GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT NR. 26

The Geological Survey of Greenland
Report no. 26

Preliminary report on the geology of Bjørneøer, Scoresby Sund

by

F. Kalsbeek

KØBENHAVN 1969

Grønlands Geologiske Undersøgelse
Østervoldgade 10, DK-1350 Copenhagen K

Recent publications

Bulletins

reprinted from Meddelelser om Grønland

No. 73 Observations on some Holocene glacier fluctuations in West Greenland. 1968 by A. Weidick.

No. 74 Precambrian organic compounds from the Ketilidian of South-West Greenland. 1968 by K. Raunsgaard Pedersen and J. Lam.

No. 75 Contributions to the mineralogy of Ilímaussaq Nos 9-11. 1968.

No. 76 A study of radioactive veins containing rare-earth minerals in the area surrounding the Ilímaussaq alkaline intrusion in South Greenland. 1968 by J. Hansen.

No. 77 Anorthosite xenoliths and plagioclase megacrysts in Precambrian intrusions of South Greenland. 1968 by D. Bridgwater and W. T. Harry.

No. 78 Homogeneous deformation of the gneisses of Vesterland, South-West Greenland. 1968 by J. Watterson.

No. 79 A tetragonal natrolite. 1969 by E. Krogh Andersen, M. Danø and O. V. Petersen.

No. 80 Xonotlite-, pectolite- and natrolite-bearing fracture veins in volcanic rocks from Nûgssuaq, West Greenland. 1969 by S. Karup-Møller.

Miscellaneous Papers

reprinted from various journals

No. 61 An Atlantic Middle Cambrian fauna from North Greenland. 1969 by V. Poulsen.

No. 62 Use of field gamma-spectrometry in the exploration of uranium and thorium deposits in South Greenland. 1968 by L. Lövborg, H. Kunzendorf and J. Hansen.

No. 63 The use of structural contour maps in the study of gneiss-metasediment relations in the Umanak area, West Greenland. 1969 by G. Henderson.

No. 64 Boundary relations between Precambrian fold belts in the Ivigtut area, Southwest Greenland. 1969 by N. Henriksen.

No. 65 Evolution of the early Precambrian basement complex of southern West Greenland. 1969 by B. F. Windley.

No. 66 Chemical relations between metabasaltic lavas and metadolerites in the Ivigtut area, South-West Greenland. 1969 by N. Henriksen.

No. 67 Rhythmic igneous layering in peralkaline intrusions. 1969 by H. Sørensen.

PRELIMINARY REPORT ON THE GEOLOGY OF BJØRNEØER, SCORESBY SUND

by

F. Kalsbeek

With 1 map and 3 figures

1969

Abstract

The Bjørneøer in Scoresby Sund consist almost entirely of migmatites and granites. Locally well preserved metasedimentary rocks also occur (well bedded paragneisses, quartzites, marbles, mica schists). Three generations of granite can be discerned. Migmatitic granites were generated during a long time span. Basic, intermediate and acid intrusive rocks occur both as larger bodies and as dykes, and were emplaced syn- and late-migmatitically. Younger granites postdate the migmatisation.

There have probably been at least two phases of folding. The foliation and local isoclinal folds were formed before the migmatisation under low pressure granulite facies conditions (characteristic minerals are cordierite and hypersthene). Migmatisation took place under granulite facies and amphibolite facies conditions. Large faults have not been found, but young crush zones are common.

No indications of mineralisation were observed.

CONTENTS

INTRODUCTION 5
a) Location of the area 5
b) Outcrops; accessibility 5
c) Maps and aerial photographs 6
d) Main rock types 6
e) Scope of the work 7
f) Previous work 7

THE METASEDIMENTARY ROCKS 8
a) Stratigraphy 9
b) Fine-grained biotite gneisses 9
c) Mica schists 10
d) Quartzites 10
e) Marbles 11

THE MIGMATITES 12
a) Degrees of migmatisation 12
b) Basic and intermediate rocks in the migmatites 13
c) Homogeneous grey gneisses in the migmatites 14

THE GRANITES 15
a) The migmatite granites 15
b) The grey granite 16
c) The younger granite 19

THE DIORITES 20
a) Diorites 20
b) Leucodiorites 21
c) Relationship between diorite and the grey granite 22

THE DYKES 22
a) Younger granite dykes 23
b) Porphyrites 24
c) Basic dykes 25
d) Pegmatitic dykes 25
e) Notes on the petrography of the dyke rocks 25

THE STRUCTURES 26
a) Foliation 27
b) Fold structures 27
c) Crush zones 29
DISCUSSION 30
a) The metasediments 30
b) The granites 30
c) The diorites 31
d) The dykes 32
REFERENCES 33

INTRODUCTION

This report deals with the field geology of the Bjørneøer and the neighbouring part of Milneland, Scoresby Sund, East Greenland (fig. 1). Most of the area was mapped by the author, with assistance of Henrik Friis, geology student at the University of Aarhus, Denmark. Island VII and some smaller parts of the area were mapped by Friis. The mapping was undertaken during GGU's East Greenland expedition in 1968, led by Niels Henriksen.

a) Location of the area

The Bjørneøer (Bear islands) lie at approx. 25° 30' W and 71° 10' N, north-east of Milneland and east of Renland, from which they are separated by the wide Ø Fjord. To the east the wide open water of Hall Bredning separates the islands from Jameson Land. The island group consists of 11 larger islands (the largest, island I, some 20 km^2 in area) and a number of minor islands and skerries. The larger islands have been numbered I-XI on an unpublished topographical map made by E. Wenk in 1934; this number notation was adopted during the field work.

b) Outcrops; accessibility

The area as a whole is extremely well exposed, but often the outcrops are dusty so that it may be difficult to see geological details in many places. Most of the area is easily accessible; locally however, especially on islands VI, IX and X, there are narrow, very steep ridges which are inaccessible; here the investigation was mainly restricted to the coast areas. The highest accessible hills lie on island I, with altitudes of approximately 540 m. The highest top lies on island IX (645 m), but this top is not accessible. The whole area is transsected by deeply eroded crush zones, which often give rise to deep gullies with steep walls and which may be very difficult to pass.

Minor parts of some islands are covered by Quaternary beach deposits, locally with Saxicava artica and other shell fragments. These have been found up to heights of 100 m above the present sea level.

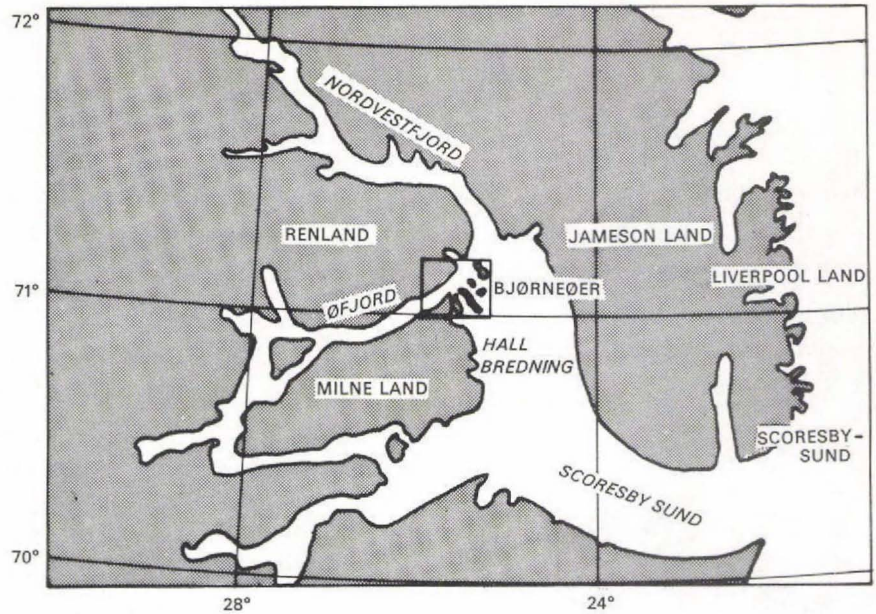


Fig. 1. Index map showing the position of Bjørneøer in the Scoresby Sund area.

c) Maps and aerial photographs

The area mapped is covered by 1:50 000 topographic sheets 71 Ø 2-A9 and 71 Ø 2-A10, which are enlargements from a 1:200 000 map made by the Geodetic Institute from oblique aerial photographs. Thus the degree of detail is less than would otherwise be expected of 1:50 000 maps. The area is also covered by oblique and vertical aerial photographs. Especially the latter have been used extensively during the field work, but due to the prevailing rock types (mainly migmatites) they hardly show anything of geological interest. For practical purposes a kilometre-square grid has been used, as shown on map 1, to indicate localities in the area. Locality 0.0-0.0 has been arbitrarily chosen 15 km west of 25° 30' W, 71° N, so that the lower left corner of map sheet 71 Ø 2-A9 has coordinates 15.0-0.0.

d) Main rock types

Most of the area consists of migmatites, granites and granitic gneisses rich in remnants of metasedimentary rocks. Locally well preserved metasediments occur, fine-grained dark biotite gneisses, mica schists, quartzites and marble being the most common. Some larger homogeneous granite bodies occur. More basic rocks, often of dioritic composition, are common throughout the area. Locally they occur as larger homogeneous masses, but generally as smaller inclusions in the migmatites. Intermediate to acid (granitic) dykes and subhorizontal sheets are very common throughout most of the area; often they are under 1 m in width.

e) Scope of the work

It was possible in one season to map the migmatites and the larger granitic and dioritic bodies. With exception of the marble occurrences, it was not possible to map the different types of metasedimentary rocks through the migmatites. The quartzites and other metasediments do not form such continuous and homogeneous horizons that they can easily be mapped, probably not even if much more time had been available.

Smaller outcrops of dioritic and granitic rocks have not been mapped. However, dark inclusions and granitic rocks occur almost throughout the whole area in the migmatites.

Most of the dykes and sheets were too narrow to be mapped on a 1 :50 000 scale; moreover, many sheets have low dips and very irregular outcrops which could only have been mapped at the cost of much time and with the help of better maps.

An attempt was made to subdivide the migmatites into several types (for example more metasediment-dominated migmatites and more granite/gneiss-dominated migmatites), but this subdivision proved to be of restricted use in the mapping.

Much time was devoted to the description of the rocks themselves in outcrop, and to the collection of representative samples. Furthermore the main structures were mapped.

A preliminary study of the rocks in thin section has been made. The results of this investigation are included in this report.

f) Previous work

The Bjørneøer were visited in 1934 by H. G. Backlund and others during an expedition through the inner fjord system of the Scoresby Sund area (Koch, 1955). In the report of this expedition (Koch, op. cit.) only brief remarks on the geology of the islands are found. Backlund regarded the crystalline rocks of the Bjørneøer as Caledonian rocks. The occurrence of a grey granodiorite on islands I and II is mentioned. During the visit a topographical map of the islands was prepared. A copy of this map, prepared by E. Wenk, is in the possession of GGU. It contains a few strike and dip symbols and indicates the local presence of chondrodite marble.

Recently, Larsen (1969) has published a K/Ar dating of biotite from a dioritic rock on Renland, just outside the area mapped. The K/Ar age of the biotite is 435 ± 12 m.y.

THE METASEDIMENTARY ROCKS

Only in relatively small parts of the area (especially in the southern part of island XI and on the smaller islands south-east of it) have more or less well preserved metasediments been found. More commonly the metasediments occur as inclusions in the migmatites and often only dark schlieren are left which can hardly be recognised as metasedimentary remnants.

Where they are well preserved one is not in doubt that one is dealing with metasedimentary rocks (this in contrast with, for example, many areas in South-West Greenland, where one generally cannot see in the field whether one is dealing with ortho- or paragneisses). The metasediments are well bedded. Often in fresh outcrops a fine lamination, probably also a bedding feature, can be seen. Locally cross-bedding was observed (loc. 21.8-16.2, island I). At a few outcrops graded bedding was suspected, but this feature was only seen in a few successive layers of some 10-15 cm thickness, and not throughout a whole outcrop (for example loc. 10.2-3.1, island XI). Furthermore, the occurrence of undoubted metasediments, such as quartzites and marbles, interbedded with the other rocks indicates that one is dealing with an original sedimentary sequence.

The most common metasediments are, in decreasing order of abundance, fine-grained biotite gneisses, mica schists, quartzites, and marbles.

a) Stratigraphy

The metasediments cannot be arranged in a stratigraphic column. Apart from the marbles, they are interbanded on a small scale, often occurring together in one outcrop.

On the steep north-east wall of Milneland, from 7.3-2.5 to 4.5-6.3, the following profile can be seen: 1) Some 800 m of migmatite, 2) approx. 100 m of marble, 3) approx. 40 m of dark brown mica schist, 4) some 1000 m of migmatite. In this section only one horizon of marble occurs and this is overlain by dark mica schists. It is probable that the marble occurrences elsewhere in the area should be correlated with this marble in Milneland. On the islands, however, the marble does not have a distinct brown schist on one side and therefore this correlation might be wrong.

The migmatites above and below the marble of Milneland are very much the same, but in the migmatites above the marble there is very little amphibolite in comparison with the migmatites below the marble.

Locally amphibolites have been found interbedded with the metasediments. They are fine-grained dark rocks, consisting mainly of hornblende and plagioclase. In a few samples hypersthene and a clinopyroxene occur. Quartz may be present.

b) Fine-grained biotite gneisses

The most common metasedimentary rock in the area is a rather fine-grained, often finely laminated, dark grey biotite gneiss. The composition of the rock is difficult to estimate in hand specimens because of the fine grain; microscopic investigation shows that the gneisses mainly consist of quartz, plagioclase (generally oligoclase), variable, often large, amounts of microcline and some 10-20 % of biotite. Some garnet is generally present and may be visible in the hand specimen. Common accessories are rounded zircon grains, opaque ore minerals and some apatite. The gneisses have granoblastic textures, locally blastopsammitic textures can be recognised.

A more calcium-rich gneiss sample lacks microcline and contains, in addition to biotite, hypersthene, diopside and brown-green hornblende. The plagioclase in this sample is very calcic (bytownite).

The fine-grained biotite gneisses are quite compact, they do not have the good fissility of mica schists. They are often well bedded, with beds of some 10 cm in width. It was in these rocks that features looking like graded bedding were seen.

Remnants of the fine-grained biotite gneisses are very common in the migmatites, forming both well preserved inclusions and half digested remnants in granitic material.

c) Mica schists

The rocks which have been called mica schists in the field (to contrast them with the fine-grained gneisses) would probably have been called gneiss in areas with real mica schists. In fact they are fairly biotite-rich gneisses with a distinct, but irregular, schistosity. They are more coarse-grained (grain size several mm) than the fine-grained biotite gneisses. They may contain garnet porphyroblasts, but muscovite has not been found. Thin sections of the mica schists show that they contain the same minerals as the biotite gneisses, but in addition cordierite and some sillimanite may occur, and a green spinel has been found locally. There are all transitions between the mica schists and the fine-grained biotite gneisses. Probably the former had a more pelitic composition.

Very often the mica schists contain thin (0.5-1 cm) quartzo-feldspathic veinlets which alternate with biotite-rich schlieren. Possibly this is an anatectic feature related with the migmatisation. Homogeneous mica schists without this splitting into light and dark components are rare. In the fine-grained biotite gneisses such anatectic (?) features have also been seen, but here less commonly.

d) Quartzites

Quartzitic rocks occur throughout the area. Often they are pure white quartzites, but locally they are grey or reddish. There are all transitions from pure quartzites through quartzitic gneisses to the fine-grained biotite gneisses.

Quite often traces of the original bedding in the quartzites can be seen. At one locality (21.8-16.2, island I) cross-bedding was seen. Ripple marks have not been found.

e) Marbles

Marbles have been found on Milneland, on island VI, and in small outcrops on islands V, VII and VIII. It has not been possible to connect the different outcrops. The marble bands follow a very irregular course. For example, much of the NE part of island VI consists of marble, but on the nearby island V, which is only separated from island VI by a narrow sound, hardly any marble is found. Here (island V) only lenses of marble are found within the granites and migmatites. On islands VII and VIII large (100 m) marble lenses occur in the dioritic rocks which are prominent there. It is not even sure that these outcrops have any relation with those on Milneland and on island VI, since the inclusions consist of a very white, coarse-grained, pure marble, which has not been found elsewhere.

The normal marble of Milneland and of island VI has a greyish colour. It is often clearly banded. Sometimes the banding is due to an alternation of quartz-bearing layers with more pure marble layers, sometimes to an alternation of marble layers with slightly different colour or texture or weathering, of which the cause is not evident.

The marbles are often strongly veined by granite and sometimes they occur as lenses in the granite. Locally calc-silicate rocks have developed at the contacts between the marble and the granitic rock. Sometimes one finds only calc-silicate inclusions in the granite or migmatite.

In the few thin sections of marbles investigated the following minerals were found: calcite (little or no dolomite), forsterite (sometimes strongly serpentinised), phlogopite, clinohumite and spinel. The clinohumite is often visible in the hand specimen as small (1 mm) greenish yellow grains.

A few calc-silicate samples which were investigated contain diopside, a very calcic plagioclase, microcline sometimes in large amounts, quartz, scapolite, some hornblende, and sphene.

THE MIGMATITES

Different types of migmatites occur in the area mapped, grading between only slightly migmatised metasediments and almost homogeneous granitic rocks.

a) Degrees of migmatisation

The first sign of migmatisation is the formation of narrow quartzo-feldspathic schlieren in the mica schists and the fine-grained biotite gneisses. The quartzo-feldspathic veins may be devoid of alkali feldspar when they occur in metasediments without alkali feldspar, but in most cases they contain large amounts of microcline. These leucocratic schlieren have dark rims, and it is probable that they mark a local splitting up of the original rock into leucocratic and melanocratic phases. The leucocratic schlieren lie mostly concordant with the foliation of the rock in which they occur. In more strongly migmatised metasediments discordant veins of quartzo-feldspathic material also occur, often with diffuse boundaries, which may form a substantial part of the rock. These migmatites must have been quite plastic; locally they contain evidently rotated angular inclusions of dark rocks.

From these metasediment-dominated migmatites there are all gradations to migmatites full of concordant and, less commonly, discordant granitic veins. Generally schlieren of metasedimentary material are present in large amounts; they lie concordantly in between the granitic sheets and often give the migmatites a fairly regular structure. The granitic sheets are often some 50-100 cm thick; the metasedimentary schlieren in this type of migmatite are commonly some 5-20 cm thick.

The metasedimentary schlieren are locally recognisable as fine-grained biotite gneiss or mica schists, but often are formed of a biotite-rich schistose rock, often containing cordierite, probably original metasediment of which most of the quartzo-feldspathic material has been incorporated in the granitic part of the rock. The granitic sheets locally cut discordantly through the metasedimentary remnants.

The most granitic migmatites consist of very homogeneous leucocratic granite-gneisses with only a few dark schlieren. Generally a faint foliation can be recognised and measured. These granitic gneisses locally contain microcline porphyroblasts which may show a preferred orientation along the foliation. At many localities only quartzites and basic rocks occur as inclusions in these gneisses and one gets the impression that the other original rocks (biotite gneisses etc.) have been incorporated in the granitic material, leaving the more resistant rock types behind. Locally, however, well preserved inclusions of fine-grained biotite gneiss have also been found.

At several places along the steep walls of Milneland and island IX one can see that zones of agmatitic basic rock may continue for many hundreds of metres within the granitic gneiss, parallel with the foliation.

The granitic rocks found in the migmatites are commonly pink, but not rarely they are white. They almost always contain some garnet. Locally they may be distinctly foliated but elsewhere they are normal granites. Larger outcrops of more homogeneous migmatite granite occur especially in the southern part of island I.

A further description of the migmatite granites will be given in the next section (p. 15).

It is impossible without a careful study of the rock samples to give an opinion on the origin of the migmatites, but one point seems evident. Incipient migmatisation may have taken place isochemically, but the more advanced stages of migmatisation certainly not. The granitic material cannot have been derived locally by anatexis of metasediments like those which have been found in the area, because generally there is far too much granite and far too little remnant metasedimentary material (75 % granitic material - 25 % metasedimentary material is common). The migmatites could have formed isochemically if a large part of the original sediments had been arkoses, but there are no reasons to think that this is the case.

b) Basic and intermediate rocks in the migmatites

Throughout the migmatites dark inclusions are so common that in most of the area one can find them in almost every outcrop. Locally larger masses of strongly migmatised basic and intermediate rocks occur, for example in the northern part of island I.

Elsewhere in the area (islands VII and VIII) there are large occurrences of dioritic rocks which are not so strongly migmatised, and for which an igneous origin is evident (see p. 20-21). On island VIII these igneous rocks are strongly migmatised in the margin, and here they remind one much of the dark rocks elsewhere that are migmatised throughout. Otherwise the basic and intermediate rocks in the migmatites do not look like the well preserved dioritic rocks. They are mostly rather fine-grained, dark, biotite-rich rocks, slightly to clearly foliated and sometimes even slightly banded. More rarely amphibolites have been found. A further description of these rocks will be given in a later section (p. 20).

c) Homogeneous grey gneisses in the migmatites

In several parts of the area (for example around 10.0 - 6.0, island XI, and around 19.7 - 21.0, island I) large occurrences of a homogeneous dark grey gneiss have been found which locally is strongly migmatised. The gneiss is rich in biotite, contains garnet and commonly feldspar porphyroblasts. It may contain angular inclusions of metasediments and basic rocks which are oriented parallel with the foliation of the gneiss. It is possible that this rock is an orthogneiss. Lithologically and in mode of occurrence these homogeneous dark gneisses recall the grey granite of islands I and II (see p. 16).

In thin section the homogeneous grey gneisses prove to have a granodioritic composition. Appreciable amounts of microcline are present. Although in mineralogical composition these gneisses agree with the grey granite, texturally they are rather different. The plagioclase does not occur in tabular crystals and Karlsbad twins have hardly been found, whereas the occurrence of tabular plagioclase crystals with Karlsbad twins is characteristic for the grey granite.

THE GRANITES

Three types of granite occur in larger homogeneous masses in the area: 1) the migmatite granites, 2) the grey granite, and 3) the younger granite. The younger granite is clearly younger than both the migmatite granites and the grey granite. The relative age of the migmatite granites and the grey granite is not completely sure, but probably the formation of the migmatite granites started before the emplacement of the grey granite (see discussion on p. 31).

a) The migmatite granites

As described in the foregoing section, large amounts of granite and granitic gneiss formed in the area during the migmatisation. The granitic rocks occur as concordant sheets, as discordant veins and as larger homogeneous masses.

The migmatite granites and the homogeneous granite-gneisses are leucocratic rocks, consisting almost completely of quartz, plagioclase (oligoclase) and microcline. In the granites, the dark minerals - biotite, some garnet and muscovite - make up only a few percent of the rock. In the gneisses slightly more biotite is present than in the granites. The rocks have equigranular textures and the different minerals show irregular outlines. Grain sizes range from a few mm to some 1 cm. Biotite may be present in larger irregular patches (perhaps earlier metasedimentary remnants), small amounts of opaque minerals are present and a few zircon grains with seemingly well rounded outlines.

The colour of the migmatite granites is pink or white, red and white patches alternating irregularly. The red and white fields may be a few tens of metres large, the boundaries are not sharp, but gradual over some 50 cm. It is very probable that these colours are only superficial; for example the colour of a granitic dyke can change within a few metres from pink to white. Furthermore, it proved in an outcrop of pink and white granite, while blasting large samples, that the pink granite became white some 20 cm below the surface.

Characteristic for the mode of occurrence of the migmatite granite is that it always locally contains large inclusions of migmatite, that it never shows sharp contacts with a country rock, and that it occurs diffusely over several parts of the area (especially in the southern part of island I).

Being a granite clearly related to the migmatisation, one could call the rock "autochthonous", but as explained before the granitic material must somehow have come from elsewhere. The mode of emplacement of the granite is not clear. Some of the migmatite granite, however, forms local intrusive dykes. Furthermore the granite and the related granite-gneisses contain numerous angular inclusions which often are evidently rotated. Some inclusions, for example of amphibolite, are distorted, and it is therefore clear that the granitic material has been very mobile and also that some of the inclusions became plastic.

b) The grey granite

About a third of island I and most of island II is formed of the "grey granite". On island I the grey granite is a homogeneous, dark, and rather coarse-grained (0.5-2 cm) granitic rock. On island II the grey granite is much less homogeneous than it generally is on island I. Here the rock is often nebulitic and at several places zones of migmatite lie within the granite. The boundaries of these migmatite zones are unsharp, and the zones are so poorly defined that they have only been indicated on the map by symbols within the granite. Similar migmatite zones have been found SE of summit 540 (19.0 - 19.0) on island I.

Thin sections show that the "grey granites" have granodioritic to quartz dioritic compositions. The grey granites contain larger amounts of dark minerals than the migmatite granites (some 25 %). Biotite predominates and a rather light green hornblende occurs in smaller amounts, commonly as aggregates of small irregular crystals. A few samples contain clinopyroxene as cores in hornblende crystals or aggregates. The dark minerals in the grey granite are often clustered together. Among the light minerals plagioclase (andesine) predominates over microcline, which may even be absent. Some 20 % of quartz is present. The plagioclase forms often well developed tabular crystals and Karlsbad twins are commonly present. Opaque minerals, sphene, apatite, zircon, and sometimes allanite occur as accessories.

Inclusions: Characteristically, the grey granite contains many inclusions. Generally these are small (up to 10 cm), but they may reach a few metres in size. It is hardly possible to find an outcrop of grey granite without inclusions. The inclusions do not show preferred orientation. Inclusions lying almost in contact with each other may have their foliations perpendicular to each other. Several types of inclusions occur. By far the most common inclusions are basic rocks, mainly amphibolites. Sometimes these have sharp boundaries with the surrounding granite, but in other cases the inclusions have diffuse outlines and the surrounding granite may be full of hornblende. Inclusions of metasedimentary rocks are common; most of them consist of the fine-grained biotite gneiss. These have almost always sharp contacts towards the granite. Less common are quartzite inclusions and inclusions of greenish calc-silicate rock. The latter are often zoned, but the boundaries are as a rule sharp.

Contact relationships: The contacts between the grey granite and its surrounding rocks (migmatites) are without exception gradual. Nearing its boundary the granite becomes more inhomogeneous. It contains more inclusions, which often show faded outlines, and often irregular and diffuse leucocratic veins are present. In the boundary zone the granite becomes more and more a nebulitic migmatite. The neighbouring migmatites consist mostly of migmatised fine-grained biotite gneiss with diffuse granitic veins and larger granitic patches which recall the grey granite. In these migmatites the same inclusions may be found as occur in the grey granite. Here, however, they are generally oriented parallel to the foliation in the migmatite, but locally inclusions have been found that evidently are rotated, and it seems that these migmatites have been quite mobile. Also in the nebulitic boundary facies of the granite the inclusions may show an orientation parallel to a faint foliation which here is often visible in the granite.

At one locality (20.7-11.8, island IV) grey granite is in contact with migmatite granite. Here the migmatite granite sends out an irregular dyke which cuts the grey granite.

The structure in the migmatites is as a rule fairly irregular, but in general one gets the impression that the foliation in the migmatites near the grey granite is roughly parallel with the granite contact. This is not the case at a larger distance from the granite. One may interpret this by assuming that the granite is intrusive and has rotated the foliation in the neighbouring migmatites to become parallel with the granite contacts.

Leucocratic facies: In the SW part of island I, the grey granite becomes more leucocratic in the neighbourhood of the migmatites. The few samples of the leucocratic facies of the grey granite investigated microscopically contain much more microcline and less dark minerals than the normal grey granite. Hornblende has not been found - some muscovite may be present instead. Apart from these differences, the rock seems in all respects identical with the normal grey granite. The zone of leucocratic grey granite is on the ridge around 20.8-16.5 about 500 m wide. The contact with the normal grey granite is gradational over a distance of a few tens of metres. Here the grey granite contains many diffuse leucocratic veins, which may or may not have something to do with the presence nearby of the more leucocratic granite. It can be shown that one of these diffuse leucocratic veins cuts a dark dyke which cuts the grey granite.

Granitic and aplitic dykes: At many places the grey granite is cut by granitic dykes and by thin aplitic dykelets. These dykes commonly show very convincing dilatational features, and there can be no doubt that the dykes are intrusive (fig. 2). Chilled margins have not been observed. Many of these dykes consist of a pink granite; the thinner aplitic veins are mostly white. These dykes belong to the third type of granite, the younger granite. They intruded into the grey granite while it was completely consolidated and brittle enough to open along cracks before the invading granite.

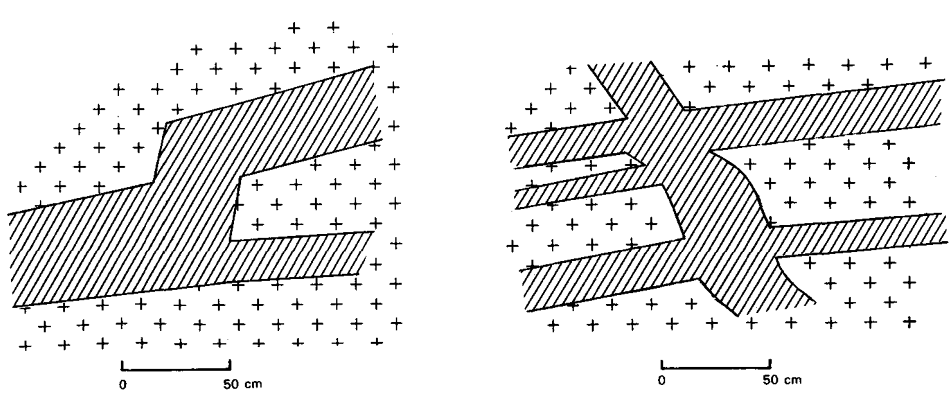


Fig. 2. Sketch showing the shapes of two granitic dykes.

c) The younger granite

The younger granite generally occurs as dykes and sheets. The larger outcrops of younger granite, on islands V and VI and islands VII and VIII, can be regarded as dykes, though very wide. Often the younger granite forms fairly flat-lying sheets and gives very irregular outcrops. Elsewhere the granite bodies are nearly vertical. The large outcrop on islands V and VI has a rather flat (about 30°) dip towards NE, and therefore the granite is not so thick as it seems on the map.

The younger granite is rather fine-grained (grain size a few mm), but it may show local feldspar phenocrysts up to 1 cm in size. The rock is rather leucocratic; it consists mainly of quartz, microcline and an acid plagioclase. Muscovite and biotite occur in minor amounts. The minerals have irregular outlines. Some apatite, opaque minerals and seemingly euhedral zircon crystals have been found. The colour of the granite varies between pink and white. On island V the granite is white, along the north coast of island VI it is pink.

The boundaries between the younger granite and its country rocks are sharp. The younger granite does not form migmatites like the migmatite granite, but locally there may be so many dykes of younger granite present that the rocks seen to become migmatites. However, the dykes have always very sharp contacts with the migmatites they intrude and dilatational features are fairly common. The younger granite hardly ever contains inclusions. At a few places younger granites have pegmatites along their contacts with the country rock.

The younger granite belongs to the youngest rocks in the area. It cuts through all other rock types, and it is itself only cut by some pegmatitic dykes. However, the younger granite is commonly faintly foliated.

THE DIORITES

Large outcrops of more melanocratic rocks occur especially on islands VII and VIII. In other parts of the area these rocks are generally strongly migmatised.

a) Diorites

On islands VII and VIII large outcrops of a dark brown homogeneous medium-grained rock occur without macroscopically visible quartz, but with much greenish feldspar. Among the dark minerals, as far as can be seen in hand specimen, biotite is predominant. The rock shows locally an ophitic texture. Since the rock seemed too light in colour to be a gabbro and the dark minerals are not characteristic for gabbroic rocks, these rocks were called "diorites" in the field. The diorites are generally strongly weathered, giving rise to irregularly rounded rock surfaces and a gravelly debris.

Microscopic investigation showed that the diorites are rather variable in composition. Generally some 30-50 % dark minerals are present. Biotite, hypersthene, clinopyroxene, and a brownish green hornblende, in this order of abundance, have been found in most samples. Among the light minerals plagioclase is most prominent, often in well developed crystals with Karlsbad twins. The plagioclase is generally a calcic andesine, but it ranges in composition from sodic andesine to labradorite, and becoming even more calcic in a hornblende-rich sample. Alkali feldspar (seemingly orthoclase) and quartz are present in minor amounts. Apatite and opaque minerals are common accessories. Euhedral zircon needles have been seen in a few samples.

Most samples have a characteristic "igneous" texture, with well developed tabular plagioclase crystals without evident preferred orientation.

Large outcrops of the same rocks occur also on other islands, but as described before (p. 13) they are mostly strongly migmatised, have often become foliated and no longer show the characteristics of the original diorites. In places well preserved diorites have been migmatised and sheared in their marginal zones. Thin sections indicate that these rocks are tectonised and recrystallised. They are more fine-grained than the normal diorites and show a strongly preferred orientation of biotite, pyroxene and plagioclase crystals. The mineral content of the rocks, however, is unchanged.

None of the large outcrops of dioritic rock (migmatised or not) is clearly discordant to its country rocks, but at several localities intrusive phenomena have been seen in detail. On island I (loc. 19.7-22.8) a dyke of dioritic rock, some 70 cm thick, cuts through homogeneous granite gneiss. On island III (loc. 16.1-13.7) a diorite sends out apophyses which cut the neighbouring migmatite. On island VIII (loc. 21.8-12.5) one gets the impression that large inclusions of migmatite lie within the diorite, but the relationships here are not quite clear.

At a few localities, on the skerries between islands VII and VIII (loc. 12.6-11.9) and the neighbouring coasts of these islands, and on the hill on island VII (loc. 12.5-10.8), large lenses (about 100 m long) of white marble lie within the dioritic rocks.

Both the diorites and the associated leucodiorites, to be described in the next section, are cut by many dykes of younger granite.

b) Leucodiorites

The western part of island VII is almost completely built up of dioritic rocks, but in a large part of this area these are more leucocratic than on island VIII. The rocks are generally greyish in colour with small patches of dark minerals. Provisionally these rocks were given the field name "leucodiorite".

In the few samples of leucodiorite investigated microscopically, microcline occurs in important amounts and the pyroxenes seem to be largely replaced by a light green hornblende, by which they are surrounded.

It is not easy to map the diorites and the leucodiorites separately. They grade into each other and often one is in doubt whether one is seeing a diorite or a leucodiorite. The leucodiorites may lie on top of the diorites, the higher parts of island VII being formed of leucodiorites and the lower areas, partly along the coasts, of diorite proper.

c) Relationship between diorite and the grey granite

At several localities (for example 14.8-14.5, island III) diorites occur together with rocks looking like grey granite. The two rock types occur together in the same outcrop, without sharp boundaries, both forming irregular patches in the outcrop. Only careful investigation shows that locally the rocks contain much quartz and remind one of grey granite, whereas elsewhere in the same outcrop the rock looks like the normal diorite. It is of interest to note that where the rocks lithologically resemble grey granite the characteristic inclusions of the grey granite also occur.

A few samples from an outcrop where the two rock types occur together have been investigated under the microscope. The rock assumed to be a diorite contains both ortho- and clinopyroxene. In the rock called grey granite no pyroxenes have been found; these seem to have been replaced by aggregates of light coloured amphibole. As described earlier (p. 16) aggregates of light coloured amphibole occur in the grey granite proper, and here cores of pyroxene have been found within such aggregates. These observations indicate that there may be a genetical relationship between the grey granites and the diorites.

On the northern part of island I (loc. around 19.5-21.3) homogeneous grey gneisses occur (see p. 14) in association with the migmatised diorite. The homogeneous grey gneisses here occur in the same relation with diorite as the grey granite on island III.

At one locality (20.5-12.0, island IV) inclusions of diorite were found in grey granite. Diorite occurs here in the migmatites which border the grey granite, and part of it occurs completely enclosed in the granite.

THE DYKES

Throughout the whole area numerous basic, intermediate and acid dykes occur. Generally they are rather narrow (less than 1 m), but some granitic dykes range up to 100 m (and more if one wishes to regard the young granites of islands VII and VIII as dykes). In the field we subdivided the dykes into "basic dykes", "porphyrites", and "granitic dykes", and although a petrographical investigation proved that these field names are not quite correct they will be used in the following description. A petrographical description of the rocks will be given at the end of this section.

In many outcrops several generations of dykes can be found. One of the many examples is from island XI (loc. 10.5-5.0). Here one finds 1) metasediments, cut by 2) thick veins of coarse-grained white granite with some garnet (probably migmatite granite), cut by 3) a thin basic dyke, cut by 4) a thin grey porphyrite dyke, cut by 5) a thin granitic vein.

At a nearby locality (10.1-4.5) the same rock types are found, but here thin basic dykes, cutting the gneisses and amphibolites, are cut by granitic veins, which in turn are cut by porphyrite dykes.

These two examples give an impression of the difficulties in establishing a dyke chronology. If one assumes that the thin basic dykes in the two outcrops have the same age and also that the porphyrites in the two outcrops are contemporaneous, then one is dealing with at least three generations of granitic veins. If one assumes that the granitic veins in the second outcrop are the same as the migmatite granite veins in the first outcrop, there must be two generations of basic dykes. There are no means whereby one can decide in the field whether two fine-grained dark dykes are petrographically the same, and even if they are this does not prove that they are contemporaneous. Moreover, it has been impossible to subdivide the thin dykes in the area into well defined basic, intermediate, and acid groups, because all gradations between very leucocratic dykes and very dark dykes occur. In spite of these difficulties one gets the impression that there was an evolution from basic through intermediate to acid dykes, the basic dykes always being older than the intermediate porphyrites and younger porphyrites being more leucocratic than older ones. Granitic dykes and veins, however, must have formed during most of the time.

a) Younger granite dykes

Dykes which probably belong to the younger granites are very common throughout most of the area and locally they may make up a large part of the total rock (perhaps some 25 % in some parts of islands IV and V).

They often form flat-lying sheets, which for example can be seen on the walls of the steep ridges of islands IX and VI. On the lower islands such flat sheets may give rise to very irregular outcrops.

b) Porphyrites

Another common type of dykes consists of rather fine-grained dark grey rocks of intermediate composition, which often (but as often do not) contain feldspar phenocrysts. We gave these rocks the field name "porphyrite".

Especially on island XI large numbers of these porphyrites occur. They often cut through migmatite granite, but they are also commonly cut by granitic veins, and locally they are even migmatised. At several localities two generations of porphyritic rocks occur, the older of which is cut by granitic veins which are in turn cut by the younger porphyrite. In those cases where two generations of porphyrites were found, the younger porphyrite is more leucocratic than the older one. Like the older porphyrites, the younger ones may be clearly porphyritic.

Unfortunately the porphyrites are not a sharply defined rock group. They grade from fairly dark (grading into the basic dykes) to quite leucocratic (where they resemble dykes of younger granite). Even within one dyke there may be a gradation from dark porphyritic to more leucocratic granitic rock. Several thick dykes on island VI (around loc. 19.0-3.5) consist of dark grey porphyrite in the central part and of granite along the margins. These porphyrites, which only locally are porphyritic, may well be related to the younger granites.

Porphyrites have mainly been found in the migmatites, where they cut through most of the granitic veins. A few porphyritic dykes occur in the grey granites and in the migmatite granites. These dykes usually have very irregular shapes, locally disappearing for short distances. There is no doubt that one is dealing with original dykes, but probably the granitic rocks into which they intruded were not quite solid at the time or have been remobilised afterwards. Without doubt the porphyrites are older than the younger granites which cut sharply through them, and they are also older than some of the irregular granitic veins which seemingly belong to the migmatites.

c) Basic dykes

Provisionally all dark dykes have been put under the heading "basic dykes". Probably this is not a homogeneous rock group. Generally these dykes are thin (10-30 cm). At several localities they prove to be older than the porphyrites. These dykes also often have irregular shapes.

A dyke of diorite was found in the homogeneous granite gneiss at loc. 19.7-22.8, island I (see p. 21). This dyke has an irregular and discontinuous outcrop, showing that the granite gneiss was not yet completely "dead" when the diorite was intruded.

At a few localities very dark basic rocks occur, in some places clearly as dykes, in others as large inclusions in the migmatites or in grey granite (island II, loc. 17.2-16.7). Some of these rocks are almost hornblenditic in composition. Perhaps they are related to the diorites.

On Renland (loc. 2.9-11.9) a 15 m thick very dark dyke was found that cuts sharply through the migmatites and through a granite dyke which looks like younger granite. The black dyke is cut by granitic veins and cannot therefore be a Tertiary dyke. Lithologically the dyke rock looks like the melanocratic rocks which occur elsewhere, for example as inclusions in the grey granite.

d) Pegmatitic dykes

Pegmatitic dykes are not as common as granitic dykes and veins, but they have been found quite regularly. Some pegmatites belong to the migmatites - these are cut by porphyrites. Others are probably related with the younger granite, and a few are clearly still younger since they form dilatational dykes in younger granite.

e) Notes on the petrography of the dyke rocks

There seem to be gradual petrographic transitions between the "basic dykes", the "porphyrites", and the "granitic dykes". The predominant dark mineral in all of them is biotite. In one sample of a basic dyke important amounts of a clinopyroxene and some hypersthene were also found. The other basic dyke samples contain almost exclusively biotite as a dark mineral, and some light green hornblende may be present. In the porphyrites biotite is the only important dark mineral, here occurring in smaller amounts than in the basic dykes. In the granitic dykes the biotite is associated with minor amounts of muscovite. Among the light minerals plagioclase is the most important. It is very calcic (bytownite?) in some of the basic dykes, but in others the calcium content ranges down to that of a calcic andesine. In the porphyrites the plagioclase generally is a calcic oligoclase or a sodic andesine, in the granitic dykes a medium to sodic oligoclase. The plagioclase is often clouded. Karlsbad twins are common. Quartz is present in all samples. Alkali feldspar (mostly microcline) is found in large amounts in all granitic dykes, and in smaller amounts in some of the porphyrites. Many porphyrites and basic dykes are devoid of alkali feldspar, although small amounts of orthoclase (?) occur in the pyroxene-bearing basic dyke.

Apart from the euhedral plagioclase phenocrysts in some of the porphyrites all the minerals have irregular shapes; the plagioclase is, however, often zoned and shows evidence of original euhedral growth.

Common accessories are zircon, apatite, and opaque minerals. Sphene occurs in the more basic dykes.

The dykes range thus in composition from quartz dioritic (the basic dykes and some porphyrites) through granodioritic (the porphyrites in part) to granitic (the granitic dykes), and they seem to have formed in this order, the basic dykes generally being cut by porphyrites and these by granitic dykes. In the two cases investigated where two porphyrites cut each other the younger contains microcline and the older does not. The very melanocratic dyke rocks mentioned on p. 25 have not yet been studied with the microscope.

THE STRUCTURES

Through lack of good marker horizons it is difficult to get an impression of the fold style in the area. The only stratigraphical marker is the marble horizon, but this is so discontinuous and irregular that it is not of much help.

In detail, the structure of the migmatites is often rather irregular, but if one looks for places where the structure is more or less regular over some distance (some 10-20 m) and makes measurements at those places, these measurements indicate a more regular structure than one would expect at first sight. Only such measurements have been indicated on the map.

a) Foliation

The measurements indicated on the map are made on foliation planes in metasedimentary rocks, in metasedimentary schlieren in the migmatites, in biotite-rich schlieren in the migmatites, in homogeneous grey gneisses, and homogeneous granitic gneisses. These structures seem to be equivalent. The foliation in the homogeneous granite gneisses, for example, is always parallel with the foliation in the schlieren which it contains. Only in angular inclusions the foliation may have a strongly deviating orientation, and foliations in such inclusions have not been measured.

Minor folds are rare in the area, but locally intrafolial isoclinal folds occur in the metasedimentary rocks, and it is probable that the rocks have undergone an early isoclinal folding which gave rise to schistosity and foliation in the metasediments. Almost everywhere, the bedding of the metasediments is parallel with the foliation. This is for example clear for the marble horizons, which follow the foliation in the neighbouring migmatites. In detail, however, the marble horizons are internally irregularly folded.

b) Fold structures

The foliations, indicated on the map, describe rather regular structures. On islands III, VI, IX, and X the foliation swings regularly from SE-NW to E-W as one goes from north-west to south-east. On islands I and II roughly NW strikes of the foliation prevail, but there is a clear tendency for the foliation to become parallel with the boundaries of the grey granite upon nearing the contact. On island XI and Milneland the foliation seems to lie in a number of regular folds.

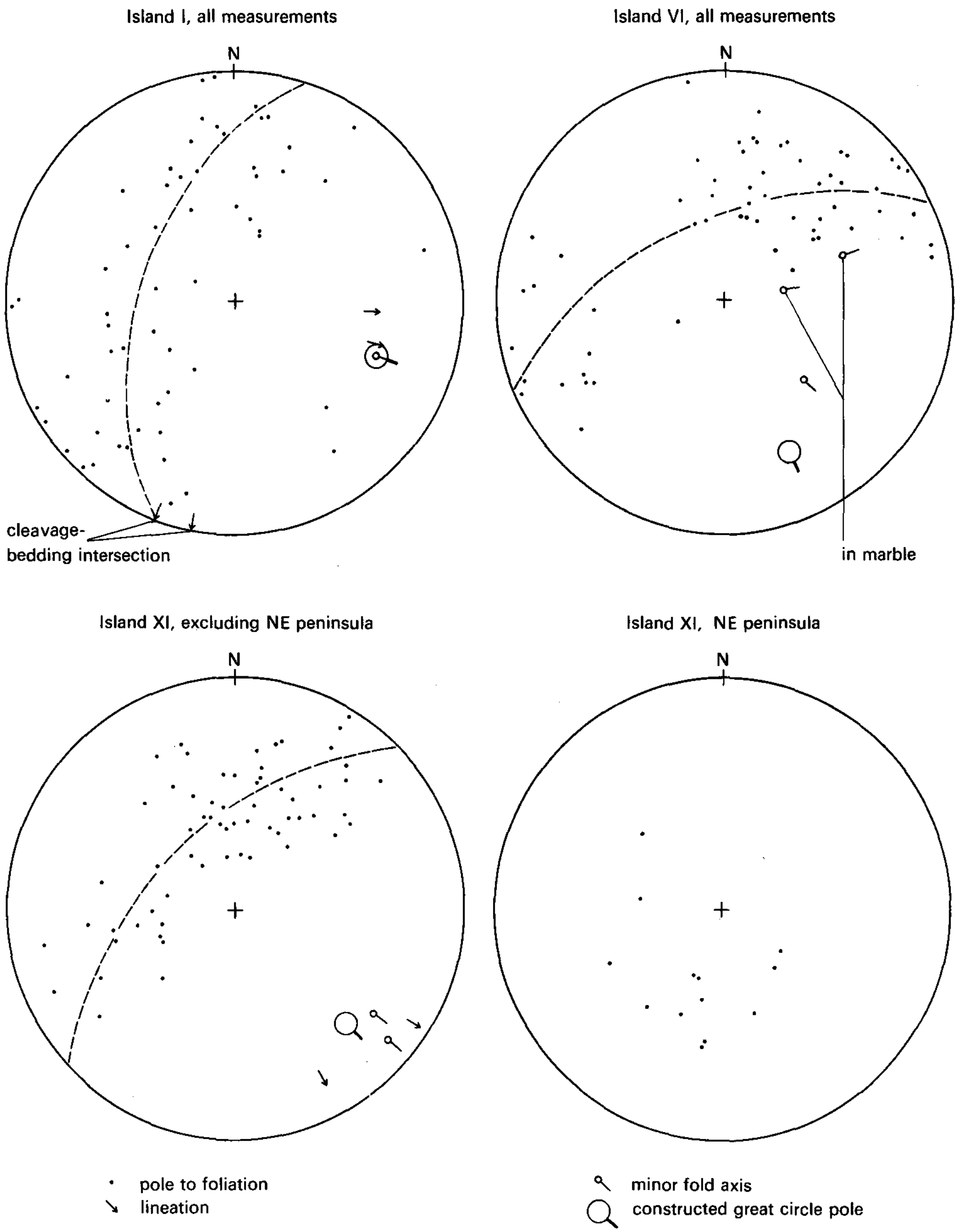


Fig. 3. Stereographic projections (lower hemisphere) of planar and linear elements on some of the islands in the Bjørneøer group.

Often the foliation dips steeply towards the north-east or south-west, and areas with north-east dipping foliations alternate with areas where the foliation dips towards the south-west. In between, the foliations are vertical (see islands IV and VI). Thus the foliation does not lie in normal syn- or antiforms, although these structures may be formed by the bedding of the metasediments even though they are unrecognisable.

Plotted on equal area diagrams the foliations spread in broad, great circle patterns with poles plunging some 30° towards the south-east. This is illustrated by diagrams with the measurements for island I, island VI, and island XI (fig. 3). There are local deviations from this pattern. The foliations on the north-eastern peninsula of island XI, for example, dip towards the north and the north-east, and do not fit into the girdles with south-east plunging poles.

On island XI several large open folds are present. Possibly one is dealing with a pattern of double folding and locally one gets the impression that the folds are slightly overturned. For example, along the south coast of island XI the foliation dips towards SSW, there is a hinge zone around 10.0-4.0, and in the other flank of the fold, around 11.0-3.8, the foliation dips towards the south-west again. Additional measurements in the hinge areas of the folds would perhaps lead to a better understanding of these folds; often, however, the structure of the rocks becomes very irregular in the hinge areas.

Probably these open structures which the foliation describes are largely late- or post-migmatitic, because it is mostly the foliation in the migmatites (schlieren etc.) which describes these structures. As said before it is probable that the foliation was largely formed during a phase of isoclinal folding, probably mainly before the migmatisation; foliated metasediments often occur as inclusions within the migmatites.

c) Crush zones

Over the whole area crush zones occur. They can easily be seen on the aerial photographs. They mostly trend N-S to NNW-SSE, but also roughly E-W crush zones occur. Several times it could be shown that these crush zones give rise to hardly any displacement of the adjoining rocks. They are not faults. Real faults have not been found in the area.

DISCUSSION

a) The metasediments

The sedimentary origin of the fine-grained biotite gneisses, mica schists, marble, and quartzites is evident in the field and will not be discussed further. The presence of hypersthene, sillimanite, clinopyroxene, biotite, hornblende, and cordierite indicates that the rocks were metamorphosed under low pressure granulite facies conditions, the occurrence of ortho- + clinopyroxene being diagnostic for the granulite facies and the occurrence of cordierite being indicative for low pressure conditions. It is of interest to note that in the inner Nordvestfjord similar metasedimentary rocks contain kyanite and sillimanite (Henriksen and Higgins, 1969) and thus were metamorphosed under high pressure conditions. These rocks form the supracrustal part of the so-called Krummedal sequence and in eastward direction they pass into migmatites and granites which occupy the outer part of Nordvestfjord and Bjørneøer (Henriksen and Higgins, op. cit.).

Inclusions of metasediments are ubiquitous in all migmatites, and the granites etc. have been emplaced into the metasediments. The metasediments must therefore be the oldest rocks in the area. If the metasediments of the Bjørneøer can be correlated with the lithologically similar rocks of the Krummedal sequence in inner Nordvestfjord which belong to the Caledonian geosyncline (Henriksen and Higgins, op. cit.) the migmatite area of the Bjørneøer cannot be regarded as a basement in relation to the Caledonian geosyncline.

b) The granites

Of the three granite types, the younger granite and the migmatite granites are real granites; the grey granite is a granodioritic to quartz dioritic rock. The younger granite is without doubt the youngest, since is forms intrusive dykes, both in the grey granite and in the migmatite granites.

The grey granite has diffuse transitions to the surrounding migmatites and has not been found as dykes. There might therefore be doubt as to the igneous origin of the granite. The fact, however, that the foliations in the surrounding migmatites seem to be rotated in the neighbourhood of the granite and the petrographical evidence (texture, type of twinning of the plagioclase) as well as the occurrence of clearly rotated angular inclusions favour an igneous origin of the grey granite.

The migmatite granite occurs irregularly distributed over the area, often in small bodies full of inclusions, and often as narrow veins in metasedimentary rocks. The origin and emplacement of the migmatite granite is one of the most interesting problems in the area. The migmatite granite cannot possibly be wholly locally derived by anatexis of the metasediments. The granite is very leucocratic and corresponding amounts of melanosome material have not been found.

The age relationship between the migmatite granite and the grey granite is difficult to establish. There are features to indicate that the grey granite is younger; diorite has been found to cut migmatite granite but occurs elsewhere as inclusions in grey granite. Other features point in the other direction; veins of migmatite granite have been found to cut grey granite, and homogeneous grey gneisses, which perhaps were derived from grey granite, are locally migmatised by migmatite garnet granite.

The most reasonable solution of this problem is to assume that the migmatisation of the rocks (and the formation of migmatite granite) was a long-drawn-out process that started before the emplacement of the grey granite and continued after the emplacement of the granite. The same applies with respect to the diorites and some of the dykes.

c) The diorites

The diorites are rather variable in composition, but the normally small amounts of alkali feldspar and quartz and the composition of the plagioclase (generally andesine) indicate an essentially dioritic composition. The igneous origin of the diorites is evident. Most of the diorites and comparable rocks occur as inclusions in the migmatites, but locally they cut through migmatites as dykes or apophyses. On islands VII and VIII the diorites have preserved their igneous textures and they are hardly foliated, but the corresponding rocks in the migmatites may show clear foliation.

From these features one gets the impression that the dioritic rocks intruded synmigmatitically or in between two periods of migmatisation. It is likely that they are younger than the (possible) early tectonic phase which gave rise to the foliation and schistosity in the metasediments, otherwise they would probably have been foliated throughout. The diorites contain hypersthene and clinopyroxene and thus have a granulite facies paragenesis. The tectonised, schistose, dioritic rocks in the migmatites may still contain both pyroxenes, and it is therefore probable that the migmatisation in this stage took place under granulite facies conditions. In the migmatite granite, however, no hypersthene has been found.

There is a possibility that the dioritic rocks and the grey granite are more or less contemporaneous and comagmatic; this question has to be investigated further.

d) The dykes

The thin basic dykes and the porphyrites cut through most of the migmatite granite veins, but often they are irregular and one gets the impression that the granites they cut were not completely solidified at the time of intrusion of these dykes. Locally the basic dykes and porphyrites are cut by granitic veins. The dykes are thus probably of late migmatitic age.

The porphyrites cut the basic dykes and must thus be younger. The porphyrites must also be younger than the grey granite which they irregularly cut. The porphyrites, although they are partly free of alkali feldspar, do not contain hypersthene and temperatures must have fallen or more water must have been present at the time of their emplacement.

The granitic dykes cut through all other rocks, and the common dilatational phenomena show that the rocks in which they intruded were completely solidified and brittle.

Petrographically there seems to be a gradual transition between the different types of dykes, and it seems possible that they are genetically related and formed from a slowly differentiating magma. Intersections of dykes confirm this point of view. The late granitic dykes seem to be related to the younger granites, the larger bodies of which can be regarded as very thick dykes.

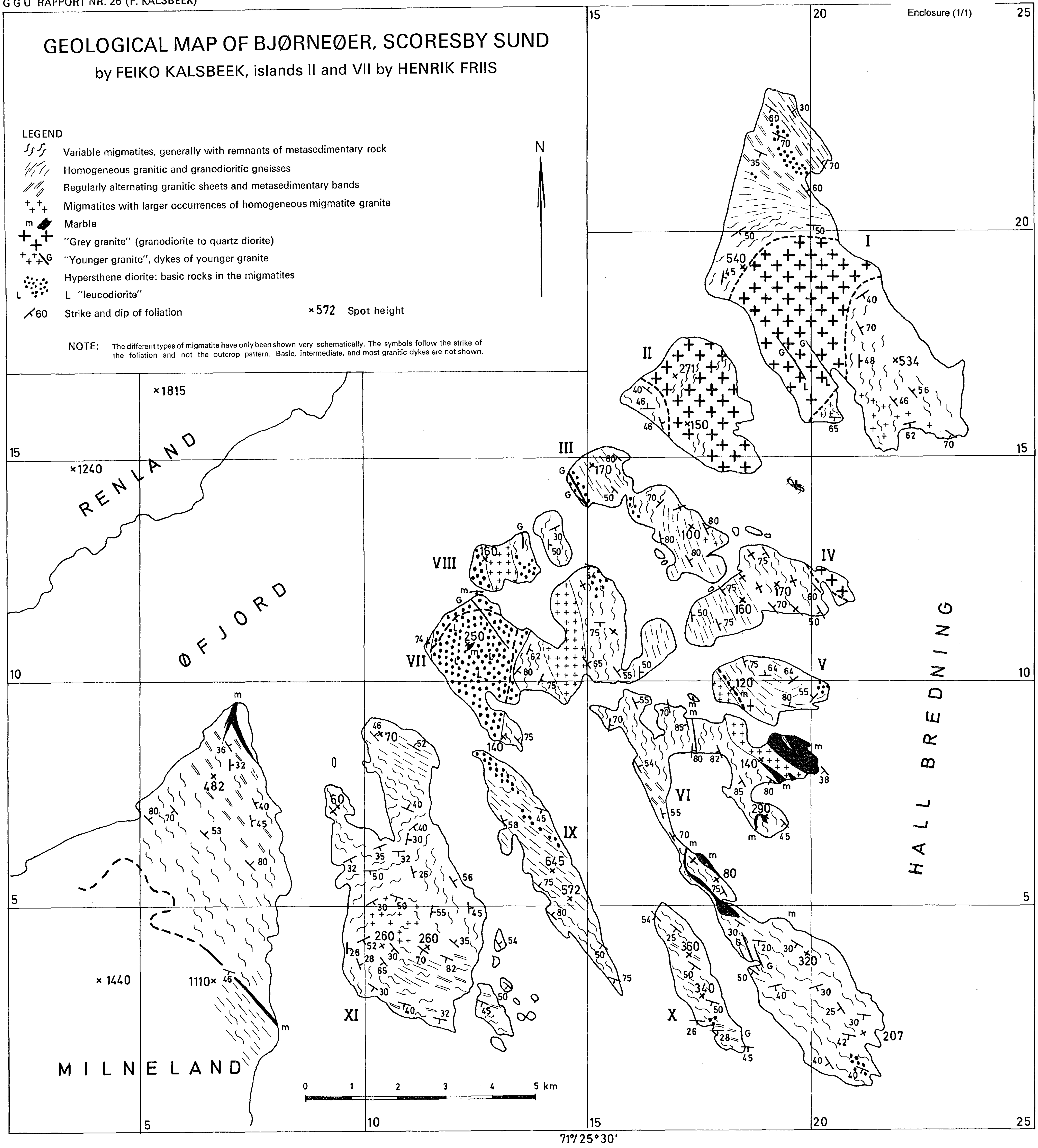
The younger granites are locally cut by pegmatitic dykes, which are the youngest rocks recognised in the area.

REFERENCES

Koch, L. (1955) Report on the expeditions to Central East Greenland 1926-39 conducted by Lauge Koch. Meddr Grønland, Bd. 143, Nr. 2.

Henriksen, N. and Higgins, A. K. (1969) Preliminary results of mapping in the crystalline complex around Nordvestfjord, Scoresby Sund, East Greenland. Rapp. Grønlands geol. Unders., Nr. 21, 5-20.

Larsen, O. (1969) K/Ar Age Determinations. Rapp. Grønlands geol. Unders., Nr. 19, 62-67.


GEOLOGICAL MAP OF BJØRNEØER, SCORESBY SUND
by FEIKO KALSBEEK, islands II and VII by HENRIK FRIIS
LEGEND
Variable migmatites, generally with remnants of metasedimentary rock
Homogeneous granitic and granodioritic gneisses
Regularly alternating granitic sheets and metasedimentary bands
Migmatites with larger occurrences of homogeneous migmatite granite
m Marble
"Grey granite" (granodiorite to quartz diorite)
G "Younger granite", dykes of younger granite
Hypersthene diorite: basic rocks in the migmatites
L "leucodiorite"
60 Strike and dip of foliation
×572 Spot height
NOTE: The different types of migmatite have only been shown very schematically. The symbols follow the strike of the foliation and not the outcrop pattern. Basic, intermediate, and most granitic dykes are not shown.
N
RENLAND
ØFJORD
MILNELAND
HALL BREDNING
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
0 1 2 3 4 5 km
71°/25°30'

Grønlands Geologiske Undersøgelse

Reports

Nr. 10 Analytical procedures used in the Geochemical Laboratory of the Survey. 1967 by B. I. Borgen. D. kr. 4.00.

No. 11 Report of activities, 1966. (Out of print).

No. 12 The chromite deposits of the Fiskenæsset region, West Greenland. 1967 by M. Ghisler and B. F. Windley. D. kr. 6.00.

No. 13 Stratigraphy and structural development of the Precambrian rocks in the area north-east of Disko Bugt, West Greenland. 1967 by A. Escher and M. Burri. D. kr. 3.50.

No. 14 Petrology and geology of the Precambrian Gardar dykes on Qaersuarssuk, South Greenland. 1968 by W. S. Watt. D. kr. 4.00.

No. 15 Report of activities, 1967. 1968. (Out of print).

No. 16 The geological setting and mineralizations west of Lilianmine, South Greenland. 1968 by M. Ghisler. D. kr. 4.00.

No. 17 The Tartoq Group on Nuna qaqortoq and in the Iterdlak area, South-West Greenland, 1968 by A. K. Higgins. D. kr. 4.00.

No. 18 Preliminary account of the geology of the Kvanefjeld area of the Ilímaussaq intrusion, South Greenland. 1969 by H. Sørensen, J. Hansen and E. Bondesen. D. kr. 6.00.

No. 19 Reports of activities. 1968. 1969. D. kr 6.00.

No. 20 On the applicability of magnetic prospecting for chromite in the Fiskenæsset region, West Greenland. 1969 by M. Ghisler and P. Vallabh Sharma. D. kr. 3.50.

No. 21 Report on the 1968 geological expedition to Scoresby Sund, East Greenland. 1969. D. kr. 6.00.

No. 22 Oil and gas prospects in the Cretaceous-Tertiary basin of West Greenland. 1969 by G. Henderson. D. kr. 6.00.

No. 23 The Precambrian rocks of the Egedesminde-Christianshåb area, West Greenland. 1969 by G. Henderson. D. kr. 4.00.

No. 24 The mode of occurrence and petrogenesis of the sapphirine-bearing and associated rocks of West Greenland. 1969 by R. K. Herd, B. F. Windley and M. Ghisler. D. kr. 4.50.

No. 25 The chronology and petrography of the Gardar dykes between Igaliko Fjord and Redekammen, South Greenland. 1969 by J. H. Allaart. D. kr. 4.50.

No. 26 Preliminary account on the geology of Bjørneøer, Scoresby Sund. 1969 by F. Kalsbeek. D. kr. 4.00.

Bulletins and Miscellaneous Papers are only available on exchange with institutions and libraries. Reports are obtainable on exchange, or may be purchased from Grønlands Geologiske Undersøgelse, Østervoldgade 10, DK–1350 Copenhagen K, Denmark.