GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT NR. 13

The Geological Survey of Greenland
Report no. 13

Stratigraphy and structural development of the Precambrian rocks in the area north-east of Disko Bugt, West Greenland

by

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KØBENHAVN 1967

Grønlands Geologiske Undersøgelse

Østervoldgade 5-7, Copenhagen K

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STRATIGRAPHY AND STRUCTURAL DEVELOPMENT OF THE PRECAMBRIAN ROCKS IN THE AREA NORTH-EAST OF DISKO BUGT, WEST GREENLAND

by

A. ESCHER AND M. BURRI

With 9 figures and 1 map

1967

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Abstract

The Precambrian rocks in the area north-east of Disko Bugt can be divided into a lower gneiss group and an upper supracrustal group. The lower part of the supracrustal group consists of quartzites, amphibolites and garnet-staurolite schists, while the upper part is mainly semipelitic schist.

The gneisses were affected by three successive phases of deformation, while in the supracrustals only the two latest phases of folding can be recognized. Evidence is given in support of the idea that the supracrustals were deposited on a gneiss basement after the first phase of folding, the basement being later reactivated mainly during the third and last deformation.

Two main tectonic complexes can be distinguished in the area mapped: a southern complex characterized by a predominant ENE direction of the fold axes and a northern complex in which the main fold axes are strongly curved around a central gneiss dome. The transition zone between the southern and northern complex is marked by the presence of several important faults and mylonites.

The gneiss dome is flanked in its northern part by a thick granite sheet. The dome structure appears to have been formed by a combination of diapiric movements and the interference between two successive deformations.

The gneisses and lower supracrustals recrystallized under amphibolite facies conditions, while greenschist facies conditions prevailed during the recrystallization of the upper supracrustals.

INTRODUCTION

During the summer of 1964 geological reconnaissance mapping was carried out in the area north-east of Disko Bugt in West Greenland (fig. 1). This area extends from Claushavn to Qeqertaq and lies between the latitudes 69°N and 70°N. The mapping was done as a part of the 1:500 000 mapping project of the Geological Survey of Greenland (GGU). It was carried out directly on aerial photographs and was subsequently compiled on 1:200 000 maps. Aerial photographs and maps were supplied by the Geodetic Institute, Copenhagen.

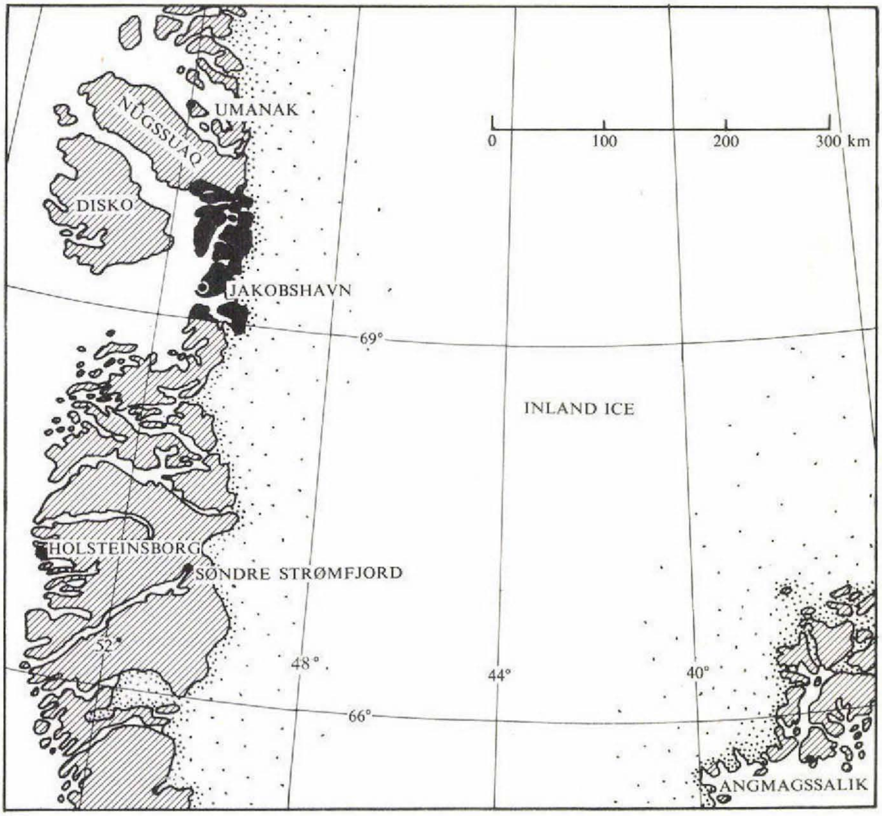

Fig. 1. Index map showing in black the location of the area described.

The limited time available for the investigation of this relatively large area did not permit a complete coverage of the region. The geology in several inland areas is therefore based only on the interpretation of aerial photographs. This report presents a summary of the geological observations and conclusions obtained during the reconnaissance mapping. It only gives the general stratigraphical and structural outlines. Much more detailed investigation will be needed to obtain a complete geological picture of the area.

Previous investigations

Giesecke (1910) visited the area in 1811 and gives mineralogical descriptions of isolated samples. Rink (1857) made a few investigations in the Jakobshavn area and on Arveprinsens Ejland. He recognized several dolerite dykes and mentions the presence of staurolite schists in the northern part of the island. The first preliminary geological map of the area was made by Sylow (1889). He recognized the presence of granite in the northern Atâ Sund region and measured a few strikes and dips. Krueger (1928) studied particularly the joint systems and their topographical significance. Ravier (1949), as a member of the French Polar Expeditions, made detailed and accurate observations in the area south of Eqe and on Qapiarfît. His observations and local geological map were of great value in the reconstruction of the geology of that area.

STRATIGRAPHY AND LITHOLOGY

The Precambrian rocks in this part of Greenland can be divided into two main groups, a lower "Jakobshavn Gneiss" group and an upper "Anap nunâ Group" comprising supracrustal rocks.

The Jakobshavn Gneiss covers most of the central and southern part of the mapped area and very similar gneiss occurs in the north, around Qeqertaq. Overlying these gneisses, the Anap nunâ Group forms a large synclinal belt in the northern part of the area.

In the Atâ Sund region a huge granite sheet occurs in the contact area between gneisses and supracrustals. This "Atâ Granite" was mainly formed by replacement.

Isotopic age determinations

Two K/Ar isotopic age determinations were made by O. Larsen of the Mineralogical-Geological Institute, Copenhagen, on biotites from gneisses near Jakobshavn and Qeqertaq. The following ages were obtained:

Gneiss near Jakobshavn: 1740 $\pm$ 30 m. y.

Gneiss near Qeqertaq: 1750 $\pm$ 50 m. y.

These values of course do not give the real age of the original deposits; they only show at which time the biotite crystallized or recrystallized, and may therefore date approximately the latest dynamothermal event which affected the rocks in the area.

The Jakobshavn Gneiss

The predominant rock type is a light-coloured granodioritic gneiss composed mainly of quartz, oligoclase (10-20 % An) and biotite. It generally contains granitic veins or bands made up essentially of microcline and quartz. Common accessory minerals are hornblende, epidote, zoisite, chlorite and sphene.

It has not been possible to recognize a detailed lithostratigraphy in the Jakobshavn Gneiss; two main formations could be distinguished: the (lower) Satût Formation and the (upper) Klokkerhuk Formation.

a) The Satût Formation

This formation is characterized by the predominance of thick horizons of siliceous gneiss and by the almost complete absence of amphibolites.

The siliceous gneisses are best preserved in the Satût area, on the south-west coast of Arveprinsens Ejland, where they form thick layers of light reddish-grey gneiss interbedded with normal granodioritic gneiss. The thickness of the siliceous layers varies from a few decimetres to several metres. They are essentially composed of quartz (55-75 vol. %) with oligoclase and biotite.

The same type of siliceous gneiss occurs farther to the north, in the central part of Arveprinsens Ejland, where it forms the core of a large anticline. Shallow-dipping siliceous gneisses occur also north of Jakobshavn where they cover large areas east of Bredebugt.

The apparent thickness of the Satût Formation can reach 1500 metres. Due to many repetitions, the true thickness cannot be measured.

b) The Klokkerhuk Formation

This formation overlies the siliceous gneisses and forms the upper part of the Jakobshavn Gneiss group. It is mainly composed of light grey granodioritic gneiss and contains many amphibolitic horizons. These dark beds vary in composition from proper amphibolite to hornblende-biotite gneiss. Their thickness is also very variable, ranging from a few centimetres to several hundreds of metres.

The Klokkerhuk Formation is best represented in the areas north and south of Jakobshavns Isfjord and in the southern part of Arveprinsens Ejland near Klokkerhuk. In these areas the gneisses are regularly banded and the amphibolites are very continuous, which makes it easy to recognize the structural features. Near Klokkerhuk the degree of metamorphism is slightly lower and one can distinguish thick beds of biotite-hornblende schist within the amphibolites and gneisses.

The Klokkerhuk Formation also forms large areas farther to the north, between Atâ Sund and the fjord Pâkitsup ilordlia. Here the rocks are often strongly migmatitic; the gneiss is irregularly banded and contains numerous granitic veins while the amphibolites are discontinuous and in many places only form thin lenses and schlieren in the gneiss.

Augen textures are very common in the Klokkerhuk gneisses directly south of the fjord Pâkitsup ilordlia.

Due to the strong folding and refolding it is not possible to give an accurate value for the thickness of the whole formation. The apparent thickness reaches at least 2000 metres.

The Anap nunâ Group

The Anap nunâ Group overlies the Jakobshavn Gneisses concordantly and forms a curved synclinal belt which extends from the northern part of Arveprinsens Ejland, over Anap nunâ and Qapiarfît, to the area east of Eqe.

The relatively low degree of metamorphism made it possible to establish a provisional lithostratigraphy (fig. 2). Two main formations can be distinguished, a (lower) Niaqornarssuaq Formation, made essentially of quartzites and mica schists, and an (upper) Qiláussaq Formation, composed mainly of semipelitic schists. These two major lithological divisions were recognized and described by Ravier (1949) in the area east of Eqe.

a) The Niaqornarssuaq Formation

Vertical and lateral variations in lithology are very common in this formation. There are however two characteristic features; its base is generally marked by the presence of quartzites and its top nearly always consists of chlorite-sericite schist (fig. 2).

The basal quartzites are particularly well developed on the Anap nunâ peninsula, where they form Niaqornarssuaq mountain. They are very pure and contain only very small amounts of carbonate, sphene, albite and hematite. Thick sills of amphibolite are often interlayered within the quartzites. On the Qapiarfît peninsula and east of Eqe the quartzites grade laterally into quartz-biotite schists.

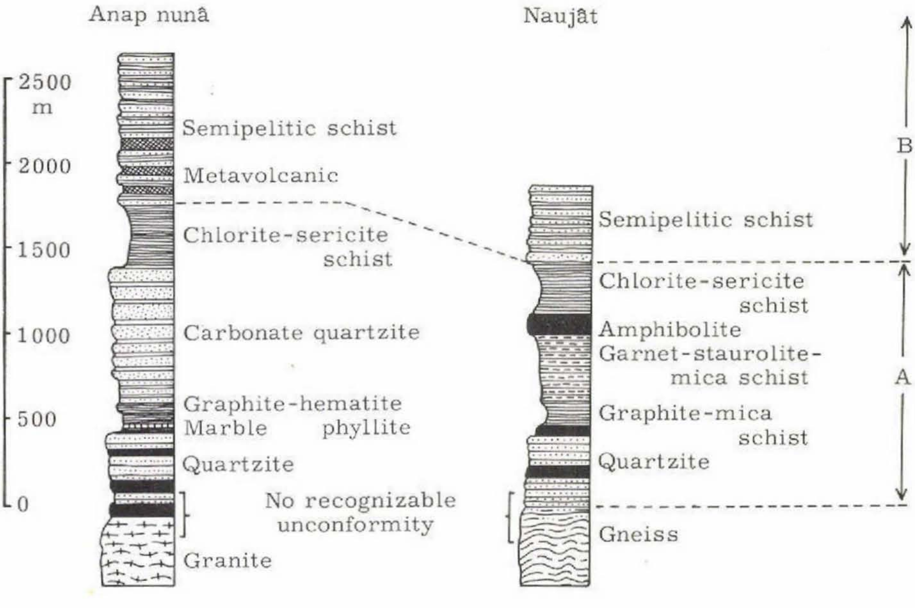

Fig. 2. Simplified columnar sections across the supracrustal rocks at Anap nunâ and Naujât. A: Niaqornarssuaq Formation. B: Qiláussaq Formation.

On Anap nunâ the basal quartzites are overlain by dark graphite-hematite phyllites which contain a thin marble horizon. Massive hematite-magnetite beds of several metres thickness occur in a few places at the base of the phyllites. Ripple marks are common in these phyllites. This sequence grades upwards into a thick formation of carbonate quartzites.

The carbonate quartzites contain between 10 and 50 vol. % carbonate, and are often brecciated. Thin conglomerate horizons are frequent. The carbonate quartzites cover large areas on the peninsulas Qapiarfît and Anap nunâ but appear to be absent in the supracrustals of north-east Arveprinsens Ejland and Naujât. Here the basal quartzites are overlain concordantly by a thick succession of biotite-muscovite schists which contain at the base graphite and hematite, and in the upper part garnet (almandine), staurolite and accessory sillimanite (fig. 2). The high cliffs of Naujât are for a large part made of these garnet-staurolite schists.

In most of the observed supracrustal areas the upper part of the Niaqornarssuaq Formation consists of chlorite-sericite schists. Epidote and zoisite are often found in these schists. Thin beds of quartzites occur locally in their upper part.

The total thickness of the Niaqornarssuaq Formation reaches a maximum of 1600 metres on the Anap nunâ peninsula. Due to repetitions, this value does not represent the true thickness.

b) The Qiláussaq Formation

This formation consists essentially of a very thick succession of semipelitic schists. In detail, these rocks are mostly composed of thin layers of quartz-biotite-muscovite schist alternating with thicker beds in which quartz and plagioclase predominate. Graded bedding and current bedding are locally well preserved in the quartz-plagioclase beds. The most common accessory minerals are secondary chlorite, graphite, apatite, tourmaline and ore.

The lower part of the Qiláussaq Formation is characterized by the presence of several thick horizons of metavolcanic rocks interlayered within the semipelitic schists. Most of these metavolcanic rocks are strongly metamorphosed into hornblende-chlorite-muscovite schists. However, in the central part of Anap nunâ, as in the area east of Eqe near the Inland Ice, original volcanic textures can easily be recognized. Most common are lapilli tuffs.

In some places the metavolcanics contain relics of pyroxenes within an ophitic arrangement of plagioclase laths.

Calc-silicate lenses, made essentially of quartz, actinolite, carbonate and plagioclase, are often found interlayered in the semipelitic schists throughout the formation.

The total thickness of the formation is not known since the top is not present. On Qapiarfît however it reaches a thickness of over 2000 metres.

The Atâ Granite

The Atâ Granite occurs in large areas around the northern part of Atâ Sund and between the fjords Torssukátak and Langebugt. Its composition varies from granodioritic or quartzdioritic at the borders to granitic in the central part. The main constituents are quartz, microcline, plagioclase (10-30 % An) and biotite. Accessory minerals are hornblende, epidote, zoisite, sphene, apatite and ore.

Field evidence shows that this granite was mainly formed by metasomatic replacement of the gneisses belonging to the upper Klokkerhuk Formation, and only for a small part by replacement of supracrustal rocks (see the general geological map). The contact between gneiss and granite is always very gradual; the banded and veined gneiss changes gradually, often over several kilometres, into a foliated granite, the strike and dip of the foliation remaining parallel to that of the country rock. The contact between basic supracrustals and granite is in most places agmatitic. In the north-west part of Arveprinsens Ejland the granite contains several very large inclusions of supracrustal rocks. These inclusions appear to have kept their original orientation during the granitization. The central part of the Atâ Granite is generally very homogeneous without any foliation. This is particularly the case on the island Igdluluarssuit.

The Atâ Granite appears to form a huge sheet overlying the gneisses of the lower Klokkerhuk Formation and underlying the supracrustal rocks of the Niaqornarssuaq Formation (fig. 7). The thickness of this granite sheet reaches over 2000 metres in the northern Atâ Sund area.

STRUCTURE

The limited time available for the mapping did not permit a detailed investigation of the area. Only the main structural features could be obtained. In a few localities, where the rocks contain good marker

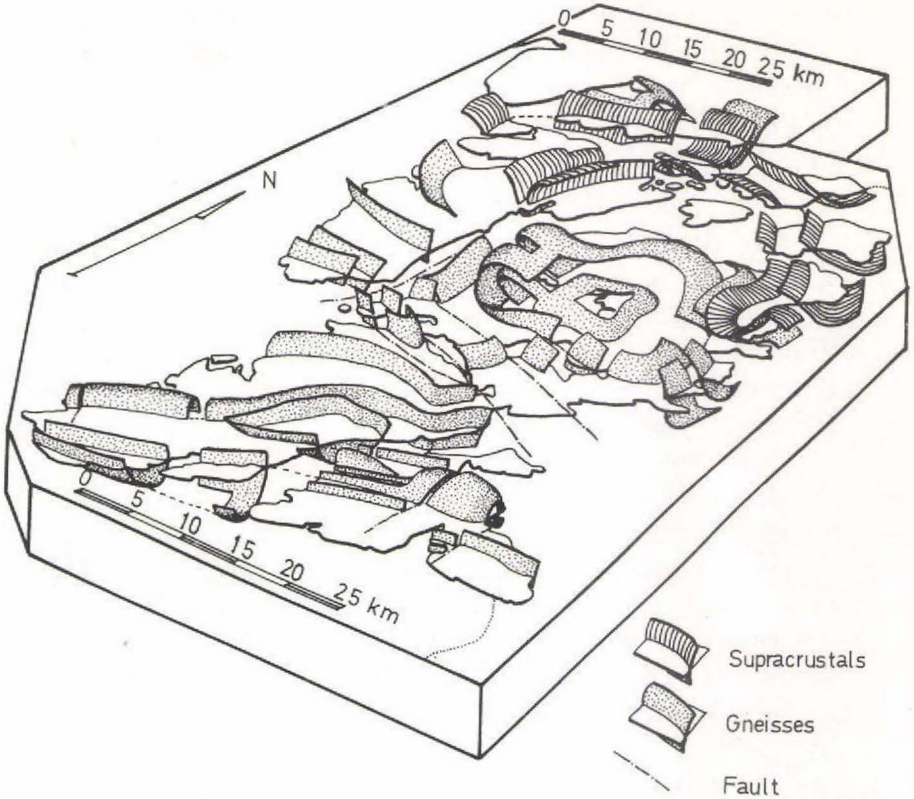

Fig. 3. Simplified stereogram showing the main structural pattern in the area between Jakobshavns Isfjord and Qeqertaq.

horizons, minor folds were examined in more detail. This was done to get additional information about the structural evolution of the area.

Two main tectonic complexes can be distinguished in the area mapped: a southern complex characterized by a predominant ENE direction of the fold axes and a northern complex in which the main fold axes are strongly curved around a central gneiss dome. Fig. 3 shows in a very schematic way these important differences in structural style between the two complexes.

The transition zone between the southern and northern complex extends approximately from the southern tip of Arveprinsens Ejland to the fjords Påkitsoq and Påkitsup ilordlia. It is marked by the presence of several important faults and mylonites. The gneisses in this transition zone show moreover a well-developed augen texture.

The southern structural complex

In this complex the effects of three phases of folding (F1, F2, F3) can be recognized.

The F1 folds are in most places difficult to distinguish and occur mainly as relic minor structures. In a small area north of Jakobshavn harbour, however, F1 folds are well preserved. They are isoclinal minor folds of similar type which in all the observed cases are clearly refolded by the F2 deformation. Due to this refolding the F1 axial trends show considerable variations, mainly between NW and NNE.

The F2 deformation seems to have been the most important in the southern structural complex. It resulted in the formation of a multitude of major and minor folds whose axial directions vary only slightly between NE and ENE. This direction corresponds with the predominant trend of the gneiss layering. Most F2 structures are close to isoclinal folds (Fleuty, 1964) with axial planes dipping steeply to the SSE. The minor F2 folds generally show a typical similar style, while the major structures often display a combination of concentric and similar style.

The F3 deformation resulted in a local buckling of the pre-existing F2 axial planes. In some places it also changed the plunge of the F2 axes. This can be observed in the area situated north-east of Jakobshavns Isfjord, where large elongated domes and basins were probably formed by interference between the F2 and F3 deformations (fig. 3). The axial trend of the F3 structures appears to vary between N and NW. In the southern structural complex most of the effects of the F3 folding can only be observed on a very large scale.

Superposed folds due to the interference between deformations F1 and F2 are well preserved in the area north of Jakobshavn. In the majority of the observed cases, isoclinal F1 folds with small amplitudes are here refolded by isoclinal F2 folds with larger amplitudes. Some of the minor F1 folds can be followed and reconstructed along both limbs of a later major F2 fold. The resulting structural pattern is represented in a very schematic way in fig. 4B. The measurement of several F1 axes

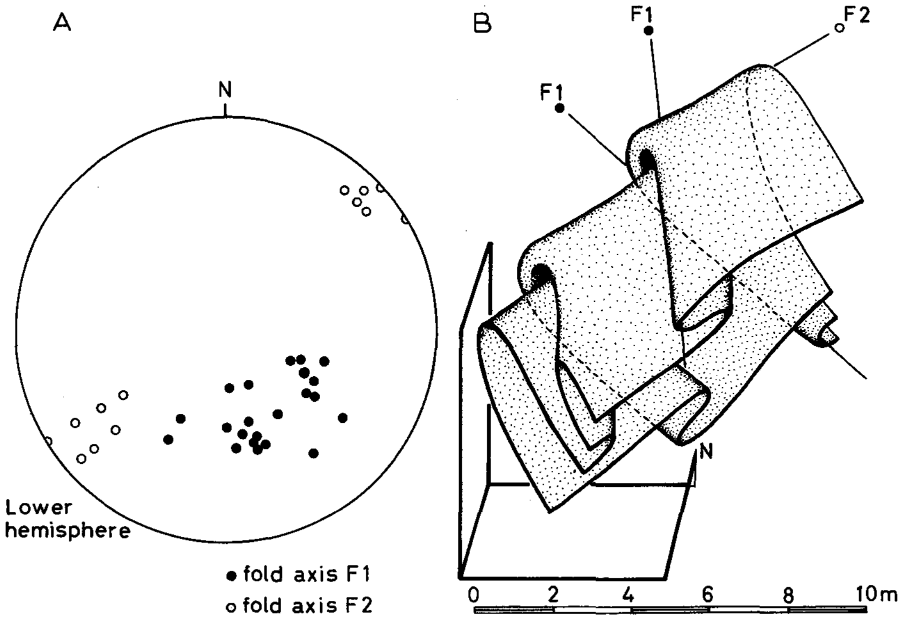

Fig. 4. A: Equal-area projection of minor fold axes in superposed folds north of Jakobshavn. B: Schematic reconstruction of these superposed folds.

of minor folds shows that there is in this limited area a considerable variation in axial plunge and trend, but that the F1 axes are roughly divided into two groups about 50^{o} apart (fig. 4A). These two directions are controlled by the angle between the original F1 axial trend and the actual F2 axial trend and by the dip of the axial plane of the major isoclinal F2 fold.

In a few places the minor F1 folds are clearly refolded by F2 folds with smaller amplitudes. One of these simple superposed folds can be seen in a good cliff exposure south of Jakobshavn (fig. 5). It shows the characteristics of an almost ideal similar-type fold (Ramsay, 1962), being slightly refolded along an F2 axis whose trend makes an angle of approximately 60^{o} with the F1 trend.

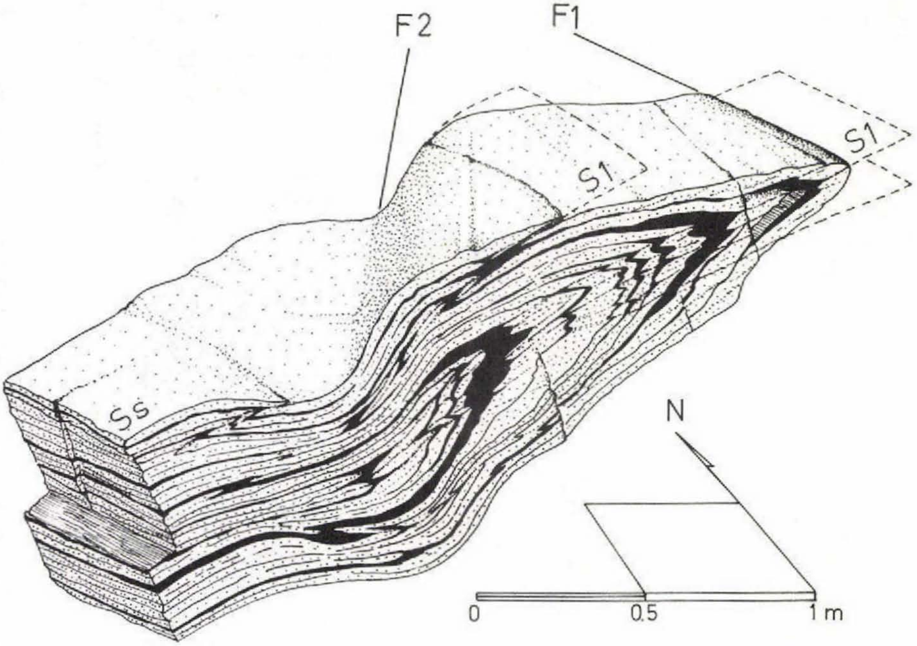

Fig. 5. F1 isoclinal similar fold refolded by an open F2 fold. The axial plane foliation S1 is clearly refolded by F2. Cliff exposure south of Jakobshavn.

The northern structural complex

North of the Pâqitsoq fault zone three closely related structural units can be distinguished: the Talorssuit gneiss dome, the Anap nunâ supracrustal belt and the Atâ Granite sheet.

The Talorssuit gneiss dome

This dome structure, which occupies the gneiss area between Atâ Sund and the Inland Ice, has a diameter of approximately 25 km (fig. 6). It is made of granodioritic gneiss belonging to the Klokkerhuk Formation and contains many amphibolitic horizons which helped to reconstruct its approximate shape. In the western part of the Talorssuit dome the gneisses are gently dipping towards the east. In the northern and southern outer zones of

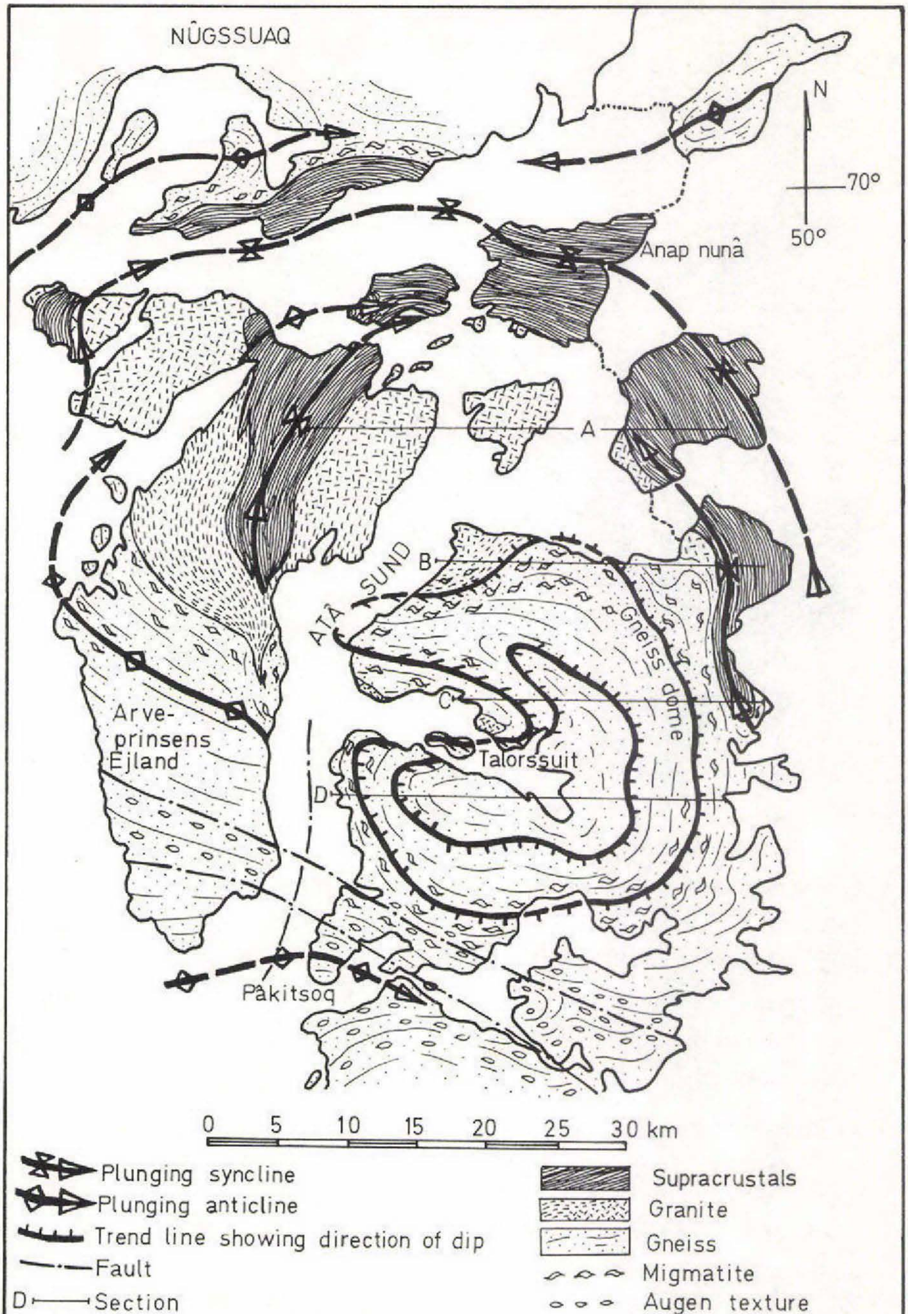

Fig. 6. Simplified structural map of the northern structural complex.

the dome this shallow dip becomes gradually vertical when going to the east and finally changes into a normal outward domal dip towards the north and south respectively. These changes in dip were observed in continuous amphibolitic horizons. The pattern described is shown in a very schematic way on fig. 6. It can best be explained by the existence of an overturned flank in the western part of the dome. The strike and dip of the amphibolite layers in the inner part of the fjord Kangerdluarssuk show

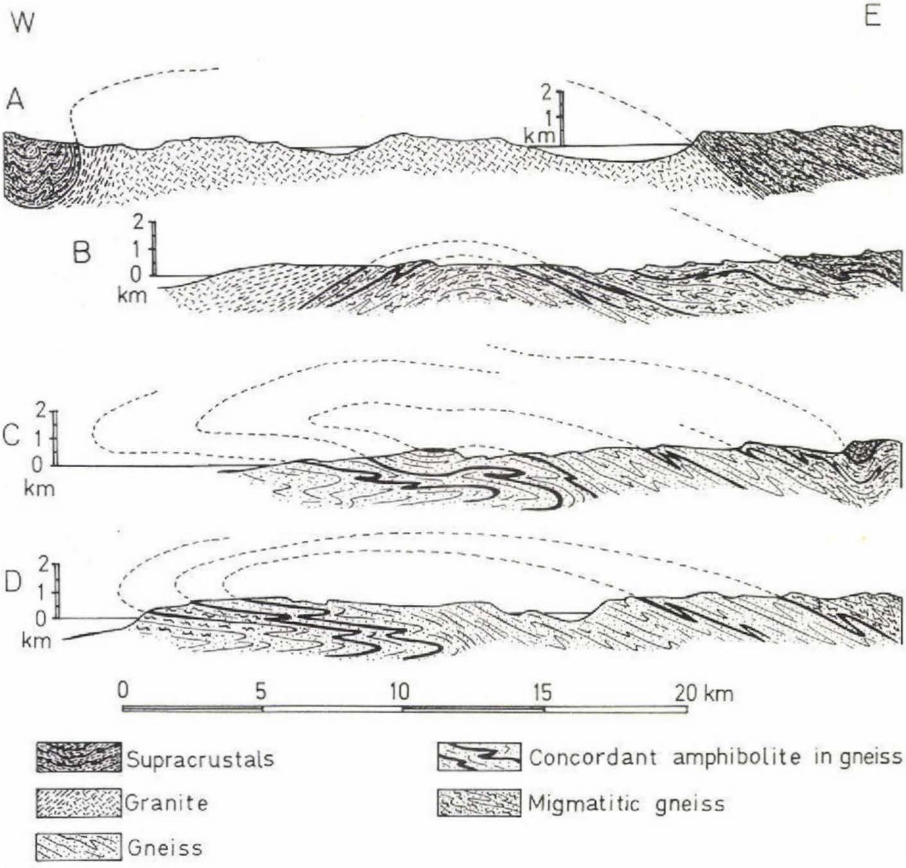

Fig. 7. Four hypothetical sections across the Talorssuit gneiss dome. The position of the sections is shown on the structural map on fig. 6.

that the overturned flank forms a nappe-like structure with locally an overlap of more than 12 km (figs. 7 and 8). If this is true the overturned gneiss dome is very similar in shape to one of Haller 's (1956) "Migmatitstirne" which he observed in the Caledonides of East Greenland. In the central part of the dome the gneiss is banded or smallfolded and it is only in the outer shell that the gneiss displays intense migmatitic features. This outer zone is in many places granitized, particularly in the northern part of the dome. The composition is thus quite different from Haller 's dome structures which mostly possess a granitic and migmatitic core.

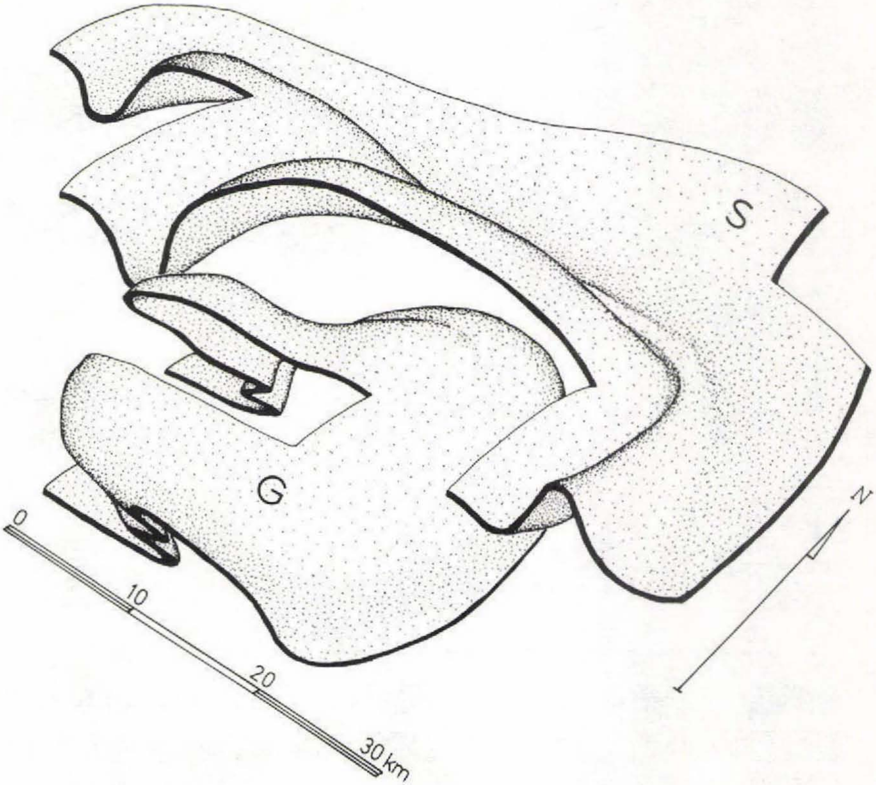

Fig. 8. Stereogram showing the theoretical reconstruction of the Talorssuit gneiss dome (G) and the Anap nunâ supracrustals belt (S).

Minor structures in the Talorssuit dome area have very variable axial directions and it is generally difficult to establish the relations between the different folds. Clearly superposed minor folds were observed on the north shore of Kangerdluarssuk fjord. These are mostly NNW trending folds which refold in a very plastic way smaller structures possessing originally an ENE axial trend. It seems logical to assume that the ENE and NNW folds correspond respectively to the F2 and F3 structures from the southern structural complex. On the north side of the fjord Påkitsup ilordlia similar refolding of F2 isoclinal folds by major F3 folds can clearly be recognized. Relics of still older folds, corresponding probably to the F1 phase of deformation, can be seen in several places in the Talorssuit gneiss dome area. They are mostly very tight isoclinal minor structures with a strongly developed axial plane foliation.

The Anap nunâ supracrustals belt

In the northern part of the northern structural complex, supracrustal rocks form a wide synclinal belt which curves around a part of the Talorssuit gneiss dome. This belt is made of two major synclines whose axial trends vary considerably in direction (figs. 6 and 8). Near the Inland Ice the two synclines are separated only by a minor anticline and the effect is that of a large synform which plunges slightly to the NW. In the western part of the belt, on Arveprinsens Ejland, the two synclines diverge and are separated by a major anticline.

Simple superposed folds were observed in the garnet-staurolite schists south of Qeqertaq. They comprise close to isoclinal, zig-zag and chevron folds trending originally E-W which are refolded by open concentric folds plunging steeply to the S (fig. 9). These two successive phases of folding correspond probably to the F2 and F3 deformations observed in the southern structural complex. No relic F1 structures could be found in the supracrustal series.

The Atâ Granite sheet

North and north-west of the Talorssuit gneiss dome a thick granite sheet separates the gneisses from the supracrustals (figs. 6 and 7). Structural evidence shows that this granite was mainly formed by replacement of gneisses and lower supracrustals. It seems likely that the total volume of the replaced rocks was smaller than the volume of the actual granite. This swelling, due to the addition of quartzo-feldspathic material, could explain

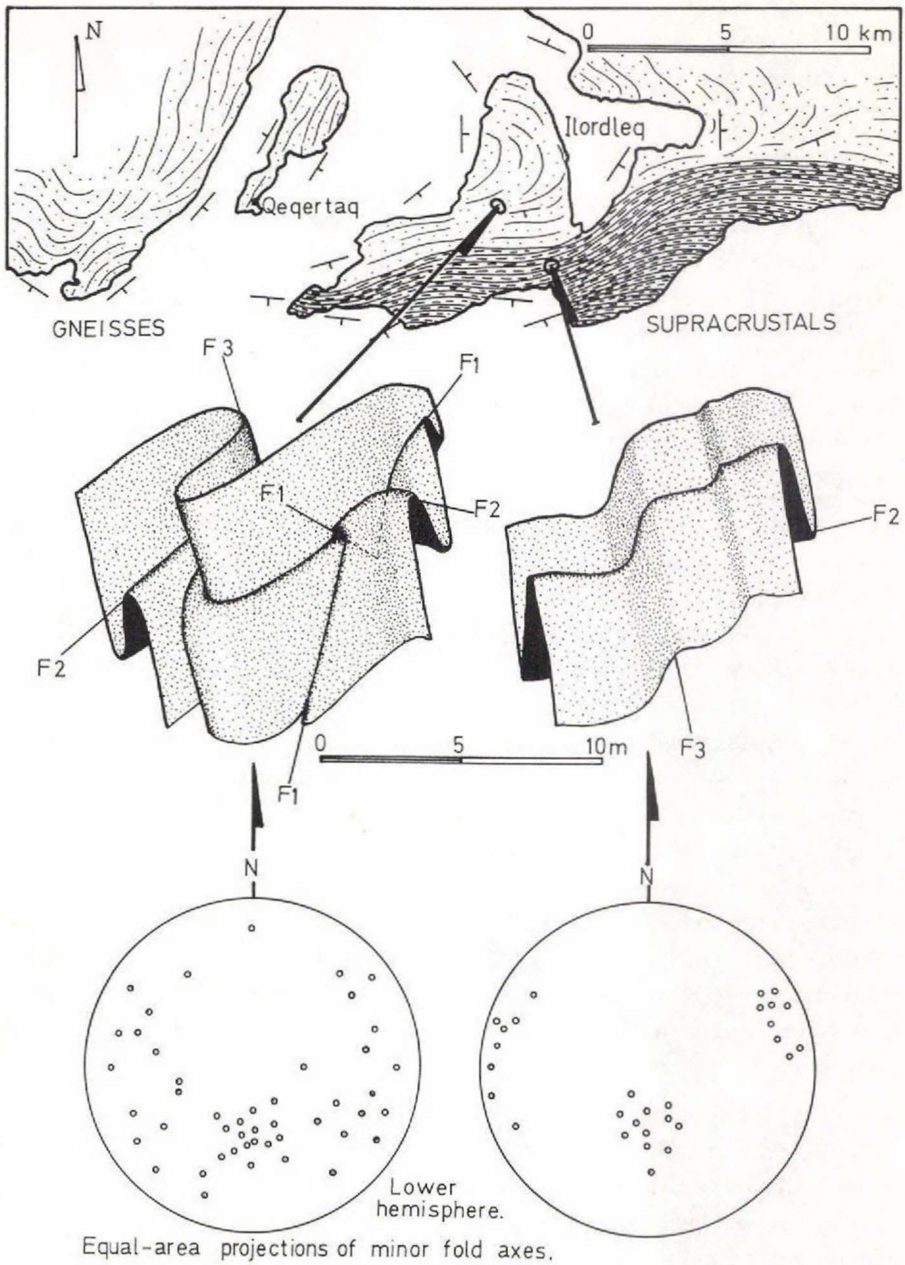

Fig. 9. Difference in structural style between the supracrustals and gneisses in the area south-east of Qeqertaq.

the eccentric position of the gneiss dome with respect to the curved belt of supracrustal rocks (fig. 6). The Atâ Granite forms a mantle over the northern part of the gneiss dome and is itself covered by the supracrustal rocks. Large granite lenses were observed on the northern shore of Kangerdluarssuk fjord, in the western part of the Talorssuit dome. Their position suggests that they are parts of the Atâ Granite, formed during the doming and folded together with the large recumbent overfold (fig. 7).

In the north-west part of Arveprinsens Ejland the granite replaced a large part of the supracrustals synclines. The approximate shape of these synclines, as it was before the granitization, was reconstructed by measuring the orientation of minor and major inclusions in the granite (fig. 8).

Summary of structural development and origin of the gneiss dome

The effects of three successive phases of deformation (F1, F2, F3) can be observed throughout the mapped area. In the southern structural complex the F2 deformation was most pronounced and caused the present predominant trend (NE to ENE) of the gneiss layering. In the northern structural complex, the F3 deformation was much more active and refolded most of the original F2 structures. This resulted in the formation of major folds with strongly curved axes (fig. 6).

The large size and the flattened shape of the Talorssuit gneiss dome make it difficult to believe that it was formed only by interference between the folding phases F2 and F3. It is likely that diapiric movements played an important part in the formation of the dome structure. The diapiric uplift of the gneisses was probably controlled by the pre-existing F2 structures and by the simultaneous F3 deformation. The large recumbent overfold in the western part of the dome may have been formed by the F3 folding during the uplift of the dome. The corresponding overfold in the supracrustals is much less pronounced; this could be due to the fact that the supracrustals were less plastic than the gneisses and acted as a superstructure during the F3 deformation. Many more observations are of course needed to prove or disprove this theory.

The northern and southern structural complexes are separated by a large zone of faulting and mylonitization. The mylonites which occur here can be several hundred metres wide. They are always completely recrystallized and form a compact rock, which in many places is cemented and veined by quartzo-feldspathic material. This important fault zone is therefore relatively old and more or less contemporaneous with the migmatisation.

RELATION BETWEEN THE GNEISS AND SUPRACRUSTALS

In most places the contact area between gneisses and supracrustals is occupied by the Atâ Granite. It is only in the limited areas east of Eqe and south-east of Qeqertaq that the direct relations can be studied. In these areas the bands in the gneisses and supracrustals are always concordant to each other and to the contact.

East of Eqe the contact is gradual; the amphibolitic rocks which here form the base of the supracrustals are strongly interlayered with beds of migmatitic gneiss. The rocks above this contact zone are strongly sheared and suggest that important movements took place here after the gneissification and migmatisation.

South-east of Qeqertaq the contact is relatively sharp. The pure basal quartzites are only slightly migmatised at their base. They appear to have formed an effective screen against the migmatisation.

There is a striking difference between the structures found in the gneisses and those found in the supracrustal rocks.

In most gneisses three phases of deformation (F1, F2, F3) can be recognized, which gave rise in some places to complicated superposed structures (fig. 9). These structures were formed under essentially plastic conditions, most folds being similar-type folds. In the supracrustals, on the contrary, not more than two phases of folding (F2, F3) could be recognized (fig. 9). They formed simple superposed structures under less plastic conditions, resulting in the formation of chevron and zig-zag folds (Fleuty, 1964), and open concentric folds.

These differences in tectonic style show that the gneisses and supracrustals each belong to a different tectonic level. During the migmatisation the supracrustals acted as superstructure with respect to the gneissic infrastructure.

The apparent absence of F1 structures in the supracrustal series might suggest that these rocks were deposited after the F1 deformation on a folded gneiss basement. The basement was later reactivated during the deformations F2 and F3. This theory is sustained by the fact that for the most part the base of the supracrustals is formed of very pure massive quartzites. According to Dapples et al. (1948), pure sandstones (orthoquartzites) are characteristic of deposits formed by the repeated reworking of the same material on a stable shelf. The observed concordance at the gneiss-metasediment boundery is to be expected even if the gneiss represents reactivated basement (Eskola, 1949; Ramsay, 1963; Windley et al., 1966).

This is an aspect of the area which merits further investigation.

METAMORPHISM

The rocks belonging to the Jakobshavn Gneiss group are essentially composed of biotite, plagioclase and quartz. Hornblende is everywhere present as an accessory mineral or in large concentrations in mafic bands. This means that the gneisses have recrystallized under amphibolite facies conditions.

The presence of staurolite, almandine garnet and sillimanite in the lowest part of the Anap nunâ Group shows that this has also recrystallized under the same amphibolite facies conditions. The middle and upper parts of the supracrustal group are characterized by the presence of chlorite, muscovite and epidote which means that they must have recrystallized under greenschist facies conditions.

Almandine garnet is found in most mafic bands together with hornblende. It is particularly abundant in the northern part of the area. According to Winkler (1965), the presence of staurolite and sillimanite together with almandine garnet indicates that the rocks were formed under intermediate pressure conditions. Many more observations and chemical analyses are needed to confirm that this was the case in the lower Anap nunâ supracrustals.

Zones of retrograde metamorphism, where the gneiss contains large quantities of epidote and chlorite, are found in several places. They are always connected with shear zones and mylonites. South of Jakobshavn, near Jakobshavns Isfjord, a very large epidote- and chlorite-rich shear zone can be observed.

It seems that the metamorphism in the gneisses and lower supracrustals outlasted the main fold movements and that the rocks recrystallized almost entirely after the latest main deformation. Neither platy nor prismatic minerals show any deformation. Only the garnets in the lower supracrustals show in some places rotated cores mantled by unoriented garnet crystals. No other remnants of syn-tectonic crystallization could be found in these rocks.

This late recrystallization of the rocks makes it unfortunately impossible to use the methods developed by Zwart (1963) to distinguish the different phases of folding and metamorphism on a microscopic scale. It is only in the semipelitic schists, which form the upper part of the supracrustals, that it would be possible to use such methods to some extent.

RELATION BETWEEN DEFORMATION, MIGMATISATION AND GRANITIZATION

Migmatisation and granitization were only observed in the northern part of the area mapped. The phenomena are closely related to each other; in one place the granite replaces migmatite veins and in another place the granite itself is veined by younger quartzo-feldspathic veins.

The lack of detailed observations makes it difficult to ascertain the exact position of the migmatisation and granitization in the structural history of the area. It seems however likely that the granite and the migmatite veins were formed mainly during the F3 deformation. This is indicated by the fact that they partly replace F3 structures and partly are folded by them. This last fact is demonstrated on a large scale by the presence of granite and migmatites inside the large F3 overfold of the gneiss dome.

If it is true that the supracrustal rocks were deposed on a folded basement, the migmatisation and granitisation could be a result of the reactivation of the gneiss basement.

DOLERITE DYKES AND SILLS

Several dolerite dykes and sills occur in the mapped area. They cut all the structures of the country rock and must therefore be relatively young. It seems possible that the dykes are related to the Tertiary basalts which occur on Disko island and Nûgssuaq. The dolerite sills appear to be locally sheared. As no shearing effects were observed in the dykes, this could mean that the sills are slightly older than the dykes. Unfortunately, the absence of intersections between dykes and sills makes it impossible to establish their true relation.

The dolerite dykes

About 20 dolerite dykes were observed in the mapped area. Their trend varies from WNW in the area near Jakobshavn to NNW in the northern regions. They transect faults and mylonite zones and are mostly between 10 and 25 m wide. Only one dyke, on Anap nunâ and south of Eqe, reaches a thickness of more than 100 m.

The dolerite sills

Dolerite sills were observed in three localities:

1) East of Rodebay, as very small isolated sills.
2) On both sides of the fjord Pâkitsup ilordlia, where they form large subconcordant lenses in the gneiss.
3) In the supracrustal series of Qapiarfît and Qeqertaq, as very continuous and wide sills.

In the Pâkitsup ilordlia area, the dolerite sills were examined in more detail. Here they are often several hundred metres long and vary in width between 5 and 30 m. Most sills were intruded along bedding planes or subconcordant fracture planes. At one place a thin vein was emplaced along a strongly curved fracture plane and gives thus the wrong impression of being folded.

The central parts of the sills generally display an ophitic texture in which euhedral or subhedral crystals of labradorite are embedded in a mesostasis of augite crystals. Near the contacts the rock can be aphanitic or porphyritic, showing crystals of augite and hypersthene in a finely crystallized groundmass.

Several alteration phenomena were observed inside the sills. Thin amphibolite veins, consisting of hornblende and surrounded by a fringe of andesine and biotite, often transect the inner parts of the dolerites. Locally epidote and scapolite crystals appear together with the pyroxene and plagioclase. The strongest alteration was observed in the thin dolerite sills east of Rodebay. The augite crystals are here for a large part replaced by hornblende and biotite. It seems that all these types of alteration can be attributed to late hydrothermal phenomena. According to Sutton and Watson (1951) these alteration minerals can also be formed by autometamorphism.

CORRELATION WITH NEIGHBOURING AREAS

The rocks situated south of the area described in this report belong to a metamorphic-tectonic unit called the Egedesminde complex by Noe-Nygaard and Ramberg (1961). This complex is very similar in lithology and structural style to the southern structural complex. The main trend of the gneiss layering is the same in both regions. A large part of the Egedesminde complex was remapped in more detail by G. Henderson in 1966. Henderson (personal communication) observed here the results of three successive deformations which are very similar in trend and amplitude to the F1, F2 and F3 structures found around Jakobshavn. It seems therefore that the southern structural complex described here simply represents the northerly extension of the Egedesminde complex.

North of the Påkitsoq fault zone, in the northern structural complex, the structural style is quite different. It is here characterized by doming, nappe-like overfolds in the gneiss and open synformal structures with strongly curved axes. A similar structural style is found in the Umanak area, north of Nûgssuaq (Henderson and Pulvertaft, 1967). Another similarity between the Umanak area and the northern structural complex is the presence in both regions of supracrustal rocks. The Anap nunâ supracrustals may well be equivalent to the lower metasediments of the Karrat Group. It is therefore likely that the rocks of the northern structural complex and those of the Umanak area belong to one lithostratigraphic-tectonic unit.

The important Påkitsoq fault zone marks the contact between two large tectonic units: a southern unit comprising the Egedesminde complex, and a northern unit forming the Umanak area and the northern structural complex. Both units probably belong to the Nagssugtoqidian fold belt.

ACKNOWLEDGMENTS

The writers wish to thank the director of Grønlands Geologiske Undersøgelse, K. Ellitsgaard-Rasmussen, for permission to publish this report. Sincere thanks are also due to Mr. T. C. R. Pulvertaft for the critical reading of the manuscript and to Dr. A. K. Higgins and Dr. B. F. Windley for help with the structural problems.

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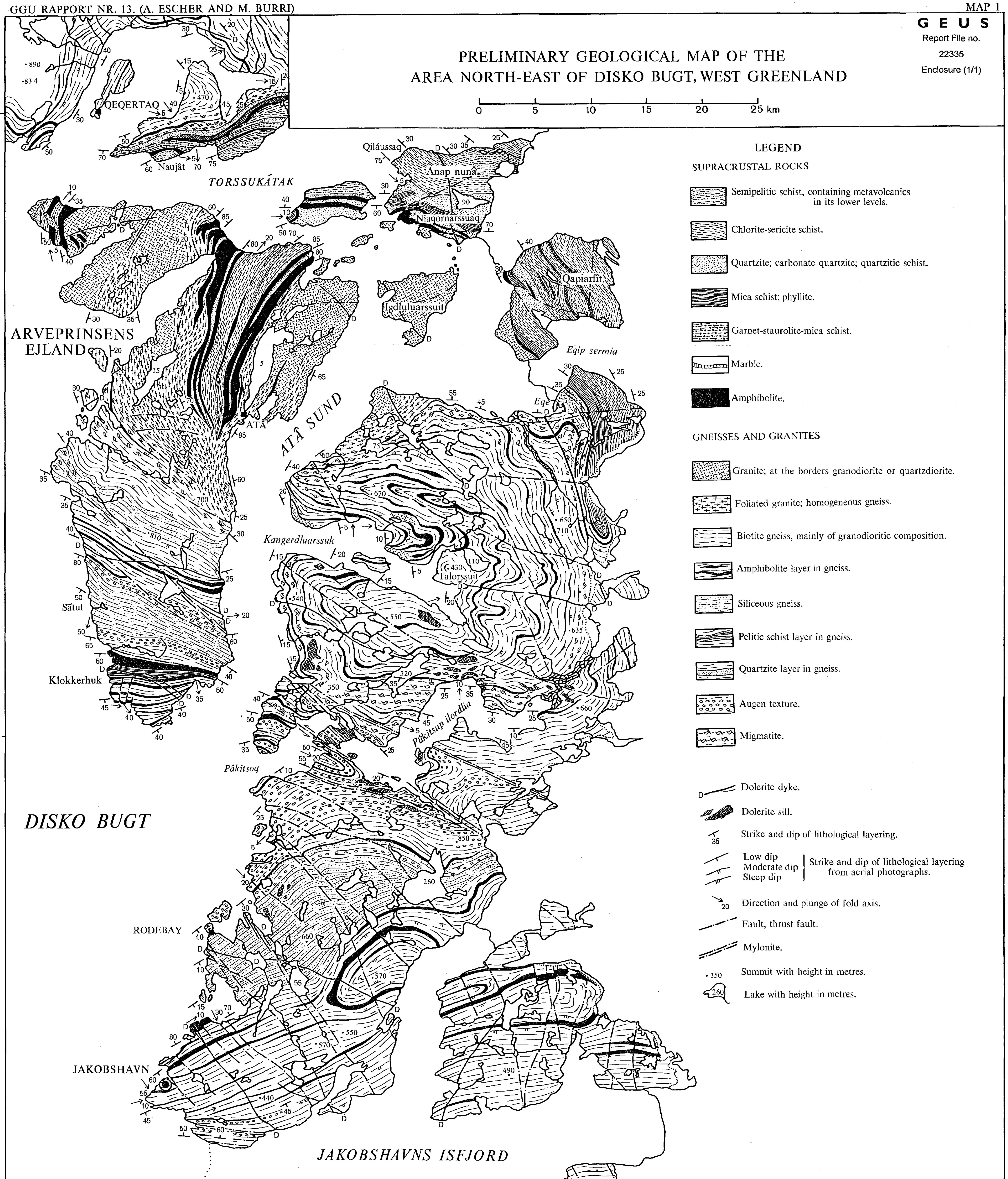
PRELIMINARY GEOLOGICAL MAP OF THE
AREA NORTH-EAST OF DISKO BUGT, WEST GREENLAND
0 5 10 15 20 25 km
LEGEND
SUPRACRUSTAL ROCKS
Semipelitic schist, containing metavolcanics in its lower levels.
Chlorite-sericite schist.
Quartzite; carbonate quartzite; quartzitic schist.
Mica schist; phyllite.
Garnet-staurolite-mica schist.
Marble.
Amphibolite.
GNEISSES AND GRANITES
Granite; at the borders granodiorite or quartzdiorite.
Foliated granite; homogeneous gneiss.
Biotite gneiss, mainly of granodioritic composition.
Amphibolite layer in gneiss.
Siliceous gneiss.
Pelitic schist layer in gneiss.
Quartzite layer in gneiss.
Augen texture.
Migmatite.
Dolerite dyke.
Dolerite sill.
Strike and dip of lithological layering.
Low dip
Moderate dip
Steep dip
Strike and dip of lithological layering from aerial photographs.
Direction and plunge of fold axis.
Fault, thrust fault.
Mylonite.
Summit with height in metres.
Lake with height in metres.
70°
69° 30'
51°
50°
QEQERTAQ
Naujât
TORSSUKÁTAK
Qiláussaq
Anap nunâ
Niaqornarssuaq
Qapiarfît
Igdluluarssuit
ARVEPRINSENS EJLAND
Eqip sermia
Eqe
ATÂ
ATÂ SUND
Kangerdluarssuk
Talorssuit
Sâtut
Klokkerhuk
Pâkitsup ilordlia
Pâkitsoq
DISKO BUGT
RODEBAY
JAKOBSHAVN
JAKOBSHAVNS ISFJORD
CLAUSHAVN
Tasiussaq

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