GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT Nr. 50

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Report No. 50

Results from a geological reconnaissance around Svartenhuk Halvø, West Greenland

by
Viggo Münther

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Results from a geological reconnaissance around Svartenhuk Halvø, West Greenland

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With 11 figures and 1 map

1973

Abstract

Svartenhuk Halvø is built up primarily of Tertiary basalts; these overlie Cretaceous and early Tertiary sediments, and overlap onto the Precambrian basement.

The basalt series can be divided into a lower and an upper series; although displaced by faults, the boundary between these series can be followed across the peninsula.

The thickness of the lower basalt series is estimated to be about 2½–3 km in the south of the peninsula and barely 1 km in the north; the sub-aquatic basalt breccia is included in these thicknesses. Faults causing repetitions of the lava succession have resulted in the series being preserved over a rather large area. The general dip of the lavas is 3–4° towards SW in the east and 8–10°, also towards SW, in the west. Locally dips between 10 and 20° or even steeper are seen; these are the result of drag along fault zones in Arfertuarssuk fjord and Kugssineq valley, and between Svartenhuk Halvø and Ubekendt Ejland.

The youngest fault has a displacement of 500 m or more and has downthrown the basement area to the north-east in relation to the sediment-basalt breccia-basalt series to the south-west.

The upper basalt series has by far the greater lateral extent and covers the gneiss and metasediment area to the north and north-east at least as far as the Inland Ice. The dip of the flows in this part of the basalt series is considerably lower than in much of the lower basalt series, but faults repeating the succession are also frequently encountered within the upper basalts.

The tectonic movements evidence a strong E–W (or NE–SW) tension, never a compression; the weak anticlinal and synclinal structures which are seen are interpreted as resulting from differential sagging.

The lower basalt series is thought to have arisen from fissure eruptions, with the main area of eruption in the east. The lavas are very rich in olivine (i. e. are picritic). The upper basalt series probably arose from central eruptions and smaller fissure eruptions, and the area of eruption is thought to have shifted to the west. The upper lavas become poorer in olivine; andesitic lavas represent perhaps a closing phase, more local in its distribution and perhaps resulting from magmatic assimilation of pre-basaltic sediments.

"Iron basalt" and intrabasaltic breccia have not been noted on Svartenhuk Halvø.

CONTENTS

INTRODUCTION

The peninsula of Svartenhuk Halvø lies at the northern margin of the Cretaceous–Tertiary basin of West Greenland. Tertiary basalts form most of the peninsula, covering the Cretaceous–Tertiary sediments and overlapping onto the Precambrian hinterland to the north and east.

The Cretaceous and early Tertiary sediments and basalts of West Greenland have attracted the attention of geologists for more than a hundred years (see for example Rosenkrantz, 1970), but never has the interest been so great as in the last three years when commercial companies have begun to turn their attention to the oil and gas prospects of the West Greenland basin and its possible offshore extension (Henderson, 1969).

A number of papers on various aspects of the geology of the West Greenland basin have appeared in recent years, and a review of the Cretaceous–Tertiary geology of this area was given by Rosenkrantz & Pulvertaft (1969). Although the faults marking the boundary of the sedimentary basin were described in this paper, very little has been written anywhere about the structure within the basin and in particular with regard to the basalts. It is obvious that the structure within the basin is of primary importance to oil exploration, both with regard to determining the situation of structural traps and with regard to the thickness of the basalts which hinder geophysical exploration.

It is with this in mind that the present author has decided to present now his impressions of the geology of Svartenhuk Halvø, gained during a reconnaissance made for GGU in 1952. In giving this account the author decided not to be swayed by what has been written more recently, but rather to present his first-hand observations as they were made in 1952.

RESULTS OF EARLIER INVESTIGATIONS

It appears from GGU investigations that the West Greenland plateau basalts poured out and attained their greatest thickness in an area which was subjected to repeated subsidence from Barremian–Aptian to early Paleocene time. The volcanism gave rise to flows which covered an area built up of limnic and marine sediments more than 2 km thick (Rosenkrantz *et al.* 1940). The basalt series appears as a breccia facies which is of subaquatic, probably submarine, origin (Munck in Rosenkrantz *et al.* 1940; Munck in Rosenkrantz *et al.* 1942), and as typical subaerial flows. The subsidence which began during sedimentation continued during the formation of the lower basalt breccia and during the extrusion of at least the first 600–700 m of plateau basalt, at least up to and including the intrabasaltic breccia (Münther in Rosenkrantz *et al.* 1940).

This subsidence occurred along a zone that runs between Arveprinsens Ejland and Disko, along the fault zone Sarqaq–Ikorfat on Nûgssuaq peninsula (Rosenkrantz *et al.* 1940), between Upernavik Ø and Ubekendt Ejland, and along the fault zone in the north-easterly part of Svartenhuk Halvø from Itsako to Simiútap kûa (Rosenkrantz *et al.* 1942). East and north-east of this zone one sees gneiss and metamorphic terrain with summits up to 1400–2200 m high. On Nûgssuaq, however, remnants of sediments are preserved locally east of the Ikorfat fault; these are the so-called Kome, Atane and Ikorfat beds of limnic origin and thin marine beds of both Senonian and Danian age (Rosenkrantz, 1970). Where one meets basalts overlying the gneiss highlands these belong, at least north-east of Sarqaq, to the upper part of the plateau basalts. Only on the north side of the peninsula are the lower basalts seen east of the fault; here they seem to wedge out eastwards under the upper basalts.

As a direct continuation and development of the basalt investigations carried out by the Nûgssuaq expeditions of 1938 and 1939, and S. Munck's studies of the basal breccia and picrite intrusion on Nûgssuaq and Disko in 1946 and 1947, the present writer proceeded with the examination and mapping of the basalt series, especially within the map sheets Qutdligssat and Agatdal. These investigations were carried out mainly in the decade following the resumption of mapping in this part of West Greenland in 1946 under the leadership of Professor A. Rosenkrantz. About a dozen geology students (since then graduated) assisted the author in his work which stopped in 1956. In more recent years supplementary work on the basalts has been carried out by students as a part of Professor Rosenkrantz's own supplementary work on Nûgssuaq. A resumé of this hitherto unpublished work on the basalts of Disko and Nûgssuaq is given in the next section.

GENERAL GEOLOGY OF THE BASALTS ON NÛGSSUAQ AND DISKO

The basalt series is roughly divided into a lower and an upper basalt series.

The lower basalt series has arisen by fissure eruption and is usually a thinly bedded olivine-porphyritic series that includes a breccia facies called the basal

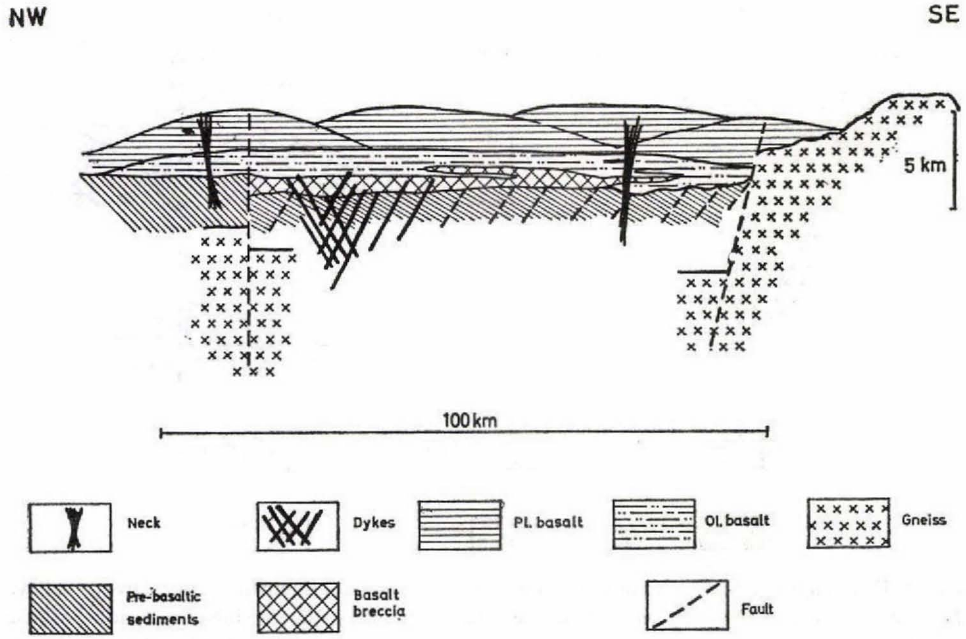

Fig. 1. Diagrammatic cross-section of the Nûgssuaq peninsula showing the main structural features of the peninsula at the close of basalt eruption.

breccia and an intrabasaltic breccia. It includes also lavas formed by the rising magma's reaction with underlying sediments, in particular the bituminous shales, which gave rise to the graphite-iron basalt (the lower iron basalt horizon) and the olivine-free basalt zones, both observed in particular in the central part of Disko (Stordal) and in north Disko and south-west Nûgssuaq (Kûgánguaq and the Vaigat coast). The maximum total thickness of the lower basalt series is about 2 km.

The upper basalt series has to some extent erupted through fissures—at the west end of the north coast of Nûgssuaq, for example—but normally it has been formed from central eruptions, as in the west of Disko and west Nûgssuaq. It consists in the main of plagioclase-porphyritic lavas with an olivine-poor to olivine-free groundmass; individual flows are often thick, and there are very subordinate tuff layers. This series includes also a breccia facies (intrabasaltic breccia) and graphite-iron basalt (upper iron basalt horizon; Münther, 1952). Furthermore, the series includes interbasaltic sediments with significant coal layers. These sediments have undoubtedly a large horizontal extent and sometimes a quite considerable thickness (200–300 m; Münther, 1952). The upper basalt series has a far greater horizontal extent and probably a greater thickness than the lower basalt series.

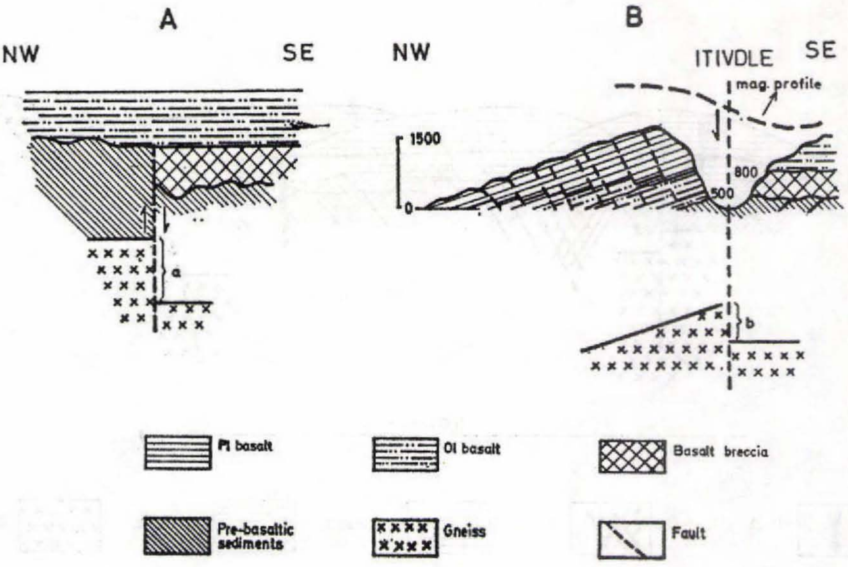

Fig. 2. Diagrammatic cross-sections showing the structural development in the Itivdle valley, Nûgssuaq. (A) The situation as it was after the eruption of the olivine-porphyritic basalts. The basement has been downthrown by an amount *a* on the east side. (B) The situation today, after downthrow to the west has reduced the apparent displacement of the basement to *b*. Note the tilting and antithetic faulting of the western block.

A basalt dyke swarm in south-west Disko may well mark a closing (or renewed?) phase of fissure eruption.

Only east of Ikorfat does the lower basalt series come to lie in places directly on gneiss. Normally it wedges out at or before the fault zone against the gneiss areas. The basalt series as a whole is cut by important fault zones with vertical displacements; in addition to the faults against the gneiss to the east one should mention NW–SE faults (e.g. the Vaigat fault), which have downthrown the basalts on Disko relative to those on Nûgssuaq, and faults with N–S and NE–SW trends which both downthrow and tilt the basalt to the west and north-west (e.g. the Itivdle fault). These block tiltings, which affect Disko west of Kûgánguaq and the Nûgssuaq peninsula west of the Itivdle valley (fig. 2), are often accompanied by a considerable number of smaller faults (displacement less than 100 m) that cause repetition of the lava series. The westward-dipping lava series includes the upper part of the lower basalt series and as much of the upper basalt series as is preserved in west Disko, Hareøen and western Nûgssuaq.

An elucidation of these important tectonic disturbances which have affected the basalt series requires the presence of distinctive marker horizons. The monotony that often characterises a basalt series, the lack of distinctive elements—in particular fossiliferous elements—on which one normally bases a division, the relatively poor degree of exposure, etc., hinder a macroscopic subdivision. The limited horizontal extent of individual lava flows makes it necessary to map in detail, even when a characteristic flow is present. However, the poor topographic maps that had to be used for the greater part of the work, the size of the area, and the limited time available made it impossible to carry out such detailed work.

During the mapping and unravelling of the tectonic relations the following have been used as marker horizons: characteristic tuff and basalt layers; the top of the basalt breccia and in particular the intrabasaltic breccias; the iron basalt horizons; interbasaltic sediment horizons, and the boundary between the olivine-porphyritic and plagioclase-porphyritic flows (subsequently referred to in this text as the ol/pl boundary). Of course none of these are marker horizons in the usual sense, but they have a comparatively large lateral extent and were originally more or less horizontal, so that within a limited area they have been usable for correlation of basalt profiles.

The greatest interest is attached to the ol/pl boundary, because this is distinctive even from a distance, and can be recognised easily both on colour photographs and on aerial photographs. It is seen as a boundary zone between generally thinly-bedded, zeolite-rich, readily crumbling, grey to variegated lava flows, and thicker, more prominent lava layers of rusty brown to bluish black colour. It is typical that a real alternation of olivine- and plagioclase-porphyritic flows is not seen in a systematic traverse across the flows in a profile. Thus plagioclase-porphyritic lavas always overly the olivine-porphyritic flows. At the level of the ol/pl boundary non-porphyritic, so-called "dense blue" lava flows are often more common than the porphyritic varieties, and this together with the poor degree of exposure often makes it more difficult to fix the ol/pl boundary during the measurement of a profile than to point to it in the surrounding plateau mountains.

It became apparent during the work that the ol/pl boundary on Disko and in the western part of Nûgssuaq coincides broadly with the boundary between lavas that have arisen through fissure eruptions and lavas mainly formed by central eruption. In the north-western part of Nûgssuaq, however, the lowest part of the plagioclase-porphyritic series also erupted from fissures, and the difference between the lower and upper basalt series is not at all so obvious as it is on Disko; nevertheless it can be recognised. On the other hand, more than 500 m up in the upper basalt series a distinct boundary between fissure eruptives and central eruptives is encountered, the latter forming thick, prominent, rusty brown to bluish-black lava layers.

As already mentioned, the ol/pl boundary occurs in the block-tilted part of Nûgssuaq; only in the central parts in the east and south is the boundary seen in essentially horizontal basalts. Here the situation appears as follows (fig. 1): from a central zone of dyke swarms a "plateau shield" of olivine-porphyritic basalt was built up, flow upon flow, with a horizontal or very gently dipping

(1°) upper surface over most of its area, and with flanks dipping 3–5°, so that the olivine-porphyritic (lower) series wedges out to the east and south, and most likely also to the west below sea level. The east–west extent of the shield is about 100 km, while the north–south extent is very variable and is marked by the irregular extent of the more or less well defined dyke zone from north-west Disko through the Itivdle valley and Ubekendt Ejland to east Svartenhuk Halvø (Noe-Nygaard, 1942; Drever & Game, 1948).

Centres of central eruption, first seen by the author in 1947, have so far been identified near the west flank of the olivine basalt "plateau" on Disko and Nûgssuaq, and in a similar position on Ubekendt Ejland (Drever & Game, 1948), in every case near zones of weakness.

THE BACKGROUND FOR THE SVARTENHUK HALVØ RECONNAISSANCE

This report concerns first and foremost the results from a reconnaissance around Svartenhuk Halvø and adjoining basalt areas, undertaken in the late summer of 1952 from GGU's cutter "K.J.V.Steenstrup". The principal problem was to find out if the division of the basalt series established in the southern areas and described in the previous section, could also be applied in the northern part of the basalt province, and, if this proved to be the case, to plot the ol/pl boundary. Furthermore there was the question as to which of the basalt series extended over the gneiss and metasediment areas.

The westerly-tilted basalt blocks on Disko and outer Nûgssuaq are cut by "repeating faults" that allow one to more than halve the apparent thickness of the lava pile as calculated simply from mean dip and lateral extent (fig. 2), but it was difficult to decide if this was correct everywhere. This was partly because not all the faults could be localised, and partly because an estimate of throw is dependent on marker horizons. Where conditions on Disko and Nûgssuaq were most favourable it could be shown that displacements are small in areas where the individual faults are closely spaced compared to those where the distances between faults are large. This means that one can postulate a roughly constant net throw per kilometre. It was of particular importance to investigate this problem in Svartenhuk Halvø, because Noe-Nygaard (1942, p. 68) had suggested that the basalts in southern Svartenhuk Halvø were more than 10 km thick.

Summing up: the purpose of the reconnaissance was to find out if one was justified in drawing parallels between the build-up and tectonics of the basalts in the northern and southern parts of the West Greenland province. The investigation concerned in particular:

(1) The position of the ol/pl boundary, and the character of the lower basalt series, in both its lateral and vertical extent.

(2) The general tectonic pattern, in particular with regard to block-faulting and tilting.

(3) The basalt cover in the basement areas.

THE RECONNAISSANCE IN THE SVARTENHUK HALVØ AREA

The route sailed during the reconnaissance is shown in map 1. About 20 localities on land were visited, both to collect samples and in most cases also to measure complete profiles. The investigation in south-eastern Svartenhuk Halvø, between Umîviup kangerdlua and Arfertuarssuk fjord, should be seen as a continuation of the work done by the 1939 Nûgssuaq expedition (Rosenkrantz *et al.*, 1942; Noe-Nygaard, 1942).

In the eastern part of the area, on the east side of Ingia Fjord near the glacier, an attempt was made to find basalt *in situ* but this could not be reached. However, about a dozen fallen blocks were picked up some 400–600 m above sea level. Only plagioclase-porphyritic basalt was represented in these blocks, i.e. the blocks are from the upper basalt series.

In Umîviup kangerdlua, and about 5–6 km up the valley Usuit kûgssuat, at about 400 m above sea level, dips of 3° SW were measured in the lavas as observed from the south. At greater heights the flows on the north side seemed to be nearly horizontal, but no discordance could be seen. It could be suggested that a weak tilting to the west of the lower flows took place during volcanism. Tectonic movements during volcanism and older than the upper basalt series have been recognised on Disko.

On the south-east side of the north ridge of Igsiatdlaup qáqâ, 400 m above sea level, one can see, as mentioned by Munck (in Rosenkrantz *et al.*, 1942), "brown breccia" overlain by "grey breccia" with an intercalated sedimentary series; the dip here is 3–4° SW, but there is also a fault striking NW–SE (fig. 3) which has been intruded by a basalt dyke; the north-east side has been downthrown about 25 m, resulting in a repetition of a small part of the series. Cross-bedding in the breccia dips east.

The entire coastal stretch Manîserqut–Niaqornakavsak is confused by landslides. Behind, in the undisrupted cliff of Kakilisait qáqât, a distinct fault in the grey

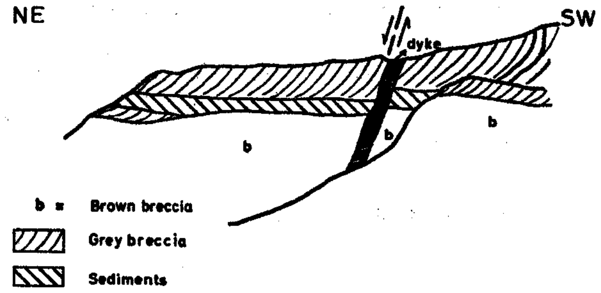

Fig. 3. Sketch of a small fault filled by a dyke on the north side of Igsiatdlaup qáqâ.

breccia can be seen where the north-east side is downthrown about 100 m (fig. 4). Along this coast the cross-bedding in the breccia dips north.

The coast stretch Manîserqut–Uligssat shows an unusual situation: in the east the layers are horizontal, in the west a dip of 6° W is seen and in the middle 1–2° W. Right on the coast one block dips 4–5° SW and another 1–2° E. A few fault lines can be seen; in the west there is one with downthrow to the east—i.e. a fault causing repetition. The varying dip of the coastal blocks indicates, in the opinion of the author, a recent slip along the coast. On the south side of the outermost, westward-tilted part of Nûgssuaq, coast-parallel faults (the Vaigat faults) are found, and while the general dip here is 10–15° NW, the low, coastal blocks dip up to 60–70° to W and SW. The recent slip of the coastal blocks has left its mark on the topography in slopes or clefts running roughly parallel to the Vaigat coast and dipping SW. The author considers that the variable dip of layers in the Manîserqut–Uligssat coast stretch is due to similar recent slips, a sort of landsliding during which blocks in a dipping lava series have acquired accidental variations in strike and dip. Here on Svartenhuk Halvø one should search for a more or less coast-parallel zone of weakness.

If one looks at the breccia/plateau basalt boundary on Svartenhuk Halvø (Rosenkrantz *et al.*, 1942, fig. 26) as mapped by Munck in the Usuit kûgssuat valley and in eastern Svartenhuk Halvø, one would expect the boundary to cut

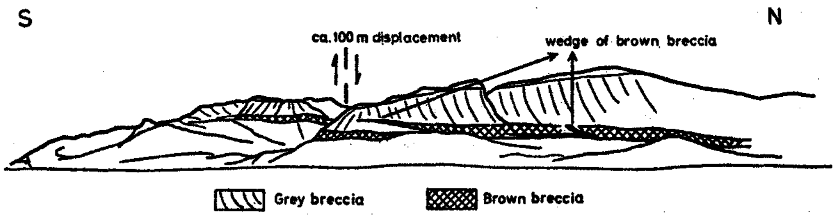

Fig. 4. Sketch of the ridge Kakilisait qáqât seen from the east.

the coast at or near Manîserqut (which is what Munck predicted), on the assumption that this boundary was originally horizontal and now dips 3–4° SW. The present author's observations on Svartenhuk Halvø confirmed the attitude and position of the breccia/plateau basalt boundary indicated by Munck and Noe-Nygaard (in Rosenkrantz *et al.*, 1942, plate 5).

Noe-Nygaard and Munck visited Schades Øer, between Ubekendt Ejland and Svartenhuk Halvø (Manîserqut), during the 1939 Nûgssuaq expedition, and observed the alternating basalt and basalt breccia. They interpreted this as a "recurrence to breccia facies" (Munck in Rosenkrantz *et al.*, 1942, p. 54), i.e. as a transgression/regression phenomenon, or the result of tidal changes in the coastal zone. As a participant in the same expedition the author noticed a similar feature at Marrait kitdlît on the south side of Nûgssuaq and interpreted it in the same way. Later geological investigations in the Marrait area in 1951–56 and 1964 have established that here one is concerned with a number of faults which cause repetition of the NE-dipping succession of breccia overlain by basalt flows; erosion on the coastal slopes has exposed the repetitions of the breccia/basalt boundary. The author has not visited Schades Øer and therefore does not dare to maintain that the situation here is the same as at Marrait. At Schades Øer the possible faults which could repeat the succession would strike NW–SE. However, the structural relations require other faults. Although the strike of the lavas at the northern end of Ubekendt Ejland is the same as that in eastern Svartenhuk Halvø, the dip in the former locality (ca. 20°) is considerably more than in eastern Svartenhuk Halvø (3–4°). This difference must mean that there has been faulting between the two areas. From the course of the breccia/basalt boundary on Svartenhuk Halvø one would expect this boundary to pass 3–5 km northeast of Schades Øer. Seen also in relation to Ubekendt Ejland, where basalt breccia is not seen (Drever & Game, 1948), Schades Øer seem to lie too far to the south-west. Intrabasaltic breccias at a suitable level above the main breccia/basalt boundary are not seen either on Svartenhuk Halvø or on Ubekendt Ejland. Either there has been faulting with lateral displacement (such faulting has been demonstrated on Nûgssuaq) or the apparent lateral displacement is the result of vertical displacement of a dipping series.

Taking into account the attitude and position of the breccia/basalt boundary on Svartenhuk Halvø, the fact that faulting must have taken place between Svartenhuk Halvø and Schades Øer and between Schades Øer and Ubekendt Ejland, and the fault seen on Kakilisait qáqât (fig. 4), the author considers it probable that there is a coast-parallel fault off southern Svartenhuk Halvø, at least off the stretch between Manîserqut and Eqûtat. The very variable dip (between 0 and 20–30°) along this stretch of the coast is regarded as the result of secondary landslide-like slips, the more so because the hinterland to this coast shows moderate dips with some variation but with a gradual increase from 3–4° in the east to 10–11° in the west in Arfertuarssuk fjord.

Along the stretch between Eqûtat and Tasiussaq a slightly different situation is thought to exist. The basalts here are still thin, zeolite-rich, olivine-porphyritic flows, i.e. lower basalt series. West of Eqûtat as far as Kap Cranstown, the flows have a considerably steeper dip to SW. As this is also thought to be the case from Tasiussaq inland to Aputitût (called "Søndre Aputitût" in Rosenkrantz *et al.*, 1942, fig. 10), another situation must exist. The dip is between 15° and 35° SW; this is evident both from the results of the 1939 Nûgssuaq expedition (Rosenkrantz *et al.*, 1942, fig. 28) and from the author's observations from the plateau above the Kugssineq valley. West of Tasiussaq there are plagioclase-porphyritic lavas with the brown colour and thick flows characteristic of the upper basalt series. It is from the stretch from the coast at the mouth of the Kugssineq valley, up this valley north to Aputitût, that Noe-Nygaard (1942, pp. 47–51) has described plagioclase-porphyritic basalt, porphyritic "laminated" basalt, agglomeratic basalt and andesitic basalt. The steep dip of the basalt series is particularly evident in the belt from Tartûssaq northwards. Many faults which repeat the basalt succession have been observed, both at Tartûssaq and in the Kugssineq area, and also around Arfertuarssuk fjord, but the high dip is only marked east of this fjord. The dip at Kap Cranstown is less—12–17° to SW. Here the lava series is also seen to be repeated along faults parallel to the strike (fig. 5), but farther north, at the inner end of Arfertuarssuk fjord and on the coast north-west of Kap Cranstown, the dip is 8–10° and still farther north it is even less. The ol/pl boundary is not clear but must be sought on the north side of Tasiussaq.

The pattern of dips outlined above is best explained by tilting associated with one or more large ca. NW–SE striking faults through Kugssineq and Tartûssaq and in Arfertuarssuk fjord, with downthrow to the west. The dip of the lower basalt series east and north-east of Tasiussaq, which increases from 3–4° in the east to 8–10° in the west, has on the other hand been affected to only an insignificant degree by such faults.

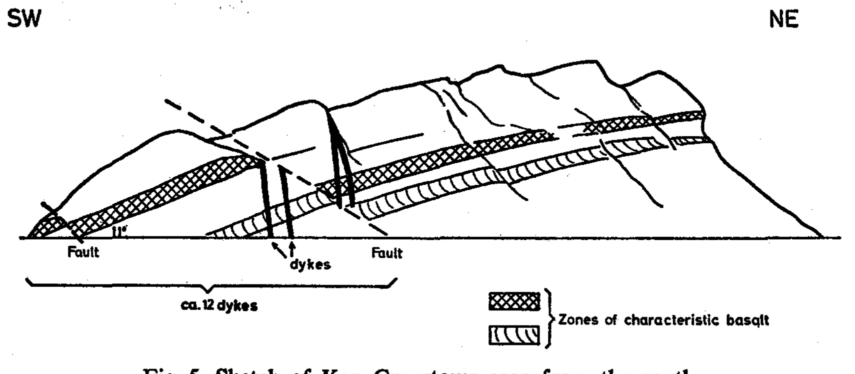

Fig. 5. Sketch of Kap Cranstown seen from the south.

"Nieland's trachyte": an anorthoclase trachyte at the head of Arfertuarssuk fjord was described by Nieland (1931) and mentioned again by Noe-Nygaard (1942, pp. 51–53) who did not however visit it. The present author visited this occurrence and is of the opinion that it is a sill intrusion. The trachyte can be followed 2–3 km NNE from the shore. The basalts here strike roughly in the same direction as the fjord, i.e. NNW–SSE. The dip is, as mentioned previously, 8–10°. The trachyte is more resistant to erosion than the overlying basalts which are seldom exposed. At the northernmost locality where the trachyte was visited this body is about 200 m above sea level. The apparent dip from here to the fjord locality is about 4°, but the true component of dip of the trachyte sill in this direction is larger; faults with downthrow to the north cut the sill so that it is now divided into four or five sectors each of which has the same dip as the surrounding basalts. North-east of the highest exposure of the sill there is another fault and on the north-east side of this basalts are seen which continue into the lower terrain. Under these the trachyte is seen again and even farther to the NNE and still lower there is possibly another trachyte exposure. To the far north only basalts are seen; the trachyte is below the level of exposure.

On the west side of Arfertuarssuk fjord, opposite the coastal exposure of the trachyte, there must be a fault, because the basalt layers have an almost anticlinal kink.

Several basalt dykes are seen on both sides of Arfertuarssuk. On the west side of the fjord, opposite Igdlúnguaq, a volcanic neck is seen; three flows can be set in direct relation to remnants of the same magma in the feeder pipe (fig. 6). Agglomerate is lacking, and zenoliths are not seen either. The neck is medium sized, less than 100 m in diameter. The body was observed under extremely favourable conditions, both with regard to the erosion surface which has roughly bisected the pipe and also with regard to light (early morning sun). The locality shows, the author believes, that one is justified in regarding the upper basalt series on Svartenhuk Halvø as having been produced from central eruptions. Thin flows however still occur at this level, and the basalt dykes provide evidence that fissures still contributed to the basalt eruption at this stage. At Kap Cranstown one can see a prominent dyke swarm, something which is otherwise

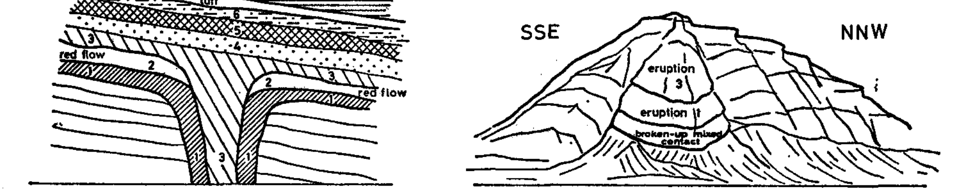

Fig. 6. Diagram and sketch of the volcanic neck on the west side of Arfertuarssuk fjord.

uncharacteristic of the upper basalt series. Regrettably, samples of these dykes were not collected, as they could represent a younger dyke swarm, unconnected with the surrounding basalts, like the late swarm known from the Faeroe Islands. Dykes in south-west Disko may also belong to this phase.

While sailing along the west coast to the point Svartenhuk, dips of 10–12° SW were noted in the southernmost stretch, near Kap Cranstown. Farther north the dip lessens to horizontal. At Qârqut qáqât a weak NE dip is seen. The coastal hills along this stretch are low, and exposures indifferent; there are no doubt some more or less coast-parallel (NW–SE) faults here. The point Svartenhuk shows a dip of 2°NE and a single fault causing a repetition. North of the point the flows are almost horizontal, though at Siggup qôrua there is still a weak easterly dip.

At Mitdlôrfik there are probably faults both in the bay itself and to the south-

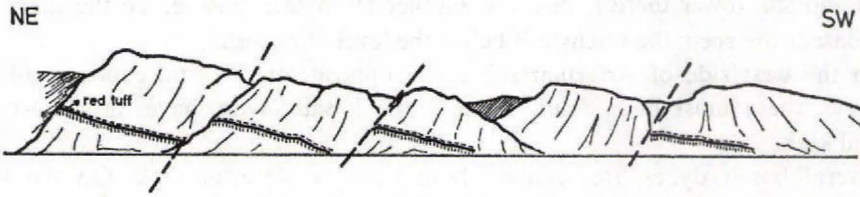

Fig. 7. Sketch of the south-east side of Umîarfik fjord north-east of Mitdlôrfik.

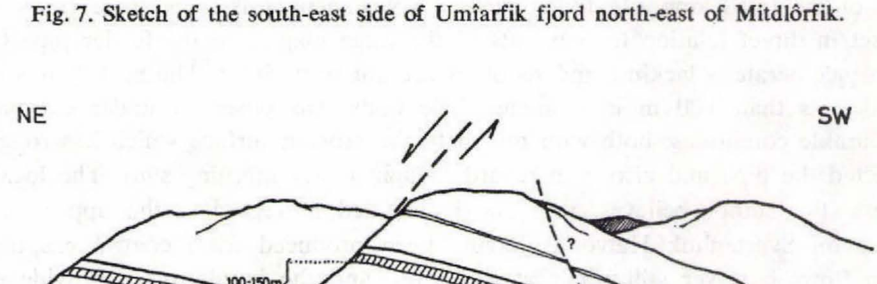

Fig. 8. Sketch of the south-east side of Umîarfik fjord south-west of Amitsoq.

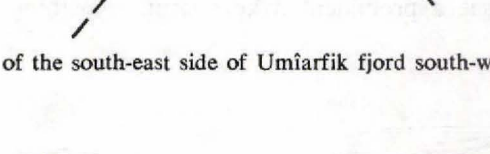

Fig. 9. Sketch of basalt flows that have flowed into each other. Amitsoq, south-east side of Umîarfik fjord.

west, since the basalt layers here dip SW at up to 10–12°. Along the coast to Amitsup suvdlua the basalts dip 8–9° SW, and several faults are seen which cause repetition in the basalt sequence—about one per kilometre with an average throw per fault of barely 100 m, though the throw on the northernmost fault, that near Amitsoq, is 100–150 m (figs 7 and 8). On this stretch of coast a single detailed observation was made of lavas which have flowed into each other (fig. 9); the individual flows are 4–6 m thick.

The east side of Skalø is shown in three sketches which should be seen in continuation (fig. 10); these show that the basalt series dips most steeply in the south—9–10°—as against 1–2° in the north. The faults, which as usual cause repetitions, have throws of over 100 m. The flows strike NW–SE, as on the mainland of Svartenhuk Halvø. Opposite (east of) Skalø, the coast below the mountain Nûit qáqât is built up of lavas with a much lower dip—ca. 2°—apart from the point Nûit on the north side of Amitsup suvdlua where the dip is 4–5°SW. The layers seem to be "nicked", perhaps due to drag on a fault in the fjord. The faults on Skalø suggest this, but the explanation could also lie in landslides.

At Nerutussoq, on the east side of Umîarfik fjord, the ol/pl boundary must be present south-west of the delta. Olivine-porphyritic flows are seen here which to the north, nearer the valley of Simiútap kûa, are underlain by basalt breccia. The dip is 2½ ° SW on both sides of Umîarfik fjord.

Particular interest is attached to the valley Simiútap kûa. Rosenkrantz *et al.* (1942, plate 5) show pre-basaltic sediments and basalt breccia on both sides of the valley. As is mentioned in their text (p. 12), the map is based on earlier geological investigations by Steenstrup (1883); this area was not included in the results of the Nûgssuaq expedition (Rosenkrantz *et al.*, op. cit. fig. 9). However in 1947 Rosenkrantz traversed Svartenhuk Halvø from Umîvik to Umîarfik and found that gneiss outcrops on the north-east side of Simiútap kûa (see the map in Rosenkrantz, 1952). In the same year (1947) B.Eske Koch studied an interbasaltic coal-bearing sediment series on the north-east side of the valley.

On arriving at Simiútap kûa the present author soon realised that there were gneiss exposures reaching quite high up the north-east side of the valley and therefore began with a profile traverse on this side. At varying heights between 170 and 300 m basement gneiss was found, with an important dolerite sill above the gneiss knolls which recalls Munck's description (1945) of the dolerite intrusion in the Sarqaq–Ikorfat fault zone on Nûgssuaq peninsula (p. 6). Overlying the gneiss there is olivine-porphyritic basalt up to 300–400 m above sea level where one meets the interbasaltic sediments that Eske Koch investigated in 1947; these comprise loose sandstone with insignificant coal layers. These sediments are overlain by typical thick plagioclase-porphyritic basalt flows—i.e. the upper basalt series. These continue up to the ca. 1500 m high summits on this side of the valley (fig. 11).

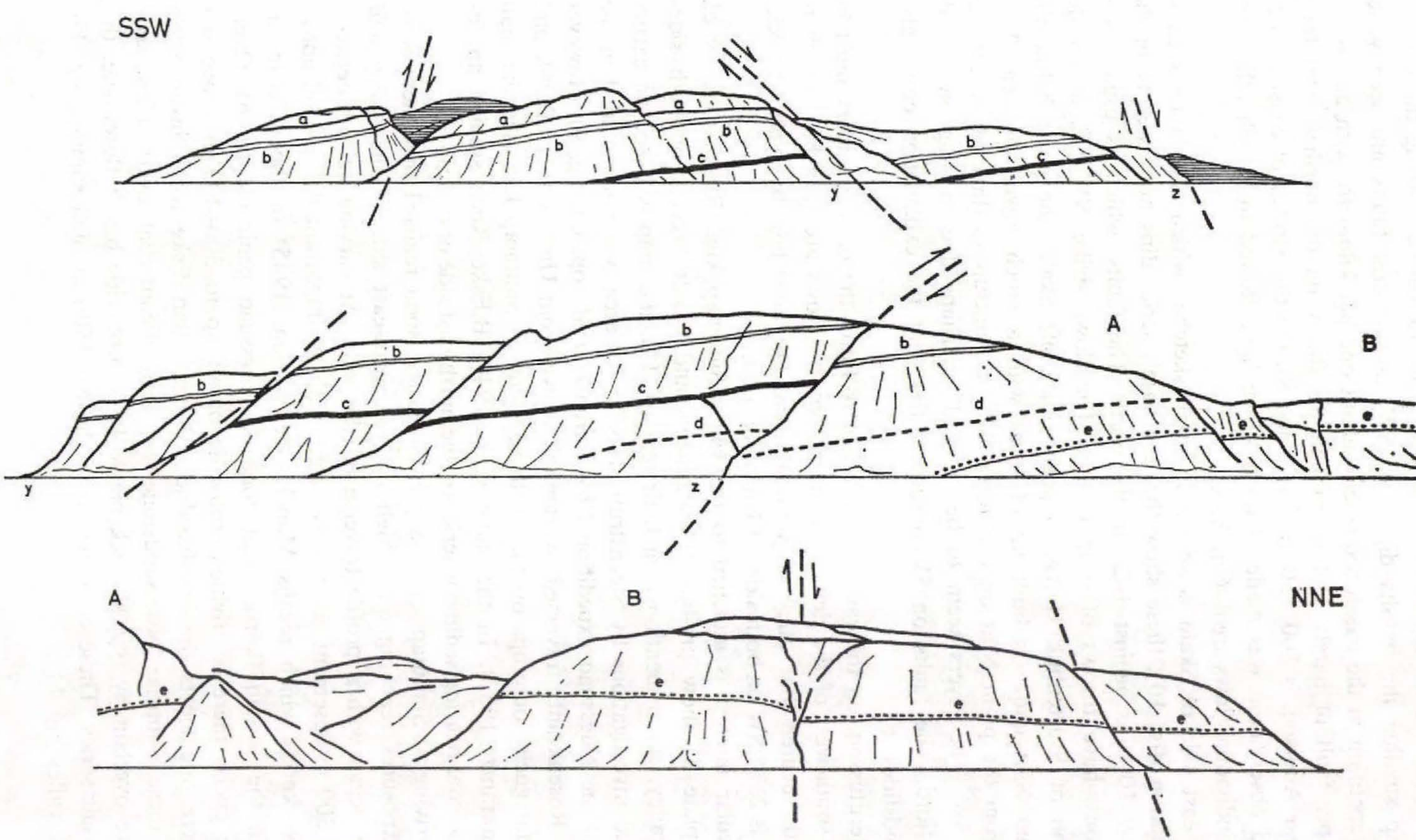

Fig. 10. Sketch of the south-eastern side af Skalø. Top is the southernmost part; middle is the continuation to the north-east; bottom is the continuation to the northern end.

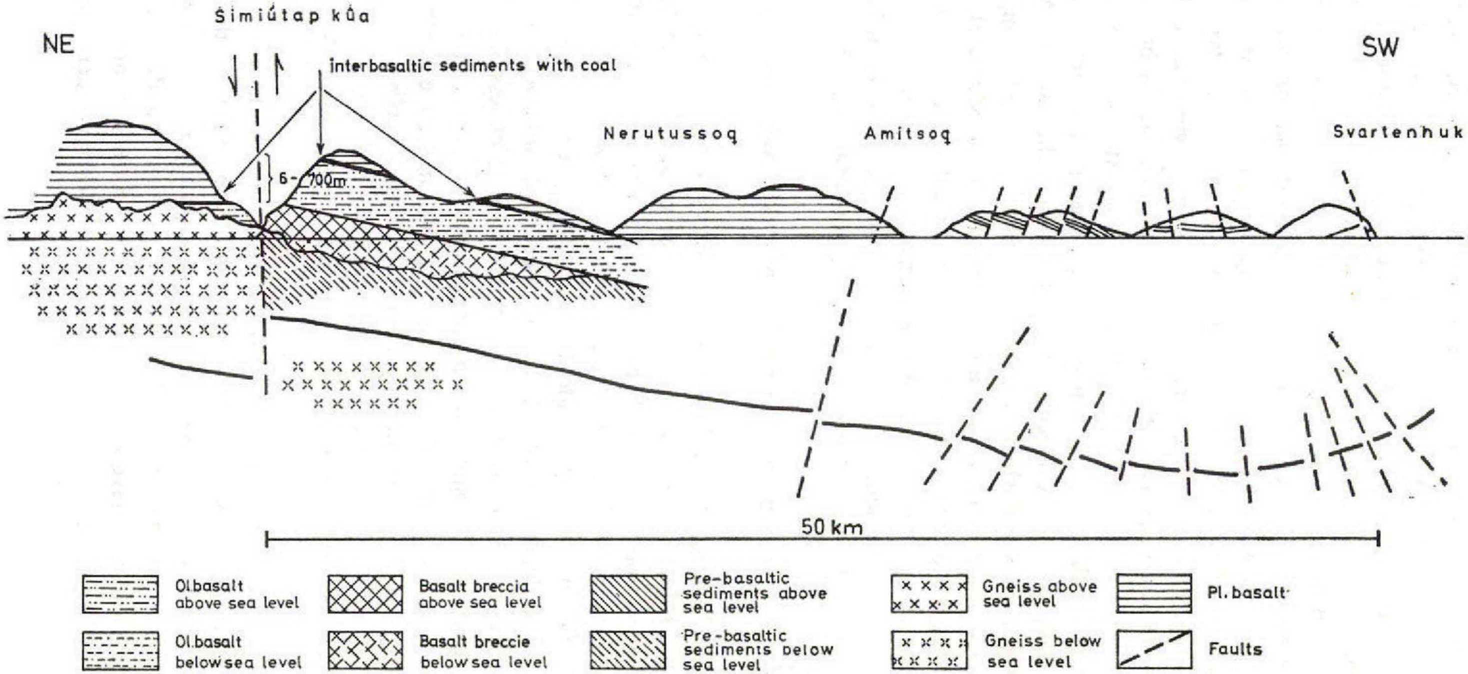

Fig. 11. Sketch section of the north-west side of Svartenhuk Halvø, along the south-east side of Umîarfik fjord. Heights and thus dips are exaggerated.

On the opposite (south-west) side of the valley, near sea level, there are sediments, as shown by Steenstrup (Hammer & Steenstrup, 1883). These consist of marine Upper Cretaceous shales and sandstone with belemnites (Birkelund, 1956) and numerous plant impressions. The sediments are overlain by basalt breccia which has in many places slipped down over the sediments. This breccia is of the brown type, its upper boundary is an almost flat surface, and it is overlain by grey breccia with typical cross-bedding dipping to the south-east. The top of the basalt breccia lies at 350 m, and above this come the typical thinly-bedded, zeolite-rich, olivine-rich basalts. At the breccia/olivine basalt boundary there may be some interlayering of the two types, but this cannot be stated with certainty as the locality is affected by landslips and exposures are few. The top of the mountain ridge here is formed of plagioclase-porphyritic basalt flows, and the ol/pl boundary must be placed 100–150 m below the summit. According to the new, revised map published in 1965 this summit is 1133 m high, which means that the ol/pl boundary is just about 1000 m above sea level. In 1956 Knud Jakobsen found interbasaltic coal-bearing sediments at about 1000 m on the south-west side of Simiútap kûa (A.Rosenkrantz, pers. comm.). These sediments must be the equivalent of the interbasaltic sediments occuring at the boundary between the lower and upper basalts at 300–400 m on the north-east side of the valley.

The result of these investigations in the Simiútap kûa valley can be summed up as follows:

(1) Pre-basaltic faulting in the Simiútap kûa valley resulted in a significant downthrow on the south-west side and deposition (or preservation) of Cretaceous sediments and subaqueous lava (basalt breccia formation). This was overlain by ca. 600–700 m of subaerial olivine-porphyritic basalt flows, of which only the uppermost 100–200 m overlapped onto the upthrown gneiss area north-east of the valley. After the deposition of interbasaltic sediments followed the extrusion of plagioclase-porphyritic flows totalling at least 1000 m in thickness (fig. 11).

(2) After extrusion of the plagioclase-porphyritic lavas movement was renewed on the fault, but this time with a downthrow of ca. 600 m on the *north-east* side. It is only the net result of movements on the fault that we observe today, and only the fact that the ol/pl boundary is preserved on both sides of the valley allows us to recognise the movement that has taken place since this boundary was established.

The north-west side of Umîarfik fjord does not appear to have followed the same tectonic development. Gneiss crops out roughly in line with the Simiútap kûa valley. Over this there is basalt breccia, basalt and, close to the base of the basalt, an intrabasaltic breccia. Higher up, due north of the delta at Nerutussoq, interbasaltic sediments have been observed; these were also noted by Steenstrup. The base of the upper basalts is seen at a lower level here than north-east of Simiútap kûa.

In the innermost part of Umîarfik fjord strong relief in the pre-Cretaceous gneiss surface was observed; tuff and coal-bearing sediments occur in the marked depressions. Olivine-porphyritic basalt has been observed in a few places at a low level, but otherwise the upper basalt series dominates completely. Sills showing beautifully developed columnar jointing with thin six-sided columns have intruded the tuffs and coal-bearing sediments between the gneiss and basalt. It seems to be a general character that the surface of the gneiss lies higher on the east side of the fjord than on the west, but no trace of a fault in the fjord was seen.

On the north side of outer Umîarfik fjord—that is in the southern part of Ingnerit peninsula—the flows of the upper basalt series are nearly horizontal; farther west the dip increases to 3° W. The north side of Skalø is disturbed by landslides. Ingnerit bay, on the west side of the peninsula of the same name, has nearly horizontal flows at the inner end, while in the outer part the flows "kink" and begin suddenly to dip 3–4° WNW. At sea level in this bay there are sediments belonging to an interbasaltic series of uncertain age, some hundreds of metres thick, which Rink (1853) visited in 1848–49. The series consists largely of tuff with intercalations of coal. The rocks seem somewhat disturbed, the dips being noticeably steeper than in the overlying basalt flows, although it seems that, as in the basalts, the easternmost sediments are almost horizontal.

Along the north part of the west coast of Ingnerit peninsula as well as on the east coast of the island Qeqertaq the layers dip 2° SW. The gneiss floor to the basalts is seen in the northern parts of Ingnerit and Qeqertaq, and the distribution of gneiss and basalt is very close to that shown in the map drawn by Rosenkrantz (1952). The "gneiss line" is thought to lie roughly on line with Simiútap kûa, i.e. NW–SE. No corresponding tectonic line could however be detected. Only the upper basalts are present; few sills were observed.

One of the northernmost basalt localities, that in the bottom of Laksefjorden at Orpît, was visited in bad weather. It was the author's impression that here there are the remains of a sill overlying the undulating gneiss surface.

The return journey southwards took the author west of Fladøerne in conditions of bad visibility; the only landing made was on Kigataq. The basalt here dips gently W or SW. A single normal fault was seen on the SE-facing coastal slope of the island.

On the west coast of Skalø four faults were observed, all repeating the basalt series which here dips at 6–7°. The faults strike NW–SE but for one which strikes N–S. At the southern end of the island several fractures strike N–S; one has been intruded by a basalt dyke.

CONCLUSIONS

The conclusions which can be drawn from the results of the reconnaissance can be said to answer the three main questions set out on p. 11.

(1) A division of the basalt series into a lower olivine-porphyritic and an upper plagioclase-porphyritic series is feasible. The ol/pl boundary runs through Svartenhuk Halvø from Tasiussaq bay in the south to the west side of Nerutussoq river in the north. Taking into account the considerable regional dip we see in the southern part of this stretch, the boundary, at sea level, is reckoned to form a curved line concave towards the west. Most of the highest summits (over 1000 m) east of this curved line have plagioclase-porphyritic basalt at the top.

The thickness of the lower basalt series, including the basalt breccia which petrologically may be included in this series, is greatest in the southern part of Svartenhuk Halvø. Disregarding the aberrant dips in the coastal blocks along the south-east shore and the exaggerated dips which are thought to be due to drag on a Kugssineq–Arfertuarssuk fault zone, and reckoning with a gradual increase in dip from 3–4° in the east to 8–10° in the west, one can calculate a total thickness for the series of 4 km. However this must be reduced to perhaps the half, when one takes into account repetitions caused by faulting. Hence we arrive at a thickness of the order of 2 km for the lower basalt series on Svartenhuk Halvø. Drawing on his experience from Nûgssuaq and Disko, and remembering that some of the series in probably "missing" in the Kugssineq–Arfertuarssuk fault zone, the author is inclined to regard this figure as too low. While on Disko the thickness of the lower basalt series is at the most 2 km, on Svartenhuk Halvø it is perhaps more realistic to reckon with 2½–3 km. The E–W lateral extent of the series is about 35 km, and the original lateral extent in this direction cannot have been more than about 70 km, as the rising gneiss and metasediment terrain to the east and north-east sets a limit on this side. This figure seems low when compared with a possible 130 km E–W lateral extent on Nûgssuaq and Disko, but the situation on Svartenhuk Halvø is in one way different from that in the southern area: the feeder dyke swarm lies considerably nearer the boundary fault system against the basement than is the case on Nûgssuaq and Disko. The lateral spread of the earlier flows was limited, and only the uppermost flows of the lower basalt series were able to spread out over the high, strongly undulating basement terrain. Although the eastern and north-eastern limit of the lower basalt series is set by the Itsako–Simiútap kûa fault system, there is also a wedging-out of the series to the north-west. This may be partly due to the higher basement north-west of Umîarfik, but the lower basalt series south-west of Simiútap kûa is also less thick; including the basalt breccia, the series here is less than 1000 m thick (p. 20). The ol/pl boundary must fall at more than the 2–3° shown by the profiles if it is to come down to sea level at the Nerutussoq delta; it should be noted that no faults are seen in this particular area (fig. 11).

The above gives what is probably in the main a correct impression of the olivine-porphyritic basalt series on Svartenhuk Halvø. Detailed mapping can fix the boundary of the series across the peninsula, and will also show how much of the series has managed to extend over the basement areas to the east and north-east.

(2) The general tectonic pattern with repetition of the lava series in connection with tilting of fault blocks is seen everywhere where conditions for observation are suitable and to a degree with which the author is familiar in Nûgssuaq and Disko. It is important to emphasize that this type of faulting is also seen where the dip of the lavas is low, for example in the mountains Igsiatdlaup qáqâ and Kakilisait qáqât (dip 3–4°; figs 3 and 4), on Skalø (dips 2–9°), and on the island Kigataq, the westernmost locality (dip 1–3°). Gentle anticlines and synclines (such as just east of the Svartenhuk headland, fig. 11) reflect varying degrees of subsidence of the basement; similar anticlinal and synclinal structures on Disko and Hareøen are interpreted in the same way. Thus the tectonic pattern in the entire region bears witness of a horizontal extension in an east-west (SE–NW or NE–SW) direction, and *never* of a compression and shortening.

Large fault zones are believed to be present in Arfertuarssuk fjord and the Kugssineq valley, and between Ubekendt Ejland and south-east Svartenhuk Halvø, and have been proved in Simiútap kûa (here younger than the ol/pl boundary). These large fractures have their analogues on Nûgssuaq and Disko, where they often cut flat-lying basalts. The fault in Simiútap kûa bears witness of fracturing at different times and with different senses of movement. A somewhat similar development has taken place along the Vaigat and Itivdle faults (p. 8). A magnetic profile of vertical intensity Z was measured in 1956 across the Itivdle valley on the north coast of Nûgssuaq. The line of profile, which was more than 4 km long, extended from the basalts and fault zone at Tuperssuartâ in the west to Pujortoq west of Niaqornat in the east. Distance between stations was 50 m. The profile showed a gradual fall in Z of 1200γ in 4 km entirely over sediments between the fault and Pujortoq. The first 800γ fall in Z took place in the first kilometre from the fault zone. The interpretation of this is given in fig. 2; the basement is interpreted as lying deeper east of the fault than it does to the west. Tectonic activity took place before volcanism (and probably activated the volcanism) and again during and after the eruption of the basalts.

A subdivision of the two basalt series on the basis of macroscopic characters was not possible. Good marker horizons such as the iron basalt and intrabasaltic breccia proved to be on Disko and Nûgssuaq were not seen on Svartenhuk Halvø (detailed mapping may yet reveal them) and thus detailed structural observations are also lacking.

(3) The basalt formation that covers the basement from Ingia Fjord in the east to the country south of Prøven in the north is nearly everywhere the olivine-free upper basalt series. This means that here, just as farther south, the upper basalt series has a far greater horizontal extent than the lower series; the upper series in the north has probably also been erupted from scattered central eruptions.

Special mention should be made of Munck's observation (Munck in Rosenkrantz *et al.* 1942, pp. 43–46) that basalt breccia overlies metasediments between 1100 and 1250 m on the "1313 m mountain" north of Itsako in the eastern part of Svartenhuk Halvø. Munck wrote that the breccia is overlain by thin amygdaloidal lava flows; these are probably olivine basalt but this was not stated. The above-mentioned summit is shown on the new map as having a height of only 1211 m, so that the breccia/basalt boundary must be at a height of 1150 m. If one projects the plane of the breccia/basalt boundary in the valley of Usuit kûgssuat (where the dip is 3–4° SW) back to the north-east, it will pass over Firefjeld to a level some 600–700 m above the position given by Munck for this boundary on the "1313 m mountain". This perhaps provides evidence of a sinking since volcanism of the metasediment area to the north-east in relation to the Cretaceous–Tertiary sediment and basalt area to the south-west, a situation similar to—indeed a continuation of—that on the Simiútap kûa fault; this however cannot be proved on the basis of the existing information. There are a number of points which are not clear in this connection, for example (1) the extent of the breccia overlying basement; Munck (op. cit.) mentions that the base of the basalt formation occurs in the steep wall on the western side of the valley Kangiussap auvfâ, and that the thickness and height of the formation here corresponds closely to that of the breccia wall on the "1313 m mountain". She thought therefore that breccia must be present west of the valley, although unable to confirm it, and that "it extended in a northern direction, as far as one could see" (op. cit., p. 46). (2) Is the breccia level north and south of Itsako the same?

At all events the youngest movement on the Simiútap kûa fault is so large that there must be some trace of it farther east: the relations described point to a continuation in the fjords north and south of Itsako. However it was the localisation of the ol/pl boundary that revealed the latest movement in the Simiútap kûa valley, and the positioning of this boundary in eastern Svartenhuk Halvø will probably solve the structure there also.

The sills which are characteristic of the upper basalt series outside areas where the lower basalt series is present, constitute another feature that Svartenhuk Halvø has in common with Nûgssuaq and Disko.

The upper basalt series has as mentioned a considerable horizontal extent; from Fladøerne in the west to the Inland Ice in the east is a distance of about 140 km.

There is not much information regarding the thickness of this series; it is seen in areas where the dip is often low, and faults which repeat the succession are frequent. The series has most likely arisen by eruption from scattered necks and fissures; its wide lateral extent bears witness of an enormous lava production, but this need not also be matched by a great thickness. It is in fact quite likely that the thickness varied considerably within the region.

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