

MEDDELELSER OM GRØNLAND

UDGIVNE AF

KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

Bd. 137 · Nr. 5

DE DANSKE NÛGSSUAQ EKSPEDITIONER 1938 OG 1939

UNDER LEDELSE AF ALFRED ROSENKRANTZ

ON THE GEOLOGY AND
PETROGRAPHY OF THE WEST GREENLAND
BASALT PROVINCE

PART V

TWO MAJOR DOLERITIC INTRUSIONS OF
THE NÛGSSUAQ PENINSULA

BY

SOLE MUNCK

WITH 13 FIGURES IN THE TEXT AND 15 PLATES

KØBENHAVN

C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI A/S

1945

UDGIVET MED STØTTE AF CARLSBERGFONDET
OG RASK-ØRSTED FONDET

CONTENTS

	Page
Preface	5
I. Introduction	7
II. The Quartz-Doleritic Intrusion at Serfat	11
A. Historical Remarks	11
B. Investigations in the Field	12
C. Petrography	17
III. The Doleritic Intrusion at Atanikerdluk and in the Sarqaq Valley	34
A. Historical Remarks	34
B. Investigations in the Field	37
C. Petrography	40
IV. Comprehensive Remarks on the Chemical Relations of the Intrusions ..	55
V. Age Problems and General Remarks	57
VI. Literature	60

PREFACE

The present work deals with some geological observations, which were made in the course of the Nûgssuaq Expeditions 1938 and 1939. It is a pleasure for me to thank Professor ALFRED ROSENKRANTZ, the leader of these expeditions, for the opportunity given me to work within the Tertiary basalt area of West Greenland, and for his encouragement and the interest which he always took in my work both in the field and at home.

Further, I should like to thank the members of the two expeditions for good comradeship, and in particular I owe a debt of gratitude to Professor ARNE NOE-NYGAARD for pleasant collaboration on the expedition and in the laboratory.

I am greatly indebted to Professor ASSAR HADDING of Lund for the readiness with which he took charge of the preparation of our thin slides during these difficult years.

The chemical analyses have been carried out by SVEN PALMQUIST, Ph. D., while the microphotographs have been made by Mr. CHR. HALKIER, and the translation into English has been undertaken by Mrs. ASLAUG MIKKELSEN, M. A.

I. INTRODUCTION

A huge fault cuts right across Nûgssuaq, being immediately obvious towards south in the Sarqaq valley¹), on the eastern side of which gneiss rocks are seen, more than 1000 m in height and here and there with basalt on the top, while the 1000 m high mountains on the western side exclusively consist of sedimentary deposits, also capped by basalt.

This striking geological feature in the Sarqaq valley has been observed and described by earlier explorers, first and foremost by K. J. V. STEENSTRUP (32, 33).

HEIM (11) was of the opinion that the gneiss country represented a pre-Tertiary coast cliff, at the base of which the sediments were deposited, but he also mentions as a possibility that the western area has been down-faulted between 500—1500 m in relation to the eastern one.

RAVN (24) is clearly in favour of a fault, which he thinks has occurred at a comparatively late period, after the deposition of the sediments (and the basalt). This fault was thought to extend from the Sarqaq valley in the south to Kûk in the north.

At Kûk, a river situated on the north coast of Nûgssuaq *vis à vis* Umanak, geological conditions similar to those of the Sarqaq valley had been observed. RAVN writes on this subject that, while the boundary between the gneiss and the covering sediments is situated almost at sea level west of this river, the gneiss immediately east of Kûk reaches several hundreds of metres.

KRUEGER (19) is also in favour of a fault, whereas KOCH (14) regards the gneiss towards east as a coast cliff, which has existed from the beginning of Cretaceous time.

The Nûgssuaq expeditions 1938/39 offered opportunities of undertaking rather exhaustive investigations of the sediment series, par-

¹) Sarqaqdalen (Sarqaq valley) was the name we used in 1938 for the huge valley west of the outpost Sarqaq with a north-southern strike and traversed by the large river Kûgssuaq. The valley has formerly been called the Kûgssuaq valley, but this name is not very apt, as Kûgssuaq is the Greenland name for every fairly large river.

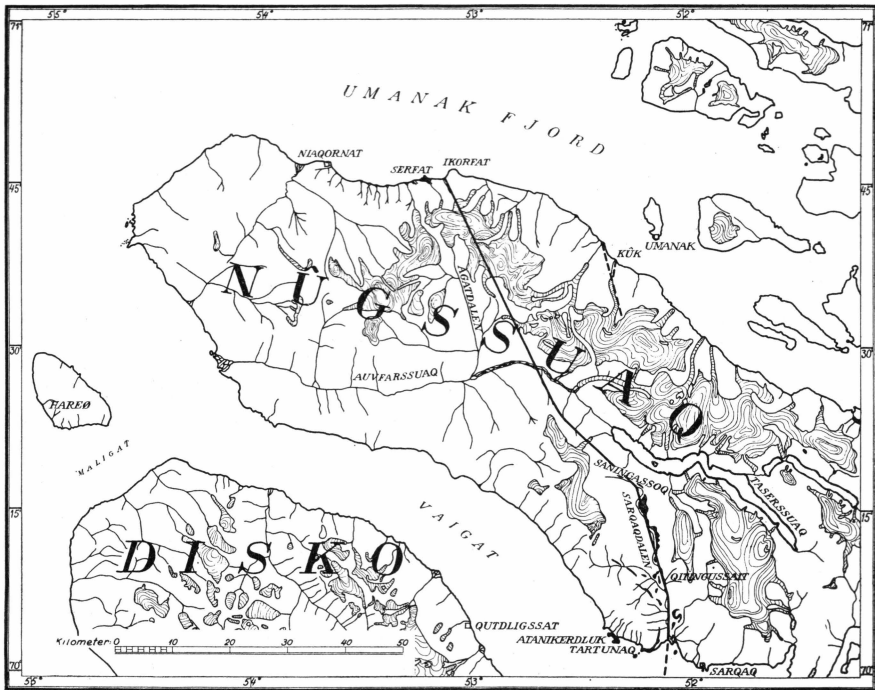


Fig. 1. Map of Nûgssuaq. The line drawn in full marks the chief fault across Nûgssuaq, the dotted line at Kûk a secondary throw. The areal distribution of the doleritic intrusions is drawn in black. Based upon maps (nos. 70 V. 1. & 70 V. 2.), published by the Danish Geodetic Institute. Fault line after the map of ROSENKRANTZ (28 a).

ticularly on the north coast of the peninsula, and it could be established with certainty that it was here a case of a large-dimensioned fault. According to ROSENKRANTZ (28 a, 29) the chief fault zone across Nûgssuaq has, however, a direction somewhat different from what had formerly been supposed. The southern part coincides with the old records, passing through the Sargaq valley in a northern direction to Sarningassoo, which lies south of the western end of the large lake, Taserssuaq. But from here it turns in a northwesterly direction to the east of the valley Agatdalen, the large side valley of Auvfarssuaq, and intersects the north coast slightly west of the short and broad gneiss peninsula Ikorfat (fig. 1).

West of this line no gneiss whatsoever is to be found, whereas to the east it rises far above sea level, in certain places as high as 2000 m. On the north coast the total throw is very great. When comparing the fossiliferous beds immediately underlying the basalt above Ikorfat, (i. e. to the east of the fault), with contemporary beds west of it, there is a difference of level of up to about 2000 m (28 a). This huge fault has, however, not been created all at once, but at various stages, partly before and partly after the Tertiary basalt eruptions (28 a). Above



A. ROSENKRANTZ phot. 5/1939.

Fig. 2. The doleritic sill at Serfat seen from northwest. In the background to the left Ikorfat. The contact metamorphosed, white sediments, which separate the dolerite from the overlying ultrabasic sill, are distinctly seen. At the top of the picture the post-basaltic throw; a large glacier has made its way along this fault zone a little to the west of Ikorfat (Moreover see the explanation given below).

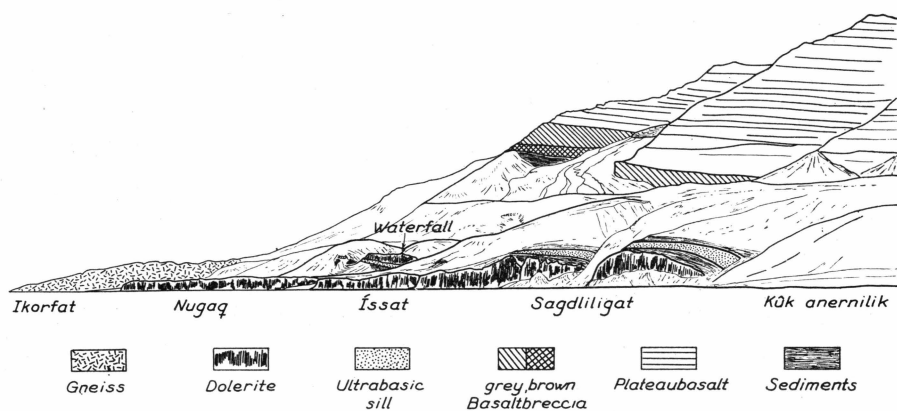


Fig. 3. Sketch of the geological conditions at Serfat. The faint signature of the foreland means screes and morainic cover.

Ikorfat a dislocation is found to have taken place in post-basaltic times, as easily recognizable beds of basalt breccia are situated at a level between 300 and 400 m lower on the west side than east of the fault zone (figs. 2 & 3).

Smaller secondary faults are found both towards north at Kùk and in the southern part of the Sarqaq valley.

The doleritic intrusions at Serfat, at Atanikerdluk and through the Sarqaq valley, which will be dealt with in the following, are situated at the northern and southern end of the said fault zone respectively. Considering their identical geological position as well as their great similarity in the field, they will be dealt with together, in spite of the fact that they offer certain points of difference, both from a chemical and from a mineralogical point of view.

II. THE QUARTZ-DOLERITIC INTRUSION AT SERFAT

A. Historical Remarks.

Serfat is situated on the north coast of Nûgssuaq, about 6 km west of Ikorfat, and a little less than 20 km east of the outpost Niaqornat (fig. 1), the steep, dark brown coast cliffs being very conspicuous when viewed from the sea. Consequently, it is all the more peculiar that exploring geologists of former times have given so few and contradictory data as to this locality.

GIESECKE's travelling journal of 1811 (7, p. 344) contains the following information regarding Serfat: "Bey dieser aus Massenbasalt bestehenden Næs, einem Lieblingsaufenthalt der Theiste (Uria Grylle) grönländisch Sergveit genannt, von welchen die Stelle den Namen hat, hört der Sandstein auf, und die Trappformation vertritt dessen Platz bis an die See."

RINK (26, p. 55) gives some determinations of the specific gravity of various Greenland basalts, among which "a crystalline trap from Sarfvæt, the Omenak district: 2.88"¹).

In 1911 HEIM writes (11, p. 181): "Bei Ekorgfat, 15—20 km nordwestlich Karsuarsuk ragt ein Gneishügel 200 m hoch in die umgebenden Sedimente hinauf. 3—4 km weiter westlich folgt wieder ein ähnlicher Hügel, Sarfat genannt."

In 1929 KOCH mentions (14, p. 98): ". gneiss localities at Sarfat and Kaersut on the north side of Nugsuak Peninsula."

Finally BERTELSEN writes (8, p. 399, translation): "At the formerly mentioned Serfat-ness there is a soapstone bed, which at the present time is of practically no importance for the population"; this information would, however, seem to support the former indications of the occurrence of gneiss but has proved not to be correct (see p. 16).

¹) The collections of the Mineralogical Museum at Copenhagen contain some rocks from Serfat, collected by RINK, among which a coarse grained dark brown basaltic rock, labelled: "Crystalline trap (Dolerite). Serfat."

B. Investigations in the Field.

In the summers of 1938 and 1939 we had several opportunities of visiting Serfat. It proved to be a great sill-like intrusion of a coarse, gabbroic rock, the surface of which towards west, immediately east of the river Kûk anernilik, is visible a little above sea level. Towards east it rises gradually to 90 m and then falls to about 50 m, more or less retaining this altitude, until it disappears in an easterly direction, covered by loose deposits (figs. 2, 3, 4). However, outcrops in the loose deposits behind the coast cliff show that the sill in reality retains the same height until its eastern termination, an outcrop slightly farther into the country at a large waterfall, where the surface of the dolerite has been measured at 110 m above sea level (figs. 3 and 4), but here the upper part of the sill has been elevated about 20 m by an intruding ultrabasic sill, which will be mentioned below.

In spite of the somewhat irregular course of the surface it clearly appeared that the dip was south-southwesterly into the country. The total thickness of the sill is unknown, as it everywhere slopes steeply into the sea, so that the substratum is nowhere visible.

Above the huge Serfat sill another, hitherto unobserved greenish black, ultrabasic sill, some 10—20 m thick, was found. Towards west the two sills are separated by sedimentary layers thinning out in an easterly direction, and their relative ages could be determined in the easternmost locality at the waterfall, where the ultrabasic sill clearly penetrates the brown Serfat sill (fig. 3). This younger sill will be dealt with by A. NOË-NYGAARD in a subsequent treatise.

On the sketch map (fig. 4) an attempt has been made to give an impression of the extent of the sill. Farthest east at the coast is seen the ness, in Greenlandic called Nûgâq, which simply means that which projects. Farthest out it is 20 m high, at the base 40 m. In the small bay to the west of Nûgâq uncommonly fresh outcrops of the brown Serfat rock are found at the shore; but apart from these the fixed rock is here completely hidden under loose deposits and does not become visible until 90 m above sea level, where small exposures are seen.

To the west of the small bay the dolerite forms a couple of steep, not very projecting cliffs, which the Greenlanders call "Íssat" (fig. 5) i. e. snow-goggles, and from a bird's eye view they also look rather like the wooden snow-goggles, which the Greenlanders made in former times. West of "Íssat" follows the long, steep coast cliff, which the Greenlanders call "Sagdliligkat" i. e. "the boards", a very appropriate name, as the form of weathering of the steep walls gives it a close re-

semblance to long, vertical boards. These slopes are completely inaccessible, a splendid resort for the white gyrfalcon, which only hatches in such places. Thus, one of its nests was found there.

The sill itself consists of a dark brownish, speckled doleritic rock, which, when fresh, is greyish black and farther down becomes extremely coarse grained with plagioclase and pyroxene crystals up to a centimetre in length. The latter may, however, also attain a considerably greater length; thus pyroxenes a few millimetres broad have been measured,

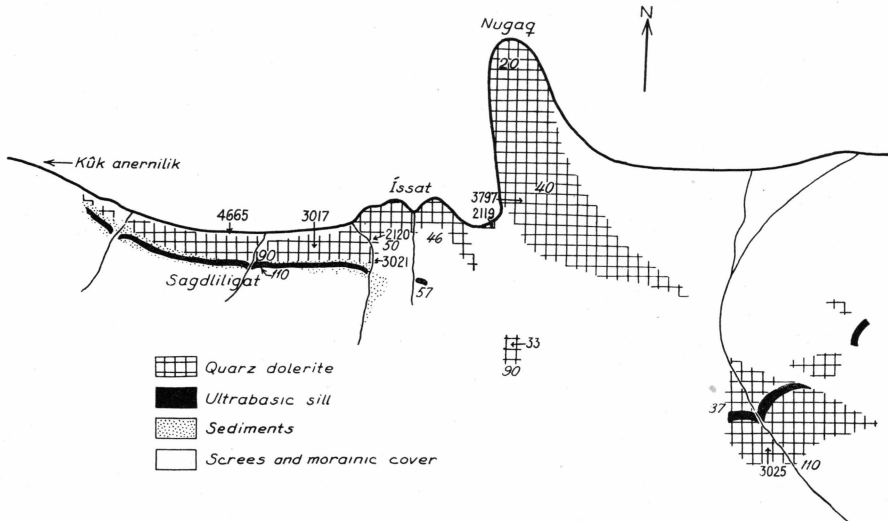
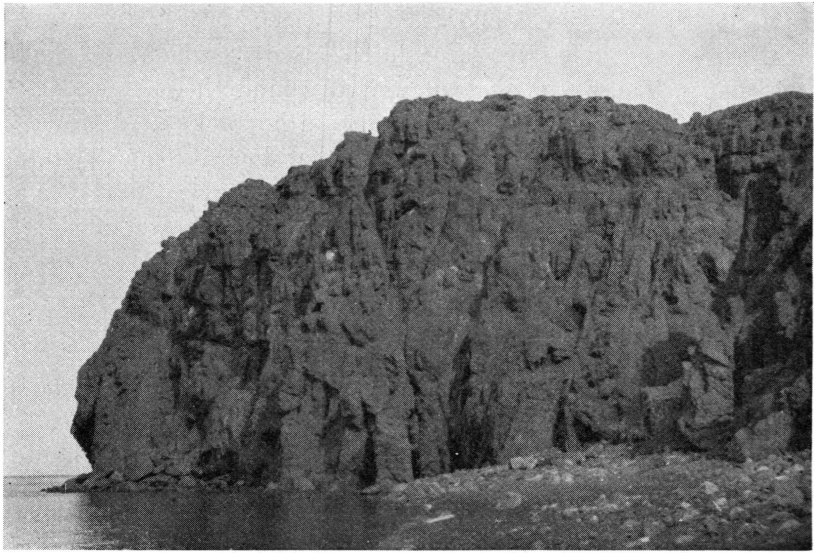


Fig. 4. Sketch map of the Serfat sill extending 2—3 km in an east-westerly direction. Ordinary figures refer to the specimens dealt with in the text, and the heights are indicated by italics.

which are more than 6 cm in length (pl. 1, fig. 1). Characteristic of the rock are further large tabular ore crystals (pl. 1, fig. 2), rarely measuring more than $\frac{1}{4}$ mm in thickness, but sometimes as large as 5 cm in length and 3 cm in width. In the greatly weathered sill are furthermore observed partly filled irregular cavities.

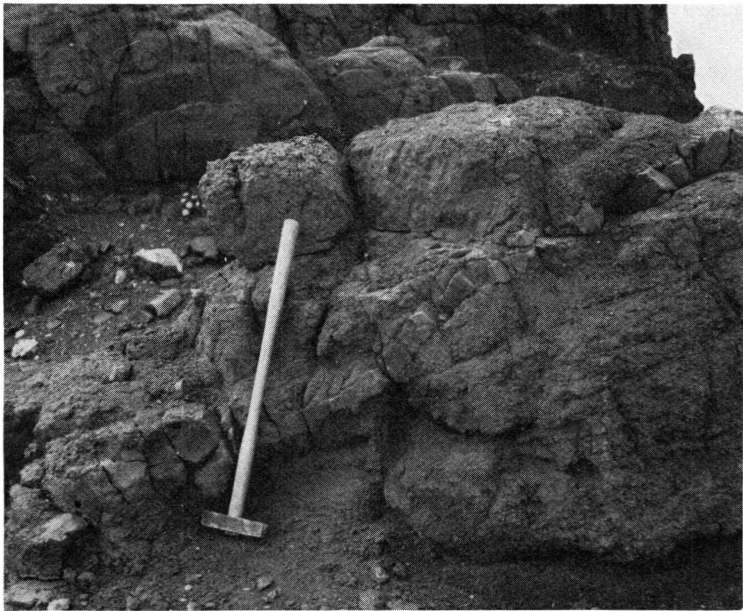
In certain places the dark brown rock passes gradually into lighter coloured areas, where the plagioclase dominates. The pyroxene and ore crystals, which are rather few in number, may also here attain considerable dimensions (pl. 1, fig. 3), whereas the plagioclase crystals attain no very great size.

Towards the top of the sill the dolerite is more fine grained and porous (pl. 2 fig. 4), and near the upper contact it passes into a whitish rock resembling a »white trap«.



AUTHOR phot. 25/7, 1938.

Fig. 5. Eastern view of Íssat, seen from the shore.



A. NOE-NYGAARD phot. 1/7, 1939.

Fig. 6. Leucocratic vein, in the Serfat sill.



AUTHOR phot. 5/7, 1939.

Fig. 7. The westernmost part of the Serfat sill, viewed from Sagdliligkat. Lowest down quartz-dolerite, higher up the younger ultrabasic sill and between them the contact metamorphosed, whitish shale.

In the Serfat sill there are three sets of joints, two of which are very pronounced and nearly vertical, one with a north-south, the other with an east-west direction, and the third one more or less horizontal. The latter is not particularly pronounced, but seems to show some degree of parallelism to the surface of the sill.

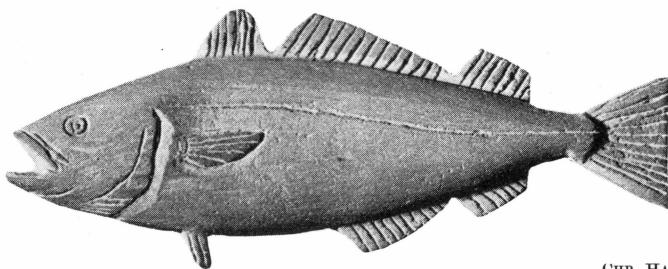
The dolerite is penetrated by narrow, leucocratic veins. They follow by preference the horizontal joint planes of the dolerite, but may also have an irregular course and at last thin out. They vary somewhat in thickness, veins having been measured of up to 10—12 cm, but as a rule they do not exceed a couple of centimetres. With their whitish grey, sometimes yellowish colour they stand out sharply against the dark dolerite. These narrow, fine textured secretions bear great resemblance to true acid veins, representing a highly specialized, late derivate from the dolerite magma (fig. 6).

The Serfat sill has intruded into sandstone and shales, and the contact effect on the latter has in certain places brought about a peculiar result. It is a case of shales, lying between the doleritic and the ultrabasic sills, and it is difficult to decide, whether it is the dolerite or the picrite basalt or perhaps both together, which have brought about this contact metamorphosis (fig. 7). The result has become a soft, whitish rock without pronounced schistosity and almost greasy to the touch. The

Greenlanders of former times—and on occasion also of the present day—have used it for the carving of art objects (fig. 8), and it is presumably this shale, transformed by contact effect, which constitutes the “soapstone bed” mentioned by BERTELSEN (3). Outwardly it also rather resembles this rock, though it has nothing whatever to do with it, as is also proved by the investigations, which have been kindly undertaken by R. BØGVAD, and which are given below.

BØGVAD writes: The material received is light grey and of the hardness of 2.5. It is infusible before the blow pipe and shows a distinct Al-reaction. When heated in the closed tube it produces water.

Under the microscope it is seen to be composed of an aggregate of tabular mica-like particles, which show a faint birefringence when lying on the cleavage plane. By this orientation the refractive index is



CHR. HALKIER phot.

Fig. 8. Cod-fish carved by the hunter KRISTEN KRUSE from Niaqornat. The material is the white, contact metamorphosed shale from Serfat.

slightly greater than 1.56. When seen from the edge the plates show a positive elongation.

In the aggregate there are numerous opaque particles, up to 5—10 μ large, and a number of particles of the same order of magnitude with a high refringence. Besides there is some quartz.

After centrifugation with methylene iodide traces are seen of zircon (?) titanite (?), apatite, magnetite and an isotropic mineral of a high refringence.

The analysis of the material has been undertaken by H. BUCHWALD, civil engineer. After the sifting of the analysis material some quartz was found in the residue.

The material analyzed is, as appears from the preceding, not pure, and it has not been possible to refer the chief part of the constituents to any known mineral. However, there seems to be some likeness between BUCHWALD's analysis and analyses of the so-called illite group published by GRIM and BRADLEY (Journ. of Am. Ceram. Soc. vol. 122, 1939, pp. 157—164).

	BUCHWALD Contact metamorphosed shale, Serfat %	GRIM & BRADLEY Illite-group %
SiO ₂	55.17	52.80 — 50.10
TiO ₂	identified but not determined	0 — 0.53
Al ₂ O ₃	27.47	24.40 — 25.90
Fe ₂ O ₃	5.92 ¹⁾)	4.21 — 5.12
FeO	—	1.10 — 1.69
MgO	trace	2.70 — 3.93
CaO	0.78	0.09 — 0.47
Na ₂ O	3.12	0.05 — 0.20
K ₂ O	2.74	5.86 — 6.93
H ₂ O+	4.57 ²⁾)	6.83 — 8.32
H ₂ O÷	0.06	1.45 — 5.56
	99.83	

C. Petrography of the Serfat Rocks.

The rocks from Serfat are rather coarse grained and of a gabbroic habit. They show a holocrystalline texture, contain more or less quartz and may be comprised under the name of quartz-dolerite. As, however, the individual slides from various parts of the sill show certain dissimilarities, which cannot be expressed according to the hypabyssic, but only according to the plutonic terminology, I have in the following supplemented the name of quartz-dolerite with characterizing plutonic terms.

In the description below the rocks have been divided into five groups, four of which comprise the main rock, while the fifth deals with the leucocratic veins.

The first group covers the commonly found quartz-dolerites. They are dark rocks with the following mineral contents: plagioclase, pyroxene, olivine, ore, apatite, quartz, micropegmatite, calcite and various alteration products. The plagioclases show a pronounced zoning, and their cores range from basic labradorite to bytownite in composition, their outer zone from medium to acid labradorite. The pyroxene is a pigeonite with $2V\gamma$ of about 47° , and c/γ of 37° (averages of 12 measurements). The axial angle of the olivine is 90° .

The second group contains a more rarely found variety of the dark quartz-dolerites, just mentioned. They are rather light coloured rocks

¹⁾ Total iron calculated as Fe₂O₃. ²⁾ Determined by ignition.

which, however, show the same mineral contingent as the dark type, though in differing proportions, the quartz and micropegmatite thus occurring in far greater quantities. The plagioclase is more acid, the core as a rule being an acid labradorite, the outer zone a medium to acid andesine.

The rocks belonging to these groups are all found in more central parts of the quartz-dolerite mass, whereas the two following groups cover rocks from the marginal parts of the Serfat sill.

The rocks of groups 3 and 4 (see below) are rather alike, except for no. 4 containing far more calcite and being richer in pores than no. 3. The mineral content agrees with that of the two first groups; only micropegmatite has not been observed. The increasing CO₂ contingent towards the contact with the sediments might possibly indicate a supply from the wall rock.

The leucocratic veins of group 5 contain acid plagioclase, alkali-felspars, quartz and micropegmatite, all of which are found intergrown in a rather intricate way. Only small amounts of dark constituents are observed.

According to the quantitative mineralogical classification of JOHANNSEN (13) the rocks belonging to the groups 1, 3 & 4 are all of a quartz-to granogabbroic type, while those of group 2 verge towards a granodioritic type, and the aplitic rock of group 5 corresponds with granodiorite-aplite in composition.

The division has consequently been as follows (the rock numbers in brackets are described in the text below):

1. Main rock, dark quartz-dolerite of quartz- to granogabbroic type (3797, 2119).
2. Variety of 1, light coloured quartz-dolerite of granogabbroic to granodioritic type (4665).
3. Transition rock between 1 & 4 (3135).
4. Rocks from upper contact zone (33, 2120, 3019, 3021).
5. Leucocratic veins of granodiorite-aplitic type (3017).

In these samples as well as in those from the Sarqaaq valley area the optical determinations of plagioclase, pyroxene and olivine have been undertaken on a Fedorow table of Leitz' construction. The anorthite contents of the plagioclases are determined according to REINHARD'S diagrams (25). The c/γ of the pyroxenes are constructed according to the method indicated by BURRI (5), and their composition is found out by plotting the measurements in the diagrams of TOMITA (34). The fayalite percent of the olivine is computed according to the determinations

of WAGER & DEER (37). As far as possible, several individuals of each mineral have been measured in every single slide. The transformation products have only been determined in exceptional cases. In the use of textural terms KROKSTRÖM (16) has been followed.

Planimetric determinations were undertaken in all the sections, where it was possible to do so, and the measurements were made by means of a Leitz integration table. The length of the indicatrix varied from 15 cm in the very fine grained aplitic rocks to 55 cm in the most coarse grained dolerite.

1. Dark Quartz-Dolerite.

3797. This sample was taken on the eastern ness Nûgâq and is a dark, brownish black rather coarse grained rock, in which the shining cleavage faces of the dark greenish pyroxenes, several centimetres in length, stand out very prominently, especially on fresh surfaces of fracture. With the naked eye it is immediately apparent that all the larger pyroxene crystals are twinned. Further, one notices the peculiarity that these larger pyroxenes are arcuated, the cleavage planes presenting an undulating course.

The felspar is not very marked and has a dark greyish colour. Consequently one gets the impression that the rock is rather dominated by the dark constituents.

In a few places ore is seen in irregular grains, but neither these nor the quartz can be observed without a pocket lens.

Under the microscope it appears that the plagioclase quantitatively far predominates over the pyroxene which, it is true, occurs in very large, but scattered crystals. The texture is only ophitic in the sense that small idiomorphic laths of plagioclase are enclosed in the pyroxene individuals, and broad felspar laths with pronouncedly tapering ends protrude far into the pyroxene (pl. 3 & 4, figs. 8, 9, 10, 11). This indicates that the plagioclase has begun to crystallize before the pyroxene, but on the other hand the latter is frequently idiomorphic towards the plagioclase, so that the periods of crystallization of these minerals can not be far apart.

The mineral constituents are: plagioclase, pyroxene, olivine, ore, apatite, quartz, micropegmatite, calcite and various alteration products.

The plagioclase appears as long, narrow, twin-lamellated laths and as broad equidimensional plates, both as a rule with pronounced zony structure. 2×0.5 mm laths are not rare, but as a rule the plagioclase individuals are considerably smaller. They show a rather high degree of idiomorphism. Albite and Karlsbad twins are of common occurrence, and Pericline lamellæ are by no means rare. Baveno twins

have been observed in three cases in the slide. The measurements yielded the following result¹):

% An, core	% An, outer zone	2 Va, core
82	59	83°
80	—	—
—	61	—
—	60	—

The pyroxene is colourless and occurs, as already mentioned, in twin-lamellated individuals, which are often of a rather considerable length. In the section they measured up to 3×0.9 mm and 5.6×0.7 mm. The twin plane halves the individuals in the longitudinal direction, and as the pyroxene is striated parallel to the base, the result has been a characteristic bilateral symmetric "herringbone structure" (pl. 4, fig. 11). This delicate basal striation seems to be accompanied by intergrowths of a greyish green, fine-fibred mineral with low interference colours and a characteristic schillerization, but the single fibres are so small that they escape further examination.

A quite similar structure is described by HARKER (9, pp. 108—110 and plate XVIII, fig. 4) from the augite of the Skye gabbros, and is by him called salite-structure. This structure is in the Serfat rocks, as well as in the Skye gabbros, most pronounced in the coarser textured rocks from the central part of the intrusion. HARKER regards it as an original structure, whereas according to other authors it is of secondary origin.

In some of the pyroxene crystals of the Serfat rocks this structure is so predominant that nothing whatsoever is left of the pure pyroxene, and the entire individual shows a peculiarly flapping extinction, through which one may now and then distinguish a veiled hour-glass structure. On a few fresh cores of pyroxene the following determinations could be undertaken:

$2 V\gamma = 46^\circ$	$c/\gamma = 38^\circ$	$\text{En}_{61}\text{Fs}_6\text{Wo}_{33}$ (according to TOMITA (34))
$2 V\gamma = 44^\circ$	$c/\gamma = 34^\circ$	
$2 V\gamma = 47^\circ$	$c/\gamma = 35^\circ$	

In the slide are found some few crystals of an almost fresh olivine (pl. 4, fig. 10), the optic angle of which is measured at 90° , that is 13% Fa. Along the borders and cracks the olivine is changed into a dark, brownish green alteration product, which elsewhere in the slide pre-

¹) All the values of this and the following tables are measured (not calculated), and figures placed on the same line indicate that the measurements originate from one and the same individual. The composition of the pyroxene (according to TOMITA) is adjoined to the most reliable measuring of each group.

dominates to the exclusion of fresh olivine. These pseudomorphs are nearly always found along the borders of the big pyroxene crystals, and the small, fresh areas, which are sometimes seen in the pseudomorphs, are found to be pyroxene, showing the same extinction and optical orientation as the neighbouring big pyroxene crystal. At a certain period the remaining fresh olivine has been replaced by pyroxene, which has continued its growth and formed the afore mentioned big pyroxene crystals. The transformation products of the olivine have been left unaffected.

The ore is very sparse and occurs chiefly as irregularly bounded individuals and crystal skeletons; in a single place a crystallographically well defined individual has been found. The ore is always idiomorphic on the pyroxene, sometimes also on the plagioclase, but on the other hand small idiomorphic plagioclases are often seen in the ore.

The fact that the relations of the minerals vary in one and the same slide leads to the conclusion that the crystallization periods of the three minerals (inclusive ore) overlapped considerably.

Apatite occurs, but is not common.

The last constituents to solidify are quartz and micropegmatite (pl. 3, fig. 9). Of these especially the quartz has a wide interstitial distribution as xenomorphic individuals, but it also occurs in certain parts of the section as micropegmatitic intergrowths with turbid orthoclase in broad brims surrounding the plagioclase laths.

Calcite is extremely rare in this slide, whereas it is very conspicuous in all the others.

The sequence of crystallization: olivine, plagioclase, pyroxene does not hold good throughout the slide, as some of the plagioclase is idiomorphic on olivine and thus preceded the olivine in crystallization.

The planimetric analysis yielded the following result:

Plagioclase.....	56.4 %
Pyroxene, fresh 5.2 }	22.8 -
— transformed 17.6 }	
Olivine, fresh 0.3 }	10.1 -
— pseudomorphic 9.8 }	
Ore.....	1.1 -
Quartz.....	4.8 -
Micropegmatite	4.7 -
Calcite.....	0.1 -

2119. The sample was taken in the small bay immediately west of Nûgâq from an outcrop at sea level. The rock is dark, brownish black and on weathered surfaces of a peculiarly speckled appearance, re-

minding greatly of diabase in the continental sense of the word. The rock is rather dark, considering that 50 per cent of it consist of plagioclase. It seems more fine grained than the preceding sample, although the felspar microscopically has the same dimensions as in 3797. Its more fine grained appearance is exclusively due to the fact that the pyroxene individuals attain a far smaller size. With a pocket lens it is possible to see that the larger pyroxene crystals also here are arcuated.

The rock chiefly consists of plagioclase and pyroxene with small quantities of ore and very little apatite. Olivine pseudomorphs are rare, and interstitially are seen quartz, potash felspar, micropegmatite, chlorite and apatite.

The plagioclase mostly appears in laths, which may be 2×0.1 mm in size, but are generally much smaller, and more rarely in rhombohedral plates, the largest diameter of which has been measured at 1.3×0.8 mm. They are all pronouncedly zonary, and along fine, irregular cracks a transformation into a greenish, birefringent mineral has taken place. The plagioclase is idiomorphic on most of the other constituents and is, for instance, seen protruding into and surrounded by pyroxene, as mentioned in detail in the preceding section. The twin laws are the same as in 3797, and in 5 cases Baveno twins have been observed. The anorthite contents and angles of optic axes have been measured at:

% An, core	% An, outer zone	$2V\alpha$, core	$2V\gamma$, outer zone
70	—	90°	—
74	58	—	—
76	46	86°	88° (?)
74	—	—	—
60	—	—	—

The pyroxene occurs in hypidiomorphic, more rarely idiomorphic crystals. Seen with one nicol they are greyish with a faint reddish tinge and no pleochroism. They show rather high interference colours and distinct cleavage cracks after (110). Like 3797 they show a striation parallel to the base, which becomes accentuated by the greyish green, fibrous intergrowths. The cores of the crystals are frequently transformed into a greenish chlorite, and the fresh pyroxene as a rule shows an undulatory extinction. Twins have only been observed in a few cases. A prismatic pyroxene individual has been measured at 1.3×0.6 mm, but they are generally much smaller and hypidiomorphic on the surrounding felspar laths. The universal stage determinations were difficult to undertake on the relatively small fresh areas found, and even in these the transformation products had penetrated into the cleavage

cracks, which consequently could only with some difficulty be adjusted, for which reason measurements of c/γ must be regarded with a certain reservation.

2 $V\gamma = 47^\circ$	$c/\gamma = 41^\circ$	En ₅₃ Fs ₁₅ Wo ₃₂
2 $V\gamma = 48^\circ$	$c/\gamma = 39^\circ$	
2 $V\gamma = 49^\circ$	$c/\gamma = 41^\circ$	
<hr/>		
Average: 2 $V\gamma = 48^\circ$	$c/\gamma = 40^\circ.5$	En ₅₃ Fs ₁₂ Wo ₃₃

Olivine is not present in a fresh state, but a few pseudomorphs on olivine have been observed, as a rule in connection with ore. The replacement of olivine by pyroxene, which is mentioned in the case of the preceding slide, also occurs here, but under far more indistinct and veiled forms.

Ore is more abundant here than in slide no. 3797. The individuals are crystallographically more or less well defined and are always idiomorphic on the pyroxene, as a rule also on the plagioclase.

Interstitially quartz is extremely wide-spread, often in xenomorphic individuals with an undulating extinction, rarer in micropegmatitic intergrowth with orthoclase more or less kaolinized, chlorite and small quantities of thin apatite needles. Quartz is further seen together with calcite, filling up smaller cavities in the rock, but this quartz has partly crystallographic outlines and is undoubtedly secondary. Measurements on the integration table yielded the following result:

Plagioclase	50.3 %
Pyroxene and transformation products as well as olivine-pseudomorphoses	26.2 -
Ore	4.0 -
Interstitial material and secondary quartz	15.6 -
Calcite	3.9 -

The texture is ophitic in so far as small idiomorphic plagioclase laths occur in the pyroxene individuals, but the latter appear at such great intervals between the criss-cross arranged plagioclase laths that the term ophitic is not very appropriate. For this slide, as for the preceding one, the term hypidiomorphic-granular would be more fit.

According to JOHANSEN'S quantitative system these two dark dolerites (viz. 3797 & 2119) are on the border line between granogabbro and quartz-gabbro, but the quartz contents of the two samples are so low that the distance to family 12 is not great. 3797 is nearest 237, i. e. granogabbro, while 2119 lies more distinctly within the area of 238, thus being purer quartz-gabbroic. The analysis of this rock agrees rather

closely with HAREWOOD's analyses of the quartz-dolerite from the great Whin Sill¹⁾ (12).

The felspar in these two samples varies from acid to basic labradorite, and as far as 3797 is concerned even with a bytownite core.

The pyroxene is a pigeonite, perhaps somewhat titaniferous.

The tabular ore crystals from the main rock (pl. 1, fig. 1) and mentioned on p. 13, have been examined by R. BØGVAD, who communicates the following: "Some of the material was separated from lighter impurities, i. a. by means of methylene iodide, and the heavy fraction was examined by A. H. NIELSEN:

	Weight %	Recalculated	"Dana"
Fe.....	35.68	39.2 %	36.8 %
Ti.....	26.98	29.7 -	31.6 -
O (calculated).....	28.25	31.1 -	31.6 -
Indissoluble (after K ₂ S ₂ O ₇).....	8.40	—	—
	99.31	100.00	100.00

The composition agrees fairly well with titaniferous iron. It is possible that other ferruginous minerals are present. However, the

Table 1.

1. Quartz-dolerite*). 2. Dark quartz-dolerite, Serfat, (no. 2119) Analyst SVEN PALMQUIST						
	1.	2.		NIGGLI-values		Miharaitic
SiO ₂	51.04	52.14	869			
TiO ₂	2.22	2.26	28	si	147	130
Al ₂ O ₃	13.69	12.18	120	ti	4.74	—
Fe ₂ O ₃	2.97	2.47	15	p	0.34	—
FeO.....	9.12	7.01	98	qz	15.84	—
MnO.....	0.22	0.11	1.5			
MgO.....	5.75	5.17	129	al	20.30	23
CaO.....	9.46	9.23	165	fm	43.74	42
Na ₂ O.....	2.27	2.24	36	c	27.92	27.5
K ₂ O.....	1.01	1.08	11.5	alk	8.04	7.5
H ₂ O+.....	1.48	1.42	—			
H ₂ O—.....	0.37	1.13	—	k	0.24	0.2
CO ₂	0.29	2.77	63	mg	0.50	0.5
P ₂ O ₅	0.30	0.33	2	c/fm	0.64	
S.....	0.12	—	—	Section IV		
BaO.....	0.03	—	—			
V ₂ O ₃	0.06	—	—			
Sum....	100.40	99.54				

*) Quartz-dolerite, Whin Sill, Scordale Beck, near Hilton Lead Mines, Westmoreland, England. HARWOOD analyst. (12, p. 513).

¹⁾ One of these analyses is cited in Table 1.

mineral could not be polished so as to make it possible by this means to identify it, but in the sample traces of pyrite were found."

Also the chemical analysis of rock 2119 indicates that the ore must be rather titaniferous.

As all the chemical analyses of the Serfat rocks show a very large CO₂ contingent, no attempt has been made to recalculate them to v. WOLFF-values, nor has the norm been computed. The NIGGLI-values have been compared with NIGGLI's "Die Magmentypen" (21), and the NIGGLI-values of the most closely related magma types found there are given in connection with every individual analysis.

2. Light Coloured Quartz-Dolerite.

4665. The sample was taken from a large loose block at the foot of Sagdliligkat, but was fixed higher up in the inaccessible part of the steep cliff. It is a light coloured, nearly white, medium grained rock, with black spots consisting of large ore flakes (titaniferous iron) and of long, greenish pyroxenes.

Under the microscope it proves to consist of the same constituents as the dark quartz-dolerite, but with certain essentially different relations.

The plagioclase is one of the chief constituents. It occurs in long laths, which are pronouncedly zonary. It is a labradorite, the composition of which is on an average more acid than that of the dark quartz-dolerite; the outermost borders, which could be measured, even correspond with andesine in composition. The very outermost, most acid part of each plagioclase individual could not be measured, being entirely penetrated by quartz forming a fine micropegmatitic intergrowth, which can, however, not disguise the fact that the extinction of this micropegmatitic felspar shows a continuation of the zonary structure of the pure plagioclase of the core. These fringes are often extremely broad, and consequently only a very small area in the centre consists of pure plagioclase, which has, however, practically always retained a rectilinear, crystallographic boundary towards the micropegmatite (pl. 5, fig. 12). The pure plagioclase cores are pronouncedly zonary, and on such the following values have been measured:

% An, centre of core	% An, margin of core	2 V γ , centre of core	2 V α , margin of core
51	—	76°	—
48	34	76°	78°
45	36	79°	—
54	—	—	—
55	—	—	—
51	—	—	—
50	—	—	—

It is rare to see plagioclase laths, which are not surrounded by micropegmatite. The size varies here as in the dark quartz-dolerite. A single individual has been measured at 4.32×0.9 mm, but sizes of 1.5×0.5 or still smaller are more common; the plagioclase is idiomorphic on the pyroxene, and in a few places it is seen to be tapering into pyroxene individuals as described in the case of 3797. In the plagioclase an incipient transformation into calcite takes place.

The pyroxene does not occur at all in a fresh and untransformed state. It is totally transversed into chlorite, calcite and dusty ore, the latter for the greater part following cracks and cleavages in the original pyroxene crystal. These three constituents are found in every single pyroxene individual, in varying proportions, and all of them are apt to protrude into cracks and fissures in the adjoining plagioclase. The characteristics of the chlorite are in favour of its being a penninite. It shows a pale-green colour with a faint pleochroism: α : pale, yellowish green, γ : green. It has a low relief and a very weak birefringence and anomalous, blue interference colours. It has a positive elongation and is optically positive with a very small angle of optical axes.

Besides occurring as a transformation product of the pyroxene, ore is also found as a primary constituent in oblong flakes and skeletons. It is a titaniferous ore.

Apatite needles, varying in length and width, are common, and in a few places biotite has been observed in very small hexagonal plates.

As already mentioned, quartz is very abundant in micropegmatitic intergrowth with felspar, but it is also seen as a filling in cavities together with calcite, as well as interstitially in xenomorphic individuals, not rarely with an undulating extinction (pl. 5, fig. 13). The cavities are generally filled in such a manner that the central part consists of calcite in large crystal individuals, surrounded by a narrow border of many small quartz crystals, which tend to be idiomorphic.

This slide is very rich in calcite, penetrating right across the rock constituents along cracks (pl. 5, fig. 13).

The planimetric analyses gave the following result:

Plagioclase	34.4 %
Transformed pyroxene	16.5 -
Ore	4.3 -
Quartz	6.1 -
Micropegmatite	35.3 -
Calcite	3.4 -

Owing to the composition of the plagioclase this lighter coloured variety of the dark quartz-dolerite is more on the lines of family 227 (13)

and becomes granodioritic in its composition. The chemical analysis of the sample also shows a fair agreement with the granodiorites; however, the FeO content is too large and the alkali percentage rather low. The mineral content of 4665, on the other hand, harmonizes very badly with that which is characteristic of granodiorite.

Table 2.

Light coloured quartz-dolerite, Serfat, (no. 4665).			Analyst SVEN PALMQUIST.	
			NIGGLI-values	Leucomiharaitic
SiO ₂	55.46	924	si 177	140
TiO ₂	2.03	25	ti 4.79	—
Al ₂ O ₃	13.78	135	p 0.19	—
Fe ₂ O ₃	1.10	7	qz 40.96	—
FeO.....	7.57	105		
MnO.....	0.14	2	al 25.86	26.5
MgO.....	2.62	65	fm 35.63	38
CaO.....	8.63	154	c 29.50	26.5
Na ₂ O.....	1.89	31	alk 9.01	9
K ₂ O.....	1.46	16		
H ₂ O+.....	2.02	—	k 0.34	0.25
H ₂ O—.....	0.37	—	mg 0.35	0.45
CO ₂	3.17	72	c/fm 0.83	
P ₂ O ₅	0.14	1		
Sum...	100.38		Section V	

As a supplement to the chemical analysis of no. 4665 the following values are given, which are spectrographically determined by SVEN PALMQUIST:

Cu.....	0.001 %
Ni.....	0.10 -
Co.....	nil.
Cr.....	0.12 -
and Pt less than 0.2 gram per ton.	

3. Transition Rock.

3025. This sample originates from the locality at the waterfall and represents a transition from the dark typical quartz-dolerite to its light coloured, fine grained contact zone. It is a rather dark, medium grained rock, and its most conspicuous constituents are the long, greenish pyroxene prisms, which penetrate the rock in all directions, the shining

planes of ore and the cleavage faces of small calcite-filled cavities. The felspar is as usual not very dominating in the hand specimen, although it is in reality the main constituent of the rock.

The mineral content is the usual one: apatite, ore, plagioclase, pyroxene and quartz, mentioned in the order of succession in which the crystallization has taken place, and besides secondary quartz, calcite, chlorite and ore.

The plagioclase is zonary and constitutes the chief part of the slide. It mostly occurs in idiomorphic laths, but is also seen in large, nearly equidimensional individuals, xenomorphically bounded towards the surrounding pyroxene. Both categories are penetrated by numerous irregular cracks, filled with a greenish, birefringent transformation product, which evidently originates from the disintegration of the pyroxene. In two places Baveno twins have been observed.

The anorthite contents were measured at: 67, 59, 54, 63, 60, 55, 67%, and the following angles of optical axes were measured: $2V\alpha = 88^\circ$, $2V\gamma = 86^\circ$, 84° .

The pyroxene is completely transformed into a greenish brown chlorite with spots of ore; only in a few places there are small remains of the original pyroxene, which is colourless. Not infrequently distinct traces of twinning are seen in a completely chloritized individual, and in a single case of an hour-glass structure. The pyroxene was too much transformed to be measured.

Ore occurs as a primary constituent in long rod-shaped individuals. Ore of a secondary origin is very widely distributed, either as dusty spots or in larger continuous irregular areas, which surround the transformed pyroxene and penetrate along cracks into the plagioclase laths. Especially within one area of the section the ore is extremely concentrated, constituting 50% of the rock. Here an impregnation of ore seems to have taken place, the latter having followed the cracks and fissures into and between the minerals (pl. 6, fig. 14).

Apatite in thin, short needles is rather sparse.

Interstitially xenomorphic quartz with undulating extinction is seen together with a fine web of numerous, very small plagioclase laths, thin apatite needles and grains of ore, but it has not been observed in micropegmatitic intergrowth with felspar. As a filling of cavities it is very common in more or less idomorphic individuals, either alone or together with calcite. The latter also occurs as a disintegration product of the pyroxene.

In the following planimetric analysis the amygdaloids are not included, and the percentage of ore exclusively comprises primary ore, the secondary one being included in the pyroxene percentage.

Plagioclase	49.7 %
Pyroxene, fresh 0.8 %	} 30.4 -
— transformed 29.6 -	
Ore	3.7 %
Interstitial matter, chiefly quartz.....	14.9 -
Calcite	1.3 -

4. Rocks from Upper Contact Zone.

The Serfat sill shows a contact towards calcareous sediments, and its upper part consists of a fairly hard, greyish, fine grained and thoroughly crystalline variety of the dolerite, very much resembling a »white trap«.

Samples from this marginal zone have been taken in various localities throughout the sill, and the description comprises the following nos. 33, 2120, 3019, 3021. Under the microscope they present quite the same appearance, and are therefore treated together.

They are fine grained rocks with a doleritic texture, intensively altered into chlorite and carbonates. The mineral contents are the same as mentioned in the preceding slide, though apatite has not been observed.

The felspar is plagioclase with the following anorthite contents: in sample 2120: 56, 58, 58¹/₂, 60, 61, 63, 64 % An, and in a single case a 2 V γ of 76° could be measured. In sample 3021 were measured: 60, 61, 66, 70 % An and the following angles of optic axes: 90°, 90°, 2 V γ 88°.

The plagioclase occurs exclusively in narrow laths, as a rule with only two or three twin lamellæ. The most ordinary size in all sections is 0.6 × 0.06 mm, but somewhat longer as well as considerably shorter individuals appear, all more or less turbid and obscured by carbonates, which impede the measurements (pl. 6, fig. 15).

As in the preceding section the pyroxene is entirely transformed into a greenish chlorite with much dusty ore. Fresh pyroxene is not found in any of the sections.

Ore is very wide-spread, partly, as already mentioned, secondarily by the disintegration of the pyroxene, partly primarily as ilmenite in thin, rod-shaped individuals or more irregular lumps. In a few places are also seen magnetite in six-sided cross sections.

Micropegmatite is not found, whereas quartz is of very common appearance, both interstitially and as a filling of cavities, either alone or together with calcite, which often occupies the central part of the cavity, whereas the generally idiomorphic quartz grains are situated along the sides of the cavity and, as it were, frame the central, later calcite.

The carbonates have a remarkably wide distribution in all the sections. They are seen between and within the plagioclase laths in the chlorite pseudomorphoses after pyroxene, filling every crack in the rock and, as mentioned, in the pores (pl. 6, fig. 15). The carbonates and the faintly greenish chlorite have both taken every possibility of penetrating into the neighbouring minerals and have obscured the structure to such an extent that a planimetric analysis is of little value. Nevertheless such an analysis was attempted in 2120. The result is given below, but there is no doubt that the calcite, as well as the pyroxene values, are too high in proportion to the plagioclase percentage. The amygdaloids are not included.

Plagioclase	39 %
Pyroxene, transformed to chlorite and dusty ore..	29 -
Ore	6 -
Quartz	12 -
Carbonates	14 -

Table 3.

Quartz-dolerite, Serfat, upper contact zone, (no. 2120).			Analyst SVEN PALMQUIST.		
			NIGGLI-values		Leucomiharaitic
SiO ₂	48.43	807	si	136	140
TiO ₂	1.45	18	ti	3.03	—
Al ₂ O ₃	13.20	129	p	0.17	—
Fe ₂ O ₃	3.00	19	qz	7.72	—
FeO	6.91	96			
MnO	0.14	2	al	21.72	26.5
MgO	4.12	103	fm	40.23	38
CaO	10.30	184	c	30.98	26.5
Na ₂ O	1.89	31	alk	7.07	9
K ₂ O	1.04	11			
H ₂ O+	3.83	—	k	0.26	0.25
H ₂ O—	0.41	—	mg	0.43	0.45
CO ₂	5.22	118	c/fm	0.77	—
P ₂ O ₅	0.15	1			
Sum...	100.09		Section V		

5. Leucocratic Veins.

3017. This sample has been taken from a 5 cm broad horizontal aplitic vein in the upper part of Sagdliligkat. It is a whitish, fine grained rock with small dark spots of greenish pyroxene and grains of ore. Under a pocket lens pyrite is distinctly visible in small cubes.

Under the microscope the rock shows a hypidiomorphic granular texture and a mineral content consisting of plagioclase, microperthite, (orthoclase), quartz, micropegmatite, ore, altered pyroxene and secondary calcite.

The plagioclase may occur in long laths (pl. 7, fig. 16) or shorter, rectangular individuals as a kind of "phenocrysts", generally consisting of two or three twin-lamellæ. They are as a rule very pronouncedly zonary and idiomorphic on the surrounding smaller quartz and felspar individuals. The largest ones were measured at 1.5×0.1 and 0.7×0.4 mm, but a more ordinary size was 0.5×0.1 mm. The longest laths are frequently broken and fractured, with small quartz crystals penetrating into the fracture. These large plagioclase individuals are in very rare cases free from intergrowths of any kind. As a rule they are penetrated by irregular veins of potash felspar, forming a typical antiperthite (pl. 7, fig. 17), and they sometimes have a core of pure plagioclase, the anorthite contents of which are measured up to 37%, and a broad micropegmatitic border, the felspar of which is either albite or microperthite (pl. 8, fig. 18). Finally, the entire individual may consist of microperthite, as a rule micropegmatitically intergrown with quartz.

The chief constituent of the rock is, however, a rather equigranular mixture of quartz, orthoclase and micropegmatite. The quartz sometimes occurs as pure quartz grains (pl. 7, figs. 16 and 17), but most frequently graphically intergrown at the border with orthoclase or microperthite. Also the orthoclase may occur as idiomorphic individuals without graphic quartz, but it is always turbid and as a rule contains veins of albite. The micropegmatite covers large areas and is generally a symplektic intergrowth of quartz with microperthite (pl. 8, fig. 19), more rarely with pure orthoclase. Finally, also quartz crystals are seen with a central micropegmatitic area, the quartz of which has since continued its growth with the same crystallographic orientation, forming individuals with greater or smaller idiomorphy. Some distance within the margin, but conformable to the latter, a band of inclusions are seen. Such quartz crystals are of secondary origin and are most frequently found on the border line to the many small, irregular cavities, the central parts of which are filled with later calcite (pl. 7, fig. 16).

The ore mostly occurs in oblong, short rod-shaped thin individuals, 0.2×0.02 mm, and is equally distributed in the section. In a few places they may also attain a rather considerable size, viz. 0.4×0.06 mm.

The pyroxene occurs nowhere in a fresh state, but is completely altered into chlorite of a light apple-green colour and very faintly birefringent.

An attempt has been made to undertake a planimetric analysis of this aplitic rock, but owing to its being so fine grained and especially to the constant changes of intergrowths between rather varying rock constituents the analysis is only approximately a true expression of the quantitative mineral contents. The term of "plagioclase" thus comprises small quantities of antiperthite, microperthite and a minimum quantity of potash feldspar, whereas "micropegmatite" comprises all the quartz-feldspar intergrowths, whether the feldspar is an orthoclase or, as is more frequently the case, microperthite. The plagioclase is generally oligoclase with a core verging on andesine in its composition, while the marginal zone varies from oligoclase-albite to pure albite.

Acid plagioclase.....	30.9 %
Quartz	28.0 -
Micropegmatite	27.0 -
Pyroxene, totally transformed.....	7.6 -
Ore.....	1.6 -
Calcite	4.9 -

Table 4.

Leucocratic vein, Serfat, (no. 3017).			Analyst SVEN PALMQUIST.	
			NIGGLI-values	Normal granodioritic
SiO ₂	72.09	1202	si 402	280
TiO ₂	0.50	6.25	ti 2.09	—
Al ₂ O ₃	12.32	121	qz 210.96	—
Fe ₂ O ₃	0.04	0.25		
FeO.....	3.01	42	al 40.49	39
MnO	0.04	0.6	fm 17.34	22
MgO	0.35	8.7	c 19.41	17
CaO.....	3.26	58	alk 22.76	22
Na ₂ O.....	1.90	31		
K ₂ O.....	3.52	37	k 0.54	0.45
H ₂ O+.....	1.17	—	mg 0.17	0.4
H ₂ O—.....	0.16	—	c/fm 1.12	—
CO ₂	1.44	32.7		
P ₂ O ₅	trace	—	Section VI	
Sum....	99.80			

According to JOHANNSEN (13) this rock is most closely allied to a granodiorite-aplite, of which he only cites three analyses, two of which furthermore originate from the same locality. The chemical analysis of 3017, however, shows a fairly good agreement with these analyses; only the Na-value of the Serfat aplite is comparatively low,

whereas its CaO value is too high; this may partly be due to the fact that the present Serfat aplite has a plagioclase, the composition of which is more rich in anorthite than the rock analyses cited by JOHANNSEN, partly to its containing a large quantity of calcite. The FeO content of the Serfat aplite is also a little too high, whereas $\text{Fe}_2\text{O}_3 + \text{FeO}$ agree very well with JOHANNSEN.

The analysis of 3017 harmonizes with the analyses of leucogranodiorite cited by JOHANNSEN, but its contents of dark constituents are a little too high to permit of its being classed with family 127.

III. THE DOLERITIC INTRUSION AT ATANIKERDLUK AND IN THE SARQAQ VALLEY

A. Historical Remarks.

Atanikerdluk and the Sarqaq valley are more frequently described in the geological literature than Serfat.

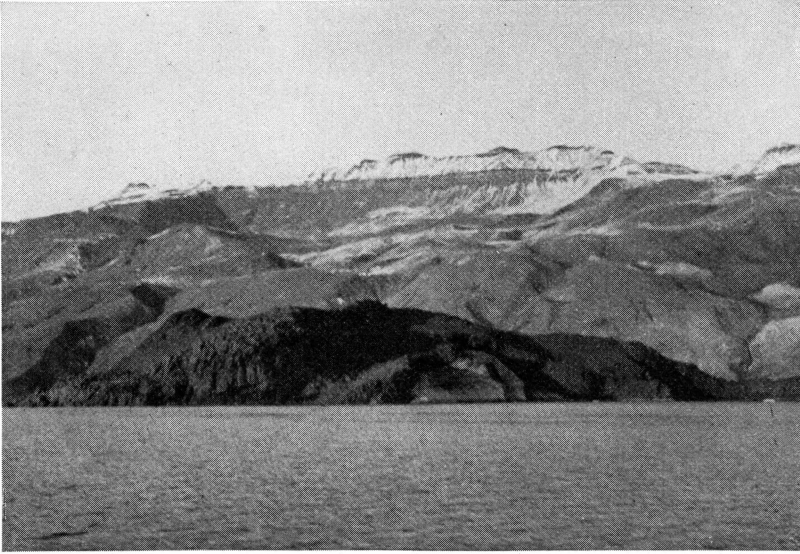
In his diary from 1811 GIESECKE mentions Atanikerdluk and the coast cliffs to the west of the small dwelling place Tartunaq, "Imnarsoit", now Ivnarssuit (7, p. 358): "Atanikerdluk bildet eine Næs, und besteht aus Massenbasalt, welcher geformt wie lange, schmale Säkke, übereinander hier liegt;—Imnarsoit aus Säulenbasalt, beyde ohne andere Gemengtheile. Aussen vor Imnarsoit liegen einige Inselklippen."

NORDENSKIÖLD writes in 1870 (23, p. 1035, translation): "At Atanikerdluk distinctly crystallized dolerite, like the Spitzbergen hyperite, forms the lower beds of the there occurring rocks, several thousand feet thick," and again later on (p. 1050): "The peninsula itself consists of a rusty brown, somewhat weathering, rather coarse grained dolerite, composed of two kinds of felspar (labradorite and sanidine?), ilmenite, crystallized into thin hexagonal flakes, and augite." He regarded the dolerite at Atanikerdluk as constituting "the oldest link of West Greenland's huge volcanic and plutonic rock series", generally regarding horizontal sills as extrusive sheets, subsequently overlain by sediments.

This view was sharply contested by STEENSTRUP, who wrote (32, p. 188, translation): "An actual basalt bed, that is a layer which is younger than the substratum and older than the overlying bed, I have never seen in the coal-bearing formations."

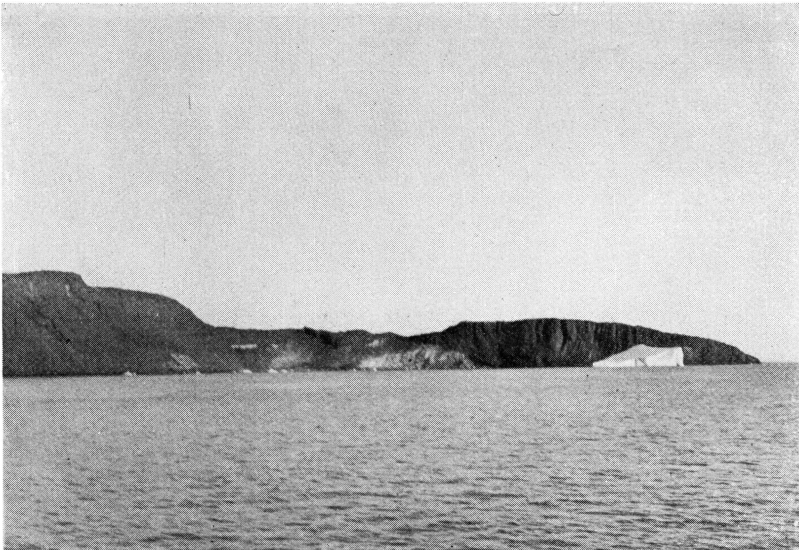
STEENSTRUP gives (33, pp. 67, 69 and 70) a description of the dolerite occurrences of the Atanikerdluk-Sarqaq (valley) area, which was fully corroborated by our observations in the summers 1938—39; it is freely rendered in the following paragraph.

Atanikerdluk forms a peninsula about 100 m high, which is connected with the continent by a low sandy plain. The peninsula mainly



H. GRAY phot. 16/9 1939.

Fig. 9. The northernmost part of the Atanikerdluk peninsula, viewed from the south. Light coloured sediments are seen under the undulating sill.



H. GRAY phot. 16/9 1939.

Fig. 10. The southern part of the double-hooked Atanikerdluk peninsula (see the map pl. 14) viewed from the west. The sediments here were rather high above sea level.

consists of a coarse grained dolerite, which must be interpreted as an oblique sill striking very nearly in the direction of the Vajgat strait and having penetrated the coal-bearing formations (fig. 9). It has undoubtedly, at one time, been associated with the Ivnarssuit sill, about 6 kilometres east of it. On the northern side of the peninsula the sandstone is visible above the basalt, and on the southern side sandstone and shale are seen below the basalt. In this latter shale, which occurs in situ a few feet above sea level on the north side of a small bay, a good deal of fossils were found¹⁾ (fig. 10). The beds were almost horizontal. At Naujat²⁾ the sequence of the coal-bearing formations is very nearly the same as at Atanikerdluk. Farthest down at the level of the sea sandstone is found, covered by columnar basalt, as may be observed at the steep cliff Ivnarssuit, the surface of which against the covering sand layer clearly shows an almost horizontal sill.

The Sarqaq valley has been created by a large-scale glacier erosion on the border of an Archæan rock and a sediment area. The quantities of sediments and plateau basalt, which in this manner have been removed by the ice, are very considerable.

STEENSTRUP also had a distinct impression of this, as appears from the following (32, p. 219, translation): “. . . . (The glacier has) cut away at least 2000 feet of sandstone and shale. When seeing these formations, constituting the mountains on the western side of the valley, and their remains, which are as it were “pasted on” to the gneiss wall on the eastern side of the valley, no one can doubt that these formations at one time filled the valley down to Sarqaq, where sand hills of more than 2000 ft. are still found, sheltered by tall gneiss cliffs.”

When reading STEENSTRUP's description, one must get the impression that he was of the opinion that there were remains of these sediments on the east side of the valley, “pasted on” to the gneiss. In 1938 we followed the eastern side of the valley all along to Taserssuaq, and in several localities we in our turn saw the dolerite “pasted on” to the gneiss wall, whereas we could not see any sediment. That STEENSTRUP has not mistaken this dolerite for sediments, clearly appears from the map, which he published in 1874 (30), for that matter the first map in existence from this area. Here in a few places basalt is indicated at the base of the gneiss mountains in the eastern side of the valley, but curiously enough the statement quoted above is the only one which he makes on this point.

In 1898 WHITE & SCHUCHERT (38) state that the sediments in West Greenland have been locally covered by early Cretaceous or pre-

1) Lower Atanikerdluk flora, by HEER (10) determined as Cenomanian, by WHITE and SCHUCHERT (38) regarded as Senonian.

2) Immediately east of Ivnarssuit.

Cretaceous basalts, and among other localities he mentions Atanikerdluk. KOCH, however, rejected this supposition in 1929 (14).

It is again NORDENSKIÖLD's conception of sills as effusive beds, which crops up here, and we meet it once more in a new and still more emphatic form in KRUEGER (18, 19). After having elucidated the geological conditions and the fault in the Sarqaq valley he writes: "Weiterhin zeigen sich in dem sonst ganz flachen Tale eine Anzahl von Basaltkuppen, die sich deutlich in eine Linie hintereinander ordnen und, soweit sie noch gut erhalten sind, in ihren äusseren Teilen ein viel feinkörnigeres und dichteres Gefüge zeigen als im Innern, wo sie zum grossen Teil sogar als grober Dolerit anzusprechen sind. Es handelt sich also offenbar um die Reste von Gangspalten und Schloten, auf denen das basaltische Magma aufdrang. Damit ist wohl die Berechtigung gegeben, in dieser Linie eine grosse Verwerfung quer durch Nugsuak anzunehmen".

Also the small basalt islands lying off Tartunaq as a continuation of the Ivnarssuit sill he regards as direct necks, stating that ". . . . sie durchaus den Eindruck alter Eruptivschlote machen."

B. Investigations in the Field.

In 1938 ROSENKRANTZ, TROELSEN, SORGENFREI and the present author, accompanied by five Greenlanders, undertook a trip on foot through the interior of the Nûgssuaq peninsula. As formerly mentioned, we followed the left bank of Kûgssuaq through the Sarqaq valley, and so we had ample opportunity to explore its eastern side.

In 1939 NOE-NYGAARD and the author spent some time at Atanikerdluk in order to investigate the geological conditions here and further east, for some distance along the western side of the Sarqaq valley and also through the long valley of Tarajornitsoq.

During these investigations we observed, not only what had already been pointed out by STEENSTRUP i. e. that the huge sill at Ivnarssuit is undoubtedly a continuation of the Atanikerdluk sill, but also that the dolerite sill which, with certain interruptions, can be followed in a north-western direction into the Tarajornitsoq valley and in a northern direction as far as Sáningassoq in the Sarqaq valley is an irregularly undulating continuation of the Atanikerdluk-Iv narssuit sill (the map pl. 14, and pl. 15, figs. 1 and 2).

To the west of the fault the dolerite has penetrated into the sediment layers as an extensive, transgressive sill of very varying thickness.

East of the fault the dolerite has not been able to penetrate into the hard gneiss wall, but has made its way along the boundary between

gneiss and overlying, later removed sediments, i. e. the steep fault plane (fig. 12). As the erosion has also here removed the overlying sediment beds, the characteristic sight is left of this steep fault plane, the gneiss wall, with the remains of the doleritic sill "pasted on" to it.

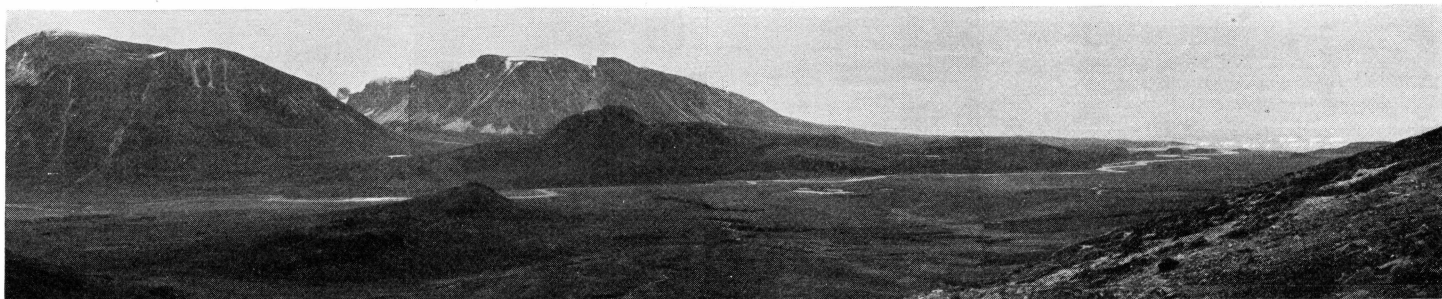
This is particularly conspicuous at Qitingussait (fig. 12 and pl. 15, fig. 3), where on the western bank of the river the some 300 m high sediment ridge is seen capped by dolerite, and on the eastern bank the same dolerite is observed to "creep" a long distance up the gneiss wall, which clearly shows that the present geological relations existed at the time when the dolerite intrusion took place.

On the distance Qitingussait-Sáningassoq the dolerite was still seen "creeping" up the gneiss in broad-tongued areas of columnar, rather coarse grained basalt (pl. 15, fig. 4). The surfaces both of gneiss and dolerite were polished by the ice, and deep glacial striæ could be observed high up the sides of the valley. In some places the gneiss became visible amidst larger areas of dolerite, but nowhere sediment between gneiss and dolerite was observed.

The huge glacial erosion has formed the Sarqaq valley in its present state, a broad U-shaped valley, by removing large quantities of basaltic and sedimentary rocks. However, contrary to expectation, the bottom of the valley is not quite level. Through it extend small, low ranges of sediment or gneiss, covered by a "roof" of dolerite, which has yielded protection against the glacier erosion (fig. 11). These erosion remains of the dolerite sill are what KRUEGER describes as "Eruptivschlote".

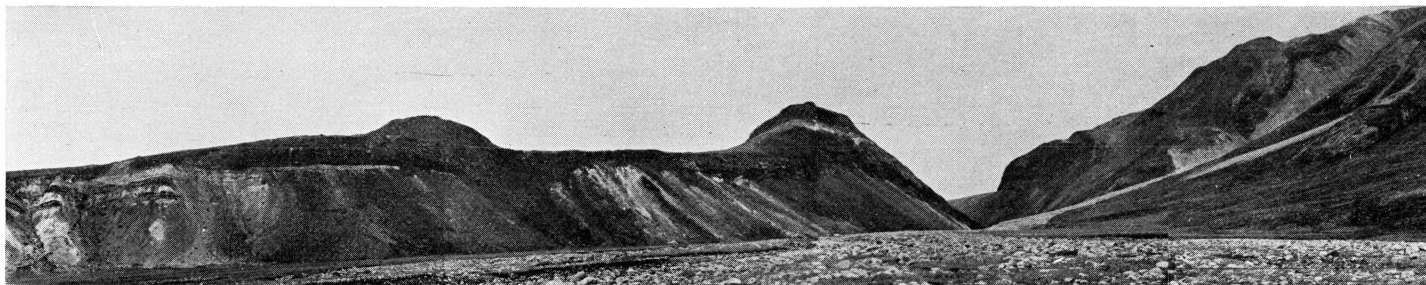
The greatest of these erosion remains is a small range or ridge, 368 m high and situated about 5 km from the debouch of Kûgssuaq into the Vajgat (cf. the map pl. 14 and pl. 15, fig. 1). Here the sill splits into two branches, the lower of which is about 5 m thick, the upper one about 20 m. They both show a pronounced columnar structure, and the columns are orientated perpendicularly to the somewhat uneven substratum, which in the southern part of the 368 m mountain consists of sediments, in the northern part of gneiss. Especially in the upper sill the dolerite is rather coarse grained and penetrated by light coloured, leucocratic veins, which in thickness vary between a few millimetres and 7 cm.

Quite similar whitish yellow veins were found in great quantities in the sill at Atanikerdluk (pl. 2, fig. 7). They bore a great resemblance to the corresponding veins in the Serfat sill, attained the same thickness over fairly long distances and were rather persistent.



Author phot. 27/8 1939.

Fig. 11. Extreme southernmost part of the Sarqaq valley, viewed from the western side of the river, about 8 km from its debouch into the Vajgat. The erosion remains, mentioned in the text, extend through the valley as small ranges consisting of gneiss and sediments, covered by dolerite. A little to the left of the centre of the picture on the eastern side of the river point 368 is seen, cf. map pl. 14 and pl. 15, fig. 1.



Author phot. 29/8 1938.

Fig. 12. Qitingussait seen from the south. Towards west coal-bearing sediments covered by dolerite, which towards east "creeps" up the gneiss wall.

C. Petrography of the Rocks from Atanikerdluk and the Sarqaq Valley.

The rocks from these localities are holocrystalline, medium grained dolerites, as a rule olivine-bearing, and they do not show such variations as the Serfat rocks.

The petrographic description of the rocks collected will, therefore, be treated according to the localities and in the following order of succession:

1. Dolerites from: Tarajornitsoq (2417), point 368 (3132, 3135), Qitingussait (3137 A & B), the distance Qitingussait-Sáningassoq (3138, -3139), Atanikerdluk (2412, 86, 98).
2. Leucocratic veins from: Atanikerdluk (97 A & B) and point 368 in the Sarqaq valley (3133).

1. Dolerites.

2417. This sample was taken at Tarajornitsoq, in the place where the large sill crosses the river bed (the map pl. 14, and pl. 15, fig. 2). It is a medium grained, dark greenish grey rock, reddish brown on the weathering surfaces.

Under the microscope it proves to have a subdoleritic to doleritic texture. The mineral contents are: apatite, ore, olivine, plagioclase, pyroxene and quartz, mentioned in the order of succession, in which the crystallization has taken place. Of secondary minerals a tawny brown chlorite is seen and very small quantities of calcite and biotite.

The feldspar is a fresh, untransformed plagioclase, mostly occurring in laths, 1—2 mm in length and consisting of a few broad twin-lamellæ. It is, however, also seen in equidimensional plates with a pronouncedly zonary structure.

In various plagioclases the following values were measured:

$2V_{\gamma}$	% An.
76°	56
76°	55
75°	54

The feldspar is thus a labradorite, and the most commonly occurring twin lamellæ are according to the Albite and the Karlsbad laws; Pericline lamellæ are, however, not uncommon, and in a few cases Baveno twins have been observed.

The fresh, untransformed pyroxene only occurs as idiomorphic to subidiomorphic, as a rule fairly equidimensional grains, and it shows

a distinct prismatic cleavage, but rarely twinning. It is a titaniferous augite with a reddish purple colour and a faint pleochroism.

2 $V\gamma$	c/γ
49°	47°
45°	41°
47°	—
Average: 47°	44°

The olivine occurs in grains of very varying sizes and forms, easily distinguishable from the reddish pyroxene because of their lack of colour and their higher refringence, which gives them a pronounced relief. Besides, they are penetrated along fissures and cracks by golden-green, faintly birefringent chloritic transformation products, and in a few cases they are entirely altered into calcite. The olivine as a rule occurs in connection with the pyroxene, which is often seen to include an olivine individual, but there has nowhere been a replacement of olivine by pyroxene, as was so characteristic of the coarsest textured rocks from Serfat. The olivine has been formed at a comparatively early period in the magmatite epoch; later on an incipient resorption has not rarely corroded the edges of the olivine grains. 2 Va was measured at 78°, and according to this the olivine contains 37% Fa.

Ore occurs abundantly as magnetite in square or rectangular grains, the boundaries of which may be somewhat irregular. Long rods and skeletal crystals hardly occur.

Apatite is found in short, thin needles and is not particularly common. Quartz is not common but occurs interstitially as a final secretion, and it is also observed as a secondary constituent.

A volumetric analysis gave the following result:

Plagioclase, including apatite	57.7%
Pyroxene, — transformation products..	28.9 -
Olivine, — —	3.2 -
Ore	9.7 -
Quartz	0.5 -

According to JOHANNSEN'S quantitative system the rock is an olivine-bearing diabase, the word "diabase" in its American sense being an equivalent of the English "dolerite", which is used here.

At the 368 m hill various samples were taken from the above mentioned two sills. Macroscopically they quite resemble the preceding sample from Tarajornitsoq, the fresh surfaces being greyish black with a greenish tinge, the weathered ones light brownish. They

vary from fine grained along the contacts to medium or even coarse grained towards the middle of the sills.

3132 was taken at the eastern side of the 368 m mountain from the lower 5 m thick sill, slightly above the contact towards the sediments.

Microscopically the texture proves to be doleritic (pl. 9, fig. 20). The chief mass of the rock as usual consists of plagioclase in long laths, which owing to the twin lamellation look as if they possess a higher idiomorphy, than they really do. The length of the laths is generally between 1—3 mm, their width between 0.1—0.4 mm.

The individual measurements gave the following result:

$2V\gamma$	% An.
80°	61
75°	54
74°	60
74°	57
80°	55
78°	52
—	58
80°	65
<hr/>	
Average: 77°	58

The pyroxene is reddish brown and very fresh. Only where ore is directly bounded by pyroxene, biotite is occasionally seen. Uralite has not been observed. The prismatic cleavage is very pronounced, and twinning is not so rare here as in the preceding sample. The individual crystals are as a rule hypidiomorphic and not very large, but gathered in groups, situated in the interstices between the felspar laths. The average of four measurements give as a result $2V\gamma = 48^\circ$, $c/\gamma = 41^\circ$.

The olivine chiefly occurs in irregularly bounded grains, the shape of which is especially dependent upon the surrounding felspar, which must thus precede the olivine in the crystallization succession. On the other hand, the crystallization of the olivine must have begun at an earlier period than the pyroxene, as it is frequently observed to occur idiomorphically well defined in larger pyroxene individuals (pl. 10, fig. 22); but the subsequent crystal growth of the three main constituents must have continued alongside each other. As in the preceding sections it is also here striking that olivine and pyroxene by preference occur together (pl. 9, fig. 21). The olivine is greyish, strongly refringent and penetrated by cracks, along which a transformation takes place into an olive-green fibrous mineral with a negative elongation, and which is very faintly refringent and birefringent. The $2Va$ of the olivine is measured at 76° , i. e. 42% Fa.

Ore is very common and occurs crystallographically more or less well defined (pl. 9, figs. 20 and 21).

Apatite is common in long needles and hexagonal cross sections. Quartz is sparse.

3135 was taken from a sill resting on gneiss on the northern side of the 368 m mountain. It greatly resembles the preceding sample, but also deviates from it in various respects. It is medium grained like **3132**, but considerably richer in dark constituents (pl. 2, fig. 6). Felspars of far greater dimensions than the majority of the felspars of the slide occur in glomerophytic groups and resemble phenocrysts. The pyroxene is titaniferous and partly chloritized, and twinning is very common. The olivine is transformed into a tawny brown, fibrous mineral of positive elongation and weak refringence and birefringence. Ore is very common in needles, cubes and branched skeletons.

The plagioclase was measured to contain 59, 56, 60 and 62% An, the latter with $2V\gamma = 82^\circ$.

On pyroxene crystals were measured:

$2V\gamma$	c/γ
48°	41°
49°	41°
49°	44°
<hr/>	
Average: 48°.6	42°

The olivine in this section has the same characteristics as in the preceding one, showing, however, a higher degree of idiomorphy (pl. 10, fig. 22).

3137 A & B were taken at Qitingussait from the sill "creeping" up the gneiss wall (pl. 15, fig. 3). Macroscopically it resembles the preceding ones, *A* being a fine grained sample from the contact towards the gneiss, *B* medium grained and taken at some distance from the contact. Both have a pronouncedly doleritic texture and the same mineral contents as the preceding samples.

The plagioclase occurring in broad twin-lamellated laths was measured at:

$2V\gamma$	% An.
78°	59
79°	55
76°	56

Reddish brown pyroxene in idiomorphic to hypidiomorphic equidimensional grains, most frequently twinned, was measured at:

$2V_{\gamma}$	c/γ
47°	41°
46°	45°
—	39°
44°	47°
—	41°
47°	—
Average: 46°	42°.5

The pyroxene in this slide is often converted into uralite and more rarely into biotite.

Olivine is rather common, but in these samples more altered than in any of the preceding ones. In many places the fresh olivine has entirely disappeared, being replaced by olive-green chloritic pseudomorphs. The $2Va$ of the olivine was measured at 80°, that is 33% Fa.

Titaniferous ore in branched individuals is the most frequently occurring ore in *A*; it also occurs in *B*, but there it is numerically exceeded by square cross sections of magnetite.

Apatite is seen here and there in long needles and in small, hexagonal cross sections. Quartz is rare.

3138 was taken from the sill "pasted on" to the gneiss along the distance Qitingussait-Sáningassoq. It is medium grained and far more light coloured than any of those previously mentioned (pl. 2, fig. 5). The felspar is white and quite fresh, and the lath-shaped cross sections of the tabular crystals present a characteristic criss-cross arrangement. With a pocket lens large olivine grains may be clearly observed.

The microscope reveals a typical ophitic texture (pl. 10, fig. 23).

The plagioclase laths, which may attain a size of 3×0.5 mm, protrude far into or are entirely enclosed by large olivines and pyroxenes, which may reach 5×6 mm in size. Measurements were undertaken in 4 pairs of twin-lamellæ in 4 different individuals.

$2V_{\gamma}$	% An.
1) 90°	69
2) —	72
1) 86°	66
2) —	68
1) —	61
2) 82°	66
1) —	68
2) —	68

Further, the An-contents for core and outer zone in 2 individuals were measured:

	% An.	
Core	64	} and 68 } — 55 }
Outer zone	52	

The faintly reddish brown titaniferous pyroxene shows, with crossed nicols, a pronouncedly undulating extinction which, however, is not zonary but very irregular. On the Fedorow table was measured:

2 V γ	c/ γ
49°	—
49°	—
50°	—
48°	—
—	41°
48°	42°
—	41°
52°	40°
Average: 49°	41°

The olivine mostly occurs in very large crystals, which bear the same relation to the felspar as the pyroxene (pl. 10, fig. 23). These large grains are relatively fresh; only along the broad cracks are seen tawny brown fibrous alteration products with a negative elongation. Smaller olivine grains are generally completely pseudomorphosed, and the transformation products have extended into the adjoining plagioclase and discolour it. The 2 Va of the olivine was measured at 76°, i. e. 42% Fa.

Ore only occurs in a few grains, and neither apatite nor quartz have been observed.

3139 was taken along the same distance as **3138**, but nearer Sáningssoq. It has a larger contingent of plagioclase, is richer in quartz and has frequently broad borders of micropegmatite surrounding the plagioclase (pl. 11, fig. 24). It is also more altered than the samples described above; the pyroxene is uralitized, fresh olivine is rare, and both primary and secondary quartz is found.

The dolerite from Atanikerdluk is not very deviating from the dolerites of the Sarqaq valley. The hand specimen has a brownish black colour, which on the weathering-surfaces verges upon reddish. The grain is different in the various parts of the sill, but is sometimes rather coarse, however, without attaining the size of those found at Serfat.

The mineral association is the same as in the dolerites of the Sarqaq valley; the texture is as in the greater part of these doleritic, and the contingent of plagioclase is surprisingly large in proportion to the colour of the rock. Two medium grained samples were examined under the microscope.

In **2412** the plagioclase is seen as laths, chiefly consisting of a very few twin-lamellæ according to the Pericline and Albite laws. The largest of these laths attain a size of 1×0.1 mm. Further, complex Manebach-Ala twins have been measured, and so were some few Baveno twins. The plagioclase is also seen in large, broad crystals of a zonary structure and more irregularly bounded, having been measured up to 1.2×1 mm. In the slide there is a glomerophytic accumulation of plagioclases, which are of considerably greater dimensions than the other plagioclases of the section, and which present a phenocryst-like appearance (pl. 11, fig. 25). They further proved to be of a somewhat more basic composition than the plagioclases of the groundmass.

In 3 pairs of broad Albite lamellæ the following data were measured:

	$2V\gamma$	% An.
1)	84°	64
2)	82°	58
1)	86°	—
2)	86°	62
1)	82°	62
2)	80°	63

For the plagioclase of the "groundmass" the following values were found:

	$2V\gamma$	% An.	
	80°	57	
	80°	62	
	—	55	
	80°	51	
	78°	52	
Same individual	{ core	80°	58
		{ outer zone	80°

The pyroxene is idiomorphic to hypidiomorphic and reddish with a faint pleochroism α : greenish, β : reddish, γ : reddish. The cleavages are not so distinct as in the dolerites of the Sarqaq valley, which is

partly due to the fact that the pyroxene in 2412 is less fresh, being to a large extent transformed into chlorite and dusty ore. The sizes of the individual grains are frequently about 0.4×0.5 mm. Its angle of optic axes and its extinction harmonizes well with the pyroxenes of the Sarqaq valley, and measurements yielded the following values:

$2 V_{\gamma}$	c/γ
52°	45°
46°	42°
48°	37°
—	44°
<hr/>	
Average: 48°	42°

Small pseudomorphs on olivine are found, but are not of common occurrence.

Titaniferous ore in narrow elongated cross sections is widely distributed. Apatite has not been observed.

86 has likewise been taken from the sill forming the Atanikerdluk peninsula. It is medium grained like the preceding one, and under the microscope it shows a typical doleritic texture. For the plagioclase the following values were measured:

	$2 V_{\gamma}$	% An.
	75°	50
	—	55
	76°	56
	74°	54
	—	50
	83°	55
Same individual	{ Core: 75°	50
	{ Outer zone: 82°	40
Same individual	{ Core: 84°	55
	{ Outer zone: 82°	42

The pyroxene entirely corresponds with that of the preceding section as regards colour and cleavage, and twinning is unusual in both.

However, some of the pyroxenes in 86 are distinguished from the ordinary type by being arcuated (pl. 12, fig. 26), a single one being of a complete "U" shape. The extinction in such crystals follows successively, as the microscope table turns between the crossed nicolls. Only few measurements could be undertaken on the pyroxenes, as they were rather obscured by transformation products.

2 V γ	c/ γ
49°	—
48°	42°
47°	—
<hr/>	
Average: 48°	42°

The greenish, chloritic transformation products are frequently of a fibrous habit and show a positive elongation. They do not only occur within the pyroxenes, but are distributed over large areas of the slide and penetrate into fissures and cracks in the plagioclase, which highly impedes the measurements, both on the integration and on the Fedorow table.

Ore occurs as magnetite in square or six-sided sections and as ilmenite in long branches (pl. 12, fig. 26).

Olivine mostly occurs in irregular grains and is not particularly common. Fresh olivine is extremely rare, and instead of that bottle-green pseudomorphs of antigorite are seen, each olivine crystal being replaced by an entire antigorite individual. The angle of optic axes could be measured in a few individuals, but owing to the advanced transformation these measurements must be taken with some degree of reservation. 2 V α was measured as lying between 76° and 80°.

Apatite occurs in the usual long needles. Quartz is found in small quantities.

Table 5.

Atanikerdluk dolerite (no. 86).			Analyst SVEN PALMQUIST.		
			NIGGLI-values	v. WOLFF-values	Norm
SiO ₂	47.64	794			
TiO ₂	5.53	69	si 124	L 47.40	Qu 4.68
Al ₂ O ₃	11.82	116	ti 10.80	M 47.14	or 11.12
Fe ₂ O ₃	4.57	28	p 0.31	Q + 5.26	ab 20.44
FeO	10.80	150	qz - 12.92		an 15.85
MnO	0.21	3		A 3.99	Σsal 52.09
MgO	3.90	97	al 18.15	C 3.87	
CaO	8.87	158	fm 47.89	K ₂ O 1.35	di 21.64
Na ₂ O	2.41	39	c 24.73	MgO 6.57	hy 6.47
K ₂ O	1.95	20	alk 9.23	C' 6.84	ap 0.67
H ₂ O +	1.41	—		F'' 8.26	il 10.49
H ₂ O —	0.63	—	k 0.34	Mt 3.80	mt 6.50
CO ₂	none	—	mg 0.32		
P ₂ O ₅	0.31	2	c/fm 0.52		Σfem 45.77
Sum...	100.05	—	Section IV		III:5:4:4:5 — Auvergnose

98. This slide shows the boundary between the dolerite and an acid vein from Atanikerdluk (pl. 12, fig. 27). Megascopically this boundary is very sharply defined and slightly undulating. Under the microscope it is possible to see constituents, especially quartz, from the fine grained aplite passing quite gradually into the intersertal material of the host.

In the table below are collected the geometric analyses of the dolerites from Atanikerdluk and the Sarqaq valley. These measurements were undertaken over an indicatrix length dependent upon the sizes of grains in the individual sections, varying from 15 cm in the fine grained aplites to 80 cm in the coarsest grained dolerities. The dolerite samples 3132, 3137 and 2417 belong to family 2312 A in JOHANNSEN'S quantitative system and may be classified as olivine-bearing diabase, whereas 3135, 3138 and 86 belong to family 3312 A as meladiabases, 3135, however, tending towards 2312 A.

Table 6.

Planimetric analyses of dolerites from the Sarqaq valley and Atanikerdluk.						
Rock number	2417	3132	3135	3137	3138	86
Plagioclase, incl. trans- formation products .	57.7*	55.9*	49.5	51.9	49.2	40.1
Pyroxene, fresh.	} 28.9	28.4	26.5	} 33.3	} 37.5	} 37.0
Pyroxene, altered. . . .		0.5	10.0			
Olivine, fresh.	} 3.2	3.1	0.9	} 4.0	6.8	} 9.5
Olivine, pseudomorphs		3.7	1.5		3.1	
Ore	9.7	8.3	11.6	10.2	3.4	12.0
Quartz.	0.5	0.1	—	0.6	—	0.2
Apatite	—	—	—	—	—	1.2
	100.0	100.0	100.0	100.0	100.0	100.0

*) incl. apatite.

Although the mutual proportions of the four chief constituents, viz. plagioclase, pyroxene, olivine and ore, are thus rather fluctuating, their optical data in the various slides are extremely alike.

The plagioclase is labradorite with a composition varying within the interval 50 %—70 % An, (in a single case 72 % An have been measured). The outermost margin of very zonary individuals may, however, be andesine. The lowest An-contents were measured in zonary feldspars from Atanikerdluk, where the An % of the outer zone fell to 42 and 40. The most commonly occurring twin laws are Albite, Karlsbad and complex Albite-Karlsbad. In addition, twins were measured

according to the Pericline and Manebach-Ala laws, while in every section up to 4 Baveno twins were observed (and measured).

In all the slides the pyroxene was a reddish, faintly pleochroic titaniferous augite, the optic angle and c/γ of which showed very small variations. An average of all the measurements gave $2V\gamma$ of very nearly 48° and c/γ of 42° .

The colourless, strongly refringent and birefringent olivine was in the various sections more or less changed into secondary products, its $2Va$ having a value between 76° and 80° . An average of all measurements yield $2Va$ 78° , i. e. 37% Fa.

The ore was mostly ilmenite in long rods or branching crystal skeletons, and magnetite.

The olivine-bearing pigeonite-dolerite sills from Itsako, West Greenland, described by NOE-NYGAARD (22), show a great petrographical resemblance to the Sarqaq valley dolerites, apart from the fact that the pyroxene of the latter is a titaniferous augite. Further, a comparison may be made with dolerites from Clavering Ø, East Greenland, described by BACKLUND & MALMQUIST (1). From Itsako no chemical analyses have been obtained, whereas the analysis of a coarse dolerite, no. 141, from Clavering Ø shows a fair accordance with the dolerite analysis from Atanikerdluk, no. 86, cited above. Only the CaO and MgO values of the latter are somewhat lower, the K_2O and TiO_2 values somewhat higher than those of no. 141.

All of the dolerites from these three localities have intruded into young Mesozoic-Tertiary sediments, the Sarqaq valley dolerite as sills, while the Itsako and Clavering Ø dolerites by the respective authors are supposed to be cone sheets. A common feature, however, is the irregularity of the intrusions, the thickness and areal distribution being very variable within one and the same sill.

Concerning the age of the dolerites, the Clavering Ø rocks are—owing to petrochemical data—by the authors supposed to belong to an early differentiation series, ranging from a slightly undersaturated basalt magma to andesites. The Itsako dolerites are—owing to field relations—presumably younger than the lower part of the extrusive basalt series (22, p. 26), and as to the age of the Sarqaq valley dolerites the reader is referred to the last chapter of this treatise.

2. Leucocratic veins.

In the 20 m thick sill, which constituted the upper part of the small 368 m high range in the Sarqaq valley, and in the large Atanikerdluk sill light coloured, fine grained aplitic veins were seen penetrating the dark dolerite (pl. 2, fig. 7).

97 *A* is a fine grained, 97 *B* a somewhat more coarse grained sample of these aplitic veins from Atanikerdluk. Their width was rather varying, generally lying between a few millimetres and 2—3 cm. They had most frequently an almost rectilinear course and retained the same width for long distances. They are light yellowish grey with a faintly reddish tinge, and in the hand specimens they present an even and fine grained, saccharoidal texture, while under the microscope the constituents show a remarkable degree of idiomorphism.

97 *B* chiefly consists of idiomorphic, rectangular felspar crystals, which in some places lie so close to one another that there is hardly any interstices between them. Wherever any such occurs, it is filled with micropegmatite and with quartz, which is either hypidiomorphic or has rounded forms tending to be idiomorphic. Pyroxene occurs, but is completely altered and appears as ragged remains in the whole slide, generally enclosed in felspar crystals. Ore is mostly seen in thin rods. The texture may possibly be termed idiomorphicgranular, in so far as the greater part of the rock constituents are idiomorphic.

The rectangular felspar crystals may be quite clear and homogeneous. But more frequently they are turbid from inclusions of formerly crystallized rock constituents, e. g. ore and especially chloritized pyroxene. A narrow twin-lamellation is occasionally seen in some of the crystals, whereas micropegmatite is very common as fringes or throughout the whole crystal (pl. 13, figs. 28, 29). The felspars are often zonary, and in the various individuals the central parts occupy unequal areas and sometimes pass gradually into the marginal zone. In other cases the central part is sharply defined and either has the same rectangular form as the entire felspar crystal or is more irregularly bounded. It may be quite homogeneous, but as a rule it is extremely inhomogeneous, showing a characteristic, flapping extinction. This inhomogeneousness is more or less pronounced and is not always limited to the central part.

The largest felspar crystals were measured at 2×1.2 and 1.2×0.8 mm, but more common sizes were 0.8×0.4 mm and 0.6×0.3 mm. On the Fedorow table the following optical data were measured. Angles of optic axes were measured in 8 individuals, which gave an average value of $2V\alpha = 51^\circ$ (the individual values lay between 48° and 54°). In sections normal to γ the optic plane showed an angle of $+8^\circ$ and $+10^\circ$ with the (001) cleavage, whereas the α - β -plane, in sections normal to β , formed an angle of $+9^\circ$ with the (010) cleavage. The refringence was very low, and also the birefringence was slight. On account of these observations the felspar was determined as an orthoclase. There was a perfect (001) cleavage and a distinct (010) cleavage, the most frequently occurring faces being the three pinacoids,

and the crystals were prismatic or tabular. On the other hand, the extremely fine quadrille structure, mentioned by Winchell as characteristic of anorthoclase, was not found here.

As a rare exception a great, twin-lamellated plagioclase crystal is observed.

The quartz is very commonly seen, chiefly in hypidiomorphic grains. Graphic intergrowths between quartz and potash felspar are very wide-spread.

The pyroxene is nearly everywhere transformed into a brownish, birefringent substance. Only in a very few places it is to be observed in a fairly fresh state, crystallographically well defined and with cleavage cracks, which are, however, so filled with the brownish transformation products that no measurements could be undertaken.

Ore is found as thin rods.

The succession of crystallization is: first ore and pyroxene followed by the idiomorphic anorthoclase, and at last micropegmatite and quartz. But some overlapping has taken place, as the periods of crystallization of the light coloured components have not been far apart (thus micropegmatite in exceptional cases occurs centrally in idiomorphic anorthoclases).

97 A resembles the preceding slide, but is more fine grained. The mineral contents are the same for both of them, but of different proportions.

The anorthoclase is seen in rectangular crystals; the greatest ones were measured at 0.5×3 mm, but they were rare; of common occurrence were sizes of 0.2×0.1 mm, but by far not so frequent as in **97 B**. Clear crystals are rare, as they are generally turbid from enclosures or filled with perthitic or micropegmatitic intergrowths. Simple twins are not uncommon.

Not identified felspar is found in irregular, large areas, nearly opaque from chloritic, brownish green transformation products and intergrown with quartz. The extinction varies greatly from the central parts towards the margin. Cleavage cracks are rare in such individuals, and where found they are filled with sericitic transformation products. Twinning does not occur.

The quantity of quartz is very considerably smaller than in **97 B**. The interstices between the felspar individuals were nearly exclusively filled with micropegmatite.

The description of ore and chloritized pyroxene in **97 B** also applies to **97 A**.

In rare cases small hexagonal flakes of biotite were observed.

3133 was taken at point 368 in the Sarqaq valley. It originates from a 2 cm broad greyish vein in the upper 20 m thick dolerite sill.

Macroscopically it looks like the samples from Atanikerdluk, the colour, however, being a little darker grey.

The broad, rectangular feldspar crystals of up to 0.6×0.4 mm are seen with or without twinning, and oblong lath-shaped feldspars consist as a rule of two single twin lamellæ. The largest of these were measured at 2×0.2 mm and 1.6×0.2 mm, but generally they were much smaller. In the former, nearly square feldspars the central part of each crystal is pronouncedly inhomogeneous, still more so than in the Atanikerdluk aplite, and shows the same decidedly flapping extinction. The marginal zone of the crystals is, on the other hand, quite homogeneous and shows a common extinction, which deviates somewhat from that of the central part. Otherwise the feldspars are, as mentioned above, impure and turbid from chloritized pyroxene and, to a smaller extent, ore. The feldspar rectangles are in some places situated so close to one another in the section that there is no room for any interstitial mass (pl. 13, fig. 29), but where it is found, it consists of quartz and micropegmatite. The feldspar of the micropegmatite, which also in this sample has a tendency to form a border round the idiomorphic feldspars, in most cases has not the same extinction as these, but is divided into small areas, each showing their separate extinction. In a very few cases the "framing" feldspar individual is seen to have the same extinction as the "framed" feldspar.

This idiomorphic feldspar is as in Atanikerdluk an anorthoclase; its $2Va$ was measured at 51° (an average of 13 measurements, where the individual values varied between 48° and 56°). In a single zony crystal with a rather homogeneous central area the following angles were measured:

$2Va$ of the core	52°
$2Va$ of the outer zone	39°

The pyroxene may occur idiomorphically, either in elongated individuals or in smaller crystals. When fresh it is white in colour with a faintly reddish tinge, without pleochroism and with a distinct prismatic cleavage. Along the cleavage cracks an incipient alteration is seen to take place. The pyroxene is as a rule rather altered, either completely chloritized or converted into uralite and biotite along the borders.

Ore is both seen in the thin rods and in square grains.

Planimetric analyses were made of *97 B* from Atanikerdluk and of *3133* from the Sarqaq valley. The same difficulties, which were mentioned under the geometrical analysis of the Serfat aplite, also apply to the results given below, viz. that owing to the fine grains and a constant change between intergrown rock constituents they only give

an approximately accurate impression of the real quantitative mineral contents. Thus the inhomogeneous areas of idiomorphic anorthoclase are included in the anorthoclase percentage, and the pyroxene value includes the biotite scales and the chloritic products originating from the desintegration of the pyroxene. In the same way no account has been rendered of the felspar entering into the micropegmatite, and the results must therefore be regarded with reservation.

As the analyses, in spite of everything, give certain information as to the proportion of quantity between the main constituents of these rocks, I have considered it expedient to mention them here.

	97 B	3133
Anorthoclase.....	52.5 %	46.2 %
Micropegmatite	25.5 -	29.6 -
Quartz	7.1 -	9.1 -
Pyroxene, including transformation products	14.0 -	11.8 -
Ore.....	0.9 -	3.3 -

Thus these two rocks belong to family 215 D in JOHANSEN'S quantitative system and correspond with kaligranite-aplite.

According to NIGGLI (21) the aplite becomes normal-alkaligranitic (see analysis below).

Table 7.

Leucocratic vein, Atanikerdluk (no. 87).			Analyst SVEN PALMQUIST.						
			NIGGLI-values		v. WOLFF-values		Norm		
SiO ₂	69.14	1152	si	342	L	70.51	Qu	22.08	
TiO ₂	0.70	9	ti	2.67	M	4.01	or	36.14	
Al ₂ O ₃	14.42	141	qz	92.44	Q	+ 25.48	ab	31.96	
Fe ₂ O ₃	3.05	19					an	1.95	
FeO.....	0.75	10	al	41.84	A	8.51	C	0.82	
MnO.....	0.06	1	fm	18.69	C	0.47			
MgO.....	0.54	14	c	2.08	K ₂ O	4.39	Σsal	92.95	
CaO.....	0.37	7	alk	37.39	MgO	0.95			
Na ₂ O.....	3.77	61			C'	0.0	il	1.37	
K ₂ O.....	6.09	65	k	0.52	Fe''	0.0	mt	0.46	
H ₂ O+.....	0.43	—	mg	0.22	Mt	1.97	hm	2.72	
H ₂ O—.....	0.66	—	c/fm	0.11	t	0.55	en	1.40	
CO ₂	—	—					Σfem	5.95	
P ₂ O ₅	—	—							
Sum...	99.98		Section I/II					I:4:1:3	
								— Liparose	

IV. COMPREHENSIVE REMARKS ON THE CHEMICAL RELATIONS OF THE INTRUSIONS

When comparing the chemical analyses of the rocks from the two localities, certain differences are found, which are evident when the constituents in question are graphically figured (fig. 13).

The Serfat quartz-dolerite which is richest in SiO_2 has higher calcium and lower alkali values than the Atanikerdluk dolerite, the characteristic feature of which is its high iron and titanium percentage (table 8). Remarkable are also the identical CaO and $\text{FeO} + \text{Fe}_2\text{O}_3$ curves and the very high CO_2 contingent of the Serfat rocks. As shown by the microscopical investigations, the latter occurs as carbonate, crystallized at a late period in the quartz-dolerite and increasing in quantity towards

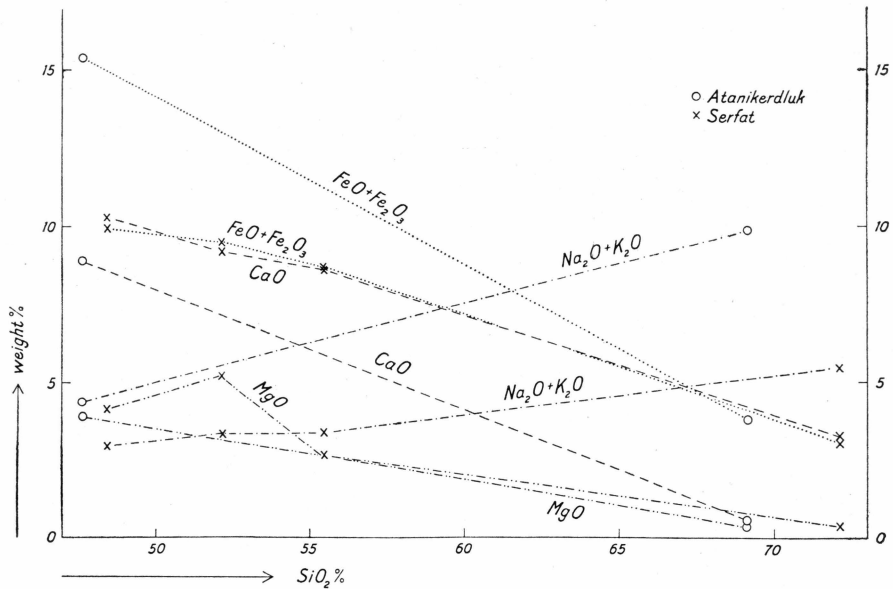


Fig. 13. Diagram in which the abscisse is weight-percent oxides of SiO_2 , and the ordinate is weight-percent oxides of $\text{FeO} + \text{Fe}_2\text{O}_3$, MgO , CaO and $\text{Na}_2\text{O} + \text{K}_2\text{O}$ of the analyzed rocks from Serfat and Atanikerdluk.

Table 8.

	Serfat. Dark quartz- dolerite (2119)	Serfat. Light quartz- dolerite (4665)	Serfat. Contact rock (2120)	Serfat. Leuco- cratic vein (3017)	Ataniker- dluk Dolerite (86)	Ataniker- dluk Leuco- cratic vein (87)
SiO ₂	52.14	55.46	48.43	72.09	47.64	69.14
Al ₂ O ₃	12.18	13.78	13.20	12.32	11.82	14.42
Fe ₂ O ₃	2.47	1.10	3.00	0.04	4.57	3.05
FeO.....	7.01	7.57	6.91	3.01	10.80	0.75
MnO.....	0.11	0.14	0.14	0.04	0.21	0.06
MgO.....	5.17	2.62	4.12	0.35	3.90	0.54
CaO.....	9.23	8.63	10.30	3.26	8.87	0.37
Na ₂ O.....	2.24	1.89	1.89	1.90	2.41	3.77
K ₂ O.....	1.08	1.46	1.04	3.52	1.95	6.09
H ₂ O+.....	1.42	2.02	3.83	1.17	1.41	0.43
H ₂ O—.....	1.13	0.37	0.41	0.16	0.63	0.66
CO ₂	2.77	3.17	5.22	1.44	—	—
TiO ₂	2.26	2.03	1.45	0.50	5.53	0.70
P ₂ O ₅	0.33	0.14	0.15	tr.	0.31	—
	99.54	100.38	100.09	99.80	100.05	99.98

the sediment contact, probably an indication of a lime supply from the country rock.

With the increasing SiO₂ contents the curves of the other constituents of the diagram fall, naturally excepting the alkali curve which is rising, and most pronouncedly in the case of the Atanikerdluk dolerite.

The difference in calcium and alkali contents of the principal rocks from Serfat and Atanikerdluk is further accentuated in the acid differentiates of the dolerites. In the Atanikerdluk aplite, which has by far the greater alkali percentage, it is less than 1/2% CaO as against about 10% alkali, which harmonizes well with the fact that the dominating feldspar is here anorthoclase. In the Serfat aplite, which is more calcic, the proportion of calcium and alkali is 3.26 as against 5.42, and in agreement with this the dominating feldspar is an acid plagioclase

V. AGE PROBLEMS AND GENERAL REMARKS.

As to the ages of the two basic intrusions rather little can be said. In the Sarqaq area the country rock consists of plant-bearing beds; the youngest sediments, which are intruded by the olivine-bearing dolerite, are found at Qitingussait and contain an upper Atanikerdluk flora. They are the youngest known sediments from this region, and HEER (10) has determined their age as Miocene, though according to more recent investigators they are considerably older and must be referred to lower Eocene (MATHIESEN in 14, p. 56).

It is possible to progress a little farther, when comparing the period of the southern dolerite intrusion with the great fault. The formerly mentioned sequence at Qitingussait (p. 38) clearly shows that the dolerite must have intruded after the faulting, which in its turn must have taken place after the deposition of the youngest known Sarqaq valley sediments, the appearance of these being just the same at a great distance from and near the fault. It is to be presumed that a steep gneiss cliff, created by faulting, would have influenced the character of sediments subsequently deposited at its base (28 b, p. 69).

The geological development of the Sarqaq valley has then briefly been as follows: after the deposition of sediments through Cretaceous times a fault—presumably at the beginning of the Tertiary period—has down-faulted the Precambrian rock towards west with its overlying sediment layers. Since then a certain erosion took place and exposed the gneiss surface towards east. Then the large-scale Tertiary volcanic action set in, producing lava in huge quantities, which covered the sediments towards west and the Precambrian rock towards east. The dolerite has intruded after the faulting had taken place, presumably in connection with the large eruptions of lava. During the glacial age huge basalt and sediment amounts were removed by the glacial erosion, and the Sarqaq valley was modelled into its present shape.

Whereas there is thus fairly good supporting evidence for the dating of the dolerites of the Sarqaq valley, the uncertainty is considerably greater as to the quartz-dolerite from Serfat. The Serfat sill, it is true, penetrates marine sediments with calcareous concretions, but

unfortunately the latter have proved not to contain fossils. ROSENKRANTZ, however, states that these sediments very much resemble marine deposits farther west, the age of which at Saviarqat must be considered as Danian.

Unfortunately the age of the Serfat dolerite cannot be viewed in relation to the fault zone, the former being separated from the main fault by a rather broad area, which is dislocated and down-faulted both in pre- and in post-basaltic times, and which is now filled with landslips parallel to the coast, and consequently it is at the present time only possible to range the Serfat dolerite as post-Danian.

It lies near at hand to adopt the old supposition of a connection between igneous action and crust movements in the case dealt with here. It might be imagined that a down-faulting has caused an upheaval of magma, which may either be intrusive or, if the pressure from below is sufficiently great, may become extrusive. The faulting of Nûgssuaq is of such dimensions that it might very well have influenced an upheaval of magma. Thus it can be proved that the throw in the northern end of the main fault zone reaches an amount of about 2000 m, as mentioned in the introduction. The maximum throw at the southern end cannot yet be stated with certainty, the level of the down-faulted gneiss surface to the west of the dislocation line being as yet unknown, but it is to be expected that at some future time this problem may be solved by means of geophysical measurements. Until then we must be content to give a minimum amount of about 1200 m.

Finally the probable level of the intrusions at both ends of the fault zone should be briefly discussed. The Sarqaq valley rocks belong to irregular sills, with conspicuously varying thicknesses within one and the same sill. They never reach such coarseness of texture as the rocks from Serfat, and they show only inconsiderable contact effect upon the country rock. They are supposed to be rather surface-near intrusions, and the transgredient course of the sills may in itself suggest a relatively high level of intrusion. From Spitsbergen TYRRELL reports the interesting observation that the nature of the sill intrusions into the Carboniferous and Permian strata on the one hand and into the Mesozoic on the other are strongly contrasted (35, p. 318). While the sills in the old formations are uniform, non-transgressive and very wide-spreading, those in the younger formations are decidedly transgressive and often ramify like a network through the strata. TYRRELL is of the opinion that this contrast is due to injection under deep and shallow covers respectively.

In Nûgssuaq no such comparison can be undertaken, as the oldest sediments found are of Cretaceous age. But if the Sarqaq valley sills are compared with the diabase sills ("diabase" in the continental sense

of the word) intruded into the late Precambrian Thule formation, similar differences are found as those described by TYRRELL. The Thule sills strikingly resemble the sills of the older Spitsbergen formations, being uniform, extensive and non-transgressive (20, p. 17), whereas the Sarqaq valley sills are transgressive. Although there are too many unknown factors (viz. amount of erosion during the time after the intrusions, and exact age of the latter), it is tempting to suppose that the difference between the sills from Thule District and the Nūgssuaq peninsula might be explained by a deeper level of intrusion as to the old Thule diabase, and a rather high level for the Tertiary dolerite sills of the Sarqaq valley.

As to the Serfat intrusion it is uncertain, whether it is a great sill or perhaps a flat laccolite, its floor being unknown, and its curved surface possibly being the dome-shaped roof of a laccolite. In reality the Serfat rocks show both abyssic and hypabyssic characteristics, and consequently they might belong as well to the one category as to the other. For some of the coarsest grained rocks the name of quartz-gabbro would undoubtedly be the most appropriate, but for the greater part of the rocks the name of quartz-dolerite is the fittest, for which reason the latter name has been used throughout.

At any rate the coarseness of texture and the considerable contact metamorphosis indicate a solidification on a deeper level than that of the Sarqaq valley sills.

VI. LITERATURE

1. BACKLUND, H. G. & MALMQVIST, D.: Zur Geologie und Petrographie der Nordostgrönländische Basaltformation. Teil I. Die basische Reihe. (pp. 1—61. Medd. om Grønland Bd. 87, Nr. 5. København 1932).
2. — — Zur Geologie und Petrographie der Nordostgrönländischen Basaltformation. Teil II. Die sauren Ergussgesteine von Kap Franklin. (pp. 1—84. Medd. om Grønland Bd. 95, Nr. 3. København 1935).
3. BERTELSEN, A.: vide Grønland i Tohundredaaret for Hans Egedes Landing (p. 399).
4. BROWN, R.: On Noursoak Peninsula, Disco Island and the Country in the Vicinity of Disco Bay, North Greenland. (pp. 55—112. Transact. of the Geol. Soc. of Glasgow, Vol. 5, Pt. 1. 1875).
5. BURRI, C.: Bestimmung der Auslöschungsschiefe monokliner Augite und Hornblenden auf (010) mittels beliebiger Schnitte. (pp. 285—89. Schweiz. Min. u. Petr. Mitt. Bd. 11, H. 2. Zürich 1931).
6. ECKERMANN, HARRY v.: Molecular Proportions. Uppsala 1925.
7. GIESECKES Mineralogisches Reisejournal über Grønland 1806—13. (pp. 1—532. Medd. om Grønland Bd. 35, 2. Udgave. København 1910).
8. Grønland i Tohundredaaret for Hans Egedes Landing, Bd. 1. (Medd. om Grønland Bd. 60. København 1921).
9. HARKER, A.: The Tertiary Igneous Rocks of Skye. (pp. 1—481. Mem. Geol. Surv. of the Unit. Kingdom. Glasgow 1904).
10. HEER, O.: Oversigt over Grønlands fossile Flora. (pp. 79—202. Medd. om Grønland Bd. 5. København 1893).
11. HEIM, A.: Über die Petrographie und Geologie der Umgebungen von Karsuarsuk, Nordseite der Halbinsel Nugsuak, W.-Grønland. (pp. 175—228. Medd. om Grønland Bd. 47. København 1911).
12. HOLMES, A. & HARWOOD, H. F.: The Age and the Composition of the Whin Sill and the related Dikes of the North of England. (pp. 493—542. The Min. Mag. Vol. 21, No. 122. London 1928).
13. JOHANSEN, A.: A Descriptive Petrography of the Igneous Rocks. Vol. I—IV. Chicago 1931—36.
14. KOCH, L.: Stratigraphy of Greenland. København 1929.
15. KROKSTRÖM, T.: The Breven Dolerite Dike. (pp. 243—330. Bull. Geol. Inst. Upsala. Vol. 23. Upsala. 1930).
16. — On the Ophitic Texture and the Order of Crystallization in Basaltic Magmas. (pp. 197—216. Bull. Geol. Inst. Upsala. Vol. 24. Upsala 1933).
17. — The Hällefors Dolerite Dike and some Problems of Basaltic Rocks. (pp. 111—263. Bull. Geol. Inst. Upsala. Vol. 26. Upsala 1936).
18. KRUEGER, H. K. E.: Die Hessische Grønlandexpedition 1925. (pp. 105—11. Petermanns Geogr. Mitt. Heft 5/6. 1926).

19. KRUEGER, H. K. E.: Zur Geologie von Westgrönland, besonders der Umgebung der Diskobucht und des Umanak-Fjordes. (pp. 97—137. Medd. om Grøn. Bd. 74. København 1928).
 20. MUNCK, S.: Geological Observations from the Thule District in the Summer of 1936. (pp. 1—36. Medd. om Grøn. Bd. 124, Nr. 4. København 1941).
 21. NIGGLI, P.: Die Magmentypen. (pp. 335—399. Schweiz. Min. u. Petr. Mitt. Bd. 16, H. 2. Zürich 1936).
 22. NOE-NYGAARD, A.: On the Geology and Petrography of the West Greenland Basalt Province. Part III. The Plateaubasalts of Svartenhuk Peninsula. (pp. 1—78. Medd. om Grøn. Bd. 137, Nr. 3. København 1942).
 23. NORDENSKIÖLD, A. E.: Redogörelse för en Expedition till Grönland År 1870. (pp. 973—1082. Öfv. av K. Vet.-Akad. Förh. 1870, Nr. 10).
 24. RAVN, J. P. J.: De marine Kridtaflejringer i Vest-Grønland og deres Fauna. (pp. 313—366. Medd. om Grøn. Bd. 56, Nr. 9. København 1918).
 25. REINHARD, M.: Universaldrehtischmethoden. (pp. 1—119. Basel 1931).
 26. RINK, H.: Om den geographiske Beskaffenhed af de danske Handelsdistrikter i Nordgrønland, tilligemed en Udsigt over Nordgrønlands Geognosi. (pp. 1—62. København 1852).
 27. ROSENBUSCH, H.: Elemente der Gesteinslehre. Stuttgart 1923.
 - 28a. ROSENKRANTZ, A., NOE-NYGAARD, A., GRY, H., MUNCK, S., LAURSEN, D.: Den danske Nûgssuaq Ekspedition 1939. (pp. 653—663. Medd. fra Dansk Geologisk Forening, Bd. 9. København 1940).
 - 28b. — NOE-NYGAARD, GRY, MUNCK, LAURSEN: A Geological Reconnaissance of the Southern Part of the Svartenhuk Peninsula, West Greenland. (pp. 1—72. Medd. om Grøn. Bd. 135, Nr. 3. København 1942).
 29. — Auvfarssuaq. (pp. 82—98. Det grønlandske Selskabs Aarsskrift 1943).
 30. STEENSTRUP, K. J. V.: Bemerkungen zu der Geognostischen Übersichtskarte der Küsten des Waigattes in Nord-Grönland. (Mit Karte). (pp. 143—44. Petermann's Geogr. Mitteil. Heft. IV, 1874).
 31. — Om de kulførende Dannelser paa Øen Disko, Hareøen og Syd-Siden af Nûgssuaq's Halvøen i Nord-Grönland. (pp. 1—39. Vidensk. Medd. fra den naturhist. Foren. i Kjøbenhavn Nr. 3—7, 1874).
 32. — Bidrag til Kjendskab til de geognostiske og geographiske Forhold i en Del af Nord-Grönland. (pp. 173—242. Medd. om Grøn. Bd. 4. København 1893).
 33. — Om Forekomsten af Forsteninger i de kulførende Dannelser i Nord-Grönland. (pp. 43—78. Medd. om Grøn. Bd. 5. København 1893).
 34. TOMITA, T.: Variation in Optical Properties, according to Chemical Composition in the Pyroxenes of the Clinoenstatite-Clinohyperstene-Diopside-Hedenbergite System. (pp. 41—58. Journ. Shanghai Sc. Inst. Sect. II, 1. 1934).
 35. TYRRELL, G. W. & SANDFORD, K. S.: Geology and Petrology of the Dolerites of Spitsbergen. (pp. 284—321. Proc. of the Royal Soc. of Edinburgh. Vol. 53, Part 3, No. 21 Edinburgh 1933).
 36. USSING, N. V.: Mineralogisk-petrografiske Undersøgelser af Grønlandske Nefelinsyeniter og beslægtede Bjergarter. (pp. 1—220. Medd. om Grøn. Bd. 14. København 1894).
 37. WAGER, L. R. & DEER, W. A.: Olivines from the Skaergaard Intrusion, Kangerdlugssuaq, East Greenland. (pp. 17—25. The Am. Min. Vol. 24, 1939).
 38. WHITE, D., & SCHUCHERT, CH.: Cretaceous Series of the West Coast of Greenland. (pp. 343—368. Bull. of the Geol. Soc. of Am. Vol. 9, 1898).
-

Færdig fra Trykkeriet den 9. Februar 1945.

PLATES

Plate 1.

- Fig. 1. Coarse grained, weathered quartz-dolerite, Serfat, with long pyroxene twins (3795).
- Fig. 2. Quartz-dolerite, Serfat, with large, reflecting ore planes to the left (light) and in the centre (dark) (3795).
- Fig. 3. Light coloured, medium grained quartz-dolerite, Serfat, with tabular ore (dark) (4665).



Fig. 1.

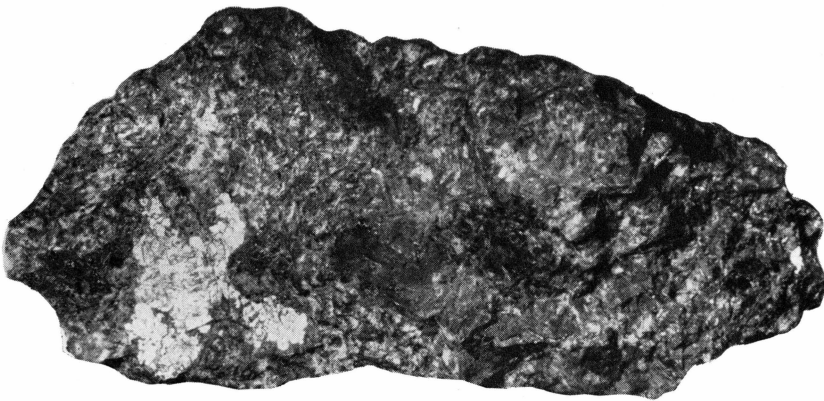


Fig. 2.

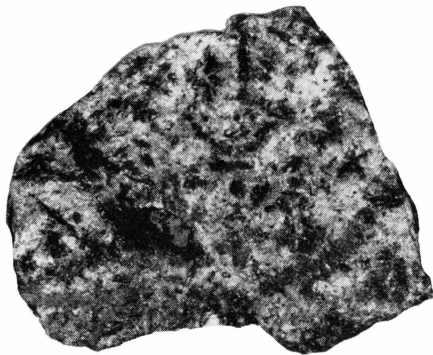


Fig. 3.

CHR. HALKIER phot.

Plate 2.

- Fig. 4. The fine grained, upper part of the Serfat sill with many cavities filled with calcite (2120).
- Fig. 5. Light coloured dolerite (3138) with ophitic texture (pl. 10, fig. 23). Sarqaq valley.
- Fig. 6. Dark, finer grained dolerite (3135). Sarqaq valley.
- Fig. 7. Light coloured, acid vein in dolerite from Atanikerdluk (1489).

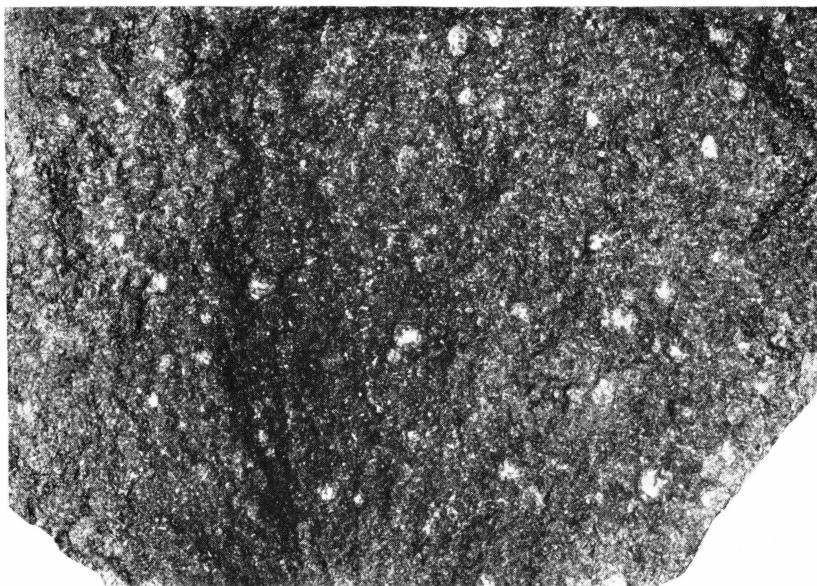


Fig. 4.

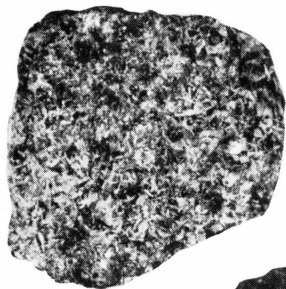


Fig. 5.

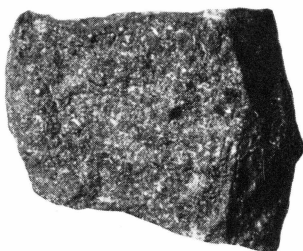


Fig. 6.

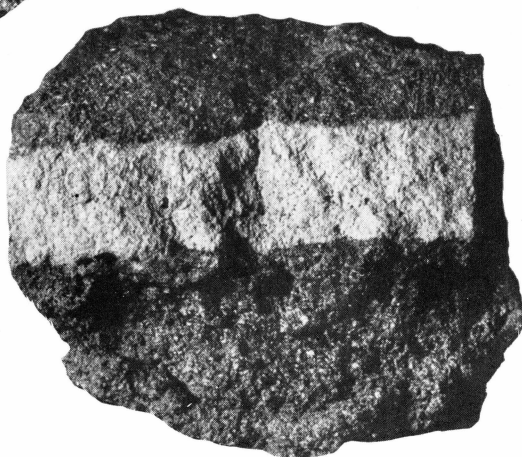


Fig. 7.

Plate 3.

Fig. 8. Quartz-dolerite of granogabbroic type (3797) Serfat. + nic. $\times 27$. Tapering felspar in pyroxene.

Fig. 9. Same slide. 1 nic. $\times 20$. In the right lower corner is seen a large, arcuated pyroxene crystal, enclosing felspar laths and with pseudomorphs on olivine along the lower border. It consists of two twin individuals with distinct cleavages. Moreover, plagioclase individuals and interstitial matter with micropegmatite and apatite are seen.



Fig. 8.



Fig. 9.

CHR. HALKIER phot.

Plate 4.

Fig. 10. Quartz-dolerite of granogabbroic type (3797) Serfat. 1 nic. $\times 40$. To the right: fresh olivine with an incipient transformation along cracks and bounded by plagioclase laths, partly protruding into it. In the left, lower corner olivine, rather transformed, which higher up is replaced by pyroxene. Both olivine and pyroxene are orientated in such a manner that one of their optic axes is almost perpendicular to the plane of the section.

Fig. 11. Same slide. 1 nic. $\times 40$. Part of large pyroxene twin, enclosing small felspar laths and with a large tapering felspar. Along the upper border to the right pseudomorphosis after early olivine (black), the light coloured areas being pyroxene, which have replaced the olivine and show the same extinction as the big pyroxene crystal. The latter is obscured by the "salite structure". (See the text p. 20).

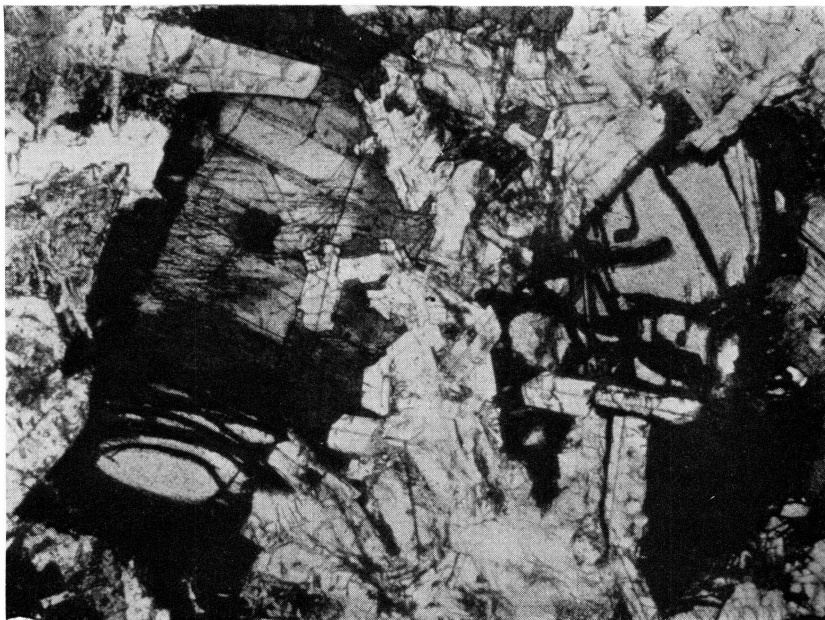


Fig. 10.

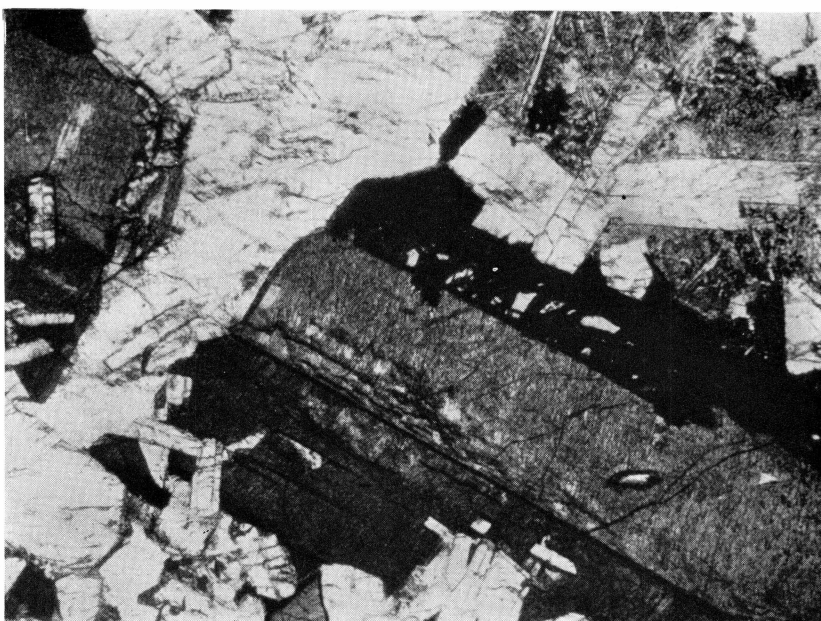


Fig. 11.

Plate 5.

Fig. 12. Quartz-dolerite of granodioritic type (4665) Serfat. + nic. $\times 63$. Plagioclases with broad, micropegmatitic borders. Along fissures and cracks in the large, twinned plagioclase an incipient transformation into calcite takes place.

Fig. 13. Same slide. + nic. $\times 20$. In the upper right corner a calcite-filled cavity, from which calcite along cracks in the rock has penetrated right through a big plagioclase and the groundmass, rich in quartz and micropegmatite.

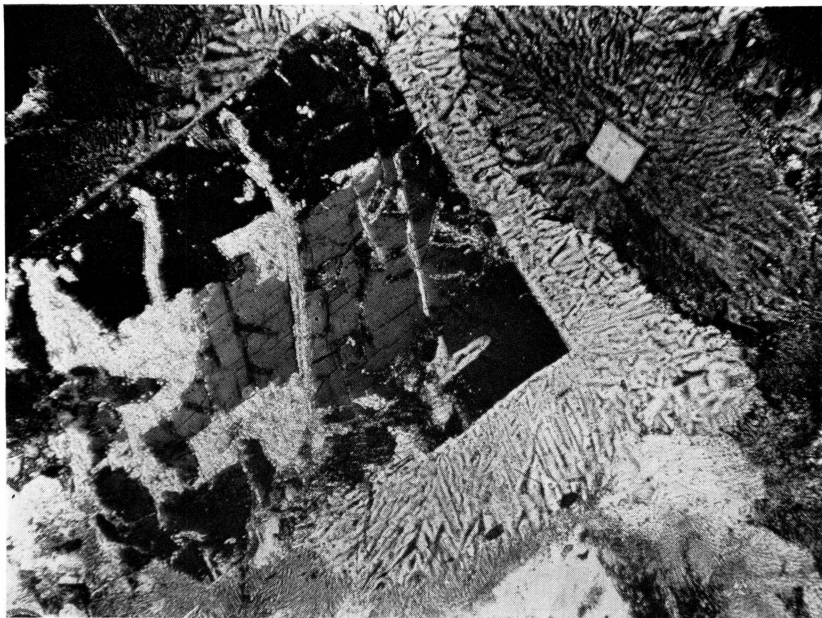


Fig. 12.



Fig. 13.

Plate 6.

Fig. 14. Quartz-dolerite (3025) Serfat. 1 nic. $\times 60$. Ore impregnation in felspar-rich rock.

Fig. 15. »White-trap« (3021) Serfat, upper contact zone. + nic. $\times 60$. Calcite replacement of plagioclase laths and groundmass. Calcite-filled cavity near the lower right corner, and a quartz-filled cavity in the centre (dark).



Fig. 14.

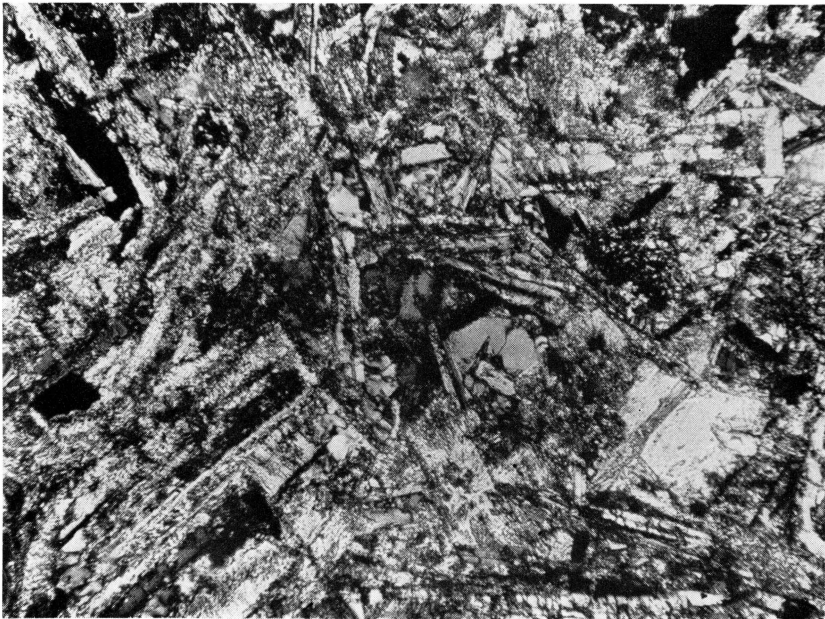


Fig. 15.

CHR. HALKIER phot.

Plate 7.

Fig. 16. Granodiorite-aplite (3017), Serfat. + nic. $\times 55$. Large plagioclase twin. Groundmass chiefly consisting of quartz, microperthite, and micropegmatitic intergrowths. Near the upper left corner: cavity with a central area of calcite surrounded by idiomorphically grown quartz with striae of inclusions parallel to the edge.

Fig. 17. Same slide. + nic. $\times 60$. Zonary, twinned oligoclase with irregular veins of potash feldspar (antiperthite). The groundmass chiefly consists of quartz and micropegmatite.



Fig. 16.



Fig. 17.

Plate 8.

Fig. 18. Granodiorite-aplite (3017), Serfat. + nic. $\times 150$. Idiomorphic, acid plagioclase with a broad, micropegmatitic border in a groundmass, chiefly consisting of quartz, micropegmatite, microperthite and calcite.

Fig. 19. Same slide. + nic. $\times 150$. Microperthite in micropegmatitic intergrowth with quartz.

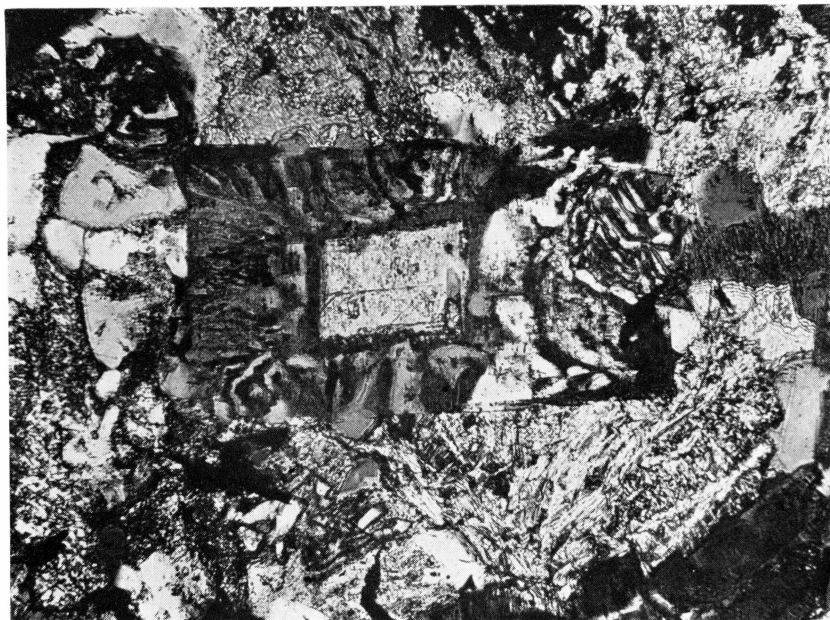


Fig. 18.



Fig. 19.

Plate 9.

Fig. 20. Dolerite (3132), Sarqaaq valley. + nic. $\times 60$. Doleritic texture. To the right pyroxene twins.

Fig. 21. Same slide. 1 nic. $\times 60$. Pyroxene partly surrounding irregularly defined olivine grains.

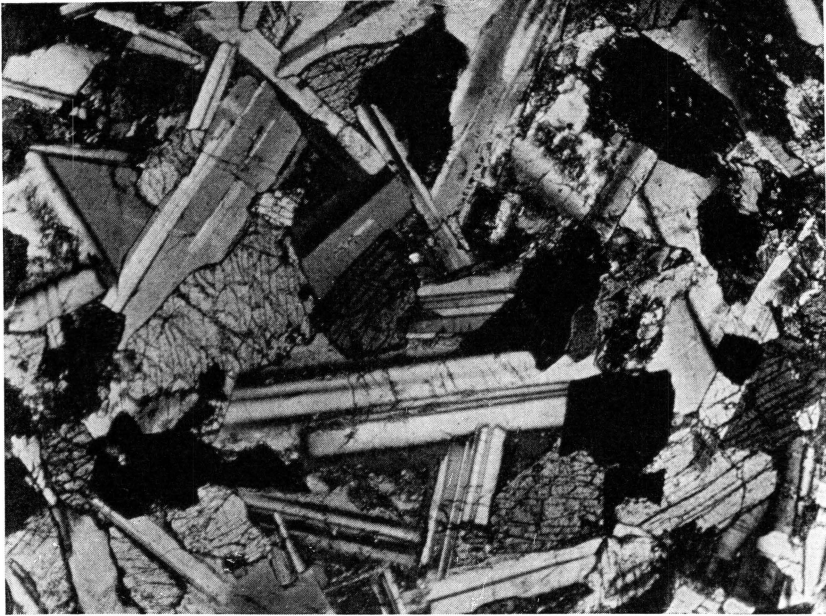


Fig. 20.

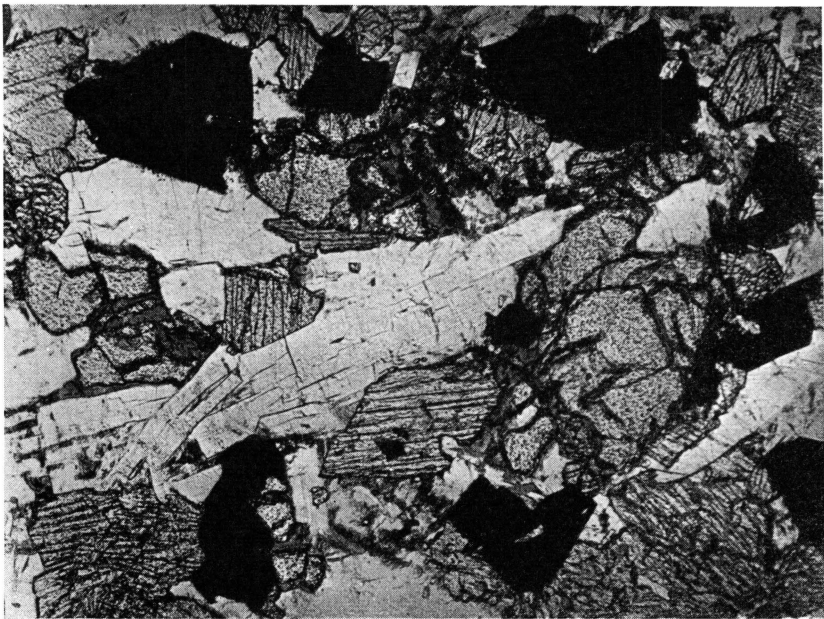


Fig. 21.

CHR. HALKIER phot.

Plate 10.

Fig. 22. Dolerite (3135), Sarqag valley. 1 nic. $\times 60$. Small, idiomorphic olivine, perfectly enclosed by pyroxene. In the centre a large olivine grain with cracks, along which an alteration of the olivine takes place.

Fig. 23. Dolerite (3138), Sarqag valley. + nic. $\times 20$. Ophitic texture. Labradorite enclosed by pyroxene (light coloured, lower half of picture), and by olivine (dark, upper half).

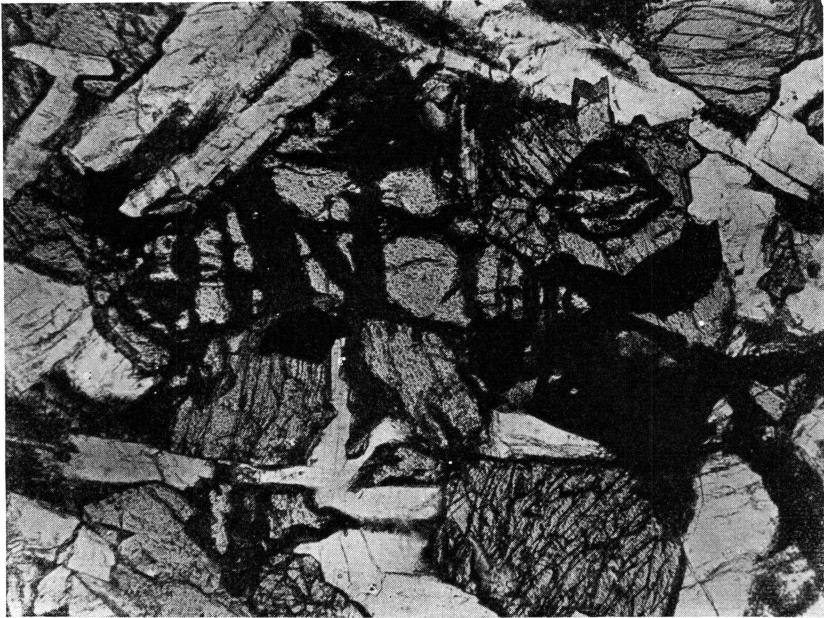


Fig. 22.



Fig. 23.

Plate 11.

Fig. 24. Dolerite (3139), Sarqaq valley. + nic. $\times 30$. Zonary feldspars. Micropegmatite interstitially (centre) and in a broad border surrounding a large plagioclase (upper left corner).

Fig. 25. Dolerite (2412), Atanikerdluk. + nic. $\times 20$. Phenocryst-like feldspar from glomerophytic accumulation of large plagioclase individuals.

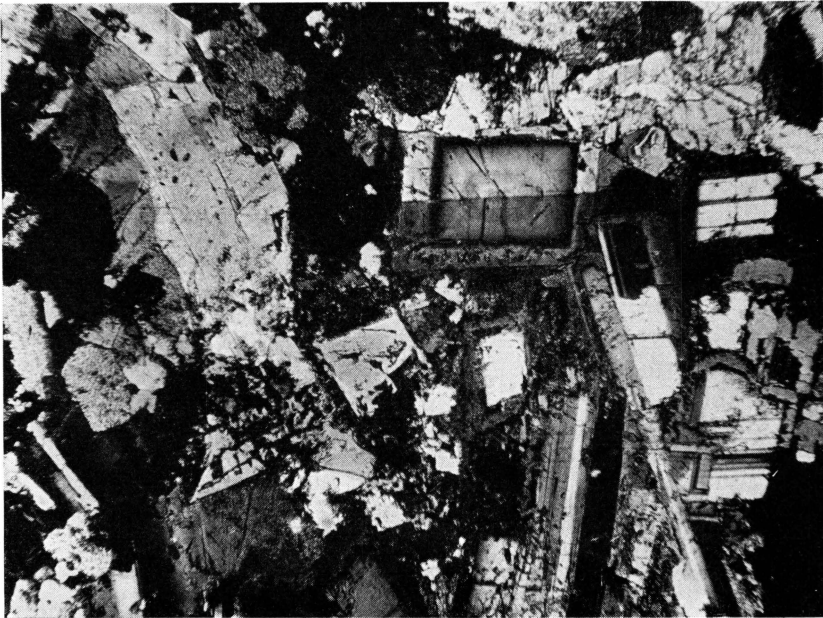


Fig. 24.

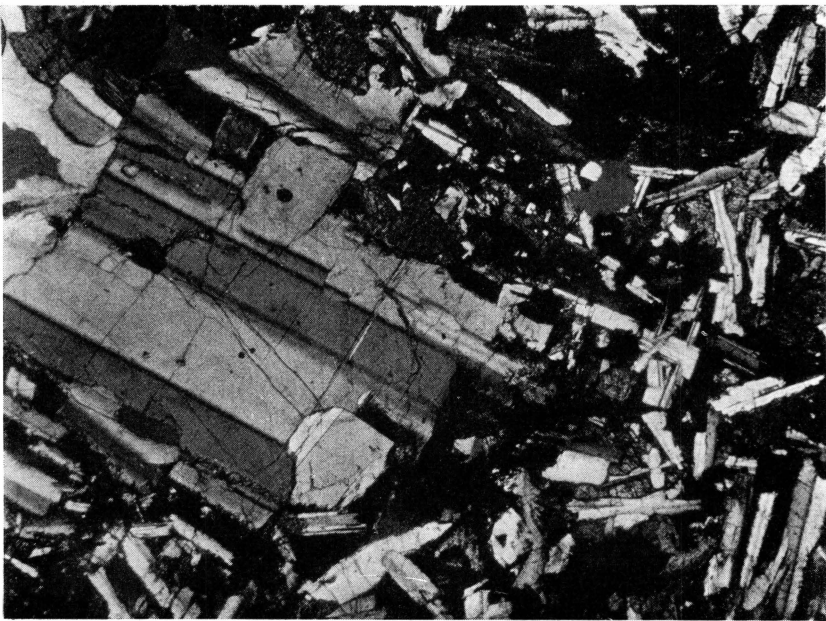


Fig. 25.

Plate 12.

Fig. 26. Dolerite (86), Atanikerdluk. 1 nic. $\times 40$. Arcuated titaniferous augite with tapering feldspar. Magnetite in lower left, ilmenite in upper right corner.

Fig. 27. Boundary between medium grained dolerite and fine grained aplite (98), Atanikerdluk. + nic. $\times 20$.

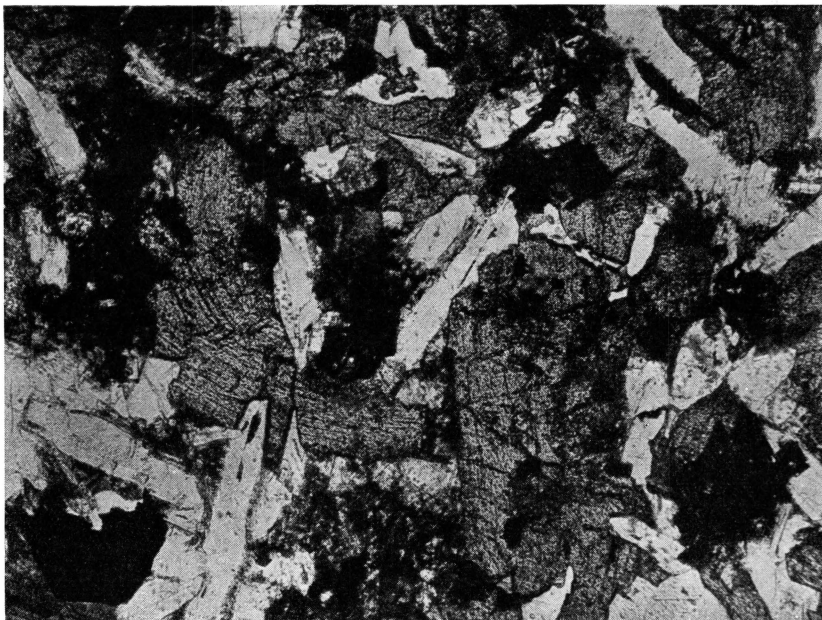


Fig. 26.



Fig. 27.

CHR. HALKIER phot.

Plate 13.

Fig. 28. Leucocratic vein (kaligranite-aplite), (97A), Atanikerdluk. + nic. $\times 60$. The rock consists of quartz, micropegmatite and anorthoclases in rectangular cross sections. To the left is seen part of an uncommonly big anorthoclase.

Fig. 29. Leucocratic vein (kaligranite-aplite), (3133), Sarqag valley. + nic. $\times 60$. Rectangular anorthoclases with many enclosures and frequently with a micropegmatitic border. Quartz grains are not common.

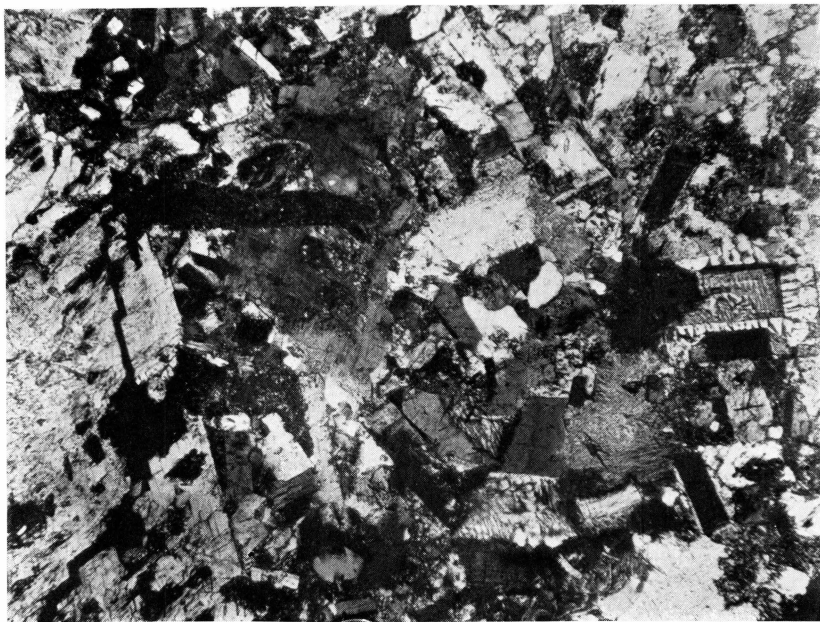


Fig. 28.

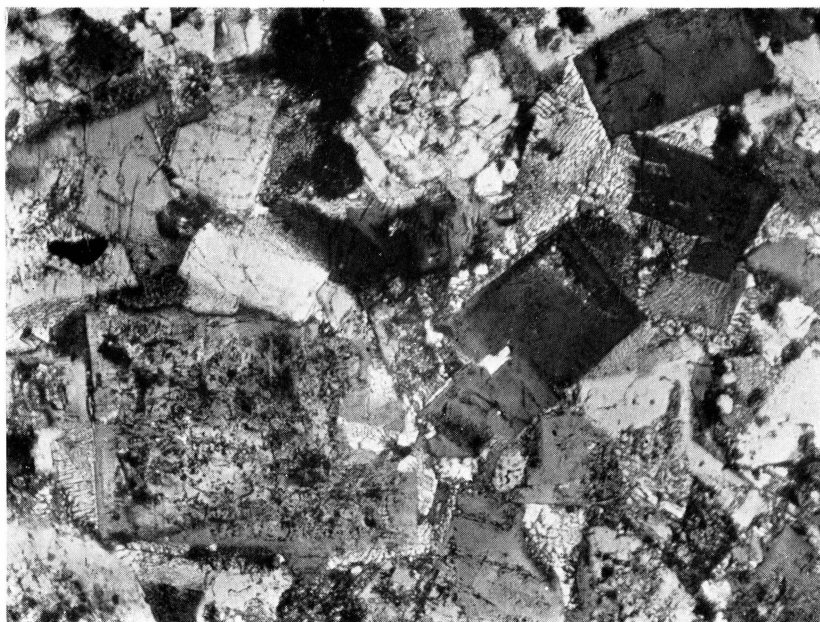
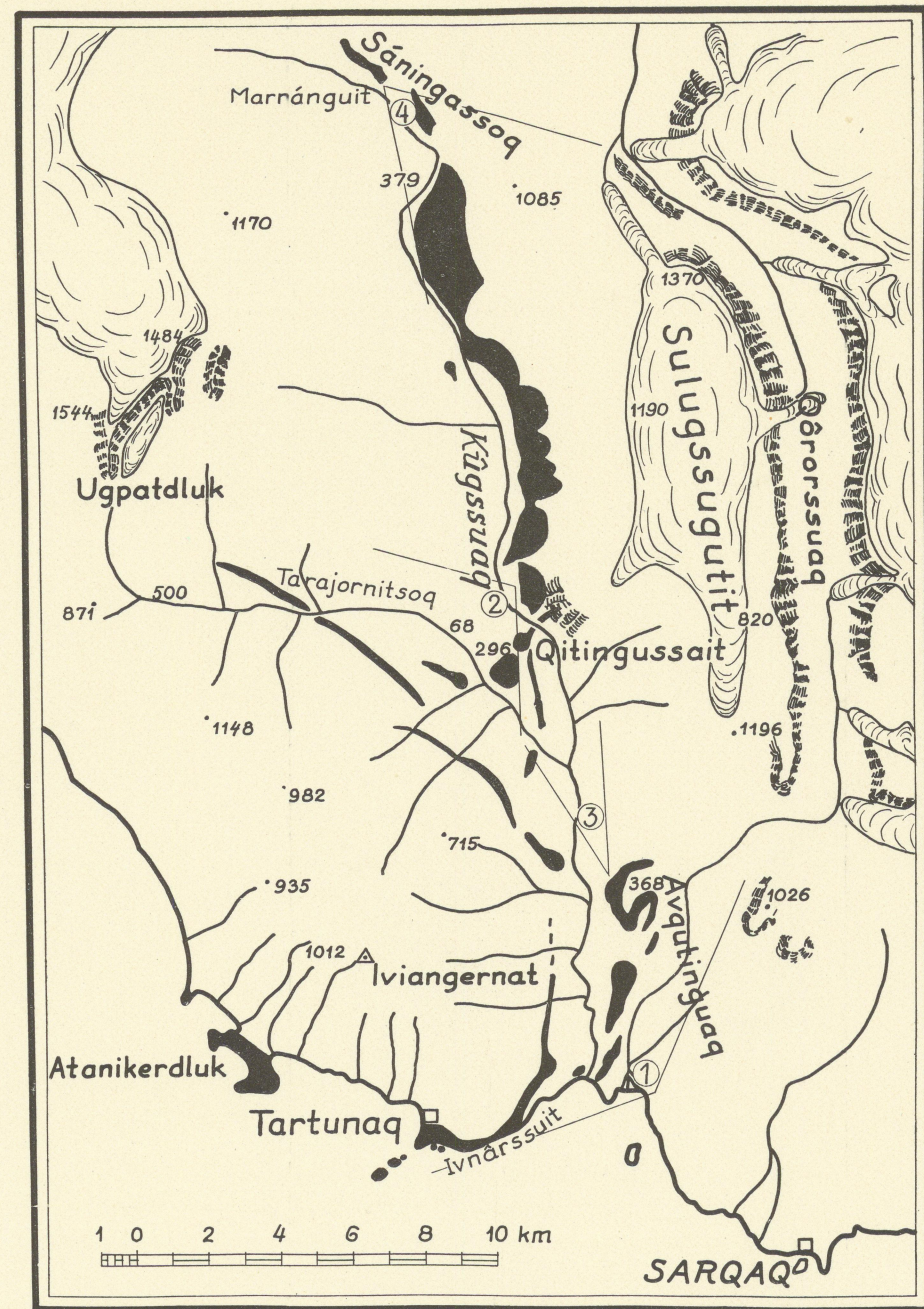


Fig. 29.



Sketch map of the distribution of the dolerite at Atanikerdluk and through Tarajornitsoq and the Sarqaq valley, as observed in 1938 and 1939. The faintly drawn angles refer to the sketches on pl. 15, the apex of the angle indicating the point of observation and the distance between the sides being the areas drawn.

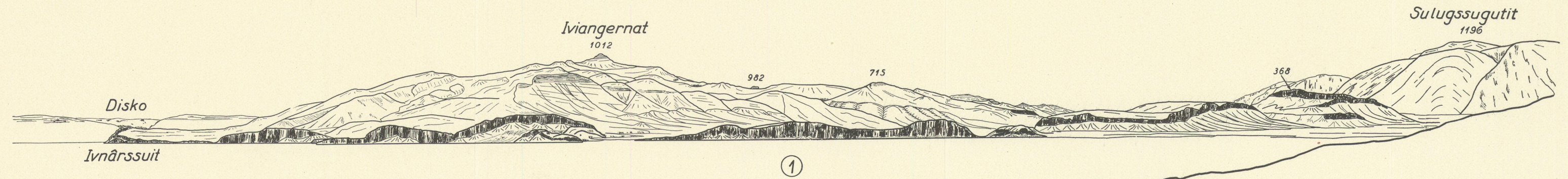


Fig. 1. The Sarqaq valley viewed from a point on the coast, situated about 7 km northwest of Sarqaq (① on the map pl. 14). The dolerite sills continue with a very undulating course from Ivnárssuít through the Sarqaq valley, as far as one can see.

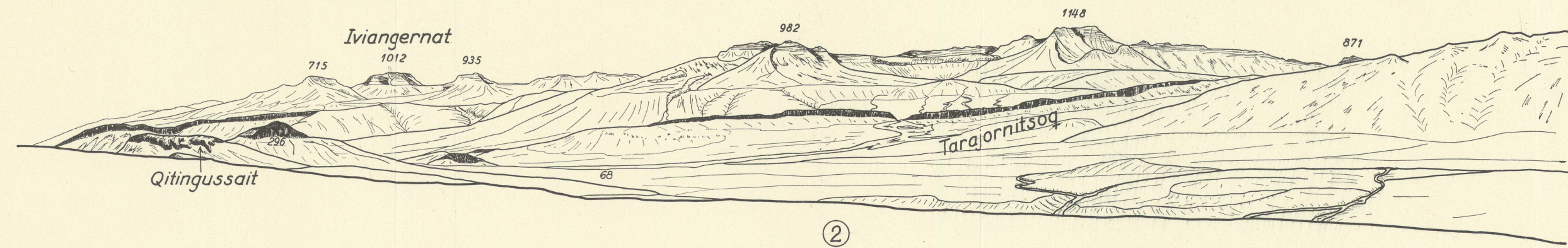


Fig. 2. View through Tarajornitsoq from a point a little to the north of Qitingussait (② on the map pl. 14). The large dolerite sill is seen to extend right across the river bed through the valley. To the left the upper part of Qitingussait.

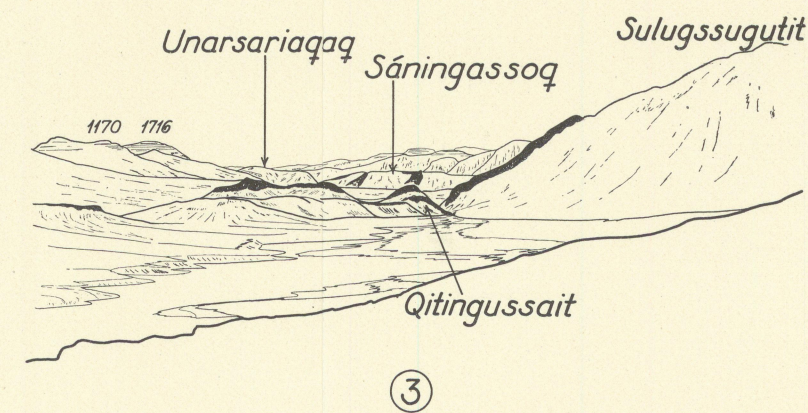


Fig. 3. Qitingussait viewed from the south (③ on the map pl. 14). Towards east the dolerite "creeps" up the steep gneiss wall.

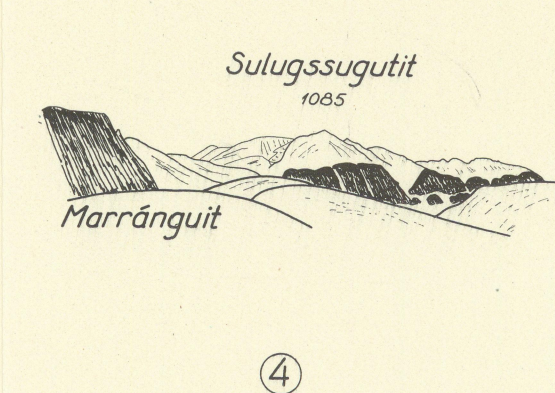


Fig. 4. Dolerite "pasted on" to the gneiss, viewed from Sáningassoq in a southern direction, (④ on the map pl. 14).