. The outlet of the Sarqaqdalen valley. Foreground: Basaltic hummocks. Background: The western slope of the valley with the southernmost sedimentary section. Cretaceous sandstone (dipping right) and Tertiary shale (Naujât member) showing horizontal bedding. The peak in the background: Point 970. (Sketch by A. Rosenkrantz).

crop at the Sarqaqdalen (fig. 2) is exposed as a northerly dip of the beds. In the greater part of the outcrop, abt. 10 m of coarser-grained clastic sediments are seen unconformably deposited upon the Atane formation; they are well consolidated and truncated forming a scarp which at the basis shows up to 4 m conglomerate; and above this follows cross-bedded sandstone. The height of the unconformity varies for the greater part of the outcrop between altitudes of 420 to 445 m. The upper limit towards the black shale of Naujât member is easily recognized, and it can averagely be estimated at abt. 10 m higher although the thickness may vary some metres (B. E. Koch 1955 fig. 17). This coarse-grained clastic occurrence seems to increase in thickness in the southern part of the outcrop. Here is a small ravine, and immediately south of this, below black shale, a few metres of sandstone are exposed. Underneath there are no fresh exposures, but the slope consists of loose quartz sand with many pieces of clay ironstone with plant fossils as known from the "Upper Atanikerdluk A" flora from *Quikavsak member* in the *Upper Atanikerdluk formation* near Atanikerdluk (ref. page 21). Even if it is impossible, because of the scree, to make observations of the exact position of the unconformity, the order of magnitude of the fossil-bearing sand occurrence shows that the thickness is greater here than in the remaining part of the outcrop.

The fossil content and the position of the strata in the profile as a whole ensures the correlation to the type locality of the profile at Atanikerdluk. With a knowledge of the other occurrences of Quikavsak member at the localities treated later in this paper (Atanikerdluk, Pautût, Atâ etc.) the idea suggests itself that in the southern part of this outcrop there is a depression of the unconformity Tertiary/Cretaceous which represents the utmost lateral part of a fossil river-bed. The boundary between this fluviatile member and the overlying shale is, in this part of the outcrop, situated at an altitude of 370 m, i. e. lower than in the

remaining and more northerly part (fig. 2). However, this does not affect the impression that the fluviatile beds in the southern part of the outcrop are of an increased thickness. A less tectonical displacement can thus be manifested, as small faults striking coastwards are known from other localities along the south coast of the Nûgssuaq peninsula. Alternatively the river-bed was not here completely filled up with coarse-grained clastic sediments before the change of the natural conditions causing the deposition of the following clay sediments occurred, or a shrinking of the river-deposits has taken place. No outcrops in this part of the valley slope are sufficiently distinct to contribute to the solution of this problem. Apart from the fossils, the lithology and the position of the strata in the whole profile suggest that it is the *Quikavsak member* of the *Upper Atanikerdluk formation* which is represented here (ref. pag. 21—25).

Naujât member: The overlying shale beds constitute the uppermost part of the outcrop (fig. 2, B. E. Koch 1955 fig. 16) the upper edge of which is situated at an altitude of abt. 520 m, but the shale can be observed further upwards in the terrain above the outcrop to abt. 630 m. The rock is mainly black, bituminous, well-consolidated shale with irregular cleavage. Thin clay-ironstone bands are seen in various horizons. In the southernmost part of the outcrop where the shale overlies Quikavsak member at an altitude of 370 m, there are, in the basal layer of the shale, brown tuff bands which are harder and more like clay ironstone than the corresponding ones at Atanikerdluk (at point 445) containing Heer's "Upper Atanikerdluk B" flora. The siderite content of the tuff approaches the rock to clay ironstone. In case of treatment with hydrocloric acid and separation, siderite and clay fraction which constitute the majority of the material are removed. The rest consists of grains of abt. 0.1 mm ±. These grains are faintly rounded and consist of an enormously pigmented palagonite (n_D 1.58) (the grains only being translucent through the thinnest edges) according to information given by mag. scient. H. Michelsen. Consequently it is a tuff rock; the majority belongs to the clay fraction, and the coarsest fraction proves to have been exposed to a relatively short water transport.

The shale is again found west of the Sarqaqdalen valley in Aussiviup kûa (pl. 5). At this place it was observed in the eastern slope down to an altitude of 520 to 530 m. It can be followed up along the torrent towards a small pass leading into the Sarqaqdalen. Below the pass the torrent is joined by a tributary from the east which derives from a ravine with precipitous slopes showing distinct outcrops of the shale up to an altitude of abt. 660 m. Arenaceous intercalations are seen in the sequence from altitudes 630 to 650 m where inter alia an ochreous-coloured sand layer stands out distinctly. It is here a question of a transition zone to the next member of the formation.

In the shale plant fossils have been found at two levels, both within the big southernmost outcrop of the western slope of the Sarqaqdalen valley. One of these levels consists of the brown tuff bands of the very basal beds of the Naujât member shale in the southernmost part of the outcrop, where the shale at an altitude of 370 m overlies Quikavsak member. These bands, less than one metre above the lower limit of the shale, contain the same species of plant fossils as Heer's "Upper Atanikerdluk B" flora. Some of the fossils which Heer described from Naujât (HEER 1883a, b) probably originate from this locality (ref. pag. 88): alt. 353 m).

More northerly, in the same big sedimentary outcrop in the western slope of the Sarqaqdalen valley, plant fossils have been found at an altitude of 490 m (B. E. KOCH 1955 pag. 39—40). Steenstrup (STEENSTRUP 1883a, HEER 1883b) writes that he discovered plant fossils in the shale at an altitude of 432 m without any exact indication of the position. It is, however, hardly the same place as that found by the author as there is a conspicuous difference in the statements of height (about the flora see pag. 89).

The occurrence described here shows the best known outcrops at the Nûgssuaq peninsula of this shale level from the lower to the upper limit. It is therefore considered the type of NAUJÂT MEMBER *of the* UPPER ATANIKERDLUK FORMATION.

Umiussat member: Naujât member is overlain with a sequence of cross-bedded sandstones of which quartz forms an integral part. The sequence contains numerous ball-shaped, coarse-grained concretions in the lowermost part. In the upper 10 m or so the concretions are irregular and red with iron compounds as cementing matter.

If we follow the brook of Aussiviup kûa upstreams, we arrive through the previously mentioned ravine in black shale (Naujât member) at a small pass which leads to the Sarqaqdalen valley. In the pass this sequence can be seen from an altitude of 670 m and it can be traced in the west slope of the pass to an altitude of 775 m towards the outcrop of truncated basalt beds overlying the sandstone sequence. On account of talus of basalt the upper limit to this sill-like basalt occurrence could not be measured exactly (fig. 3) but it lies between altitudes of 750 to 760 m measured at the uppermost visible sand occurrence and the lowermost stationary basalt, respectively. No fossils are known from this member which, according to its position in the profile as a whole (overlying Naujât member and overlain by the basalt level of the Aussivik member) (ref. pag. 12 and fig. 3), is identical with what was designated Upper Fluviatile Series above Atanikerdluk (B. E. KOCH 1955) and now called *Umiussat member* (ref. pag. 38—39).

Aussivik member: The measuring of the profile was continued from the above-mentioned pass alongside the spur trending SE and forming the very limit between the Sarqaqdalen valley and the coastward trending slope alongside the Vaigat strait. This spur stretches up towards the peak with point 970 (fig. 3). Alongside this spur above Umiussat member (fig. 3: U) follows, as mentioned before, a sill-like occurrence of truncated basalt beds with a lower limit between altitudes of 750 and 760 m and an upper limit at an altitude of abt. 810 m measured at the precipitous, somewhat projecting basalt "nose" (fig. 3:B). Abt. $^1/_2$ km more northerly, on the slope of the Sarqaqdalen valley and closer to point 970, the surface is at an altitude of 825 m. The basalt is overlain with the sediments described below. This basalt level is known from many observations made alongside the coastal slope towards northwest over a stretch of 10 probably 20 km at the same stratigraphical level, and as mentioned later the author is of opinion that it is the oldest lava flows of the district (in contradiction to (B. E. Koch 1955) where it is mentioned as "sill "), though the problem has not yet been solved. In the slope of the Sarqaqdalen, where the basalt is truncated, it consists of an upper thinner bed of abt. 10 m's thickness separated from the lower and thicker (bisected) basalt "bed" of up to 10 m black shale. On fig. 3 is seen a terrace in the basalt horizon B in front of 970 caused by this shale. It seems to be baked against the overlying basalt, but this observation was made at a distance, and the occurrence being inaccessible the observation is not reliable.

The shale sequence which is normally situated beneath the basalt level (pag. 28, and 34) could not be observed within the limited area on which this profile is based. The more westerly occurrence of the Aussivik member comprises this basalt horizon (pag. 81), and it is therefore also here described under this member.

Above the basalt horizon is black, bituminous shale (fig. 3:A) which is succeeded by light, greyish brown shale. There are thin clay-ironstone bands in the whole shale member, and besides the light shale contains a number of small concretions, averagely a few cm in diametre. These contain fish fossils such as scales and spines. Further scattered pisolitic clay-ironstone concretions with undeterminable plant fossils. No suggestions of contact effect at the lower limit to the basalt have been observed. By its lithological bisection, the presence of the basalt level and its position in the profile, this occurrence corresponds to the member which in (B. E. Koch 1955) is mentioned Upper Shale Series at Atanikerdluk. The upper limit of the shale member is at an altitude of 860 m below point 970.

As described here this shale is defined as the Aussivik Member *of the* Upper Atanikerdluk Formation *with this locality as type.*

Fig. 3. The peak of point 970 west of the Sarqaqdalen valley with southerly trending spur showing sedimentary outcrops. Foreground: Small pass between Aussiviup kûa and Sarqaqdalen. U: Umiussat member, B: Basalt level of Aussivik member, A: Upper shale of Aussivik member, P: Point 976 member, b: Plateau basalts.

Point 976 member: Above the Aussivik member is light quartz sand, the structure of which could not be observed as no clean sections could be found (fig. 3: P). These sands could be followed to an altitude of 920 m where they are overlain by the Plateau basalts which forms the peak with point 970. From their position in the profile these layers correspond to those described below as *Point 976 member* at Atanikerdluk (pag. 29—30).

Summary of the Sarqaqdalen Valley Profile

The profile of the western slope of the Sarqaqdalen valley just described proves by its structure and succession to correspond with the one described by the author from Atanikerdluk (B. E. Koch 1955), but it is more complete seeing that Naujât member is in situ and undisturbed by landslides, and the limit to Umiussat member can be determined more precisely. Further, the members of Naujât and Umiussat are exposed in their whole thickness.

The Sarqaqdalen Valley — Atanikerdluk.

In the area between the profile described above at the outlet of the Sarqaqdalen valley and Quikavsaup kûa at Atanikerdluk, a stretch of 2 or 3 km along the Vaigat, no sedimentary outcrops along the coast reach an altitude of more than abt. 500 m, and do not reach the level of

the Tertiary sequence. Along the coast the outcrops show deposits belonging to the *Atane formation;* on top of this is an area with landslide "coulisses" with the typical, highly undulating morphology (B. E. KOCH 1955 fig. 14). Most of the landslide "coulisses" must be very old as they are strongly overgrown. Here and there are outcrops in the slopes of the "coulisses" showing either basalt beds with considerable, northerly dip, or they expose a caotic heap of angular basalt blocks.

From the members of the Upper Atanikerdluk formation which are found in the profile at the Sarqaqdalen valley, it is possible to trace the basalt horizon of Aussivik member SE of point 970 and towards point 1033 (Iviangernat) at the same level as measured in the above profile.

Atanikerdluk — Siorqat kûat.

As the Tertiary sequence have previously been the object of a detailed description (B. E. KOCH 1955), this paper will only give a summary including a few new observations and some corrections involved by these. As an illustration is further referred to the geological map: Atanikerdluk 1: 10 000. — Meddelelser om Grønland Bd. 162 No. 4 1959.

The most important outcrops are found in Quikavsaup kûa (fig. 4), the great gash immediately southeast of Atanikerdluk, and in the steep slope forming the northern limitation of the cirque-like landslide area between Atanikerdluk and Siorqat kûat (fig. 6).

Quikavsaup kûa and Environs.

In the west slope of Quikavsaup kûa the Tertiary sediments are exposed distinctly unconformably upon the deposits of the *Atane formation* at an altitude of 365 to 370 m (fig. 4). The very unconformity surface, e.i. the surface making up the lower limit of the Tertiary sediments, will be specially treated. After having gained more knowledge of the geological conditions of the Tertiary basal beds at several localities along the southcoast of the Nûgssuaq peninsula, it is considerably easier to gather the observations made from Quikavsaup kûa in a reliable picture of the structure of the deposits.

Outcrops of the *Quikavsak member* of the *Upper Atanikerdluk formation* are found as described in (B. E. KOCH 1955), which designates this member the Lower Fluviatile Series:

1) In the angle between the upper part of Quikavsaup kûa (above dyke III) (ref. B. E. KOCH 1955 and the geological map: Atanikerdluk 1:10000. — Medd. om Grønland Bd. 162 No. 4 1959)) and its eastern tributary (following dyke III). At this place the Tertiary sequence is exposed in the east slope of Quikavsaup kûa (fig. 5),

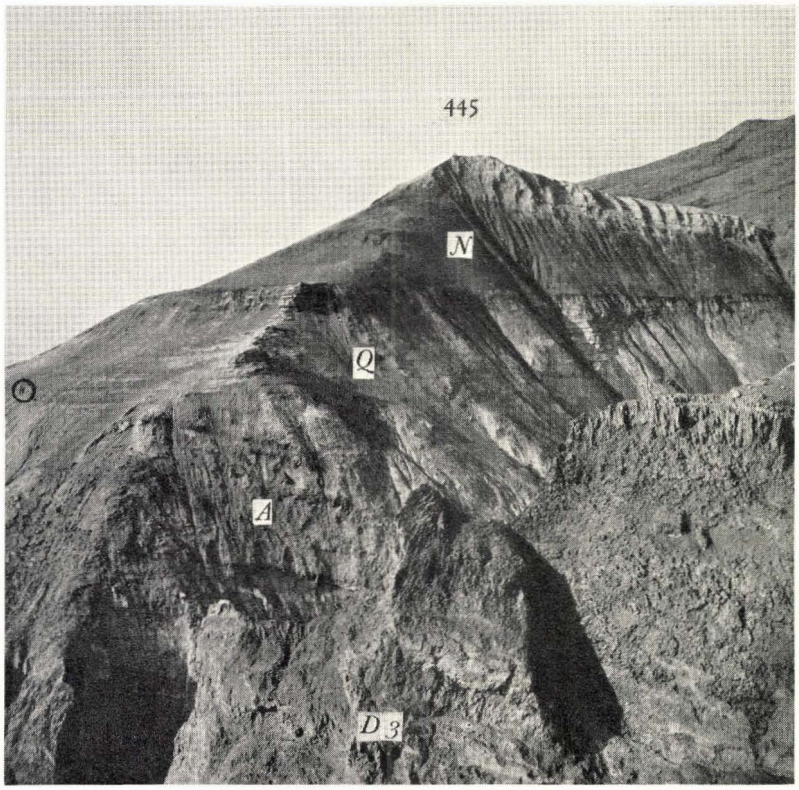


Fig. 4. Western slope of Quikavsaup kûa with point 445. Encircled 2 persons. D 3: Dyke III, A: Atane formation (Cretaceous), Q: Quikavsak member (Lower Paleocene), traversed by "Profile Ridge", N: Naujât member (Lower Paleocene) (dislocated) overlayn by light coloured dislocated sandstones making up point 445. (H. Gry phot.).

2) In the east and south slope of the hill with point 445 (fig. 4). The east slope of this hill constitutes part of the west slope of upper Quikavsaup kûa where there are clean outcrops. This is also the case in the small gully situated immediately west of point 445 (B. E. Koch 1955 fig. 11).

3) In the Liriodendronkløft gully immediately below the place where it crosses dyke II which forms a natural dam across it (B. E. Koch 1955 flg. 12).

In the eastern slope of Quikavsaup kûa above dyke III the northernmost outcrop of the Tertiary sediments (fig. 5: Q) is observed in a spur. This is the very place where the torrent alters its course from a southwesterly direction to south and southeast towards the waterfall where the gash intersects dyke III. The strata here underlying the Tertiary beds consist of cross-bedded quartz sandstone of a considerable thickness

(abt. 20 m), of which a part is strongly consolidated and forms a vertical wall, which in the northern part of the outcrop is weathered into several projecting "noses". Immediately north of the northernmost of these "noses" (abt. 20 m) a spur is showing exposed Tertiary beds. It is being covered with scree, and the greater part of the underlying Cretaceous sandstone is already hidden. The lower limit of the Tertiary is here found at an altitude of 389 m (fig. 5). A little to the south (20—30 m), on the northernmost of these "noses", the same limit is found at an altitude of 395 m. This heigt seems to be kept in the remaining southern part of that small occurrence.

On the northernmost of the projecting "noses" of Cretaceous sandstone, some of the Tertiary basal layer is observed (B. E. Koch 1955 page 20), and the very limit Tertiary/Cretaceous is thus visible. The uppermost part of the Cretaceous sandstone, which is normally of a faint yellowish colour, shows a distinct decoloration into grey which decreases from the limit downwards through a zone of $^1/_2$ to 1 m to a rusty zone which can be interpreted as a fossil iron-pan occurrence (B. E. Koch 1955 fig. 6).

Underneath the sandstone has its normal colour. It must be a question of a fossil podsol profile and suggests that the unconformity is caused by Tertiary sediments deposited on a surface resulted from subaeric erosion, consequently an old land surface modelled into the inclined Cretaceous sediments.

The sediments which lie directly on the unconformity surface is mentioned in (B. E. Koch 1955). They begin with abt. 10 cm ironstone consisting of very fine-grained sand cemented with siderite. On top of this there is a layer of 10 cm of a "breccia" of shale fragments abt. 2 mm in diametre which are slightly cemented by clay. This layer was misleadingly described as mould-like in (B. E. Koch 1955); however, the expression only covers the habitual impression one gets on a superficial view and indicates a connection with mould which has not been proved. It is rather a result of an outwash of erosional products from a shale outcrop on the surface of the valley in which the Tertiary sediments has been deposited. The succession mentioned is repeated once before the normal Tertiary sequence begins (B. E. Koch 1955 figs. 6—7).

The lower limit of the Tertiary sequence shows a tendency to dip towards NNW which is shown by the dip of 5 or 6 m between the northernmost "nose" and the northernmost spur with outcrops of the Tertiary sequence (from altitudes of 395 to 389 m), a distance of 20 to 30 m in the direction N 325°. But as the remaining part of this outcrop only shows a slight dip, it will be necessary to consider the dip as 5 or 6 m in a north-western direction at a distance of abt. 200 m, as compared with dips in other directions.

Fig. 5. The exposure of the eastern slope of Quikavsaup kûa above the water fall. Black line shows the limit between Cretaceous sandstone and Tertiary beds. The limit rises towards south. Background: Basaltic landslides.

In the western slope of the Quikavsaup kûa gash below point 445 the lower limit is somewhat even (in the direction of the section N 30°—40°) from the end of the gash to the small dykes in the middle of the outcrop. The limit is here at an altitude of abt. 365 m. In the southern end, but to the north of the "Profile Ridge" (see B. E. Koch 1955 fig. 4) a small culmination may be found; it is not quite clear whether it is the Cretaceous sandstone which rises somewhat as the lower parts of the slope is mostly covered with scree (fig. 4), and the talus reaches up above the Tertiary/Cretaceous limit directly north of the "Profile Ridge". But to mention this unevenness as a fossil hill as done by the author (B. E. Koch 1955) would be to exaggerate seeing that the culmination is quite inconsiderable.

Seen in its proper perspective, the heights which it was possible to obtain of the lower limit of the Tertiary, suggest that Quikavsak member lies in a trough-shaped depression in the old substratum, which gives

rise to considerable differences in height on the limit Tertiary/Cretaceous within the Atanikerdluk area (pl. 5 and the geological map: Atanikerdluk 1:10 000. — Meddelelser om Grønland Bd. 162 No. 4 1959). As already mentioned, a dip in direction N 325° was recorded in the east slope of Quikavsaup kûa, consequently in a northwesterly direction. Further, there is a considerable dip in the direction across Quikavsaup kûa. As mentioned, a measuring was made in the east slope showing an altitude of 389 m (pag. 18). Opposite, at the other side of the great gash, between the two small dykes (B. E. KOCH 1955 figs. 4, 8), the same limit is exposed at an altitude of 365 m, i.e. a dip of 20 m in the direction N 263°, almost due west. The distance between the two points of observation is abt. 150 m. It will be remembered that the unconformity keeps the altitude of 365 m in the direction of the section N 30°—40°, and that the above-mentioned culmination at the "Profile Ridge" is situated where the profile alters its course to a more south-easterly direction, and considering the fact that the great gash alters its course and the profile projects towards SE, the culmination can be looked upon as a result of the westerly dip of the limit, not as a bar. On the map (Geological map: Atanikerdluk 1:10000. — Meddelelser om Grønland, Bd. 162, No. 4 1959) the boundary has been drawn between the points where reliable measurings could be made:

(1) The west side of Quikavsaup kûa, the northern half of the outcrop: alt. 365 m (fig. 4).

(2) Between the "Profile Ridge" and the small dykes in the middle of the outcrop: alt. 370 m (B. E. KOCH 1955 figs. 4, 8).

(3) The "Profile Ridge" (fig. 4): alt. 365 m. (1951 measured 370 m here. As 365 m was measured simultaneously with the above-mentioned elevations, this will be used).

(4) In the funnel-shaped ravine north of the spur extending to point 333 at dyke III (Geological map: Atanikerdluk 1:10000. — Meddelelser om Grønland, Bd. 162, No. 4 1959): Between 355 m and 360 m.

(5) A small gash in the southern slope of the hill with point 445, abt. 100 m east of the gash (6): between 345 and 350 m.

(6) In the eastern slope of the gully, west of 445, (B. E. KOCH 1955 fig. 11): Here is the upper limit of a scarp owing to a truncated sandstone bed belonging to the *Atane formation*, at an altitude of 360 m, while the Tertiary sediments are found at an altitude of 385 m. The limit is situated within the interjacent interval covered with scree.

(7) The slope immediately west of the same gully (ref. 6): Layers of Atane facies with few corroded fossils suggest that the *Atane formation* at least reaches the altitude of the exposed Tertiary beds in the eastern slope of the gully. So the limit is not below the altitude of 385 m.

(8) The Liriodendronkløft gully where intersected by dyke II (B. E. KOCH 1955 fig. 12): abt. alt. 390 m.

The general impression is that the Tertiary sediments fill up a depression the lowest height of which, in a section from east to west, lies at an altitude of 445 to 450 m (SE of point 445), and the axis of which is near the direction of the section in the western slope of Quikavsaup kûa (N 30°—40°) as, with the aids at our disposal, the dip of the unconformity surface proved immeasurable in this direction. The extension of the occurrence in an east-westerly direction is therefore highly limited. In the east slope of the tributary to Quikavsaup kûa, Quikavsak member is not represented (B. E. Koch 1955 pp. 28—29), but the Atane formation is exposed up to an altitude of abt. 400 m and in the slopes above this altitude along the torrent passing point 444 (ref. Geological map: Atanikerdluk 1:10000. — Meddelelser om Grønland Bd. 162 No. 4 1959) to an altitude of more than 422 m where the fossiliferous beds with fossil plants of the types from the Atane flora have been found. About 750 m NE of point 445 and S of point 638 (Geological map: Atanikerdluk 1:10000. — Meddelelser om Grønland Bd. 162, No. 4, 1959) sediments with the dip of the Atane formation are exposed at altitudes from 465 to 495 m. This means that the unconformity surface rises sharply to the east which is already indicated by the difference between the west side and the east side of Quikavsaup kûa above dyke III (a gradient of 25 to 30 m at a distance of abt. 150 m.

For the sake of completeness it should be stated that the extent of the member to the west cannot be ascertained exactly. The most westerly occurrence is in the Liriodendronkløft gully. The next large outcrop to the west where the Tertiary/Cretaceous limit can be observed, is at Siorqat kûat, 2 km more westerly. The limit is here at an altitude of 485 m, and Quikavsak member is not represented.

An attempt, by measuring dip and strike of the cross-laminated fluviatile sediments, to judge about the direction of the stream gave no clear result, as the dips obtained were spread over the interval SW, NW, N, NE, even an easterly and a southerly dip were measured. As the number of the measurings is far from gaining statistical certainty, it can only be pointed out that most of them show that the direction of the stream has had a northerly component, and that there is no proof, as stated in (B. E. Koch 1955 p. 25), that it came from the eastern half of the compass card. This information is based on very few and wrongly chosen measurings. Against this statement can also be said that even with a south-easterly to north-westerly direction of the Tertiary river-bed Quikavsak member should be represented in the eastern slope of Quikavsaup kûa. All these observations taken into consideration, the axis of the trough is probably near N-S.

Quikavsak member: Quikavsak member of the Upper Atanikerdluk formation (B. E. Koch 1955: Lower Fluviatile Series) is discordantly

deposited upon the Atane formation in a probably trough-shaped depression in the sediments of this formation, and in the hill with point 445 it is exposed with a maximum thickness of 50 m (at the "Profile Ridge" abt. 30 m). The upper limit is everywhere in the hill at an altitude of abt. 400 m (the "Profile Ridge": alt. 402 m, the gully west of point 445: alt. 400 m). The sequence is nearly horizontal. In such fluviatile beds where the lenticular shape is the dominating structure, it is difficult to obtain a valuable measuring for dip and strike. Regionally the dip of the Tertiary beds has a slight easterly component (less than 1°), and when the author in 1951 at the most suitable places obtained a strike of 40° to 60° and dip in a northeasterly direction, it may be the lenticular structure and possibly the gradient of the river-bed which make themselves felt.

The sequence has been measured alongside a spur which from point 445 stretches down towards dyke III in a southeasterly direction (N168°) (the "Profile Ridge": B. E. KOCH 1955 fig. 4), and the profile is here as follows (fig. 4):

	Quikavsak member is here overlain by black shale
Alt.: 402 m...	belonging to NAUJÂT MEMBER (ref. pag. 26).
	Ochreous, ductile, hard sandstone of medium grain-size, with small, angular, bright quartz grains and coal particles in a fine-grained, dark ochreous
0.2 m...	weathered ground ..... (13)
	Badly consolidated, dark ochreous sandstone rich in angular quartz grains and with coal particles seen on the bedding plains. It contains a 5 cm thick shale band, and basally a band of the same sandstone but with high
0.4 m...	fissility ..... (12)
	Grey, fine-grained sandstone with irregular fracture and mica grains seen on the fracture. The lowermost part of the layer is ochreous
0.9 m...	weathered ..... (11)
	Light coloured (grey-white) quartz sand of
0.3 m...	medium grain-size ..... (10)
	Brown, highly fissile shale alternating with bands of black, bituminous shale and thin, flat
1.0 m...	lenses of coarse sand ..... (9)
	Black, bituminous, highly fissile shale with
0.1 m...	plant fossils ..... (8)
	Badly consolidated sandstone in lenses (their maximum thickness varying between 10—60 cm) separated in the upper part by shale bands which entwine the lenses. Almost in the middle a traversing band is found, thickness 30 cm, in the upper part consisting of

		brown, silty shale, and in the lower one of black, bituminous shale. Below this band the sand lenses are entwined with pure white, coarse-grained quartz sand with coal pieces contrary to the lenses in which the sand is of an ochreous colour. This ochreous sand is so conspicuous that the horizon is easily followed all through the section. Above the traversing shale bed the sand lenses are rich in feldspar and have a rosy colour. Within the lenses	
	2.5 m...	coarse and fine sand bands are changing....	(7)
		Brown shale with several thin bands of highly bituminous, fissile shale grading into coal, with	
	0.6 m...	badly preserved plant fossils.....	(6)
		Light coloured (white-rose) sand rich in quartz and of varying grain-size (sand-gravel) with some veins of coaly detritus and some thin	
	0.6 m...	shale veins.....	(5)
		Shale with brown weathering colour, and	
Alt.: 396 m...	0.3 m...	badly preserved plant fossils.....	(4)
		Alternating beds of light grey quartz sand and shale with clay-ironstone concretions and sideritic silty shale often passing into homogeneous beds. The sideritic rocks contain the amount of plant fossils, mostly impressions, making up the "Upper Atanikerdluk A" flora (HEER 1883a, b). Fragments of coal are found scattered in the sand, big pieces of incoaled wood are often found in the shales. In the upper part of (3) incoaled trunks in vertical position are found (B. E. KOCH 1955 fig. 9, 10). The sand shows cross-bedding, and the thickness of the beds range from $^1/_2$ to 1 m. The shale beds	
	25 m ...	are often thinner, about 0.25 m.....	(3)
	0.5 m...	Brown sand with yellow veins.....	(2)
		Sandy clay, downwards passing into grey,	
Alt.: 370 m...	0.75 m..	pure clay.....	(1)

— Unconformity —

Beds belonging to the Atane formation.

SW of the hill with point 445 in the eastern slope of the gully there is a minor outcrop (B. E. KOCH 1955 fig. 11) which mainly comprises beds (3) from altitudes of 385 to abt. 400 m; these elevations deviate from those stated in (B. E. KOCH 1955 p. 26) and are the result of more correct measurings. The sequence here is different from the one mentioned above from the western slope of Quikavsaup kûa in the way that

beds of gravel with cross-lamination are common in (3) while coarse-grained quartz sand was dominating at the "Profile Ridge" and gravel not observed. Also here are incoaled trunks vertically placed (B. E. KOCH 1955 fig. 10), and a great many clay-ironstone concretions with plant fossils are found on the slopes immediately east of the section. The under limit to the Atane formation is not exposed, but is not below alt. 360 m under which is a truncated bed of hard sandstone belonging to this formation. Between the gully west of point 445 and the profile spur at Quikavsaup kûa no real clean outcrops are found though Quikavsak member is visible all the way. The Tertiary/Cretaceous limit appears as a terrain limit between the less consolidated Tertiary beds, which show a less steep gradient, and hard Cretaceous sandstone, which forms a more abrupt surface. This condition has made the above measuring possible.

In the upper part of the Liriodendronkløft gully, where dyke II intersects it, there is a small occurrence of Quikavsak member (B. E. KOCH 1955 fig. 12). The outcrop is found in the western slope of the gash close to the big dyke which traverses the gully like a natural dam. Here sandstone and shale belonging to the Atane formation is exposed at the bottom of the gully from an altitude of 384 m. The central part of the section is covered with scree, and only abt. 10 m above the torrent of the gully a few metres of the Tertiary sediments are visible. The lower limit of these is situated at an altitude of abt. 390 m. The thickness here is hardly more than 10 m as, on the opposite side of the dyke at an altitude of 400 m, there is an area with crushed, black shale of facies as Naujât member.

At Atanikerdluk this deposit varies in thickness on account of the trough-shaped structure, but the maximum thickness is 50 m. The sediments are typically fluviatile. In evidence of this can be mentioned:

(1) Cross-laminated sand and gravel beds alternating with original fine-grained sand, silt, or shale beds which owing to a strong siderite precipitation form all the transitions between clay-ironstone and shale or sandstone with siderite as cement and most important component.

(2) No marine fossils but an abundance of plant fossils in the sideritic rocks. Being very well-preserved, they have not been exposed to long-distance transport. The fossils are mostly dicotyledonous leaves, coniferous shoots and cones, and occasionally other fossil fruits. Finally lumps of coal from wood which can also be found in the sand and gravel beds.

(3) Incoaled trunks in a vertical position through sand and shale beds. An example where the central wood has decayed before being covered with sand is seen in (B. E. KOCH 1955) fig. 9.

(4) Fossil insects and ostracodes.

(5) The local character of the deposit, its structure and form, and its position in the Tertiary succession on the southcoast of the Nûgssuaq peninsula on the vhole.

There is no basal conglomerate as is the case in most of the other occurrences described.

As the fluviatile deposit has been described in the above chapter, it will be considered type of the QUIKAVSAK MEMBER *of the* UPPER ATANIKERDLUK FORMATION *of which, as it appears from the following, several occurrences along the south coast of the Nûgssuaq peninsula have been observed.*

From the structure of the sediments it appears that the stream in the above-mentioned Tertiary watercourse has been moderate at the maximum flow, and from the shale it appears that it has even been low periodically. In support of this can besides be mentioned the considerable number of incoaled trunks in a vertical position showing that the river banks have carried trees. The many lumps of coal in the sediments together with an abundance of well-preserved plant fossils, and consequently plant fossils of a short-distance transport, show that here was once a forest-bordered watercourse. The constant change between cross-bedded sand and sediments of silt and clay grade (the sideritic beds) indicates a periodically alternating flow about the cause of which one can only guess. The strong precipitation of siderite in the plant-bearing beds must be considered on the basis of the great portion of accumulated plant residue, which made the beds mostly organic directly after the deposition and which through its putrefaction (obs. cuticula residue rare on the leaf impressions!), has contributed to make the millieu predisposed to the sideritic precipitation. The plant content shows that the fine-grained fossiliferous beds each represents a coincidence of a reduced flow and the defoliation of the autumn. This is indicated by the enormous accumulation of dicotyledoneous leaves of temperated genera in connection with an enormous deposit of deciduous short shoots and cones of *Metasequoia occidentalis* (Newb.) Chaney and fertile organs of many kinds.

Historical-biographical informations regarding the investigation of the sequence are found in (B. E. KOCH 1955).

Naujât member: This member overlays Quikavsak member in the hill with point 445 and is exposed at an altitude of 402 to 440 m on the "Profile Ridge" (fig. 4). The occurrence is not in situ, but strongly dislocated. However it is hardly any change of importance as compared with the original level (B. E. KOCH 1955 pag. 29ff.).

On op. cit. pag. 29 is mentioned that this shale contains "bands of a brown clay (tuff?) containing the fossil flora named by (HEER 1883a,b) as "Upper Atanikerdluk B". It is a brown claystone with a content of siderite which approaches the rock to clay-ironstone as was more clearly the case with the corresponding similar rock from this member at Naujât.

A distinct chalk content can also be observed. On treatment with hydrocloric acid and separation the siderite, chalk, and clay fraction are removed, constituting the greater part of the material. The coarsest fraction consists of grains of abt. 0.1 mm±. The grains are subangular and consist of brown pigmented palagonite, which suggests that it is a tuff rock. (Information by mag. scient. H. Michelsen).

Similar tuff layers are remembered from Naujât and are known in considerable thickness at Kingigtoq treated later on. At both places they are found at the basis of the Naujât member shale and only in the basal part of it. So there is reason to suppose that the dislocated shale occurrence in the hill with point 445 represents the basal part of Naujât member, as the other possibility: Aussivik member above the basalt level was previously rejected (B. E. Koch 1955).

The uppermost part of the hill with point 445 contains a sandstone occurrence, also dislocated, which may represent the transitional zone between Naujât member and Umiussat member which was observed in the profile at the Sarqaqdalen valley, or it may originate from the basal part of Umiussat member. This is less probable as there are no concretions in the occurrence at point 445, while such are in abundance in Umiussat member (see besides B. E. Koch 1955 pag. 30).

The Mountains between Atanikerdluk and Siorqat kûat.

The was above the outcrops in Quikavsaup kûa consists mainly of landslide "coulisses" as far as Mt. Iviangernat, which comprises the two highest peaks in the area (970 and 1033 m). On an aerial view belonging to the Danish Geodetical Institute are seen a few minor outcrops below the westernmost peak at Iviangernat, point 970, and in the pass between this point and point 1033 which, from the knowledge we have acquired of the structure of the area on the whole, must be assumed to be sedimentary.[1]) They are situated immediately above the basalt level of Aussivik member which can be traced from the outcrop described below to this place. The two peaks called Mt. Iviangernat consist as the neighbouring mountains of the Plateau basalts, the lower limit of which are not visible on account of talus. In Mt. Iviangernat stationary basalt beds are exposed at an altitude of 950 m and more.

To get an idea of the upper sediments at Atanikerdluk it is necessary to turn to the landslide area at the mountain immediately west of Atanikerdluk, about 1 km wide and 2 or 3 km west of Quikavsaup kûa. Towards northwest this depression in the mountain slope is limited by a scarp from an altitude of abt. 650 to abt. 950 m containing a continuous section of the upper sediments in the sequence (fig. 6). Below this,

[1]) Probably shale of the Aussivik member and sandstones of the Point 976 member.

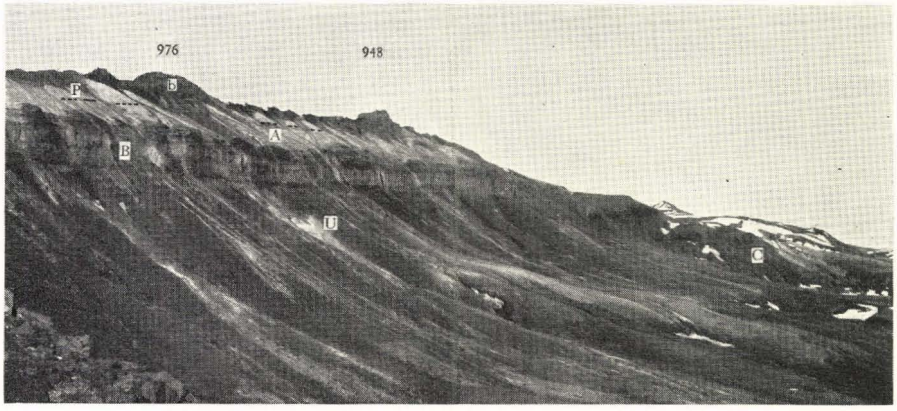


Fig. 6. The scarp with Tertiary outcrops above Iluarâ. U: Umiussat member, B: Basalt level of Aussivik member, A: Upper shale of Aussivik member, P: Point 976 member, b: Plateau basalts, C: Landslide consisting of (B).

and facing the westernmost part of Iluarâ and Nûnguaq, there are but few, minor outcrops in small gashes at the coast. Apart from these there are only slopes covered with vegetation and Quaternary deposits with numerous old landslides up to an altitude of abt. 650 m at this stretch of the coast. Some of the hills representing landslides have slight exposures at the top, and such showing crushed, black shale are found at altitudes of abt. 445 m, abt. 490 m, and in the hill with point 493 (Geological map: Atanikerdluk 1:10000. — Meddelelser om Grønland, Bd. 162, No. 4 1959). These shale occurrences may originate either from Naujât member or Aussivik member. Nothing has been found which show the origin adequately. Basalt landslides are common but highly levelled out and covered with vegetation.

In the northwesterly limitation of the depression the lowermost parts of the scarp are mostly covered with talus, but several spurs, especially in the southeasterly part of the scarp, show clean outcrops. In these it is possible to trace the sediments from an altitude of 730 m and upwards. The profile is reproduced in (B. E. Koch 1955) as follows:

		Basalt	
Alt.: 780 m		Black bituminous shale with	
773 m	7.0 m	bands of clay ironstone	(26)
	1.2 m	Chalky, dirty quartz sand	(25)
771 m	0.3 m	White and ochreous sands	(24)
	0.3 m	Chalky, dirty quartz sand	(23)
	0.1 m	Bituminous shale	(22)
770 m	1.0 m	White sand with bands of ochreous sand	(21)
748 m	22 m	Sand alternating with shale. In the upper part the sand is of an ochreous colour	(20)

Umiussat member: (ref. fig. 6: U). The sequence up to an altitude of 773 m was described as the Upper Fluviatile Series in (B. E. KOCH 1955) (now: Umiussat member). The lower part of this unit, its limit to the Lower Shale Series (now: Naujât member), and the thickness of the Lower Shale Series remained unknown for the locality. As it appears from (B. E. KOCH 1955 pl. I), a suggestion on this problem was advanced supported by supplementary observations from the section at the western slope of the Sarqaqdalen valley. By comparison with the section described above (pag. 13) at the Sarqaqdalen and with the areas west of Atanikerdluk, which will be described later (ref. the type locality Umiussat, pag. 38), the impression of the correctness of this suggestion is strengthened although it remains a theory.

Aussivik member: (ref. fig. 6: A:B). Above Umiussat member follows black, bituminous shale with concretionary bands (clay ironstone) alt. 773 to 780 m, which in (B. E. KOCH 1955) is described as the lowermost part of the Upper Shale Series as the basalt occurrence situated above (fig. 6) was considered a sill, though tentatively. This sill was then supposed intruded into the Upper Shale Series (now: Aussivik member). The basalt occurrence has a total thickness of 55 to 70 m, and can be traced eastwards in the terrain as far as Mt. Iviangernat and further eastwards to the Sarqaqdalen valley (pag. 14). In a westerly direction it can be observed as far as west of Qagdloq (pag. 34) and possibly as far as Kingigtoq on the same stratigraphical level (pl. 5, 6). It evidently consists of 3 beds of which the upper one is comparatively thin, and at a distance it stands out on the outcrop distinctly separated from the underlying by a terrace owing to softer rocks. The upper basalt bed has a thickness of 10 to 15 m, and the terrace below, in the westernmost part of the section, appears to be due to black shale of a thickness of abt. 10 m; however, it seems to vary in thickness. Underneath follows at least 40 m basalt consisting of two enormous beds of columnar structure. They adjoins each other without any intermediate layer. In the eastern part of the outcrop the thickness of the basalts is abt. 70 m (lower limit: alt. abt. 780 m, upper limit: alt. abt. 850 m) while in the western part it is abt. 55 m (lower limit: alt. abt. 815 m, upper limit: alt. abt. 865 m). Thus there is a slight rise towards west.

The distinct bedding, the structure of the beds, the fine-grained rock, lack of characteristic contact effects, the intercalated shale known from the Sarqaqdalen valley and Atanikerdluk, and the fact that the basalt keeps the same stratigraphical level over a very long stretch indicate that it is a question of flows of surface lava though this has not been finally proved. Also the question of contact effect needs a thorough investigation as, on a last visit to the profile in 1956 a small occurrence

was found of baked (?) rocks on top of the uppermost basalt bed; the origin of this occurrence is not certain as it may also be referred to a structure which intersects the basalt at this part of the profile, and of which no further investigation has been made. It is so far the only direct observation which might suggest that the basalt is intrusive. In the following it will be named by the neutral designation "The Basalt Level of Aussivik Member".

Black, bituminous shale (fig. 6) overlays the basalt level and contains, within the lowermost few metres, a brown mudstone band (tuff) of the same facies as those containing HEER's "Upper Atanikerdluk B" flora at the basis of Naujât member; a sample showed the same properties as those contained in the basal part of Naujât member (ref. pag. 12 and 25). Consequently it must be tuff (H. MICHELSEN). In these bands of Aussivik member no fossils have been found so far. From the neighbouring black shale is known a leaf of *Cercidiphyllum arcticum* (HEER) BROWN. In one of the westernmost sedimentary spurs above the basalt horizon in the outcrop of the mountain slope the shale can be followed from the lower limit at an altitude of 872 m to an altitude of 902 m. At an altitude of 905 m is exposed a brown, micaceous, silty shale under talus consisting of sand from the overlying Point 976 member. The upper limit of Aussivik member is not exactly ascertained. The overlying sandstone sequence is seen from an altitude of 915 m. The shale at alt. 905 m shows already the tendency to coarser sedimentation. In the eastern part of the outcrop above the basalt level of Aussivik member and between points 976 and 948 (fig. 6) the limit shale/basalt is at an altitude of abt. 860 m. Uppermost in this part of the outcrop below talus, at an altitude of 874 m, is exposed 1 m light greyish brown shale, which is also known from the section at the Sarqaqdalen valley as the uppermost part of the Aussivik member shale. Below point 948, i. e. a little more easterly, the lower limit of the black shale to the basalt level is at an altitude of 850 m. Here is a large shale outcrop, and the light greyish brown shale shows great thickness (abt. 10 m). (Ref. besides B. E. KOCH 1955 pag. 35).

Point 976 member: (ref. fig. 6: P). Above Aussivik member follows yellowish sand and sandstone with subordinate beds of silt. The sandstone is coarse-grained to fine-grained and rich in quartz, and the upper part contains lots of concretionary bodies consisting of cemented coarse-grained sand. Pieces of fossil wood of *Taxodioxylon* type with growth rings, poor leaf impressions, and coniferous shoots are known from this member (B. E. KOCH 1955 pag. 36). The upper limit, measured below point 948, is found at an altitude of 935 m, while it is somewhat higher at the westernmost end of the outcrop (alt. abt. 940 m). This member is overlain by basalt flows, generally designated the Plateau basalts,

here only visible as single scattered minor occurrences above the sedimentary section, i. e. the hills 940/948, 976, and 945 which consist of basalt. *This locality is considered type of* POINT 976 MEMBER *of the* UPPER ATANIKERDLUK FORMATION *comprising the sandstone sequence between Aussivik member and the Plateau basalts.*

The sediments between the basalt level of Aussivik member and the Plateau basalts may also in the following be designated "the Intrabasaltic Sediments of Atanikerdluk".

Big Gashes at Qagdlúnguaq.

In the area northwest of Atanikerdluk there are four big gashes. Counting from northwest to southeast they are: Qagdlúnguaq NW and Qagdlúnguaq SE[1]), Qagdlorssûp kûa, and Siorqat kûat. Each of the three southeasterly gashes shows large clean sections, while the outcrops in Qagdlúnguaq NW are smaller and to a greater extent covered with scree being situated on the outskirts of a big landslide area.

Above and east of the uppermost part of Siorqat kûat stands part of a steeply dipping dyke with strike N 24° the coastward wall of which is exposed. In the slopes below, the sediments are strongly dislocated. They consist of sandstone and shale probably belonging to the Atane formation, and the dislocation must be referred to the great landslides which have taken place in the area. Above the dyke a big dislocated area of black shale is visible between alt. 438 m and alt. 466 m, overlain by yellow sand in the hill with point 517. It is a landslide including some of the sequence which was once at the place where the cirque-like depression is now situated. It must be a question of Naujât member being overlain by Umiussat member, and it must be the basal part of the latter which is not elsewhere exposed at the areas of Atanikerdluk and Qagdlúnguaq. It is hardly probable that it is the members of Aussivik and Point 976 as a large part of the basalt level of the Aussivik member should then be present below the shale in the landslide. The above-mentioned dyke below the shale is undisturbed and coherent, and must not be mistaken for part of such a landslide.

Siorqat kûat.

In the western slope of Siorqat kûat the Atane formation reaches an altitude of 490 m. The layers underlying the Tertiary consist here of a coarse-grained, laminated sandstone with a considerable northeasterly dip.

[1]) At Qagdlûnguaq there are two gashes, still unnamed and in this paper mentioned as the northwestern and the southeastern, abbreviated: Qagdlúnguaq NW and Qagdlúnguaq SE.

Naujât member: Above the sandstone just mentioned follows a slightly dislocated occurrence of black, bituminous shale in a clean outcrop up to an altitude of 532 m. The shale is, however, so abundantly present in the scree below the hill with the points 587/592 (Geological map: Atanikerdluk 1:10000, Meddelelser om Grønland Bd. 162, No. 4, 1959) up to an altitude of 533 m that it may also reach this altitude below the thalus mantle. The hill with the points 587/592 consists of basalt which is damaged by landslide movements. In the basalt talus underneath there are spots of yellow sand.

On the coastal slope between Siorqat kûat and Qagdlorssûp kûa, abt. 350 m northwest of the first-mentioned gash, there is a ravine where the limit shale/Atane formation is exposed at an altitude of 504 m. Only a few metres of shale is exposed above the limit.

Qagdlorssûp kûa.

Quikavsak member: In the uppermost part of Qagdlorssûp kûa a minor outcrop was observed in the eastern slope where brown weathered sandstone is unconformably deposited upon the Atane formation. It contains no fossils, but being unconformably deposited upon the Atane formation it is referred to Quikavsak member tentatively. The occurrence is of small thickness, variying up to 2 m. It is overlain by black shale.

Naujât member: The black shale of Qagdlorssûp kûa is situated upon the Atane formation in both slopes of the upper part of the gash, locally upon the just mentioned occurrence of Quikavsak member. In the eastern slope the limit lies at an altitude of abt. 514 m. At the head of the big gash the shale is found at an altitude of 514 to 590 m where it is covered with solifluction and vegetation. In the western slope of the big gash a large outcrop of the black shale is visible with the lower limit to the Atane formation at an altitude of abt. 490 to 500 m. The shale which is exposed in this big gash seems to be undisturbed in situ.

Qagdlúnguaq SE.

Naujât member: In the eastern wall of Qagdlúnguaq SE, strong dislocations are observed above the Atane formation, which must be the result of landslides (fig. 7). The limit between the Atane formation and a layer of black shale, apparently undisturbed Naujât member shale, is found at the head of the big gash at an altitude of abt. 470 m and can be followed to an altitude of abt. 490 m overlain by talus of yellow sand to an altitude of 515 m. At the mouth of the gash the limit between the black shale and the Atane formation is found at an altitude of 458 m. Here, at an altitude of abt. 470 m, the shale contains brown claystone

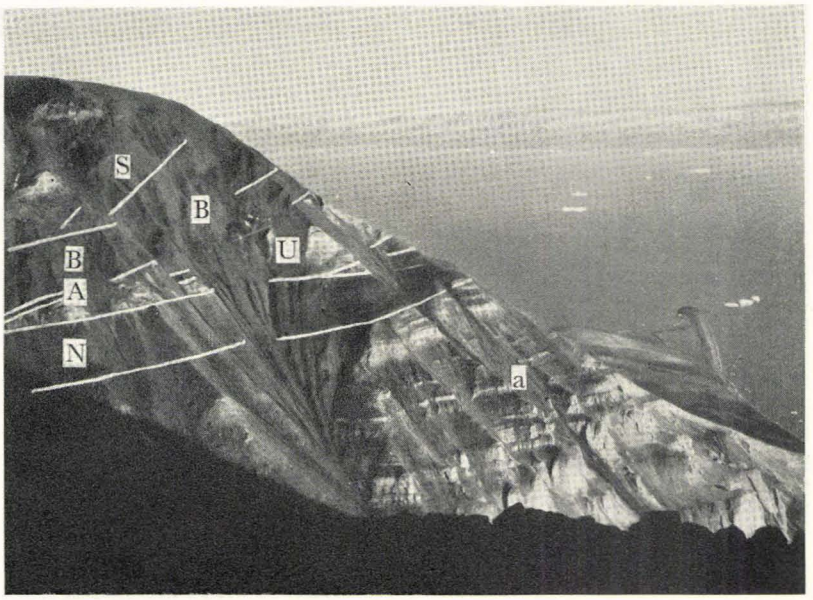


Fig. 7. The big gash of Qagdlúnguaq SW, upper part of the gash. Eastern slope with strongly dislocated beds.

Cretaceous: a: Atane formation. *Tertiary:* N: Naujât member (probably in situ), U: Umiussat member (dislocated), A: Lower shale of Aussivik member (dislocated), B: Basalt level of Aussivik member (dislocated), S: Shale (dislocated). Background: Coast of Vaigat with Nûnguaq pen., Disko Isl. in the distance.

bands (tuff) of the same kind as those found in Naujât member at Atanikerdluk and Naujât.

Dislocations: (ref. fig. 7). Above the undisturbed succession of the east slope of Qagdlúnguaq SE is seen a sequence with a considerable dip towards NE, and here it is possible to recognize a section of the sequence stationary on a higher level of the ideal profile of the area. As it appears from fig. 7, the dislocated occurrence may be interpreted in the way that below there is a section of Umiussat member (U), above this a shale bed (A), which may be co-ordinated with the part of Aussivik member situated below the basalt level (pag. 28, 34—35). The basalt level is also present (B). Above this is again shale (S), but whether it represents the Aussivik member shale above the basalt level or Naujât member in a higher situated landslide, is uncertain. In the former case the ligh sand at a higher altitude in the gash slope can be interpreted as Point 976 member.

Qagdlúnguaq NW.

In Qagdlúnguaq NW the uppermost parts of the Atane formation are red-burnt and partly dislocated, and here the Tertiary shale of Naujât

Fig. 8. Qagdlúnguaq. Foreground and background to the right: Basaltic landslide "coulisses" (C) above Qagdlúnguaq, N: Dislocated Naujât member shale. Upper left corner: Exposure of undislocated deposits, U: Umiussat member, A: Lower shale of Aussivik member, B: Basalt level of Aussivik member (2-bedded!), K: Keglen.

member is only seen as dislocated occurrences (fig. 8). The original limit Tertiary/Cretaceous cannot be observed. If one follows the mountain slope upwards immediately southeast of the gash, black shale is observed between altitudes of 458 and 504 m, overlain by sandstone up to 524 m. The dip of the shale in the slope of the gash is steeper than the dip of the underlying Cretaceous beds.

About the original limit Tertiary/Cretaceous can be said nothing on account of the dislocations. The black shale belonging to Naujât member can be observed as a dislocated occurrence up to an altitude of 555 m (fig. 8), above which the original upper limit must have been.

Below alt. 100 m immediately west of Qagdlúnguaq NW is an area with red, burned shale which is the ruin of an old landslide. From this the material which Seward & Conway described from Kagdlunguaq (= Qagdlúnguaq) 1939 (Seward & Conway 1939) probably originates. No doubt this burnt shale has, to a certain degree, its origin in Naujât member, but on which level in this thick sequence is not known.

All the occurrences of the black shale mentioned here show by their level that they must be occurrences from Naujât member of the Upper Atanikerdluk formation. These occurrences are, for the greater part, deposited directly upon the Atane formation and only at one place, upon Quikavsak member. This is only represented by the small local occurrence in Qagdlorssûp kûa. The unconformity lies in all the places observed higher than was the case more easterly, and it shows a small culmination on the east side of Qagdlorssûp kûa.

Only few plant fossils have been found in situ in Naujât member in this area. In the Mineralogical and Geological Museum of the University of Copenhagen is a collection of plant fossils in a brown tuff collected by N. Hartz, which is mentioned in (B. E. Koch 1955). The rock is identical with the one containing Heer's "Upper Atanikerdluk B" flora from Atanikerdluk, and includes leaf types well known from this level. These fossils may originate from a big landslide of black shale at an altitude of 40 to 50 m forming the eastern slope of Siorqat kûat. There the brown tuff may be found, though occasionally. It is the unburnt shale landslide at a low level situated closest to Qagdlúnguaq, the locality given on Hartz' label. Hartz mentions, however, that the finding was made at an altitude of 82 m.

Above the outcrops in the area round Qagdlúnguaq treated here the rock is covered with Quaternary deposits, especially landslide "coulisses". They are highly developed at Qagdlúnguaq NW in the east side of a big landslide area (fig. 8). The landslide "coulisses" above Qagdlúnguaq NW and Qagdloq are rather fresh as they mostly appear as big heaps of sharp-edged pieces of basalt without any trace of coincidence as compared with many of the "coulisses" at Atanikerdluk where most of the basalt beds are preserved as a whole. However, this also applies to the uppermost "coulisses" above Qagdlúnguaq NW (fig. 8). Most of the hills, except for the depressions in between them, are completely naked. Of vegetation only scattered lichen and moss have obtained a foothold.

The members of Umiussat and Aussivik: The basalt level of Aussivik member, mentioned on pag. 28, can be followed from the cirque-like depression above Iluarâ westwards below the mountain Keglen (point 942) and further on to the basalt mountain Umiussat. Between this mountain and Keglen the basalt level forms the crest of a ridge pointing N—S, which separates the coastal slope from the cirque Puiagtugssuaq (pl. 5). Point 830 is situated on this ridge the surface of which consists of the basalt level (figs. 8, 9). On this stretch it contains two truncated, columnar jointed beds and must correspond to the two lower basalt beds of great thickness in the outcrop of the basalt level above Iluarâ.

Underneath the basalt level above Qagdlúnguaq a few outcrops of the sediments are visible on the strongly talus-covered slope. The outcrops show the following profile immediately northwest of point 830 at the eastern tributary to Qagdlup kûa (figs. 8, 9):

Alt.: 830 m .....
„ 782 m ..... Columnar jointed basalt in two beds.....
„ 768 m... 14 m ... Black, bituminous shale ..... (26)

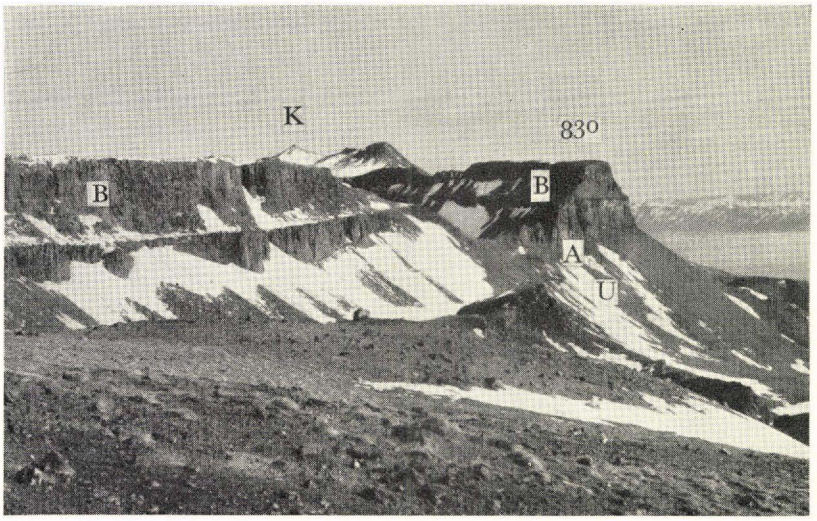


Fig. 9. Basalt level of Aussivik member forming crest of ridge between Qagdloq and Puiagtugssuaq. View from the surface of downthrown block of (B) on southwestern flank of the ridge. U: Umiussat member, A: Lower shale of Aussivik member, B: Basalt level of Aussivik member (2-bedded!), K: Keglen.

			Uppermost yellow sand, which from alt. 759 m
Alt.:	750 m...	18 m ...	goes out into pale grey quartz sand.....
„	747 m...	3 m...	Black shale .....
			Grey, cross-laminated quartz sand with a
„	718 m...	29 m ...	yellow sand layer of $^1/_2$ m at alt. 746 m.....

This sequence corresponds to the one found below the basalt level of Aussivik member above Iluarâ containing the lowermost part of Aussivik member and the uppermost part of Umiussat member. The sequence is continuous between these two profiles, which appear from minor outcrops and from sediments in the talus below the basalt level east of point 830 above Qagdlúnguaq. Above the basalt level at Qagdlorssûp kûa Keglen (figs. 8, 9) consists of the same intrabasaltic sequence which is known from the mountains above Iluarâ (pag. 29) though no clean outcrops are found (ref. B. E. Koch 1955 pag. 35—36). Keglen has no cover of Quaternary deposits, so evidently it consists of Aussivik member and Point 976 member, with a small heap of basalt blocks on top in memory of the Plateau basalts which was previously present here. West of Keglen only faint traces are found of these sediments. On the ridge between the coastal slope and Puiagtugssuaq at the southern edge of the mountain with point 1010 spots of yellow sand in the solifluction are seen at an altitude of 883 m on top of the basalt level of Aussivik member, part of which on the western side of the ridge is downthrown

from its original, almost horizontal position into a position dipping faintly south. The southernmost portion of this part is further downthrown and has a sharper dip towards south (fig. 9). This can be referred to the strong landslide action of which the "coulisse" area below gives evidence. In the northernmost part of the downthrown block of the basalt level below point 1010 the basalt is exposed from alt. 755 m up to alt. 785 m. Here upon the basalt is further an integral portion of black shale and yellow sand up to an altitude of 840 m, and sand together with basalt talus is seen up to an altitude of 846 m. This shows that the intrabasaltic sediments above the basalt level of Aussivik member have previously stretched as far as this place immediately south of point 1010. The upper limit of the stationary part of the basalt level is here at an altitude of 845 m and goes into the mountain of Umiussat where, as far as the author has been able to judge, *it is overlain directly by the Plateau basalts* of which this mountain is built up. The basalt level of Aussivik member forms its basal layer. At Umiussat the country must thus have been exposed to an invasion of basaltic lava flows before and simultaneous with the deposition of the intrabasaltic sediments in the area to the east and have diked in a basin in which the upper shale of Aussivik member was deposited, or erosion has removed this shale at Umiussat down to the basalt level before the Plateau basalts forced its way to the place. No signs of any longer erosion period between the deposition of the intrabasaltic sediments and the Plateau basalts have however been observed so far in the area described.

The mountain Umiussat consists of 350 to 400 m basalts, which means that the lava flows from the time when the upper shale of Aussivik member began its deposition, or from a geological point of view shortly after, overflowed this area "continuously", and a few early, especially productive eruptions would easily spread to the Sarqaqdalen valley over the flat surface as indicated by the boundaries of the deposits at this level. The idea that the basalt level of Aussivik member consists of surface lava is therefore rendered most probable.

Umiussat.

West of Qagdloq below Umiussat is a large area with landslide "coulisses", stretching alongside the coast for abt. 3 km and into the country for a similar distance. The vegetation forms a continuous cover, and outcrops of the stationary rock are only found in the mountain area of Umiussat, which constitutes the northeastern boundary of the landslide area. This mountain consists of Plateau basalts as far as the highest peak, point 1175. The lower limit of the basalt is, as mentioned previously, only exposed in the southeastern part below point 1010 and in the

Fig. 10. East slope of the pass between Umiussat and Tarajornitsoq qáqâ. N: Naujât member, U: Umiussat member, B: Basalt level of Aussivik member.

northwestern part west of point 1040, the former at an altitude of abt. 790 m and the latter at an altitude of abt. 840 m.

In the northwestern part of Umiussat, both the coastwise one at point 890 and the slopes of the pass between this massif and Tarajornitsup qáqâ, are sedimentary outcrops (fig. 10). The same applies to the area alongside the brook running from the pass towards the coast, especially in the ridge east of the brook. But the outcrops here only comprises the sequence till a little below the limit between the Tertiary beds and the Atane formation, the latter only visible as a small outcrop west of the brook below the 5 m thick basalt sill which is here situated on the limit. The greater part of the coastal escarpment below is covered with vegetation, and only shows outcrops of landslides with black shale and parts of the above-mentioned sill east of the pass brook. So immediately east of the brook a small portion of the sill is broken off and downthrown. Part of this stands out with a considerably northeastern dip, which is also the case with the underlying well-consolidated sandstone forming in situ a vertical scarp westwards to Igpigârssuaraq; this sandstone lies in huge blocks down the slopes towards the coast, and shows burnt areas of an ochreous colour. At an altitude of abt. 485 m a regular landslide with black shale containing red-burnt parts was observed.

Naujât member: The Tertiary sequence begins above the sill with black, bituminous shale from abt. 575 m and can be traced on the slopes east of the pass brook, and in the east side of the pass (fig. 10), where the section is not quite clean, though admissible for observations of the upper limit of the shale. The shale can be followed continuously until, at an altitude of abt. 770 m by an abt. 10 m thick transition zone, it changes into a coarse-clastic sequence. The transition zone is characterized by a black shale with distinct grains of quartz. The same rock may, however, also be found at a lower level.

On the ridge towards point 890 east of the pass brook is a basalt

dyke which intersects the shale at an altitude of abt. 660 m. It is 1.2 m thick and shows a narrow, but distinct zone of contact effect. This is also the case with the shale. The dyke has strike N 101° and is almost vertical. At the level of the outcrop of the dyke the shale contains several concretional bands and bands of fine-grained sand. A thin concretional layer of a yellow weathering colour includes plant fossils (*Cercidiphyllum arcticum* (Heer) Brown). Also at this level at an altitude of abt. 660 m is black shale with many quartz grains.

The members of Umiussat and Aussivik: Above the black shale (Naujât member) follows from an altitude of abt. 780 m a sequence of light, ochreous, micaceous sandstones medium- or thin-bedded and with fine-grained sandstones with thin cleavage. Neither these beds nor the following ones are visible in clean sections, so details in the succession cannot be demonstrated (fig. 10: U).

Between altitudes of 810—815 m there is shale overlain by sandstones up to an altitude of 830 m. On top of this is black shale alternating with sandstones to an altitude of 840 m, above which is a cover of basalt talus. The lower limit of the stationary basalt is estimated to be at an altitude of abt. 850 m.

South-southeast of point 890, i. e. at the coastwise slope of Umiussat, and abt. 1 km southeast of the pass between Umiussat and Tarajornitsup qâqâ, is a ravine above the eastern part of a terrace with luxuriant vegetation. The ravine shows outcrops of the uppermost parts of the sediments:

Alt.: 840 m		Columnar jointed basalt.
Alt.: 825 m	15 m	Black, bituminous shale with clay-ironstone bands and vivid ochreous, weathered concretional bands with plenty of secondary minerals (26)
		Dirty, dark brown sand in an unweathered condition, ochreous in a weathered. It is partially consolidated by secondary gypsium in small crystals. Exactly the same rock is mentioned by the author from Atanikerdluk pag. 27 as layer 25 and 23.
	0.75 m	Underneath abt. 25 cm black, bituminous shale (25)
Alt. abt. 823 m	1.0 m	Almost white quartz sand with ochreous laminae and cross-lamination (24)
	0.3 m	Brown, strongly consolidated sandstone (23)
Alt.: 800 m	23 m	Almost white quartz sand with ochreous laminae in the upper part. The sand shows cross-lamination (22–20)
		Grey sand with abt. 40 cm thin bands of black, coarse shale separated by sand-beds of varying thicknesses.

Alt.: 790 m ..... Lowermost 2 m sand.....
Alt.: 780 m ..... Black, coarse shale.....
Alt.: 775 m... 5 m .... Cream-coloured quartz sandstone.....

Underneath the rocks are covered with scree, but sand is visible through talus at several places down to an altitude of abt. 750 m.

The sediments below the basalts here correspond in broad outline with those known as the lying of the basalt level of Aussivik member at Atanikerdluk and Qagdlúnguaq. Here, at the northwestern part of Umiussat is exposed, as described, the coarse-clastic sequence between the shale sequences of Naujât and Aussivik members in its whole thickness and more distinctly exposed than at any other place at the stretch described on the southcoast of the Nûgssuaq peninsula. *This occurrence is therefore established as type of the litho-stratigraphical unit designated* UMIUSSAT MEMBER of the structure, succession, and composition as described above.

The basalts above the sediments consist also here of two large columnar jointed beds analogously with the above-treated and more easterly outcrops of the basalt level of Aussivik member, and which are also situated above the same sedimentary succession. The Tertiary at Umiussat consists of Naujât member, Umiussat member, and the shale of Aussivik member below the basalt level. Naujât member has a thickness of abt. 200 m, and Umiussat member abt. 70 m.

Tarajornitsup qáqâ — Kingigtoq.

Kingigtoq is the border land between the coastal mountain ridge (with Tarajornitsup qáqâ) and a large depression between Manik and Ipeqarfiúnge (fig. 17). Distinct outcrops in the Tertiary sequence are found in the big gashes at Igpigârssuaraq, indicated on the map pl. 6 with numbers and letters.

At Kingigtoq is an area with typical landslides of which the lowest situated ones are red-burnt (figs. 13, 14, pl. 6). This area is limited to the west by an escarpment with outcrops of the Atane formation facing the low country, and to the east by the valley with tributary T to torrent 12. The western slope of this valley shows sections through the uppermost landslides, while the eastern one is an escarpment of several hundred metres with a large outcrop of the Atane formation overlain by shale occurrences (fig. 11). This escarpment is intersected by several ravines from where the brooks T, U, V, and X have their rise (ref. pl. 6). The western tributary (V) to torrent 13 borders the lowermost part of the landslide area towards east, while the eastern tributary (Y) has its origin in a big ravine, the first one east of Kingigtoq in the coastal escarpment. That, too, shows outcrops of the Atane formation and part of the

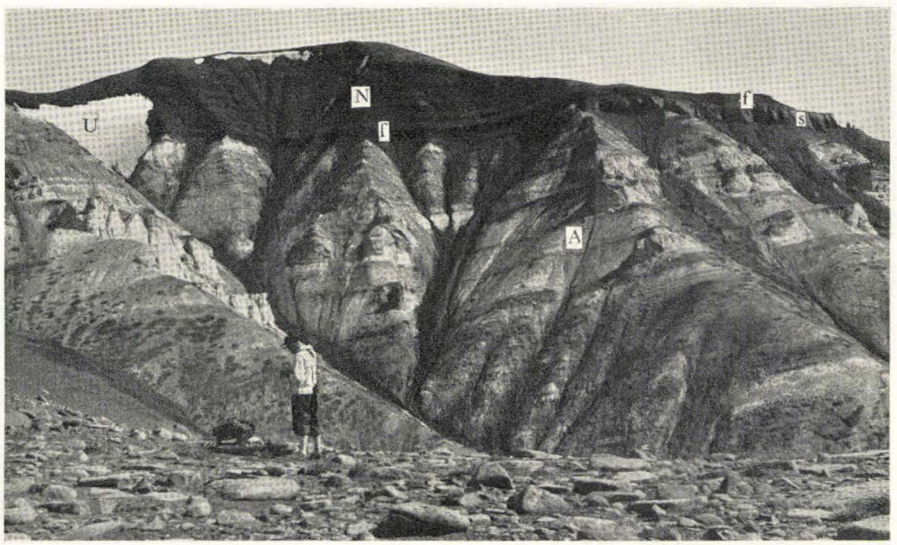


Fig. 11. Eastern slope of the Igpigârssuaraq valley (torrent 12), seen from the crest of landslide "coulisse" No. 4 (part of the western slope of the valley). A: Atane formation (Cretaceous), s: Sill, f: Brown fossiliferous basal shale of Naujât member, N: Naujât member, U: Ravine U.
(K. Raunsgaard Pedersen phot.).

overlying Tertiary shale sequence. The escarpment below point 760 (i.e. the east slope of the valley with torrent T) facing the landslide area (fig. 11) exposes the Atane formation from an altitude of abt. 200 m, (fig. 11: A) showing clean outcrops up to an altitude of abt. 650 m. At the head of the Igpigârssuaraq valley, at an altitude of abt. 655 m, it is overlain by the Tertiary shale sequence designated Naujât member (fig. 11: N) (at T on pl. 6). Some hundred metres more southerly on the spur between the head of the Igpigârssuaraq valley (torrent T) and the ravine with torrent U, the same limit is found at an altitude of abt. 700 m. In the ravine with torrent Y the limit is found at the bottom of the ravine at an altitude of abt. 650 m reckoned from above the sill which from this place and eastwards separates the Atane formation and the Tertiary. Apart from the outcrops in the gashes east of Igpigârssuaraq, the coastal escarpment is covered with vegetation. Only the uppermost part of the Atane formation with the overlying sill forms a vertical scarp stretching from torrent Y to torrent 19. On this stretch the sill is still overlain by the Tertiary shale. Immediately east of torrent 14 is the basis of the Tertiary at an altitude of 630 m, and that of the sill at 620 m. At torrent 15 the bottom of the Tertiary shale (Naujât member) is at an altitude of 595 m. The sill, which shows a great extent towards southeast, is in the eastern slope of the Igpigârssuaraq valley seen to

wedge out towards north between the ravines with the torrents Y and U (fig. 11) so that the shale (Naujât member) directly overlays the Atane formation at the head of this valley (with torrent T).

The measurings given above of the limit Tertiary/Cretaceous show a culmination on the spur between the head of the Igpigârssuaraq valley and the ravine with torrent U at which place the limit reaches an altitude of 700 m with a dip to north and south. On the northern side of this culmination on the old land surface represented by the unconformity, is seen a small occurrence of coarse, ochreous sandstone and conglomerate cemented by iron compounds locally replaced by light ochreous quartz sand of medium grain size. The bed is abt. $^1/_2$ m thick. Litho-stratigraphically it may be designated QUIKAVSAK MEMBER without the age being presumed. It contains no fossils.

Naujât member: With a lower limit the conditions of which appear from the above description, follows on top of the Atane formation the enormous shale sequence the basal layers of which at Kingigtoq consist of brown shale 5—10 m thick (fig. 11:f). On a closer investigation (according to information given by mag. scient. H. Michelsen), the siderite and clay fraction which make up the greater part of the material, was removed. The remaining part i. e. the coarsest fraction (grain size > 0.3 mm) consists of strongly pigmented palagonite grains which, however, are translucent at the edges. The grains are faintly rounded. Consequently it is tuff, and — at any rate — the coarsest fraction appears to have been exposed to a shorter water transport.

The rock is fossil-bearing. As will be shown later, the red-burnt beds in the landslide, from where a fossil flora was described by (SEWARD & CONWAY 1939), have their origin in this bed. Above follows black, bituminous shale with conchoidal fracture. The shale can be followed up in the terrain in the direction of point 981. It can be followed directly to an altitude of abt. 750 m, but the weathering debris consists mostly of shale up to an altitude of abt. 800 m, where it changes into such a solid cover of yellow sandstone that the upper limit of the shale must be supposed to be near an altitude of 800 m and overlain by a coarse, clastic sequence as is the case eastwards. The shales contain numerous thin clay-ironstone bands some of which are of an ochreous colour. Besides, a number of sandstone "dykes" traverse the sequence in various directions. Most of them are but few centimetres thick, though one sandstone dyke has been observed showing a thickness of 40 m. It can hardly be anything but fissure fillings which imply earth quakes at the very time when the overlying sandstone (Point 976 member) had commenced its deposition. In the east slope of the Igpigârssuaraq valley Naujât member is observed to be unconformably deposited upon the Atane formation (fig. 11).

Fig. 12. Northern slope of Tarajornitsoq valley. N: Naujât member, U: Outcrops of Umiussat member. Background left: Point 1300 S of Gieseckes Monument.

Umiussat member: The overlying sandstone sequence has been observed up to an altitude of 895 m where the uppermost occurrence was found in basalt talus below the peak with point 981. There is a slope of less than 50 m vertical distance covered with talus between the uppermost sandstone occurrence observed and the stationary basalt outcrop of the peak with point 981 which exposes two thick columnar jointed beds of olivine-porphyric basalt. If we take into consideration the faint easterly dip of the Tertiary sequence, its altitude above sea-level shows that the basalt of point 981 may be considered a continuation of the basal layers of the basalts in the mountain Umiussat (i. e. the basalt level of Aussivik member). In Umiussat the two beds reach as far as point 890 at the pass between Umiussat and Tarajornitsup qâqâ. It is also visible in the other peaks of the last-mentioned mountains. At point 890 of Umiussat the basalts are eroded as far as the surface of the uppermost one of the two beds on which surface the mentioned point is situated. The

thickness of the two basalt beds of the Aussivik member is about 50 m applying to the whole area east of Kingigtoq described in earlier chapters, and point 981 shows no essential deviation even if it has been impossible to undertake a direct measuring. The limit between Umiussat member and the basalts of point 981 may therefore be estimated at an altitude of 920 to 930 m.

Tarajornitsoq.

Northeast of the coastal mountain ridge that has been our object as far as the Sarqaqdalen, lies the valley of Tarajornitsoq. The watershed of this valley towards the Manik depression is situated behind Kingigtoq which is only separated from the valley by a narrow shale ridge. The slopes of Tarajornitsoq are, to a great extent, covered with vegetation. At the southern one, behind Kingigtoq, shale of Naujât member is visible in several spurs. At the northern slope (fig. 12) Naujât member can be followed up to an altitude of abt. 750 m, and from this altitude sand (Umiussat member) continues up to 840 m in slopes mostly covered with scree and without clean outcrops. Further, loose sandstone blocks are seen as far as altitude abt. 840 m.

The Landslide Area at Kingigtoq.

In the western slope of the Igpigârssuaraq valley a range of weathered landslide "coulisses" is observed from an altitude of abt. 600 m, stretching down towards the coast. In the interior part of the valley, where the eastern tributary of torrent 12 (T) has its course, there are sections through the 6 uppermost ones (figs. 13, 14). The rocks and structure of the landslides are less damaged by the sliding the farther one ascends. The lowermost landslides are, on the contrary, strongly red-burnt. Landslide 6 is of a highly red colour, but not enough dislocated to blur the structure which stands out rather distinctly. A 7th "coulisse" (fig. 13) below coulisse 6, not included in fig. 14, is also of a red colour but so weathered that its structure cannot be distinguished. In the area between the lowermost parts of torrents 12 and 13 the individual landslides cannot be distinguished, here are only large surfaces of burnt rocks: red shale and reddish-yellow sandstone.

All the landslides appear to be of a similar structure, making up a section of the sequence around the unconformity with part of the Atane formation underneath, succeeded by the brown and the black shale (fig. 14). This is very easily recognized as far as the upper, fresher coulisses are concerned. The vertically truncated brown shale bed forms a contrast to the fainter surface gradient of the hanging and the lying. Its natural cohesive force has been further increased through burning which is also the initiary cause of the highly red colour of the lowermost "cou-

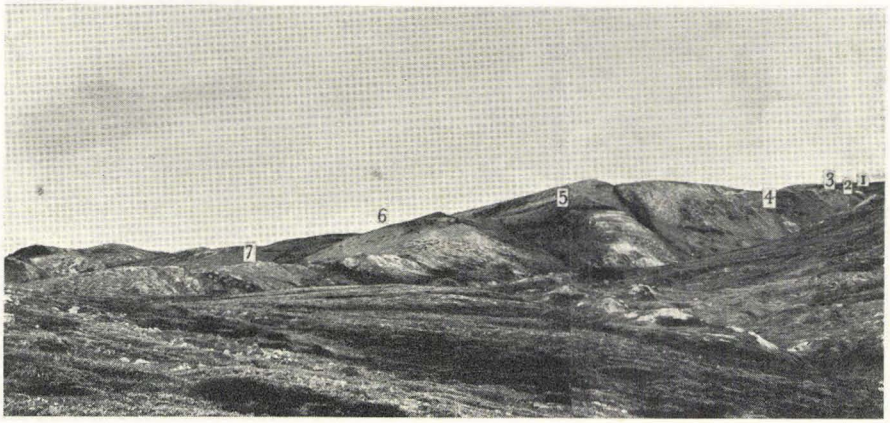


Fig. 13. Western slope of Igpigârssuaraq valley (torrent 12) with exposures of landslides in 7 generations (1—7). Letters 4—5—6 are placed just at the red bed representing the fossiliferous basal shale of Naujât member. 6: A. C. Seward's fossil locality.

lisses". The brown basal layer of Naujât member is thus easily recognized in all the landslides as a 5 to 10 m thick bed forming a vertical scarp (fig. 13: nos. 4, 5, and 6 are placed standing on it). The black shale which is greatly crushed, makes out the main part of the fresher landslides (1—5).

From the 7 uppermost, i. e. youngest, generations of landslides situated alongside torrent T, it appears that the lowermost ones have been transformed most severely, i. e. most dislocated and most burnt. As they all include the brown basal Naujât member shale, fresh or converted, they are all sections of somewhat the same stationary sequence. The lowermost are then the ones which have undergone the longest transport during the landslide, and consequently far enough for combustion. The 5 uppermost have been transported the shortest distance and show no burning. The distance of the sliding has been too short to develop the heat necessary for combustion.

The purpose of the investigation of these landslide "coulisses" was to clear up where the fossils described by (SEWARD & CONWAY 1939) had their origin in the stationary sequence. It appears from the description by these authors and from the rock containing the plant fossils that the material has been collected at a hill at an altitude of 380 m. This can be no one but the 6th landslide "coulisse", where there are also plenty of fossils in the truncated red bed, which is equivalent to the brown basal layer of Naujât member immediately above the unconformity which is fossil-bearing in situ too.

In the brown basal layer of Naujât member a collection of fossil plants was made, and this collection comprises the most essential species from the Tertiary element in Seward and Conway's flora (ref. pag. 93).

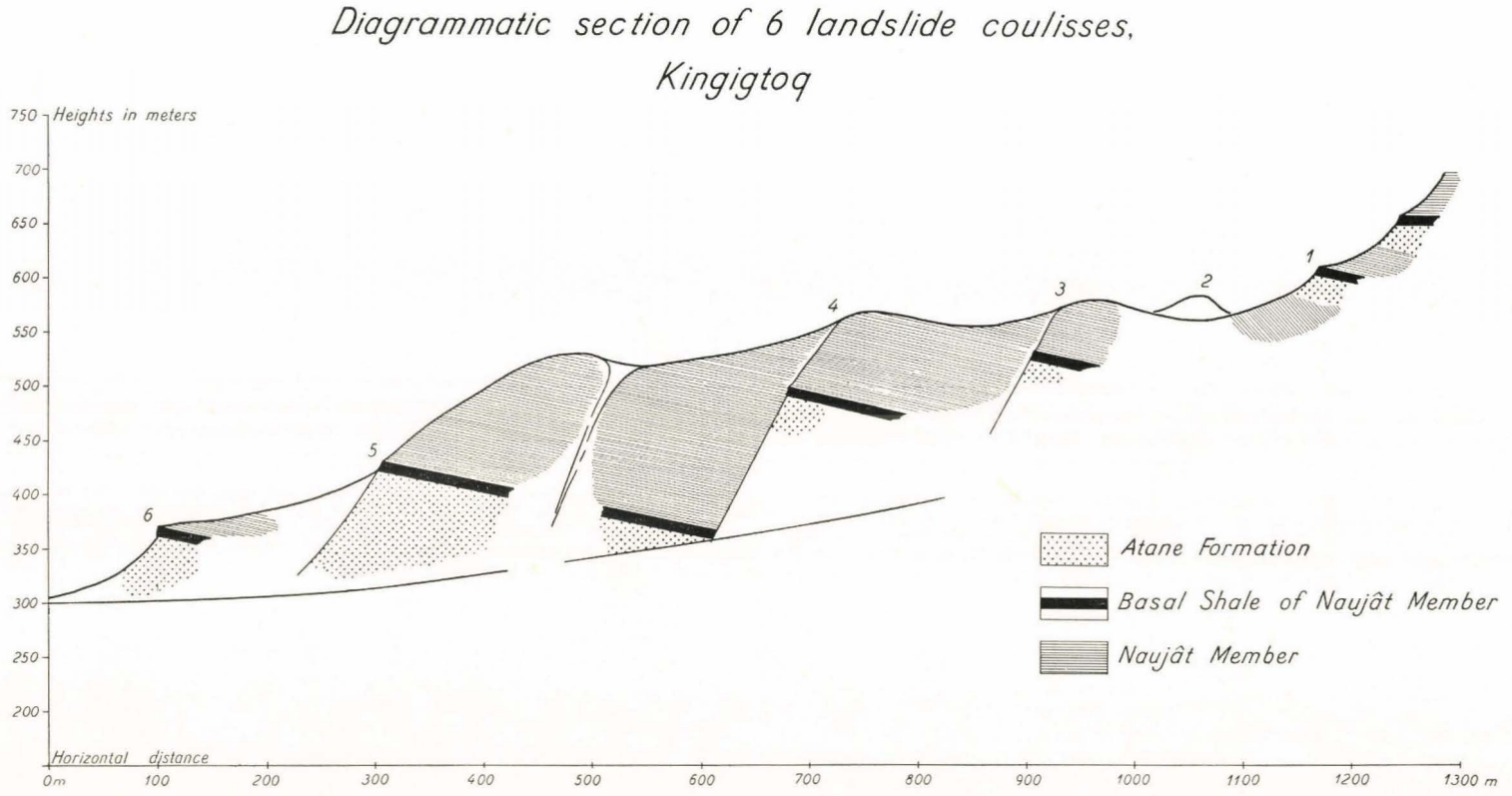


Fig. 14. Diagrammatic section through 6 landslide "coulisses" just west of torrent 12 (ref. fig. 13) based upon exposures of the slope along this torrent. Upper right corner: Horizontal strata symbolize the undislocated sequence above the inclining dislocated strata of the landslides.

As mentioned the Atane formation is usually represented in the basal part of the landslides. However, the rocks of this formation are normally yellow after burning and easily distinguished from the Tertiary red ones. None of Seward and Conway's depicted species are found in these yellowish rocks. The characteristic Cretaceous species are found in a liver-brown clay ironstone which is not influenced by burning and appears to originate not from the landslides but from the eastern slope of the Ipigârssuaraq valley. Here it is found stationary at an altitude of 570 m, and as loose debris at an altitude of abt. 585 m. The finding place is the spur between the head of the blind valley (torrent T) and the ravine of torrent U, consequently in situ in the Atane formation. Pieces collected by the author, contain *Laurophyllum plutonium* (Heer) Seward and Conway as is the case with the Cretaceous element by (Seward & Conway 1939).

On considering Seward and Conway's fossils from Kingigtoq, it is possible at once to sort out the material into liver-brown clay ironstone belonging to the Cretaceous, and black and red to reddish-brown shale (not sandstone) belonging to the Tertiary. Of course, this distinction does not apply generally, as red shales are known from Danian as well as from the Atane beds in other places on the Nûgssuaq peninsula.

Seward and Conway have without knowledge of the difference in facies been able to make a sharp distinction between the Tertiary and the Cretaceous element. These two elements in Seward and Conway's flora are stratigraphically well separated and belong to two different deposits, *the Atane formation* and *the Lower Tertiary*, separated by an unconformity representing a lacuna from, at any rate, *Senonian* to *Paleocene.*

Manik — Ipeqarfiúnge.

Along the coast and behind it on the stretch between Manik (11) and Ipeqarfiúnge (9), a distance of abt. 4 km, there is a depression with a depth of abt. 6 km inland (fig. 17), where it is bounded by high mountains: To the east by the mountain ridge with Giesekes Monument (point 1578), and to the north by the ice-capped mesa with points 1760 and 1551 and the pyramidal mountain with point 1580.

Sediments at Gieseckes Monument.

The central part of the Tarajornitsoq valley debouches, above a low watershed behind Kingigtoq, into the eastern slope of the depression mentioned above. From this place the Tertiary sediments, the outcrops of which in Tarajornitsoq has been mentioned on page 43, can be traced northwards in the eastern slope of the depression along the foot of the mountains south of Gieseckes Monument. South of these basalt mountains,

which rise to heights of more than 1300 m, and facing Tarajornitsoq there is a basalt area which is assumed to consist of devastated landslides. These landslides are separated from the stationary rock to the north by a minor gash debouching into the depression. On both sides of its outlet there are sedimentary sections. To the south, at S (pl. 6), black shale (Naujât member) is exposed from an altitude of abt. 600 m up to 770 m. In succession of this is a series of yellow sandstones (Umiussat member) which extends to an altitude of 780 m, at which level the sediments are covered with solifluction and talus.

To the north of the small gash, at R (pl. 6), there is a sedimentary spur facing the depression at the southwestern corner of the basalt mountain. Here black shale (Naujât member) is exposed from an altitude of 580 to abt. 810 m, only interrupted by a few thinner sandstone levels of which one is abt. 5 m thick (alt. 790 to 795 m). As is typical for this area, the shale is succeeded by a sequence of sandstone (Umiussat member) which shows no clean outcrops. On top follows abt. 10 m of black shale overlain by the stationary basalt at an altitude of 855 to 860 m. This is strongly columnar.

Members of Aussivik and Point 976: About one km further to the north, in the southwestern wall of the mountain with point 1300, there is an intrabasaltic sedimentary occurrence (pl. 6: Q) (fig. 15: A) being the complement of the profile for the east side of the depression. It is underlain by strongly columnar basalt forming a vertical scarp below the sedimentary outcrops. Below this great truncated basalt bed there are only slopes covered with Quaternary deposits the limit to the pre-basaltic sediments being unknown at this place; however, the thickness of the basalt must be estimated at abt. 100 m, as the gentle slopes below the basalt are assumed to reflect the faintly consolidated sediments.

The lower limit of the intrabasaltic sediments lies at an altitude of 990 m, and they consist of black shale with no clean outcrops being weathered into a pale grey colour. This light-coloured sedimentary occurrence hangs like a shelf on the vertical dark basalt wall and is visible at a distance. A 1.1 m thick coal seam appears at an altitude of 1040 m. It consists of hard, bituminous banded coal with lignite of the type designated Surturbrand: Incoaled trunks showing growth rings and representing bright coals of Tertiary age, the incoaling process of which has been accelerated by volcanic heating influence. The coal seam has grey underclay, which also occurs as flat lenses in the seam itself. On top follows yellow sand which a few metres higher is covered with the basalt talus. The faint sloping of the surface up to the stationary basalt at an altitude of 1070 m suggests, however, that the sediments extend to this level below the talus. The sedimentary succession corresponds to the one at Atanikerdluk situated above the basalt level of Aussivik member

Fig. 15. The basalt mountains with Gieseckes Monument (G) and intrabasaltic occurrence of Aussivik member and Point 976 member (A) facing the big depression. B: Plateau basalts.

where Aussivik member is succeeded by Point 976 member, and the total thickness of the sediments show the same dimensions although the shale is a few metres thicker here at Gieseckes Monument.

This sequence continues in a more northerly spur where the shale outcrops are bifurcated by a basalt body of a strongly columnar structure. It shows a zonal division: Strongly columnar at the bottom, faintly irregularly columnar at the top, and of chaotic structures in the central part reminding of the description given on page 52 of a lava flow which might have flown into a shallow water basin (fig. 16, 19). A closer investigation of this was not made, but of observations made from the above-mentioned occurrence it may be estimated that there are 20 to 30 m of shale below the basalt occurrence the thickness of which has not been measured. The shale above is estimated at abt. 40 m.

There are several assumptions as to the explanation of this basalt embodied by shale. It may be an intrusion which has been pressed into the weak zone represented by the shale level as compared with the basalt which encircles the occurrence. It may also be explained as the result of the complicated interaction between the basaltic volcanism and sedimentation, considering that the two elements have been working simultaneously, or temporarily alternating. If so, it may be a cross section of a lava flow, and the wedging out—as seen on fig. 16—must then be due to the lateral wedging out of the lava flow.

On fig. 15 it will be noted that the single basalt beds in the mountain above the intrabasaltic sedimentary occurrence are distinctly separated

Fig. 16. View towards north from the occurrence of Aussivik member below Gieseckes Monument (from lok. A. at fig. 15). Basalt body (lava flow) separating the sedimentary occurrence in an upper and a lower part. s: Aussivik member shale. Background, i: Aussivik member below the mountain with point 1551, b: Plateau basalts.

by what, from a morphological point of view, can hardly be anything but the thin sedimentary layers which are so often seen between the single flows in case of Plateau basalts. Through the above-mentioned sequence it is thus demonstrated that an interaction taken place between the elements: sedimentation and volcanism, has marked this period of the geological history of Gieseckes Monument, suggesting that the last-mentioned solution is the nearest approach to the truth.

Sediments at Ipeqarfiúnge.

Behind the valley at Ipeqarfiúnge (9), adjacent to the northwestern part of the big depression, is a district with landslide coulisses (fig. 17), in which basalt breccia (ref. Sole Munck in: Rosenkrantz et. al. 1942 pp. 43—54) is the dominant feature, as the basal part of the volcanic Tertiary sequence from Ipeqarfiúnge and westwards has developed as this subaquatic extrusive facies. A very few of the lowest situated landslide "coulisses" suggest the presence of sediments either as shadows through the solifluction or as small spots of sedimentary debris in the top of such a hill. Thus a landslide "coulisse" is seen to contain yellow sand at an altitude of abt. 940 m behind the valley at Ipeqarfiúnge (9) and

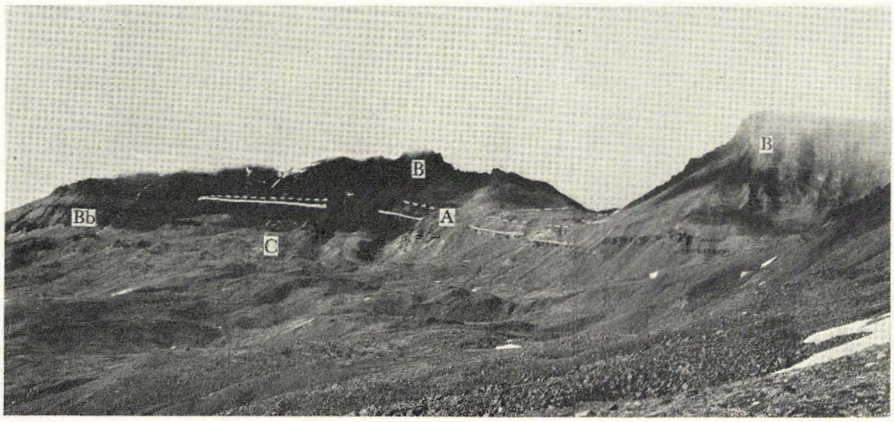


Fig. 17. View over the northern part of the big depression between Kingigtoq and Ipeqarfiúnge. C: Landslides, Bb: Basalt breccia, A: Aussivik member the lower limit of which is indicated by the white line. The hatched white line shows the supposed upper limit, B: Plateau basalts, to the left in the mountain with point 1551, to the right in the mountain with point 1580.

northeast of point 870. Uppermost in the Ipeqarfiúnge valley there is a large area of black shale with the character of a landslide.

In the western slope of Ipeqarfiúnge valley Cretaceous sediments (*the Patoot formation* (ref. TROELSEN 1956)) are seen of the type normally occurring in the south coast areas of the Nûgssuaq peninsula with alternating light quartz sandstone and black shale which is often carrying coal seams. These show, as is also the case close to the coast at Pautût, a dip towards the coast of the Vaigat strait (i. e. SW), consequently contrary to the regional dip of the younger Cretaceous at the Nûgssuaq peninsula which is northeasterly. The Cretaceous sediments at Ipeqarfiúnge are exposed up to an altitude of abt. 750 m, where they are covered with Quaternary deposits, especially till. Below the till there seems to be a minor occurrence of black shale which may be Tertiary, but as observations have only been made from the eastern slope of the valley, it is not certain.

Immediately north of point 870 is the above-mentioned large occurrence of black, bituminous shale from an altitude of 795 m at the head of the valley to 870 m in a hill east of the valley. The shale is exposed to an altitude of abt. 900 m, overlain by basalt breccia probably placed on top of the shale by a landslide. This outcrop constitutes the end of the valley. No doubt it is an occurrence of Naujât member, and the above mentioned sand occurrence in a landslide "coulisse" at an altitude of abt. 940 m suggests that the shale is present in its whole thickness overlain by Umiussat member, which according to the "coulisse" occur-

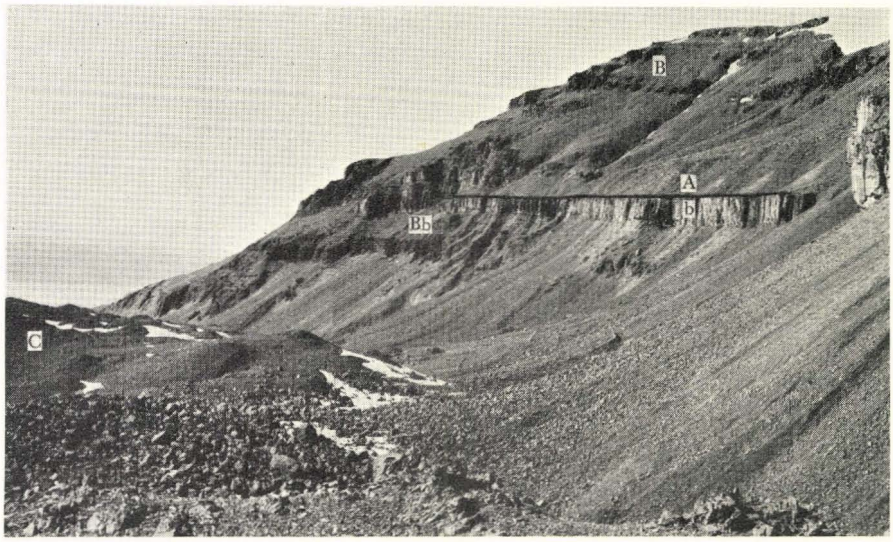


Fig. 18. Southern slope of ice-capped mountain with point 1760 above Ipeqarfiúnge (facing the big depression). A: Intrabasaltic Aussivik member wedging out towards west, b: Basalt bed below sediments Bb: Basalt breccia, B: Plateau basalts, C: Landslides consisting of (b) and (Bb). To the left the Vaigat strait and Disko Isl. in hazy background.

rence at any rate ex parte must have been deposited as far to the west as Ipeqarfiúnge.

Landslides of basalt breccia and basalt lie here along the western slope of the large depression up to an altitude of abt. 1000—1100 m as a gigantic talus (fig. 17). At Ipeqarfiúnge the stationary basalt breccia is exposed down to an altitude of abt. 1000 m. If one follows the wall of the basalt breccia in the northern side of the depression from the Ipeqarfiúnge valley and eastwards at abt. 1000 m's level and above the landslide "coulisses" (fig. 18), one finds abt. $^1/_2$ km east of the torrent N (pl. 6) that an intrabasaltic sedimentary occurrence begins here, downwards only separated from the basalt breccia by a strongly columnar basalt bed (fig. 17, 18: b). The sediments are overlain by the Plateau basalts (fig. 18: B). They appear as a row of minor outcrops of shale, in between covered with talus, but the continuity appears from the fainter sloping of the surface which forms a shelf in the otherwise steep basalt mountain (fig. 18). This slope seems to exhibit an increasing thickness of the sediments to the east, i. e. that it is a question of a sedimentary occurrence wedging out into complete obscurity towards west. The place where it disappears lies at an altitude of abt. 1290 m, 5 km from the coast and $1^1/_2$ km S of point 1760. Innermost where the northern slope of the depression (direction ENE) turns towards southeast, at the torrent P

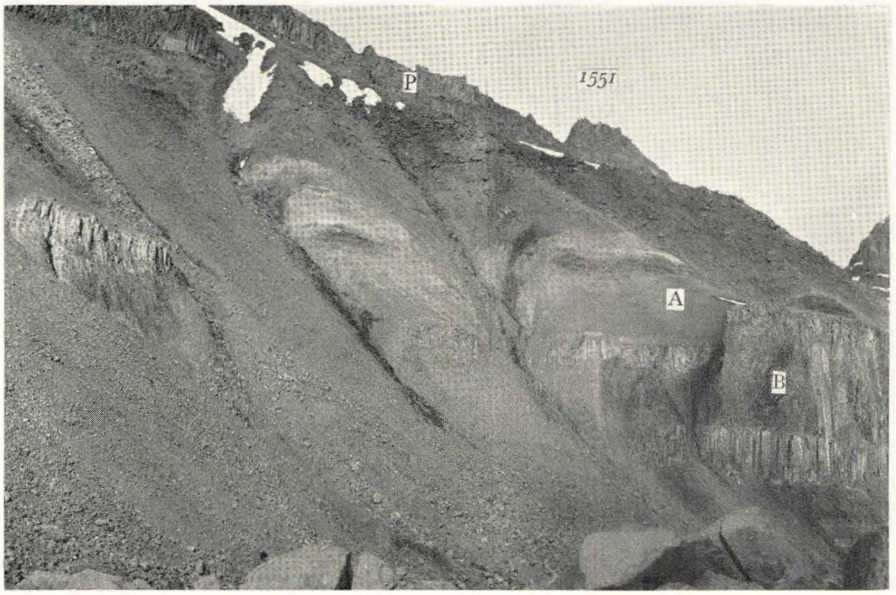


Fig. 19. Intrabasaltic Aussivik member (A) in the mountain with points 1760 and 1551 at torrent 9P with the fossiliferous bed (dark bed above letter A). B: Basalt flow with collapsed roof, P: Plateau basalts.

(pl. 6), admissible and rather large outcrops in shale are observed (fig. 19) immediately northeast of a small "intrusion" which here for a shorter distance (abt. 100 m) replaces the shale. The shale overlies the basalt with a somewhat varying surface (alt. 1219—1230 m) and of a typical structure.

The structure of the basalt bed below the shale stands out distinctly in a landslide coulisse some hundred metres southwest of this place on the northern slope of the depression at an altitude of abt. 1150 m. Here the basalt overlies the basalt breccia. The lowermost zone, 5 or 6 m thick, of the abt. 15 m thick basalt bed is distinctly and strongly columnar. Uppermost is an abt. 2 m thick columnar zone. Between these a zone of chaotic structure. The columnar zones may be those of extreme cooling and the first solidified ones of the flow. The same is demonstrated in fig. 19, where the roof first hardened has sunk in before the final hardening of the interior of the basalt flow and caused the deviation of the surface level of the bed as mentioned above.

At an altitude of abt. 1240 m in the shale outcrop mentioned is a truncated shale bed a few metres high, which is continuous for the section with shale seen in the vicinity (fig. 19). The shale here is brownish, and especially a thin layer in the middle of the bed has a great similarity to the basal brown shale of Naujât member at Kingigtoq and to the brown

bands of claystone from Naujât and Aussivik members at Atanikerdluk, which contain siderite as these. It cleaves in even, thick slabs contrary to the rest of the shale of the section showing an uneven conchoidal cleavage being more fissile and of a black colour. The brown claystone contains plant fossils which applies to this zone only.

On treatment with hydrocloric acid and separation the siderite and clay fraction being the essential part of the material of the brown claystone are removed. About the remaining coarsest fraction mag. scient. H. Michelsen states: "Grain size abt. 0,1 m±. The grains being faintly rounded, consisting of strongly pigmented palagonite which owing to the pigment is almost opaque." It is thus a tuff.

The sediments can at this place be traced to an altitude of 1270 m where they are completely covered with talus. Uppermost there are layers of fine-grained sand, but the details of their structure are not observable. At an altitude of 1265 m was found a clay-ironstone concretion with a shell of *Unio sp.* So it must be a freshwater deposit.

The sediments, the underlying basalt and basalt breccia, can be traced eastwards towards the pass between the mountains with points 1551 and 1580, partly by outcrops below point 1551, and partly by the morphology where solifluction and vegetation cover the stationary rock, the sediments showing a fainter gradient of the surface than the underlying basalt - basalt breccia. It is evident that the sediments and the underlying basalt - basalt breccia from the above fossil locality (pl. 6: at P) incline considerably eastwards (fig. 16, 17). Without having direct measurings I would estimate that the sediments at the pass between the mountains with points 1551 and 1580 are extending down to altitudes between 1100 and 1000 m, and the upper limit to the basalt breccia to be at abt. 1000 m.

This sedimentary sequence must be a continuation of the intrabasaltic sequence in the eastern side of the depression (pag. 47–48, fig. 16) and *can be considered identical with the members of Aussivik and Point 976.*

The central part of the large depression near point 1580 was not visited and must be investigated before the conditions of these intrabasaltic sediments and their relationship to the corresponding ones in the eastern side of the depression can be fully unravelled. In spite of a considerable cover of Quaternary deposits here, it might be possible to make further observations of the eastern limitation of the basalt breccia and its transition into the subaeric lava flows which is supposed in this area. The sharp inclination of the surface of the basalt breccia eastwards may suggest that it is wedging out in an easterly direction in contradiction to the intrabasaltic sedimentary sequence which is wedging out to the west. How the development of the basalt separating the sediments

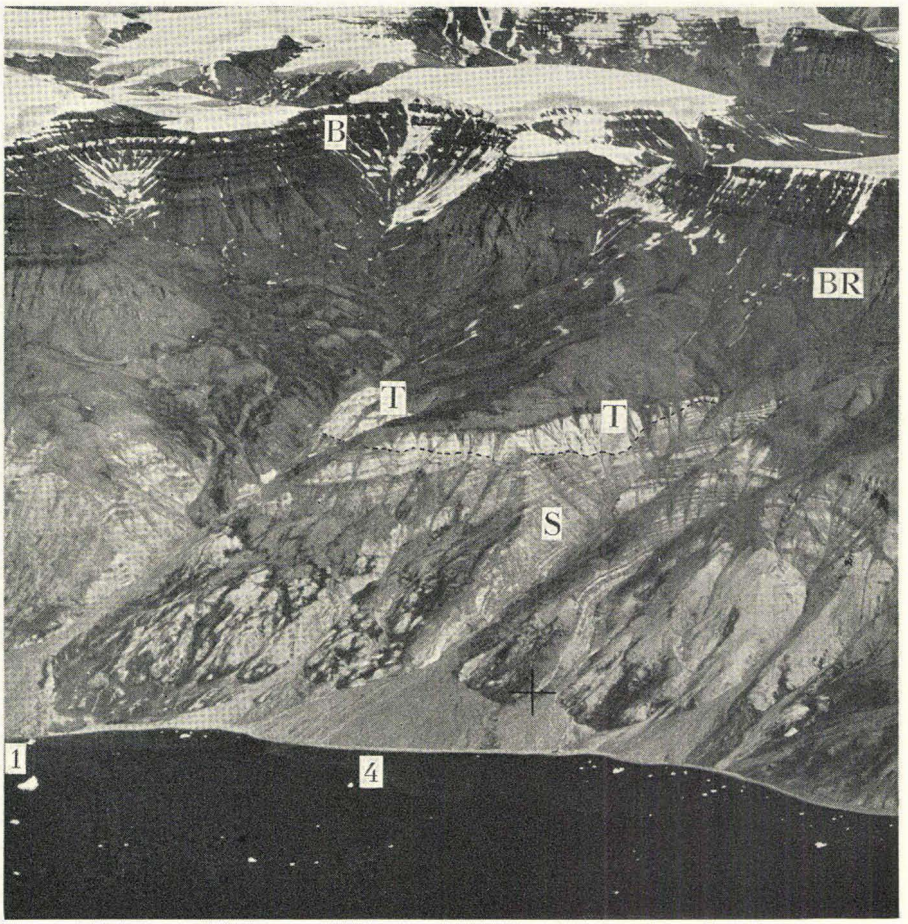


Fig. 20. Aerial view of the coast mountains at Pautût with cirque-like depression. 1: Pautûtdalen, 4: Igpigârssukkløften, both with good exposures, S: Senonian (Pautût formation), T: Quikavsak member of the Upper Atanikerdluk formation (Lower Paleocene), BR: Basalt breccia, B: Plateau basalt

from the basalt breccia turns out, for example whether it increases in thickness eastwards and replaces the basalt breccia, observations made so far do not suffice for an answer. As the intrabasaltic sediments at Gieseckes Monument is only 20 to 30 m thicker than those in the north slope of the depression at torrent P, the increase in thickness is far from squaring out the difference in level of abt. 200 m which is ascertained between the upper limit of each of these two fixed occurrences. There may also be a tectonical cause: A dome structure, with its centre near Pautût, a suggestion also supported by the structure of the Cretaceous beds at Pautût dipping in a westerly direction (ref. also pag. 50).

Pautût.

West of Ipeqarfiúnge the Tertiary sediments do not occur continuously along the coast but as isolated occurrences, and the Cretaceous sediments often extend to considerable heights so that it is near to assume that the basalt breccia at several places is deposited directly upon them. West of Ipeqarfiúnge the volcanic sequence above the sediments always begins with the basalt breccia (SOLE MUNCK in: ROSENKRANTZ et al. 1942 pp. 43—54).

At Pautût (fig. 20) the country rises steeply to an altitude of abt. 800 m behind the foreland. On top of this, below the ice-capped mesa with point 1900, there is a large corrie. Two valleys (torrents 1 and 4) are cut into the country on respectively the east side and the west side of this corrie showing good sections of the sedimentary sequence. In the following the western one will be designated as the Pautûtdalen valley (1), the eastern one the Igpigârssukkløften (4). On the coastal slope between these two valleys, several minor ravines cross the upper part of the sedimentary outcrops. They are referred to as F, G, and H (pl. 6).

The western slope of the Igpigârssukkløften exhibits a very distinct unconformity (fig. 20: along the dotted line, fig. 21) the Cretaceous sequences (fig. 20, 21) being a constant alternation between dark shale beds and light sandstones in which a uniform sandstone formation belonging to the Tertiary is submerged. The Igpigârssukkløften forks into two gashes separated by a very sharp spur. Immediately above the division point three ravines branch off from the western one (fig. 21: I, K, L) passing through the large outcrop of the Tertiary occurrences. The lower limit of the Tertiary was here measured as follows. If one begins at the spur dividing the coastal slope from the west wall of the Igpigârssukkløften, the heights of the unconformity will be:

1) The spur between the coastal escarpment and the Igpigârssukkløften ..... 675 (680) m
2) Ravine I, the east slope ..... 677 m
3) Ravine K, the west slope ..... 672 m
4) Ravine L, the west slope ..... 620 m
5) Ravine L, the east slope ..... 620 m
6) Ravine M, the west slope ..... 750 m.

The uppermost end of the western gash of the Igpigârssukkløften divides into two ravines of which the westernmost is called ravine M (fig. 21).

If following the lower limit of the Tertiary sequence to the west along the coastal slope, one gets the following heights in the ravines H, G, F, E (fig. 22) reckoned from the Igpigârssukkløften and westwards:

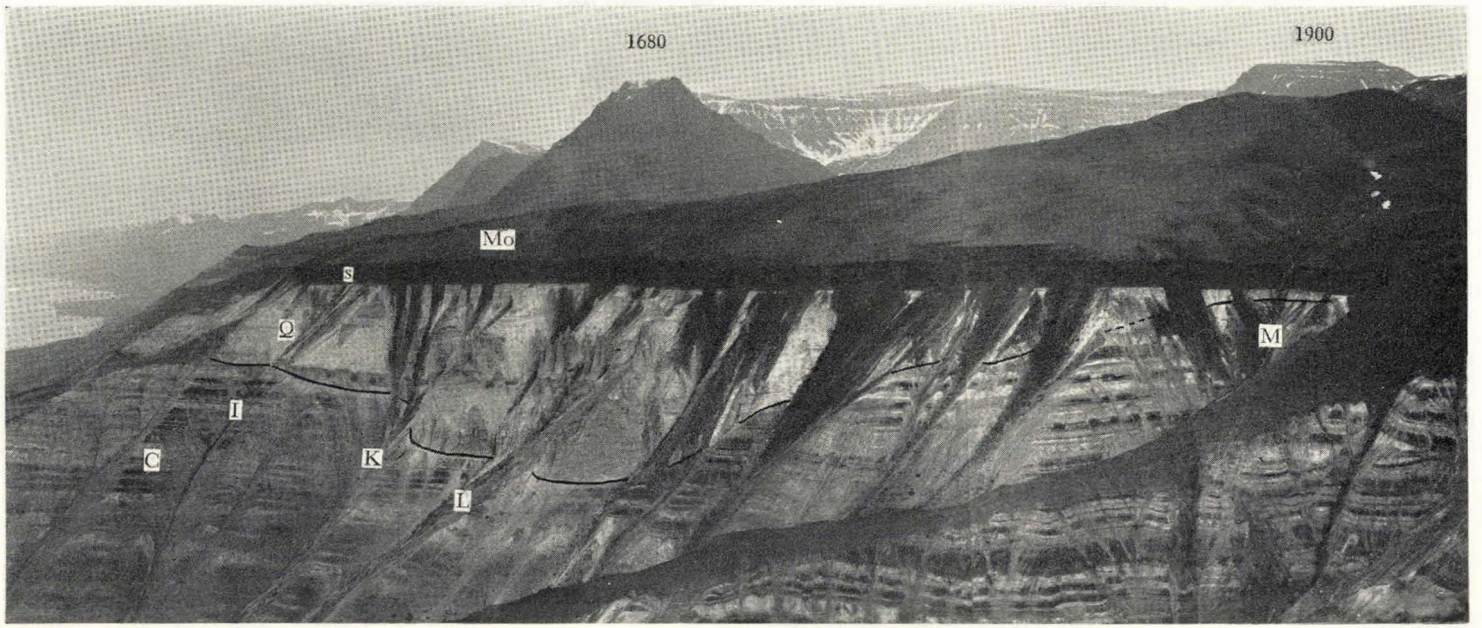


Fig. 21. Western slope of Igpigârssukkløften at Pautût with section through Tertiary river accumulations (Quikavsak member). Black line: Limit between Cretaceous Pautût formation (Senonian) and Tertiary Quikavsak member. Letters I, K, L, and M refer to ravines mentioned in the text. C: Cretaceous (Senonian), Q: Quikavsak member (Tertiary), s: Sill, Mo: Moraine. To the left the coast of Vaigat strait.

Fig. 22. The coastal slope between torrents 1 and 4 (ref. pl. 6) with ravines E, G, and H (ref. text). View from the shore of the Vaigat strait. Black line represents limit between Cretaceous Pautût formation and Tertiary Quikavsak member.

7) Between the ravines H and G ..... 680—690 m
8) The west slope of ravine G ..... 690 m
9) The bottom of ravine F ..... 715 m
10) Ravine E, the west slope near the outlet ..... 730 m
11) The bottom of ravine E ..... 710 m.

So the unconformity rises faintly westwards along the coastal slope, and in ravine E there is likewise demonstrated a dip into the country (towards NE).

In the Pautûtdalen valley there are large outcrops in the eastern slope (fig. 23, 24), where several ravines of a considerable size traverse the sediments and show good outcrops of the Tertiary sequence. From southwest towards northeast they are designated as D, C, B, and A. D is a gash with numerous ravines branching off, forming the shape of a fan.

The heights of the unconformity are as follows:

12) Ravine D, the south slope ..... 697 m
13) Ravine D, the spur separating the ravines D and C .... 635 m
14) The bottom of ravine C ..... 575 m
15) The spur between the ravines C and B ..... 590 m
16) The spur between the ravines B and A ..... 625 m
17) Northernmost small spur with Tertiary sediments exposed (aiming at point 1630: N 328°) ..... 730 m.

Fig. 23. Exposures of ravine D (ref. text) of eastern slope of the Pautûtdalen. Hatched line: Limit between Cretaceous Pautût formation (C) and Tertiary Quikavsak member (Q). The limit dips northwards. M: Moraine. Background: Vaigat strait and Disko Isl.

From this information it appears that the unconformity is V-shaped in the sections of the two valleys, i. e. sections in a northeasterly direction. The lowest height in the Igpigârssukkløften (620 m) is much closer to the coast than the lowest height in the Pautûtdalen (575 m). The difference is about $^1/_2$ kilometre. Coastwise the unconformity rises faintly westwards from ravine E (680 m) to ravine H (710—730 m).

It is thus obvious that the Tertiary sediments fill up a trough-shaped depression in the older substratum. The axis of the trough has the direction NNW—SSE making an acute angle with the coast.

Quikavsak member: In the profile of the western slope of the Igpigârssukkløften, above the unconformity in the ravine I, is exposed a

Fig. 24. View towards the outlet of the Pautûtdalen valley (from mouth of ravine B). To the left the southern slope of ravine B with Cretaceous Pautût formation (C) (clearly bedded) and Tertiary Quikavsak member (Q) with its special columnar erosional pattern. The limit between (C) and (Q) distinct. (C) in upper left corner designates Cretaceous beds in the southern part of ravine D on the opposite side of the Tertiary river deposit. Background: Vaigat strait and Disko Isl.

4 m coarse conglomerate with cobbles the majority of which has a cross section of more than 10 cm, and in ravines K and L similar conglomerates are found at the basis of the Tertiary, though barely so coarse. The pebbles and cobbles of the conglomerate consist of quarts and metamorphic rocks. Also coal pieces originating from trunks and wood pieces are often found. On top of this follows a sequence of cross-laminated loose sandstone rich in quartz. Several gravel beds with pebbles of up to one cm and coal pieces are intercalated. The cross-bedding of the fluviatile sand shows a consequent dip towards NNW which agrees well with the direction of the trough (fig. 25). The direction of the stream has been approximately from south to north. In this sandstone sequence,

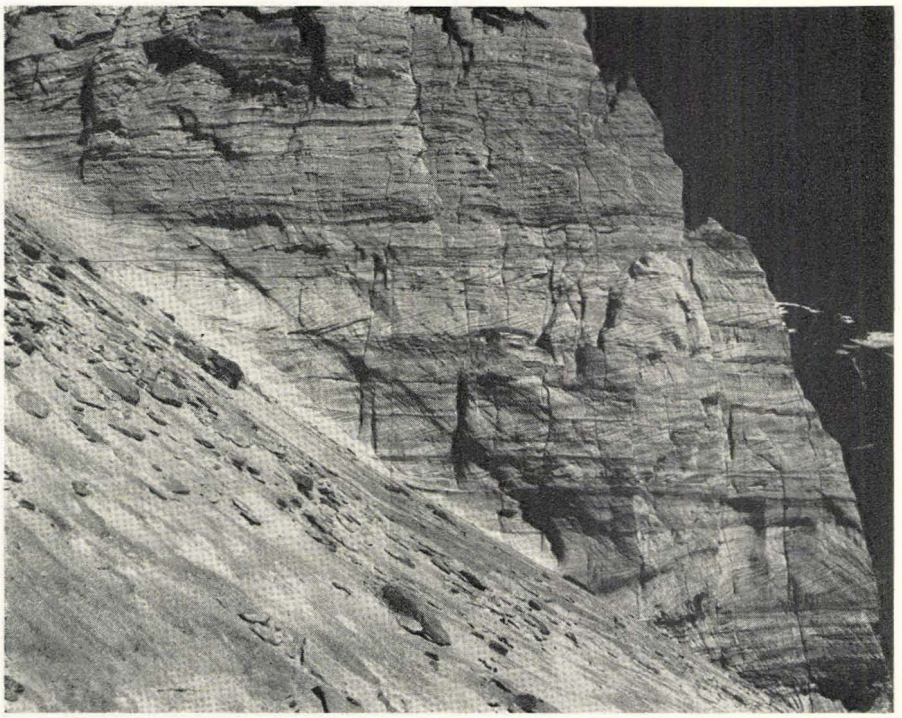


Fig. 25. Detail of western slope of the Igpigârssukkløften: Spur between ravines I and K. Sandstones showing cross-bedding with lamination dip consequently towards NNW (direction of the wall: N. 334°).

between ravines I and K at an altitude of 707 m and 10 to 15 cm thick, a layer of shale is seen in which some plant fossils were found. At an altitude of 730 m another silty shale bed, rather coarse and broken by a narrow jointing was found, and further at an altitude of 750 m another thin silty shale bed. Above this the fluviatile sand continues. But it is on this level of a more rusty colour and contains many lengthy, ochreous concretions. The sandstone may be cemented by these iron compounds. In this uppermost part were collected a few leaf impressions preserved by siderite precipitation. On the spur between the valley and the coastal slope a few marine molluscs have been found (K. Skou leg.) abt. 5 m below the basalt still on top of the outcrop mentioned. According to Professor A. Rosenkrantz it is a question of types from the Lower Paleocene. The greater content of iron compounds in the upper part of the Tertiary sand may naturally be connected with this assumption seeing that marine moluscs require a certain salt content of the water and the colloidal ferric oxides transported in river water, stabilized by organic colloids will be brought to precipitation by electrolytes (MOORE, E. S. & MAYNARD, J. E. 1929).

In the uppermost part of the section, at an altitude of 780 to 785 m, the arenaceous sequence is overlain by a black shale layer with plant fossils exclusively consisting of grass-like leaves. On top a basalt sill (fig. 21).

Innermost in the western branch of the Igpigârssukkløften above ravine M the same sill rests upon the sediments at an altitude of 780 m, and its upper surface is at abt. 800 m. Then a little black shale is visible in the scree, but otherwise there is nothing but till above it.

At the coastal slope (fig. 22), in the western slope of ravine G, was observed a projection with the Tertiary basal conglomerate the lower limit of which being at an altitude of 690 m. The lower limit has a dip towards NE. Above this "nose" west of ravine G there are covers of clay ironstone on the surface and especially of red sandstones with leaf impressions. In ravine G is also found ironstone with plant impressions in considerable portions scattered on the surface. These are further found at the spur between the ravines H and G, where the fossil-bearing rock is more sandy. The covers are situated such that the fossils must originate from the lowermost Tertiary beds exposed in H—G, the upwards succeeding light cross-laminated sandstones being poor in fossils. Regarding the fossil flora see page 93.

In the other ravines along the coastal slope one meets the same sequence of quarts sand with basal conglomerate.

In the Pautûtdalen valley the sequence is of the same character as that in the Igpigârssukkløften outcrop. At both places more durable parts cemented by iron compounds give rise to a characteristic erosional pattern with projecting sandstone peaks and columns protected by such durable layer of ironstone on top. It is the erosional patern of "earth pillars" that are especially characteristic in the Pautûtdalen valley. On account of the erosional pattern the sediments are easily recognized at a long distance.

In the eastern slope of the Igpigârssukkløften gash three minor "pockets" of fluviatile sand are exposed, of which the biggest is situated at the outlet of the valley and stretches into the neighbouring small gully immediately to the east.

All the outcrops at the Igpigârssukkløften and the Pautûtdalen end upwards in a basalt sill which has acted as a protecting cover against niviation. The upper limit of the sediments to this sill is in the Igpigârssukkløften and on the coastal slope found at an altitude of abt. 780 m, and varies in the Pautûtdalen valley between altitudes of 780 and 750 m. Its thickness ranges from 10 to 20 m. It is, for the greater part, overlain by till except in ravine M (the Igpigârssukkløften gash) where a small portion of black shale is seen between altitudes of 800 and 805 m. Moraine deposits together with a few probably old landslides, strongly

worn by erosion, form the bottom of the truncated cirque which is situated above these gashes. At an altitude of abt. 1080 m is in the cirque a hill of basalt with a yellowish surface which at a distance looks like sediments, but it is only solifluction of a yellowish colour the origin of which has not been ascertained. The basalt breccia is exposed in the further end wall of the cirque down to an altitude of abt. 920 m in the eastern part, but no traces have been found of intrabasaltic sediments like those known from Ipeqarfiúnge.

As is the case at Atanikerdluk, but far more distinct, the Tertiary sediments at Pautût was deposited in a valley eroded into the Cretaceous sandstone which belongs here to the Senonian (J. P. J. RAVN, 1910, J. P. J. RAVN 1918, ROSENKRANTZ 1951). Ravn described the fossils from the landslides. The same fossils have later been found in situ (K. Raunsgaard Pedersen leg. 1956) at several places at Pautût. The carving of this river bed has taken place in the period between *Senonian* and *Lower Paleocene*, and seeing that the same deposit has been observed at other places (Atâ) cut down into *Danian*, the event may be determined between the transgressions of *Danian* and *Paleocene*. In the transgressional period at the beginning of *Paleocene*, the sedimentation of the fluviatile beds has begun in the river valley, and the few marine fossils known from the Igpigârssukkløften give evidence that the marine transgression has reached this place before the complete filling in of the valley. The fossil flora (ref. pag. 93) consists of types well-known from Quikavsak member at Atanikerdluk and the Lower Paleocene of the Agatdalen valley (ref. pag. 94). An indication of shale above these sandstone beds, mainly fluviatile, may of the Pautût area imply the same course of events as is the case eastwards at Atanikerdluk and more westerly at Atâ where Naujât member succeeds Quikavsak member. The close connection with the conditions of the previously described localities leaves no doubt that this fluviatile occurrence and Quikavsak member at Atanikerdluk are coordinated. The occurrence is therefore referred to *Quikavsak member* of the *Upper Atanikerdluk formation.*

Immediately west of the Pautûtdalen valley is a number of clear-cut gashes (ref. pl. 6). In the gash marked O on plate 6 Mr. K. Raunsgaard Pedersen observed the Cretaceous deposits normal for this area up to an altitude of 695 m, at which level they are concealed by detritus. In the eastern slope of the gash (0) at an altitude of 725 m, at the south side of a small ravine, a strongly rusty-coloured rock juts out of the scree. It consists of oyster shells cemented by siderite. Also in the north slope of the ravine such occurrences were observed. Further, this rock was found as scattered boulders on the surface of the ravine at a lower level. It must be a question of a continuous layer of some distribution below the detritus. According to Professor A. Rosenkrantz this layer consists

Fig. 26. Eastern slope of Atâta kûa valley: Gash with occurrence of Tertiary Quikavsak member below Ivigssussat qáqât. K: Cretaceous, Q: Quikavsak member with black line showing lower limit, Bb: Basalt breccia. B: Plateau basalts.

of oysters (*Ostrea* sp.) recalling types from the marine *Lower Paleocene* in the Agatdalen valley in contradiction to the older marine deposits of West Greenland, where these types are unknown in spite of the comprehensive collections of fossils known from this area. This compared with the high level of the occurrence close below the basalt breccia and the presence of established Tertiary occurrences at a short distance east of this place make us assume that here is another evidence of a marine *Lower Paleocene* intercalation into the Tertiary sequence at Pautût (ref. pag. 60).

Ivigssússat qáqât.

In the east slope of Atâta kûa below the big mountain Ivigssússat qáqât is an isolated sedimentary occurrence, presumably belonging to the Tertiary which, as is the case at Pautût, is unconformably deposited upon Cretaceous sediments of the well-known type with alternating

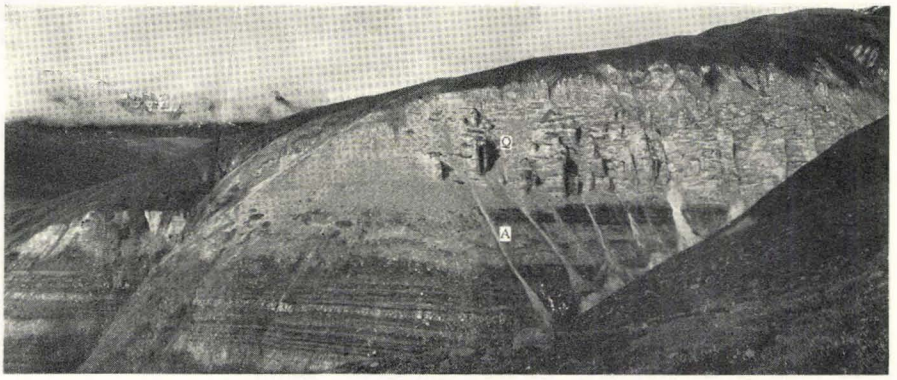


Fig. 27. Occurrence of Tertiary beds in gash in eastern slope of Atâta kûa valley. Section nearly parallel to direction of the Tertiary river-bed and strike of underlying Cretaceous beds. A: Cretaceous beds, Q: Quikavsak member. Background left: Western slope of Atâta kûa valley partly hidden by clouds.

sandstone and shale. It is situated $4^1/_2$ km from the coast in a tributary gash to Atâta kûa (at 17 pl. 7) (fig. 26), the valley with the large delta, Kugssinerssuaq.

At the entrance of Atâta kûa, in the spur which from Ivigssússat qáqât trends westwards towards Kugssinerssuaq, Cretaceous deposits are visible up to alt. abt. 730 m without their upper limit being reached, according to observations in the north slope of the above spur facing the depression drained by torrents 18 and 19. To the north in the next tributary gash (17) the supposed Tertiary beds are exposed in the north slope and continuing into the northern one of the two branches into which the gash is divided within the outcrop (fig. 27). These sediments are discordantly deposited upon the Cretaceous sediments which appear most distinctly in the outer part of the occurrence (the northwestern part of the outcrop). In the gash the bottom of the occurrence is almost horizontal and nearly parallel to the bedding of the Cretaceous sediments. The axial direction of this trough-shaped structure is thus approximately parallel to the wall of the gash. The lower limit is at an altitude of 547 m.

Quikavsak member: The sedimentary sequence is coarse clastic with a coarse basal conglomerate of abt. 2 m with gneiss boulders (fig. 28) the size of a head; the biggest observed has a cross section of abt. 1 m. Further, there are many cobbles and pebbles of quartz, coal, and shale. The latter may be found as large crusts basally in the conglomerate. On top alternating beds of gravel, cross-laminated finer and coarser sands. Frequent recurrences in the sand of single pebbles and many coal pieces. Scattered on the whole outcrop there are durable lenticular layers in

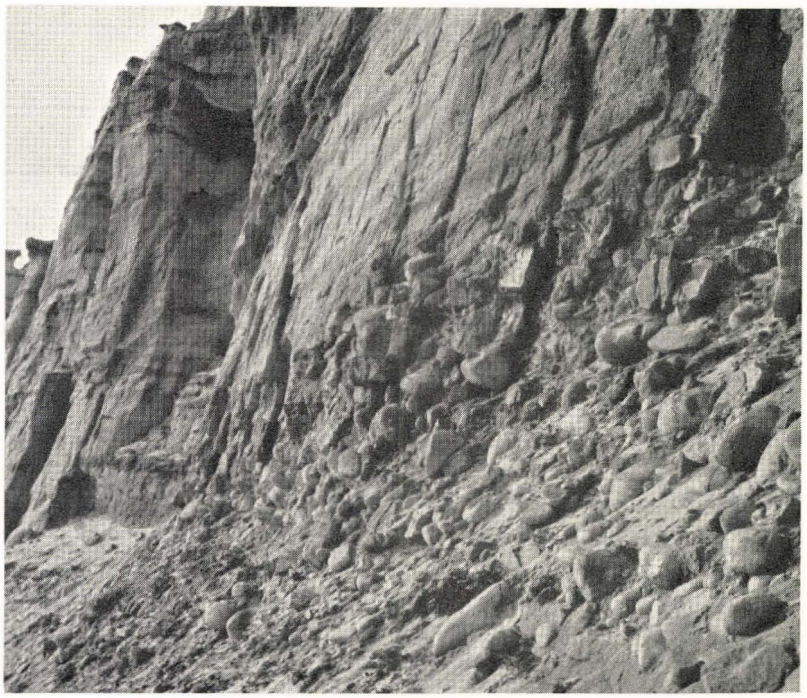


Fig. 28. Occurrence of Tertiary beds in gash of eastern slope of Atâta kûa. Fluviatile gravels: Basal conglomerate of Quikavsak member.

which the sand is cemented by iron compounds. With their ability to resist the erosion they give rise to an irregular erosional pattern with sandstone columns, caves etc. which was also a characteristic feature at Pautût (fig. 27). The uppermost outcrop was observed at an altitude of 727 m where the sediments are covered with solifluction and vegetation, the basalt breccia still not being reached here.

There were no fossils, but the altitude and facies of the sedimentary occurrence and its discordant deposition suggest that this occurrence is to be correlated to the one at Pautût and the similar occurrence west of Kugssinerssuaq described in the following. It forms a natural extension of the fossil river-valley at Pautût, which again, by its direction, points towards this occurrence.

Atâ — Tupaussat.

Atâ.

At Atâ west of Kugssinerssuaq, at the entrance of Atâta kûa the Cretaceous alternating sandstone and shale beds are found basally in the mountains. Upon this a shale sequence is unconformably deposited with an uneven lower limit (Gry in Rosenkrantz et al. 1940). According to

Fig. 29. Outcrops above former village of Atâ. View from shore of the Vaigat strait. D: Danian shale, Ds: Danian?, sandstone and shale, Q: Tertiary Quikavsak member, Bb: Basalt breccia of peak with point 1010.

Professor Rosenkrantz (Rosenkrantz et al. 1940) this shale belongs to *Danian*. On top of it follows unconformably a coarse clastic sequence the downward limit of which appears to be fluctuating (fig. 29). This deposit can be traced along the coast to Tupaussat to the west, and from what is known of the similar occurrences of the Tertiary river-bed previously described, it is obvious that the unconformity surface forms the limit of a trough-shaped structure making an acute angle with the coastal slope at Atâ, and from this place it follows the coast to the west.

The members of Quikavsak and Naujât: On the spur forming the limit between the western slope of Atâta kûa and the coastal slope, is the boundary between Danian shale and the Tertiary at an altitude of abt. 540 m (520 m). From this place and stretching over a distance of abt. $^1/_2$ km to the west is a large outcrop of these sediments (fig. 29—30), coarse clastic Tertiary overlying Danian shale. The latter

Fig. 30. Outcrops facing the coast below the peak of point 1010 by Atâ. D: Danian shale, Q: Tertiary Quikavsak member, s: Sill, N: Tertiary Naujât member, Bb: Basalt breccia.

continues, however, west of the Tertiary outcrop into coarser facies. In this outcrop the Tertiary comprises a basal conglomerate of several metres' thickness. Upwards it changes into gravel and cross-laminated sandstone of which the main part of the outcrop consists. Here and there are zones in the sandstone cemented by iron compounds as was also observed at the locality of Quikavsak member in the eastern slope of Atâta kûa, a phenomenon that gives a very irregular erosion pattern with sandstone columns etc. also known from the occurrences in the eastern slope of Atâta kûa (Ivigssússat qáqât) and Pautût, and it belongs to the *Quikavsak member* of the *Upper Atanikerdluk formation* at Atâ too.

On the spur, the eastern limitation of the outcrop, the coarse clastic sediments are overlain by a sill abt. 5 m thick (alt. 660 to 665 m) (fig. 30). This sill is succeeded by a layer of black, bituminous shale (fig. 30) up to the lower limit of the basalt breccia at alt. abt. 735 m. The shale contains a sill (?) at alt. 715 to 725 m. It may belong to Naujât member of

the above formation. Neither the sandstone nor the shale have yielded fossils of any use. West of the big Tertiary section there is, from alt. abt. 420 m at torrent 16, an exposure of sandstones and shales which by its level must be assumed to belong to Danian of coarser facies, though no fossils have been found (fig. 29). Above this, at torrent 16b, there is a somewhat screecovered spur. At an altitude of 630 m this place exhibits a dense cover of conglomerate boulders and cobbles, up to the size of a head, consisting of quartz and metamorphic rocks and with a great content of quartz pebbles and cobbles. It must be the Tertiary basal conglomerate being in situ at this level (fig. 29). In agreement with this the weathered slopes above mainly show a sandy surface up to altitude 665 m. Here the sill is again found which also westwards overlies the coarse clastic Tertiary sequence, and which obvious appears to be the same sill. Above torrent 15c is a small conglomerate with quartz pebbles at an altitude of 640 m. In torrent 15d the Danian shale is exposed up to alt. 650 m, and abt. 100 m more westerly at about the same level there is on the surface a sand area with quartz pebbles at abt. 655 m in the basalt talus.

From these observations it appears that the Danian/Tertiary limit rises from Atâta kûa where the limit keeps the alt. of 540 m up to 655 m 2 km more westerly. In the large outcrop at the entrance of Atâta kûa the rise seems only faint. Between this section and torrent 16 the rise is considerable over a stretch of $^1/_2$ km, then again faint between the torrents 16 and 15.

West of the outcrops of Atâ is an area where the coastal slope, over a stretch of abt. 750 m, is covered with huge boulders of basalt breccia with luxuriant vegetation in between. The place is called Agssapait. This represents an old landslide (fig. 31) which has left a big scar in the mountain above. On this stretch there are no sedimentary outcrops.

Tupaussat.

West of the landslide area at Agssapait and further on to Tupaussat, high up in the mountains, there is a continuous sedimentary outcrop representing Danian and Tertiary (fig. 31), whereas the older Cretaceous is only represented by inconsiderable sections along the water courses at lower levels. The Danian-Tertiary outcrop is traversed by a number of ravines indicated by the letters e, f, g, h, i on the map (pl. 7). The lower limit of the Tertiary is measured as follows:

1)	Ravine i: at a tributary to torrent 9, the eastern slope .	alt. 550 m
2)	Ravine h: i.e. the western tributary ravine of g (torrent 10), the western slope	„ 585 m
3)	Ravine g: the east slope, torrent 10	„ 545 m

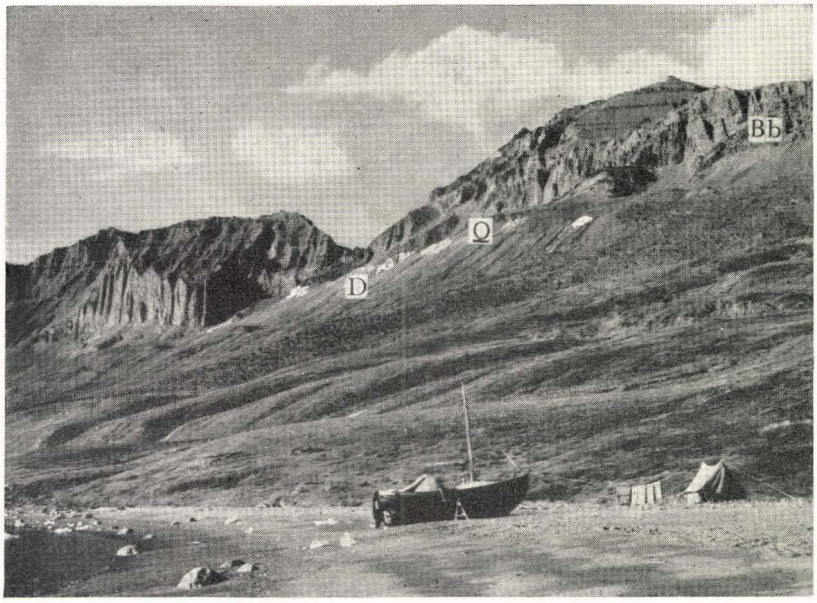


Fig. 31. View from Atâ to westerly exposures between Atâ and Tupaussat. Diagonally from upper right to lower left: The landslide at Agssapait. Behind this the sedimentary outcrops: D: Danian shale (light grey), Q: Tertiary Quikavsak member (white), Bb: Basalt breccia.

4) Halfway between the ravines g (torrent 10) and f (torrent 11) ..... alt. abt. 600 m
5) Ravine f: the west slope (torrent 11) ..... alt. 640 m
6) Between the ravines f (torrent 11) and e (torrent 11) ... „ 605 m
7) The ravine with torrent 13..... „ 595 m
8) Immediately east of torrent 13 ..... alt. 580–590 m
9) Between torrents 14 and 13..... alt. abt. 640 m?

West of the landslides at Agssapait between torrents 14 and 13, the lower limit of the Tertiary is not situated essentially lower than the occurrence at torrent 15 immediately east of the landslide area.

West of Agssapait there is, according to the above diagram, a depression of the unconformity at torrent 13, a culmination at torrent 11, ravine f, from where it again slopes westwards to Tupaussat. As the coastal slope with its ravines, gashes, and spurs, (inequalities of several orders) represents a very irregular section through the sediments, only records over a long stretch will show the tendency of the unconformity to rise or fall which may be of importance when forming an estimate of the structures (e. g. the course of the Tertiary river-bed).

The Tertiary sedimentary occurrence, downward limited by the "unconformity surface", reasonably had an irregular winding course as

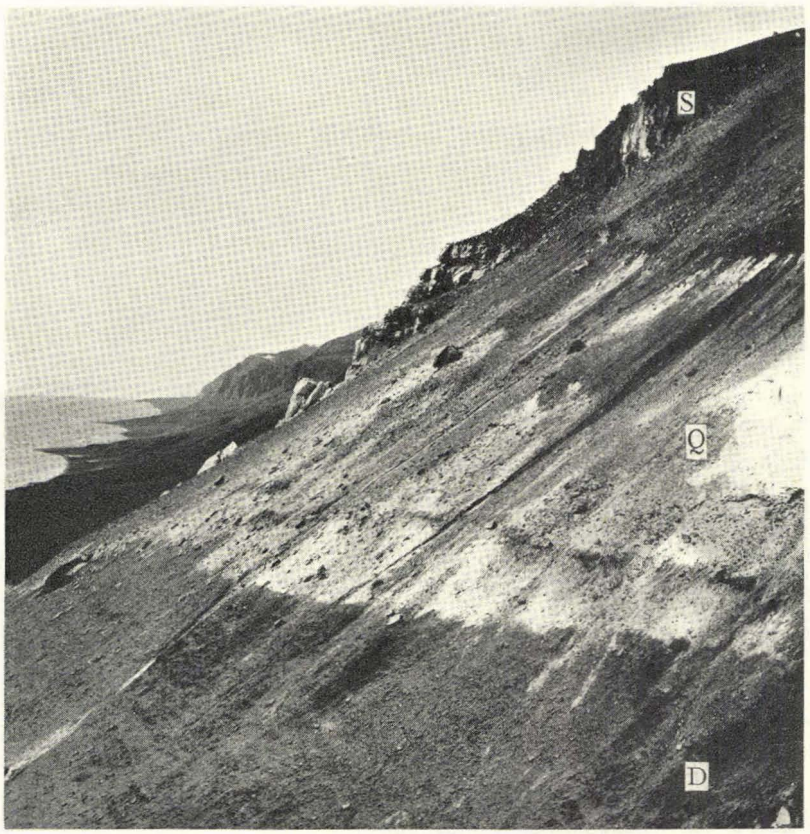


Fig. 32. Exposure between Atâ and Tupaussat just west of ravine f facing the coast. D: Danian shale, Q: Tertiary Quikavsak member, S: Sill. Background left: Vaigat strait.

that followed by the recent water course valleys in comparatively less consolidated deposits of a coastal lowland. So, it can only be expected that the limit shows a winding course considering that the exposures are the products of this trough-shaped and winding occurrence and the irregular mountain slope that cuts it. The lower the altitude of the lower limit of the Tertiary beds, the closer the section is to the central part of the fossil valley.

According to this the variation of the heights of the lower limit is not greater than it should be if we take into consideration that the Tertiary river-valley has taken the direction of the coastal slope between Atâ and Tupaussat. The decline of the limit at Tupaussat is due to the fact that the valley of torrent 9 at this place makes a cut into the Tertiary occurrence towards the more central part of it.

Quikavsak member: Everywhere in the outcrops at Tupaussat the basal layers of the Tertiary consist of a coarse conglomerate. Between the ravines i and h the greatest thickness observed reaches abt. 10 m. Cobbles the size of a head, mainly consisting of quartz and chert, are seen here, but also several other metamorphic rocks. At some places there are big lumps of strongly weathered shale of a pale grey colour which may originally have been black. It is probably the Danian shale which has loosened from the cliffs of the river-bed and deposited as part of the rudaceous fraction. This conglomerate is upwards changing into gravel and quartz sand which is cross-laminated. Precipitations of iron-compounds have formed durable parts, and at the limit to the overlying shale it has formed clay ironstone which may contain plant fossils, for example in the western slope of ravine h. West of ravine h the same coarse clastic sequence is exposed at an altitude of 585 to 600 m (fig. 33). At 600 to 605 m was found brown and black, micaceous shale with conchoidal fracture. In the basal shale plant fossils are common. (Ref. the flora list pag. 94).

Above follows ochreous sandstone at an altitude of 605 to 610 m, and this is again overlain by greyish black, micaceous shale at alt. 610 to 615 m. On top follows light, cross-laminated sandstones to alt. 650 m where the sedimentary sequence is covered with abt. 10 m basaltic sill overlain by till and talus.

The above-mentioned shale layers are only observed in the western half of the occurrence, between ravines i and g, and a little east of ravine g. This may be the consequence of the altitude of the limit Danian/Tertiary having its lowest heights at the western end of the outcrop and rises towards east until the exposed section becomes so lateral in the trough-shaped Tertiary occurrence that only the levels of the fluviatile sediment overlying the shale, are exposed.

Immediately east of the ravine with torrent 13 loose pieces of clay-ironstone and ochreous sandstone containing plant fossils were found at an altitude of abt. 620 m (Ref. the flora list pag. 94).

The upper limit of the Tertiary sediments with the overlying basalt sill is as follows:

1)	Ravine i, the east slope	alt. 675 m
2)	Ravine h, the west slope	„ 650 m
3)	Half-way between the ravines g and f	„ 645 m
4)	The ravine with torrent 13	„ 620 m
5)	Between torrents 13 and 14	„ 650 m

The composition, the facies, the position in the sedimentary succession, and the fossils justify that the Tertiary sediments are determined to belong to the *Quikavsak member* of the *Upper Atanikerdluk formation.*

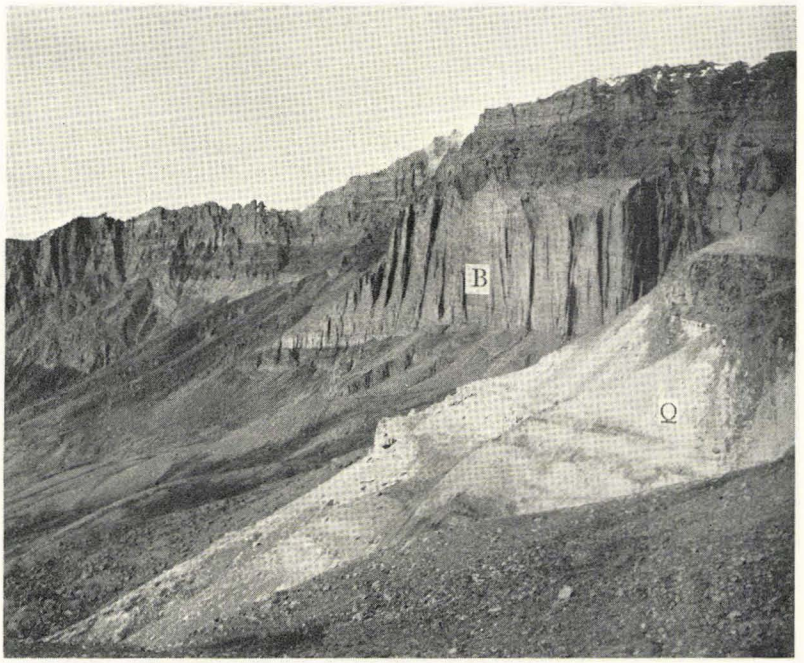


Fig. 33. Exposures in ravine h of Tertiary Quikavsak member (ref. pag. 71) with fossil-bearing shale beds. Background: The valley at Tupaussat bounded to the west by vertical wall of basalt breccia (B).

Tupaussat — Nûk qiterdleq.

Between Tupaussat and Nûk qiterdleq, in the coastal slope below the mountain with point 1580, is a large outcrop of light-coloured rocks traversed by 6 ravines which, as seen on the map pl. 7, are drained by torrents 1—5.

Nethermost, in ravines m and k, which converge downwards, and in ravine 4 the Cretaceous sequence of sandstones and shales is visible. It is unconformably overlain by what is evidently a continuation of the Tertiary fluviatile sediments described in the preceding chapters.

The lower limit of the Tertiary sequence is, in the spur between ravines m and k, situated at an altitude of 352 m, and at the bottom of ravine k at alt. 328 to 330 m. So the lower limit at this place inclines towards north. The same applies to ravine 4 where the limit in the utmost part of the eastern slope of the ravine is found at an altitude of 342 m and at the bottom at 322 m. The northern inclination of the basal limit must thus be general for the occurrence.

The section of ravine 4 is as follows:

Fig. 34. Occurrence of Tertiary Quikavsak member between Tupaussat and Nûk qiterdleq. C: Cretaceous. Q: Quikavsak member. View from Vaigat strait. (H. Wienberg Rasmussen phot.).

Alt.: 502 m		Strongly columnar basalt.	
	92 m	Sequence of sandstone deviating from the sanded sequences in the lower parts of the section on account of lack of conglomerates analogous with the western sections (Atâ, Tupaussat, Pautût). Mainly quartz sand often showing crossbedding and laminal carbonaceous detritus and containing coal pieces (incoaled wood pieces). The colour of the sand is yellowish (light yellow—ochreous)	(6)
„ 410 m			
	10 m	Shale with thin sandstone bands and numerous clay-ironstone layers with plant fossils. Incoaled trunks are found in a vertical position	(5)
„ 400 m			
„ 360 m	40 m	Alternating sand and conglomerate	(4)
„ 350 m	10 m	Conglomerate of varying thickness (abt. 10 m) with cobbles the size of a fist	(3)
	10 m	Coarse, micaceous shale which may include subordinate lenses of sandstone. The entire occurrence is lenticular and wedges out towards south in both sides of ravine 5 (most distinctly in the east side where the shale has disappeared at the outlet of the ravine)	(2)
Alt.: 340 m			
		Sandstone uppermost. At the basis abt. 10 m conglomerate with cobbles the size of up to a	

fist, but with pebbles in the majority. The
18 m cobbles and pebbles are embedded by rust-
Alt.: 322 m ..... coloured sand ..... (1)

Underneath follows the Cretaceous sequence.

In ravine k the shale (5) was observed to be of a somewhat greater thickness: Alt. 404 to 428 m. Apart from ravine 4 plant fossils were also found on the spur west of this ravine, probably from the same bed. (As to the fossils ref. pag. 94). The plant fossils refer the occurrence to *Paleocene*?; the facies and the position of the sequence in the entire succession justify a reference to the *Quikavsak member* of the *Upper Atanikerdluk formation.* It should be mentioned that, above the overlying basalt after a talus-covered lacuna there is basalt breccia from alt. 595 to alt. 1150 m (information by V. Münther).

The upper limit of the sediments is also between the ravines k and 3 measured to alt. 502 m.

Nûk kitdleq.

Immediately east of Nûk kitdleq is a big gash in the mountain with point 1490. In this gash is seen a sequence consisting of alternating sandstones and shales which can be followed up to alt. abt. 400 m. It is probably Cretaceous deposits, the same as will be remembered were found at the basis of the outcrop at Nûk qiterdleq, and which are also exposed to the west at Alianaitsúnguaq. At alt. abt. 415 m the gash slope shows no fresh outcrops, but, according to Professor A. Rosenkrantz, scattered boulders consisting of a sandstone with numerous small *Ostrea* sp. were found in the scree. Professor A. Rosenkrantz who has great experience on the paleontology of the marine deposits of West Greenland has informed the author that those Ostreas much remind of the ostreïdes in the marine *Lower Paleocene* of the area round the Agatdalen valley some 25 km farther to the northeast of the Lower Paleocene coast. This occurrence, which is covered with talus must be situated immediately underneath the basalt breccia which is exposed above from alt. abt. 415 m. At this level it can hardly be anything but the marine *Lower Paleocene*, consequently an occurrence identical with the one mentioned in connection with one of the gashes west of Pautût (ref. pl. 6, torrent O).

The Central Part of the Nûgssuaq Peninsula.

The Area round the Agatdalen Valley.

In the northern part of the Agatdalen valley, situated in the central part of the Nûgssuaq peninsula (fig. 1, 35), a *Paleocene* area occurs (*The Agatdal formation*, ROSENKRANTZ), comprising a fossil marine fauna and a fossil flora. Professor A. Rosenkrantz referred the fossil fauna to the *Lower Paleocene* (*Montian*) (ROSENKRANTZ 1951), and the flora was examined by the author, but the descriptions has not yet been published (ref. pag. 94–96).

Professor A. ROSENKRANTZ has kindly given the following statements of the geological conditions of the Agatdalen area, which he discovered in 1939, and of which he has since made thorough investigations:

"The type locality of *the Agatdal formation* is a big section situated in the northern slope of the Turritellakløften gorge. The formation is here divided in 3 members: The Turritellakløft member, the Andreas member, and the Abraham member referred in ascending order.

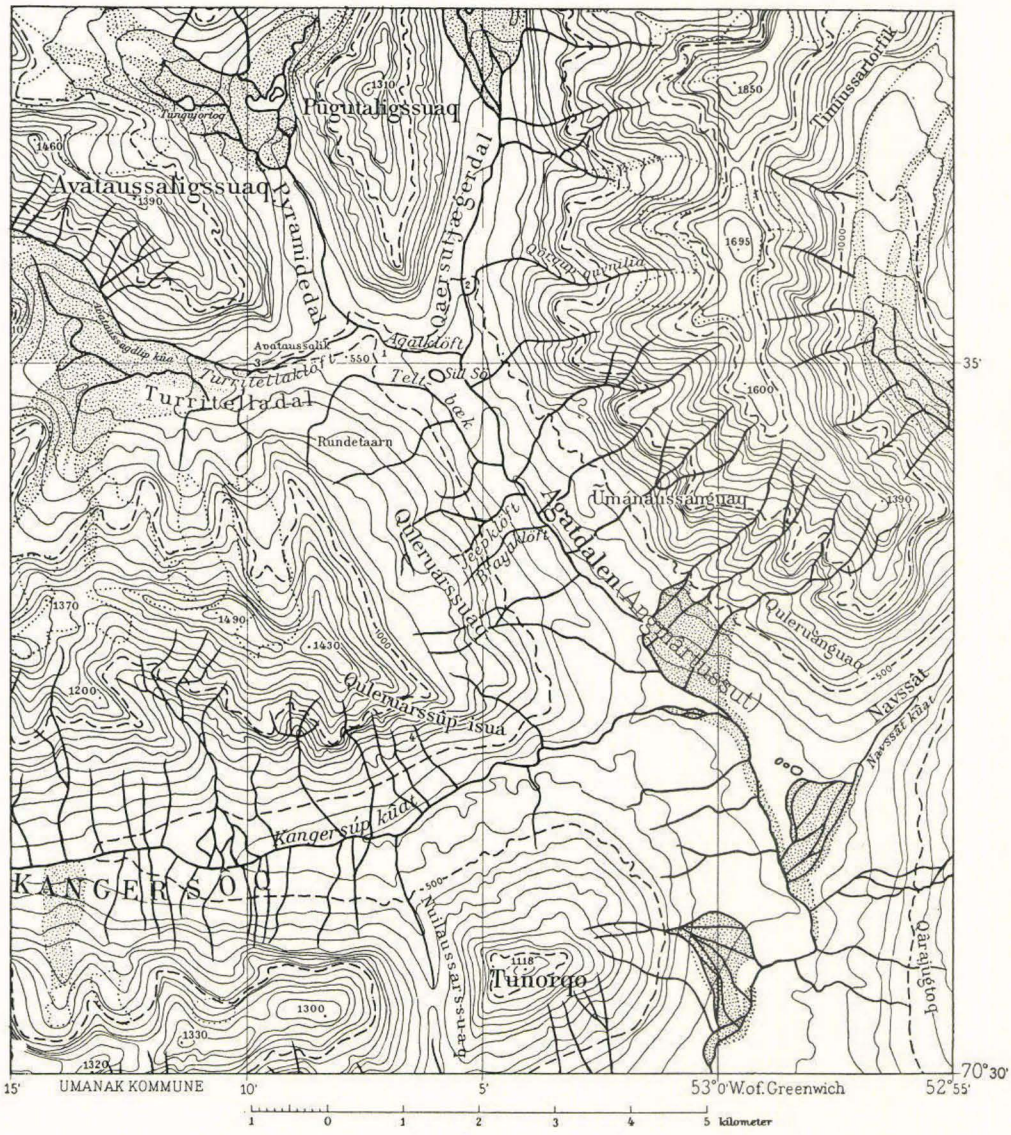
THE TURRITELLAKLØFT MEMBER consists of a sequence of black shales up to 50 m thick including numerous sandstone lenses carrying plenty of marine fossils.

This sequence is overlain by THE ANDREAS MEMBER consisting of a delta-like deposit of coarse sandstone with very few fossils. Its thickness increases eastward from 10 m to 25 m until the section is completely covered with scree.

On top of this delta deposit follows THE ABRAHAM MEMBER, an up to 12 m thick series of alternating black shales and rather coarse, fossiliferous tuffs. The tuff layers are dominating in the upper part of the sequence. At an altitude of abt. 550 m the Abraham member is here succeeded by the basalt breccia, a series of pillow lavas belonging to the basalts, this again is succeeded by the Plateau basalts, the sequence of subaeric basalt flows.

In the south scarp of the Turritellakløft gorge, on a small spur (the Scaphitesnæsen), is found a minor exposure of *Paleocene* beds with marine zoo-fossils and an abundance of fossil fruits. Here the shales are overlain by beds of fossiliferous sandstone.

In the Agatkløften gorge the *Paleocene* sequence begins with a coarse basal conglomerate of several metres thickness rich in gneisses, which covers the *Danian* beds unconformably. Over the conglomerate alternating sandstones and shales occur, succeeded by another gneiss conglomerate abt. 8 m above the basal one; then follows a sequence of arcosic gravel beds and lenticular sandstones or more percurrent sand-



Danish Geodetic Institute, copyright.

Fig. 35. Map of the Agatdalen-area 1:100000. Localities with fossil plants marked with numbers:

1: The Agatkløften. 2: The Qarsutjægerdalen.
3: The Scaphitesnæsen. 4: Kangersôq.

stone layers, besides bands and regular beds of shale. At a level abt. 30 m above the basal conglomerate the arcose lenses contain plant fossils, while marine zoo-fossils are also found at several levels through the whole section, preferably in sandstones and conglomerates. Carbonaceous

Fig. 36. The Agatkløften gorge, just south of the outlet of the Turritellakløften with Lower Paleocene delta deposits (Sonja member) overlayn by shale. S: Sonja member, A: Shale.

detritus play an important role all through the section. This sequence is exposed in a big section of the west cliff of the Agatkløften gorge between the outlets of the Qarsutjægerdalen and the Turritellakløft gorge (fig. 36). This sequence is named THE SONJA MEMBER of the Agatdal formation.

These coarse clastic members of the *Paleocene* deposits in the Agatdalen valley (Sonja and Andreas members) show a somewhat varying thickness on account of the deltaic origin. The alternating facies, horizontal as well as vertical, the lenticular structures, the fossils and the geological environment prove that they are delta deposits. The maximum thickness may be estimated at abt. 75 m. In the west cliff of the Agatkløften gorge this sequence is succeeded by black, bituminous shale.

Also in the east cliff of the Agatkløften gorge, *Lower Paleocene* beds containing plant fossils are known in the gorge and opposite the big section described above.

The basal conglomerate also appears more northerly in the east cliff of the Agatkløften gorge, but the remaining part of the coarse clastic delta sequence is not exposed here. In the upper part of this section the Abraham member with shales and tuff layers is typically developed and upwards succeeded by the basalt breccia.

In the Qarsutjægerdalen valley the *Lower Paleocene* basal conglomerate is found unconformably above a sequence of black shale (*Danian* ?). On top occurs a sandstone sequence of about 7 m, in the

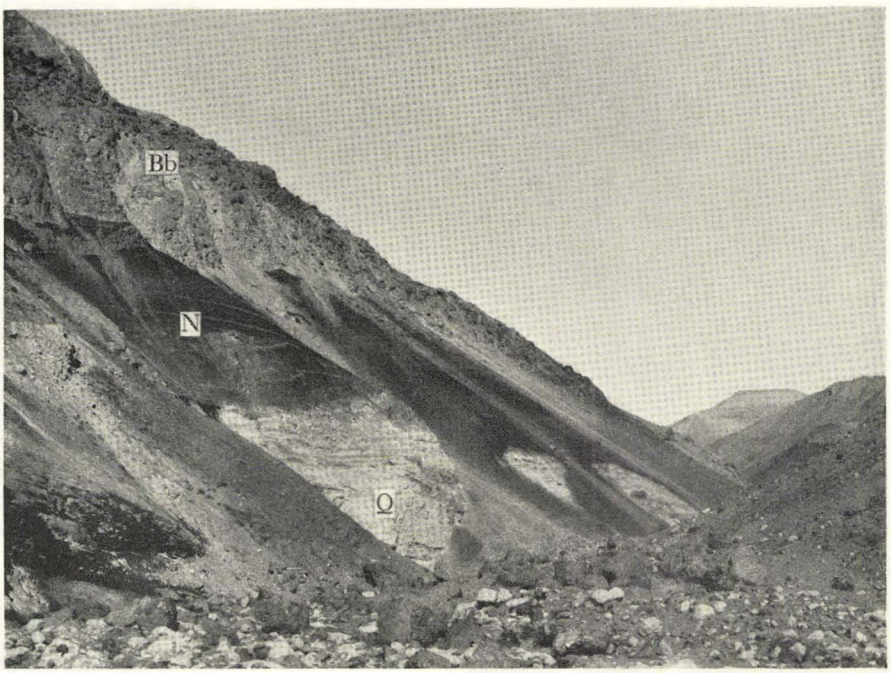


Fig. 37. The Navssât valley: Sedimentary exposures in western slope showing coarse, clastic beds (Q) and black, bituminous shale (N). Sediments are covered with basalt breccia (Bb).

upper part with plenty of marine zoo-fossils as well as fossil fruits and leaf fragments. The coarse clastic layers are succeeded by abt. 10 m of shales alternating with tuff beds overlain by basalt breccia.

In the tributary valley Navssât coarse clastic sediments are likewise seen overlain by black, bituminous shale (fig. 37) of a rather considerable thickness, though it has not been possible to give an exact measuring (abt. 100 m).

On the north slope and in the outer part of the tributary valley Kangersôq, there is an occurrence consisting of alternating sandstone and shales with *Paleocene* plant fossils. Owing to scree on the slope it was not possible to find any marked limit to the underlying deposits. Above the plant fossil-bearing beds neither shale nor tuff was observed but the basalt breccia overlies the coarse clastic sediments directly. A short distance farther into the valley marine *Lower Paleocene* beds occur at nearly the same level underlain by marine *Danian* deposits".

The ash-bearing shale, here designated Abraham member of the Agatdal formation, and overlying the coarse clastic *Lower Paleocene* (Turritellakløft member — Andreas member, and Sonja member) is of a far smaller thickness than Naujât member of the Upper Atanikerdluk

formation in the southeastern part of the south coast of the Nûgssuaq peninsula, to which Abraham member corresponds according to its position in the succession immediately below the basal basalt breccia. The profile at Atâ at the western part of the south coast of the Nûgssuaq peninsula is on the contrary very close to the ideal profile of the Agatdalen.

The sedimentary succession is in the main identical with the more westerly part of the south coast where the coarse clastic sediments (Quikavsak member of the Upper Atanikerdluk formation) is succeeded by black, bituminous shale (Naujât member of the Upper Atanikerdluk formation) which is again overlain by the basalt breccia. The similarity is locally accentuated by marine intercalations in the basal coarse clastic member.

INTRABASALTIC SEDIMENTS

Apart from the Tertiary sediments of the Sedimentary Area of Northwest Greenland described in the preceding chapters, which for the greater part can be designated *pre-basaltic*, there are, especially in the younger parts of the Plateau basalts, intercalated sediments of a smaller thickness which are designated *intrabasaltic*. Such are found at the Hareøen (Qeqertarssuatsiaq), the Kulelv valley (Qissugssarigsup qôrua), Qernertuarssuit and many other places within the map Nûgssuaq 1:250000. These will not be described in this paper, but are only mentioned for the sake of the stratigraphic-paleontological scheme on page 95–96.

A SUMMARY OF THE GEOLOGICAL CONDITIONS

On an overall view of the profiles described here (pl. 4) it may be ascertained that the Tertiary sequence everywhere rests unconformably on the older substratum. The unconformity rises regionally from the Sarqaqdalen valley to Pautût and inclines from that place westwards, but contains minor local depressions. The sequence may litho-stratigraphically be divided into 5 members, which are subordinated the *Upper Atanikerdluk formation* owing to the continuity with the type locality (Atanikerdluk). The individual members are from the top and downwards:

Point 976 member ..... (7)
Aussivik member..... (5)—(6)
Umiussat member..... (4)
Naujât member..... (3)
Quikavsak member..... (2)
(the numbers refer to pl. 4).

The limits of each single member show the same tendency as mentioned in connection with the unconformity: that it regionally rises from the Sarqaqdalen valley and westwards towards the Pautût area, and from here it seems to incline in a westerly direction. This may be looked upon as a tectonically determined culmination around Pautût which also makes itself felt through the considerable decline of the Aussivik mem-

ber from Ipeqarfiúnge towards Gieseckes Monument (to the east) and through the dip of the Cretaceous beds towards SW in the coastal zone at Pautût, i. e. opposite to the regional dip of the Cretaceous deposits.

About the single members the following remarks should be made:

1) Members with a continuous area of distribution.

Naujât member: This continues from Naujât to Kingigtoq only broken by landslide areas in which the shale forms a part. At Ipeqarfiúnge the occurrence is so big, though possibly dislocated, that the member must be assumed to be present in its full thickness though no observations of the limits have been possible. It is supported by sandstone which occurs in a landslide above the shale, but below the basalt breccia. This sandstone must be the overlying *Umiussat member*. The occurrence of shale above Quikav sakmember at the Igpigârssukkløften gash at Pautût may, according to the observations, be doubted, but the shale occurs again at Atà though with a considerably reduced thickness. This supports the assumption that *Naujât member* is present also, though not exposed at Pautût.

The basal beds of the member contain tuff of mainly clay grade over the stretch Naûjat-Kingigtoq. At Naujât, Atanikerdluk, and the gashes at Qagdlúnguaq they appear as thin bands, at Kingigtoq as a basal bed of a thickness of abt. 10 m.

Also the coarse clastic *Paleocene* in the Agatdalen valley is overlain by black, bituminous shale with tuff layers of coarse sand grade (*Abraham member*) which must be coordinated with *Naujât member*.

Umiussat member: As Naujât member this continues from Naujât to Kingigtoq-Ugpatdluk (Gieseckes Monument) and as mentioned it may be assumed to occur in a landslide below the basalt breccia, but above Naujât member at Ipeqarfiúnge. It is not known more westerly, nor in the Agatdalen area.

Aussivik member: This shale sequence with its characteristic 2—3 bedded basalt level, 50—80 m thick, stretches from Naujât to Keglen by Qagdlorssûp kûa and reaches as scattered clots in the solifluction above the basalt level as far as the east edge of Umiussat. The shale is found below the basalt level at Umiussat and is again exposed at Ugpatdluk (Gieseckes Monument). The reason why this occurrence is correlated with Aussivik member is that the characteristic basalt level of this member can be followed from the west side of Mt. Umiussat and to the peaks above Kingigtoq. The heights of these peaks agree with the height of the likewise strongly columnar basalt below the sediments at Ugpatdluk, at the same time as the members of Naujât and Umiussat and the part

of the Aussivik shale measuring less than 10 m below the basalt level continues from Kingigtoq by Tarajornitsoq valley to $^1/_2$ km south of the Ugpatdluk sediments. On this stretch of $^1/_2$ km there are again no indications of faulting.

Further, the Ugpatdluk intrabasaltic occurrence is correlated with the intrabasaltic shale at Ipeqarfiúnge in the northwestern slope of the depression. This is situated considerably higher than the Ugpatdluk sediments (abt. 200 m) but slopes so steeply towards east that a coordination must be justified and is also supported by direct observations at some distance. *At Ipeqarfiúnge, Aussivik member is thus above the basalt breccia.*

Point 976 member: This sandstone succeeds Aussivik member everywhere where the member occurs. Wheather the same is the case at Ipeqarfiúnge is not certain as the talus cover prevents a correct observation. Sand in the scree suggests an occurrence.

The above-mentioned members make out the part of the prebasaltic sequence which is continuous along the south coast of the Nûgssuaq peninsula (though parts are substituted by the basalt breccia more westerly (pag. 84)). They overlie the local occurrences of Quikavsak member.

2) Members with no continuous area of distribution.

Quikavsak member: According to its genesis as an infilling of a pre-Tertiary deeply carved river-bed, this member cannot be followed continuously in the section offered by the coastal mountain slopes, but appears as local occurrences at Naujât, Atanikerdluk, Pautût, Ivigssússat qáqât, Atâ, Tupaussat, and Nûk qiterdleq. The fluviatile character of the sediment is common for all of them. It is mainly sand and gravel distinctly cross-bedded. Plant fossils are common, and siderite secretion has been strong. At Atanikerdluk incoaled trunks stand on the root.

The easternmost, well exposed occurrence, Atanikerdluk, consists of alternating sandstone beds of less than 1 m and thin fossil-bearing shale beds transformed into ironstone. At Pautût this alternation has ceased, shale is rarer but appears as single beds of which some are abt. $^1/_2$ m each. At Atâ no shale is observed. But at Tupaussat as well as Nûk qiterdleq there are few but thick shale beds: At Tupaussat two beds of abt. 5 m each, and at Nûk qiterdleq two beds of 10 m each.

At the Igpigârssukkløften gashes at Pautût and at Nûk kitdleq marine fossils have been found (according to Professor A. Rosenkrantz). They indicate that the *Lower Paleocene* transgression, the deposits of which are known from the north coast of the Nûgssuaq peninsula as well as from the Agatdalen valley (Rosenkrantz 1951), has penetrated into the river valley and transformed its more westerly part (as far as

Pautût) into a drowned valley. So far it may therefore be ascertained that the more westerly occurrences belong to the *Lower Paleocene.*

Marine fossils are not known from the two more easterly occurrences which means that at Pautût we have the farthest provable penetration of the sea into the valley. Remembering that electrolytes (i.e. NaCl) is one of the agents immediately causing precipitation of the colloidal iron content of the river waters (MOORE, E. S. & J. E. MAYNARD 1929), the considerable areal precipitation together with the sedimentation of beds Nos. 7, 8, 12, 13 at Atanikerdluk (ref. pag. 22–23) at the very top of the member profile may indicate the same event. The marine invasion has taken place immediately before the final infilling of the river-bed with sediments, seeing that the fossils of Pautût were found in the uppermost 5 m of the member and as at Nûk kitdleq just below the overlying basalt breccia. Whether this represents the maximum of the transgression is uncertain; but it seems natural that Naujât member is a result of the continued transgression. The same applies to the basalt breccia. The occurrences with provable marine infiltration in Quikavsak member are as expected when situated nearest to the Lower Paleocene sea, the ones with the greatest sedimentary thickness (abt. 200 m) and also the greatest thicknesses of the finest fraction (clay-shale) which show increasing thicknesses though in fewer beds to the west of Pautût.

Quikavsak member contains, as it appears from the chapter: "Remarks on the fossil flora" on page 87, in all the occurrences (Atâ-Tupaussat regarded as one) species which are characteristic of and common for this level, the oldest Tertiary member in West Greenland, and the lowermost 10 m of Naujât member.

Quikavsak member is overlain by *Naujât member* which is continuous from the Sarqaqdalen valley and possibly as far as Atâ, though the occurrence at Pautût may be doubted.

Further all occurrences of *Quikavsak member* are overlain by the same sequence or the equivalating basalt breccia. In the area Naujât-Manik they are overlain by a sequence consisting of alternating members of black, bituminous shale and sandstone of fluviatile or lacustrine origin: *Naujât member* (shale) — *Umiussat member* (sandstone) — *Aussivik member* (shale) with the 2-3 bedded basalt level — *Point 976 member* (sandstone) — *the Plateau basalts.*

Between the east and the west slope of the great depression in the terrain between Manik and Ipeqarfiúnge there is a marked change. At Ipeqarfiúnge there is such a comprehensive occurrence of *Naujât member* that it must be assumed to be present in a great thickness underneath the Quaternary. Also a small portion of sandstone in a landslide (pag. 49) suggests that at any rate a minor part of *Umiussat member* reaches as far as Ipeqarfiúnge. This involves that *Naujât member* is present in its whole

thickness at this locality. Above follows basalt breccia which is only known from this place and westwards. *Being overlain by the shale of* AUSSIVIK MEMBER, *the basalt breccia must be equivalent to the basalt level of that member and probably also to a large part of* UMIUSSAT MEMBER *at Ipeqarfiúnge.* The thickness of the basalt breccia is increasing westwards (pl. 4) and substitutes the sedimentary sequence more and more. Thus *Naujât member* at Atâ is reduced to a thickness of 80 m and this even includes 15—20 m sills (compare Kingigtoq: 150 m, Umiussat: 200 m), and already at Nûk qiterdleq the whole of this member is replaced. The lava must have been introduced into the area from a direction with a northwesterly component and has penetrated subaquatically (about the genesis ref. SOLE MUNCK in: ROSENKRANTZ et al. 1951) from Nûk qiterdleq to Ipeqarfiúnge in the course of a spell corresponding to the deposition of Naujât member and part of Umiussat member. *Thus the* BASALT BRECCIA *equivalates more and more of the* UPPER ATANIKERDLUK FORMATION *the more westerly it reaches along the south coast of the Nûgssuaq peninsula.* The basalt breccia may at a given place on the stretch Ipeqarfiúnge-Nûk qiterdleq be considered to equivalate what might be lacking upwards of the *members of Naujât and Umiussat*, the basalt of *Aussivik member* and its underlying shale, as compared with the area round Atanikerdluk.

That eruptions have been alive already from the beginning of the deposition of Naujât member, also appears from the fact that tuff is found in the basal part of the member at Naujât, Atanikerdluk, the gashes at Qagdlúnguaq and Kingigtoq. At the last-mentioned of the said localities the basal part of the member consists of abt. 10 m of tuff while the other localities only have bands. This suggests an increasing tuff thickness in a northwesterly direction along the coast at this stratigraphical level outside the basalt breccia area.

While the ash from the Abraham member of the Agatdal formation consists of coarse sand grade, it is fine-grained, mainly clay grade, at the same stratigraphical level (the basal beds of the Naujât member) at the eastern part of the south coast of the Nûgssuaq peninsula.

The ash may thus offer a further support to the assumption that the eruptions have started in an area north to west in relation to the southeastern part of the Nûgssuaq peninsula, though a closer investigation of the whole sedimentary area is necessary for a final and closer statement on this basis.

CONCLUSION I

The occurrences of *Quikavsak member* equivalate each other in a succession of events which begins with the regression succeeding the deposition of the marine *Danian*. In this way the water courses were activated, and river-beds were eroded to depths of up to some hundred metres. A change into positive epeirogeny stopped erosion to make way for sedimentation. The rivers filled the valleys with coarse clastic sediments: the *Quikavsak member*. At the same time the sea transgressed the coast. Marine fossils in the western occurrences of Quikavsak member and its equivalents of the Agatdalen valley show that it is the *Paleocene* transgression that set in. It is this transgression which can most obviously be registered in the delta deposits in the areas of the Agatdalen valley and determined as *Lower Paleocene* (ROSENKRANTZ 1951). In this area the same succession is observed as on the south coast of the Nûgssuaq peninsula, the profile being much like that at Atâ: The coarse clastic delta deposits succeeded by bituminous shale, the fossils of which showing the *Paleocene* age (in the Agatdalen valley), and overlain by basalt breccia. This also determines at any rate the basal part of *Naujât member* to belong to the *Lower Paleocene*.

The transgression continued eastwards. While sedimentation was prevented by subaquatic basalt eruptions in the western part, bituminous mud and some ash layers disclosing the eruptions (*Naujât member*) were deposited in the eastern coastal waters or lagoons which were muddled and perhaps poisoned so that no marine fauna could develop. During stagnation of the transgression the coastal waters were filled in, and sedimentation became coarse, possibly a delta deposition passing into the sheer fluviatile one (*Umiussat member*). Volcanism changed from subaquatic to subaeric, and the lava flows reached as far as the Sarqaqdalen valley caused by a few initiate but violent eruptions. The positive epeirogeny could still be traced in the present area of the eastern part of the Nûgssuaq peninsula by deposition of mud (the shale of *Aussivik member*), which however, at any rate for some of it, is clearly fresh water or brackish water deposits (findings of *Unio* at Ipeqarfiúnge!). Also at this level tuff layers give evidence of the continued volcanic activity.

After the coarse clastic sediments of *Point 976 member*, basaltic lava flows completely covered the Nûgssuaq peninsula with the exception of minor in time as well as in space scattered sedimentation basins represented by the intrabasaltic sediments (ref. pag. 80).

No doubt all occurrences of *Quikavsak member* along the south coast of the Nûgssuaq peninsula are fractions of the same deposition, and as regards age they are equivalent to the *Lower Paleocene* occurrence at the area of the Agatdalen valley. This appears clearly from the fact that each occurrence, as shown, is overlain by the sequence or equivalent sequences as far as the Plateau basalts. As the *Paleocene* transgression, clearly established for the Agatdalen valley, is a consequence of a positive epeirogeny, and a positive epeirogeny must also be the cause of the sedimentation of *Quikavsak member*, it may be considered established that *Quikavsak member* at the southeastern part of the Nûgssuaq peninsula is contemporary with the *Lower Paleocene* of the Agatdalen valley with the rich fossil fauna and flora which gave rise to the assumption of this connection. Taking this for granted, one can proceed with the comparison of the profiles of the Agatdalen valley and the south coast of the Nûgssuaq peninsula, and show that the lower part of *Naujât member* belongs to *Lower Paleocene* as stated above, which is just the case with the equivalent *Abraham member* of the Agatdalen. This means too that Heer's "*Upper Atanikerdluk B*" *flora* is age-determined as it happens to be found in the basal tuff-bearing part of *Naujât member*. The differences stated between this flora and Heer's "Upper Atanikerdluk A" flora from Quikavsak member must therefore be due to separation during transport and sedimentation.

Paleontologically the author could not get any further than to show that the Lower Paleocene flora from the Agatdalen and the "Upper Atanikerdluk A" flora are of the same age within the time interval in which the very floral type (*Macclintockia — Metasequoia—Cercidiphyllum* "association") which characterizes these occurrences lingered in the extreme North. How long this was the case could not be ascertained as age-determined fossil floras from these latitudes did not suffice. The geological proof which completes the investigation is not only a support to the paleontological one, but in this case it is the superior, and so the two floral occurrences may be declared to be of the same age on the basis of the geological investigation.

REMARKS ON THE FOSSIL FLORA

While this investigation was carried out, it became possible to correct a few misunderstandings regarding the fossil flora within the field described; new findings were made and through the knowledge of the geological conditions possibilities offered of combining the findings from several localities at the same stratigraphical level to one fossil flora etc. These objects are treated in this chapter, each locality is being treated and the results valid for each member pointed out. The localities treated are: Naujât, Atanikerdluk, Kingigtoq, Ipeqarfiúnge, Pautût, Tupaussat, Nûk qiterdleq, and the Agatdalen area.

Naujât.

(the Outlet of the Sarqaqdalen Valley).

Plant fossils from Naujât were collected by K. J. V. Steenstrup and described by O. Heer (HEER 1883a) and later only mentioned in (B. E. KOCH 1955). It appeared already from (HEER 1883a) (Zweiter Theil, IV, p. 196) that these fossils are found at several levels and Steenstrup (STEENSTRUP 1883a p. 245) states that they are found in various sedimentary facies. But it does not appear distinctly from the papers mentioned which species were found in the various levels, as Heer treats all the findings as one fossil flora and rightly as it appears from the conclusion. With knowledge of the sedimentary facies at Naujât the material described can be sorted out as follows. The portion of Steenstrup's fossils from Naujât which are found in red clay ironstone no doubt originate in the sand in the southern part of the big outcrop in the western slope of the Sarqaqdalen valley where such fossils were abundantly present (pag. 11), even if there is a difference of abt. 30 m between the level stated by Steenstrup (STEENSTRUP 1883a, p. 245) and that stated by the author (Steenstrup: up to alt. 340 m, in this paper: up to 370 m).

Quikavsak member: This investigation did not add new species to the list of O. Heer. The fossils are stated to be found in "siderite" or

"Eisenstein", which is a flaming-red clay ironstone identical with the one known from the same sedimentary member at Atanikerdluk, and a sandy red-violet ironstone found in the boundary to the overlying shale, respectively. From this is known the following fossils with statement of later revisions according to the determination by Heer:

Older terms:	Revisions:
Sphaeria interpungens Heer	
Libocedrus Sabiniana Heer	cfr. *Cupressinocladus* Sew. & Conw.
Thuya (Thuyopsis) gracilis Heer	*Thuya* (*Thuyopsis*) *naujâtica* (Heer) LaMotte
(*Thuya (Biota) borealis* Heer)	
Glyptostrobus Ungeri Heer	*Glyptostrobus europaeus* (*Brongn.*) Heer
Sequoia Langsdorfii Brongn.	*Metasequoia occidentalis* (Newb.) Chaney
Taxodium distichum miocenum Heer	*Metasequoia occidentalis* (Newb.) Chaney
Carex noursoakensis Heer	
Populus arctica Heer	*Cercidiphyllum arcticum* (Heer) Brown
Populus Richardsoni Heer	*Cercidiphyllum arcticum* (Heer) Brown
Salix Raeana Heer	
Carpinus grandis Ung.	
Corylus M'Quarrii Forb.	
Quercus Lyelli Heer	*Dicotylophyllum Lyelli* (Heer)
(*Quercus juglandina* Heer)	
Juglans acuminata A. Braun	
Juglans Strozziana Gaudin	The fossil undeterminable.
(*Juglans denticulata* Heer	*Juglans crossii* Knowlt.)
Myrica Langeana Heer	
Magnolia Inglefieldi Heer	
Laurus Reussii Ett	*Echinotium lanceolatum* Ett.
Diospyros brachysepala A. Braun	
Hedera M'Clurii Heer	*Cercidiphyllum arcticum* (Heer) Brown.

Naujât member: This member contains several levels with plant fossils. The brown tuff bands ("*brauner Thon*" according to Heer) in the basal part of the member contains the following fossils according to (O. Heer 1883a, b); the level is estimated at 353 m:

Older terms:	Revisions:
Glyptostrobus Ungeri Heer	*Glyptostrobus europaeus* Heer
Libocedrus Sabiniana Heer	cfr. *Cupressinocladus* Sew. & Conw.
Thuya (Biota) borealis Heer	
Thuya (Biota) Ehrenswärdi Heer	
Taxodium distichum miocenum Heer	*Metasequoia occidentalis* (Newb.) Chaney
Sequoia sp.	
(Quercus juglandina Heer)	
Quercus platania Heer	
Carpinus grandis Ung.	
Juglans denticulata Heer	*Juglans crossii* Knowlt.
Juglans (Carya) Heerii Ett.	*Carya Heerii* (Ett.) Heer
Magnolia primigenia Ung.	
Myrica sp.	
Diospyros (probably *D. brachysepala* A. Br.).	

The following species have been found in the black shale at an altitude of 432 m (HEER 1883a, b):

Older terms:	Revisions:
Thuya (Biota) Ehrenswärdi Heer	
Sequoia (?) *obtusifolia* Heer	
Populus Richardsoni Heer	*Cercidiphyllum arcticum* (Heer) Brown
Populus arctica Heer	*Cercidiphyllum arcticum* (Heer) Brown
Ulmus borealis Heer	*Dicotylophyllum boreale* Sew. & Conw.
Pterocarya denticulata (Web.) Heer	
Laurus primigenia Ung.	
Magnolia Inglefieldi Heer	
Myrsine groenlandica Heer	
Andromeda arctica Heer (the species is not known from the descriptions, only from pl. LXXXV. 4 in HEER 1883a.)	

From the black shale at an altitude of 490 m the following fossils are recognized according to (B. E. KOCH 1955) (followed by Heer's determinations):

Revisions:	Older terms:
Sequoia-like coniferous sprays	
Cladophlebis groenlandica (Heer) Bell	*Pteris groenlandica* Heer
Dicotylophyllum Lyelli (Heer)	*Quercus Lyelli* Heer
Juglans crossii Knowlton	*Juglans denticulata* Heer
Cercidiphyllum arcticum (Heer) Brown	*Populus arctica* m. m.
Laurus primigenia Ung.	

This flora is designated "Upper Atanikerdluk C".

Atanikerdluk.

Atanikerdluk is known for its localities with plant fossils (ref. B. E. KOCH 1955).

Quikavsak member: This member contains several levels with fossil plants of which the shale and clay ironstone of layer 11 are the ones which have yielded the greatest number of the fossils seen in the museums and known from O. Heer's description in "Flora Fossilis Arctica" (O. HEER 1868—83). This fossil flora has not been revised as a whole since Heer published "Flora Fossilis Groenlandica" (O. HEER 1883a) in which it is designated "Upper Atanikerdluk A".

Part of the fossil coniferous remains have been touched by the revisions of Chaney (R. W. CHANEY 1950), and on this occasion the material of *Sequoia Langsdorfii* Brongn., *Taxodium distichum miocenum* Heer etc. was mostly determined to be *Metasequoia occidentalis* (Newb.) Chaney. The author agrees in principle with Chaney. As far as some of them are concerned, the cones seem however to show a somewhat deviating phyllotaxi, but an investigation just commenced has given no final result. Cones are frequent in the deposit, and the leaf-bearing shoots occur in abundance.

Likewise must be referred to Brown's revision of the bulk of Populus and other genera to *Cercidiphyllum arcticum* (Heer) Brown (R. W. BROWN 1939). According to the author's investigation the variation supposed by Brown of *Cercidiphyllum arcticum* is not exceeded. The fruits which by Brown are referred to this species (Heer: *Nyssa arctica* etc.) are common, as also the leaves occur abundantly. On the other hand, the author found no seeds which can be ascribed to *Cercidiphyllum*, assumably because there were no conditions for deposition of such small particles in this coarse-grained fluviatile environment. These two species show a wide extension, vertically as well as horizontally, in the Tertiary of West Greenland.

Regarding further revisions of the species from Quikavsak member at Atanikerdluk can be referred to (SEWARD & CONWAY 1939) and the author's revisions during the treatment of the fossil flora from the *Lower Paleocene* of the Agatdalen valley (pag. 95–96).

Naujât member: This contains in the brown tuff bands the flora which Heer designated "Upper Atanikerdluk B". It is not revised as a whole, and it will be connected with great difficulties to do so as the specimens on account of narrow jointing of the shale are very fragmentary. It seems in Heer's representation to be different from the flora in Quikavsak member ("Upper Atanikerdluk A"). However there is such a difference in facies between the two members containing these fossil floras that one

cannot leave out of account that a separation during transport and sedimentation may have given rise to the differences in the same way as separation of the minerogene components takes place. This is supported by the fact that the basal part of Naujât member together with Quikavsak member on the south coast of the Nûgssuaq peninsula must be referred to *Lower Paleocene* as it appeared from the geological conclusion (pag. 86). The geological investigation has shown the extension of Naujât member and made Heer's "Upper Atanikerdluk B" flora from Atanikerdluk a single part of a larger flora from the basal part of Naujât member. Floras from this part of the member are known at Naujât, Atanikerdluk, Qagdlúnguaq, and Kingigtoq in the brown tuff and were described by (HEER 1883a) and (SEWARD & CONWAY 1939). Thus some of the conspicuous differences observed between the "Upper Atanikerdluk A" and "Upper Atanikerdluk B" fossil floras as they were presented by Heer, are removed. It was, for example, conspicuous that *Populus arctica* Heer, *Populus Richardsoni* Heer, *Zizyphus hyperboreus* Heer etc. (as Brown revised to *Cercidiphyllum arcticum* (Heer)Brown) are especially rare in "Upper Atanikerdluk B" where no specimens have been found by the author; however, Heer quotes *Populus arctica* Heer from Naujât in his summary floral list (HEER 1883a). They are nevertheless common in the "Upper Atanikerdluk C" flora (Naujât, at a higher level: 490m) and at Qagdlúnguaq.

Likewise, the *Macclintockia* species (except M. trinervis) were not found in "Upper Atanikerdluk B" at Atanikerdluk. They are common at Kingigtoq as is *Betulaceae* which also seems to be lacking in "Upper Atanikerdluk B" according to Heer. It certainly would be noteworthy if these species suddenly disappeared from the area.

In being able to consider several localities as one, from a floristical point of view, representing the same level, a more representative collection is obtained also showing that the genera and species mentioned above are still present. *Cercidiphyllum arcticum* (Heer) Brown and *Betulaceae* are also present as far as the intrabasaltic sediments. The youngest occurrences of the *Macclintockia* species occur in the basal part of Naujât member at Kingigtoq. Regarding the revisions of the floras can be referred to (SEWARD & CONWAY 1939).

Kingigtoq.

As it appears from the investigation of the landslide "coulisses" at Kingigtoq (pag. 43—46) it is possible to separate the fossils which in situ are found in the Tertiary and in the Cretaceous, respectively, alone on account of the rock in which they are found. On the basis of the fragments figured by (SEWARD & CONWAY 1939) and included in the collections in the Mineralogical and Geological Museum of the University of

Copenhagen, the following specimens can be said to originate in the Tertiary occurrences:

Equisetites kingigtokense sp. nov.	Pl. 1 fig. 1[1])
Pityospermum cedroides sp. nov.....	„ 1 „ 3
Pityospermum kingigtokense sp. nov. ..	„ 1 „ 4, 2
Pinus sp......	„ 1 „ 7
Sequoites Langsdorfii (Brongn.).....	„ 1 „ 5, 10
Cupressinocladus sp......	Text fig. 2
Juniperites gracilis Heer	Pl. 2 fig. 11
Elatocladus Mathieseni sp. nov.....	„ 2 „ 12
	„ 5 „ 37
Elatocladus Ungeri (Heer)	„ 1 „ 8
Elatocladus sp.....	„ 1 „ 6
Corylites hebridica Sew. & Holtt.....	Text fig. 4
Dryophyllum Johnstrupi (Heer)	Text fig. 6
	Pl. 4 fig. 29
Dryophyllum sp......	Text fig. 7
Macclintockia Kanei (Heer).....	Pl. 2 fig. 16, 17, 20
Macclintockia Lyallii Heer	Text fig. 20, 21
Platanophyllum sp.	Pl. 3 fig. 28
Dicotylophyllum bellum (Heer).....	Text fig. 16
Dicotylophyllum boreale (Heer)	Pl. 3 fig. 27
Dicotylophyllum kingigtokense sp.....	„ 2 „ 21
Dicotylophyllum Olafseni (Heer).....	Text fig. 11
Dicotylophyllum Steenstrupianum	Text fig. 12
(Heer)	Pl. 2 fig. 19
Dicotylophyllum washingtonense.....	Text fig. 17, 18
(Knowlton).....	Pl. 5 fig. 36
Dicotylophyllum sp.....	Text fig. 14
Dicotylophyllum sp.....	Text fig. 19
Palaeanthus Hollicki sp. nov.	Pl. 2 fig. 13, 14
Carpolithus sp. A.....	Pl. 2 fig. 15
Carpolithus sp. B.....	Pl. 2 fig. 18

The following species from (SEWARD & CONWAY 1939) may on the basis of the rock be referred to the Atane formation:

Sciadopitytes borealis (Heer).....	Pl. 3 fig. 25, 26
Dicotylophyllum Gaudini (Heer).....	„ 4 „ 33

Among the species stated by (SEWARD & CONWAY 1939) the author found the below-mentioned in the brown clay ironstone of the Atane formation:

Laurophyllum plutonium (Heer) Sew. & Conw.

The species mentioned below, which is not included in the collections in the Mineralogical and Geological Museum of the University of Copenhagen, could not be added to the above lists:

Moriconia cyclotoxon Deb. & Ett.	Text fig. 1

[1]) Plates and figures refer to (SEW. & CONW. 1939).

For the same reason the following fragments could not be included:

Laurophyllum plutonium (Heer) ..... Text fig. 10
Macclintockia Kanei (Heer)..... Text fig. 9
Dicotylophyllum Gaudini (Heer)..... Text fig. 13
Dicotylophyllum bellum (Heer)..... Text fig. 15

These species are through other samples already referred to the above groups.

In the discussion of the relation of the landslide "coulisses" to the stationary sequence was mentioned that plant fossils were found in the brown tuff layer in the basal part of Naujât member comprising the essential species of the Tertiary element in Seward & Conway's flora (SEWARD & CONWAY 1939). In the basal bed of Naujât member were thus found and determined by the author:

Pinus sp. (leaves)
Pityospermum kingigtokense Sew. & Conw.
Elatocladus sp. Sew. & Conw.
Elatocladus Ungeri (Heer) Sew. & Conw.
Elatocladus Mathieseni Sew. & Conw.
Juniperites gracilis Heer
Macclintockia Kanei (Heer) Sew. & Conw.
Macclintockia Lyallii (Heer)
Dicotylophyllum bellum (Heer) Sew. & Conw.
Dicotylophyllum Olafseni (Heer) Sew. & Conw.
Dicotylophyllum Steenstrupianum (Heer) Sew. & Conw.

Ipeqarfiúnge.

At this place samples of a fossil flora were found in 1954 and collected in 1956 in Aussivik member in brown tuff at alt. 1240 m. The fossil flora is not examined, but its composition is unfamiliar to he who is accustomed to the floras of Quikavsak and Naujât member, unless it may be within the range of the older Tertiary.

Pautût.

In the ravines H and G of the coastal slope near the Igpigarssukkløften gash the following species have been found in Quikavsak member and determined by the author:

Metasequoia occidentalis (Newb.) Chaney
Corylites M'Quarrii Forb.
Cercidiphyllum arcticum (Heer) Brown
Magnolia Inglefieldi Heer
Pterospermites (Credneria?) sp.
Macclintockia Kanei (Heer) Sew. & Conw.
Dicotylophyllum Lyelli (Heer).
Cfr. Platanus aceroides Goepp.

Tupaussat.

From Quikavsak member the following fossil plants are determined by the author:

1) from the west slope of ravine h, the shale, alt. 600—605 m:

Metasequoia occidentalis (Newb.) Chaney
Cercidiphyllum arcticum (Heer) Brown
Platanus aceroides Goepp.
Magnolia Inglefieldi Heer
Macclintockia Lyallii Heer
Pterospermites (Credneria?) spectabilis (Heer)
Dicotylophyllum bellum (Heer) Sew. & Conw.
Dicotylophyllum Eridani (Heer)

This collection is in Copenhagen filed under the Greenland Geological Survey label No. 9241.

2) from immediately east of the ravine with torrent 13:

Quercus groenlandica Heer
Dicotylophyllum bellum (Heer) Sew. & Conw.
Macclintockia cfr. Lyallii Heer

These are filed under the Greenland Geological Survey label No. 9244.

Nûk qiterdleq.

From Quikavsak member, bed No. 5 of this locality, the following fossil plants are determined by the author:

Taxodium-like twigs
Cercidiphyllum arcticum (Heer) Brown
Dicotylophyllum div. sp.
Macclintockia Kanei (Heer) Sew. & Conw.

The Agatdalen Valley.

The fossil Tertiary flora from the area of the Agatdalen valley is the only Tertiary flora in West Greenland which can be dated by means of zoo-fossils. The dating was made by Professor A. Rosenkrantz who refers it to *Lower Paleocene*. In a paper by the author, not yet published, the flora is described the species of which are briefly mentioned in the following with statement of the main conclusion of the work. The diagram shows the distribution of the species in the below members and localities:

Legend:

The Lower Paleocene of the Agatdalen valley, indicated by Ag.

Quikavsak member, Atanikerdluk, indicated by Atk. A.

Naujât member, basal part, the south coast of the Nûgssuaq peninsula, indicated by N. M.

The intrabasaltic sediments, indicated by Ib.

The Flora of the Area round the Agatdalen Valley.

Older terminology of fossil plants from Greenland	Revised terms	Ag	Atk. A	NM	Ib
Pteris grönlandica Hr.	*Cladophlebis grönlandica* (Hr.) Bell	+	+	+	
Ginkgo adiantoides (Ung.) Hr.	*Ginkgo adiantoides* (Ung.) sp. em. Shaparenko	+	+		+
Sequoia Langsdorfii (Brongn.) Hr., *Taxodium dubium* (Stbg.) Hr., *Taxodium distichum miocenum* Heer	*Metasequoia occidentalis* (Newb.) Chaney	+	+	+	+
Quercus grönlandica Heer ex parte, *Fagus castaneaefolia* Ung. ex parte, *Castanea Ungeri* Hr. ex parte	*Quercus grönlandica* (Hr.) sp. em. B. E. Koch	+	+		+
Castanea atavia Ung. ex parte?	*Quercus furcinervis americana* (Rossm.) Knowlton	+		?	
Castanea Kubinyi Kov.?	*Cupuliferites angmartusutensis* n. sp.	+		?	(+)
Quercus Lyelli Hr. ex parte	*Juglandiphyllum sp. A.*	+	+	+	
Populus arctica Hr., *Populus Richardsoni* Hr., *Populus Zaddachi* Hr. ex parte, *Zizyphus hyperboreus* Hr., *Paliurus columbi* Hr.	*Cercidiphyllum arcticum* (Hr.) Brown	+	+	+	+
	Corylopsiphyllum grönlandicum n. sp.	+	+		
Platanus aceroides Goepp		+	+	+	+
Cfr. Vitis Olriki Hr.		+	+		
(*Sassafras Ferretiana* Mass?)	*Laurophyllum* sp. A.	+	?		
Quercus Steenstrupiana Hr.	*Dicotylophyllum Steenstrupiana* (Hr.)	+	+	?	
Quercus Lyelli Hr. ex parte	*Dicotylophyllum Lyellii* (Hr.)	+	+	+	+
Prunus Scottii Hr. ex parte	*Dicotylophyllum Scottii* (Hr.)	+	+		

(continued)

The Flora of the Area round the Agatdalen Valley (cont.).

Older terminology of fossil plants from Greenland	Revised terms	Ag	Atk. A	NM	Ib
Rhus bella Hr., *Andromeda denticulata* Hr.	*Dicotylophyllum bellum* (Hr.) Sew.& Conw. (pl. 3 fig. 1–2)	+	+	+	
Rhamnus Eridani Ung., *Juglans denticulata* Hr.??	*Dicotylophyllum Eridani* (Hr.)	+	+	?	
Daphnogene Kanei Hr.	*Macclintockia Kanei* (Hr.) Sew. & Conw. (pl. 1)	+	+	+	
Macclintockia Lyallii Hr. pl. 2 fig. 1		+	+	+	
Macclintockia dentata Hr. (pl. 2 fig. 2)		+	+		
Pterospermites spectabilis Hr., *Pterospermites alternans* Hr.	*Pterospermites* (*Credneria* ?) *spectabilis* (Hr.)	+	+	+	?
Nordenskiöldia borealis Hr.		+	+		

It appears from this table that there is an essential agreement between Ag. and Atk. A, and a decreasing amount of common species in the sequence in ascending order by N M to Ib. The comparison comprises 22 "species" of the Agatdalen-valley flora which I consider determined thoroughly enough to be used for stratigraphical purposes. Of these can be distinguished 19(20) in Atk. A, 10(11) in N M, and 7(8) in Ib.

5 species which, however, are easily recognized, have in Greenland only been found in Ag. and Atk. A and further support their similarity:

Corylopsiphyllum grönlandicum n. sp.
Vitis Olriki Heer
Dicotylophyllum Scottii (Heer)
Macclintockia dentata Heer
Nordenskiöldia borealis Heer

From the overwhelming number of species common to the *Lower Paleocene* flora of the Agatdalen valley (Ag.) and the flora of Quikavsak member of Atanikerdluk (Atk. A), is concluded that they belong to the same flora community (the Macclintockia-Metasequoia-Cercidiphyllum "association"), and that they must be assumed to be contemporary within the cronological limits connected with the occurrence of this "association" in the extreme North. These limits are not at present sufficiently established as most of the occurrences known in the extreme North have not furnished sufficient information so far.

Further the following species from Ag. and Atk. A only occur as far as Naujât member:

Juglandiphyllum sp. A.
Dicotylophyllum Steenstrupianum (Heer) Sew. & Conw.
Dicotylophyllum bellum (Heer) Sew. & Conw.
Dicotylophyllum Eridani (Heer)
Macclintockia Kanei (Heer) Sew. & Conw.
Macclintockia Lyallii Heer

From the geological investigations described in this paper (ref. Conclution I pag. 85) it appears that at least the basal 10 metres of Naujât member must reasonably be included in the Lower Paleocene. This is reflected by the Tertiary flora from Naujât member of Kingigtoq comprising several of the fossils indicating the "Upper Atanikerdluk A" flora, and evidently these again contribute to the high number of fossils common to Atk. A and N M.

The agreement in age between the two fossil floras Ag. and Atk. A is apart from the high percentage of common species further emphasized when the similarities demonstrated above are considered on the basis of the decreasing number of species common to the Agatdalen valley flora (Ag.) and those of higher stratigraphical levels of the Tertiary sequence when treated in ascending order as shown in the table. There is thus reason to assume that the flora of Quikavsak member of Atanikerdluk is a *Paleocene* one as is the case with the Agatdalen valley-flora at the same litho-stratigraphical level, but the flora alone was no final proof of the full stratigraphical identity. The geological investigations were necessary in order to proceed with this problem the solution of which already appeared in the preceding chapters.

CONCLUSION II

By the investigation described it was pointed out that the Tertiary sequence of the south coast of the Nûgssuaq peninsula can be divided into 5 members of which the lowermost (Quikavsak member) and the basal bed of the following (Naujât member) prove to belong to the *Lower Paleocene* (ref. Conclution I pag. 85). Within this epoch the plant remnants of Naujât member are younger than those of Quikavsak member. The plant fossils known from the basal tuffs in Naujât member at Naujât, Atanikerdluk ("Upper Atanikerdluk B" flora), Qagdlúnguaq (Hartz's collection), and Kingigtoq (the Tertiary element in (SEWARD & CONWAY 1939)) are contemporaries as the tuff embodying them is situated on the very same stratigraphical level, and must be assumed to originate from the same eruptions.

The whole investigation of the relations between the Tertiary of the Agatdalen-valley area and the Tertiary of the southeastern part of the Nûgssuaq peninsula shows that the known floral type represented by Heer's "Upper Atanikerdluk A" flora (*Macclintockia-Metasequoia-Cercidiphyllum* "association") can be declared characteristic of Quikavsak member and the basal part of Naujât member, i. e. that it only occurs in *Lower Paleocene* in Northwest Greenland. The *Macclintockia* species (*M. Kanei* (Heer) Sew. & Conw. (pl. 1), *M. Lyallii* Heer (pl. 2 fig. 1), and *M. dentata* Heer (pl. 2 fig. 2)) are index fossils for this zone, which in a bio-stratigraphical classification should be designated the MACCLINTOCKIA-zone. The genus *Macclintockia* is common, and as its species are very characteristic, they are well suited to indicate a zone. Also *Dicotylophyllum bellum* (Heer) Sew. & Conw. (pl. 3) will be a good indicator of this zone in spite of the tentative determination.

The MACCLINTOCKIA*-zone comprises the whole Quikavsak member, and the upper limit is defined to 10 m above the lower limit of Naujât member, and the brown shale which at Kingigtoq is the basal bed of Naujât member is thus included.*

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Færdig fra trykkeriet den 21. januar 1959.

PLATES

Plate 1.

Macclintockia Kanei (Heer) Sew. & Conw. in grey arcose, The Agatkløften. 2:3.
G.G.U. Label No. 12896.90.
Chr. Halkier phot.

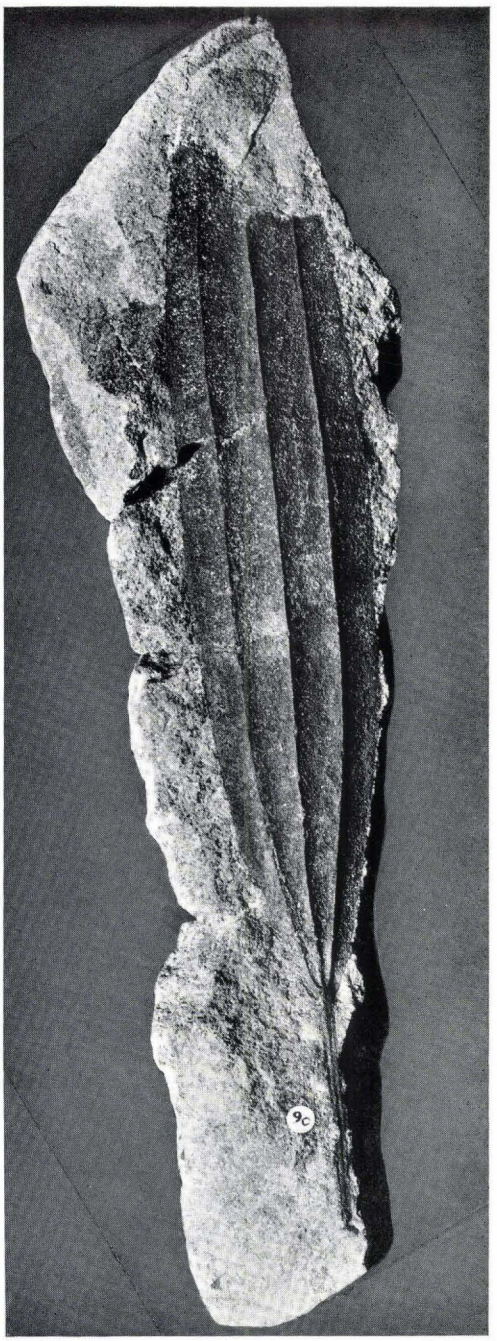

9c

Plate 2.

1. *Macclintockia Lyalii* Heer.

Well-preserved fragment of a leaf with 5 primaries, the characteristic polygonale meshes of secondaries and tertiaries and the forwardly curved teeth near the apex. Kangersôq valley. 1:1. G. G. U. Label No. 35492.63.

Chr. Halkier phot.

2. *Macclintockia dentata* Heer.

Leaf fragment with 9 primaries and apical dentition. From rose-coloured arcose. The Agatkløften. 1:1. G. G. U. Label No. 12896.12.

Chr. Halkier phot.

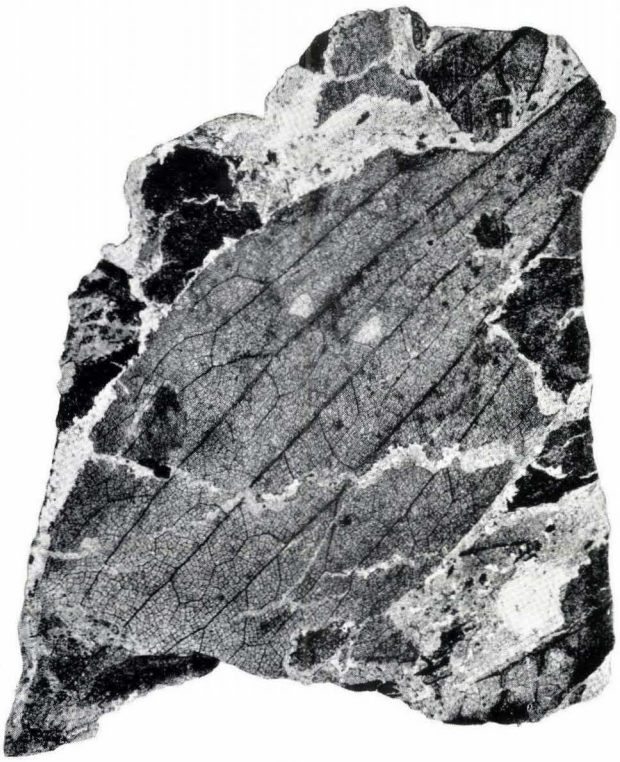


Fig. 1.

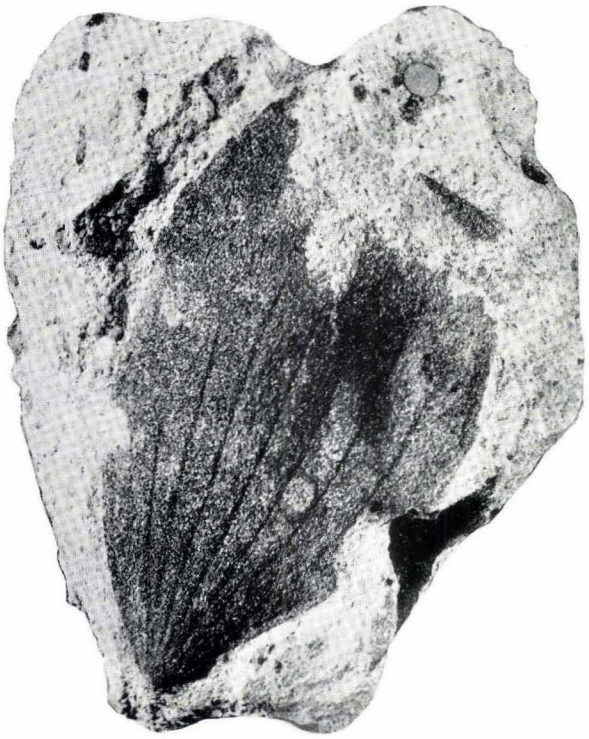


Fig. 2.

Plate 3.

Dicotylophyllum bellum (Heer) Sew. & Conw.

1. 3 leaflets together with undetermined leaf fragments. Kangersôq valley. 1 : 1. G. G. U. Label No. 35492.46.
Chr. Halkier phot.

2. 3 leaflets in grey arcose. The Agatkløften. 1:1. G. G. U. Label No. 12896.141.
Chr. Halkier phot.

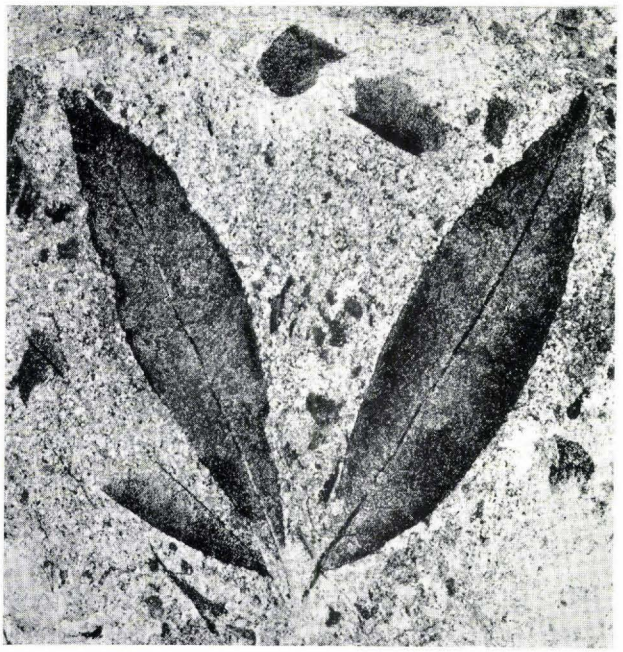


Fig. 1.

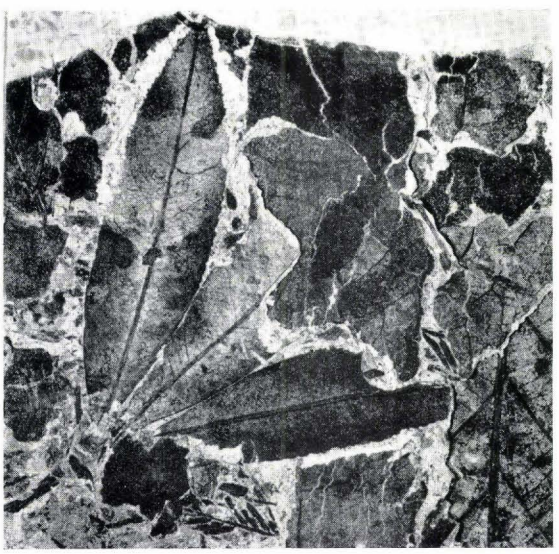


Fig. 2.

Plate 4.

Diagrammatic account of the Profiles situated on the South Coast of the Nûgssuaq peninsula from the Sarqaqdalen valley to Nûk qiterdleq treated in the text.

Each column represents the profile of one of the localities treated, to which the numbers below refer:

1. Sarqaqdalen (Naujât)
2. Atanikerdluk (Quikavsaup kûa and upper exposures).
3. Qagdlúnguaq
4. Umiussat
5. Igpigârssuaraq (Tarajornitsup qáqâ)
6. Tarajornitsoq — Gieseckes Monument
7. Ipeqarfiúnge
8. Pautûtdalen
9. Ivigssússat qáqât
10. Atâ
11. Tupaussat — Nûk qiterdleq.

The basal horizontal line represents the sea-level.

Small numbers to the left of the columns: Altitudes in metres of the limits between formations and members respectively. (The subdivision of each column is metric as well as the distances between the columns).

Big numbers to the right of the columns:

1. Cretaceous*)
2. Quikavsak member
3. Naujât member
4. Umiussat member
5. Basalt level of the Aussivik member
6. Aussivik member, upper shale

6a. „ „ lower shale

7. Point 976 member.
8. Plateau basalts
9. Basalt breccia.

*) ref. below: "*Erratum*".

The limits established with certainty are connected from column to column.

? within a column: no observations owing to talus and Quaternary deposits.

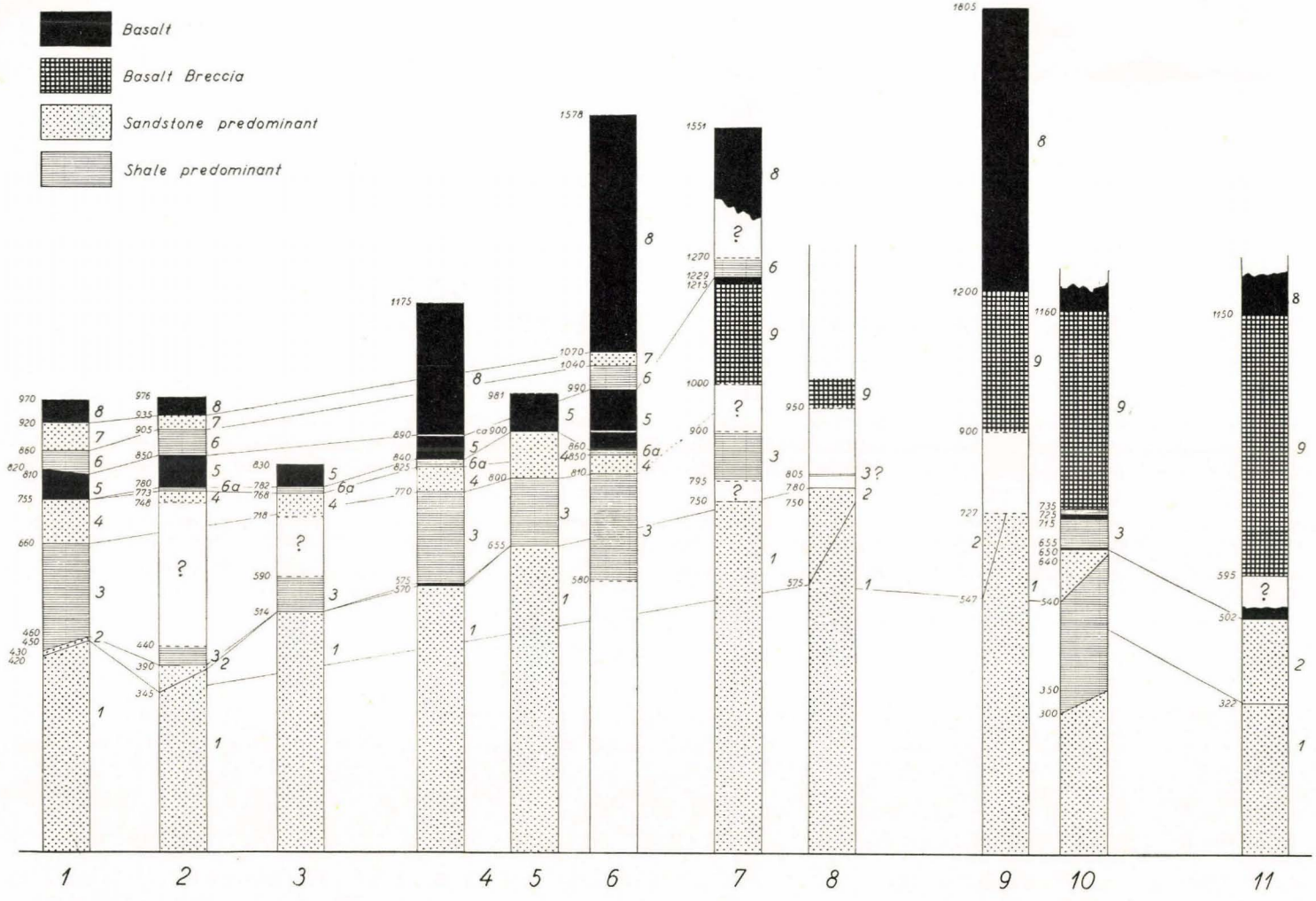
Full Line: Certain limit towards another stratigraphical entity.

Broken line: Resp. uppermost or lowermost height of deposits observed bounded by talus or Quaternary deposits.

Irregular limit: The deposit continues for an unknown amount of metres.

Column not filled to the top: The measuring has not reached the top of the mountains, which are known to consists of basalts (V. Münther).

Erratum: Column 10: Lowermost dotted area: Atane formation. Lowermost hatched area: Danian.


Basalt
Basalt Breccia
Sandstone predominant
Shale predominant
1
2
3
4
5
6
7
8
9
10
11

Preliminary Geological Map of the Coast between QAGDLÚNGUAQ AND KÛGSSUAQ (SARQAQ DALEN), THE SOUTH COAST OF NÛGSSUAQ PENINSULA

By B. Eske Koch

1:50 000

1 0 5km

Heights in meters. Contour interval 50 m.

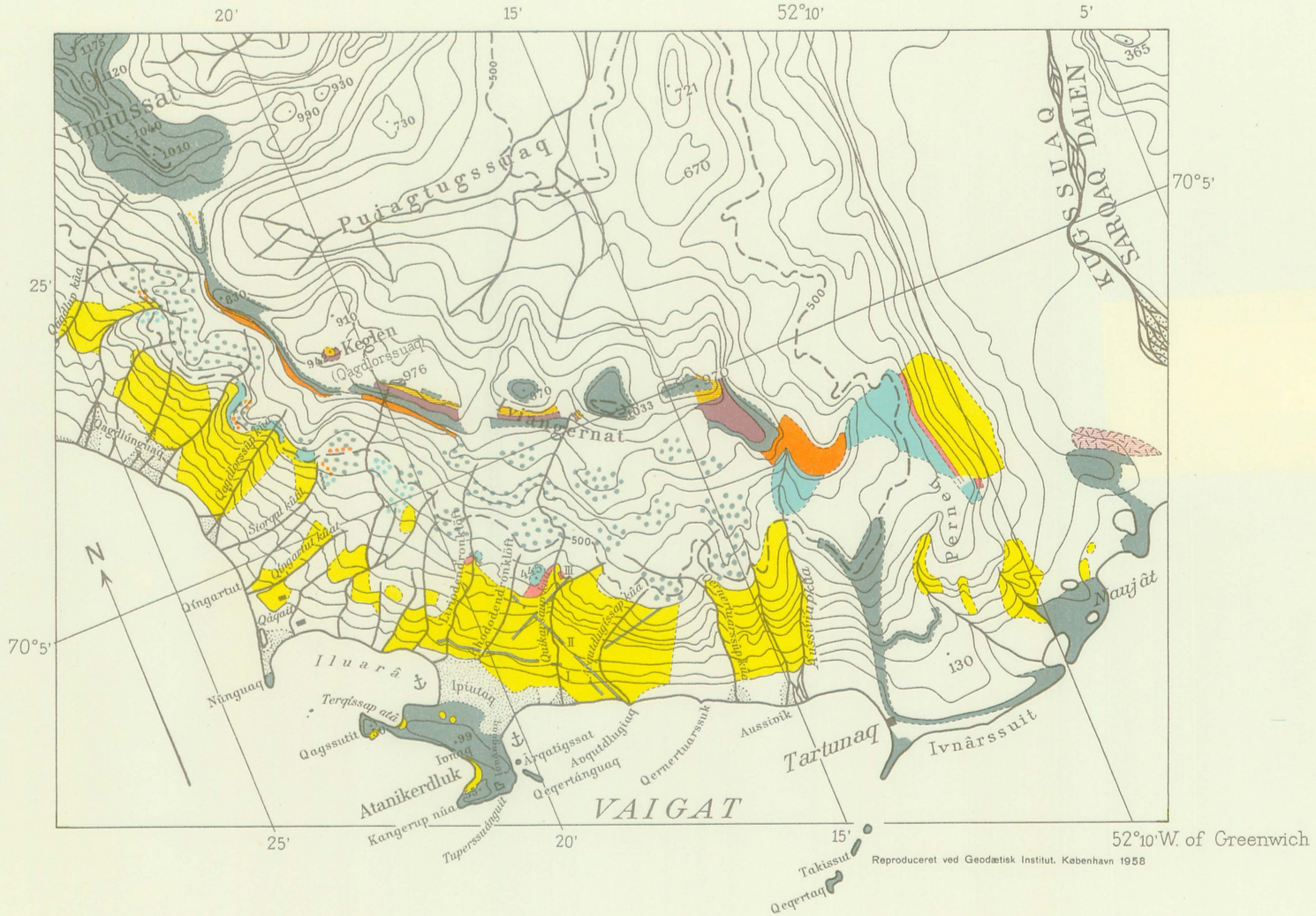
Tertiary — Upper Atanikerdluk Formation
- Basalt *
- Point 976 Member Sediments
- Aussivik Member "
- Umiussat Member * "
- Naujât Member * "
- Quikavsak Member " (Lower Paleocene)

Cretaceous
- Atane Formation.

Archaicum
- Gneiss

* Dotted colours indicate landslide coulisses
Fine, black dotting indicate outwash.

Topographical map by the Geodetic Institute, Copenhagen



Preliminary Geological Map of the Coast between PAÛTUT AND UMIUSSAT, THE SOUTH COAST OF NÛGSSUAQ PENINSULA

By B. Eske Koch

1:50 000

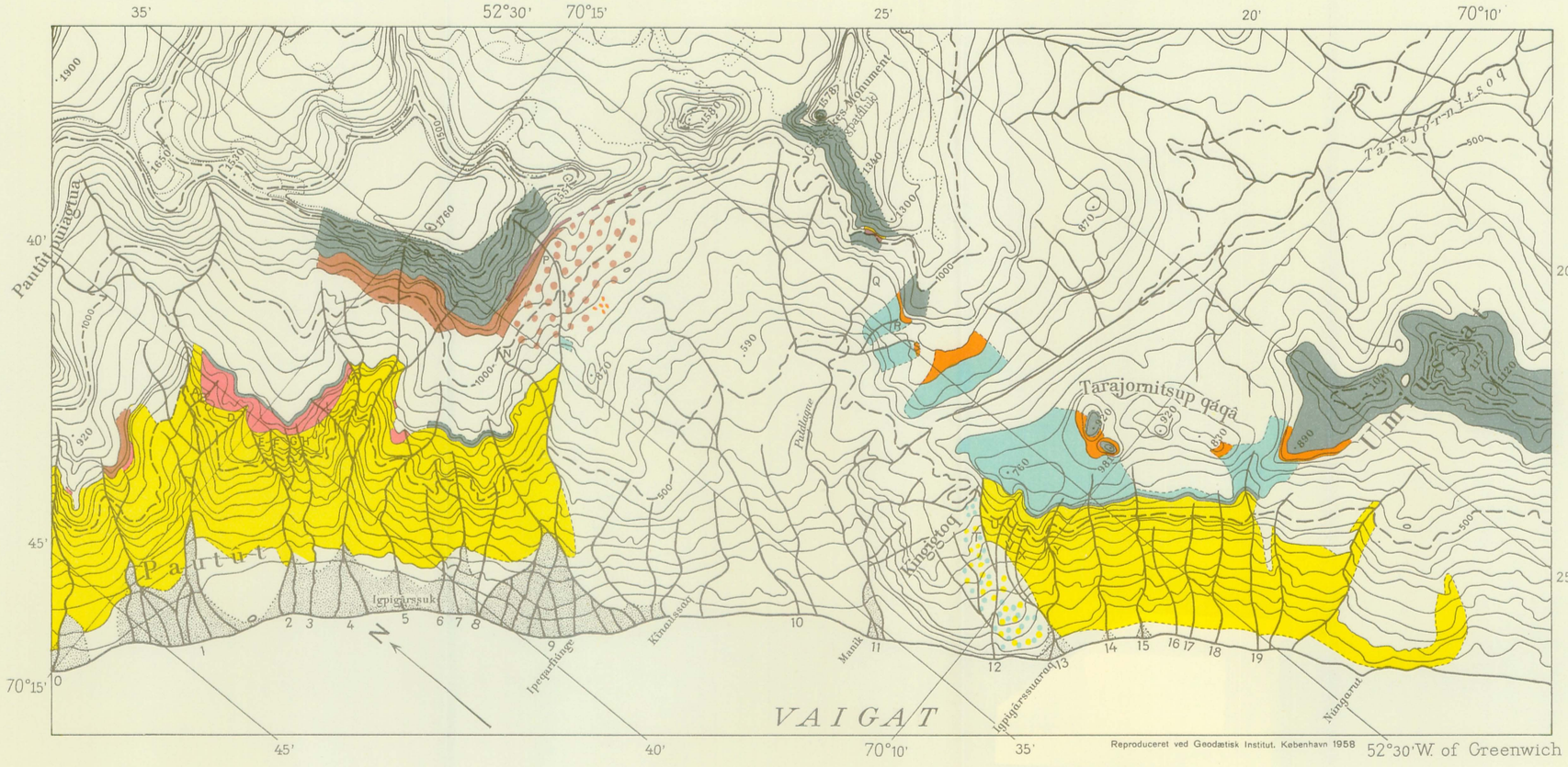
1 0 5km

Heights in meters. Contour interval 50 m.

- Tertiary
  - Upper Atanikerdluk Formation
    - Basalt
    - Basalt Breccia *
    - Point 976 Member Sediments
    - Aussivik Member ,,
    - Umiussat Member * ,,
    - Naujât Member * ,,
    - Quikavsak Member ,, (Lower Paleocene)
- Cretaceous
  - Atane Formation. *

* Dotted colours indicate landslide coulisses
Fine, black dotting indicate outwash.

Topographical map by the Geodetic Institute, Copenhagen



Preliminary Geological Map of the Coast between

NÛK QITERDLEQ AND IVIGSSÚSSAT QÁQÂT, THE SOUTH COAST OF NÛGSSUAQ PENINSULA

By B. Eske Koch

1:50 000

1 0 5km

Heights in meters. Contour interval 50 m.

Tertiary
- Upper Atanikerdluk Formation
  - Basalt
  - Basalt Breccia
  - Naujât Member — Sediments
  - Quikavsak Member — ,, — (Lower Paleocene)

Cretaceous
- Danian
- Atane Formation.

Fine, black dotting indicate outwash.

Topographical map by the Geodetic Institute, Copenhagen