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KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
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GRØNLANDS GEOLOGISKE UNDERSØGELSE

GEOLOGICAL MAP OF GREENLAND 1:100000

JULIANEHÅB

60 V. 2 NORD

DESCRIPTIVE TEXT BY
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WITH 11 FIGURES AND 2 TABLES IN THE TEXT, AND 1 PLATE

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BIANCO LUNOS BOGTRYKKERI A/S
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Abstract

The oldest rocks are metasediments, metavolcanics, gneisses and gneissose granites and they occupy about 15 % of the map area. Their age is unknown. They are extensively broken up by a complex of granitic rocks collectively called the Julianehåb granite which occupies about 80 % of the map area. This granite complex developed by a combination of intrusion and reactivation of existing granitic gneisses (during late Early Proterozoic time) before 1750 m.y. ago.

Subsequently the area was uplifted and subjected to erosion and faulting accompanied by the accumulation of 3000 m of sandstones, and basalt and trachytic lavas. They were intruded by alkaline dykes and intrusive centres of which Ilímaussaq is the most famous. These unmetamorphosed supracrustal and alkaline intrusive rocks occupy 5 % of the area and are of Late Proterozoic (Gardar) age.

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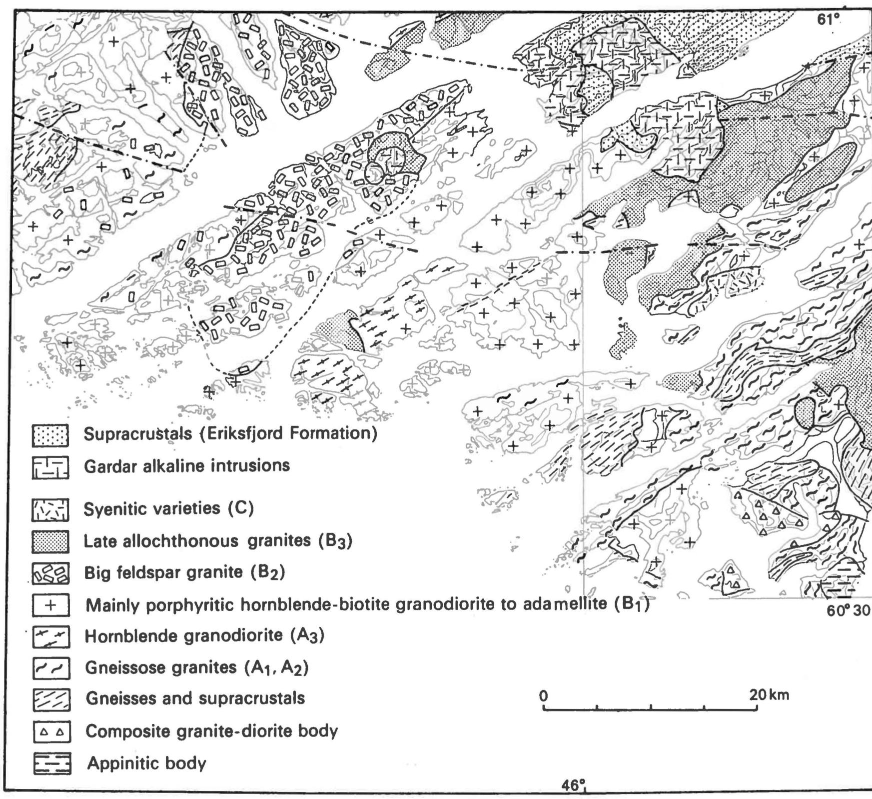

Fig. 1. The map area showing the main rock types.

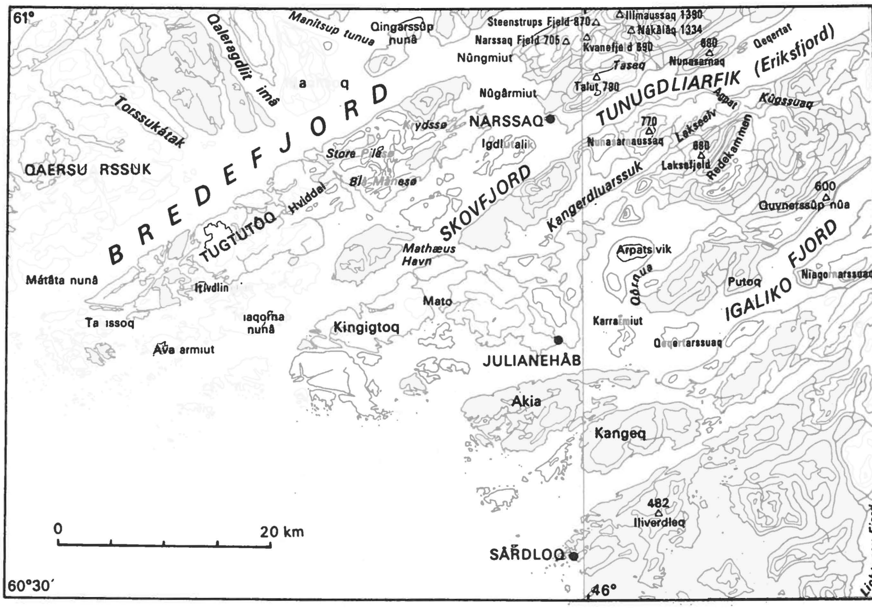

Fig. 2. The map area with names of localities used in the description. Correction: Qingarssûp nunâ should read Qingârssûp nunâ.

INTRODUCTION

The Julianehåb map sheet covers part of an ENE-trending belt of granitic rocks occurring immediately south-west of the north-western marginal zone of the Ketilidian mobile belt of South Greenland. The westernmost part of this granitic belt is covered by the Nunarssuit map sheet, to the west, and the marginal zone by the Ivigtut map sheet to the west of the map sheet Akutaq (see map sheet).

The mapping of the Julianehåb sheet took about 25 man summers of about 100 days.

In fig. 1 a general view of the geological divisions within the sheet area is given. Fig. 2 indicates the names which are used in the descriptive text. Table 1 on p. 23 gives the chronology of the area.

The Julianehåb sheet is one of five map sheets covering practically the whole of southern Greenland where Gardar intrusive and extrusive igneous activity has taken place.

GRANITIC BASEMENT

Supracrustals and gneisses

Supracrustals and gneisses are relatively common in the western part of the sheet area and outside the Julianehåb granite in the south-east. An important gneiss band associated with metavolcanics occurs on the Julianehåb peninsula.

Metasediments

Banded semipelite (symbol **sp**) occurs as zones in areas of granitic gneiss in the north-western part of Qaersuarssuk (WATT, 1965).

Feldspathic quartzites occur as layers up to several metres thick at various places along the south-eastern contact of the gneiss band of the Julianehåb peninsula.

Meta-arkoses or acid metavolcanics are fine-grained rocks of granitic to granodioritic composition. Muscovite is an important constituent besides biotite. They form bands 20 m wide in the banded semipelites of north-west Qaersuarssuk. Other occurrences are indicated as siliceous gneiss (**qgn**) east of the fjord Qaleragdlit imâ and as aplitic gneiss in the eastern part of the map around Sârdloq.

Metavolcanics (symbol vs)

There are two important occurrences of basic to intermediate volcanic rocks. (1) East of the fjord Qaleragdlit imâ in the north-west an elongated outcrop is bounded by siliceous gneiss. The metavolcanics form a monotonous alternation of two varieties of porphyritic rocks, one with phenocrysts of plagioclase (An_{50-25}) and hornblende with the composition of a quartz latite, the other variety contains more hornblende and biotite. Phenocrysts are almost exclusively plagioclase. (2) On and around the tiny island of Mato, in the centre of the map sheet, a 30 m thick series of tuffaceous rocks with pronounced mineral banding and occasional cross-bedded horizons overlies unbanded, homogeneous amphibolitic rocks. There are several horizons of agglomeratic material and some of these are basic while others are intermediate in composition and contain fragments of chert. The tuffaceous rocks and the amphibolites clearly overlie the surrounding gneisses, but the original contact relations have been destroyed by deformation, metamorphism and granite emplacement.

Other less important occurrences of similar but unbanded rocks occur on the peninsula east of the sound Qôrnua. These have been indicated as basic rocks of uncertain origin (symbol **a**).

Gneisses (gn)

In the outer parts of Bredefjord and north of Putoq, north-east of Igaliko Fjord, gneiss bands alternate regularly with conformable zones of granite. On the Julianehåb peninsula a broad ENE-trending zone of gneiss and intercalated supracrustals has been mapped by NESBITT (1961). This zone can be followed for at least 15 km. Larger areas of gneiss occur in the western part of Qaersuarssuk and in the south-eastern part of the map area.

The gneisses are usually fine grained, consisting of plagioclase (An_{20-30}), microcline, quartz, hornblende, biotite and epidote. The composition is generally quartz-dioritic to granodioritic. Biotite and hornblende-rich bands are frequent and outline the fold structures.

Bands of amphibolite, often slightly discordant, are frequent in places. At least some of these might have been basic dykes.

In the Sârdloq area, south-east of the Julianehåb granite, bands of gneiss can be followed over long distances (WINDLEY, 1966a; 1966b). Two varieties can be distinguished. (1) *Banded gneisses* consist of regularly alternating light and dark bands. The light bands are granodioritic in composition and consist of quartz, plagioclase (An_{30}) and microcline. The dark bands are composed of diopside, hornblende, biotite and also quartz, plagioclase and microcline. (2) *Veined gneisses* are typical migmatites with leucocratic veins and lenses consisting of plagioclase (An_{30}), quartz and microcline. The matrix is made up of biotite, muscovite, rarely hornblende with plagioclase and quartz. In both varieties epidote and chlorite are secondary minerals.

Aplitic gneiss. East of Iliverdleq, in the south-east, sheet-like bodies of very leucocratic homogeneous gneisses occur. These are fine to medium grained and consist of plagioclase, microcline, quartz and some biotite. The foliation in the rocks is pronounced and their composition is granodioritic.

Granites

The granites can be divided into two main groups: (A) early granites which generally contain continuous bands of gneiss, early amphibolitic relict dykes and medium and large scale structures defined by the regional foliation; (B) late relatively homogeneous granites which lack relict major structures. A third minor group C includes syenitic varieties. Each group is subdivided into units which are described in turn below (see fig .1).

A_1. Gneissose or foliated, porphyritic hornblende-biotite granodiorite to adamellite (fig. 3). This variety is relatively mafic and medium to coarse grained. Hornblende and biotite make up 10–25 % of the rock

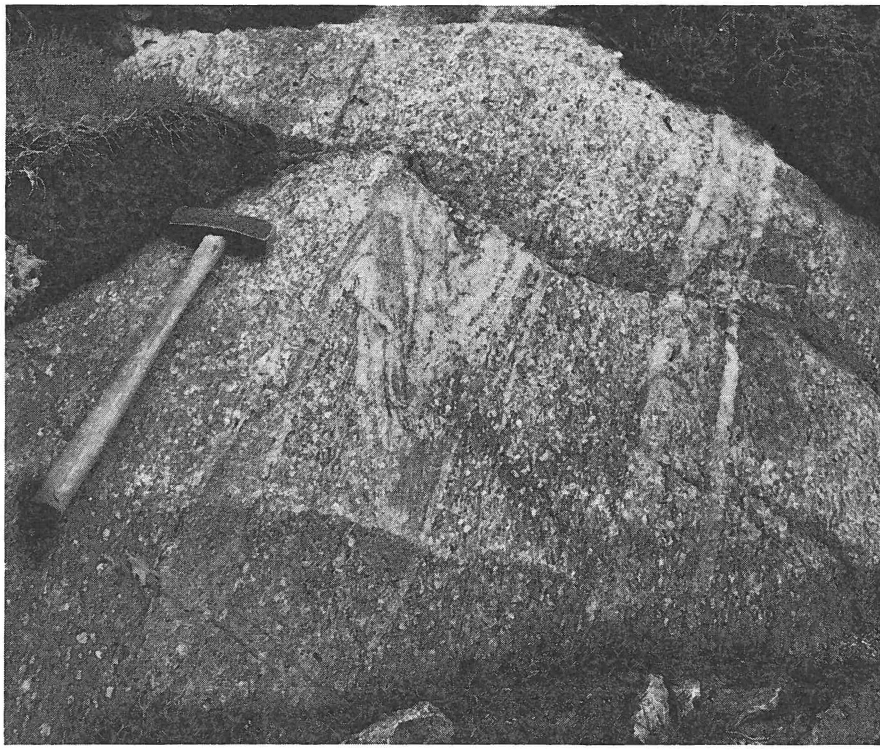

Fig. 3. Gneissose porphyritic granodiorite to adamellite (variety A_1, symbol **g**) from the area east of Sârdloq. Photo: B. F. WINDLEY.

volume. The rock is porphyritic to very porphyritic and the very porphyritic varieties have an adamellitic composition. Microcline phenocrysts occur up to 3 cm long and are generally well oriented. Small lenticular basic inclusions are abundant. The foliation is marked by the orientation of the mafic minerals, inclusions and microcline phenocrysts. In many places bands of relatively leucocratic granodiorite with few inclusions alternate with darker granodiorite with abundant inclusions. The bands are usually parallel to the foliation, but often the foliation cross-cuts the banding. In one locality the bands are severely folded and the foliation is parallel to the axial planes of the folds.

This variety constitutes the main variety in the south-eastern part of the map area outside the Julianehåb granite and also in the area between Qôrnua and Igaliko Fjord. It is very similar to a banded, porphyritic granodiorite in the outer parts of Bredefjord, but here the microcline megacrysts are larger and identical to those of the Big-feldspar granite (variety B_2).

A_2. Non-porphyritic varieties. Along Torssukátak fjord and the outer parts of Bredefjord, especially at its southern side, non-porphyritic

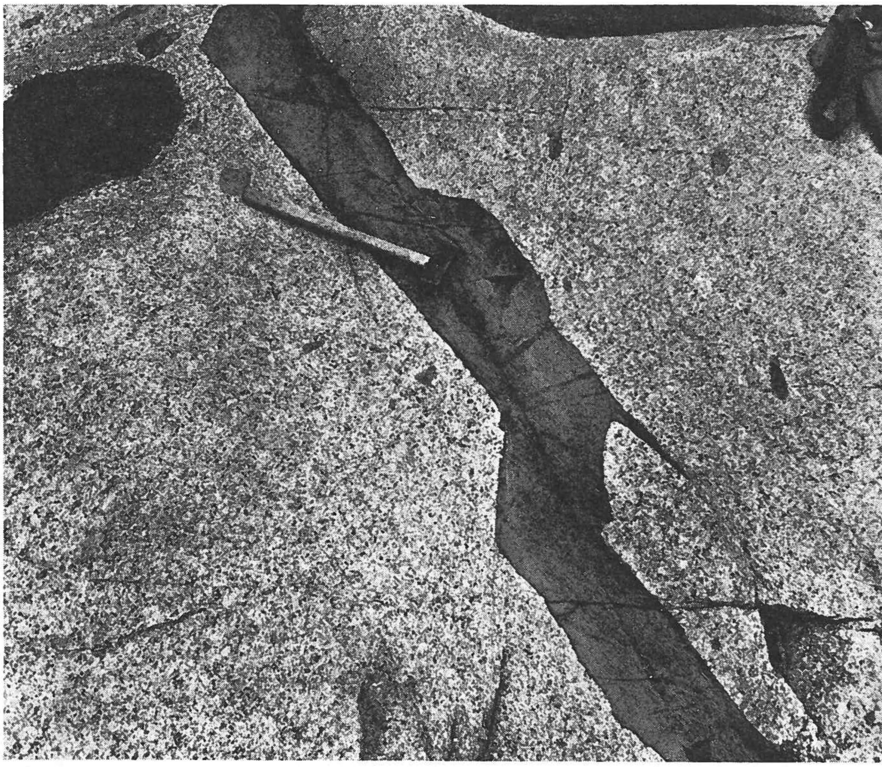

Fig. 4. Porphyritic granodiorite to adamellite (symbol g, variety B_1) cross-cut by a basic dyke intruded into an active shear zone.

varieties of granodiorite alternate with gneiss bands. These are less mafic than variety A_1, but show a similar compositional banding. In many places the foliation is not very pronounced and there is great similarity to variety B_1.

A_3. Mafic hornblende-biotite granodiorite. The rock is medium grained, relatively mafic and fairly homogeneous. Hornblende is the main dark mineral, biotite occurs in varying amounts. Foliation is marked by the orientation of the minerals and of the basic inclusions which are abundant. Their distribution is variable. Zones rich in inclusions often alternate with others poorer in inclusions. The mafic granodiorite is exposed in the extreme north of the sheet area, (where medium and large scale fold structures with north-west and north-east trends have been recorded) in parts of Kingigtoq and on Qeqertarssuaq north-east of Akia.

B_1. Porphyritic or slightly porphyritic biotite-hornblende granodiorite to adamellite. This occurs in many parts of the area but especially within the Julianehåb granite. It is generally more homogeneous and less mafic than all the varieties described above. It varies from medium to

coarse grained and from granodiorite to adamellite and is variably porphyritic with a weak foliation. Its microcline crystals are bigger than those of plagioclase and quartz. Biotite and hornblende make up between 5 and 15 % of the rock volume. It contains basic to intermediate inclusions but they are less abundant than in the early granites.

A body of this type occurs in the south-eastern part of the Julianehåb peninsula (fig. 4) with its longitudinal axis parallel to the regional structures. Up to 2 to 3 km from its north-western margin it is a granodiorite and is only slightly porphyritic. It encloses many inclusions of gneiss and supracrustal rocks, and early amphibolitic relict dykes. Farther southwards towards the centre of the body it is homogeneous and porphyritic and contains scattered oval-shaped basic inclusions in which no original structures can be recognised. Evidently this central part is more homogenised and porphyritic because of greater mobility of alkalis than in the marginal facies. A Rb-Sr whole rock isochron of this rock gives an age of 1776 ± 37 m.y. (VAN BREEMEN *et al.*, in press). These granites are probably allochthonous.

B_2. *Coarsely porphyritic granodiorite (Big-feldspar granite).* An extensive body of coarsely porphyritic granite (fig. 5) comprises large parts of Tugtutôq and the area north of Bredefjord. Relatively small areas of it also occur on Qaersuarssuk and on the islands immediately west of Tugtutôq in close association with gneiss bands. It is characterised by euhedral to anhedral megacrysts of microcline averaging 4 cm in length. They lie in a medium- to coarse-grained matrix which is generally more mafic but similar to all the granites described above. On Qaersuarssuk and the islands immediately west of Tugtutôq it contains a banding, which was probably inherited from variety A_1.

In most places the contact of the Big-feldspar granite dips gently or moderately inwards, but along its western side it dips steeply inwards. The contact is usually distinct and marked by the sudden appearance of large microclines. Lenses and layers of Big-feldspar granite occur abundantly just outside the main contact.

The foliation in the major body trends north-east to ENE, but in its north-western part major fold structures with north-west trending axes occur. The structures of the surrounding Julianehåb granite appear to continue without break through the body.

B_3. *Late allochthonous leucocratic granites (Redekammen type) and aplite granites* (symbol gi). These granites are fine to medium grained and are often slightly porphyritic with microcline megacrysts less than 1.5 cm long. The largest bodies have steep contacts whilst the smaller ones have sheet-like forms.

Fig. 5. Big-feldspar granite (variety B_2, symbol **g**).

The most important intrusion occurs east of Redekammen and on the island Arpatsivik. In the area north-east of Torssukåtak fjord a body of early leucocratic granite (variety A_2) grades into a very broad mantle of homogeneous aplite granite which veins the Big-feldspar granite lying to the east. The origin of the aplitic granite mantle is not understood.

C_1. Primary syenitic varieties (**sg** and **sgi** with mineral symbols). Around Putoq an early monzonite and a later syenite occur. The monzonite is medium to coarse grained, usually foliated and similar to the earlier granites except for its lack of quartz. Its contacts with the surrounding granites are gradual. Around basic bodies which occur within the monzonite it is unfoliated, medium grained and relatively melanocratic.

The monzonite encloses a smaller body of leucocratic syenite which includes many dioritic xenoliths. The syenite is rich in microcline. Relics of plagioclase occur in various stages of break-down to smaller crystal aggregates. Biotite and green hornblende occur in small quantities.

Between the broad E–W valley of Kûgssuaq and Tunugdliarfik a body of aplitic granite occurs partly enclosing another body of biotite monzonite. Both bodies are intrusive into the surrounding Redekammen type granite. The mutual contacts of the bodies do not indicate clear age relations. The monzonite has a clear magmatic texture with euhedral, tabular plagioclase (andesine), lath-shaped biotite and broad relatively large crystals of perthitic microcline which contain numerous inclusions of the two other minerals.

C_2. *Albitised rocks* (sg). Small bodies of almost pure albite occur in various places throughout the map sheet. The largest body is one kilometre long, but generally they are much smaller. These rocks originated by soda metasomatism of original granitic country rocks. Relict porphyritic textures are well preserved. Basic schlieren of biotite and hornblende are continuous into the albite body without a break, but within it their mineralogy changes to clinochlore, hematite and occasionally actinolitic hornblende. Under the microscope it can be seen that the albitisation has not destroyed the original grain boundaries of the pre-existing minerals. The albitised plagioclase crystals always enclose many epidote crystals. Original microcline has been altered into chess-board albite and the quartz into albite. The albite generally shows wavy extinction and bent twin planes. It has not been possible to establish the age relations of the albitisation processes. HARRY & OEN (1964) also described albitisation and desilication of Julianehåb granite just south of Kobberminebugt and concluded that these processes might have taken place in association with copper mineralisation during Gardar time.

Basic to intermediate igneous activity

Revaluation of the dyke chronology

The systematic mapping in the early sixties suggested that the plutonic development of the Early Proterozoic mobile belt of South Greenland could be divided into two stages, called Ketilidian and Sanerutian. These stages were thought to be separated by an episode marked by a retreat of geo-isotherms and tensional conditions during which basic dykes were intruded. As the overall structure of the mobile belt emerged several writers suggested that the apparent division into Ketilidian and Sanerutian episodes represents different plutonic stages of a single orogenic cycle.

After 1965 it was realised that the field evidence for the retreat of the geo-isotherms between the two episodes could be interpreted in other ways. It became clear (V. R. MCGREGOR, 1966, in discussion) that a large number of the supposed intra-orogenic dykes belong to a suite of basic to intermediate igneous rocks connected with late orogenic granite activity and were intruded under plutonic conditions into hot crust which still possessed a high degree of mobility. The remaining dykes which are folded and deformed belong to a group of pre-orogenic to early orogenic dykes intruded into cold granitic crust. The plutonic development of the mobile belt has thus been continuous with deformation, regional metamorphism and granite generation followed by granite intrusion and associated basic igneous activity. Thus, there are two important groups of basic to intermediate intrusions.

Early intrusions and relict dykes

Along Torssukåtak fjord a slightly discordant metagabbro intrusion (basic intrusive rocks: gi) occurs in gneissose granite (variety A_1). Close to its contact the rock is a fine-grained amphibolite. Thin apophyses of it extend into the gneissose granite parallel to the granite foliation. In the metagabbro deformation has produced foliation which destroyed earlier textures and reduced the original grain size. In the least deformed parts of the body the metagabbro is coarse grained and consists of equidimensional hornblende crystals, 5 cm in diameter, sieved with plagioclase crystals. Two episodes of deformation can be recognised separated by at least two generations of leucocratic veining. This is the only basic intrusion which shows signs of strong deformation (see also Allaart, 1967, p. 73).

In the gneissose granites in the south-east and in the area of the Julianehåb granite there are considerable numbers of thin amphibolitic relict dykes which are almost parallel to the foliation. These have been best preserved in areas of gneiss or gneissose granite, i.e. the peninsula east of Sârdloq, the islands Kangeq and Akia, the peninsula Niaqornarssuaq east of Igaliko Fjord and Måtâta nunâ along the outer parts of Bredefjord. They generally cross-cut the banding and regional foliation of the gneisses or granites. Here and there the bodies are folded and the axial planes are parallel to the regional foliation (Berrangé, 1966; Allaart, 1967). In a few places they are seen to be folded twice. The fact that these relict dykes preserved their basic composition under severe deformation indicates that they were originally intruded into gneiss or granite. It is thought that they are relics of pre-orogenic or early orogenic dykes intruded into granitic and gneissic basement which has been partially or wholly reconstituted during late Early Proterozoic plutonism without the original relations between the rocks of differing composition being effaced.

Later basic to intermediate intrusions (symbols pd and di)

Appinitic rocks. On Qaersuarssuk, just north of the outer parts of Bredefjord several intrusions with appinitic affinities occur (Watt, 1963). Two of these are indicated on the sheet. The others are narrow bodies of 100–200 m length and occur along the shore of the fjord. The bodies consist of very basic rock in which hornblende megacrysts up to a centimetre occur in a matrix consisting mainly of hornblende and plagioclase. Relics of orthopyroxene have been detected occasionally. Clinopyroxene is widespread and is usually replaced by hornblende. Biotite occurs in association with the hornblende megacrysts. These rocks are similar to the appinites *sensu stricto* as defined by BAILEY & MAUFE (1960).

From the appinitic bodies dykes extend which belong to a swarm occurring along both sides of outer Bredefjord. The individual dykes can be followed over several kilometres. Their spacing averages 20 dykes per kilometre. Their width usually varies between 10 cm and 2 m and the thickest dyke is 10 m wide.

The dyke rocks are fine grained and contain abundant hornblende aggregates a few millimetres across. The distribution of the aggregates is variable and is the result of flow of the magma in the dyke fissure. The aggregates are often elongated and oriented defining a sygmoidal schistosity. In many dykes the schistosity is less clear. Metamorphic textures are clearly developed in most thin sections. Clinopyroxene is common and occurs in the hornblende aggregates and in the matrix together with hornblende and plagioclase. Biotite usually occurs as oriented flakes.

The dykes of the Bredefjord swarm clearly post-date all phases of regional deformation in the nebulitic gneisses and granites. It is probable that the Bredefjord dykes were intruded into active shear zones like the synkinematic dykes of the Julianehåb peninsula (ALLAART, 1967) and that their metamorphic textures mainly developed contemporaneously with the dyke intrusion. However, at the same time, the surrounding granites show clear signs of mobility, a distinct contrast with the conditions in the granite around Julianehåb.

Hypersthene gabbro intrusions. In an ENE-trending belt across the sheet area passing several kilometres north of Julianehåb there are several bodies of hypersthene gabbro. There are four occurrences just south-east of 60°45′ N, 46°30′ W, two on the Julianehåb peninsula, three east of Qaqortoq and one on the eastern margin of the sheet. The largest one is situated in the south-east corner of the sheet along Lichtenau Fjord.

These intrusions usually have a marginal facies of dioritic rock which grades inwards into gabbro. Mineral layering is common. Occasionally there are occurrences of cortlandtite. In the big body from Lichtenau Fjord basic hornblende phenocryst rock (appinite) occurs locally.

The main variety is a coarse-grained rock consisting of olivine, hypersthene, hornblende, plagioclase, clinopyroxene, biotite, apatite and opaque minerals. An older generation of brown hornblende is succeeded by a light green one. The latest primary mineral, biotite, is either reddish brown or light green.

Only occasionally are the intrusions migmatised by the surrounding granite. However, on the island Itívdlingûjuk a strongly migmatised body occurs with well preserved relics of cortlandtite. The intrusion along Lichtenau Fjord is strongly deformed and migmatised along its margins. Another body of hypersthene gabbro occurs as a 400 m long fragment with its original contact preserved at one side with vertical layering and erosion structures, which, however, are truncated by the surrounding granite at the other side. This fragment was probably detached from a once larger body and disoriented as a result of a high degree of mobility in the surrounding Big-feldspar granite. It is not known whether these three occurrences are of the same age as the other hypersthene gabbro bodies or are much older.

Pyroxene-bearing diorites. On Avatarmiut (on longitude 46°45′ W) and the island to its north-east there are a few laccolithic intrusions of diorite (marked with pd). From these a great many low-dipping sheets invade the surrounding granite at regular intervals. Sheets and dykes of this rock type are common between Akia and Takissoq (due west of Julianehåb). They can be followed for long distances and are schematically indicated as late orogenic dykes ai.

The rocks of the laccolithic intrusions vary from medium to almost coarse grained. Zoned plagioclase ($An_{46\text{-}20}$) occurs in ophitic relation to hornblende crystals which contain relics of clinopyroxene. Biotite forms either large plates or small flakes which are related to later shearing. In the sheets and dykes signs of slight recrystallisation are ubiquitous whilst the margins of the bodies are often strongly recrystallised.

The pyroxene-bearing diorites show a type of net-veining identical to that of the net-veined diorites (see fig. 6); however, it is generally not developed as strongly as in the net-veined diorites. There are also vertical pipe-like bodies of granitic material which is identical to that of the net-veins in the diorite. The granitic and dioritic components have been intruded practically contemporaneously (see for origin of the net-veining, Windley, 1965). The high degree of mobility of the surrounding granite immediately after the intrusion of the pyroxene-bearing diorites is shown by back-veining (fig. 6).

Composite net-veined diorites. In a large triangular area between Mátâta nunâ, at the outer part of Bredefjord, Akia in the south and Quvnerssûp nûa (600 m) at the eastern shore of Igaliko Fjord net-veined diorite bodies are abundant. On Akia and Kangeq and surrounding islands

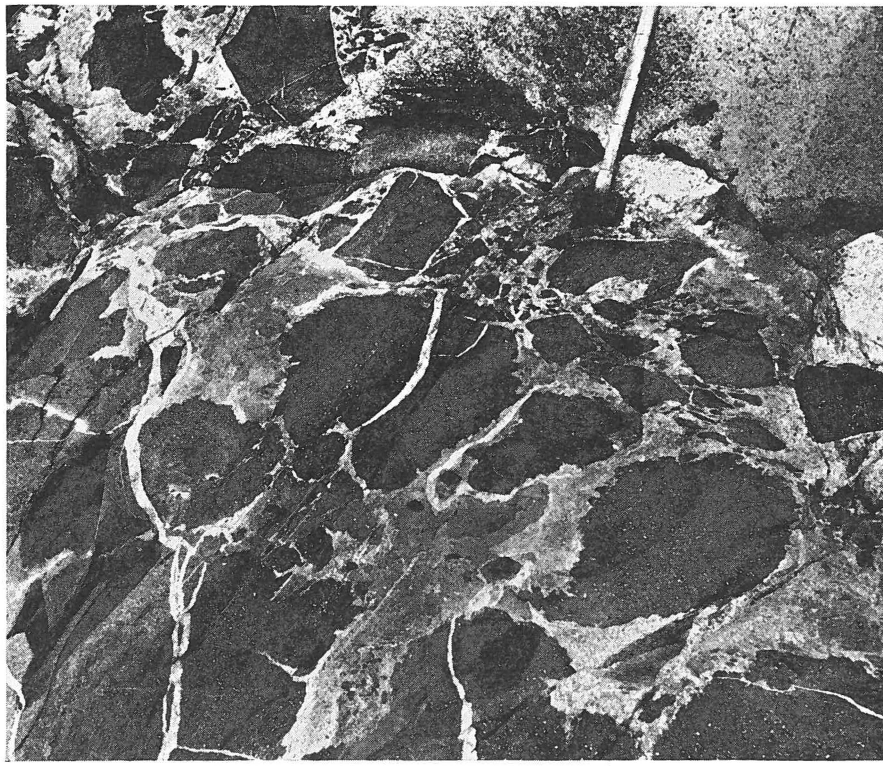

Fig. 6. Pyroxene-bearing diorite with marginal net-veins which are cross-cut by veins of mobilised country rock granite.

these are indicated by the symbol di and in some other places as late orogenic dykes ai. They form a fracture filling system in which flat sheets strongly predominate over vertical dykes. Generally the margins of the sheets and dykes are occupied by a leucocratic granite or aplite differing from the country rock granite. From the margins veins penetrate the inner parts of the bodies forming a network which divides the diorite into pillow-shaped blocks (fig. 6). As a rule the sheets and dykes show no signs of internal deformation.

The net-veined diorites are the latest generation of the late plutonic basic to intermediate igneous suite. They post-date all major granite phases, but are contemporaneous with the latest generations of leucocratic veins.

Except in the late Redekammen type granites (variety B_3) the country rock granite does not vein the diorite bodies. At the southern side of Avatarmiut and of Arpatsivik (one sheet indicated on the map), east of the Julianehåb peninsula, diorite sheets cross-cut leucocratic Redekammen type granite of which veins penetrate the diorite and its aplite margin. This behaviour indicates that after the intrusion of the net-veined diorites the Redekammen type granites were still in a less advanced stage of solidification than the older granites.

The fact that the net-veined diorites generally intruded granites which were practically dead demonstrates that the aplite cannot have been derived from the wall rock, but from lower levels in the crust. The occurrence of straight and practically vertical granite pipes in these diorite bodies suggests (Elwell, 1958) that the granitic material was available in the sheets before the consolidation of the diorite. For a full discussion of the origin of net-veins the reader is referred to Elwell *et al.* (1962) and Windley (1965).

Structures

In the area between Bredefjord and Igaliko Fjord the foliation and other planar elements have a predominant ENE-trend and are practically vertical. In some areas, for instance in the outer parts of Bredefjord, low-dipping attitudes are common. In several localities where gneisses and supracrustals are exposed folds with NW and NE trends could be distinguished. The observations are, however, too isolated to produce a coherent regional picture of the succession of deformation phases.

The intercalations of vertical units of gneiss and banded and veined gneiss in the south-east is dominated by ENE- to NNE-trending meso- and megascopic fairly tightly closed structures with subhorizontal axes and vertical axial planes. Whether the granite units are intrusive sheets parallel to the axial planes of the folds or thrust sheets is not known. However, the emplacement of the gneissose granite has evidently taken place at an early stage. Continued deformation has produced buckling of the early foliation about vertical axes (Windley, 1966b; Berrangé, 1966). The most important example of these buckling structures occurs south of Putoq.

GARDAR SUPRACRUSTALS, IGNEOUS ACTIVITY AND POST-GARDAR EVENTS

Eriksfjord Formation

After the cessation of the late Early Proterozoic plutonism South Greenland was subjected to denudation, faulting, deposition of red beds and lavas and development of alkaline intrusive centres. Between the Narssaq area and the inland ice towards the ENE, relics of a succession of red sandstones and lavas, the Eriksfjord Formation (Poulsen, 1964), have been preserved. They chiefly lie within an ENE-trending block bounded by faults. Most other occurrences are small and situated along the borders of alkaline intrusive bodies and dip inwards towards these bodies. It is thought that the preservation of this succession has been caused by subsidence above a deep-seated ENE-trending magma chamber between Tugtutôq in the WSW and the inland ice towards the ENE.

There are indications that the sedimentary basin once extended farther southwards. Xenoliths of basalt and in one case of sandstone occur in Gardar diatremes on Tugtutôq, Igdlutalik and Niaqornap nunâ (UPTON, 1962). Moreover, sandstone dykes have been found on the island Qingârssûp nunâ (SCHARBERT, 1963) and in two places on the peninsula east of Tunugdliarfik just north of the broad E–W trending valley of Kûgssuaq.

Type section (fig. 7, *top row*)

Although the 30 km long type section, situated between Mâjût and Ilímaussaq, lies partly outside the map area, a short description of the whole section will be given. The Eriksfjord Formation comprises six members; its total cumulative thickness is 3085 m.

Mâjût Sandstone Member. At the type locality, outside the map sheet, the basement granite is overlain by a basal conglomerate and arkose which pass upwards into bedded, red sandstone. Most or all of the Mâjût sandstone has been water-laid; cross-bedding and ripple marks and other structures indicating periodic emergence are abundant.

Mussartût Member. The lowest 420 m comprises three to four sills of columnar basalt which together are 70 m thick. These alternate with red sandstone in which continuous conglomerate layers are common. The basalts of the sills are aphyric and olivine-free except the uppermost sill which locally contains accessory olivine. The upper 300 m consists of an alternation of a series of basalt flows and sandstones with conglomerate layers and layers of sandy tuff which are red in colour.

Naujarssuit Sandstone Member. The lowest 100 m consists of soft, red sandstone and the uppermost 350 m of a hard, white quartzite. Most of this unit has probably been water-laid. Occasional ripple marks indicate that the basin was shallow. The upper part of the member is exposed on the Qeqertat islands, in a strip to the north-east along Tunugdliarfik, in an area a few kilometres due north of Qeqertat, and also just along the shore of Bredefjord north-west of Steenstrups Fjeld.

Ulukasik Volcanic Member. This member is 250 m thick and is made up of a succession of flows extruded in rapid succession in a sandy desert environment. The dominant rock type is a grey or purple weathering

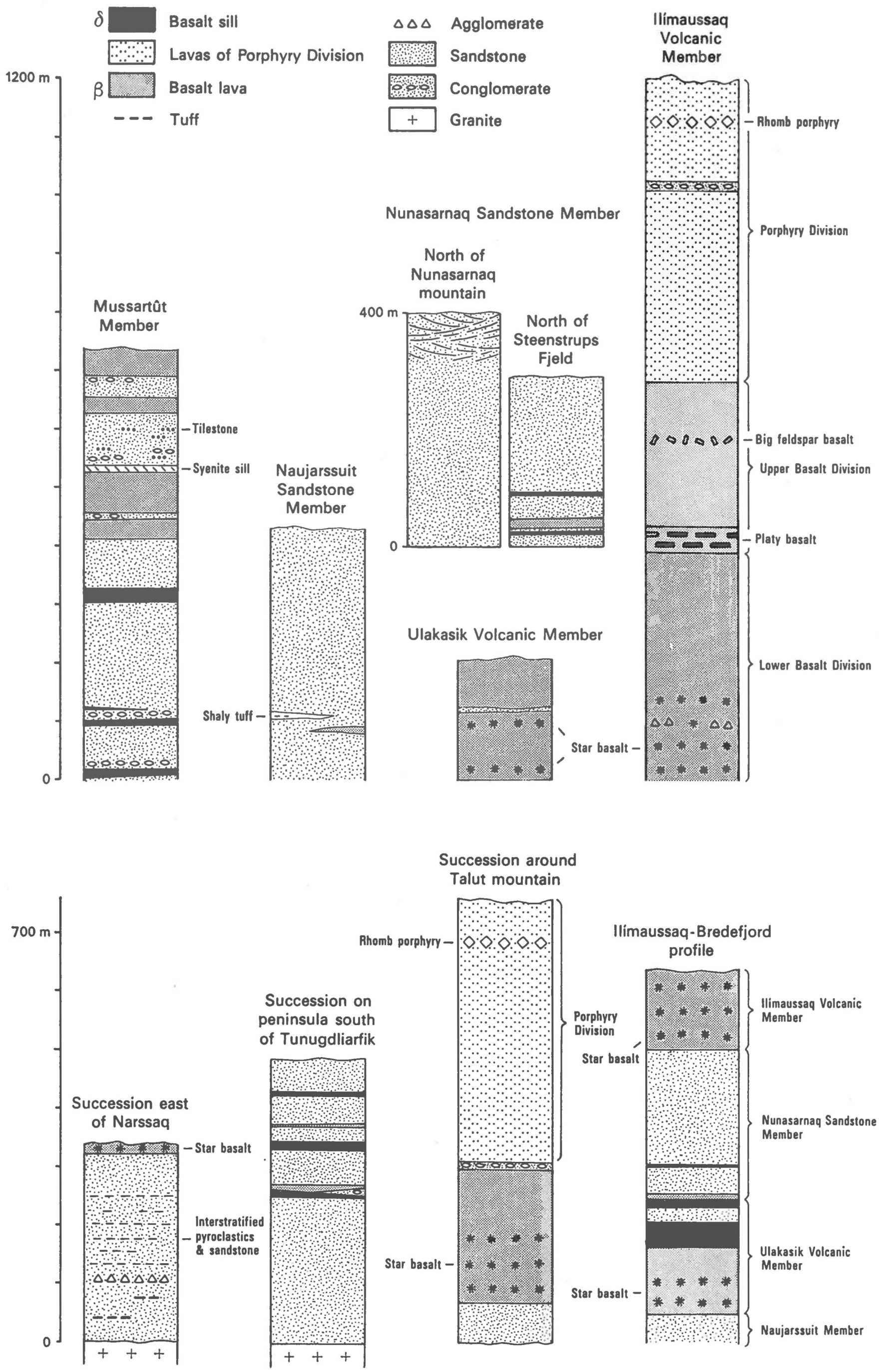

Fig. 7. Successions of the members of the Eriksfjord Formation. *Top row* at the type section ENE of Ilímaussaq (the oldest member—Mâjût Sandstone Member—is not given as it only consists of sandstone). *Bottom row* at other places than the type section. After J. W. STEWART, 1964.

Correction: Ulakasik should read Ulukasik.

olivine basalt. One variety is aphyric whilst the other contains distinctive stellate groups of thin, white laminar plagioclase phenocrysts ("star basalt", STEWART, 1964). Flow structures, including oxydised, corded surfaces and slaggy scoracious tops are frequently seen. Cavities in the scoracious flow tops are often filled with windblown sand. Thin sporadic intercalations of sandstone occur between flows and flow units. In the map area the member is exposed to the north-east of Nunasarnaq mountain, and in the cliff above Bredefjord, north-west of Steenstrups Fjeld, it forms a horizon about 200 m thick.

Nunasarnaq Sandstone Member. This member is 400 m thick east of Nunasarnaq but its thickness decreases to the west. Between Bredefjord and Steenstrups Fjeld it is 290 m thick of which 32 m is basalt.

In the upper fifth part of the sequence cross-bedding is well developed. It appears on such a large scale that wind action provides the only explanation. Relics of dunes have also been reported.

Ilímaussaq Volcanic Member. STEWART (1964) has shown that in the country east of Ilímaussaq the sequence consists entirely of extrusives in which flow follows flow in orderly succession for hundreds of metres. East of Ilímaussaq intrusion the Member is divided as follows from top to bottom:

Porphyry Division	350 m
Upper Basalt Division	290 m
Lower Basalt Division	390 m

The lowest third of the lower Basalt Division consists almost entirely of "star basalt", while the upper two thirds are largely aphyric. The lowest flow, or group of flows, of the Upper Basalt Division is of platy basalt, forming a horizon 40 to 50 m thick. It contains characteristically abundant, large, thin, tabular plagioclase phenocrysts with flow alignment. They are closely packed in a coarse granular matrix. The remainder of the Upper Basalt Division consists of aphyric or sub-porphyritic basalt flows. The Porphyry Division consists of basaltic and trachytic lavas. The latter are porphyritic to slightly porphyritic and pale grey or mauve in colour. Clastic horizons with an average thickness of 50 cm occur frequently.

Eriksfjord Formation around Nunasarnaussaq

Along Tunugdliarfik a basal conglomerate overlies the granite in some places. In many other places the lowest ten metres of sediment is an arkosic grit. It passes into a *c.* 200 m thick layer of bedded sandstone with occasional horizons of coarse conglomerate and is succeeded by about 100 m of rapidly alternating dark tuff and pale sandstone with regular stratification. The highest layer of tuff is followed by 70–80 m of tuff-free sandstone which is interrupted by a 10 m sill of aphyric basalt and overlain by a 20–60 m thick sill of olivine basalt which persists around the western side of Nunasarnaussaq mountain (USSING, 1912), wedging out at its south-western corner. The top of the series consists of a 90 m thick layer of extrusive basalt. The uppermost 20 m of this layer is made up of typical star basalt identical to the star basalt of the Ilímaussaq peninsula.

Eriksfjord Formation east of Narssaq (fig. 7, *bottom row*)

The granite east of Narssaq is successively overlain by an arkosic grit up to 10 m thick, a red-coloured, cross-bedded sandstone not more than 5 m thick and 90 m white sandstone which locally is purple or green with few thin, dark bands of fine volcanic ash.

About 100 m above the base of the Gardar series there is a bed, less than 5 m thick, of volcanic breccia with a black, fine-grained matrix and angular fragments of quartzite up to 0.5 m across. Probably this rock is similar to the lamprophyric rocks at Nunasarnaussaq. The breccia is succeeded by ultramafic pyroclastics which are exposed for several hundreds of metres, adjacent to the gabbro which intrudes them. Then follow finely banded tuffs with alternating pale green and black bands. Higher in the series quartzites occur which are overlain by fine-grained basic volcanic rocks and also a basalt which approaches star basalt.

Eriksfjord Formation on the peninsula south of Tunugdliarfik (fig. 7, *bottom row*)

The base of the Mâjût Sandstone Member is exposed due to tilting of blocks immediately north of the fault between the sandstones and the Julianehåb granite. A basal conglomerate has not been observed. On the tilted block (top 640 m) red and pink layers of several tens of metres alternate. The Mussartût Member is exposed near the margin of the sheet. Conglomerate layers contain many pebbles of chert. The thickness of the Mâjût and Mussartût Members in this area is less than $^2/_3$ of that at the type section.

Eriksfjord Formation around Talut (790 m) NE of Narssaq (fig. 7, *bottom row*)

In this area the rocks dip at 5° to the north-east. 70 m of sandstone is exposed along the fjord. This is successively overlain by a 140 m thick layer of "star basalt", a 100 m layer of fine-grained, grey, aphyric basalt and a 5 m layer of conglomerate. Then follow vesicular and fine-grained volcanics. Red coloured, porphyritic alkali-rich rocks of the Porphyry Division occur on the 600 m ridge overlooking Tunugdliarfik and in the river valley to the north-west. Rhomb porphyry is an important variety of the alkaline extrusives.

Eriksfjord Formation north and NW of the Ilímaussaq intrusion (fig. 7, *bottom row*)

The strata of the Eriksfjord Formation north of the Ilímaussaq intrusion are almost horizontal. The top of the Nunasarnaq Sandstone Member lies just below the 500 m contour east of Narssaq Fjeld and at the 550 m contour farther to the east. North of Steenstrups Fjeld the base of this Member is at an altitude of 250 m. The Ulukasik Volcanic Member is exposed lower down on the slope of Steenstrups Fjeld and its base reaches sea level about 0.5 km below the top margin of the sheet. The uppermost part of the Naujarssuit Member is also exposed at sea level. The Nunasarnaq Sandstone Member is overlain by "star basalt" of the Ilímaussaq Volcanic Member. On the western side of Steenstrups Fjeld a platy basalt horizon occurs. Other intercalations of this type have been found immediately south of lake 455 m, and on the eastern side of Narssaq Fjeld. South of Narssaq Fjeld (705 m) alkaline rocks of the Porphyry Division, at least 175 m thick, overlie the lavas of the Upper Basalt Division.

Volcanics in the roof zone of the Ilímaussaq intrusion

There are isolated areas of metamorphosed volcanic rocks on the mountain Nákâlâq (1334m) and on the hill 1185 m high to its south-west. These are thought to be relics of the original roof of the Ilímaussaq intrusion. They consist of rhomb porphyry and other varieties of alkali-rich rocks and belong to the Porphyry Division, but seem to represent a stratigraphical level which is higher than the succession on the eastern margin of the intrusion. According to STEWART (1964) these outliers have subsided 300 to 400 m relative to the strata in the country north and east of the intrusion.

Gardar igneous activity

The Gardar intrusions form a suite of basic to alkaline dykes and intrusive centres which will be treated in chronological order (see table 1).

Early dolerites

Between Qaersuarssuk and Kingigtoq there is a 10 km wide swarm of ESE-trending dolerites of varying widths. East of Kingigtoq the

Table 1. *Chronology of South Greenland*

			Events and rocks	Ages (m.y.)
PHANERO-ZOIC			NW–SE dolerites Camptonitic sills	242 (K/Ar wr)
PROTEROZOIC	Middle	Gardar	Ilímaussaq intrusion Tugtutôq central complex Narssaq intrusion (syenite & granite) ENE alkaline dykes (main part) Gabbro giant dykes Hviddal composite dyke Early dolerites (WNW–ESE) Eriksfjord Formation	1180 ± 37 (Rb/Sr wr) 1187 ± 9 (Rb/Sr wr)
PROTEROZOIC	Early	Ketilidian	Late granitic intrusions (reactivation) & appinitic intrusions *Sanerutian* Regional metamorphism, deformation & generation of early granites *main Ketilidian* Sediments and volcanics? dyking?	1776 ± 37 (Rb/Sr wr)
PROTEROZOIC	Early		Older basement?	

northern and southern components of the swarms start diverging whilst their trends gradually change to E–W and eventually to ENE. To the west and east of the Ilímaussaq peninsula several 50 to 120 m wide dykes form a swarm a little less than 10 km wide. To the north-west of the peninsula the dykes trend NW to WNW, but to the east the trends average E–W. This swarm exhibits the same kind of variation in trend as the swarm described above.

The rocks consist of an ophitic to subophitic aggregate of plagioclase, clinopyroxene, generally altered olivine and ilmenomagnetite. Thinner dykes often show a granular texture. Small quantities of quartz are widespread. Locally there are 2–3 cm long plagioclase phenocrysts. Here and there lenses of coarse pegmatitic material occur.

As a rule the country rock granite is red coloured up to 25 m from the dyke contacts. In the marginal phase and in the country rock granite, shear and mylonite zones of 0.5–1 m are common parallel to the contacts. Quartz veining is widespread both in and adjacent to the dykes. Veins and joint fillings of calcite, often with fluorite, are especially abundant in the dykes to the east and west of the Ilímaussaq peninsula.

Hviddal composite giant dyke

A large ENE-trending dyke crosses central and eastern Tugtutôq for a distance of about 22 km. Its width varies between 350 and 700 m and averages 500 m. The dyke has a broad central component of syenitic rock and margins of gabbroic rock 50–100 m wide. The western half of the dyke consists of slightly undersaturated ferroaugite-bearing syenite and the eastern half of strongly undersaturated nepheline syenites.

The marginal syenogabbro displays a moderately well chilled contact facies against the earlier granite. Towards the syenogabbro the central syenites do not develop a fine-grained facies but they become more and more pegmatitic whereas the transitional zone consists of hybridised gabbroic rocks cut by veins of syenite pegmatite. These relations suggest (UPTON, 1964c) that the dyke was formed as a result of two closely spaced intrusions. The first formed a gabbroic dyke 100–200 m wide which was split down its centre by the intrusion of a syenite magma. The hybridisation, the absence of chilling of the gabbro towards the syenite and the constant width of the gabbroic marginal zones can be explained by intrusion of the syenitic magma before the gabbro was completely solidified. This would imply that deeper in the crust or in the mantle two magmas of different composition have been available when the Hviddal composite dyke was intruded.

The syenogabbro is even grained, hypidiomorphic-granular and sometimes ophitic. It consists of plagioclase (An_{57-32}) and alkali feldspar, olivine (Fa_{54-64}), ilmenomagnetite, clinopyroxene, biotite and apatite. The grain size does not exceed 4 mm. Occasional weakly developed melanocratic banding can be seen dipping inwards from the dyke walls towards the central nepheline syenites.

A Rb-Sr whole rock isochron of the Hviddal dyke gave 1187 ± 9 m.y. (VAN BREEMEN & UPTON, 1972).

ENE-trending dolerites and giant gabbro dykes

The dykes of this group are not as abundant as in the Nunarssuit and Ivigtut regions. Only north-east of Skovfjord do ENE-trending dolerites occur regularly, and generally they occupy less than 1–2 $^0/_0$ of the area. Their width is generally less than 20 m. The most important dyke in the north-western part of the sheet area is 72 m broad. Its width decreases towards the north-east. The total cumulative width of all recorded ENE dolerites north-east of Bredefjord is less than 170 m.

On Tugtutôq there is an ENE-trending system of two giant dykes with mainly vertical contacts. Towards the ENE the dykes broaden and coalesce when approaching Narssaq.

The thinner dykes are generally parallel-sided bodies. The giant dykes on Tugtutôq show abrupt changes in width and some of the branches terminate bluntly against old joint systems in the surrounding granite. Such features are difficult to explain by dilation of the wall rocks alone.

Fine-grained chilled margins occur up to a few centimetres wide in thinner dykes and up to one metre wide in the giant dykes. Back veining from the granite has occasionally been observed on a small scale. In Tugtutôq there is only very slight melting of the wall rocks of the giant dykes.

Vertical mineral banding occurs occasionally on Qaersuarssuk and Tugtutôq. In the southern giant dyke system, rhythmic layering and/or feldspar lamination define synformal structures within the dykes. These persist for only a few kilometres with the laminated or layered rocks grading into massive gabbro.

The dyke of Qaersuarssuk (WATT, 1968) is medium to coarse grained and has a doleritic to sub-doleritic texture with 74 % plagioclase (labradorite), 9 % olivine (Fa_{49-38}), 6 % pyroxene (mean composition $Ca_{40}Mg_{29}Fe_{31}$), 6 % ilmenite, 3 % biotite and apatite as an accessory.

In the gabbro giant dyke system (UPTON, 1964b) the typical rocks contain 60–70 % calcic labradorite with local rims of alkali feldspar. Occasional patches of micaceous material might be pseudomorphs after nepheline. Olivine (Fa_{32-55}) comprises 15–30 % of the rock. Interstitial titanaugite varies in quantity between 12 and less than 1 %. Lepidomelane forms reaction rims around ilmenomagnetite.

In east Tugtutôq, immediately west of the constriction in the northern giant dyke, east of Krydssø, a lenticular body of syenogabbro occupies the central part of the dyke. This body is interpreted as a separate intrusion into the cooling gabbro. About 60 % of the rock consists of feldspar. The rest consists of clinopyroxene, iron-rich olivine, ilmenomagnetite and some apatite. Poorly-defined olivine-rich bands within the syenogabbro define a shallow synformal structure.

ENE-trending intermediate and alkaline dykes

Trachydolerites, saturated and undersaturated microsyenites and alkali micrograntic (comendite) dykes are common in the area between Igaliko Fjord and the north-eastern corner of the sheet area. Their width is generally not more than 15 m. The greatest concentrations occur on Tugtutôq and along the northern side of Ilímaussaq peninsula. They have been emplaced over a considerable period of time, but most of them post-date the giant gabbros and are earlier than the Ilímaussaq intrusion and the latest phase of WNW to E–W faulting in the area. There is great variation in textures in the dykes. The most conspicuous types are the plagioclase xenocryst dykes (BRIDGWATER & HARRY, 1968), with trachydoleritic centres and trachytic margins. They contain great amounts of anorthosite inclusions and giant xenocrysts of basic plagioclase. These dykes are well represented in the main dyke concentration on Tugtutôq and the Ilímaussaq peninsula. Quartz syenites and alkali microgranites only occur on Tugtutôq (UPTON, 1964a), while farther away at both sides of the main concentration just-saturated and undersaturated dykes are represented (WATT, 1968; ALLAART, 1969).

Narssaq intrusion

The Narssaq intrusion consists of three main phases, gabbro, syenite and granite. These originated in a magma chamber deeper in the crust and were intruded in quick succession.

Gabbros and associated intrusives. The Narssaq gabbro constitutes the continuation of the gabbro giant dyke system on Tugtutôq and is thought to represent a higher erosional level than that of the giant dykes. The gabbro is chiefly covered by gravel devoid of vegetation. Feldspar commonly defines a low-dipping lamination. Layering occurs in the vicinity of the peninsula Nûgârmiut; it trends E–W and dips at low or moderate angles towards the original centre of the complex in the north which is now occupied by the later phases of the intrusion. The contact of the gabbro is vertical against the basement granite at Narssaq, whilst it is inclined and transgressive against the overlying sandstones of the Eriksfjord Formation until it follows the contact of an agglomerate horizon.

Around the Narssaq intrusion several bodies of feldsparphyric olivine gabbro have been recorded and most of these are considered to be sills intruded into the continental series. The rocks are medium to coarse grained and contain platy plagioclase phenocrysts which often show lamination. Here and there mineral layering occurs. The body of Talut mountain, north-east of Narssaq is anorthositic in composition. The others are more mafic.

Syenites. The gabbroic rocks are intruded by saturated to oversaturated syenites. In the lowlands between Narssaq and the bay east of Nûgârmiut a creamy coloured, *just saturated syenite* is exposed. The rock is coarse grained and is made up of an aggregate of alkali feldspar crystals 1–1.5 cm long, with interstitial hornblende, pyroxene and biotite.

Quartz syenite. In the north-western part of the intrusion small amounts of quartz are present in the rock which is aphyric. South-west of Narssaq Fjeld (705 m) a pegmatitic variety is exposed. Along Bredefjord coast and the bay south-east of Nûngmiut a variety occurs in which traces of mineral layering are widespread.

A variety of *porphyritic pyroxene syenite* is widespread in the south-eastern and in the northern parts of the intrusion. Phenocrysts of alkali feldspar occur in a fine-grained matrix of feldspar and dark minerals. The proportion of phenocrysts to matrix is variable.

Contacts between the different varieties are generally regular and abrupt. Indications of chilling of one variety against the other or of one veining the other have not been observed.

Alkali granite. North of the great cross-cutting fault the commonest variety is a cream coloured, medium- to coarse-grained rock with a euhedral-granular texture. Main constituents are microcline-perthite, arfvedsonite and quartz. Porphyritic texture is only developed in an area 2 km due east of Nûngmiut.

Along the NNW-trending contact between granite and syenite just south of the great cross-cutting fault no chilling features have been observed. These relations might indicate that the granite was intruded when the syenite was still hot. However, at several localities the alkali granite shows a clearly intrusive character against all the syenite varieties.

Tugtutôq central complex

The intrusives of the Tugtutôq central complex (Upton, 1964a) cut through the Hviddal giant dyke, the northern giant gabbro dyke and the later ENE alkaline dykes. A few generations of these alkaline dykes cross-cut the Narssaq intrusion to the north-east. Together with the Ilímaussaq intrusion the central complex of Tugtutôq constitute the youngest major intrusions in the region. A Rb-Sr whole rock isochron of the central complex gave 1180 ± 37 m.y. (van Breemen & Upton, 1972).

The first phase of intrusion (unit 1) is represented by two ring dykes of microsyenite. One of about 600 m diameter in the south-west and a second of 2 km diameter of which only two arcuate outcrops have been preserved more or less centrally arranged in the eastern centre. These outcrops are not indicated on the map.

Eastern centre. Four further episodes of roof fracturing and block subsidence have taken place in quick succession around the southern part of Store Pilesø. Unit 2, consisting of strongly xenolithic quartz syenite, forms a central plug. The syenite contains a large amount of foreign inclusions. In the western and north-western parts of the unit these consist of two types of country rock granite, i.e. the Big-feldspar granite and the aplite granite. In the south-east the inclusions are of basalt, basic agglomerate and quartzite of the Eriksfjord Formation, and of olivine gabbro and porphyritic syenite. This was quickly followed by the intrusion of unit 3 which almost surrounds unit 2. Before these units were fully consolidated an outer ring dyke, unit 4, was intruded slightly excentric to the two earlier ones. No chilled internal contacts occur between these three units but often pegmatitic development. Finally a narrow ring dyke of quartz syenite (unit 5), several metres wide, was intruded and intersected units 3 and 4. The successive intrusions of the eastern centre contain an increasing amount of low-temperature minerals.

The Blå Månesø centre (unit 6). This is a subcircular intrusion, 1.5 km in diameter, which occurs around Blå Månesø. It consists almost completely of feldspar with interstitial biotite, soda amphibole, aegirine, magnetite and quartz. This perthosite is coarse grained and shows a variable texture. In the medium- to coarse-grained syenite spherical pegmatite masses with large bluish grey feldspars are abundantly developed. The observations have shown that the relatively fine-grained facies of this unit represents an original texture and the pegmatitic facies originated by recrystallisation of the syenite at lower magmatic temperatures.

Ilímaussaq intrusion

For an account of research on the Ilímaussaq intrusion the reader is referred to an historical outline written by H. SØRENSEN (1967). The most important information is presented in USSING (1912), H. SØRENSEN (1958), FERGUSON (1964), HAMILTON (1964), H. SØRENSEN *et al.* (1969), FERGUSON (1970) and BOHSE *et al.* (1971).

The intrusion comprises a series of conformable, saucer-shaped sheets of alkali granite and syenites overlying four varieties of agpaitic syenites (for definition see H. SØRENSEN, 1970 and for mineralogical compositions table 2) enclosed by an envelope of augite syenite. Conspicuous minerals include steenstrupine, astrophyllite, tugtupite, chkalovite, Li-mica, neptunite, pyrochlore, sørensenite and ussingite.

Augite syenite. South of Tunugdliarfik the augite syenite forms an almost continuous marginal envelope with a vertical or steeply outward dipping attitude. North of the fjord it occurs south and just east of lake Taseq. On Kvanefjeld inclusions of augite syenite occur in an 800 m broad zone of lujavrite along the contact of the intrusion. In the north-central part of the intrusion a conformable sheet of augite syenite is overlain by a sheet of quartz syenite and partly underlain by sheets of quartz syenite and alkali granite (see fig. 8).

Against the Julianehåb granite and the supracrustals of the Eriksfjord Formation a fine-grained marginal facies 3–10 m wide is developed in the augite syenite.

Table 2. *Mineralogical compositions of the members of the Ilímaussaq intrusion* (after FERGUSON, 1964)

	Feldspar	Nepheline	Sodalite	Quartz	Olivine	Pyroxene	Arfvedsonite	Biotite	Aenigmatite	Eudialyte	Magnetite	Apatite
Augite syenite	75 (crypto-perthite)				5	10 (Aug. + aeg. aug.)		3			5	2
Augite syenite chill	65 (crypto-perthite)				10	15 (Aug. + aeg. aug.)		2			8	1
Alkali granite	70 (perthite)			15		1 (aegirine)	12		2			
Quartz syenite	60–75 (perthite)			0-15		10 (soda pyr.)	5					
Pulaskite	70 (anti-perthite)	7				12 (aegirine)	5		5			
Naujaite	23	14	39			20 (mafics)				4		
Kakortokite (white)	50	18				9	13			10		
Kakortokite (red)	36	17				6	12			29		
Kakortokite (black)	18	18				13 (aegirine)	40			11		
Lujavrite (black)	18 (microcline) 13 (albite)	24	1			5 (aegirine)	30			9		
Lujavrite (green)	25 (microcline) 15 (albite)	13	1			28 (aegirine)	8			10		

The rock has a reddish brown weathering colour. It is medium to coarse grained and equigranular. Nepheline does not occur in the chill facies, but does occur farther from the contact (for mineralogical composition see table 2). Locally mineral banding is developed, generally close to the outer contact. Dips are always inward and steep averaging 60°.

Alkali granite. In the central part of the northern half of the intrusion two conformable sheets less than 100 m thick of alkali granite (table 2) occur, one above and another below the sheet of augite syenite (see fig. 8). South of Tunugdliarfik two very small bodies of alkali granite a few metres in diameter occur in the blankets of heterogeneous syenite (colour symbol λ) north-east of Nunasarnaussaq.

The rock is non-porphyritic, without preferred orientation of the minerals and with a subhedral texture. On fresh surfaces the medium-grained granite is light green.

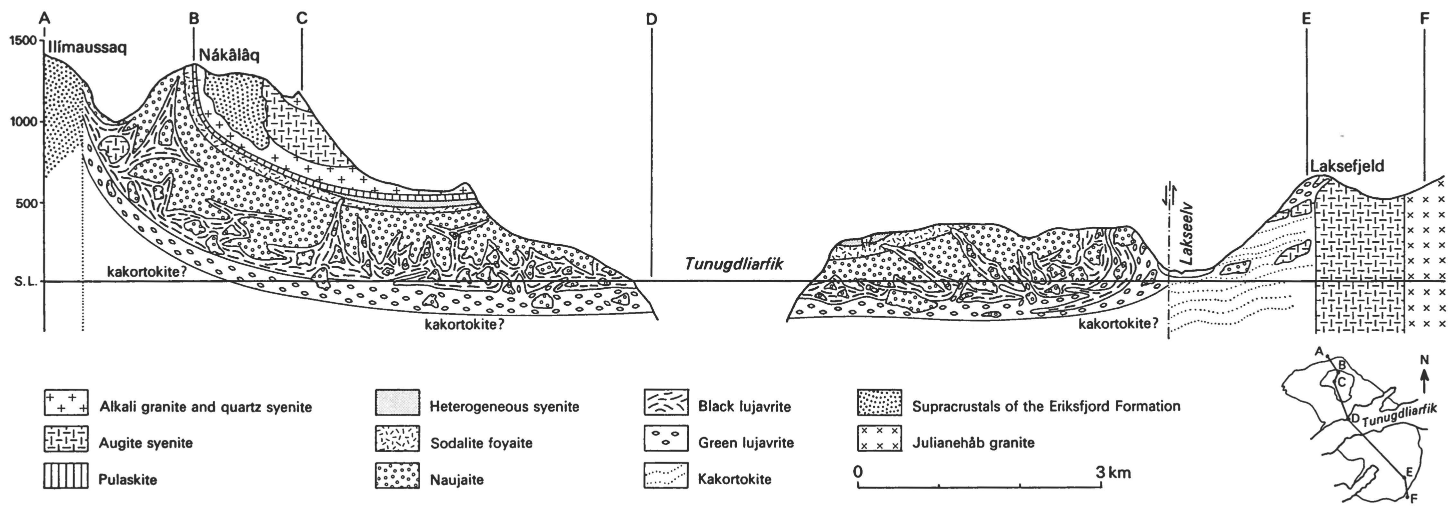

Fig. 8. Profile across the Ilímaussaq intrusion, slightly modified after Ferguson, 1964, plate 1.

Transition series. (USSING, 1912, p. 80). To the north of Tunugdliarfik, south of Nákâlâq peak the lower sheet of alkali granite (see fig. 8) grades downward successively into quartz syenite, pulaskite and heterogeneous syenite (see table 2). The transition of the alkali granite to the 5–10 m thick sheet of quartz syenite is gradual. The granite and syenite are very similar in the field. The quartz syenite grades downwards into a 10–30 m sheet of pulaskite. The texture of the syenite and pulaskite is similar but the former is green and the latter grey. The pulaskite in turn grades into sodalite foyaite, one of the agpaitic members of the Ilímaussaq intrusion.

Another occurrence of the sheets of the transition series overlying sodalite foyaite is situated 600 m south of Taseq. These are together indicated as just saturated syenite (λ). The sheets are only a few metres thick and consist of an upward succession of sodalite foyaite, heterogeneous syenite, pulaskite (15 m thick) and quartz syenite. There is no alkali granite. The sheets form a NNW-trending synclinal structure.

In three places south of Tunugdliarfik the heterogeneous syenite forms blankets overlying the sodalite foyaite. The pulaskite and quartz syenite form small separate bodies with vertical and conformable relations to the heterogeneous syenite.

Agpaitic rocks. The agpaitic members comprise 75 % of the exposed area of the intrusion. Two of these are thought to have crystallised from the roof downwards while the lowest member, the kakortokite, crystallised contemporaneously from the bottom of the magma chamber upwards. Eventually a lujavritic rest magma was trapped between the naujaites and kakortokites and was intruded into the overlying naujaites.

Sodalite foyaite. In all three occurrences the sodalite foyaite forms a sheet that overlies the naujaites. The largest occurrence underlies the transition series in the northern half of the intrusion south of Nákâlâq. It averages 18 m with a maximum thickness of 100 m. The second occurrence is situated between the fjords Tunugdliarfik and Kangerdluarssuk where it is only overlain by the heterogeneous syenite. The sheet generally dips 15° north. FERGUSON (1970, p. 24) estimated the maximum thickness of the sheet as 120 m with an average of 40 m. The smallest occurrence is found south of Taseq where a 0–20 m thick sheet underlies an elliptical area of rocks of the transitional series. According to USSING (1912, p. 68) and FERGUSON (1970, p. 24) the sodalite foyaite originally formed a continuous basin-shaped sheet (see fig. 8).

This coarse-grained rock is grey in colour. Randomly oriented microperthitic feldspar tablets, up to 2 cm in length, are the most conspicuous

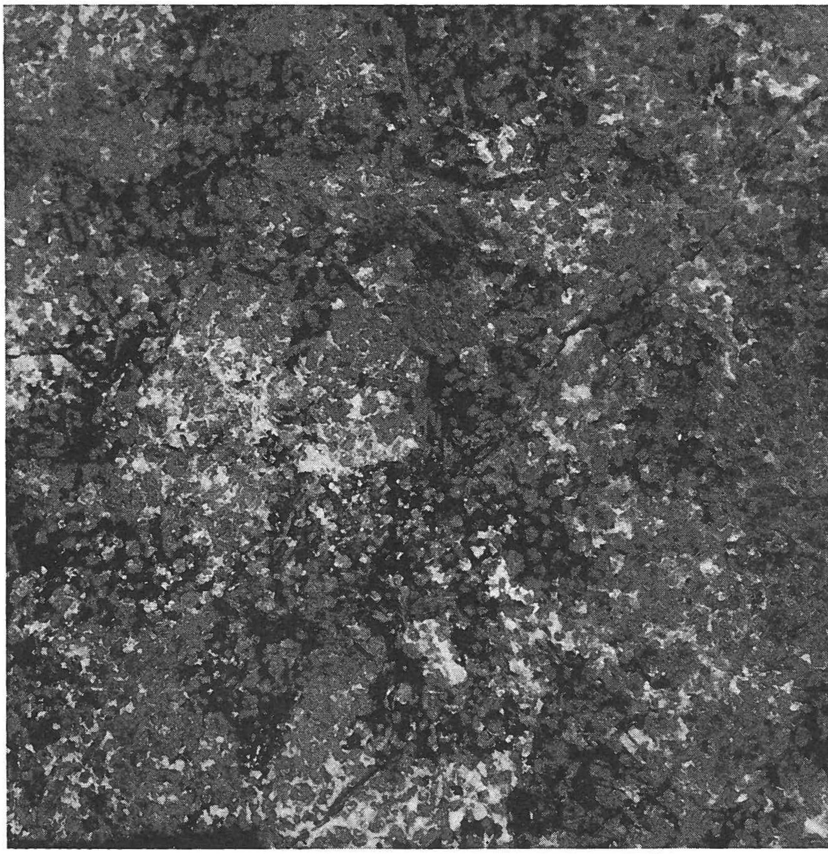

Fig. 9. Naujaite with typical poikilitic texture, approx. scale 1:2. Photo: J. FERGUSON.

constituents. The space between the tablets is occupied by sodalite, nepheline, hedenbergitic to acmitic pyroxene, arfvedsonite and eudialyte which is often abundant.

Naujaite. The naujaite constitutes the most conspicuous member of the intrusion (USSING, 1912, p. 143) and underlies the sodalite foyaite. Of all units it has the widest distribution. The probable sheet-like nature of the naujaite body is obscured by the lujavrites which brecciate and intrude the lower parts of the naujaite body. The brecciation of the naujaite by lujavrite is well exposed along the northern margin of the intrusion at Kvanefjeld, on the peninsula of Nunasarnaq and north of Lakseelv. FERGUSON (1970, p. 25) estimated the thickness of the naujaite layer at 600 to 800 m.

The rock (see table 2) is very coarse grained and shows a characteristic poikilitic texture (fig. 9). Very large megacrysts of feldspar, arfved-

Fig. 10. Layering in kakortokites with zone of inclusions which compress the layers due to their weight. Photo: F. L. JACOBSEN.

sonite, aegirine and eudialyte enclose sodalite crystals 2–3 mm in diameter. Nepheline makes up rectangular phenocrysts 0.5–1 cm in size. Accessories include aenigmatite, schizolite, rinkite, Li-mica, britholite and astrophyllite.

Kakortokites. The kakortokites, which form a series 400 m thick are only exposed in the southernmost part of the intrusion and they probably represent its deepest accessible parts (H. SØRENSEN, 1958, p. 32; FERGUSON & PULVERTAFT, 1963, p. 16). Layering is the most characteristic feature of these rocks (fig. 10). It is expressed by the rhythmic mineralogical variations of arfvedsonite, eudialyte and feldspar–nepheline respectively which in ascending order produce units of a black, red and white layer (see table 2). Occasionally any of the layers of a unit but most often the red layers may be absent. BOHSE *et al.* (1971) counted and mapped 29 major rhythmic units. The layering is weakly undulating.

Previous workers have reported the occurrence of large inclusions of augite syenite and naujaite in the kakortokites. BOHSE *et al.* (1971) have shown that these inclusions are almost entirely confined to a single horizon, about halfway down the exposed succession. The inclusions are therefore interpreted as representing a single stage of large-scale roof collapse. This is good evidence in favour of the thesis that the naujaites and kakortokites crystallised contemporaneously at different levels of the same agpaitic magma chamber.

Between the kakortokites and the marginal augite syenite a 50 m wide zone of agpaitic pegmatite occurs (FERGUSON, 1964). This rock has the same mineralogical composition as the kakortokites, but is extremely heterogeneous. At about 50–100 m from the contact with the pegmatite the typical kakortokite layering becomes indistinct.

Concentrations of Zr and associated Nb occur in the red bands and in the marginal pegmatite in the mineral eudialyte.

Lujavrites. These rocks form a zone of variable thickness. In this zone the black lujavrites occupy the upper part and the green lujavrites the lower part (fig. 8). The relations can be best studied in the area east and west of Lakseelv, the main area of occurrence of the lujavrites. Here the black lujavrites which occupy the structurally higher position, occur north-west of Lakseelv, between Kangerdluarssuk and Agpat, while the green lujavrites are exposed south-east of Lakseelv and west of Agpat. The upper part of the lujavrite zone forms an intrusion breccia and contains numerous blocks of overlying units and of the country rocks: these are naujaite around Lakseelv, but augite syenite and volcanic and anorthositic country rocks in the lujavrites along the margins of the intrusion.

Along the boundary between the lower green and the higher black lujavrites compositional banding is concentrated in a mixed zone of approximately 50 m thickness.

The lujavrites show a pronounced mineral orientation (fig. 11) and have crystallised under stress conditions. The black and green lujavrites have a very similar habit. They are fine to medium grained. The green lujavrites are rich in aegirine; the black lujavrites are rich in arfvedsonite.

Rare earths and U and Th are concentrated in the lujavrites occurring in steenstrupine, eudialyte, monazite, thorite and radioactive pigment. The lujavrites around Kvanefjeld are more radioactive than those of the southern half of the intrusion (P. SØRENSEN, 1971).

Late hydrothermal activity associated with the lujavrites is strongly developed in the Kvanefjeld area and north-west of Taseq and has caused concentration of several economically important elements. High concentrations of U, Th and rare earths occur, (1) along contacts between lujavrites and contact-metamorphosed Gardar lavas, (2) in places where the lujavrites are cut by hydrothermal veins which contain analcime, steenstrupine, and monazite. Concentrations of niobium occur, (1) in analcime veins associated with medium- to coarse-grained lujavrites; these contain pyrochlore and epistolite, (2) in sheared country rock and augite syenite. Beryllium mineralisation occurs in, (1) albite-natrolite

Fig. 11. Fissile lujavrite folded around naujaite block. Photo: J. Ferguson.

veins mainly with beryllium minerals chkalovite and tugtupite, cutting augite syenite and naujaite, (2) analcime veins with sørensenite as most common beryllium mineral, cross-cutting lujavrite.

Petrogenesis. The Ilímaussaq intrusion occurs in a place where important ENE, E–W, ESE trending faults and an ENE-trending dyke zone intersect. Ussing (1912) provided evidence that block subsidence has been important during the intrusion and Ferguson (1970, p. 118) concluded that it took place by ring dyking and cauldron subsidence.

Ferguson's interpretation about the development of the intrusion is as follows. The original magma is represented by chilled augite syenite, a just-saturated magma, which differentiated inwards and from the roof and margins following an undersaturated trend to produce the heterogeneous syenite. Contemporaneously an intrusion of two horizons of alkali granite occurred in the roof, one above and another below the augite syenite. Along the contacts of the granite reaction took place with the augite syenite and its differentiates to produce hybrid rocks: quartz syenite and pulaskite.

This was followed by further undersaturated differentiation and concentration of volatiles in the inner parts of the chamber with the production of the agpaitic rocks. The sodalite foyaites, just below the sheet of heterogeneous syenite, and the naujaites successively crystallised downwards from the roof of the magma chamber. In the naujaites the cumulus sodalite crystals floated in the magma and were trapped in a downwards crystallising rock. The kakortokites crystallised simultaneously with the naujaites as a bottom accumulation. The origin of the layering in the kakortokites is still an open question (BOHSE *et al.* 1971, p. 19; H. SØRENSEN, 1969) but it might be analogous to that found in many intrusions of basic composition.

Finally, a volatile-rich rest magma was caught between the naujaites above and the kakortokites below. As a result of slumping and faulting (FERGUSON, 1970, p. 129) or by subsidence (of the roof of the magma chamber) which reached its maximum beneath the central part of the intrusion (USSING, 1912, p. 322), an intrusion breccia was formed with the naujaites, augite syenite and locally the country rocks.

The naujaites and part of the roof rocks of the intrusion subsequently underwent hydrothermal alteration and were invaded by hydrothermal veins. This hydrothermal activity originated from a volatile phase squeezed out during the late stages of solidification of the lujavrites. These contain the highest concentrations of U, Th, Nb, Be and rare earths.

Faulting

The main faults trend between NW and NNW and between E–W and WNW. The most pronounced topographical direction expressed by the ENE-trending fjords is parallel to the general foliation direction of the gneisses and granites. However, no important faults with this trend have been detected.

During the Gardar period an early episode of dyke intrusion producing at least two generations of dolerites with ESE directions was followed by repeated ENE dyking which produced dykes with a great range of compositions. In the map area there is no evidence of faulting before the intrusion of the ESE dolerites. However, in the Ivigtut region to the north-west, ESE faulting was shown (HENRIKSEN, 1960) to occur in pre-Gardar time. It is therefore possible that at least some of the early dolerites were intruded along pre-existing WNW faults. In the Qaersuarssuk area WATT (1968) has shown that the early dolerites were followed by repeated wrench faulting along NNW and WNW trends alternating with repeated ENE dyking. The latest movements took place along the WNW faults which displace the giant gabbro dykes and most of the ENE alkaline dykes on Tugtutôq and also the Narssaq intrusion.

The faults of the map area appear to be wrench faults. However, as the only markers in most of the area are vertical dykes it is impossible to estimate the vertical components of displacement except in the northern part of the area where flat-lying Gardar rocks occur. On the Ilímaussaq peninsula east of the Ilímaussaq intrusion members of the Eriksfjord Formation are fairly constant in thickness. The strata dip at 10° or less to the south and it appears that the block has been tilted around an E–W axis with the Ilímaussaq intrusion situated in the place of maximum downward movement. Just east of the intrusion the Ilímaussaq Volcanic Member is underlain by a 1000–2000 m thick pile of volcanics and sandstones. This suggests a downward movement of at least 1000 m of the tilting block. Petrographic investigations (Upton, 1964b, c) of the Hvid-dal composite dyke and the gabbro giant dykes of Tugtutôq suggest that these 20–30 km long dyke systems have been tilted along their own axes some 5° to the ENE. The axis of tilting would in this case trend NNW. However, the present erosion level of this southern tilted block lies at a deeper crustal level than that east of Ilímaussaq. This is in accordance with the observed fault displacements along the southern side of the area of sandstones and volcanics. The southern side of the southern border fault between sandstone and granite east of Tunugdliarfik shows an upthrow of 800 m (Stewart, 1964). On the north side of Tunugdliarfik, between Talut mountain and Tunugdliarfik, the Basalt Division is 400 m thinner than in the type section north-east of the Ilímaussaq intrusion. This suggests an upward movement in relation to the deposits in the north-east. There is a concealed fault, with a trend between E–W and NW–SE, separating the sandstones east of Narssaq from the volcanics south-east of Talut. Its southern side is uplifted by *c.* 2000 m (Stewart, 1964).

When one traces the early dolerites and the WNW faults from west to east it appears that their trends gradually rotate anti-clockwise from WNW to almost ENE. Observations in the eastern part of the sheet area show that other fault directions have also undergone anti-clockwise rotation and it seems clear that the stress fields in the eastern and western parts of the sheet during most of the Gardar period had different orientations. It is also possible that there is a connection between this variation in stress fields and the tilting of blocks around the Ilímaussaq intrusion. This can be best illustrated in the swarm of early dolerites on Qaersuarssuk. The dykes diverge when traced eastwards and each successively more southerly dyke shifts its trend from WNW to ESE in a place which is situated in the prolongation of the NW–SE axis of the Ilímaussaq intrusion.

Post-Gardar igneous activity

Camptonitic sills

In the area between Bredefjord, Akia and Qôrnua there are several basic sills generally less than 4 m thick. These are often continuous and have gently undulating courses. They post-date the giant dykes, the central complex of Tugtutôq and the ENE-trending alkaline dykes and appear to be one of the latest generations in the area (UPTON, 1965). A K/Ar whole rock age determination of a sill of this group at Mathæus Havn (BRIDGWATER, 1970) gave an age of 212 ± 5 m.y. The sills are cut by dykes of the Mesozoic coast-parallel dolerite swarm (WATT, 1969) (described below). The rocks consist of camptonitic dolerite and contain strongly zoned plagioclase ($An_{56\text{-}47}$) with alkali feldspar rims, brown hornblende with relics of zoned titanaugite, completely pseudomorphosed olivine, ilmenomagnetite with biotite fringes and accessorial apatite. Banding, marked by variation in grain size is common especially in the upper parts of the sills. In the central parts of the sheets layers occur mainly consisting of oligoclase and hornblende with concentrations of ocelli comprising analcite calcite and zeolites. The sills are thought (UPTON, 1965), to have crystallised against the floor and roof zones from a CO_2 and H_2O rich camptonitic magma whilst the ocelli-rich layers represent the later magma fraction.

NW–SE dolerite dykes

The final episode of dyke intrusion produced numerous dolerites in the southern part of the map sheet. Between Qaersuarssuk and Kingigtoq the dykes trend ESE and between the Julianehåb peninsula and the south-eastern corner of the sheet they trend SE to SSE. The dykes are generally between 5 and 15 m wide but occur up to 40 m wide. They are vertical or dip steeply towards the ocean. The dykes often show a characteristic flow banding parallel to the walls and a well developed columnar jointing normal to this direction. The dolerites consist of strongly zoned plagioclase ($An_{56\text{-}17}$) which crystallised in two generations, titaniferous augite, largely altered olivine ($Fa_{55\text{-}42}$), biotite and ilmenomagnetite. Ovoids filled with zeolites and discontinuous carbonate veins occur in the centres of some dykes.

ECONOMIC GEOLOGY

Copper. On the island Karrarmiut (Frederik VII mine), east of Julianehåb, a small copper deposit was discovered early in the 19th century (BALL, 1922). Bornite, chalcocite and secondary malachite and azurite were found in quartz veins in an E–W trending crush zone. In 1851 when the deposit was exhausted about 15 tons of ore had been recovered.

Small occasional occurrences of bornite and associated secondary minerals were found in crush zones, for instance in the gneisses along the northern shore of Torssukátak fjord.

Fluorine mineralisation is very common in the Gardar intrusions. It is generally of late hydrothermal origin. The water soluble fluor mineral villiaumite (NaF) has been found in large amounts in drill cores in the Ilímaussaq intrusion mainly in the lujavrites. This intrusion is also extremely rich in chlorine. Fluorite is common in the lavas of the Basalt Division which surround and cap the intrusion and also in faults east and west of it.

Mineralisations of *uranium*, *thorium*, *zirconium*, *beryllium*, *niobium* and associated *rare earths* occur in the Ilímaussaq intrusion and have been described on pp. 34 and 35.

Iron. The granites are red in colour where they are crossed by faults and crush zones. This colorisation is mainly caused by hematite exsolution in the feldspars. Large concentrations of hematite only occur in the fault zone between the two lakes in the eastern end of the broad E–W valley of Kûgssuaq, in the north-eastern corner of the sheet, where the hematite mineralisation covers an area of 2 km by 50 m.

Carbonates. Small pockets of carbonate occur regularly in fault and mylonite zones especially in the northern part of the area.

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REFERENCES

ALLAART, J. H. 1967: Basic and intermediate igneous activity and its relationships to the evolution of the Julianehåb granite, South Greenland. *Bull. Grønlands geol. Unders.* **69** (also *Meddr Grønland* **175**[1]) 136 pp.

— 1969: The chronology and petrography of the Gardar dykes between Igaliko Fjord and Redekammen, South Greenland. *Rapp. Grønlands geol. Unders.* **25**, 26 pp.

BAILEY, E. B. & MAUFE, H. B. 1960 (2nd edition): *The geology of Ben Nevis and Glen Coe (explanation of sheet* **53**). Mem. geol. Surv. Scotland. 307 pp.

BALL, S. H. 1922: The mineral resources of Greenland. *Meddr Grønland* **63**[1], 60 pp.

BERRANGÉ, J. P. 1966: The bedrock geology of Vatnahverfi, Julianehåb district, South Greenland. *Rapp. Grønlands geol. Unders.* **3**, 48 pp.

BOHSE, H., BROOKS, C. K. & KUNZENDORF, H. 1971: Field observations on the kakortokites of the Ilímaussaq intrusion, South Greenland. *Rapp. Grønlands geol. Unders.* **38**, 43 pp.

BREEMEN, O. VAN, ALLAART, J. H. & AFTALION, M. (in press): Isotopic and geochronological studies on granites in the Ketilidian mobile belt of South Greenland. *Bull. geol. Soc. Am.*

BREEMEN, O. VAN & UPTON, B. G. J. 1972: Age of some Gardar intrusive complexes, South Greenland. *Bull. geol. Soc. Am.* **83**, 3381–3390.

BRIDGWATER, D. 1970: A compilation of K/Ar age determination on rocks from Greenland carried out in 1969. *Rapp. Grønlands geol. Unders.* **28**, 47–55.

— & HARRY, W. T. 1968: Anorthosite xenoliths and plagioclase megacrysts in Precambrian intrusions of South Greenland. *Bull. Grønlands geol. Unders.* **77** (also *Meddr Grønland* **185**[2]) 243 pp.

ELWELL, R. W. D. 1958: Granophyre and hybrid pipes in a dolerite layer at Slieve Gullion. *J. Geol.* **66**, 57–71.

— , SKELHORN, R. R. & DRYSDAL, A. R. 1962: Net-veining in the diorite of N.E. Guernsey, Channel Islands. *J. Geol.* **70**, 215–226.

FERGUSON, J. 1964: The geology of the Ilímaussaq alkaline intrusion, South Greenland. *Bull. Grønlands geol. Unders.* **39** (also *Meddr Grønland* **172**[4]) 82 pp.

— 1970: The significance of the kakortokite in the evolution of the Ilímaussaq intrusion, South Greenland. *Bull. Grønlands geol. Unders.* **89** (also *Meddr Grønland* **190**[1]) 193 pp.

— & PULVERTAFT, T. C. R. 1963: Contrasted styles of igneous layering in the Gardar province of South Greenland. *Miner. Soc. Am. Special Paper* **1**, 10–21.

HAMILTON, E. I. 1964: The geochemistry of the northern part of the Ilímaussaq intrusion, S.W. Greenland. *Bull. Grønlands geol. Unders.* **42** (also *Meddr Grønland* **162**[10]) 104 pp.

HARRY, W. T. & OEN, I. S. 1964: The Pre-Cambrian basement of Alángorssuaq, South Greenland and its copper mineralisation at Josvaminen. *Bull. Grønlands geol. Unders.* **47** (also *Meddr Grønland* **179**[1]) 72 pp.

HENRIKSEN, N. 1960: Structural analysis of a fault in south-west Greenland. *Bull. Grønlands geol. Unders.* **26** (also *Meddr Grønland* **162**[9]) 15–41.

NESBITT, R. W. 1961: The petrology and structure of the country around Julianehaab, South-West Greenland. Unpubl. Ph.D. thesis, Durham University, 351 pp.

POULSEN, V. 1964: The sandstones of the Precambrian Eriksfjord Formation in South Greenland. *Rapp. Grønlands geol. Unders.* **2**, 12 pp.

SCHARBERT, H. G. 1963: A sandstone dyke in the Julianehåb granite of Qeqertarssuaq, Julianehåb district. *Meddr dansk geol. Foren.* **15**, 183–188.

STEWART, J. W. 1964: The earlier Gardar igneous rocks of the Ilímaussaq area, South Greenland. Unpubl. Ph.D. thesis, Durham University.

SØRENSEN, H. 1958: The Ilímaussaq batholith; a review and discussion. *Bull. Grønlands geol. Unders.* **19** (also *Meddr Grønland* **162**³) 48 pp.

— 1967: On the history of exploration of the Ilímaussaq alkaline intrusion, South Greenland. *Bull. Grønlands geol. Unders.* **68** (also *Meddr Grønland* **181**³) 32 pp.

— 1969: Rhythmic igneous layering in peralkaline intrusions. *Lithos* **2**, 261–283.

— 1970: Internal structures and geological setting of three agpaitic intrusions—Khibina and Lovozero of the Kola peninsula and Ilímaussaq, South Greenland. *Can. Miner.* **10**, 299–334.

— , HANSEN, J. & BONDESEN, E. 1969: Preliminary account of the geology of the Kvanefjeld area of the Ilímaussaq intrusion, South Greenland. *Rapp. Grønlands geol. Unders.* **18**, 40 pp.

SØRENSEN, P. 1971: Field measurements of thorium and uranium in lujavrites from the Ilímaussaq intrusion. *Rapp. Grønlands geol. Unders.* **35**, 27–29.

UPTON, B. G. J. 1962: Geology of Tugtutôq and neighbouring islands, South Greenland. Part I. *Bull. Grønlands geol. Unders.* **34** (also *Meddr Grønland* **169**⁸) 60 pp.

— 1964a: The geology of Tugtutôq and neighbouring islands, South Greenland. Part II. Nordmarkitic syenites and related alkaline rocks. *Bull. Grønlands geol. Unders.* **44** (also *Meddr Grønland* **169**²) 62 pp.

— 1964b: The geology of Tugtutôq and neighbouring islands, South Greenland. Part III. Olivine gabbros, syeno-gabbros and anorthosites. *Bull. Grønlands geol. Unders.* **48** (also *Meddr Grønland* **169**³) 1–47.

— 1964c: The geology of Tugtutôq and neighbouring islands, South Greenland. Part IV. The nepheline syenites of the Hviddal composite dyke. *Bull. Grønlands geol. Unders.* **48** (also *Meddr Grønland* **169**³) 49–80.

— 1965: The petrology of a composite sill in South Greenland. *Bull. Grønlands geol. Unders.* **50** (also *Meddr Grønland* **169**¹¹) 19 pp.

USSING, N. V. 1912: Geology of the country around Julianehaab, Greenland. *Meddr Grønland* **38**, 426 pp.

WATT, W. S. 1963: The geology of Qaersuarssuk, Julianehaab district, South Greenland. Unpubl. Ph.D. thesis, Durham University, 228 pp.

— 1965: Textural and field relationships of basement granitic rocks Qaersuarssuk, South Greenland. *Bull. Grønlands geol. Unders.* **54** (also *Meddr Grønland* **179**⁸) 34 pp.

— 1968: Petrology and geology of the Precambrian Gardar dykes on Qaersuarssuk, South Greenland. *Rapp. Grønlands geol. Unders.* **14**, 50 pp.

— 1969: The coast-parallel dike swarm of southwest Greenland in relation to the opening of the Labrador Sea. *Can. J. Earth Sci.* **6**, 1320–1321.

WINDLEY, B. F. 1965: The composite net-veined diorite intrusives of the Julianehåb district, South Greenland. *Bull. Grønlands geol. Unders.* **58** (also *Meddr Grønland* **172**⁸) 60 pp.

— 1966a: The Precambrian geology of the Sârdloq area, South Greenland. *Rapp. Grønlands geol. Unders.* **5**, 48 pp.

— 1966b: Superposed deformations of the Ketilidian gneisses in the Sârdloq area, South Greenland. *Bull. Grønlands geol. Unders.* **64** (also *Meddr Grønland* **179**³) 55 pp.

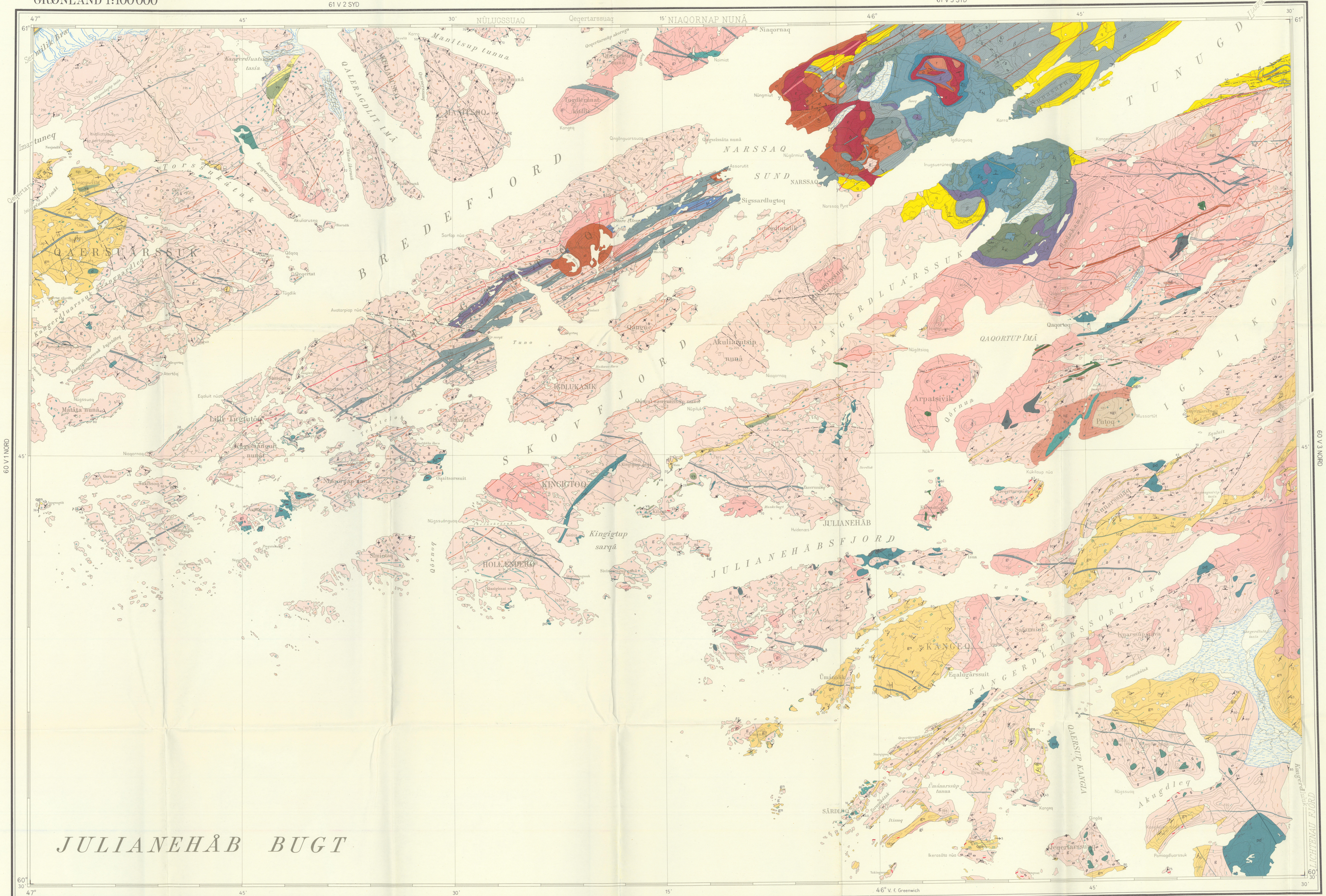
Færdig fra trykkeriet den 21. december 1973

MEDDELELSER OM GRØNLAND BD. 192 NR. 4 (J. H. ALLAART)

DANMARK
GRØNLAND 1:100 000

GRØNLANDS GEOLOGISKE UNDERSØGELSE
THE GEOLOGICAL SURVEY OF GREENLAND

GEOLOGISK KORT OVER GRØNLAND
60 V. 2 NORD JULIANEHÅB



Kartografi: Susanne Heide Jørgensen og Birgit H. Petersen

Trykt ved Geodætisk Institut 1972

1:100 000

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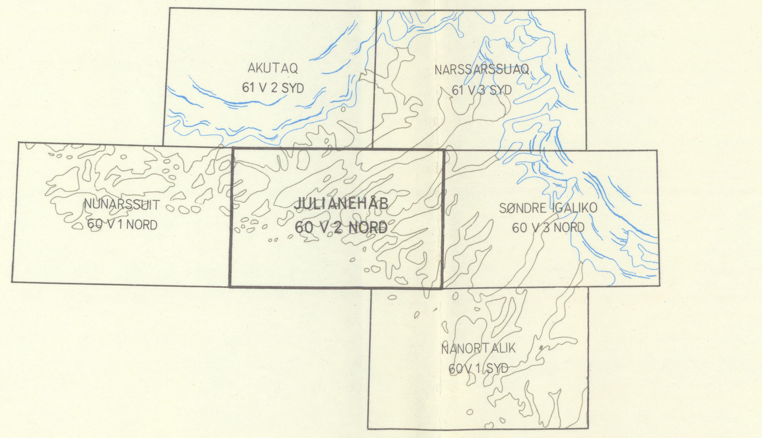
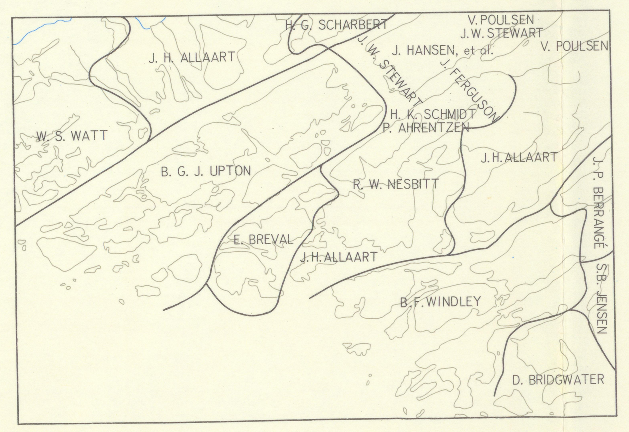
0 2 4 6 8 Statute miles

Højdeforskellen mellem kurverne 100 m
Contour interval 100 m



Topography based on preliminary 1:20 000 maps prepared photogrammetrically from vertical aerial photographs by the Geodetic Institute, Copenhagen.

Geology based on mapping at 1:20 000 carried out during the seasons 1958–1963. The delimitation of areas mapped by individual geologists is shown in the index map. Compilation by J. H. Allaart, 1967.



LEGEND

GARDAR INTRUSIVE ROCKS

- ε — ALKALI GRANITE. Members of Narssaq and Ilímaussaq intrusions.
- σ — SYENITE. Various quartz syenite members of Tugtutôq central complex; quartz syenites of Narssaq and Ilímaussaq intrusions; porphyritic pyroxene syenite of Narssaq intrusion.
- λ — SYENITE. Just undersaturated augite syenite of composite Hviddal giant dyke on Tugtutôq; augite syenite, heterogeneous syenite and pulaskite of Ilímaussaq intrusion.
- ψ — NEPHELINE SYENITE. Foyaitic syenite of eastern part of composite Hviddal giant dyke (Tugtutôq).
- χ_S — AGPAITE, sodalite foyaite
- χ_L — „ lujavrite
- χ_N — „ naujaite
- χ_K — „ kakortokite

  (agpaites: Ilímaussaq intrusion.)
- α — ANORTHOSITE.
- δ — GABBRO. Olivine gabbro of Narssaq and of giant dykes of Tugtutôq (Krydsø syenogabbro); marginal syenogabbro phase of composite Hviddal giant dyke; various sills of olivine gabbro in Ilímaussaq Volcanic Member of Eriksfjord Formation; sills of compact olivine-free basalt in lower part of Eriksfjord Formation west of Igaliko.
- ω — ULTRABASICS. Magnetite pyroxenite plugs in Narssaq gabbro.

- γ — ACID DYKES.
- σ — TRACHYTE AND MICROSYENITE DYKES, both saturated and undersaturated.
- δ — DOLERITE DYKES, including occasional trachydolerites and dykes with a large content of foreign plagioclase and anorthosite.

GARDAR EXTRUSIVE ROCKS

- β — BASALT, undifferentiated.
  - „ olivine basalt, mainly aphyric.
  - „ olivine basalt, feldsparphyric (platy basalt).
- τ — SATURATED EFFUSIVES WITHOUT QUARTZ (trachyte). The greater part of the porphyry division of the Ilímaussaq Volcanic Member of the Eriksfjord Formation.
- q — SANDSTONE. QUARTZITE. Sandstones of Eriksfjord Formation.

- gi — LATE ALLOCHTHONOUS GRANITE (s. l.). Aplite granite.
- gi — „ „ Leucocratic granites of Redekammen type.
- sgi — „ „ syenitic varieties. Microcline syenite east of Putoq; biotite monzonite northeast of Kugssuaq.
- pd — LATE-OROGENIC ULTRABASIC TO INTERMEDIATE INTRUSIVES. A varied suite of rocks mainly composed of hornblende and plagioclase with pyroxene, olivine and biotite as common constituents (e. g. appinitic rocks).
- di — DIORITIC INTRUSIVE ROCKS. Composite net-veined diorite intrusives of Akia, Kangeq and surrounding islands; dioritic rocks of uncertain age on the peninsula east of Arpatsivik.
- ai — BASIC INTRUSIVE ROCKS of uncertain age.
- ai — LATE-OROGENIC DYKES AND SHEETS: basic dykes, dioritic appinitic rocks and composite net-veined diorites. Only the most important bodies or concentrations have been indicated.

JULIANEHÅB GRANITE

- g — GRANITE s. l. IN PART AUTOCHTHONOUS OR PARAUTOCHTHONOUS.
  - „ „ Biotitic, foliated biotitic, pelitic enclaves, banded.
  - „ „ Hornblendic, foliated hornblendic, banded.
  - „ „ Amphibolitic and ultrabasic lenses, basic agmatite.
  - „ „ Very porphyritic granodiorite to adamellite (Big-feldspar granite).
  - „ „ Other less conspicuous porphyritic varieties.
- sg — „ „ Albitised rocks.
- sg — „ „ Hornblende monzonite around Putoq and on Pârdlît.
- g — „ „ Gneissose granites mainly in the area of regenerated gneisses and granites outside the Julianehåb Granite. To the west of Igaliko fjord, inside the Julianehåb Granite, gneiss bands are usually frequent in the gneissose granites (nebulitic series).

Variations in the spacing of the coloured symbols express relative differences in the quantity of the mafic minerals in the rocks.

- qgn — SILICEOUS GNEISS. In the Sârdloq area aplitic gneiss.
- sp — SEMIPELITIC METASEDIMENTS.
- m — MARLY METASEDIMENTS.
- vs — MIXED METASEDIMENTS AND METAVOLCANIC ROCKS. Mainly tuffitic rocks at Mato and surroundings; amphibolitic rocks west of Marraq.
- gn — GNEISS.
  - „ Biotitic, biotitic veined.
  - „ Hornblendic, banded, ultrabasic lenses.
- d — DIORITIC ROCKS OF UNKNOWN ORIGIN.
- a — BASIC ROCKS OF UNCERTAIN ORIGIN.

- MIGMATISATION.
- PEGMATITES.

- ICE AND PERENNIAL SNOW BANKS.
- FLUVIO-GLACIAL DEPOSITS. Small areas of talus, which occur mainly in the mountainous districts, have not been shown.

- Boundary, established.
  - „ inferred.
  - „ arbitrary, used to indicate transitional boundaries.
- 75 — Strike and dip of lithological layering of any origin.
- 43 — Strike and dip of foliation.
- 19 — Direction and plunge of lineation.
- 20 — Direction and plunge of fold axis (measured).
- Fault.
- Conglomerate.
- Tuff.
- Porphyritic texture (feldspar megacrysts).
- Cu — Mine, abandoned.