GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT NR. 3

The Geological Survey of Greenland
Report no. 3

The Bedrock Geology of Vatnahverfi, Julianehåb district, South Greenland

by

Jevan P. Berrangé

KØBENHAVN 1966

THE BEDROCK GEOLOGY OF VATNAHVERFI

JULIANEHÅB DISTRICT, SOUTH GREENLAND

by

JEVAN P. BERRANGÉ

With 8 figures, 1 plate
and 2 maps

CONTENTS

Abstract

I INTRODUCTION

- (1) General Statement
- (2) Regional Geology

II PETROLOGY AND STRUCTURE

- (1) Ketilidian, Kuanitic and Sanerutian Periods
  - (a) Migmatites including Granites (G1) and Aplite-Pegmatite (AP1)
  - (b) Structure of the Migmatite Complex
  - (c) The Julianehåb Granite: Tonalitic Facies (G1), Leucocratic Facies (G2)
  - (d) Folded Discordant Amphibolites (DA1 ?)
  - (e) Discordant Amphibolite (DA2) and Microdiorite (MD2) Dykes
  - (f) Hornblende Gabbro and Olivine Norite (GN2)
  - (g) Discordant Amphibolite Dykes (DA3)
  - (h) Meladiorite - Leucogranodiorite Suite (MD3)
  - (i) Redekammen-type Granitic Rocks (G3), (G4) and ($G4^1$)
  - (j) Aplite and Pegmatite (all generations)
- (2) Gardar Period
  - (a) Old Dolerite (OD)
  - (b) Olivine Dolerite (OvD)
  - (c) Lamprophyre (La)
  - (d) Mafic Micromonzonite (MM)
  - (e) Nepheline Trachyte (NTr)
  - (f) Flaggy Nepheline Trachyte (FNTr)
  - (g) Feldspar-Nepheline Porphyry and Trachydolerite Porphyry (Po)
  - (h) Plagioclase-Pyroxene-phyric Trachyte (PPTr)

III ECONOMIC GEOLOGY

IV REFERENCES

Abstract

The petrology, structure and chronology of the Vatnahverfi area comprising ca. 300 sq. km SE of Igaliko fjord, Julianehåb district, S Greenland, is described. All the rocks are of Precambrian age and belong to the Ketilidian, Kuanitic, Sanerutian and Gardar periods. The Ketilidian period is represented by a migmatite complex comprising various biotite and hornblende gneisses showing relict supracrustal structures and intermingled with foliated granites. The complex belongs to the lower amphibolite facies. Mapping combined with stereographic structural analysis shows that the complex was initially folded about NE-trending B1 axes and subsequently on vertical to NW-trending B2 axes. The Kuanitic period was a hiatus in the plutonism and is represented by the intrusion of discordant dolerite and microdiorite dykes and hornblende gabbro (appinitic) plutons. Renewed plutonism during the Sanerutian period caused local reactivation of the Julianehåb granite as is indicated by fragmentation and granitisation of the older basic bodies. Discordant amphibolite dykes and sheets, including a net-veined meladiorite - leucogranodiorite suite, were subsequently intruded under synplutonic conditions. A discordant batholith and satellitic sheets of biotite adamellite were emplaced towards the close of the Sanerutian period. The subsequent Gardar period is represented by faulting, mineralisation and the intrusion of various generations of dolerite, trachyte and alkali trachyte dykes.

I INTRODUCTION

(1) General Statement

This report covers an area of ca. 300 sq. km mapped during the summers of 1962 and 1963 by the author whilst working for the Geological Survey of Greenland as one of a team of geologists under the supervision of J.H. Allaart.

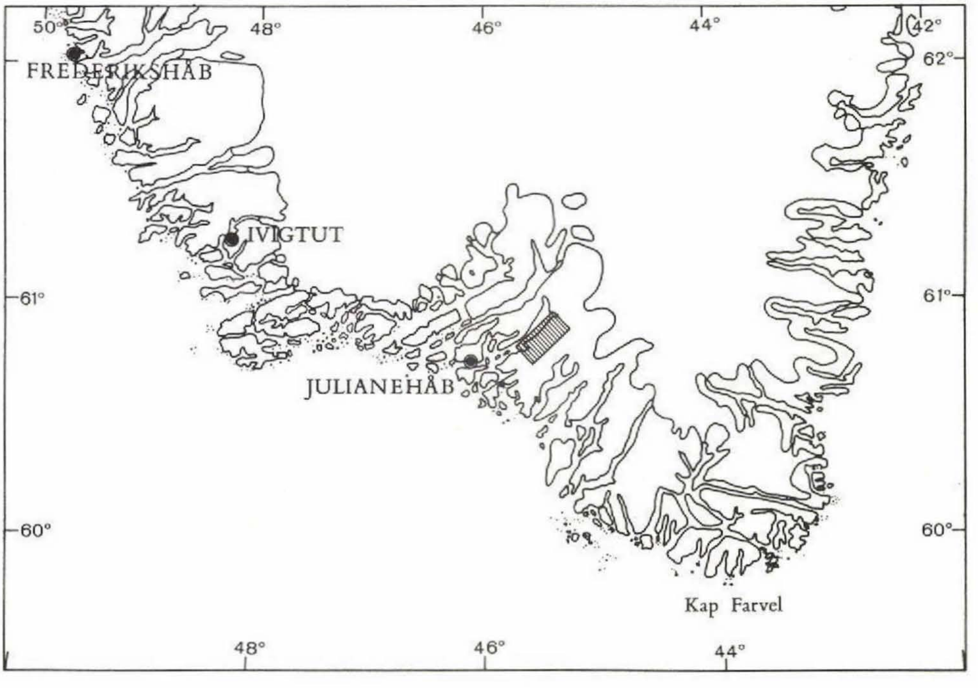


Fig. 1. Index map showing the position of the Vatnahverfi area in South Greenland.

The location of the map-area is shown on Fig. 1. It is bordered to the northwest by Igaliko fjord between the bay of Eqaluit and Søndre Igaliko lying ca. 25 km to the northeast, and extends 11-12 km inland. Adjoining areas were mapped by Windley (1963) working in the southwest, Buttet (1962, 1963) in the southeast, and Steen Andersen in the northeast.

Eighty-seven days were spent field mapping. Topographic maps (1: 20, 000, 25 m contour interval) and vertical aerial photographs (1:40, 000) both supplied by the Geodetic Institute, Copenhagen, were used. Most of the mapping were done from 12 camps (see Map 1) although some of the shoreline was mapped with the aid of a cutter. Two Bell 47-J helicopters were used for moving camp and bringing supplies.

For South Greenland the area has a paucity of outcrop and a relatively low relief, the highest point being 705 m. It comprises a terrain of undulating valleys and hills, there being only a few unscalable cliffs. These factors have for long combined to make this area favoured for settlement and farming. It comprises the greater part of the region called "Vatnahverfi" by the ancient Norse settlers (11th to 15th Century) and judging from the distribution of their ruins was a very densely populated part of the country. Today the area affords excellent pasture for numerous sheep belonging to Greenlandic farmers, Abel Kristiansen (Eqaluit), Henning Lund (Qanisartut) and Abel Christiansen (Søndre Igaliko) whose farmsteads are on sites originally occupied by the Nordic settlers, and to whom I am indebted for generous hospitality.

From these comments it is obvious that the area is generally unsuited to geological observations. It proved impossible to follow marker bands or dykes for any appreciable distances and hence the chronology is erected on tenuous circumstantial evidence, supplemented by observations made on team excursions elsewhere in the Julianehåb district and by discussions with my colleagues. This report is based on field observations supplemented by a rapid scanning of thin-sections.

(2) Regional Geology

The various rocks of South Greenland acquired their present dominant characteristics during the Precambrian Ketilidian, Kuanitic, Sanerutian and Gardar periods. Pre-Ketilidian gneisses formed a basement on which were deposited geosynclinal sediments and volcanics that were intruded by basic dykes (1st period) and that are now preserved in the Ivigtut and Syd Sermilik-Tasermiut (Nanortalik) regions (cf. Berthelsen, 1960; Escher, in press;Dawes, 1963). Later in the Ketilidian period these rocks were subjected to orogenic deformation, metamorphism and migmatisation, thus being partly transformed into an infracrustal migmatite complex in the amphibolite facies. There followed an hiatus known as the Kuanitic period characterised by the intrusion of basic and intermediate dykes (2nd period) (cf. Watterson, 1964). These were closely followed by the emplacement of an appinitic suite of plutons ranging from ultrabasic to intermediate in composition (cf. Walton, in press). The Sanerutian period is characterised by a series of reactivations of the earlier granitoid rocks to produce a new series of younger, higher level, granites. The 2nd period basic dykes and appinitic bodies were metamorphosed and granitised and several generations of synplutonic basic to intermediate dykes were intruded (3rd period). The Sanerutian plutons, both basic and acid, are generally discordant, parautochthonous and of partly igneous habit (volcanic in the sense of Read, 1957). During the Gardar period continental arenites and lavas were deposited and a complex suite of igneous rocks, both basic and alkaline, were emplaced as dykes and other injected high-level plutons (e.g. Ilímaussaq, Nunarssuit, Igaliko Syenite Complex, Kûngnât, etc.). Subsequently, dolerite dykes (Tertiary?) were intruded as swarms generally parallel to the regional coastline.

For a more comprehensive account of the geology of South Greenland and of the problems involved reference should be made to the above references and to Allaart (1964) and Bridgwater (in press). The accompanying chronological table shows the succession of rocks present in the Vatnahverfi map-area.

CHRONOLOGICAL TABLE VATNAHVERFI MAP-AREA

GARDAR "VOLCANISM"	Mineralisation: silica, fluorite, calcite, hematite, epidote, chlorite, Cu-Fe sulphides. Lamprophyres, olivine dolerite, trachytes feldspathoidal trachytes etc. Quartzo-feldspathic mineralisation Old dolerite	Faulting SE Faulting NE Faulting ENE Faulting NE - E Faulting
SANERUTIAN PLUTONISM	Biotite Adamellite $G4^{1}$ Aplite-Pegmatite AP4 Biotite Adamellite G4	Reactivation anatexis and mobilisation producing discordant plutons.
	Aplite-Pegmatite dykes and sheets AP3 Meladiorite - Leucogranodiorite Suite MD3 (net-veined) Discordant Amphibolite sheets and dykes DA3	Synplutonic intrusion of basic to acid dykes and sheets.
	Fine-grained Biotite Granodiorite sheets and dykes G3 Aplite - Pegmatite dykes and sheets AP2 Leucocratic facies of Julianehåb Granite G2	Reactivation. Metamorphism, veining and granitisation of basic bodies. Recrystallisation partial anatexis and mobilisation of granite.
HIATUS	Hornblende Gabbro - Olivine Norite plutons GN2 Discordant Microdiorite dykes and sheets MD2 Discordant Amphibolite dykes and sheets DA2	Intrusion of basic and intermediate dykes and gabbroic plutons.
KETILIDIAN PLUTONISM	Foliated Tonalitic facies of Julianehåb Granite G1 Migmatites: various biotite and hornblende gneisses showing relict supracrustal structures and intermingled with Foliated Granites G1, and Aplite - Pegmatite AP1 Folded Discordant Amphibolite (DA1 ?)	Metamorphism (low amphibolite facies); partial anatexis and mobilisation acidic segments. Folding B1 NE axes. Folding B2 vertical to W-NW axes.
KETILIDIAN SEDIMENTATION		Geosynclinal sedimentn. on pre-Ketilidian basement. Intrusion and/or extrusion of basic magma into and/or onto sediments and/or pre-Ketilidian.

II PETROLOGY AND STRUCTURE

(1) Ketilidian, Kuanitic and Sanerutian Periods

(a) Migmatites including Granites (G1) and Aplite-Pegmatites (AP1)

The greater part of the map-area is underlain by a migmatite complex comprising various types of gneiss intimately associated with several varieties of conformable granitoid rocks. The feature that distinguishes this complex from the adjacent Julianehåb granite is that, considered as a whole, it maintained a larger measure of competency throughout its plutonic history. In most cases it is therefore still possible on a mesoscopic scale to recognise structures of relict supracrustal origin, e.g. banding, striping, small-folding, and amphibolite dykes (DA1 ?) that are folded and/or boudinaged.

All the usual structural types of gneiss can be recognised in the field -banded, striped, small-folded, veined, augen, streaky and nebulitic gneiss- and they can be further classified on the basis of whether biotite or hornblende is characteristic (cf. Berthelsen, 1961). The general distribution of the quantitatively more important types of gneiss is shown on Map 2. The gneisses are intercalated with, or merge into, "homogeneous gneisses" or foliated granites (G1) that form concordant masses having widths ranging from less than a meter to a few km.

Although various petrographic types of granite can be recognised in the field, the differences between them reflect original structural and mineralogical differences in the rock from which they were recrystallised, rather than a sequence of granites of different ages. It seems likely that the rock types of the migmatite complex belong to various stages in an ultrametamorphic series, augen-gneiss → venite → arterite → migmatite → anatexite, and that the stage to which each rock belongs (i. e. its degree of mobilisation or anatexis) was governed by its original structure and mineralogy. There is a possibility that the granitic rocks within this complex have been reactivated during the late Ketilidian or Sanerutian plutonism but no evidence for this was found. Accordingly, all the granites forming an integral part of the Ketilidian migmatites are designated G1.

Augen-gneiss occurs commonly in the vicinity of the contact between the migmatite complex and the Julianehåb granite. In the environs of Eqaluit, a light grey, biotite-hornblende augen-gneiss containing numerous feldspar augen forms part of recumbent fold. The feldspar megacrysts are generally aligned parallel to the foliation, measure up to 3.5 x 1.75 cm, are subidioblastic and have granulated margins. These and other features suggest a synkinematic (B1) crystallisation of this augen-gneiss. In comparison, the augen-gneiss in the vicinity of the contact between the migmatites and the young Redekammen-type granite (G4) has idioblastic randomly oriented feldspar megacrysts. It seems as if there were at least two periods of augen-gneiss development - Ketilidian synkinematic and late Sanerutian postkinematic.

The gneisses and G1 granites all have the same mineral assemblage; primary essential minerals are finely perthitic microcline, oligoclase, quartz, brownish-green biotite and/or hornblende. Both the microcline and the plagioclase form porphyroblasts. In the hornblende gneisses and amphibolites, plagioclase porphyroblasts are more common than those of microcline and quartz is generally scarce (less than 5%). Some of these hornblendic rocks have a palimpsest subophitic texture and the amphibole has a uralitic appearance suggestive of an origin by alteration of pyroxene. Rocks in which this is seen are probably metamorphosed gabbros or dolerites (e.g. subarea 5 between Taserssuaq and Tasikuloq; subarea 19 N of Rusip kûa). Primary accessory minerals in the gneisses generally include zircon, apatite, opaque oxide, orthite, sphene and myrmekite, this latter being associated in time and space with the microcline. The biotite is more or less altered to pennine. In addition, most rocks contain one or more of the epidote group minerals that are clearly secondary after mica, hornblende and/or the plagioclase. Sericite is another alteration product of the plagioclase. The opaque oxide is commonly mantled by secondary granular leucoxene that is distinct from the primary sphene.

The secondary minerals described above are probably of partly retrograde origin and partly the product of subsequent events in the geological history, i.e., Sanerutian reactivation, and Gardar volcanism and faulting with associated alteration. The complex belongs to the lowest subfacies of the almandine amphibolite facies, as does the Julianehåb granite including G1 and G2.

The oldest generation of pegmatites, AP1, recognisable in the area are simple, coarse-grained, quartzo-feldspathic lenses concordant with the surrounding gneisses with which they appear to be folded. These lenses may pinch and swell and vary in width from a few cm to a few tens of cm. These are the pegmatites that comprise the quartzo-feldspathic part of the veined gneisses and the cementing material of some of the agmatites. They are essentially of the same age as the granites G1. They must have started developing during early synkinematic time but their coarse subidioblastic fabric indicates that they ceased crystallisation only in postkinematic time. Bodies of pure aplite of this generation have not been recognised (cf. Jahns and Tuttle, 1963, p. 79).

(b) Structure of the Migmatite Complex

Three successive periods of folding have been generally recognised throughout South Greenland (Fig. 1) from the Ivigtut region in the north (Berthelsen, 1960), through the Julianehåb region in the centre (Windley, 1963), to the Nanortalik region in the south (Escher, in press). Furthermore, there is general agreement that the first folding was premigmatitic on northeast trending axes, that the second deformation was synmigmatitic on northwesterly axes, whilst the final deformation was about north trending axes.

In the Vatnahverfi area analysis of the structure has been hindered by: (a) the reconnaissance nature of the mapping, (b) the great intensity of the ultrametamorphic processes (especially static recrystallisation, partial anatexis and mobilisation, (c) the absence of marker beds, (d) the poor exposure, (cf. Berthelsen et al., 1962). Two directions of fold axes can be recognised; B1, gentle east and west to northeast and southwest plunge, synmigmatitic; B2, vertical to steep west-northwest plunge.

An analysis of the structure was made by subdividing the map-area into subareas. Poles to the various S-plane measurements in each subarea were plotted on the lower hemisphere of an equal area net and the great circle(s) that fitted best were drawn through these poles. The fold axes, β-axes, are the poles to these S-pole girdles. After a preliminary stereographic study, the subareas were redelimited by amalgamation of structurally homogeneous areas and subdivision of those showing disorder. β poles were plotted for the redelimited 29 subareas (Fig. 2).

From Map 2 it can be seen that the migmatites are disposed in a major antiform and synform with vertical axial planes (B1 axes) the traces

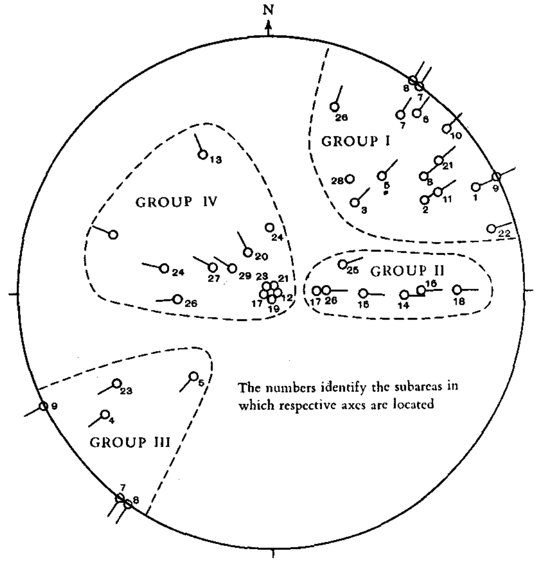


Fig. 2. Stereographic plot of constructed fold axes (β axes).

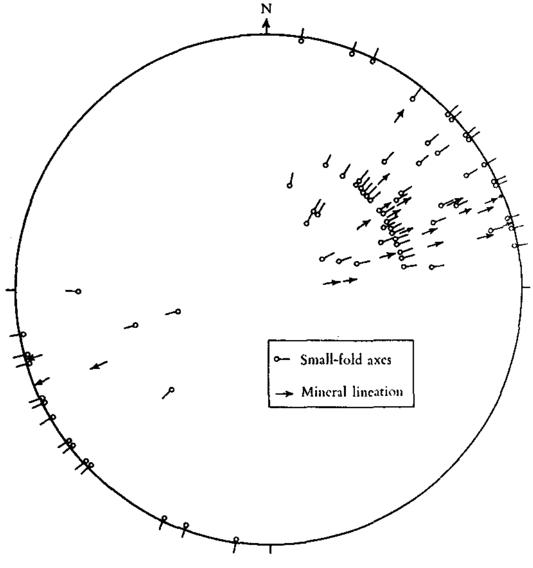


Fig. 3. Stereographic plot of small-fold axes (b axes) and mineral lineations.

of which trend between north-northeast and east-northeast and which have a 4 to 6 km wave length. The foliation dips very steeply to the north or south on opposite sides of these main axes and closure is virtually impossible to find. However, five Z-shaped small-folds north of the antiform and two S-shaped small-folds south of it indicate that it closes to the northeast. No exceptions to this pattern of small-fold vergence were noted.

Almost all the measured mineral lineations and b axes of small folds plunge 0^{o} to 70^{o} east-northeast or west-southwest (Map 2, Fig. 3). Comparison of their attitudes with those of the constructed β axes (Fig. 2) shows that they are concentrated in the region of the β axes in Group I and between Groups I and II, as well as in, and north of, the concentration of β axes in Group III. As the β axes in Groups I and III are those least affected by the second period of folding and those in Group II show intermediate amounts of interference by this folding, it is concluded that the small-folds were formed during the first period of folding and that the second deformations caused a clockwise rotation and increase in the plunge of these axes.

Fig. 4 shows some of the styles of small-folds seen in the area. A fairly common type (shown in Fig. 4, B and C) occurs in which the axial plane is parallel to the adjacent foliation that truncates the limbs of the small-fold thereby giving the impression of a tectonic inclusion of intrafolial fold in the gneiss. Windley (1963) has noted similar intrafolial folds in the Sârdloq area that is on strike to the southwest, and he concluded that they represent a fold period (his B1) earlier than that which gave rise to his B2 folds which are the equivalent of my B1 folds. If this is the case, the parallelism of the small-fold axial planes to the foliation in the enclosing gneiss indicates that the deforming forces must have had the same orientation in both his B1 and B2 periods. The present writer prefers to explain these intrafolial structures as small-folds (B1) formed by flexural folding early in the first deformation and subsequently modified in shape by shear folding of the same deformation period.

In subareas 1-11 most of the constructed (β) and measured (b) axes have a trend about northeast-southwest and are horizontal or plunge at less than 45^{o} northeast or southwest. These subareas are the least affected by the second deformation.

In the country south of Eqaluit (including portions of subareas 7, 9, 10 and 11) is a zone of flat-lying augen-gneiss that forms a recumbent fold rooted to the northwest. Constructed and measured axes are horizontal or

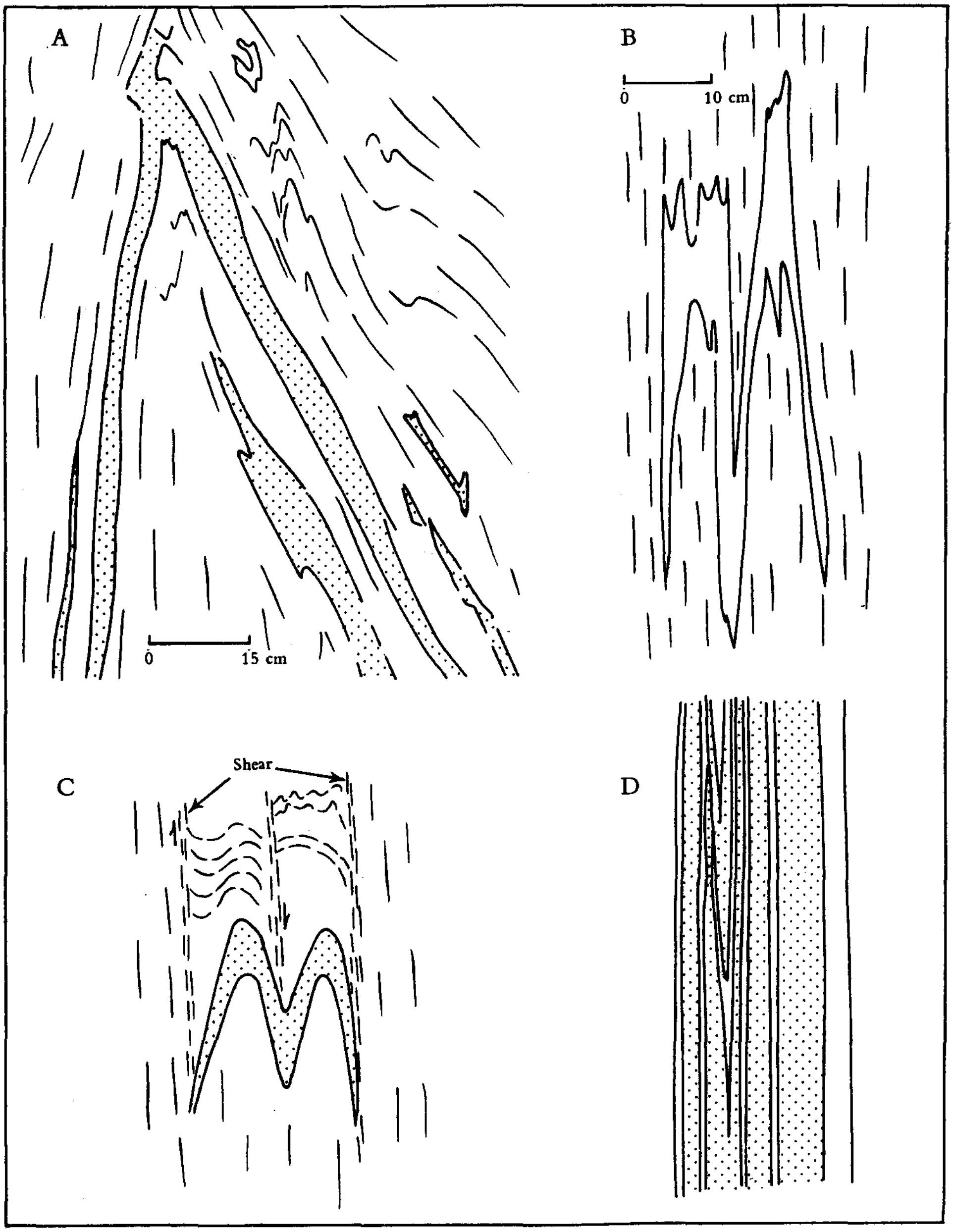


Fig. 4. Styles of small-folds in banded gneiss.

plunge at less than 24^{O} northeast. This fold and its associated β and b axes were formed during the first movements.

The first period of folding is syn- to postmigmatitic as indicated by the plastic and disharmonic style of the numerous shear-folded leucocratic veins (AP1), the concordancy of the G1 granites, and by the marginal granulation of the feldspar megacrysts in the Eqaluit recumbent fold.

A second generation of folding is indicated on a macroscopic and mesoscopic scale (Map 2) by a regular bending round of vertical S-planes through more than 90^{O}, and by gentle warps in the axial traces of the B1 folds. This defines a B2 axis with a vertical or steep plunge. The variation in the attitude of this axis is shown by the β axes in Group IV on Fig. 2. Most of these $\beta 2$ axes are vertical or plunge west-northwest at more than 55^{O}.

In subareas 12 and 13 only $\beta 2$ axes could be constructed. In all the remaining 15 subareas, numbers 14-29, $\beta 1$, b1, and $\beta 2$ axes are found.

There is an indication (Map 2) that the second folding was more intense in the proximity of the Julianehåb granite (subareas 12, 19, 20, 13, 21 and 22) e.g. In subarea 1 where its effect is negligible β is 64/10^{O}NE; in subareas 14, 15 and 16 nearer the Julianehåb granite β plunges 90/50^{O}E, in subarea 17 it is 90/75^{O}E to vertical, whereas in subarea 12 adjacent the granite only a vertical axis can be constructed.

Similarly there is a preferential development of steep fold axes, $\beta 2$, to the east and west of the pluton of Redekammen-type granite (G4) (subareas 23-26). As this granite is the late Sanerutian and the reactivation of the Julianehåb granite early Sanerutian, there is a probability that the vertical, so-called B2, axes belong to two separate Sanerutian periods of deformation.

(c) The Julianehåb Granite: Tonalitic Facies (G1), Leucocratic Facies (G2)

Northwestwards, the migmatite complex gives way to the Julianehåb granite that crops out in a zone extending 1-3 km inwards from the southeast shore of Igaliko fjord. The contact between the migmatites and the granite is gradational over a few tens of meters to several hundred meters, and the location of the boundary is therefore to a large extent arbitrary. The contact zone is marked by homogenisation, and the gradual increase in abundance of feldspar megacrysts, the rock thereby changing from heterogeneous gneiss into granite. Structures in the granite are concordant with those in the gneiss.

As outlined above, the Julianehåb granite, considered as a whole, can be distinguished from the migmatite complex in that during one or more stages in its development it was homogenised and behaved as an incompetent mass. Accordingly, few palimpsest supracrustal structures are preserved and isolated disoriented enclaves of amphibolite and quartzite testify to significant mobilisation. It is problematical whether, prior to the intrusion of the DA2 dykes, the terrain now underlain by the Julianehåb granite was heterogeneous gneiss similar to that in the migmatite complex, or homogeneous granite. Two patches of mixed gneiss with structures concordant to those in the surrounding granite and remoter migmatites were mapped in the Julianehåb granite. However, the more general picture is of an older foliated tonalitic rock (G1) intruded by, or merging into, a younger leucocratic granite (G2). The granitisation and fragmentation of probable DA2 dykes in the granite indicate that the G2 granites are the product of Sanerutian reactivation. It would be necessary to find Julianehåb granite where the DA2 dykes are unaffected by Sanerutian reactivation in order to determine the character of the rocks into which they were intruded. This was impossible in the Vatnahverfi area. However, it is known that the reactivation was not aggressive in the vicinity of Igaliko fjord between Qanisartût and Nuniagiarfik because the hornblende gabbro bodies in this vicinity are but slightly granitised, and it seems that these plutons were emplaced into foliated homogeneous tonalite and not into heterogeneous gneisses. Accordingly, as a working hypothesis it is suggested that at the peak of the Ketilidian folding when the G1 granites were being generated by various ultrametamorphic processes in the migmatite complex, the area now occupied by the Julianehåb granite (heart of the geosyncline) underwent more complete homogenisation and anatexis. After a hiatus marked by the intrusion of the DA2 dykes and hornblende gabbro plutons, this foliated tonalitic facies was reactivated to produce a leucogranite G2. As the DA2 dykes in the migmatite complex are generally less granitised and disintegrated than their equivalents in the Julianehåb granite it is inferred that this reactivation was confined to that area now referrable to as the Julianehåb granite.

The G1 and G2 granites are so intimately intermingled that it is impossible to map them separately but in places either one of them may predominate. At some localities they merge gradationally into one another, but elsewhere the G2 leucogranites appear intrusive as indicated by inclusions and by sharp contacts cutting off amphibolite schlieren, foliation and hot mylonite zones in the older tonalitic types. The G2 granites can form irregular masses within the G1 types in which case a single mass may show both gradational contacts, and sharp contacts associated with apophyses and dykelets penetrating the older tonalite. This is attributed to partial anatexis resulting in local mobilisation.

The granitic rocks least affected by the Sanerutian reactivation are generally grey, medium-grained, foliated, biotite-hornblende tonalites or granodiorites, erratically studded with feldspar megacrysts. Primary essential minerals are plagioclase (calcic oligoclase to andesine), slightly perthitic microcline, quartz, green biotite and hornblende. The plagioclase comprises more than 2/3 of the total feldspar and quartz is commonly less than 10% of the rock. Primary accessory minerals are myrmekite associated with the microcline, opaque oxide, apatite, sphene, orthite and zircon. The biotite and hornblende are more or less chloritised, the opaque oxide is mantled by leucoxene, and minerals of the epidote group have formed from the mafics and plagioclase.

The granitic rocks, G2, referable to as the end products of the Sanerutian reactivation, are generally pale grey or pinkish grey, medium-grained, hypidiomorphic, biotite leucogranites. They may have a vague foliation and contain a few scattered feldspar megacrysts. Primary essential minerals are microcline microperthite, plagioclase (sodic oligoclase), quartz and green biotite. The microcline comprises more than 2/3 of the total feldspar, and quartz more than 15% of the rock. Primary accessory minerals are myrmekite associated with the microcline, apatite, zircon, sphene, orthite and opaque oxide. The biotite is commonly more or less chloritised whilst minerals of the epidote group and sericite have partly replaced the plagioclase and biotite.

(d) Folded Discordant Amphibolites (DA1 ?)

A number of amphibolite dykes up to ca. 0.5 m wide have been found with features suggesting that they were derived from basic dykes of possibly pre- or inter-Ketilidian age. These dykes occur in a limited zone on the south-southeastern slopes facing Eqaluit tasiat where banded-, streaky-

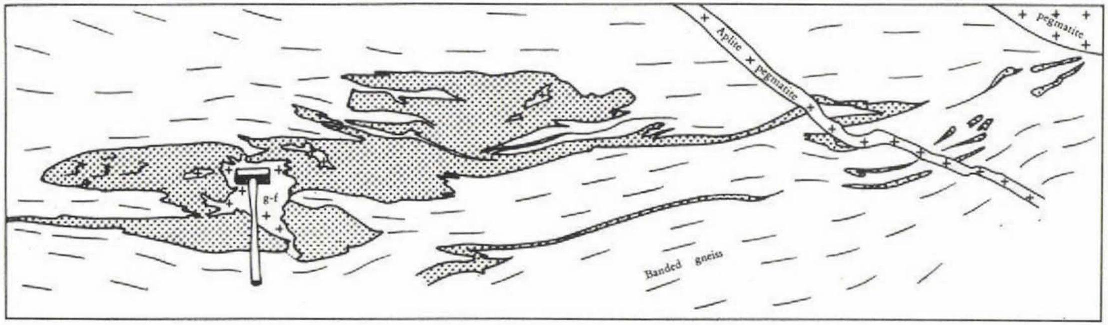


Fig. 5. Discordant amphibolite dyke, possibly double-folded, in banded augen-gneiss.

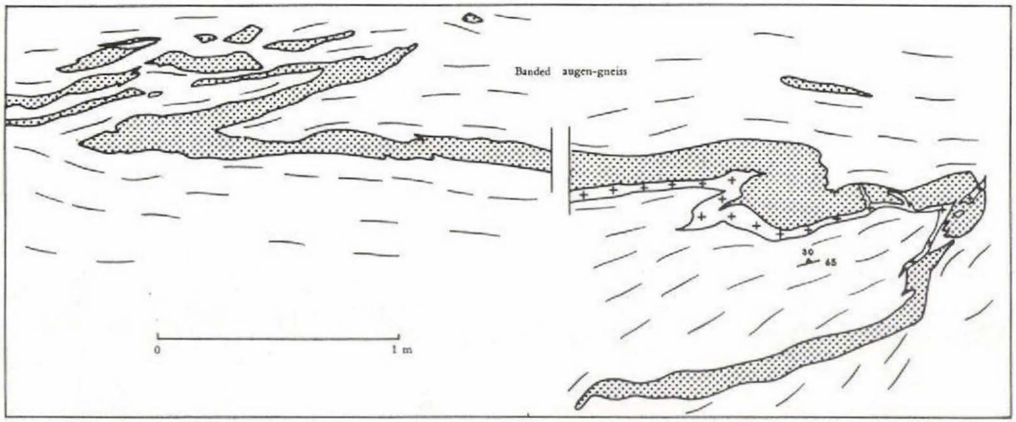


Fig. 6. Shear-folded discordant amphibolite dyke in banded augen-gneiss.

and augen-gneiss dip ca. 45^{o} NNW into the hillside.

As shown on Figs. 5 and 6 these dykes have been shear folded together with the surrounding gneiss so that the original discordance has been almost obliterated, although it is still clearly evident that these were once discordant dykes. In some cases the dyke is represented by several elongate boudinaged blocks strung out like beads on a string that zigzags across the foliation (up the hillside). The boudinage effect is due to extension caused by differential shearing along the S-planes of the enclosing gneisses affecting a relatively competent dyke making a large angle with the foliation. The axial planes and internal foliations of these folded-boudinaged dykes are parallel to the surrounding foliation in the gneiss. Structural analysis of the subareas (nos. 21, 22, 11) containing these dykes shows that the gneisses have been affected by both the first and second deformations and although one of the dykes has a form that suggests it has been double folded (Fig. 5) the evidence is inconclusive. The dykes are slightly granitised by quartzo-feldspathic material continuous with, and a part of, the surrounding gneisses. Some of the small quartzo-feldspathic veinlets in the hinge-zone of the dyke in Fig. 5 are also shear folded. In addition the dykes are cut by discordant aplites and pegmatites (AP2 or 3).

Petrographically these dykes are not distinctive. They are either dark greenish (hornblende rich) or greenish-grey (biotite rich), fine-grained, foliate-lineate, or granulose amphibolites. Their composition is essentially oligoclase, $\pm$quartz, green hornblende that commonly forms glomeroblasts giving hand specimens a spotted aspect, olive green biotite and a trifle of epidote. Accessory minerals are metamic allanite (mantled by epidote), sphene, zircon, apatite and opaque oxide. No relict textures or chilled margins are visible.

Although there is no conclusive proof available, the shear folding of these dykes by apparently the first folding movements suggests a pretectonic Ketilidian age for them. However, as local zones of later shearing have been found elsewhere in the Julianehåb region, they could be DA2 dykes folded during the Sanerutian plutonism. Their relatively slight granitisation suggests a DA2 age. For the definite identification of a pre-DA2 dyke it must be shown to be poly-folded or cut by a DA2. One thing seems fairly certain about the folded dykes - their marked discordance indicates that they were intruded into competent crystalline rocks, either pre-Ketilidian basement or Ketilidian gneisses, and not into sediments.

(e) Discordant Amphibolite (DA2) and Microdiorite (MD2) Dykes

The migmatite complex and Julianehåb granite contain a number of discordant amphibolite (DA2) and microdiorite (MD2) dykes that are interpreted as being the equivalent in age to some of the Kuanitic dykes of the Ivigtût region (Berthelsen, 1960). Most of these second period dykes are less than a meter wide although a few larger ones up to 10 m wide have been seen. Their distribution is shown on Map 1. The original features of the second period dykes are better preserved in the migmatite complex than in the Julianehåb granite where they have been broken up and granitised by reactivation after their emplacement. The following examples illustrate the petrography and field relations of a selection of representative second period amphibolites and microdiorites in different environments.

On the northwest slopes of Equaluit qaqâ (ca. 200 m alt.) a dark greenish-grey, fine-grained, discordant amphibolite dyke with a relict ophitic texture (readily visible on weathered surfaces) cuts Ketilidian augen-gneiss with thin bands of feldspathic quartzite. The dyke is represented by a number of angular agmatitic fragments up to 2 m in diameter strung out like beads on a string trending 140^{o} across the gneissosity trending 60^{o}. In thin sections this amphibolite is seen to consist essentially of randomly oriented andesine laths with interstitial green hornblende. The ophitic texture is clearly preserved. The plagioclase is well zoned whilst the hornblende seems to be recrystallised from a primary hornblende or pyroxene, i.e. it has a non-uniform patchy pleochroism, inclusions of opaque oxide granules and forms xenoblastic crystals with ragged borders. In addition to these minerals there is about 5% of brown biotite showing rough dimensional orientation and slightly chloritised. Accessory minerals include sphene, calcite, epidote group minerals, apatite and opaque oxide. An identical dyke cuts porphyroblastic Julianehåb granite in an outcrop 700 m west-southwest, but there is insufficient outcrop to determine whether this is the same dyke or swarm. Here the dyke is represented by three boudinaged elongate segments 70-90 cm wide and aligned parallel to the foliation in the granite, 83/90^{o}. They are cut by small granite apophyses. A relict chill margin is preserved; at the original contacts on either side of the segments the rock is finer grained than in the interior whereas at the ends between boudins it is the normal grain size. In thin section this amphibolite is identical to the one in the gneiss except that the plagioclase laths tend to be broken up and represented by a number of equidimensional plagioclase grains, but the ophitic texture is still clearly preserved. No potash feldspar was found in either of the two amphibolites. Both dykes are second period metadolerites or DA2s.

On either side of Qanisartût a microdiorite dyke (7-8 m wide on south shore) discordantly cuts pinkish-grey, foliated, porphyroblastic Julianehåb granite intermediate in character between G1 and G2. It is exposed for a length of ca. 400 m and has a variable attitude 60-120/70° N. The dyke has a schistosity parallel to its contacts and is more schistose and granitised near the margins than in the centre. The granite veinlets are either concordant or discordant, the latter being shear-folded so that the axial planes are parallel to the foliation in the microdiorite. On the southwest shore of Qanisartût this granitised dyke is cut by an ungranitised quartz diorite (MD3) dyke that is in turn cut by an aplite which has been partially pegmatitised. The chronology is therefore:

$\left.\begin{array}{l}\text{Pegmatitisation of aplite}\\ \text{Intrusion of aplite}\end{array}\right\}$ AP3
Intrusion of quartz diorite MD3
Reactivation of tonalite G1 to granite G2; granitisation and shearing of MD2
Intrusion of discordant microdiorite MD2
Tonalitic granite G1 ?

The MD2 is a dark greenish-grey, fine-grained, foliate microdiorite, locally spotted with lensoid hornblende glomeroblasts. Thin sections show that the rock consists essentially of sodic oligoclase, dark green hornblende and pennine. The oligoclase occurs as equidimensional grains in the groundmass and as rare subhedral zoned phenocrysts, both forms having numerous inclusions of apatite, hornblende and opaque oxide. It has clearly been metamorphically recrystallised. The hornblende occurs mainly as equidimensional crystals forming lensoid glomeroblasts together with lesser amounts of opaque oxide mantled by granular leucoxene. Pennine is the main mafic in the groundmass and is secondary after biotite. This chloritisation is related to Gardar faulting and mineralisation in the vicinity. Accessory minerals include sphene, pistacite and apatite. The schistose fabric is developed by the orientation of the glomeroblasts and pennine. The relict plagioclase phenocrysts do not conform to the schistosity.

On the Serfat coastline just north of the Serfat kûat hornblende gabbro pluton, the Julianehåb granite is cut by at least 6 basic dykes over a distance of 300 m. Three of these dykes have been granitised by the surrounding granite and are therefore diagnosed as belonging to the second period of dyking whilst the others are not granitised and belong to the meladiorite-leucogranodiorite suite (MD3). One of the granitised bodies is a 2-3 m wide sheet, attitude $90/30^{\circ}$ S, that cuts discordantly the vertical foliation in the granite. The sheet has a flaggy aspect due to a well developed foliation parallel to the contacts. It is penetrated by numerous apophyses of granite which extend up to 20 cm in from the contact. Towards the centre it is studded with microcline porphyroblasts. Everything is cut by a discordant very coarse-grained pegmatite. The dyke is a dark grey, fine-grained, microdiorite locally spotted by lensoid hornblende glomeroblasts. Thin sections show the rock to consist essentially of sodic oligoclase, brown biotite and green hornblende and opaque oxide. The oligoclase occurs both in the groundmass and as rare, subhedral zoned and highly strained phenocrysts or glomeroblasts (fragmented phenocrysts) with random orientation. It is in all cases crowded with numerous inclusions of the other minerals, this indicating that it has been metamorphically recrystallised. In the larger phenocrysts these inclusions are confined to the margins. The biotite comprises 2/3 of the total mafics and is aligned and deflected by the plagioclase phenocrysts in a manner suggestive of flow texture. The hornblende forms small xenoblastic grains. The opaque oxide is mantled by leucoxene and commonly aggregated, in which case it is surrounded by a leucocratic zone free of mafics. There is accessory apatite and sphene. Both megascopically and microscopically this MD2 dyke resembles the diorites of the MD3 suite. It is also very similar to the DA2 described immediately above.

On the Kujatdleq coastline called Napajinga, an amphibolite dyke, about 6 m wide, attitude $50/75^{\circ}$ SE, can be traced for about 200 m inland. It cuts the foliation in the surrounding granite at ca. 20°. The dyke is considerably agmatitised, and near the margins is invaded by the surrounding Julianehåb granite. It is cut also by quartzo-feldspathic veins (AP2) that are mostly parallel to the schistosity. Several ungranitised dykes and sheets of granodiorite and diorite of the MD3 suite cut all this but are in turn cut by a 40 cm wide composite aplite-pegmatite sheet AP3. The DA2 is a dark grey, fine-grained, foliate amphibolite locally spotted by hornblende glomeroblasts. Thin sections show it to be essentially a granoblastic aggregate of sodic oligoclase and green hornblende that is aggregated to a varying extent. In addition there is a little olive green biotite, and accessory pistacite, sphene, opaque oxide mantled by leucoxene, and apatite. Quartz and microcline are confined to the quartzo-feldspathic veins cutting the amphibolite.

In the terrain south of 1963 Camp IV and between Skygge Sø and Undir Høfda Elv the homogeneous biotite-hornblende gneisses are cut by numerous discordant, medium-dark grey, fine-grained, schistose amphibolite dykes. They are relatively straight, trend between northeast and east-northeast, and are mostly less than 50 cm wide but are up to 2 m in width. Delicate thin amphibolite apophyses are still preserved; boudinage is slight. At one locality a 50 cm wide dyke, one of a swarm of six, was traced for about 100 m without any boudinage being seen although outcrop was good but not continuous. The dykes are generally foliated parallel or oblique to their contacts, and some have shear-folded leucocratic veinlets. Plate 1 shows another swarm of these dykes as seen on a single outcrop. They cut agmatitic and folded fragments of older amphibolite possibly representing first period amphibolites. Thin sections of these second period dykes show them to consist essentially of oligoclase, green hornblende and green biotite. The plagioclase occurs as equidimensional xenoblastic grains, the hornblende shows a tendency to aggregate and the alignment of the biotite, which comprises less than 1/3 of the total mafics, gives the rock its foliation. Microcline comprises less than 5% and has an erratic distribution. Accessory minerals are pistacite, sphene, apatite and opaque oxide.

Every dyke is cut by small dykelets or tongues of granite that is clearly an integral part of the enclosing gneiss. Discordant aplite and pegmatite dykes cut everything. Although the granitisation is slight, it indicates that these are second period dykes. Their primary structures are well preserved because of the lack of aggressivness of the surrounding gneisses during the Sanerutian reactivation, (cf. DA2 dykes in the more aggressive Julianehåb granite). These dykes could, of course, be of the third period and granitised by late Sanerutian reactivation connected with the formation of the Redekammen-type granite (G4). To prove conclusively that they are either second or third period dykes it would be necessary to find these two generations intersecting or in close proximity and showing respectively greater or lesser degrees of granitisation.

(f) Hornblende Gabbro and Olivine Norite (GN2)

A metamorphosed basic pluton is exposed over an area of ca. 1 sq. km centred on Serfat kûat on the southeast shore of Igaliko fjord. It is possibly part of a larger mass represented by two small exposures of similar rocks 1-2 km northeast along the shore and by a similar mass on the opposite northwest shore of the fjord. The Serfat kûat pluton is discordant to the Julianehåb granite foliation which has the appearance of trying, without quite succeeding, to follow the outline of the basic mass. The discordance is marked where two elongate protuberances extend into the country rock.

The form of the body is unknown. Its contacts appear to be steep, judging from the apparent absence of topographic control in their trend. Relict primary igneous layering measured within 100 m of the contacts dips at 45° or more either inwards or outwards, whilst in the more mafic core the layering is essentially horizontal.

The pluton has a composite core of melanocratic, coarse-grained, olivine norite and hornblende gabbro that merges outwardsinto more leucocratic, coarse- to medium-grained hornblende gabbro. In places along the contact, a chilled marginal zone, up to a meter wide, of finer grained hornblende gabbro was seen. On the scale of an outcrop the contact is abrupt but irregular. Hornblende gabbro was seen to cut structures in the surrounding Julianehåb granite and to be penetrated in turn by tongues of reactivated granite (Fig. 7). In addition, the hornblende gabbro is cut by numerous aplite-pegmatite dykes and sheets (AP2 and AP3), a fine-grained biotite granite sheet (G3), and by composite sheets and dykes of the meladiorite - leucogranodiorite suite (MD3). Although second period dykes are not uncommon in the granite around the pluton they were not found within it or cut off by it. The evidence of discordancy, the distribution of the younger and older dykes and the degree of metamorphism (see ahead) all suggest that the gabbro-norite pluton was emplaced slightly after the second period basic dykes (to which it may be genetically related) and was subsequently metamorphosed during the Sanerutian reactivation.

The least metamorphosed rock found in the core of the Serfat kûat pluton is, as seen in hand specimens, a medium-dark grey, medium-grained, poikilitic olivine norite. In thin sections this rock is found to consist essentially of calcic andesine (30% estimated), hypersthene (15%), olivine (15%), augite (15%), brown mica (10%), opaque oxide (5%) and two varieties of

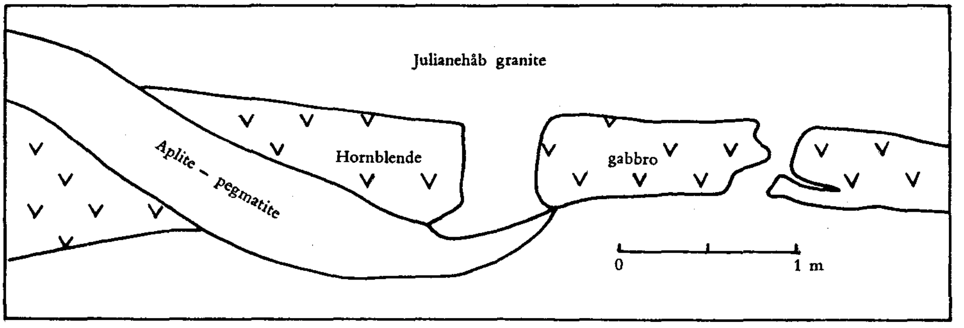
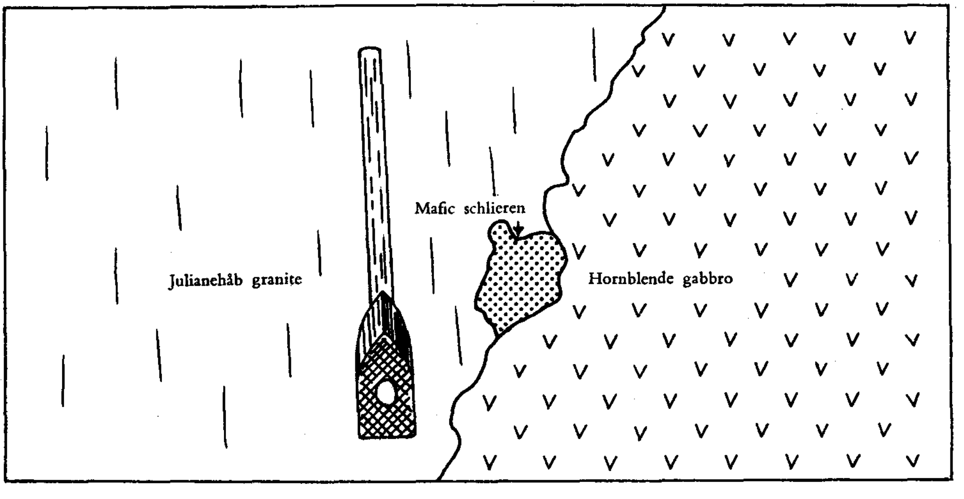


Fig. 7. A) Elongate tongue of hornblende gabbro broken up by remobilised Julianehåb granite (G2) that is in turn cut by a tongue of aplite-pegmatite.



B) Hornblende gabbro cutting foliation and mafic schlieren in Julianehåb granite (G2).

hornblende (5%). The andesine is unmetamorphosed and unaffected by secondary alteration and can show good zoning. It forms subhedral crystals with a subophitic relationship to the mafics. The olivine forms fresh anhedral crystals. The hypersthene occurs as euhedral tablets with very fine schiller inclusions, whereas the augite crystallised as later anhedral grains. The mica is dark yellowish-orange (phologopite?) and crystallised as primary anhedral grains between, or as skeletal crystals poikilitically enclosing, the pyroxene, olivine and opaque oxide. The primary hornblende bears the same relationship to the older minerals as the mica with which it is contemporaneous. This hornblende varies from pale- to dark yellowish-brown and seems to grade into a green variety that in part forms reaction rims around earlier minerals. Corona structure is characteristic e.g. opaque (core) - phlogopite - green hornblende - plagioclase; olivine (core) opaque oxide - phlogopite - green hornblende - plagioclase.

The commonest rock in the core of the Serfat kûat pluton is a melanocratic hornblende gabbro. In hand specimens it is a greyish-black, coarse-grained rock composed of large hornblende crystals up to 3 cm in diameter and containing poikilitic inclusions of plagioclase. In thin sections the essential minerals are seen to be andesine, three varieties of amphibole, biotite and lesser amounts of opaque oxide. The plagioclase comprises less than 30%, is vaguely zoned, has a composition of around An_{40}, and has been metamorphically recrystallised as is indicated by numerous inclusions of biotite and secondary amphibole which can also be seen to have grown into the plagioclase from adjacent mafic clusters. It has subsequently been considerably altered to a fine, felted mass of sericite and epidote. The oldest generation of amphibole is of primary magmatic origin. Characteristically it forms skeletal crystals poikilitically enclosing the plagioclase and apatite. This hornblende is pleochroic from dark to pale yellowish-green (commonly with brownish tinges) and is crowded with myriads of minute schiller inclusions of black and red oxides. It is more or less altered to fibrous aggregates of colourless anthophyllite, a pale green to neutral hornblende, and brown biotite. Anthophyllite-biotite aggregates are commonly mantled and partly replaced by the pale green hornblende that is apparently later in the paragenesis. The alteration of primary hornblende with schiller inclusions is accompanied by the concentration of the iron oxide in relatively large aggregates. Apatite (1-3%) forms very elongated idioblastic crystals. The overall texture is relict ophitic to poikilitic.

The relation of the hornblende gabbro to the olivine norite is not known. The former does not seem simply a metamorphic equivalent of the latter. It appears that they are different primary rocks.

There is a gradual change in the composition of the hornblende gabbros from the centre of the pluton towards the margins. In the outer parts of the pluton and in the dyke-like projections, the rocks are more leucocratic. The plagioclase comprises more than 40% and is generally much altered to secondary sericite, epidote and scapolite. A trifle of microcline is erratically distributed in most samples, and up to about 5% quartz, mainly interstitial to the plagioclase, is not unusual. Although the primary hornblende with schiller inclusions (pleochroic from pale- to dark yellowish green) is found, it is largely replaced by a metamorphic hornblende (patchy clear pale green to neutral colouration) associated with poikilitic quartz and opaque oxide (as relatively large aggregates formed from the schiller inclusions). This metamorphic transformation is analagous to the formation, in the amphibolite facies, of hornblende from pyroxene. The biotite in these marginal metagabbros forms appreciably larger crystals than in the less metamorphosed hornblende gabbros. In addition, it is highly strained, partly altered to pennine and to an epidote group mineral along the cleavage. In many instances the opaque oxide is rimmed by granular leucoxene.

The two small basic masses on the shore northeast of the Serfat kûat pluton show the same field relations as the larger pluton. They are composed of matagabbros essentially the same as those in the marginal parts of the Serfat kûat body but slightly more granitised as is shown by the presence of feldspar porphyroblasts and quartz ocelli with mafic mantles.

In the younger adamellite (G4) in the vicinity of Qaqâta tasia there are five small sheets of metagabbro very similar to that forming the extreme marginal facies of the Serfat kûat pluton and to the other small basic bodies on Igaliko fjord. They are correlated solely on the basis of petrographic similarity. These Qaqâta metagabbros are cut by dykes of adamellite (G4), aplite and pegmatite. They are variably granitised (up to 15% microperthitic microcline, 5% quartz) and completely recrystallised.

(g) Discordant Amphibolite Dykes (DA3)

In the terrain bordered by Tasikulôq, Vig Sø and Uvkusik tasia the Ketilidian migmatites are discordantly cut by a number of amphibolite dykes and sheets, all less than a meter in width. As they were nowhere seen to be boudinaged or granitised by the country rock they are tentatively assigned to the third period of basic dykes. However, they were not traced for sufficient distance for this diagnosis to be reliable. In the region known as Uvkusik, vertical biotite-hornblende gneiss is cut by a swarm of four parallel amphibolite sheets up to a meter wide. These sheets have a curviplanar Z-shaped foliation and give off long thin apophyses in healed mylonite zones cutting the gneissosity. The sheets have a heterogeneous composition and are characterised by spindle-shaped masses of amphibole-rich material in a more leucocratic groundmass. These masses vary from a mm to a cm in diameter and define to foliation. Locally there are folded leucocratic veins. There is no granitisation or boudinage. Thin sections show that the amphibolites consist essentially of plagioclase, microcline, green hornblende and partly chloritised green biotite, plus accessory epidote, orthite, sphene, apatite and opaque oxide. It is noteworthy that, although the sheets are ungranitised, microcline is an essential mineral comprising ca. a quarter of the total feldspar.

The features shown by these diorites are characteristic of the third period "amphibolite" dykes which have been demonstrably intruded under plutonic conditions of moderately elevated temperatures and intermittent stress (Watterson, in press).

(h) Meladiorite - Leucogranodiorite Suite (MD3)

A suite of calcalkali, intermediate to acid rocks form sheets and less commonly dykes cutting all the rocks listed below them in the chronology. They were observed to be cut by younger dykes of aplite and pegmatite (AP3) and by a sheet of fine-grained biotite granite (G4). The rocks of this suite occur through most of the Julianehåb granite and in the hornblende gabbro on Igaliko fjord, but are confined to that part of the migmatite complex within a few hundred meters from the Julianehåb granite (see Map 1). These dykes and sheets characteristically thicken and thin, change attitude, and send off long thin apophyses. Widths vary from a few tens of cm to ca. 10 m. Contacts with the country rock are invariably sharp and relatively straight. Chilled margins are absent.

Where the various members of this suite have intruded country rocks in the amphibolite facies (Ketilidian gneisses, Julianehåb granite, amphibolite dykes, and metagabbro GN2), contact metamorphic phenomena are not visible. However, all the observed MD3 dykes and sheets cutting the granulite facies olivine norite and the hornblende gabbro forming the core of the Serfat kûat pluton have contact metamorphosed the adjacent country rock. These metamorphic effects decrease progressively away from the contacts but are extensive and clearly visible in the field on either side of a sheet or dyke for a distance equal to the width of the intrusive body e.g. On the shore of Igaliko fjord about 100 m south of Serfat kûat, a 20 cm wide sheet of pale grey, medium-grained, hypidiomorphic granodiorite has cut olivine norite which is highly altered for 20 cm above and below the sheet, whilst the effect of metamorphism can be vaguely discerned for 40 cm on either side. Within the inner 20 cm zone, the olivine norite mineral assemblage andesine + olivine + hypersthene + augite + phlogopite + opaque oxide + primary brown hornblende (see p.22) has been metamorphosed to a dark greenish-black hornfels consisting essentially of equal amounts of neutral to pale green secondary hornblende and reddish-brown biotite, plus lesser amounts of opaque oxide (5%) and apatite (3%). The hornblende occurs as small crystals with a patchy pleochroism, randomly oriented and intimately intergrown. A few relics of primary, dark green, hornblende remain. The biotite also forms small, randomly oriented, intergrown crystals but there are a few large skeletal, highly strained, crystals that probably represent relict primary mica. The overall texture is typically decussate and there is a marked segregation of the hornblende from the biotite, both these features producing a very stable rock with a low free energy. The relatively wide aureole and the nature of the mineralogical changes suggest that it is not of simple isochemical retrograde metamorphic origin but that there was metasomatic introduction of K and OH.

Although there are simple sheets and dykes comprising any one of the rock types (see ahead), the intrusions are usually composite, in which case a more leucocratic facies has invaded and more or less assimilated a meladiorite or diorite, thereby producing various intermediate types. The more leucocratic rocks occur preferentially along the contacts, the hanging-wall being favoured in the case of the sheets. In many of the larger sheets and dykes the leucocratic material branches out from the marginal zones to form a ramifying system of veins enclosing circular and pillow-shaped masses of older host rock giving a net-veined structure (Fig. 8). This structure is quite distinctive from granitisation structures found in the older amphibolites and microdiorites. The net-veins do not penetrate the adjacent country rock, irrespective of its composition, and clearly have an affinity for the inner dioritic material. In the larger bodies the central portions may be free of net-veins which are wider and form a closer network towards the margins. Where pillow-shaped forms occur, these are oriented with their longest axes parallel to the contacts of the body. These pillows seem to have acquired their characteristic form by the enlargement of areas of granitic material, where the veins that are parallel to the contacts ("sheet-veins", Elwell et al., 1962) intersect veins normal to them ("cross-connections"). The structure is reminiscent of that formed by sulphides showing preferential replacement at intersecting fractures. There are all transitions from simple sheets of meladiorite or diorite, through composite meladiorite or diorite sheets with granodioritic margins, to sheets with subordinate net-veins, to sheets in which the net-vein granodiorite predominates, and to granodioritic sheets in which the original dioritic material exists only as ghostly remnants showing various stages in assimilation or replacement.

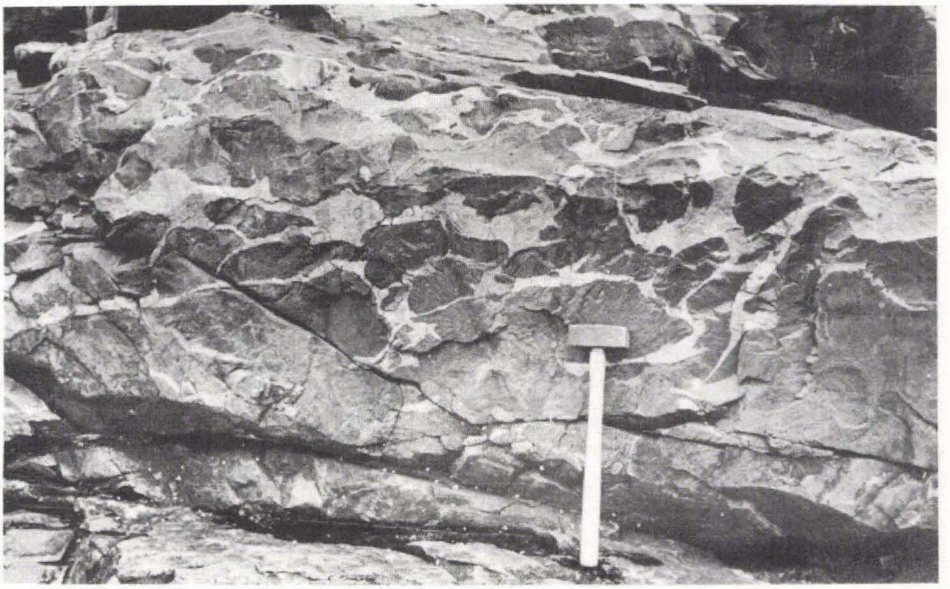


Fig. 8. Meladiorite dyke, 2-3 m wide, net-veined by leucogranodiorite (modal analysis sample 24197). Hammer handle rests on basal leucogranodiorite margin.

It is not uncommon for either the granodioritic rocks that form thin sheets and dykes, or the leucocratic margins of the composite bodies to be partly altered to pegmatite (AP3). This pegmatisation does not affect the internal net-veins, the older diorite or the country rock. It is manifested by the growth in the granodiorite of medium- to coarse-grained pegmatite as irregular patches or as distinct bands. Where pegmatite has formed at the contact between the granodiorite and the country rock or the meladiorite, it has replaced only the granodiorite with which it has an irregular (scalloped) replacement-type contact. This pegmatitisation is considered to be a deuteric phenomenon related to the mise en place of the granodiorite.

Modal analyses of selected typical representatives of the meladiorite - leucogranodiorite suite are shown below:

Name	GGU No.	Plagio-clase	Micro-cline	Quartz	Bio-tite	Horn-blende	+Acces-sories	Colour index
Leucogd.	24197	55	20	24	1	-	-	1
Granodiorite	24202	59	9	24	7	-	1	8
Granodiorite	24204	61	10	17	10	-	2	12
Diorite	24068	62	9	9	12	4	4	20
Diorite	24063	52	13	9	13	9	4	26
Diorite	24061	43	15	9	15	11	7	33
Meladiorite	24203	49	6	9	22	13	5	40
Meladiorite	24197	56	2	-	25	9	8	42
Meladiorite	24202	52	6	-	20	15	7	42

Leucogranodiorite 24197	Net-vein material from a 2-3 m wide, net-veined meladiorite sheet with leucogranodiorite margins, cutting hornblende gabbro, see Fig. 8; Igaliko fjord, Serfat kûat.
Granodiorite 24202	Net-vein material from a 3 m wide, net-veined meladiorite sheet with granodiorite margins, cutting Julianehåb granite; Igaliko fjord, 200 m NE of Serfat kûat.
Granodiorite 24204	Plagioclase - phyric, medium - grained granodiorite that net-veins meladiorite (no. 24203); from a large body of indeterminate attitude cutting Julianehåb granite; Igaliko fjord, 500 m NE of Serfat kûat.
Diorites 24063 and 24061	Respectively medium - and fine-grained diorites from a composite net-veined sheet, ca. 5 m wide, cutting Julianehåb granite; WSW Qanisartût.
Diorite 24068	Represents a 30 m wide dyke cutting Julianehåb granite; Igaliko fjord, Qanisartût.
+Accessories	Include mainly opaque oxide, sphene, and epidote group minerals.

As indicated by the above modes these rocks have a very varied composition and appearance. The meladiorites and diorites are generally medium to dark grey, fine-grained rocks, commonly spotted with tiny, dark greenish hornblende aggregates. These mafic rocks generally have a pilotaxitic flow texture that produces a flagginess in the sheets. The more leucocratic granodiorites are progressively paler coloured, not so fine grained and lack the directional fabric, being hypidiomorphic to allotriomorphic granular. Some of the leucogranodiorites resemble white aplites, and some of the granodiorites are richly porphyritic containing euhedral plagioclase phenocrysts measuring up to 1.5 x 3.0 cm.

Thin sections of the meladiorites show that they consist essentially of oligoclase, microcline (<10%), quartz (<10%), biotite and hornblende, which together with the abundant accessories give these rocks a colour index of over 40. The diorites consist essentially of the same minerals but generally contain more microcline (<15%), more quartz (<10%), and have a colour index of less than 40. In both rocks the oligoclase occurs in the groundmass as well as in microphenocrysts showing strong magmatic growth zoning. In some meladiorites the phenocrysts are euhedral tablets that deflect the surrounding flow texture shown by the biotite. In other dykes, instead of this feldspar-phyric pilotaxitic texture, there is a seriate fabric, the plagioclase phenocrysts being intimately intergrown with, and in this way sutured to, the surrounding groundmass. Even in the dykes with a well developed microporphyritic texture many of the phenocrysts are intergrown with the groundmass which suggests that they completed their crystallisation simultaneously with the surroundings. The microcline and quartz are erratically distributed and interstitial to the plagioclase. There are myriads of minute inclusions of apatite, opaque oxide, biotite and hornblende in the quartz, microcline, groundmass plagioclase and throughout the plagioclase phenocrysts. This feature is typical of all the meladiorites, and of the diorites that pre-date the younger more leucocratic diorites and granodiorites. The biotite is olive green and, in most meladiorites, occurs as subhedral laths defining the magmatic flow texture. The green hornblende commonly forms larger crystals than the biotite, and in part forms oriented aggregates (parallel to the flow texture) that seem to be comminuted phenocrysts. In addition, minerals of the epidote group, including orthite mantled by epidote, opaque oxide, sphene and apatite, are widely distributed accessories. Although the meladiorites and most of the diorites have features of obvious igneous origin (zoned phenocrysts, flow texture) they have been partly recrystallised as shown by the sutured borders of some phenocrysts, the break-up of the hornblende, and especially by the minute inclusions in the feldspars and quartz.

The granodiorites and leucogranodiorites consist essentially of plagioclase, microcline, quartz ($>20\%$) and biotite ($<10\%$). The plagioclase (oligoclase) is strongly zoned, commonly in an oscillatory manner, and tends to form phenocrysts or subhedral crystals in the groundmass. A trifle of myremekite is commonly present and the microcline is generally finely perthitic. The quartz occurs interstitially and has strain shadows. The biotite is olive green and comprises as little as 1% in the leucogranodiorites. Sparsely distributed accessories are green hornblende, epidote group minerals including orthite, opaque oxide, sphene, apatite and zircon. The texture is hypidiomorphic to allotriomorphic granular, some dykes also being plagioclase-phyric.

It is noteworthy that these leucocratic rocks do not have any of the recrystallisation features of the mafic rocks. This suggests that the meladiorites and diorites were recrystallised prior to, or simulaneously with, the emplacement of the leucocratic margins and net-veins. This recrystallisation is a form of either autometamorphism or contact metamorphism related to the emplacement of the younger granodioritic rocks, or a combination of both.

The contact between the leucocratic margins or the net-veins and the more mafic older rock is sharp but irregular and can be both concordant and discordant to the flow structure in the diorite host. The leucogranodiorite is not chilled against the diorite. Adjacent to some of the net-veins there is a dark zone, less than 5 mm wide, representing the recrystallisation of the diorite. This zone is marked by: (1) an increase in the grain size of all constituents, (2) an increase in the tenor of orthite which is mantled by epidote, (3) a marked increase in the ratio of biotite to hornblende, (4) an overall increase in the tenor of mafics, (5) an increase in the amount of sphene which characteristically has leucocratic haloes representing metamorphic diffusion into the sphene aggregates. These changes indicate that recrystallisation of the marginal diorite was accomplished by a change in chemical composition. This could have originated by either metasomatic transfer of material from the invading net-veins, or by transfer of material from the internal diorite towards the contacts by metamorphic diffusion activated by the emplacement of the hotter net-veins. Either of both processes could have been operative.

The evidence of the chronological position of these bodies, their form, the absence of chilled margins to the country rock and their truncation by numerous younger discordant pegmatites all suggest that they were emplaced under plutonic conditions when the surrounding granites were still hot. Windley (in press) has studied identical net-veined bodies in the adjoining Sârdloq area and concluded that the diorite fractured before it was completely solid and was still at a high temperature. The leucocratic material forming the margins and net-veins was derived by rheomorphism of granitic rocks at depth, the magma so formed penetrating, and more or less replacing, the cracked dioritic dykes and sheets. The present author finds Windley's evidence and reasoning very convincing and applicable to the Vatnahverfi area. The presence of a gas and an acid magma phase accounts for the convergence of magmatic and metamorphic - metasomatic features shown by these bodies. The following features indicate a strong influence of the latter: (1) contact metasomatism of country rock, (2) deuteric pegmatitisation of the granodioritic facies, (3) wide ranges in the composition of the rocks over short distances within a single body, (4) pillow shapes, (5) absence of chilled margins, (6) microscopic evidence of partial recrystallisation of the older dioritic host rocks.

(i) Redekammen-type Granitic Rocks (G3), (G4) and ($G4^1$)

Several bodies, ranging from small 10 cm wide dykes to batholithic plutons of fine- to medium-grained, biotite-bearing granitic rocks of postkinematic aspect were emplaced at different times towards the end of the Sanerutian period.

On the shore of Igaliko fjord the Julianehåb granite (G2) and hornblende gabbro are cut by a number of small dykes and sheets of granodiorite that is in turn cut by dykes and sheets of the meladiorite - leucogranodiorite suite. This granodiorite (G3) is light grey, fine- to medium-grained, hypidiomorphic and biotite-bearing, and in some bodies there are megacrysts of microcline and/or plagioclase. Thin sections show these granodiorites to consist essentially of oligoclase, microcline, quartz and biotite. The oligoclase commonly shows good oscillatory zoning. Microcline may be absent or constitute almost half the total feldspar. The biotite is reddish-brown (cf. olive green biotite of the MD3 Suite) and may be partly penninised. Primary accessory minerals are limited to opaque oxide, zircon and apatite. There may be a few secondary epidote group minerals.

A similar granodiorite sheet, 2 m wide, cuts the hornblende gabbro and diorite MD3 on the Igaliko fjord shore. This younger sheet (G4) is in fact a biotite adamellite in which the microcline comprises a third to a half of the total feldspar and occurs as subhedral megacrysts. Furthermore, this adamellite differs from the granodiorites G3 in containing myrmekite, a richer crop of primary accessory minerals - opaque oxide, zircon, apatite, orthite and fluorite - and in the virtual absence of zoning in the plagioclase.

Biotite adamellite of postkinematic aspect forms a batholith, part of which is exposed in the southwest of the map-area between Uvkusîp taserssuaq and Qaqâta tasia. Contacts of this body are steep, vary from sharp to gradational, and intersect the surrounding migmatites with marked discordancy. The surrounding vertical migmatites are cut by several large outlying sheets of the same adamellite and by especially numerous aplites and pegmatites. The gneisses in the vicinity of this pluton and its satellites are characterised by numerous untectonised, idioblastic, randomly oriented, feldspar megacrysts. East of Qaqâta tasia there is a ghost structure represented by biotite-hornblende migmatites in the form of a fold, and to the south of the same lake are three highly fragmented hornblende gabbro sheets that seem to be in place. The Qaqâta adamellite and its satellitic sheets have therefore features of both granitisation in situ and magmatic intrusion. The writer believes that these "contradictory relationships" can be understood if the adamellite is considered as originating by a mechanism of local anatexis that formed migmas and/or magmas.

Pegmatites and aplites are the only dykes seen cutting the Qaqâta adamellite which are therefore correlated with the adamellite sheet (G4) on Igaliko fjord.

The Qaqâta adamellite is characterised by a very well developed sub-horizontal sheeting which is expressed by a topography that is much subdued in comparison to that developed on the migmatites. In addition, there are two vertical joint sets normal to one another that allow the adamellite to break naturally into large rectangular slabs.

In the field, the Qaqâta adamellites appear as very light grey, fine- to medium-grained, hypidiomorphic, biotite granites. A few microcline megacrysts are present locally. Weathered surfaces are off-white, but there is a very distinctive 1-2 cm wide zone of orange colouration immediately below the weathered surface.

Thin sections show these rocks to consist essentially of oligoclase, microcline, quartz and biotite. The oligoclase has been highly strained and forms fractured and bent crystals with a patchy extinction. The microcline comprises between a third and two-thirds of the total feldspar (hence adamellite) and occurs as late crystallising anhedral to subhedral crystals with an erratic development of string microperthite. It forms the megacrysts seen locally. Myrmekite is invariably associated with the microcline. The quartz (25 - 40%) has been intensely deformed and grains are fractured and have marked strain shadows. The biotite (dark yellowish-brown to moderate yellow) forms small flakes that have also been deformed and bent, comprises 5-10% and may be slightly chloritised. Commonly there is a trifle of muscovite. Accessory minerals include relatively large subhedral sphene crystals, orthite (up to 6 crystals per slide), epidote, zircon, opaque oxide and apatite. The texture is typically fine- to medium-grained hypidiomorphic.

The adamellite (G4) described above is well exposed on the north shore at the head of Kangerdluarssorujuk where it is cut by numerous straight-walled pegmatite dykes. Towards Angmagssivik its place is taken by a distinctly different adamellite ($G4^1$) in which not a single pegmatite was found. The actual contact is not exposed but must be very sharp. This rock is a very light grey, medium-grained, hypidiomorphic adamellite. Thin sections show that it consists essentially of highly strained and broken up albite in the process of being replaced by skeletal microcline crystals. The quartz has the usual strain shadows and there is some micropegmatite. The biotite (10%) is also strained and forms large anhedral crystals that are partly chloritised. Accessory minerals include muscovite, zircon, opaque oxide, orthite (10 crystals per slide) and about 1% fluorite. The mineralogy suggests that this is a late pegmatitic facies of the more widespread (G4) adamellite and not a younger period of granite.

(j) Aplite and Pegmatite (all generations)

There have been four distinct periods of aplite-pegmatite genesis, each related to, and closely following, the mise en place of granitic bodies of larger volume and wider extent, i. e. G1 - AP1, G2 - AP2, granodiorite MD3 - concordant pegmatites (and AP3), G4 - AP4. In the migmatite complex and Julianehåb granite it is generally impossible to distinguish between the various aplite-pegmatite bodies unless they are both cut by, and themselves intersect younger bodies. The aplite-pegmatite chronology is based on intersections and the age of the host containing the dyke. In some cases the picture is complicated because an aplite dyke belonging to an early generation can have been replaced by pegmatite of a younger generation. All the pegmatites seen in the area have a simple limited mineral assemblage. Their bulk is formed by K-feldspar that can be perthitic, sodic plagioclase, quartz and graphic feldspar-quartz intergrowths. Biotite is the commonest mafic accessory, followed by magnetite, hornblende, garnet and in a few cases molybdenite.

The oldest generation of aplite-pegmatite bodies (AP1) has been described together with the migmatites of which they are an intergral part.

Most of the bodies definitely identifiable as AP2 occur in the Julianehåb granite and hornblende gabbro plutons and it is thought that this represents a true picture of their distribution. There is evidence that the numerous masses of aplite-pegmatite in the Julianehåb granite are a final product of the reactivation that produced the G2 granites. Aplite-pegmatite occurs preferentially at places of heterogeneity e. g. along the contact between the hornblende gabbro and the Julianehåb granite, around amphibolites and along contacts between G1 and G2. Bodies referrable to as AP2 show various forms of zoning from a gross layering between aplite and pegmatite, through relatively coarse layering shown by systematic differences in the mineralogy of an individual pegmatite, to a fine layering in aplite i. e. "line rock". Aplite is appreciably more abundant than pegmatite. These aplites are generally pale grey to pale pink, fine-grained, allotriomorphic granular. The aplite-pegmatite masses of this generation form dykes, sheets or irregular bodies of all sizes up to a few tens of square meters in diameter.

Discordant, straight-walled, dilational sheets, and less commonly dykes, of aplite-pegmatite are common in the gneisses bordering Eqaluit. These sheets are commonly zoned in various scales. They vary from pure aplite, through composite aplite-pegmatite bodies to pure pegmatite. Some of the aplite in these composite aplite-pegmatite sheets has a clearly developed layered structure that has been called "line rock" (Redden, 1963). One of these sheets (average width 25 cm, dip less than 20°) consists of pegmatite with an internal band near the footwall of white fine-grained, allotriomorphic aplite containing three very continuous dark layers (2 are marginal) enriched in fine, granular, pink garnets. Although these garnet layers are generally parallel to one another and to the outer contacts, individual layers bulge up locally in which case a coarse pegmatite, or single feldspar megacryst forms the core. Here and there, large downward tapeing feldspar megacrysts interrupt the garnet bands which both wrap around the tops of and pass through the megacrysts as phantom layers marking lines of growth surfaces within them (structure identical to Fig. 7C, Jahns and Tuttle, 1963). The marginal pegmatite is very coarse-grained and consists chiefly of pink K-feldspar, lesser amounts of quartz, graphic granite, and grey plagioclase and a trifle of biotite, magnetite and pink garnet. The observed relationships between the line-rock, the feldspar megacrysts with plantom layers and the adjacent pegmatites can best be explained in terms of "rhythmic primary crystallisation with the development of successive laminations (of the line-rock) in situ", simultaneously with the growth of the feldspar megacrysts and adjacent pegmatite (from Jahns and Tuttle, 1963). The age of these sheets is unknown but they probably belong to the AP2 generation. A detailed field description and discussion of layered aplite-pegmatite sheets presumably belonging to the same suite is given by Windley and Bridgwater (in press).

Deuteric pegmatites (AP3) related to the meladiorite - leucogranodiorite suite have been described (p. 29). In addition, pegmatitised bodies of this suite are cut by younger aplite-pegmatite dykes (AP3). These are commonly zoned and markedly discordant. If, as the evidence suggests, the granite was still hot and not completely "dead" when the meladiorite - leucogranodiorite suite was intruded, then its ultimate cooling and "death" would be sensibly manifested by the emplacement of aplite-pegmatite (AP3) in joints. It must also be considered likely that these discordant AP3 dykes are genetically related to the granodioritic rocks and concordant pegmatites of the MD3 suite, i. e. that all have a common origin in a magma derived by anatexis at depth, naturally facilitated by the granite being not quite "dead".

The young Qaqâta granite (G4) is cut by scattered aplite-pegmatite dykes (AP4). These are more abundant in the marginal zones of this granite and especially in the adjacent migmatitic gneisses.

(2) Gardar Period

In the Vatnahverfi map-area the Gardar period is represented by extensive faulting, numerous dykes including various different kinds and generations of lamprophyres, dolerites, trachytes, undersaturated trachytes and dykes intermediate in composition between these types, as well as by hydrothermal mineralisation and alteration. The area is criss-crossed by a network of faults that governed the direction of most of the dykes, localised the hydrothermal activity and promoted relatively rapid weathering to produce a terrain of moderate relief. The dominant trend of the most continuous faults and dykes is between east and northeast. There has been movement along this set of faults before, during, and after the emplacement of the various generations of dykes. The only fault on which a displacement could be measured trends northeast through Angmagssivîp tasia on the border between the Vatnahverfi and Sârdloq areas; it has produced a sinistral strike separation of 1,200 m on an olivine dolerite dyke. In the northeast, a younger set of southeast faults cut off most of the different Gardar dykes. Only a generalised dyke-fault-mineralisation chronology can be given (see Chronological Table p. 6). The most important Gardar dykes from a quantitative aspect and those which were recognised and mapped as distinct types are described below.

(a) Old Dolerite (OD)

Old dolerite forms irregular-shaped elongate plutons up to 200 m wide, and vertical dykes up to 40 m wide and trending 55°, 65° and 80°. Even the straighter dykes are characterised by a thickening and thinning and bifurcation so as to enclose screens of country rock. This old dolerite is cut by dykes of lamprophyre (La), mafic micromonzonite (MM), nepheline trachyte (NTr), flaggy nepheline trachyte (FNTr), plagioclase-pyroxene-phyric trachyte (PPTr) and by southeast-, east-northeast- and northeast-trending faults. Without doubt it is the oldest Gardar rock in the area. Bodies of this old dolerite are easily distinguished from younger dolerites in being invariably criss-crossed by epidotised and slickensided fractures related to younger faulting. In the northeast, some of these fractures have quartzo-feldspathic material, presumably connected with igneous activity of the Igaliko Complex. The dark greenish-grey colour produced by intense saussauritisation of these rocks is also distinctive, as is the medium-grained ophitic texture. The old dolerites are also distinctive in thin section. They consist essentially of highly saussauritised, zoned plagioclase laths in ophitic relation to pinkish titanaugite and interstitial masses of bright green biotite-chlorite. Accessories are primary opaque oxide and secondary uralitic amphibole. Plagioclase xenocrysts are found locally but seem especially concentrated in zones parallel to the contacts and about a meter in.

Locally the xenocrysts are so huge and abundant that the name "Big Feldspar Dyke" or feldspathic dyke is applicable (Bridgwater and Harry, in preparation). The dyke on the shore of Kujatdleq contains a patch with euhedral, opaque white plagioclase megacrysts measuring up to 3 x 7 cm. Although abundant, the xenocrysts do not touch one another. Another "Big Feldspar Dyke" occurs cutting the Redekammen-type granite in the southwest of the area. Where this dyke bifurcated into two channels, 7 and 4 m wide respectively. the narrower channel contains numerous but erratically distributed, opaque white, sub- to euhedral plagioclase xenocrysts measuring up to 10 x 6.5 cm. In thin section some of these have anomalous blue or brown interference colours. There are associated masses, measuring up to 10 x 15 cm, of medium- to coarse-grained, granular anorthosite composed of randomly oriented, roughly equant, plagioclase anhedra.

(b) Olivine Dolerite (OvD)

Dykes of this type, a dark grey, fine-grained, ophitic dolerite, are localised in the southern part of the area. They trend between 70° and 90° and are vertical or steeply dipping. No intersections with other dykes were seen. They are not affected by movement on adjacent parallel faults. The persistent dyke in the southwest has been apparently offset 1,200 m by movement along a northeast-trending fault through Angmagssivîp tasia on the border between the Vatnahverfi and Sardloq map-areas. These olivine dolerites are continuous dykes, commonly 10-20 m wide, and it is even possible to trace 1-2 m wide dykes for several km. They are distinguished from the old dolerite (OD) by their dark grey colour and fresh unfractured appearance. In thin section these dykes consist essentially of laths of plagioclase in ophitic relationship with pinkish titanaugite. There is appreciable olivine, more or less replaced by serpentine and/or iddingsite, with associated granules of secondary opaque oxide, calcite and uralitic amphibole. Primary opaque oxide occurs in accessory amounts. Some dykes are sparsely plagioclase-phyric.

(c) Lamprophyre (La)

Dykes of this type, black, fine-grained porphyritic lamprophyre, occur along the coast of Igaliko fjord and inland as far as the chain of lakes Taserssuaq - Saqâta tasia - Skygge Sø - Undir Høfda Sø. They become appreciably more common towards the northeast and they abound in the vicinity of Søndre Igaliko. Characteristically these dykes are under 2 m wide and all are less than 10 m wide and they tend to occur in swarms of several discontinuous individual dykes that aruptly thicken or thin and die out. The swarms trend between 55° and 80°. En bayonet and en echelon offsetting on various scales and apophyses are common, as is the presence of compositional flow banding parallel to the contacts and the chilled margins. The dykes are commonly faulted by the east-northeast-trending faults whose courses they follow, and are cut off by southeast-trending faults. They cut old dolerites and trachyte. Thin sections show these dykes to consist essentially of varying proportions of cryptocrystalline material, plagioclase, ±alkali feldspar, clinopyroxene, brown hornblende, opaque oxide and a variety of secondary minerals including carbonate, serpentine, bowlingite, iddingsite, talc, chlorite and scapolite. The groundmass texture varies from intersertal to intergranular to pilotaxitic. There are abundant phenocrysts of strongly zoned clinopyroxene with clear green cores and pink rims, and/or brown hornblende, and/or serpentine and carbonate pseudomorphing olivine. Weathering out of these soft phenocrysts gives the rocks a characteristic pitted or rough, brownish weathered surface. A few magnetite phenocrysts and scattered specks of iron sulphides occur in some of these dykes.

(d) Mafic Micromonzonite (MM)

On the northeast slopes of Nuniagiarfuip qâqâ, a mafic micromonzonite dyke trending 60° can be traced for ca. 3 km. It is only 25 cm wide at its southeast end but gradually increase to ca. 10 m in width in the northeast. It cuts old dolerite and is cut by southeast-trending faults. This is a multiple dyke formed of 2 of 3 individual dykes of the same composition. Internal contacts are welded and not chilled like the marginal contacts with the country rock. In hand specimen it is seen to be an olive grey, medium-grained, intersertal mafic micromonzonite. Thin sections show that it consists essentially of plagioclase, K-feldspar, titanaugite, brown biotite showing various stages of alteration to a greenish micaceous mineral, as well as opaque oxide. K-feldspar comprises between a quarter and a half of the total feldspar. In addition there is a moderate amount of an unidentified interstitial mineral (colour clear-neutral, high negative relief, isotropic to very low grey birefrigence, erratic crosshatch twinning, biaxial positive figure).

(e) Nepheline Trachyte (NTr)

In the northeast of the area, between Serfat and Søndre Igaliko, dykes of nepheline trachyte were observed cutting old dolerite. They are cut by the plagioclase-pyroxene-phyric trachyte (PPTr) and by the southeast-trending faults. These nepheline trachytes almost invariably have distinctive chilled margins. A marginal aphanitic texture gives way inwards to a layered-spherulitic texture in which the spacing of the layers and the diameter of the spherules increases progressively. Some of the narrower (<2 m) dykes are composed entirely of spherules that are up to 3 cm in diameter. Normally the wider (>5 m) dykes are composed of medium-dark grey, fine-grained nepheline trachyte with a trachytic texture well shown on weathered surfaces. Here and there are found phenocrysts of nepheline and plagioclase, commonly less than 1 cm, but up to 3.5 x 5.0 cm in diameter, and mafic inclusions themselves containing numbers of nepheline and plagioclase megacrysts. The orientation of the phenocrysts and inclusions, the layered margins and the trachytic texture make the flow texture readily apparent. A finely pitted weathered surface and an underlying shell, ca. 2 mm wide, of pale grey weathered trachyte are also characteristic of this particular nepheline trachyte. Thin sections show these dykes to consist essentially of feldspar, nepheline, pyroxene and biotite. The feldspar forms long thin laths composed partly of polysynthetically twinned albite and partly of K-feldspar. There are approximately equal amounts of each component and so the texture (only visible after staining for K-feldspar) is a sort of microperthite or micro-antiperthite. The feldspar laths have a parallel orientation that defines the trachytic texture, and all the other minerals occur interstitial to them. The nepheline is more or less altered to fine fibrous secondary minerals and in some slides there is a fair quantity of fresh analcite (or sodalite). The pyroxene crystsls are zoned - mauvish titanaugite cores merge outwards into bright green aegirine which also forms small discrete crystals. The biotite (orange-brown to dark brown) was the last mineral to crystallise and mantles all the other mafics, especially the opaque oxide.

(f) Flaggy Nepheline Trachyte (FNTr)

In the northeast of the area, from Nuniagiarfuip qâqâ to Søndre Igaliko, flaggy nepheline trachyte dykes with a trend of about 60° are common. They are cut by the southeast-trending faults. In the field this trachyte is bluish-grey and fine-grained, and contains numerous thin (<1 mm wide) elongated feldspar tablets oriented parallel to the contacts. On weathering these dykes characteristically break into many flaggy pieces. Thin sections show that the dykes consist essentially of feldspar, nepheline and aegirine. The feldspar in the groundmass and phenocrysts forms long thin tablets with both Carlsbad and polysynthetic albite twinning. However, staining indicates the feldspar has appreciable potash and is probably K-rich albite. It is set in a groundmass of nepheline with or without associated analcite (or sodalite). A few phenocrysts of nepheline may be present. The aegirine forms oriented prismatic crystals. There is accessory biotite and opaque oxide.

(g) Feldspar-Nepheline Porphyry and Trachydolerite Porphyry (Po)

In the northeast of the map-area, between Serfat and Søndre Igaliko there are many dykes of various kinds of porphyry. They all trend approximately east-northeast and are cut off by the southeast faults. In the field some of the porphyries resemble the flaggy nepheline trachyte whereas others are similar to dolerites. They are richly studded with euhedral feldspar rhombs and nepheline phenocrysts. Feldspar phenocrysts are more abundant than those of nepheline which may be lacking in some dykes. These dykes can have nepheline in the groundmass or no feldspathoid at all. In all these porphyries including the trachydolerite, there is appreciable K-feldspar and titanaugite is the chief mafic mineral. Two of these dykes have erratic concentrations of numerous huge plagioclase xenocrysts and anorthosite xenoliths, i.e., they are "Big Feldspar Dykes", (Bridgwater and Harry, in prep.).

The big feldspar dyke at Søndre Igaliko is a trachydolerite composed essentially of highly saussauritised plagioclase, K-feldspar, titanaugite, reddish-brown biotite and a greenish micaceous mineral, as well as opaque oxide. This dyke is 8-10 m wide, has an attitude of 60/90°, and has numerous huge plagioclase xenocrysts that locally comprise approximately 20% of the dyke. They occur across the entire width and are generally smaller in the chilled marginal zones. These megacrysts are subhedral to euhedral and measurable in tens of cm. Most have white opaque margins and white translucent cores but several have amber-coloured translucent cores. Tiny poikilitic mafic inclusions are common only in the margins. The xenocrysts have many fractures that do not extend into the surrounding trachydolerite. They have a subparallel vertical flow orientation. Also, here and there, are inclusions of medium-grained, granular anorthosite composed of roughly equant plagioclase euhedral and less than 5% mafics.

Another "Big Feldspar Dyke" is located ca. 2 km southwest of Søndre Igaliko. It is a feldspar-nepheline porphyry containing numerous euhedral phenocrysts of nepheline, plagioclase with K-feldspar mantles, plus a few smaller ones of titanaugite mantled by aegirine, all in a groundmass of albite, K-feldspar, nepheline, aegirine and biotite. It is badly exposed, is ca. 10 m wide and seems to have patches with huge plagioclase xenocrysts and anorthosite xenoliths both similar to those described above for the dyke at Søndre Igaliko.

(g) Plagioclase-Pyroxene-phyric Trachyte (PPTr)

On Nuniagiarfik, dykes of plagioclase-pyroxene-phyric trachyte were observed cutting old dolerite (OD) and nepheline trachyte (NTr). Younger quartz veins cut this porphyritic trachyte. The dykes are up to 6 m wide and trend 60°. In hand specimen this is a fine-grained rock with a brownish tinge, crowded with numerous unoriented plagioclase phenocrysts plus a few of pyroxene. Thin sections show this trachyte to consist essentially of plagioclase, K-feldspar, pyroxene and opaque oxide. The plagioclase phenocrysts and the larger plagioclase crystals in the groundmass are strongly zoned, their outermost zones being K-feldspar. The pyroxene phenocrysts are mauvish titanaugite mantled by aegirine which also forms small crystals in the groundmass. There is abundant opaque oxide which in some slides forms a symplectic intergrowth with the feldspar. Accessory biotite, apatite, sodic amphibole and zircon are found. The texture is porphyritic intersertal.

III ECONOMIC GEOLOGY

The economic potential of an area should be considered in the light of the interaction between various favourable geological controls on the development of ore bodies, for example: favourable host rocks, fracture patterns, secondary alteration zones, sources of valuable minerals, and geological events likely to concentrate valuable elements.

In the map-area, the late northeast and southeast faulting was accompained by extensive secondary alteration expressed by hematitisation (reddening of the feldspars), chloritisation and epidotisation of the mafic minerals, silicification in places so intense as to produce patches of pale green-white cherty-looking rock or vuggy quartz veins, introduction of relatively small amounts of fluorite, calcite, iron and copper sulphides. This secondary alteration has the appearance normally associated with wallrock alteration around hydrothermal sulphides and gold deposits. Although the host rock is not favourable for this type of deposits the following zones warrant prospecting: (1) Northeast fault zone between Eqaluit tasiat and Qernertût tasia, especially the southwest and between Angmagssivik and Qernertût tasia. (2) Southeast faults in the northeast of the map-area, especially the fault on the shore of Kujatdleq between Napajinga and Nuniagiarfik, and on the northeast shore of Nuniagiarfik. (3) East-northeast fault zone on the south shore of Eqaluit. Six selected samples of altered and mineralised rock from this locality were spectrographically assayed for Cu, Pb, Zn, the platinoids and Au. Copper ranged from 0.001% to 0.3%; no lead, zinz or platinoids were detected and gold was found in only one sample - 0.2 p.p.m.

The hornblende gabbro is a potential host rock for magmatic concentrations of the platinoids, Cr, Cu, Ni and Co. Accordingly, a sample of friable and rusty hornblende gabbro from the Serfat kûat pluton was spectrographically assayed for these elements and gave no detectable platinoids, 0.005% Cr, 0.006% Cu, 0.005% Ni, and 0.004% Co. These amounts are less than the average background values for the elements concerned in this type of rock.

The intrusion of the nearby Ilímaussaq pluton and the Igaliko Syenite Complex, both composed of rocks normally associated with radioactive mineralisation of various kinds, coupled with contemporaneous faulting, is favourable for the concentration of U and Nb. Accordingly, geiger counter readings were taken in many of the fault zones (and on Sanerutian pegmatites). However, no measurements more than four times background were recorded.

The Qaqâta biotite adamellite potentially is an excellent building and monument stone on account of its widely spaced but well defined three joint sets perpendicular to one another, its homogeneous leucocratic nature and the absence of vugs and impurities such as iron sulphides.

IV REFERENCES

Allaart, J.H., 1964. Review of the work on the Precambrian basement (pre-Gardar) between Kobberminebugt and Frederiksdal, South Greenland. Rapp. Grønlands geol. Unders. nr. 1.

Berthelsen, A., 1960. An example of a structural approach to the migmatite problem. Rep. 21st Intern. Geol. Congr., Pt. 14, 149-157.

-------------, 1961. Structural classification of gneiss - as used in team work in SW. Greenland. Rep. 21st Intern. Geol. Congr., Pt. 26, 69-71.

-------------, Bondesen, E. and Jensen, S.B., 1962. On the so-called wildmigmatites. Krystalinikum 1, 31-50, (Prague).

Bridgwater, D., in press. Isotopic age determinations from South Greenland and their geological setting. Medd. Grønland, Bd. 179, nr. 4.

-------------- and Harry, W.T., in prep. Anorthositic xenoliths and plagioclase xenocrysts in Precambrian intrusions of South Greenland. Medd. Grønland.

Buttet, P., 1962. Rapport préliminaire Agdluitsoq fjord; géologie de la région de Qagdlumiut. Unpublished report, Grønlands geol. Unders.

---------, 1963. Géologie de la région de Qagdlumiut; rapport préliminaire. Unpublished report, Grønlands geol. Unders.

Dawes, P.R., 1963. Field report on the geology of the Tasiussak area, South Greenland. Unpublished report, Grønlands geol. Unders.

Elwell, R., Skelhorn, R.C. and Drysdall, A.R., 1962. Net-veining in the diorite of N.E. Guernsey, Channel Islands. J. Geol., Vol. 70, 215-228.

Escher, A., in press. The deformation and granitisation of Ketilidian rocks in the Nanortalik area, South Greenland. Medd. Grønland, Bd. 172, nr. 9.

Jahns, R.H. and Tuttle, O.F., 1963. Layered aplite-pegmatite intrusives. Miner. Soc. Amer. Spec. Paper No. 1, 78-92.

Read, H.H., 1957. The Granite Controversy. London.

Redden, J.A., 1963. Geology and pegmatites of the Fourmile quadrangle. Black Hills, South Dakota. U.S. geol. Surv. Prof. Paper 297-D, 199-291.

Walton, B. J., in press. Sanerutian appinitic rocks and Gardar dykes and diatremes, north of Narssarssuaq, South Greenland. Medd. Grønland, Bd. 179, nr. 9.

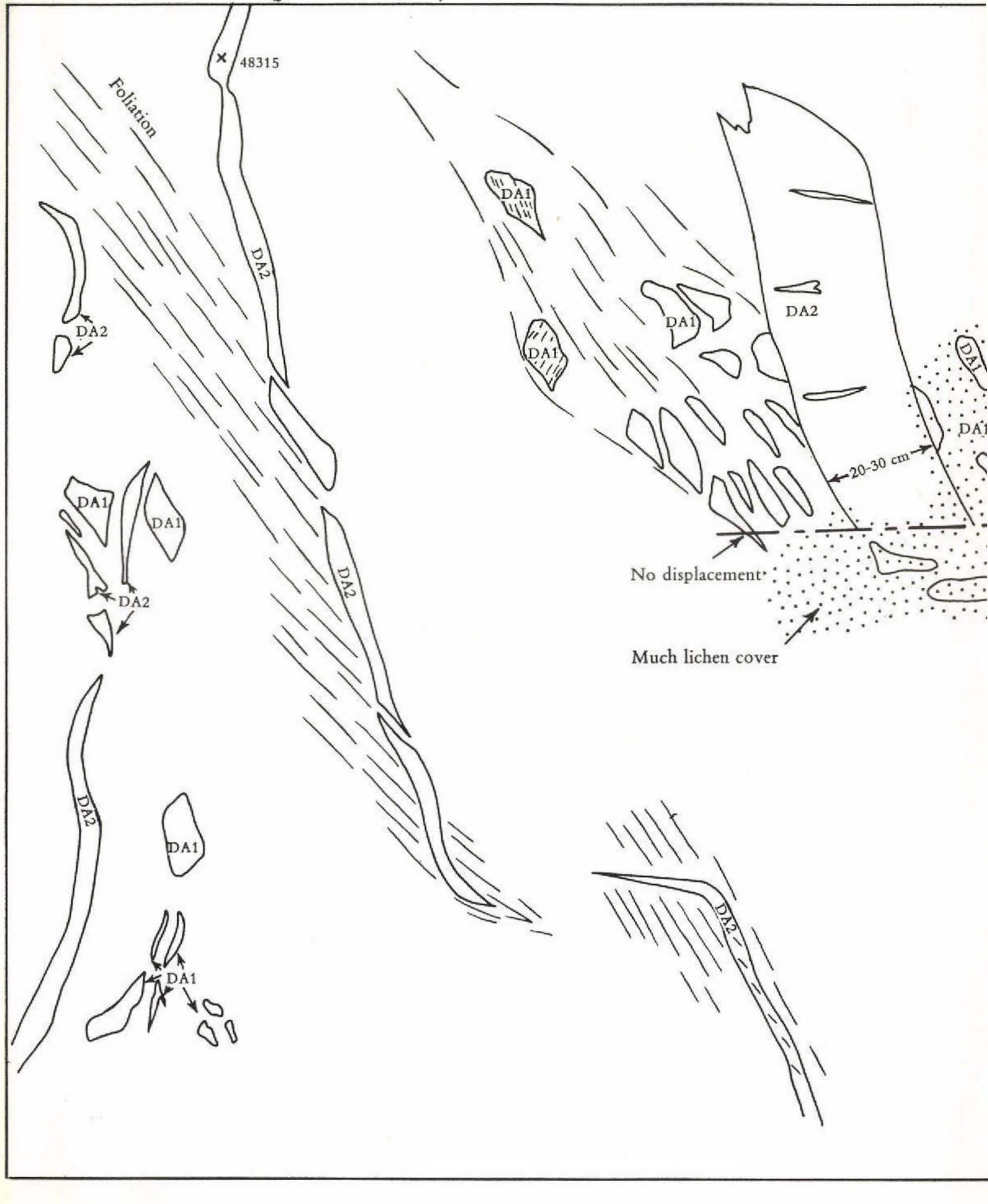
Watterson, J. S., in press. Plutonic development of the Ilordleq area, South Greenland. Pt. 1: Chronology, and the occurrence and recognition of metamorphosed basic dykes. Medd. Grønland, Bd. 172, nr. 7.

Windley, B. F., 1963. The plutonic development of the Sardloq area, South Greenland. Unpublished Ph. D. thesis, University of Exeter, England.

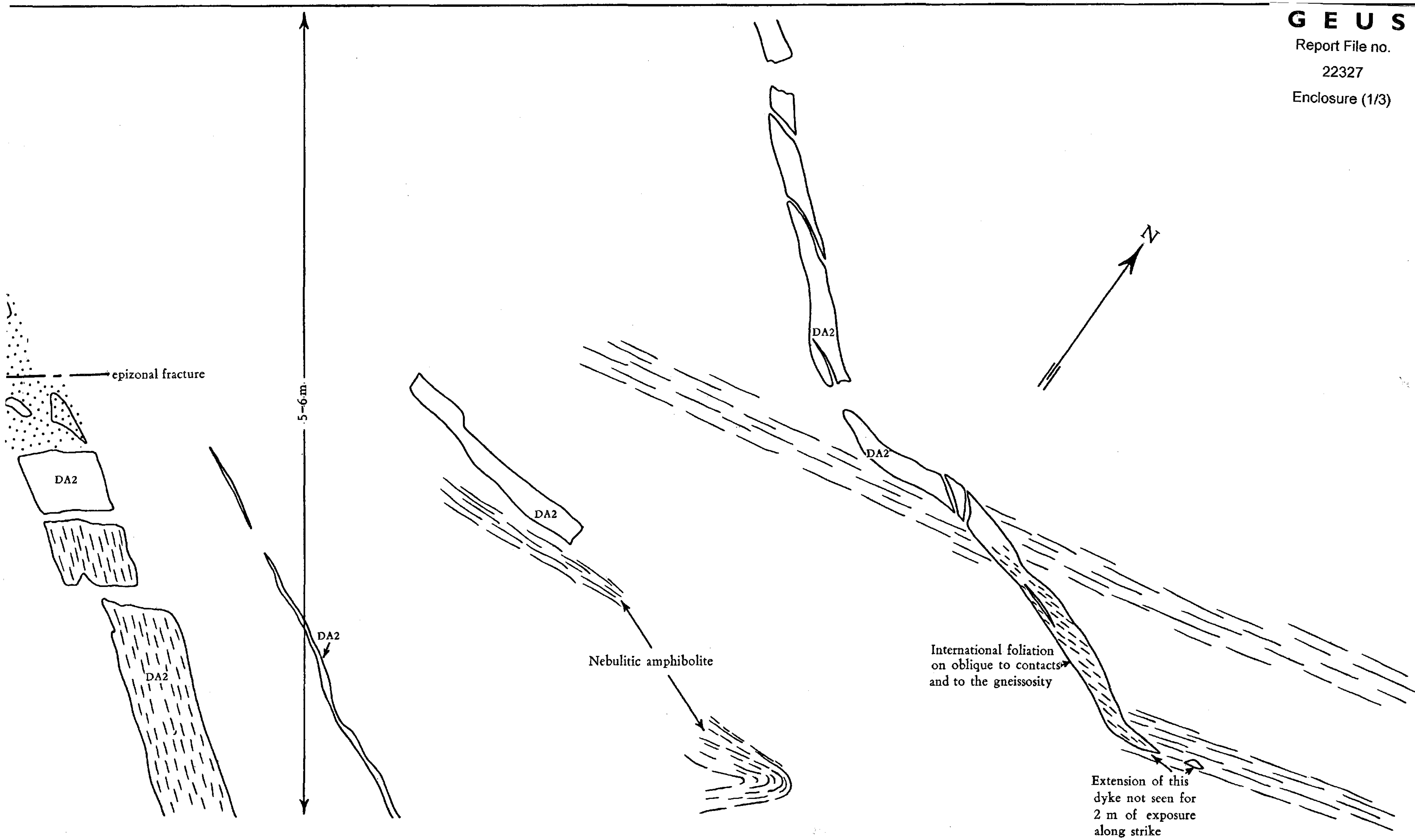
-------------, in press. The composite net-veined diorite intrusives of the Julianehåb district, South Greenland. Medd. Grønland, Bd. 172, nr. 8.

------------- and Bridgwater, D., in press. The layered aplite-pegmatite sheets of Kînâlik, South Greenland. Medd. Grønland, Bd. 179, nr. 10.

Plate 1. Swarm of DA2 dykes cutting agmatitic and folded older amphibolite (DA1 ?) in homogeneous to streaky biotite gneiss.



PL. 1.


epizonal fracture
DA2
DA2
DA2
5–6 m
DA2
Nebulitic amphibolite
DA2
DA2
N
International foliation
on oblique to contacts
and to the gneissosity
Extension of this
dyke not seen for
2 m of exposure
along strike

GRØNLANDS GEOLOGISKE UNDERSØGELSE
THE GEOLOGICAL SURVEY OF GREENLAND

MAP 1

GRØNLANDS GEOLOGISKE UNDERSØGELSE
THE GEOLOGICAL SURVEY OF GREENLAND