MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 127 · Nr. 7

DANSK PEARYLAND EKSPEDITION 1947–50
Leader: Eigil Knuth

FEATURES OF THE GEOLOGY OF THE FOLDING RANGE OF PEARY LAND NORTH GREENLAND

BY

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WITH 28 FIGURES IN THE TEXT
AND 5 PLATES

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BIANCO LUNOS BOGTRYKKERI A/S
1955

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INTRODUCTION

Material for the present work was collected during a two months' sledge journey in March, April and May 1950. The journey was undertaken from the winter quarters of the Danish Peary Land Expedition 1947—50, of which the author was a member.

From our winter quarters at Jørgen Brønlund Fjord a visit to the folding range in north Peary Land, North Greenland, could be made by two different routes. The first possibility was to go by sleigh westwards through Wandels Dal and J. P. Koch Fjord to Nansen Land and the deep fjords in north-west Peary Land. This route should offer good opportunities for a study of cliffs with profiles athwart the folding range, which indeed it did. The alternative was to go east round Peary Land to Frederick E. Hyde Fjord and the north-east coast. However, the journey was longer, and one would have to work with a profile parallel with the regional folding axis, which was not desirable. The level plains on the north-east coast were equally unsuited as points of attack. So I chose to travel north-westwards to Nansen Land and started from the base on March 8th with the north coast as my goal. On the whole journey I was accompanied by Tobias Samuelsen, a native Greenlander. During earlier expeditions the district of my choice had proved to be very poor in game. As I expected to have some 25 days' work in places of scientific interest, I did not want to depend on chance as the area in question might lack game altogether. So stores had to be laid out, and this took longer than expected as the going in J. P. Koch Fjord was very heavy and the temperature very low. During the first month we had temperatures of more than 40 degrees below zero (min. — 47° C). The difficult going, hard work, low temperatures and, above all, insufficient rations of pemmican for the dogs weakened the small teams and, consequently, we were seriously delayed. For this reason a reconnaissance of the deep fjords in the northern part of the range had to be given up. During the two months' journey we thus had fifteen working days in the field and on many of them the temperature was below ÷ 30° C, which in connection with wind and drift snow greatly hampered our work.

I should like to express my gratitude to all who helped me to bring out the present publication. First and foremost my thanks are due to Count Eigil Knuth, leader of the Peary Land Expedition. For good companionship and undisturbed working conditions always maintained in our winter quarters I am indebted both to E. Knuth and my fellow members of the expedition. I also wish to thank Professor A. Noe-Nygaard, my chief at the Mineralogical Museum, Copenhagen, for giving me the chance of wintering in Peary Land in 1949—50, and for his interest in my work. To all other colleagues who in some way have assisted me, my thanks are due, particularly to Mr. Bruno Thomsen for valuable guidance in connection with the heavy mineral separation and the microscopical analysis of those minerals. Mrs. Aase Holst has undertaken the translation of the manuscript into English, and Mr. C. A. Jensen made the thin sections. The microphotographs were taken by Mr. Chr. Halkier.

For financial support to the work I am indebted to the Carlsberg Foundation.

The present publication does not pretend to be a complete investigation of the area discussed. The structural profile and the poor maps made combination very difficult. The heavy snow cover undoubtedly concealed much. However, if the work can furnish future investigators with more exact knowledge of the folding range, its rocks, metamorphism, etc., much will have been won. Then they would not, as the writer did, have to start from scratch with regard to material available.

Copenhagen, May 1954.

EARLIER EXPEDITIONS AND THEIR RESULTS

The folding range in northern Peary Land was first visited by a geologist in 1917, in which year LAUGE KOCH was attached to KNUD RASMUSSEN's 2. Thule Expedition as geologist. The expedition visited Nansen Land, which largely is the district covered by the present writer when a member of the Danish Peary Land Expedition in 1950. KOCH (1918, —19, —20) mentioned the existence of a folding range in Peary Land. Its southern boundary passed through Freuchen Land from where it extended as far northwards as the expedition advanced. By sketches of fjord profiles from the westernmost part of Nansen Land and the islands immediately west thereof KOCH determined the principal features of the structure. He also found the regional strike E—W. The folded material was chiefly slightly metamorphosed sandstone. KOCH found some intrusive bodies as well. Four years later, in 1921, he travelled in the same area and succeeded in adding further observations of the Peary Land folding range. The south boundary was also traced in east Peary Land at G. B. Schley Fjord. Northwards the range extended to Kap Morris Jesup. In connection with the folding range the most important feature of the expedition was KOCH's find of crystalline schists at the northern point of Greenland, which meant that the degree of metamorphism was higher here than at Nansen Land farther west. KOCH assumed the existence of a crystalline core in central Peary Land. Numerous intrusives were found on the north-west coast particularly at De Long Bugt. On basis of studies of erratic boulders in connection with reflections on morphology KOCH concluded that the great Quarternary glaciation had not included Peary Land. He assumed the age of the folding to be late Caledonian. KOCH's evidence was probably inconclusive, but J. C. TROELSEN's work in Ellesmere Island in 1952 gave substantial support to KOCH's theory without, however, fully proving it. TROELSEN observed that in Ellesmere Island, the folding had taken place between the Late Silurian and the Middle Carboniferous. When in 1949 he visited eastern Peary Land he was only able to show that here the folding was younger than the Middle Ordovician but older than the Upper Carboniferous. No evidence was found by the present writer during his work in Nansen Land.

In their attempts to reach the North Pole other expeditions had visited Peary Land before L. KOCH, but had not brought geological material home. In 1908, however, members of the Danmark Expedition succeeded in collecting samples from the mouth of Frederick E. Hyde Fjord. Apart from J. P. KOCH's preliminary field descriptions no examination was made of the samples, at any rate it has not been possible to find any publication on the subject. Hence a brief description of the specimens has been included in the present work.

The material collected on the Bicentenary Expedition 1921 consisted of a sample of mica schist from Kap Morris Jesup.

FOLDING AND STRUCTURE

The cross-section of the folding range shows that the folding begins in the middle part of J. P. Kochs Fjord (Figs. 1, 2, 28). The first traecs are met with in the northern part of the island Merqujôq (profile P—Q, fig. 1). The unfolded strata, presumably sandstone of the Thule complex, have a northward dip of about 10° at the head of the fjord. The rocks at Merqujôq consist of a fine-grained gray sandstone in alternate layers with graywacke with crossbedding structure. The folding here is not very pronounced. Both at Merqujôq and at Freuchen Land the folds are homoclinal with a southward dip (Fig. 3). Following the homoclinal stage which forms the southernmost part of the folding range gentle folds of an asymmetrical nature occur. They are very faint at Merqujôq but more pronounced at Freuchen Land. The limbs of these folds are very broad and show small secondary homoclinal folds here and there. The undisturbed picture with faintly undulating layers may suddenly be interrupted by zones with a steep upthrust of the layers accompanied by fine folds. Such a zone may be seen at the northeast corner of Navarana Fjord (Fig. 4, Fig. 1, loc. 16). It appears suddenly and seems to be a local product of a more violent disturbance during the folding process. The layers are steep (cf. Fig. 5) and have many small, irregular folds and structural discordances. A similar occurrence may be observed in the northeast side of the large bend at J. P. Kochs Fjord nearly opposite the mouth of Navarana Fjord. Among the undisturbed folds steep layers of a light-gray sandstone suddenly appear. This stone resembles the light-coloured sandstone farther up the fjord, which was referred to the Thule complex.

On the north coast of Koch Fjord in a river bed near loc. 15 (Fig. 1) a rock occurs with strongly developed, steeply dipping slaty cleavage and primary bedding, the dip of which is 45° N. The structure is somewhat disturbed and varies greatly within small areas. It is obvious to connect this zone with the aforementioned other two disturbed zones. At the south point of Elison Ø a slate alternately layered with fine and coarse sandstones has a similar orientation, although here the original strati-

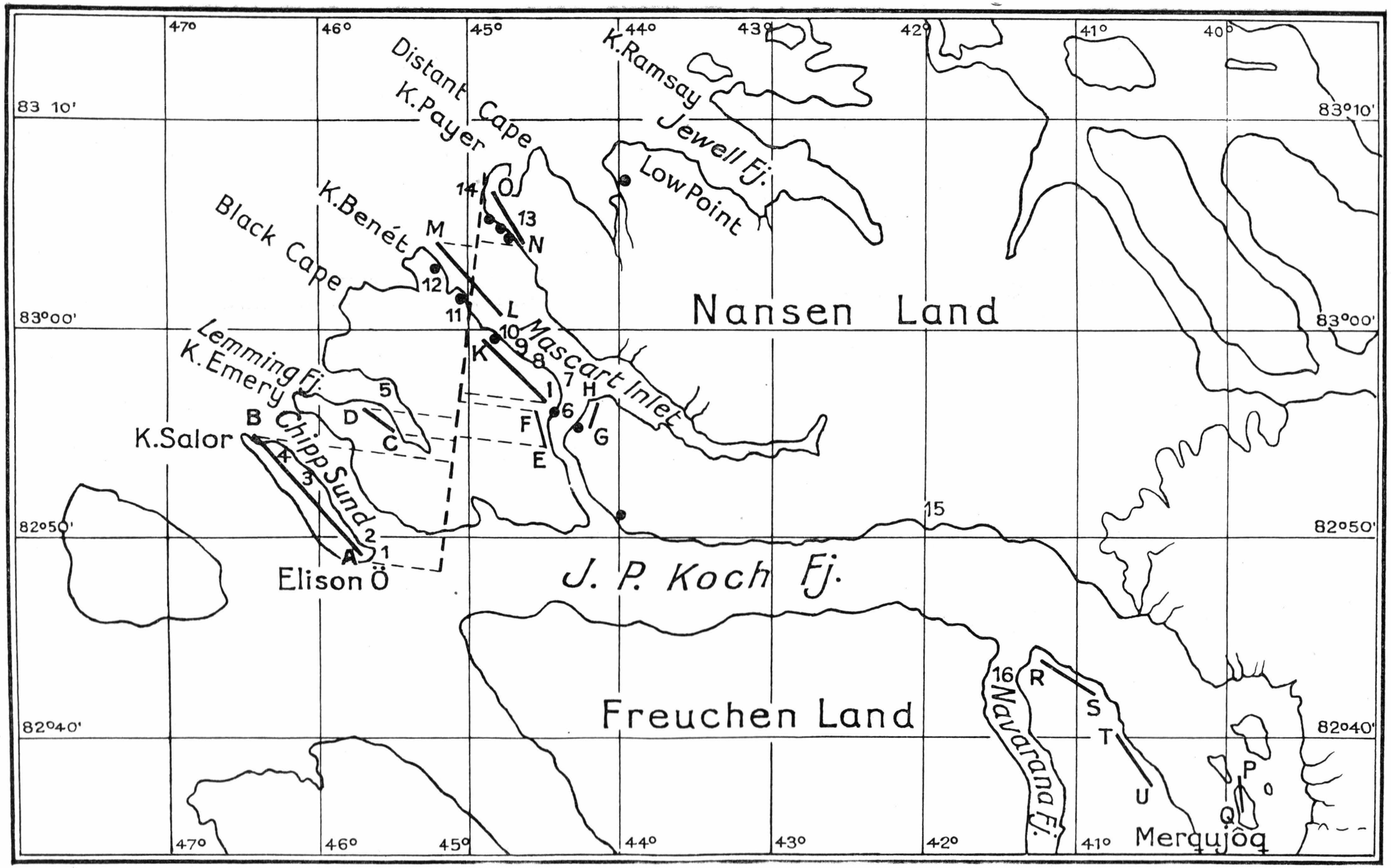

Fig. 1. Map of north-west Peary Land to the scale of app. 1 : 750.000. The figures indicate localities mentioned in the text. Dots indicate finds of intrusive dykes. The profiles drawn are indicated by thick lines and letters. The profiles AB, CD, EF, GH, KI, LM and ON are shown in Fig. 2 projected on the dotted line which marks a plane at right angles to the regional folding axis.

fication has a northerly dip of a few degrees. The locality is the fourth on the line round J. P. Koch Fjord. However, Elison Ø presents certain features unknown from the other localities. The slate, which has a distinct, almost vertical flow cleavage (*vide* Figs. 1, 6, 19) with a strike parallel to the axial plane, also shows fracture cleavage forming an angle of ab. 45° with the axial plane. Such a structure points to a shear fold. It appears, however, that a general shear tendency cannot be demonstrated for the whole area. There has undoubtedly also been a general compression at work together with the shearing.

After this zone with its pronounced transverse cleavage the folds farther north run an undisturbed and regular course. On Elison Ø nearly all folds are symmetrical or only slightly asymmetrical (Figs. 7, 8). In the latter case the axial plane has a steep southerly dip. Only in the northern part are the folds tightly compressed with a tendency to more recumbent folds (Fig. 9). Thus, in the folds farthest north (Loc. 4, Fig. 1) the axial plane dips southwards at ab. 40—50 degrees. The profile shows that the folds are connected. The possibility of a thrust plane here cannot be disregarded.

As said before, the axial planes have a southward dip. If, therefore, overthrusting should occur anywhere, it might be expected to display thrust planes with a southward inclination or a tendency in that direction. The initial thrust plane would be developed between the north limb of an anticline and the south limb of a syncline. The mountain of 810 metres at Elison Ø, however, differs in this respect. Fig. 2 shows a composite anticline which between the south limb of a secondary anticline and the north limb of a secondary syncline has formed a steep thrust plane exposed for ab. 100 metres (*vide* present author, 1950). This occurrence indicates a tendency to thrusting either of the northern or the southern block. From the present material it is not possible to associate the occurrence with the aforementioned deformation zones. The possibility exists, however, and future investigators should bear it in mind.

Immediately connected in the north with Elison Ø is the region southeast of Kap Emery. At Lemming Fjord an excellent profile, D—C, is visible, a large, asymmetrical syncline with a steep, somewhat undulating south limb and a north limb dipping ab. 30°. The latter shows a number of small, similar folds in a narrow zone in the foliation plane. At this spot (ab. 100—300 m above sea level) the folds seem to be heaped on top of one another. The layers both above and below have the same southerly dip, the bottom layers being slightly steeper than those on top. This may be a very sharp asymmetrical anticline. An investigation of the position of the strata near the shore line during field work gave no confirmation of this theory.

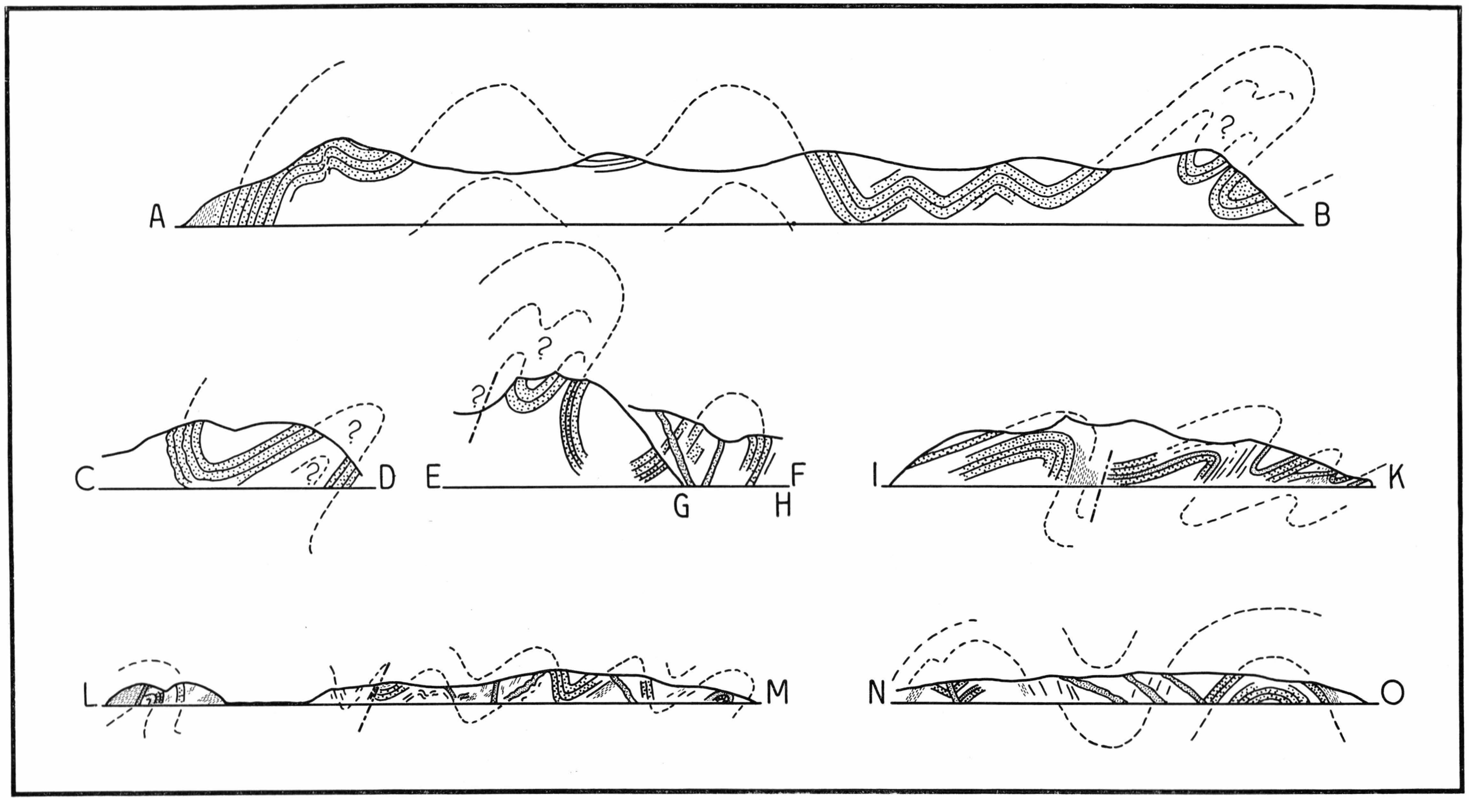

Fig. 2. Transverse profiles of the folding range. Scale app. 1 : 125.000. The position of the profile may be seen in Fig. 1 where it is marked by the dotted line. Large-dotted areas are quartz-sandstone and graywacke, finely dotted are quartzites, and parallel lines indicate slates and incipient schists. Homogenous signs indicate intrusive dykes.

In the regional strike direction of profile DC at Lemming Fjord the two profiles EF and GH (Figs. 1, 2) are in the bend between Strømstedet and Mascart Inlet (Fig. 10). It is difficult to say whether there is any correspondence between DC and the two profiles mentioned. They have been drawn up separately in the profile. EF and GH have been compiled to one profile as correspondence is very evident here. At Mascart Inlet the good quality of the profiles exposed along the cliffs of the fjord offers good opportunities for a study of the further structural development displayed by profiles IK and LM (Figs. 11, 12). In this part of the range the folds are simple at the southern end but composite in the north towards Kap Benét, with small-sized folds occurring in the south limbs of the main folds. They are marked in the steep walls by resistant yellow quartzite bands. A study of the continued structural development northwards by Kap Payer, profile ON, and Distant Cape, reveals that the folds are all of the same type. Here the limbs of the folds have secondary folds on both the north and the south side. The southern Kap Payer profile presents an occurrence reminiscent of a chevron fold (Loc. 13, Fig. 1). It is situated on the south limb of an anticline. On the northern limb of an anticline between Kap Payer and Distant Cape is a very fine structural terrace.

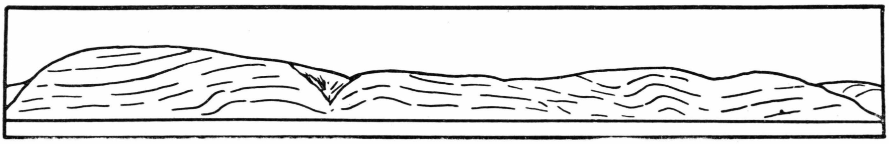

Fig. 3. Sketch of the folding structure at J. P. Koch Fjord, west side of Freuchen Land. Profile UT seen from east to west.

The transverse profile shows about 18—20 folds—anticlines and synclines of various types. The profile should not be read as a cross-section of the folding range in the place where it was drawn. The individual parts of the profile only make a projected picture—at right angles to the folding axis—of the many folds. The construction at the place in question should only be taken as an attempt at giving a general impression of the occurrence. Whether or not such a construction is permissible in the present case will be briefly illustrated. If the folding range has been built up from compression folds, the latter would be almost parallel. The possibility exists, as the strike determinations in the area investigated differ very little round the value of the regional strike N 80°W. The folding axis is horizontal or with a slight westward pitch between 3° and 10° measured on the crenulation folds. This makes an undulating movement of the folds rather improbable. In connection with certain features of the joint net and the petrography, the close position of the folds with their secondary folds and asymmetrical construction in many places, particularly in the north, points to a compression folding. In that case the shifting to a complete profile is quite justifiable. On the other hand, much points to the existence of pitching folds by shearing stresses. At southern Elison Ø the aforementioned indisputable flow cleavage structure of a slate clearly indicates a shear. The circumstance that it was not possible to find the same fold from one side of an island to the other points in the same direction. On basis of aerophotographs a number of structural directions for the whole folding range have been entered on Fig. 28. The strike varies slightly here and there. In the east it is more north-westerly than in the west, while about Kap Morris Jesup the direction is E—W. Also, many folds must simply peter out when approaching the south boundary of the folding range. Shear movements may also account for these conditions. One more circumstance points in the same direction. Almost all fjords in northwest Peary Land are in many places situated according to the direction NW—SE, in other words, they cut across the folding axis at an angle of ab. 45° (cf. Fig. 28). Many factors thus indicate that both types of action have been at work.

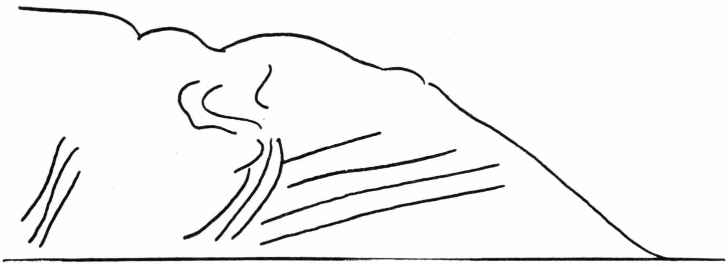

Fig. 4. Structural discordance at Navarana Fjord. Fig. 1, loc. 16.

Fig. 5. Structural discordance at J. P. Koch Fjord. Profile RS, Fig. 1, seen from north to south.

In addition to the 18—20 folds mentioned, four or five more may safely be added. With this addition and provided no overthrusting but only movements on steep faults have taken place, the compression in this part of the folding range amounts to ab. 40 per cent.

The thickness of the layers included in the folding was no doubt considerable, although the material available does not allow an exact determination. As the structure of the range is slightly asymmetrical, the strata in the northern area may not represent the same horizons as in the south. However, a structural profile like the present is not enough to decide the question, and as the mineral facies shows no changes, it is impossible from this to form an idea of the depth of the folding range. Apart herefrom, however, the profile clearly shows that the southern foreland of the Smith Sund (Franklinian) geosyncline has had a compressive effect so that an overthrusting has taken place in the north, where a deeper-lying resistance block than the foreland block has existed. Viewed from a tectonical angle it seems that the area hitherto presumed to be the foreland of the geosyncline really is the hinterland. A picture of the folding range should thus show that the north is closer to the central core with a simultaneous rise of the degree of metamorphism in the development of the mineral facies. This impression seems to be in agreement with that of LAUGE KOCH, who reports garnet mica schists observed at Kap Morris Jesup during the Bicentenary Expedition. From

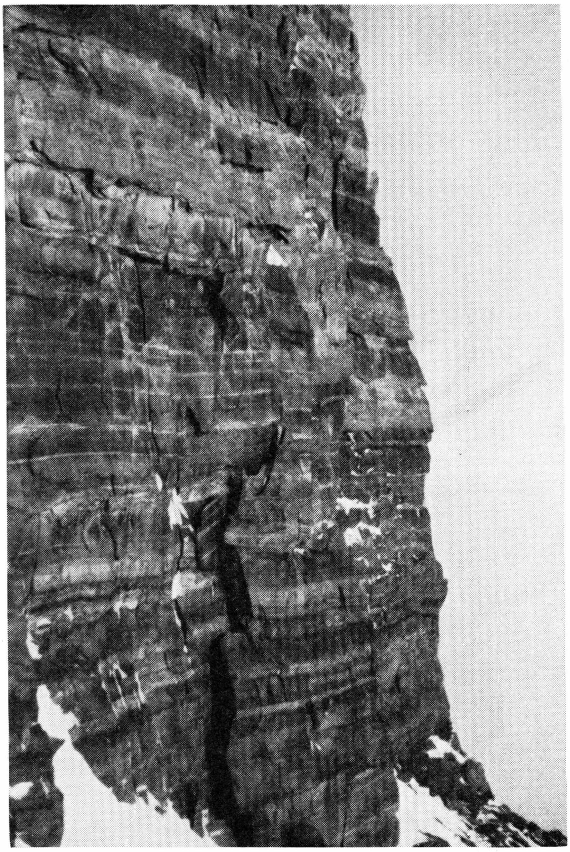

Fig. 6. Horizontal primary bedding and vertical fissility developed as flow-cleavage. Elison Ø, Fig. 1, loc. 1. The height of the wall app. 2 m.

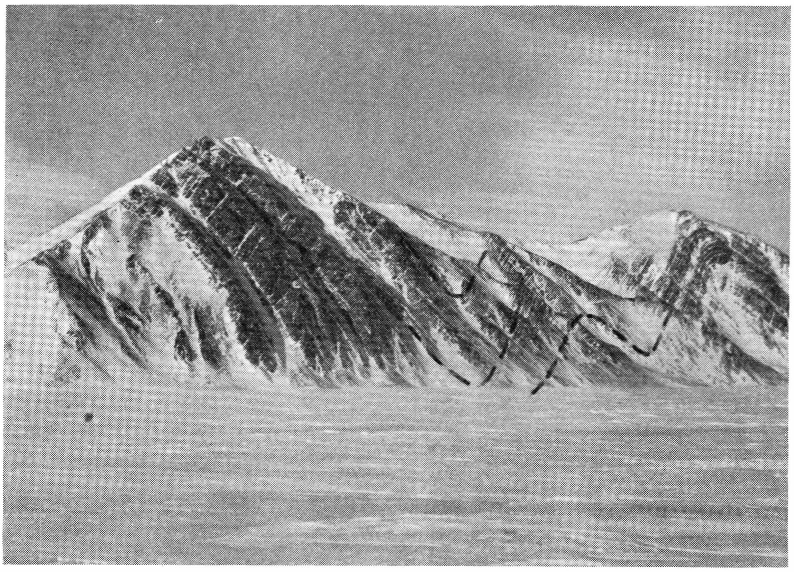

Fig. 7. Symmetrical folds from the central part of Elison Ø. The rocks are chiefly quartz-sandstone. The profile is seen from Chipp Sund. Cf. Figs. 8, 9.

Fig. 8. Symmetrical folds from the northern half of Elison Ø. The rocks are chiefly quartz-sandstone. The profile is seen from Chipp Sund. Cf. Figs. 7, 9.

the same place (Koch 1923) Koch reports that the metamorphism increases eastwards. This is in a way correct, but in my opinion it is nearer the actual condition to say that the metamorphism increases northwards

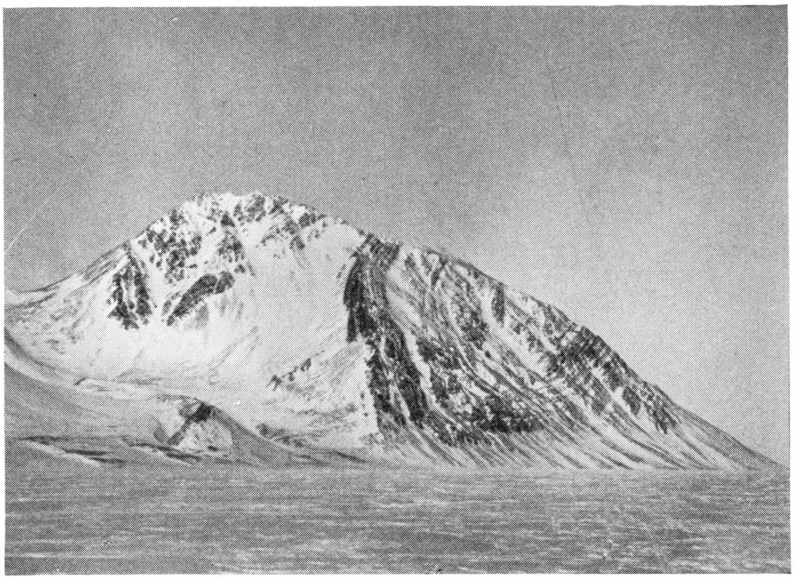

Fig. 9. Two synclines developed in the sandstone series. The profile is from the northern point of Elison Ø, and the folds may be a continuation of the two synclines in Fig. 10 from Mascart Inlet.

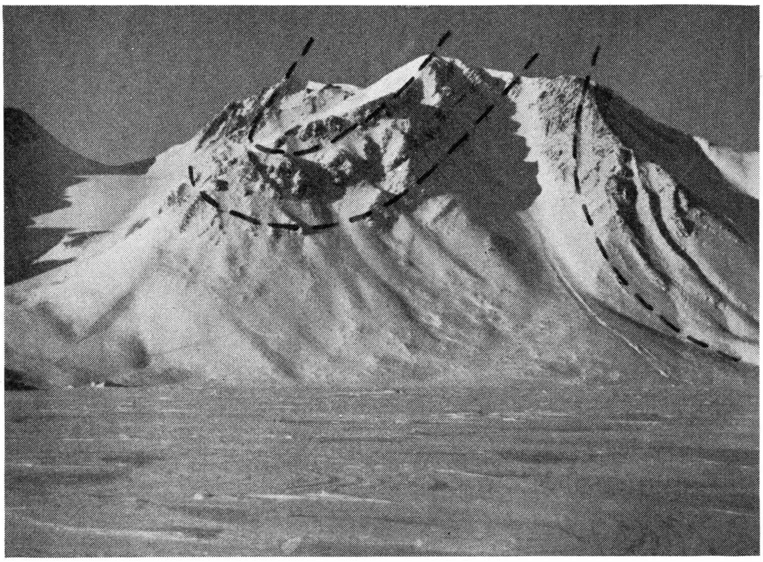

Fig. 10. Two synclines developed in the sandstone series. The direction of the profile plane is almost N-S. The profile may be seen in the bend between Strømstedet and Mascart Inlet. They may be the same folds as shown in Fig. 9 from the northern point of Elison Ø.

towards the core of the folding. There is all the more reason to do so as the regional folding axis has a slight, westerly dip, that is, towards a

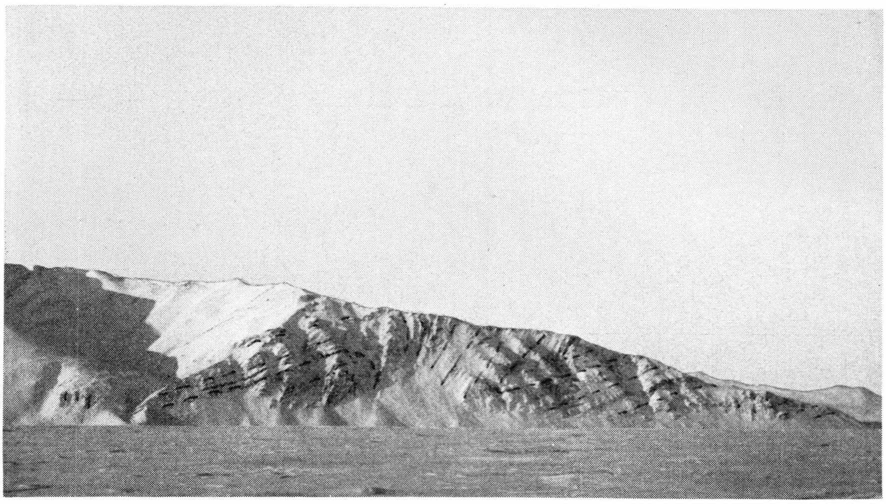

Fig. 11. Asymmetrical folds. Mascart Inlet. Profile IK, Figs. 1, 2.

lower level in the range (which of course is no absolute indication of a rise in the degree of metamorphism). This is further confirmed by the samples of rocks and sand brought home from central Peary Land by E. KNUTH, which will be discussed later.

LAUGE KOCH's work from 1920 contains a table with sketches of the folding structure of the whole range in Northeast Greenland, and the sketches are both from Peary Land and other areas farther to the southwest. KOCH's observations and mine seem to be in fairly good agreement. The folds are gentle, symmetrical or slightly asymmetrical. Secondary folds were observed here and there by KOCH. A sketch from Victoria Fjord presents an interesting feature. Farthest south in the profile the folds seem to be quite intense and without system (KOCH 1920, p. 70). Northwards they seem to become more regular. The style is, I think, identical with that of the district at J. P. Koch Fjord. In the abovementioned deformation zone along the fjord greatly disturbed strata occurred with irregular and, one may say, inexplicable movements in the mouth of Navarana Fjord. Concerning the structure of the southern Elison Ø, however, KOCH and the present writer seem to differ slightly. KOCH indicated my initial shear thrust plane as secondary folds[1]).

In his publications on the folding range KOCH further reports that thrust planes doubtless exist, but that it has not been possible to prove

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[1]) On p. 67 of the same paper KOCH has two sketches, Figs. 9 & 10. These two landscape sketches have been interchanged by KOCH. Fig. 9 is a view of the southern point of Elison Ø from J. P. Koch Fjord. The tall mountain with the initial thrust plane can easily be discerned. Fig. 10 shows the Low Point cairn to the right and Kap Ramsay farthest left.

Fig. 12. Asymmetrical anticline at Mascart Inlet. Profile LM. Fig. 1, loc. 11.

them. In a profile sketch of John Murray Ø (KOCH 1920) there is a discordant structure in the northern part which might be due to a thrust plane. I did not succeed in finding definite thrust planes in the part of the folding range visited, but observed one or two structural discordancies supposedly originating from post-orogenic faults (Fig. 13). In Mascart Inlet at loc. 6 (Fig. 1) a certain fault exists, its main direction parallel with the regional strike of the island. On the south side of the ravine a basic dyke cuts discordantly through the structure of the sediments. The dip of the stratification of the slates is different on the north and the south side, and slickensides are evident in the north wall of the ravine. From the appearance of the slickensides it was not possible to make a certain determination of directions, but it is probable that the south block moved downwards and the north block upwards. The fault plane was very steep with a slight southwesterly dip. Due southeast of loc. 8 (Fig. 1) in the profile IK is a second possible fault in the large ravine. On account of the heavy snow cover I was unable to make further investigations, but there was no agreement between the strata on either side of the gorge. As the rocks on the south side of the ravine are made up of soft, incompetent strata with flow cleavage and the rocks on the north side of resistent sandstones with preserved primary stratification, we get a structural discordancy which need not be a thrust. At loc. 12 (Fig. 1) in the profile LM a fault was observed where the plane had a southerly dip, Fig. 13. The discordancies mentioned are the only ones which, as I see it, with any certainty may be due to faults. Others were observed, and some of them look like thrust planes, but as they were

Fig. 13. Structural unconformity. Mascart Inlet. Profile LM, Fig. 1.

observed on rather remote mountain sides, the likeness may be deceptive on account of an oblique angle between structural direction and profile surface. The only structural discordancy to be read from Koch's profile sketch from 1920 is, as already mentioned, on John Murray Ø. It appears, however, to have a northerly dip, a fact which if we are dealing with a thrust plane is difficult to connect with the slightly asymmetrical structure of the range with its tendency to overthrusting northwards.

On pp. 68—69 L. Koch has a brief description of the morphology of the folding range. Weathering has reached a stage where the synclines protrude as mountain peaks and the anticlines as valleys. In the section of the folding range discussed it should be easy to identify a number of valleys and fjords as anticlinal valleys while, according to Koch, it is very difficult to see the connection between the individual synclinal peaks. Koch mentions Mascart Inlet as one of the best examples of an anticlinal valley, and this seems very plausible considering the direction of the fjord as shown by Koch's sketch in the same publication. However, with the new maps it holds good only for the very head of the fjord. The regional folding axis and the outer part of the fjord intersect at an angle of ab. 40°, and in this place folds cut across the fjord. It must be the outer part of the fjord Koch meant, as the inner has only been known a short time. There can, however, be no doubt that the area is deeply influenced by the structure of the folding range, in particular the alpine morphology noticeable here and there, which makes north Peary Land different from the southern flat, unfolded Peary Land.

JOINTS

The joints play an all-important part in forming the morphology of the rocks and also serve to make the nature of the rock-forming forces more easily understood. The hard, weather-resisting sandstones crop out everywhere as ridges and peaks from the softer, less resistant slates. This facilitates a study of the structure during a winter journey, as the hard "beds" serve as a kind of index horizons.

The joints occur in their widest forms in the sandstones. Both strike joints and dip joints are well developed. The most frequent occurrence are two strike joints and one dip joint (Figs. 14, 15). The two conjugate strike joints usually form an almost right angle with each other. Together the three sets of joints cause a division of the sandstones into large cubes the sides of which often run into metres. The one strike joint here might also be called bedding joint as it always serves as our means of realizing the folding structure on the mountain sides and coincides nearly everywhere with an original bedding plane, although disagreement has been observed. The distance between the individual bedding joint planes is nearly always equidistant. The two conjugate strike joint sets should be interpreted as shear joints on the folding limbs. The very circumstance that there is an angle of nearly 90° between the two sets on the folding limb indicates that the shear has been stronger than external compression during the folding movement. In the soft, incompetent layers the joints are less conspicuous. But on account of shear movements the angle between the joint fissures is always more acute here. The great distance between the joint fissures found in coarse-grained sandstone cannot always be taken as a sign of slight deformation but rather as a proof that the sandstones were very resistant to the folding. Nor does it indicate how deep down the accessible part of the range was formed or how far from flow conditions the material has been. During a summer visit to Peary Land a study of the joints will be profitable to our understanding of the folding mechanism.

At the crest of the anticlines it is evident in some places that the strike joints conjugate with the bedding joints are tension joints. At Kap Payer the profile shows an equidistant "bedding" joint with a

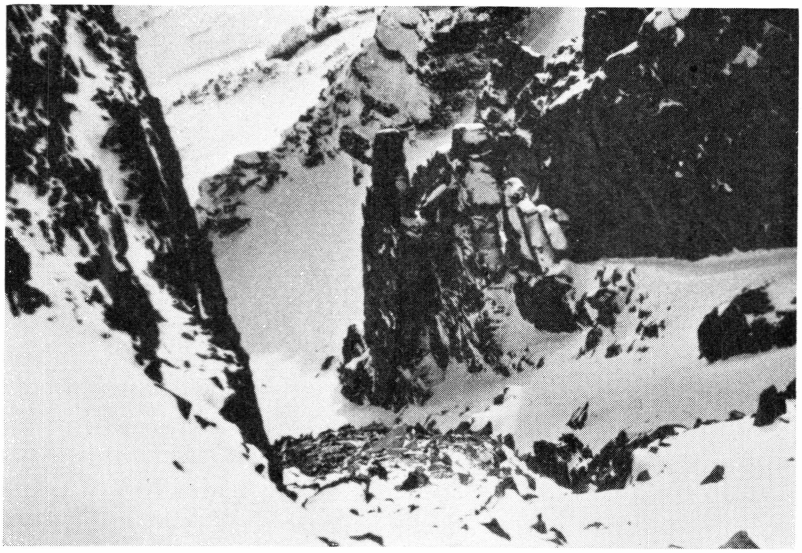

Fig. 14. Strike joints developed in graywacke. Mascart Inlet. Fig. 1, loc. 9.

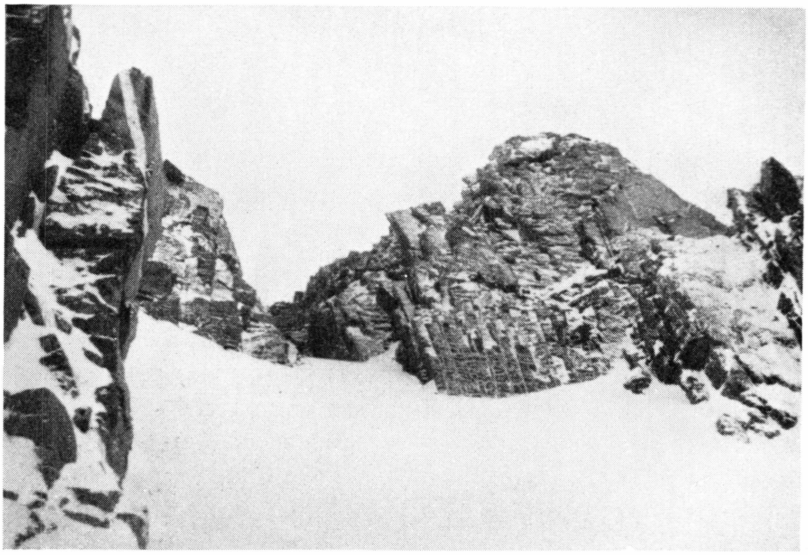

Fig. 15. Joints in graywacke sandstone. Elison Ø. Fig. 1, loc. 2.

tension joint indicating a parallel fold. The joints in the "false" similar folds at Lemming Fjord (p. 11) in particular indicated a fold of the type mentioned.

A striking proof of the highly homogenous nature of the sandstone is that on many surfaces sheet joints occur of the very type observed in homogenous granites (Fig. 16). No doubt the joints in question have their origin in the orogenesis although some of them may be post-orogenic. In most cases the rocks have preserved the primary bedding structure which facilitates the establishment of the up and down position. Where this is the case and the joints coincide with the main

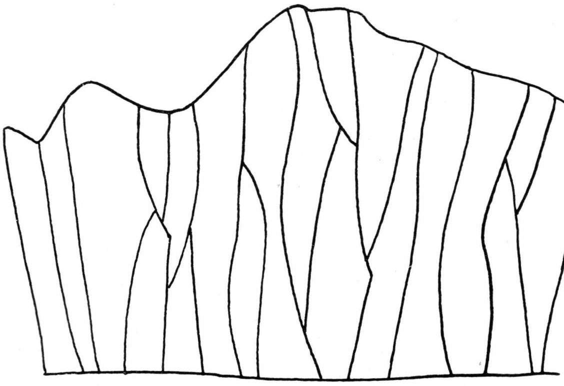

Fig. 16. Sheet joint in a competent, deformed sandstone on Elison Ø. Scale app. 1 : 10.

direction of the unconformity of the structure in question, the age cannot be established with any certainty. The syn- og post-orogenic origin is very evident in places where primary bedding plane and bedding joints (strike joints) are discordant. The bedding plane is accentuated by sudden transitions between coarse- and fine-grained sandstone.

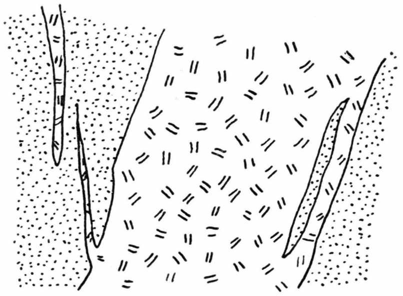

Fig. 17. Quartz vein in deformed sandstone (dotted). Scale 1:2.

Closely connected with the folding and the shaping of the joints are numerous fissures filled with mineral deposits. Like the joint fissures they occur only or very predominantly in the series of grayish-green graywacke and in the few bands of light-coloured quartzite.

In the graywacke series fissures occur going in all directions. On account of their fillings of white quartz they are easily discernible. Of course, a more regular occurrence of fissures also exists. Fissures with a strike at right angles to the strike joint planes are phenomena which must be closely related to the tensions prevalent in the area during the folding movement. The fissures are tension products, a fact which may be seen from the boundaries between the quartz fillings and the graywacke rock. The boundaries are frequently sharp and split up into thin flags. There is often a thin lentil of sandstone in the quartz mass (Fig. 17). Thus, the cause of the fissures must also be sought in a tension. Another striking proof of it is feather joints belonging to a release of tension at right angles to the folding axis. Fig. 18 shows such gash joints from the south part of Elison Ø. This joint may have to be connected with an axial culmination or, perhaps more likely, placed on an anticlinal nose which, as already mentioned, must occur near the southern boundary of the folding.

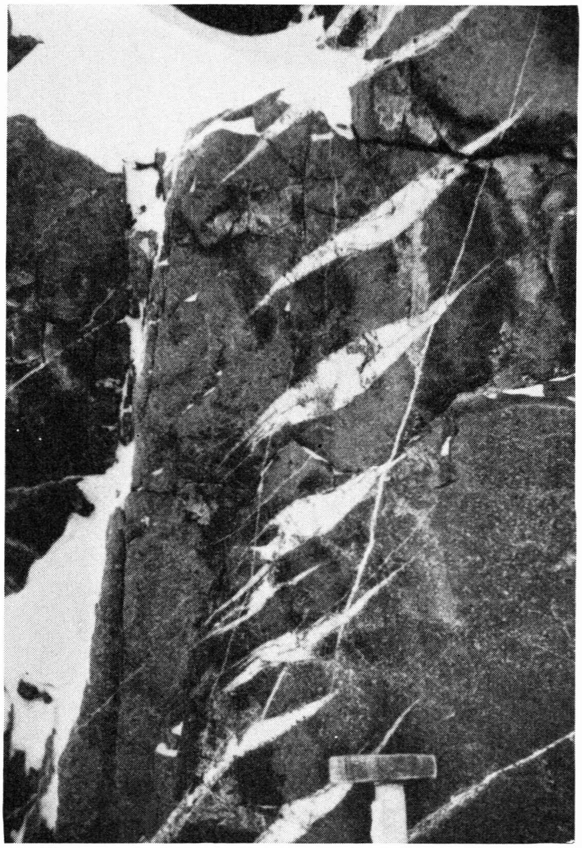

Fig. 18. Feather joints. The fissures are filled with quartz and calcite. Elison Ø. Fig. 1, loc. 2.

In addition to the fissures and joints with mineral deposits already mentioned a younger, faintly developed set exists. These youngest fissures occur both with and without mineral deposits. Of this system fissures exceeding 1—2 millimetres in thickness were not found. In all fissures the mineral assemblage is very monotonous—quartz, chlorite and calcite. It has undoubtedly been formed during or after the last phase of the compression. The quartz material often presents rupture surfaces, which shows that movements took place after the formation and refilling of the fissures.

PETROGRAPHY

The rocks of the area visited are naturally divided into two groups, one comprising the sedimentary rocks and the other the igneous. The former group will be more thoroughly discussed in the present work, while the latter with the igneous, intrusive rocks and problems pertinent to them will be dealt with later together with the numerous intrusives of the unfolded foreland in Sydpasset and upper Independence Fjord. The intrusives of the folding range seem to be closely related to those of the foreland for which reason a division of the material seems natural and hence justified.

The petrography of the sedimentary rocks in the Nansen Land folding range is of a special kind. The metamorphism of the rocks caused by or occurring during the folding movement is very slight. Recrystallization has only partly veiled the original nature of the material. The primary bedding conditions, stratification and size of grains are well preserved and in most cases easily determinable. Thus, the present products should not offer serious problems with regard to our understanding of the nature of the primary material.

The quality of the maps which to a field geologist were highly unsatisfactory, and the lack of stratigraphic index horizons made it impossible during a short winter journey when the ground was covered by deep snow to clear up the different strata from fold to fold and from one locality to the next. The only possible procedure was to treat the material from a purely petrographical angle starting with an investigation of the degree of metamorphism to which the material has been submitted. This so to speak divides the material into two groups, a competent sandstone series which has been able to resist the strong external influences and still preserve the stratification, and, secondly, an incompetent series chiefly consisting of original shales which now display various cleavage structures and slate-schist characteristics. On account of the incomplete structural picture mentioned above the most typical localities must be treated separately with as much consideration of the whole as possible.

On the south side of Elison Ø in the south side of a large composite anticline transverse cleavage has been developed in soft slates. The

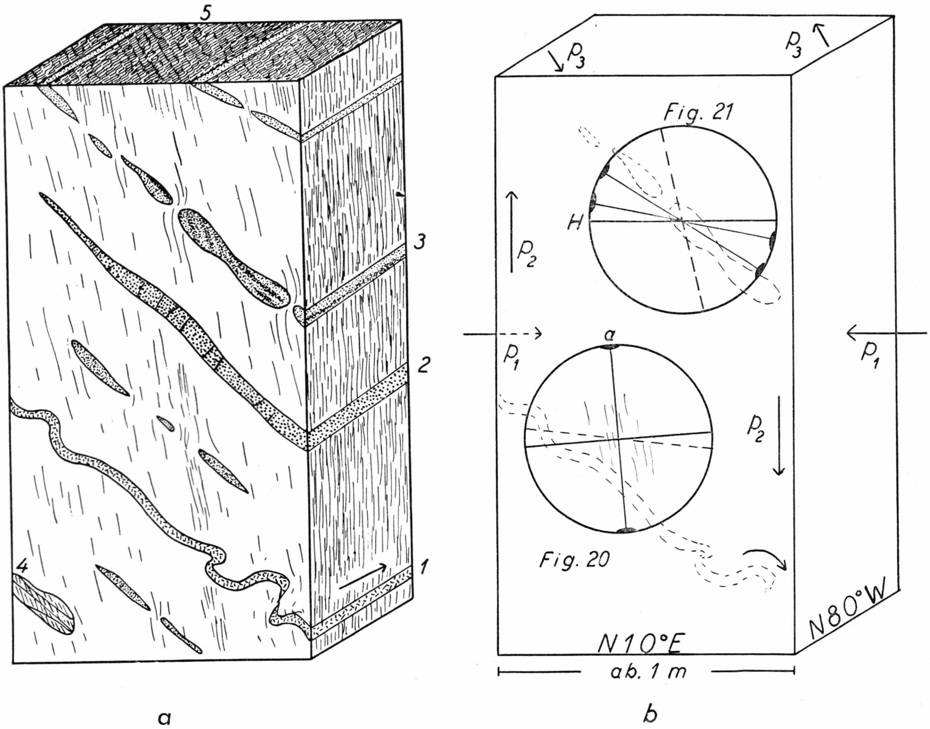

Fig. 19. Outlined block diagram illustrating the structural development of a small sequence from the southern Elison Ø. (a). 1: thin layer of calcite, 2: coarse-grained sandstone with tension joints, 3: fine-grained sandstone to mica-quartz schists, 4: lenticle of fine-grained quartz-sandstone with relic cross-bedding, and 5: fracture cleavage crossing flow cleavage. (b), the arrows p_1, p_2, p_3 indicate the forces active during the development of the structure. The difference between primary bedding in the block diagram and in the two petrofabric diagrams is due to the circumstance that in the latter pp was measured in the samples in question.

block diagram Fig. 19 illustrates the conditions. The strata with a slight northward dip represent the original stratification. The folds of the calcite layer are crenulation folds with a northern thrust tendency. The calcite of the stratum must have recrystallized before or during the folding as it is much deformed in the small syn- and anticlines while rupture surfaces were observed on the folding limbs (Pl. 2, Fig. 1). The other layers consist of sandstone with grains of varying size. The finest-grained layers are broken and rolled out to lentil-like bodies. The coarser-grained layers are unaffected or broken by small transverse cracks. In the bottom left corner is a lentil with a structure similar to wave-built cross-bedding. The original, incompetent clay layers have quite lost their original structure in favour of a pronounced secondary cleavage. The cleavage of the rock is here parallel with the axial surface. Flow cleavage lends an irregular, finely undulating, foliated appearance to the cleavage surfaces. The sandstone must be classified as a quartzitic sandstone as the original size and shape of the grains are preserved in a slightly recrystallized matrix with small scales of chlorite. Certain parts however, are equigranular. Some of the lighter-coloured layers in the slate have recrystallized with a development of light green chlorite and a small quantity of steatite. In the darker layers the rocks are much discoloured by carbon. They have a closely spaced flow cleavage, and their slaty structure is characterized by mica scales and chlorite with ultra-blue interference colour. Larger, light green penninite porphyroblasts—0.06 mm—in a "transverse" position frequently occur (Pl. 1, Fig. 1). The laminae are almost at right angles to the axial plane and parallel with the folding axis. Fig. 20 shows an orientation diagram for the penninite. It was measured on the (001)-cleavages where they were most clearly developed. The unmistakable polar diagram shows that the orientation can only be the result of a recrystallization of the chlorite after the real cleavage had been developed according to a ab-plane. Penninite also occurs in the green chlorite-quartzite mentioned on p. 30, but here the crystallographic (001)-plane is parallel with the foliation, which is consistent with experience in general. The abnormal orientation registrered on the diagram should no doubt be connected with the flow structure visible on the base surface of Fig. 19. In the same figure the arrows indicate how the structure is a result of shear p_2, p_3 as well as compression p_1. The penninite thus seems to have been developed at a late stage after the compression with folding and rotational component movements had taken place.

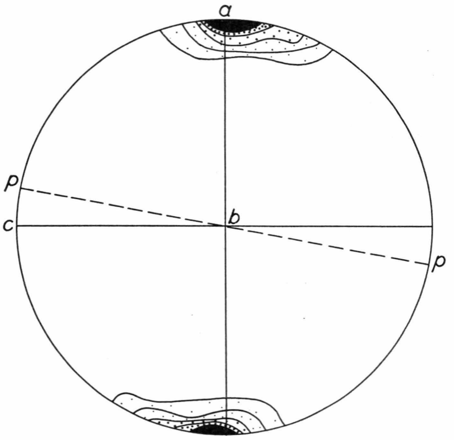

Fig. 20. Orientation diagram for penninite in quartz-chlorite-muscovite schist. Elison Ø (11389). Poles of (001) – cleavage in 100 crystals. Contours at 20 %, 15 %, 10 %, 5 %, > 0 % per 1 % area. p — p = primary bedding.

In many cases the penninite shows signs of a mechanical action, although the penninite porphyroblasts cannot, as said before, have been placed into position by rotation. The penninite has doubtless been developed at a later stage of recrystallization than the quartz. The cleavage of the rock according to the ab-plane was developed simultaneously with the neocrystallization of the quartz in the lentils. The anomalous orientation of the chlorite in the slate can be co-ordinated with the shear flow development which left no traces on the rigid layers and lentils of quartz-sandstone. In favour of this assumption also speaks the disagreement between the orientation of the penninite (001)-planes and the two s-planes of the quartz diagram (Fig. 21) although this is not synonymous.

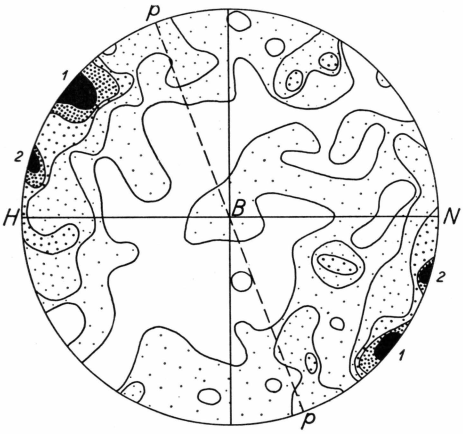

Fig. 21. Orientation diagram for quartz in mica-quartzite. Elison Ø (11392). Optic axes of 300 grains. Contours at 5 %, 4 %, 3 %, 2 %, 1 % per 1 % area. H-N = north-south, horizontal plane, p-p = primary bedding plane, B = folding axes.

All strata of the area visited have been altered to a degree of metamorphism not very different from the part of the south Elison Ø just outlined. Wherever primary black shales occur, they have been transformed to incipient slates. Many of the rocks are of a maculose structure with a "fleckschiefer" tendency. Small nodules are visible on the cleavage fragments of the rocks. A thin section from such a surface in the northern part of the profile ML at Mascart inlet shows a very fine-grained groundmass of mica and chlorite scales with no definite orientation (Pl. 1, Fig. 2). One or two penninite porphyroblasts occur in the flow cleavage plane. The groundmass presents an unusual, flickering extinction composed of the extinctions of the many small crystal individuals. Small rod-shaped mineral grains only 0.5 mm long occur everywhere in even distribution. The great impurity of the grains makes a determination of the mineral difficult. There are two cleavage directions parallel with the longitudinal direction and a rather irregular, parallel extinction with faintly ultrablue interfence colours. Birefringence is low, refringence values being 1.71—1.74. The absorption is at a maximum longitudinally with blue-green and at a minimum latitudinally with pale green. The data hold good for an epidote elongated along the crystallographic b-axis. Opaque grains are not infrequent.

A crystalline slate of a totally different type was found in a number of places in the northern half of the profile. There, in a syncline at Loc. 10 (Fig. 1) and in a structural terrace near Distant Cape strata occur made up of a light green slate which is exceedingly fine-grained and quite soft. The fine-grained structure allows a determination of the hardness which proved to be ab. 3. The slate splits easily into large, paper-thin flakes which are quite plane. No thin sections were made of the slate, but at loc. 10 it occurs in close connection with the aforementioned green quartzite from the same locality and is similar to certain layers in the latter. Accordingly, the slate is a very fine-grained quartzite with an admixture of a light green chlorite.

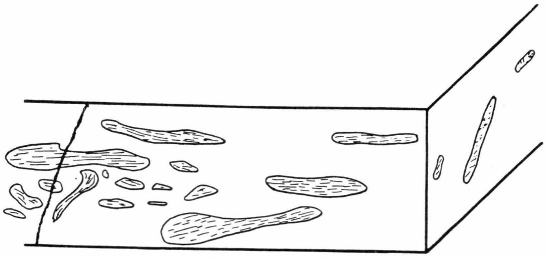

Fig. 22. Rolled-out slate fragments in deformed graywacke. The line in the left side designates a fissure.

The soft shales (slates) do not only occur in separate layers but also crop up as fragments in the quartz-rich sandstone (Fig. 22). The shape of the fragments varies a good deal. Usually they have been rolled out into lenticular plates although angular individuals also are of common occurrence. The latter have undoubtedly preserved their shape because the surrounding coarse-grained rock has acted as a protective armour during the process of deformation. In places where the armour has been unable to withstand the pressure from without, a flattening has taken place.

The shale fragments came from the district of derivation together with the large individuals of quartz and feldspar. The size of the shales never exceeds a few centimetres. The original dimensions may have changed, e. g. during the dynamic metamorphism, which resulted in paper-thin flakes such as may be found in the profile GH at Mascart Inlet.

a. Petrography of the Sandstones.

The sandstones are very uniform in the whole area although different types stand out clearly. In any case the original qualitites of the sandstones have been changed either by diagenesis or incipient metamorphism. The change in the size of the grains may be a result of very sudden transitions. Within the thickness of centimetres changes from coarse-grained to very fine-grained rocks may be observed. Fig. 23 shows such a variation with small cycles. The sample comes from an deposit at Mascart Inlet. From the same locality the variation in a sequence of a series is given below. It will serve as an illustration both of conditions during sedimentation, and of how well the material and the primary structure has been preserved during the metamorphism.

10 cm	Black slate with faint transverse cleavage.
50 cm	Fine-grained sandstone with scattered larger grains. Gradual transition to Coarse sandstone (grain size: 5—10 mm).
10 cm	Black slate with transverse cleavage.
100 cm	Irregular sedimentation of fine-grained graywacke with many slate fragments.
10 m	Smoothly developed quartz-sandstone without major variations.
50 cm	Fine-grained dark quartz-sandstone with a few large grains.

The sequence, described above, is a good representative of the quartz-sandstone series. Variations of this sequence may be observed everywhere.

The size of quartz and feldspar grains varies to some extent within the same thin section (Pl. 3, Fig. 1 & 2), and so does the groundmass. The content of calcite may often be considerable (Pl. 4, Fig. 1), but in other cases it consists of of a carbonaceous clayey substance which has been transformed to chlorite and sericite. The amount of dark components such as hornblende, augite and biotite is very small or, most often, the minerals do not occur at all. Shale fragments, on the other hand, are very common. The grayish-green colour, the definitely clayey material in the matrix, and the frequent shale fragments determine the sandstones as graywackes. In the tables below the small mineral scales in the groundmass have not been deciphered but added as a whole. Consequently, this value must include some quartz, so the figure for this mineral is a little too low.

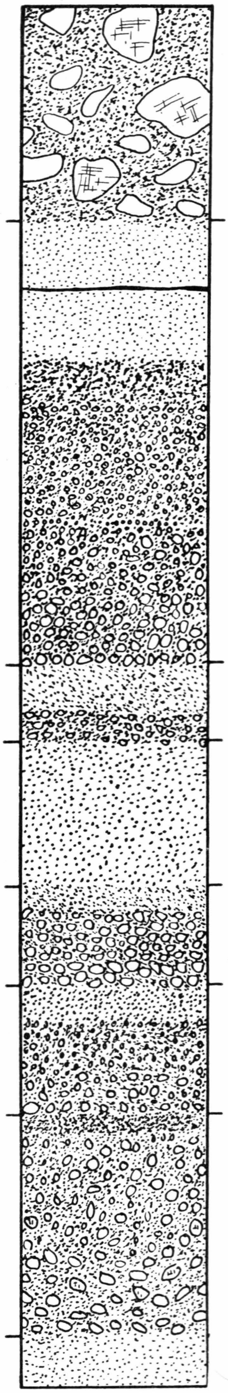

Fig. 23. Graded bedding with eight small sedimentation cycles in deformed sandstone. Nat. size.

Table 1. Planimetric analysis of two sandstones.

The values are given in vol. per cent.

	11332	11340
Quartz	58	77
Sericite, chlorite, accessories and indeterminable groundmass	32	1
Feldspar	7	2
CO_3-minerals	3	20
	100	100
Quartz-Feldspar ratio	8.3	38.5

The first of the rocks may be determined as graywacke to sub-graywacke on account of the low feldspar content, while the second is a calcareous sandstone according to the nomenclature given by PETTIJOHN (1949, p. 227). The indices of maturity represented by Quartz-to-Feldspar give values considerably higher than usual for graywackes. This is due to the incipient recrystallization with secondary outgrowths on the quartz grains and neo-crystallization of quartz. This increases the quartz content in relation to the feldspar which as a rule does not increase but deteriorates during formation of sericite. Other ratios are difficult to determine, as the diagenetic calcite and the authigenic derivatives do not represent primary minerals. Notwithstanding the high ratios the sandstones must be described as graywackes on account of their colour and the content of shale fragments. In all types quartz is the most common mineral. Feldspar and carbonate minerals come second and their propartionate quantity may vary. At a rough estimate the content of feldspar rarely reaches 15—20 per cent. The often well rounded quartz grains are consistent herewith, and in many cases the sandstones conform more to the definition of sub-graywacke than to graywacke (PETTIJOHN, p. 255)[1]. Lastly, there is a good deal of chlorite and sericite. Accessories are few. One or two grains of zircon, apatite and rutile (in quartz) and a single grain of staurolite(?) have been noted. The last mineral is not primary in the rock.

Feldspar is always of secondary origin and more or less rounded, although quite angular fragments were also observed. One grain with

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[1] PETTIJOHN's (p. 244) definition of a graywacke has been used in the present work. The dark mineral components have been disregarded, which makes the classification inconsistent with the definition frequently used, *vide* TWENHOFEL 1926, p. 175, and Committee on Sedimentation (Nat. Research Council, 1936, p. 31) where it is maintained that the graywackes are weathering products of basic rocks, that is, equivalents of arkoses.

secondary outgrowth was also found. Both plagioclase, ortoclase and microcline occur. None of these feldspars outweighs the others. In a few cases the plagioclases were determined to have ab. $10^0/_0$ An after complex albite-Ala twin laws, less than $10^0/_0$ An in some other individuals, one with $30^0/_0$ An determined according to the albite-Ala complex (low temp. opt.) and, lastly, one with $40^0/_0$ An (low temp. opt.). The majority of the feldspars are highly polluted by later metamorphism. Undulating extinction was less frequent in feldspar than in quartz. The most interesting point in connection with the feldspar is the secondary growth of feldspar under physical conditions generally unable to stabilize the formation of feldspar.

Quartz is by far the most important mineral in the sandstones. Quantitatively it is always the most frequent and contains the most certain traces of the development of the sandstones. The grain size varies in all samples from fractions of millimetres to centimetres. The very small individuals are often xenoblastic, while the large grains show pronounced rounding as a result of transportation. The origin of the former must be ascribed to a late recrystallization in the rocks during diagenesis and the incipient metamorphism, whereas the latter are sure to be of secondary origin. Among them it is possible to distinguish genetically different types of quartz. One of these has many small, irregular inclusions which give the effect of pollution. This quartz is presumably of metamorphic origin, the quartz individuals having grown and enclosed small clay minerals etc. Accordingly, this quartz probably originates from metamorphosed crystalline schists. The other type of quartz is clear and filled with one or two grains of zirkon and long rods and needles which may be rutile. It must be assumed that this quartz comes from granitic rocks. This agrees with the content of microcline and ortoclase in the rock. The latter type of quartz is far less frequent than the former. Under convergent light or reduced light the many often well-rounded grains proved to consist of several parts with different refringences (Pl. 4, Fig. 2 and Pl. 3, Fig. 1). A grain may have a core filled with inclusions of indeterminable nature surrounded by a quite clear mantle of quartz with a lower refringence than the central part. Such a development may well have taken place in the present sandstone. By such a growth the shape of the original grain may well be preserved. It will be harder to explain when a grain of sand is much rounded and filled with one or more angular fragments where the individual pieces are full of impurities. The structure may presumably be explained by the fact that the grains of sand in the present rock have been redeposited three times. Such quartz grains must have taken part in two earlier cycles. In the first the quartz was developed by netamorphism with inclusions, in the second angular fragments of the earlier product were cemented with quartz. This product was then finally broken up and rounded to its present shape. To make a certain determination is, of course, a difficult and rather precarious matter but viewed from a different angle it is difficult to see how the rounded form can come from angular pieces. A microstylolitic intergrowth of quartz individuals occurring in many rounded grains also points to an intermediate cycle (Pl. 3, Fig. 1). More grains would not have grown together stylolitically and acquired a rounded appearance in the same rock of the same cycle. To all the individuals in a common grain a deformation has in most cases been added resulting in an undulating extinction under crossed nicolls. The deformation must be attributed to the present orogen as the sandstones in some fabric diagrams show pronounced orientation. The possibility cannot, however, be excluded that during the present development a microstylolitic development may have taken place in the quartz, but it can in no way alter the picture just mentioned. In other types of sandstones which may be described as quartzites, the quartz grains are granoblastic and consist of pure quartz in which different zones cannot be discerned. In the latter types replacement of sericite and chlorite is very frequent along the surfaces of the grains (Pl. 2, Fig. 2). It may also be observed in more typical sandstones. The replacement has always placed the laminae of the minerals mentioned at right angles to the grain surfaces. It is doubtless a replacement which occurs during the first part of a metamorphism where the quartz grains must supply silicium and the groundmass the other elements needed to build up sericite and chlorite. The said metamorphism should only be regarded at a definitely incipient stage as, on the whole, there is no clear foliation for the small mineral scales. As already mentioned, the only orientation is their position at right angles to the grain surfaces, a position which may sometimes approach parallel schistosity. This structural development may equally well be called an advanced diagenesis. Replacement processes between quartz and calcite (sometimes—although less extensively—dolomite) are frequently seen with a development of corroded boundaries. In some rocks the calcite also makes up a considerable percentage of the rock, which may be seen from Table 1, p. 33. In all cases it is a faintly brown calcite, its birefringence closely approaching that of pure calcite. Where calcite occurs in fairly large quantities, the quartz grains are often completely surrounded by a crystalloblastic calcite. In some cases the extinction of the calcite is as undulating as that of the quartz, while in others it is quite undisturbed. This indicates a difference in age of the calcites from the various localities. During the folding process the mechanical action on the quartz and the calcite has been considerable and left unmistakable traces. Besides the two samples from the south part of Elison Ø already mentioned determinations of the mineral orientation were in some instances made by measuring of orientation diagrams. These are intended to assist in the determination of the degree of the dynamic metamorphism rather than the clearing up of the tectonical conditions[1])[2]).

In a sandstone from Lemming Fjord two diagrams were measured, one for a rounded quartz grain of the order 0.6 mm—1.2 mm (Fig. 24), and one for xenoblastic, neocrystalline quartz individuals of less than 0.1 mm across. The two diagrams present many similarities. Both are transitional stages between S- and B-tectonites. The spread of the poles gives two caps on both diagrams. The rounded, larger grains show caps with better defined boundaries than the xenoblastic grains. B. Sander (1930, p. 303) seems to have come to the same conclusion in connection with quartz schists from Tyrol. It should be noted that the rounded grains have two maxima while the neocrystalline only have one. This agrees with Sander (*op. cit.*). It either means that the larger grains

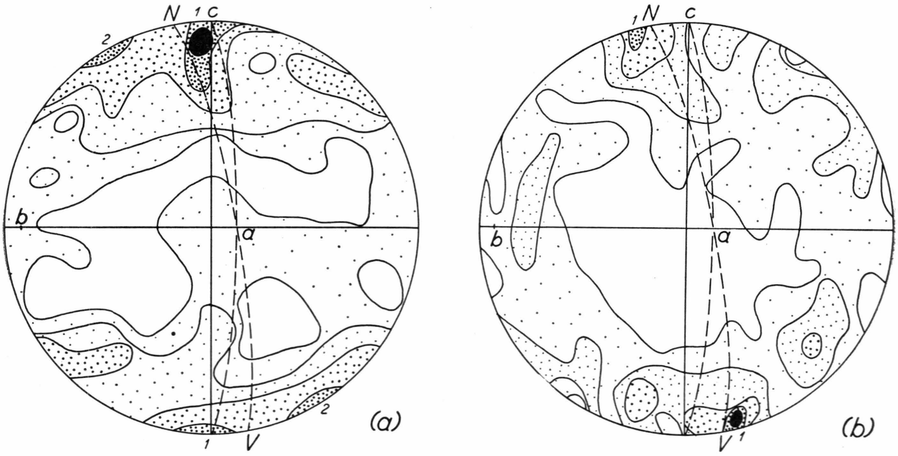

Fig. 24. Orientation diagrams for quartz in deformed sandstone. Lemming Fjord (11383). (a) Optic axes of 200 selected "non-recrystallized" grains. Contours at 7,5 %, 6 %, 4,5 %, 3 %, 1,5 % per 2 % area. N ⊥ V = north-south, vertical plane. (b) Optic axes of 300 selected recrystallized grains. Contours at 5 %, 4 %, 3 %, 2 %, 1 % per 1 % area.

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[1]) The measuring was carried out with a Leitz U-stage, and the results were plotted on the lower hemisphere of an equal area spherical projection.

[2]) It must be admitted that the number of orientated samples collected in the field is inadequate. It is due to the circumstance of the sandstone samples revealing no or a very slight metamorphism, for which reason the possibilities of petrofabric examinations were only considered at a very late stage of the field work. With material thus collected it would be too uncertain to make further investigations on which a structural picture of the weak points of the profile could be constructed.

get their orientation before the small, neocrystalline grains or that the large ones have preserved an earlier appositional or deformational character. Further, the diagrams are characterized by the fact that the "growing" girdle is situated in the bc-plane which goes against the diagram Fig. 21 from Elison Ø, where it was in a tectonic ac-plane. The reason may be sought in the following circumstances. At Lemming Fjord the sample was collected from a large, solid series of sandstone, while at Elison Ø the sample was collected from a sandstone lentil embedded in softer slates. Different "matrixes" may cause different reactions to shear influences the activity of which on the southern point of Elison Ø has been definitely proved.

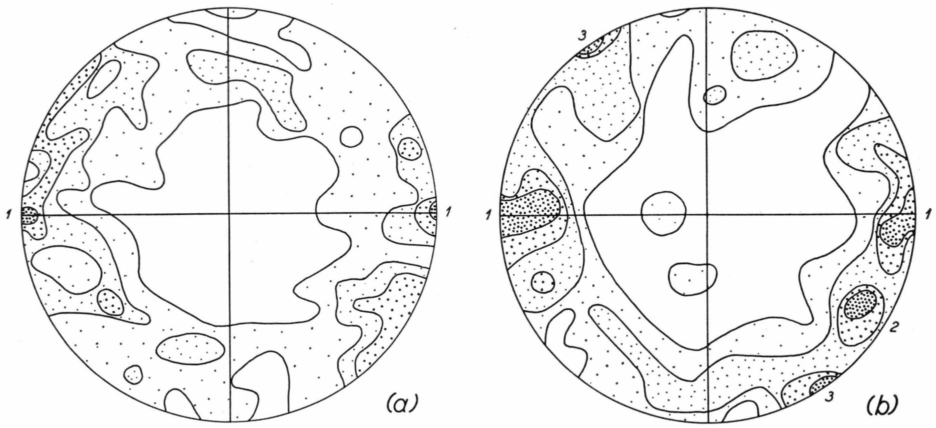

Fig. 25. Orientation diagrams for quartz and calcite in deformed sandstone. Mascart Inlet (11340). Contours at 4 %, 3 %, 2 %, 1 % per 1 % area. (a) Quartz: optic, axes of 300 grains. (b) Calcite: optic axes of 300 grains.

Rupture surfaces are less common in the quartz grains, although in one sample they were very evident while the shape of the sand grains was intact. A polar diagram of the rupture surfaces shows that they are not relics but came into existence as a result of a mechanical influence during the formation of the rock. The corresponding diagram for the optic axes shows a zonal distribution of the poles with a maximum, in other words, a less characteristic orientation than that of the rupture surfaces, which agrees with usual observations. As said before, a number of the sandstones contain some calcite. This mineral often has undulating extinction, while optically pure calcite may also be found. For a determination of the degree of influence during deformation two diagrams were measured, Fig. 25, for the purpose of comparison between quartz and calcite in the same sample. The degree of orientation is apparently the same. Twins in the calcite come out clearly in the diagram. It may thus be concluded that the calcite, which in any case is neocrystalline, also is pre- to paracrystalline. That the calcite content in many places has altered after the folding is evident.

The diagrams mentioned support the theory of the grains being mechanically deformed, that is, they are exponents of the degree of the dynamic metamorphism. In 1939, however, R. G. Wayland demonstrated that the ordovician St. Peter sandstone from the upper Mississippi valley and Arkansas shows a marked appositional fabric which gave diagrams identical with those obtained from the Peary Land material. Wayland maintains that a fabric diagram presenting a preferred orientation need not indicate a deformation of the quartz grains. One sandstone from Peary Land was measured for parallelism of the longest directions of the quartz grains as it appears in the plane of the slice. Only elongated, rounded to sub-rounded grains were measured. 115 grains were plotted, and in Fig. 26 the outlines show the percentage concentration within a unit arc (10°) of the reference circle. The diagram shows complete agreement with the petrofabric diagram Fig. 24. The longitudinal direction of the grains coincides with the direction of the optic axes. This corresponds to conditions in the St. Peter sandstone. When the orientation of the Peary Land sandstones is taken as proof of a mechanical deformation, it is due, firstly, to the close agreement between the symmetry of the diagrams and the tectonic co-ordinates, secondly, to the agreement between optic orientation and rupture surfaces in the quartz grains as seen in Fig. 27, thirdly, the diagram for the calcite matrix shows agreement with the tectonic symmetry and,

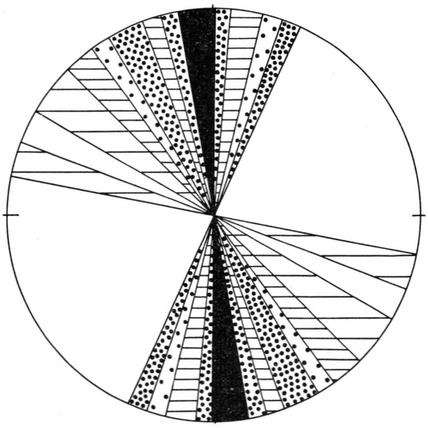

Fig. 26. Orientation diagram of 115 elongated "non-recrystallized" quartz grains. The diagram shows the percentage concentration of the elongation within a unit arc of the reference circle. Black: 15%, dotted: 12% and 9%, hatched: 6% and 3%.

fourthly, the frequently undulating extinction. The last point is the weakest as the grains may as well have preserved the undulating extinction from an earlier phase. At the same time we get information of the rounded form of the grains. It may have two causes: 1. During deformation ellipsoid grains without orientation in the original sandstone have turned in the soft clay matrix so that their longitudinal axis coincided with the tectonic b-axis. 2. Other grains, not oblong, have in course of gradual recrystallization been pressed into an elongated shape. The small, neocrystalline grains have presumably been orientated by the second process while larger individuals received their orientation from both 1 and 2).

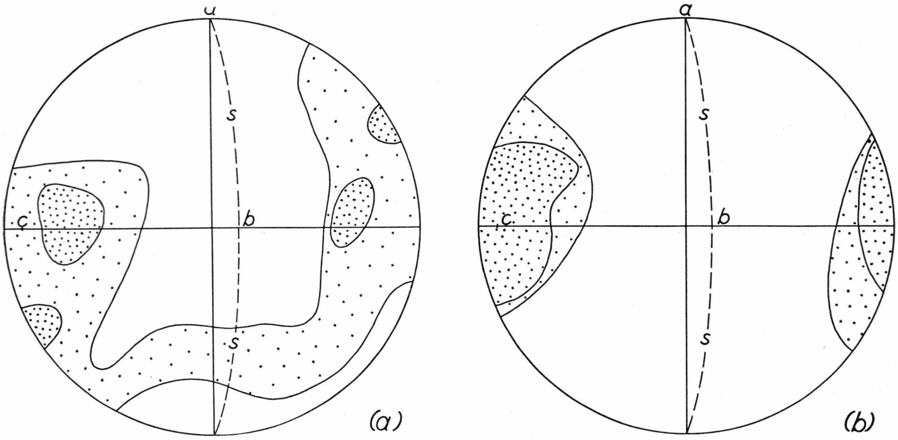

Fig. 27. Orientation diagrams for quartz in deformed sandstone. Mascart Inlet (11332). (a) Optic axes of 60 selected quartz grains. Contours at 10 %, 5 %, per 4 % area. (b) Poles of ruptures in 40 selected quartz grains. Contours at 20 %, 10 % per 4 % area.

In spite of the development which took place in the rock material it is quite clear that we are dealing with a typically geosynclinal facies. It is not possible now to say anything of the thickness of the deposits, but of the structure it may be said that graded bedding frequently occurs. Ripple marks were not observed although a surface structure on one or two layers may be interpreted as such. The size limit often varies, and the roundness of the grains is very rarely maximum. Intraformational slate fragments abound. In one place in a loose boulder an embedded erratic gneiss boulder was observed. Graywackes and sandstones are the principal rocks, while slate and quartzite are less frequent. There is a noticeable lack of limestones as of chemical sediments in general. Thus, the accessible part of the geosynclinal material is the top series or the highest floor of the folding range which obviously was the least transformed during the folding movement. It is, however, hardly justifiable to assume that we are dealing with formations in the graywackes much too near the coast. Although the large grains of sand and the shales required a heavy flow of water, no traces of such a flow were observed. Apart from faint indications in one or two cases no cross bedding was observed. Graded bedding only occurs as sedimentation structure when the even, uniform character of the sandstone is broken. Heavy flows of water near a coastal region might of course deposit coarse-grained rocks, but these would hardly show graded bedding. Should it happen that a shift of the stream would make the said structure possible, this would be much thicker in the individual cycles than is actually the case in the present sandstones where the individual cycles only amount to a few centimetres. Consequently, the graywacke sandstones are not quite coastal occurrences, and an explanation of the often inconsequent presence of shales in structureless rocks must therefore be sought. This also holds good of the discontinuation of the unsorted, uniform graywackes caused by a sudden occurrence of series with graded bedding. The problem is known from elsewhere, e.g. in European old-paleozoic geosynclinal bedding and has been treated by Bailey (1930) and others. He holds the view that the graded bedding structure is the result of hurricanes and seaquakes. The sudden, coarse occurrence should be due to such forces of nature. Bailey supports his view with an example from Scotland where such a phenomenon is enough every 2000 years. However, until better stratigraphic, petrographic and structural investigations from Peary Land are available, it would not be advisable to study the genetics of the sandstones in greater detail so as not to venture too far into the bog of pure speculation.

In connection with the slight recrystallization it is interesting to note that traces of geosynclinal volcanic activity cannot be found anywhere. The only indication of intrusive action is the post-orogenic dykes, whereas no trace of intrusive or extrusive activity of greenstone, tuff, etc. was found. This, however, should not be taken as proof of the occurrence being a wholly amagmatic miogeosyncline (Stille, 1940). As the petrographic conditions indicate that we are in the upper geosynclinal sedimentation storey or in the southern, outer zone of the geosyncline, magmatic activity may well have taken place in the central, lower geosynclinal sediments, which would not have been possible to observe in the field visited. It is known from other regions that miogeosynclines reveal a less continuous course of development than magmatic eugeosynclinals. As too little is yet known of the detailed development of the folding range and its stages, it would be rash to give further consideration to the conditions described above for the purpose of obtaining agreement or disagreement, as the case may be, between the various data. A closer determination of the climatic conditions prevailing at the time of weathering and sedimentation of the material will hardly be possible. It may, however, be established that the climate was not tropical, but that conditions make temperate, cool or arctic climates possible.

b. Petrography of the veins in the joints and the fissures.

In the chapter on the joints its relation to the rigid, quartzitic rocks was mentioned. Many of the fissures are filled with a mineral deposit of a very monotous nature: quartz, chlorite and calcite. Chlorite is not always present in the vein material. In samples the quartz is often green, in certain parts attaining a size of 1—2 cm for each aggregate individual. In most cases it has a very undulating extinction and many rupture surfaces when examined under the microscope. The green colour comes from a very large number of enclosed vermicular chlorite crystals (Pl. 5, Fig. 1). The crystals are randomly distributed, in the quartz. A few parts carry much chlorite, others do not. Between such parts clear as well as diffuse outlines are very frequent. The individual crystals attain an average size of 0.04 mm, and the scales are piled up one above the other like a pile of plates. The chlorite scales may be so frequent that they amalgamate into larger chlorite areas. The interference colour is ultrablue and the birefringence very low.

In the grayish-brown quartzitic sandstones the calcite is always a brown calcite with the usual optic data, whereas in other rocks it may be white and colourless under the microscope.

The veins mentioned should doubtless be interpreted as hydrothermal products.

c. Intrusives.

The intrusives of the folding range will, as already mentioned, be more thoroughly discussed in a later publication. They are quite frequent, a fact also observed by Lauge Koch during his journeys. The intrusives observed by the present writer were always steep, post-orogenically intruded dykes. The thickness varies but never runs to more than tens of metres. They are dolerites of varying composition. A porphyritic dyke with pronounced columns was found both at Black Cape and at Loc. 6, (Fig. 1.). It is tempting to assume it to be the same dyke that runs through Sverdrup Ø, since it is different in appearance to others. A small dyke was found in the profile IK, and in profile LM two different types occur. At Nansen Land near Strømstedet I collected a sample—unfortunately now lost—from a dyke. In the profile GH a dyke of the same brown colour as at Loc. 9 was found. The Kap Payer profile ON contains no less than three dykes one of which is composite. This means that intrusive types of at least three different rocks occur, two of which at any rate are of different ages. In the profile IR a fairly large dyke crops up through the strata. A smaller dyke exists near Low Point in Jewell Fjord.

GEOLOGY OF CENTRAL PEARY LAND NEAR FREDERICK E. HYDE FJORD

As I was unable to visit both Nansen Land and the central parts of Peary Land in Frederick E. Hyde Fjord, a discussion of the geological conditions, especially the metamorphism in the folding range, will have to be based on samples of rocks and sand kindly collected for me by E. Knuth on his sleigh journey to the fjord in question (Fig. 28). They do, however, help us to get a more exact impression of the prevailing conditions than hitherto possible. Until now our knowledge of the degree of metamorphism has been based on L. Koch's investigations from the Bicentenary Expedition round the north of Greenland in 1921. Koch travelled by dog sleigh along the coast. On the plains towards the Arctic Ocean in the north and north-eastern parts of the country Koch observed a number of crystalline gneiss and granite boulders. As such occurrences could not have come from the coastal areas of the districts which should consist of garnet-mica schists, they must have been transported from the heart of the country. Hence Koch concluded that a highly metamorphosed core of gneiss existed in the central parts of the country. Koch excluded the possibility that the blocks could have their origin farther south, i.e. from a crystalline basement under the ice cap, which was the basis of the pre-Cambrian sandstone series as is known from the east and west coasts of Greenland. His assumption was based on morphological observations. North Peary Land was alpine country with nunataks, which accounts for it never having been covered by the ice cap but only subjected to local glaciation. According to Koch, the limit of the maximum glaciation almost coincided with the longitudinal axis, i.e. a little way south of Frederick E. Hyde Fjord. Consequently, the crystalline boulders must have come from central Peary Land. Unfortunately, no detailed information was given as to the real nature of the boulders, nor were samples collected.

Against the presence of a gneiss core in central Peary Land near Frederick E. Hyde Fjord, as shown on Koch's map, speaks the material collected during the Peary Land Expedition 1949—50.

Description of the samples collected in Frederick E. Hyde Fjord by E. Knuth.

11562. Light green chlorite-talc slate.
11563. Black, grayish-black phyllite with transverse cleavage and crenulations folds.
11564. Grayish-green coarse-grained quartzitic sandstone. The quartz is often bluish. The sample intersected by white quartz veins.
11565. Coarse-grained, green, quartzitic graywacke with veins of white quartz and calcite.
11566. Grayish-green, medium-grained quartzitic sandstone with some chlorite in the interstitial matrix.
11567. Coarse-grained, grayish-green quartzitic sandstone (like 11564 & 11566).
11568. Crush product of slate with veins of quartz and calcite. Contains centimetre-large polycrystalline pyrite balls.
11569. Dark, bituminous limestone.
11570. Laminated shale with light green or black-gray bands. The structure is slightly flattened and small faults—size in millimetres—occur. One or two grains of pyrite.
11571. Maroon slate with chlorite-covered slickensides.
11572. Dark, bituminous limestone.
11573. Dark, greenish-brown mudstone with brown slickensides.
11574. Contains two samples. One is a fine-bedded, light gray shale, the other a chert conglomerate.
11575. Fine-grained sandstone.
11576. Dolomitic limestone with gray and black bands.
11577. Brown shale.
11578. Gray shale.
11579. Maroon slate with a slightly greasy look caused by a small content of steatite in the rock.
11580. Dark, bituminous limestone with veins of quartz and white calcite.
11581. Light gray, fine-grained sandstone.
11583. Dark, bituminous limestone.
11584. Sandstone of distinctly metamorphic character owing to mica and chlorite scales.

Samples of Sand.

Of the samples of sand from Frederick E. Hyde Fjord (Fig. 28) a heavy mineral separation was made with the limit at 2.90 (Acetylene tetrabromide). As the collection data (*vide* overleaf) did not allow for a quantitative examination, only qualitative and semi-quantitative examinations were made. The content of heavy minerals in the samples varied a good deal. The minimum was $0.6\,^0/_0$, maximum $21.5\,^0/_0$. The mineral content was very monotonous as will be seen from the table attached where samples of sand from Nansen Land have been included.

The present description of 22 samples from solid rock proves that in all cases the rocks were not or only slightly altered. The highest degree of metamorphism reached are slickensides covered with talc and chlorite and a similar mineral development caused by flow in less competent layers. If a regional, highly metamorphosed core had existed,

Table 2.

No. cf. Fig. 28	G. G. U. No.	App. weight per cent heavy minerals	Augite	Chlorite	Ore {Pyrite, Limonite	Amphibole	Biotite	Garnet	Andalusite	Carbonates	Epidote	Tourmaline	Zircon	Kyanite	Chloritoid	Enstatite	Actinotite	„Alterites and Indeterminables“
1	11355–56	6	××	×	××	○	○	..	..	..	○	○	○(?)	..	..	..	..	×
2	11357	9	××	×	×	○	..	..	..	..	○	×	○	..	..	○(?)	○	×
3	11369	22	×××	..	×	○	○	..	..	..	○(?)	○	..	..	..	..	..	×
4	11378	17	×××	○	×	○	..	..	..	..	..	○	..	..	..	..	..	×
5	11391	10	××	××	×	○	..	..	..	..	..	..	○	..	..	..	..	×
6	11415	11	××	×	××	..	..	○	..	..	○	..	..	..	..	..	..	×
7	11416	11	×××	×	××	..	..	..	○(?)	..	..	○	..	..	..	..	..	×
8	11553	3	×	×××	×	○	..	..	..	..	..	×	×	..	..	..	..	×
9	11554	3	○	×××	×	○	..	..	..	○	..	..	..	..	○(?)	○(?)	..	×
10	11555	12	××	×	××	○	..	..	..	..	○	..	..	..	..	..	..	×
11	11556	4	××	××	×	..	..	..	..	..	..	○	○	..	..	..	..	×
12	11557	11	×××	..	××	..	..	..	..	○	..	..	..	..	..	..	..	×
13	11558	3	×	××	××	..	..	..	..	..	○	..	○	..	..	..	..	×
14	11559	1	××	××	××	○	..	..	○(?)	..	..	..	..	..	..	..	..	×
15	11560	1	××	××	××	..	..	..	..	..	..	..	..	..	..	..	..	×
16	11561	2	×	×	×	..	○	..	..	○	..	..	○	○(?)	..	..	..	××

× indicates that the mineral in question occurs in quantities below ab. 20 %, ×× indicates ab. 20 %—60 %, ××× above ab. 60 %. ○ means that very few grains, e. g. 1.2 or 5, were found.

material randomly collected like the present would have contained a number of gneiss samples.

An analysis of the samples of sand from the northern side of the fjord points in the same direction (Table 2, p. 45). First, the heavy mineral content varies greatly. To some extent this may be due to a not too careful collection of the samples, which was made during a winter journey where one had to dig through the snow cover and then cut through a layer of ice, before it was possible to reach a very stony material which again had to be roughly sorted before being taken home. This method of collection excludes the possibility of a quantitative determination of the heavy minerals, since nothing is known of accumulation conditions at the locality in question. A very selective separation may have taken place at the very spot where the material of sand was collected. From this circumstance, however, it is hardly possible to explain the variation in the content of heavy minerals which may be from ab. 1 to ab. 20 per cent. It is quite consistent with the mineral assemblage which is characterized everywhere by the presence of brown basaltic augite and green chlorite. Apart from chlorite, typical metamorphic minerals such

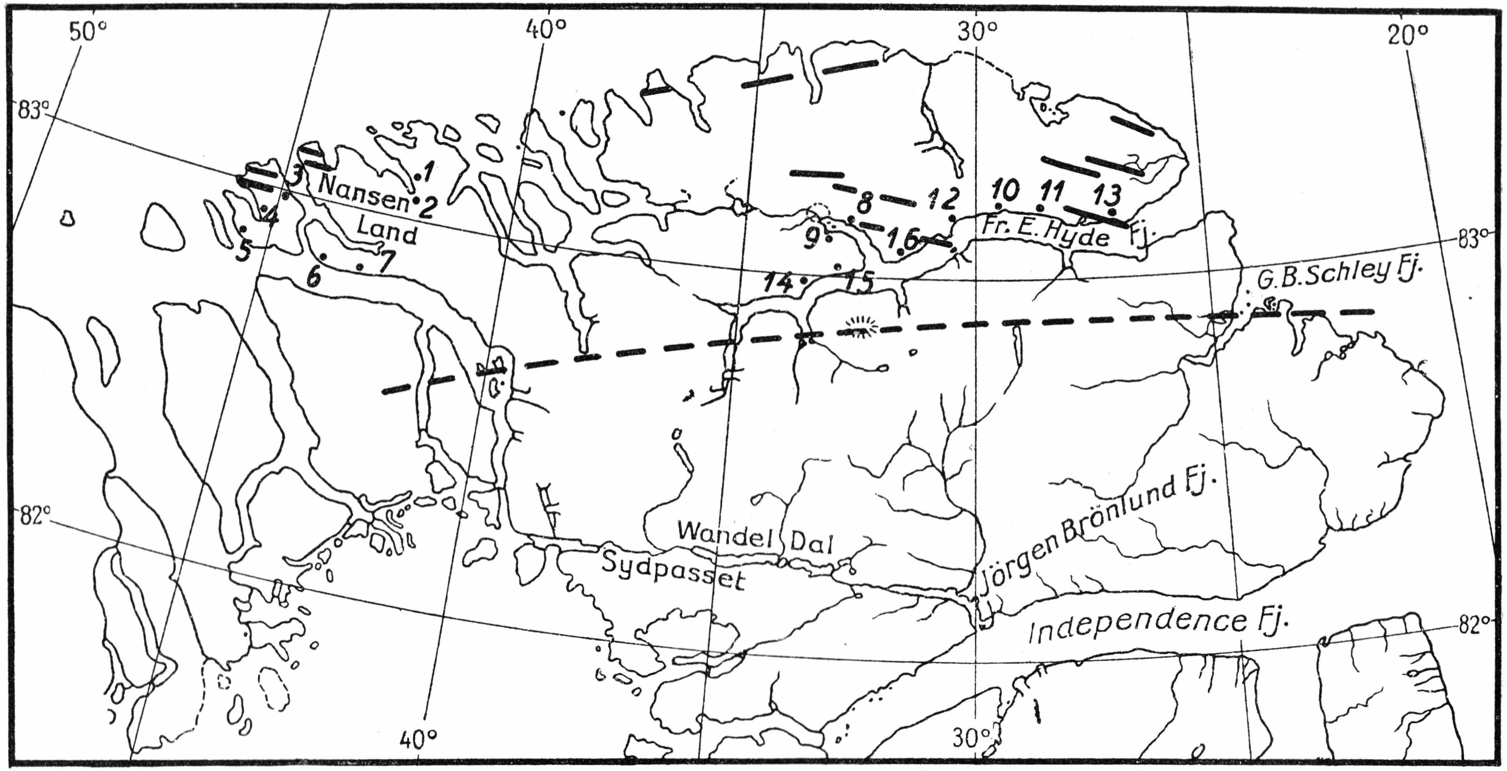

Fig. 28. Map of Peary Land. Scale app. 1 : 2.300.000. The figures indicate localities where the sand samples were collected (cf. Table 2, p. 45). 1—7 are the samples from Nansen Land, 8—9 from Friggs Fjord and 10—16 from Frederick E. Hyde Fjord. The dotted line E—W indicates the south boundary of the folding range. The thick lines in the folding range show the structural directions as they appear from the Geodetic Institute aerial pictures,

as sillimanite and staurolite do not occur (as for garnet and kyanite, see later). According to L. Koch, however, the folding range at Nansen Land and near Lockwood Ø contains numerous intrusives. Their position in relation to the river beds is naturally accidental. Samples of sand from rivers crossing dykes or other intrusive phenomena get more heavy minerals than those from rivers not connected with intrusives. Had the sand been from a regional gneiss complex near rivers crossing the regional strike, the heavy mineral content in the samples would doubtless have been far more constant. In itself this makes the gneiss core improbable. It will be seen from the chart of sand analyses that very few typically metamorphic minerals were found (Table 2). There was only one grain of garnet which might as well have come from an earlier cycle, and the sand was moreover collected at Strømstedet near Nansen Land outside the supposed gneiss core. The absence of garnet in an area where there ought to be gneiss is most remarkable. One or two doubtful grains of andalusite and kyanite were observed. Of definite, metamorphic minerals only chlorite and epidote were found. Zirkon is no more significant than the grain of garnet. The brown pyroxenes and hornblendes no doubt also originate from the intrusives.

A circumstance which renders the presence of a gneiss core in the area in question equally improbable is the structure of the folding range at Nansen Land, which was visited and described by L. Koch in 1920, -23, -25, and -28 etc. The folding axis is almost horizontal with a slight westward dip. The metamorphism and transformation of the rocks of the area definitely show that they took place by lateral compression, only with flow parallel with the axial surface in the incompetent layers. On the other hand an area 50 kilometres farther east in the same regional strike (further verified by conditions on the folded strata near G. B. Schley Fjord) should be on quite a different level of the geosyncline with high temperature and greater possibilities of flow than the presence of a gneiss core would offer. The probability of such a change is very small in spite of the westward dip of the regional folding axis.

The lack of agreement between the two theories regarding the crystalline core is quite natural as, according to literature, L. Koch's own view of the possible existence of a gneiss core seems to have been rather uncertain. On his return from the Bicentenary Expedition in 1921 Koch wrote of the folding range in Peary Land (1923, p. 193): "The range is here over 100 kilometres broad, and I think the central parts contain some granitic batholiths, at any rate, intrusives indicating such occur on the northernmost point of Greenland (in one place I found solid mica slate with garnets)". It is understandable that the acid intrusives led Koch to assume the presence of granitic batholiths in the folding range of Peary Land, but why he mentioned the crystalline, sedimentogenous schists is harder to understand. The occurrence of mica schists need not indicate the existence of granitic batholiths in the central part. Two years later Koch revised his opinion to: "the mountains in Peary Land seem partly to be composed of gneiss and granite (mica-schist is found everywhere west of the northern point)" (1925, p. 275). In other words, Koch now assumed the presence of gneiss in central Peary Land and the widespread occurrence of mica schist. And, lastly, in 1928 (p. 504) Koch says: "at any rate there is a nucleus of gneiss" and further on the same page " — several blocks of granite on the north coast of Peary Land seem to originate from such a nucleus". This must mean that both gneiss and granite had been found on the north coast. It is, however, at variance with Koch's statement on p. 515 of the same work: "When on my journey eastward I reached the northern coast of Peary Land proper, I found that the highly fossiliferous erratic blocks, common farther south, were absent, as were also the gneiss blocks from the interior of Greenland". This must allude to the country south of Peary Land and not the folding range in the latter country. But how it is possible to distinguish between gneiss blocks from an area south of Peary Land and central Peary Land when both territories are unknown, one covered with the ice cap and the other never visited, is difficult to understand.

In my opinion the origin of the blocks of gneiss and granite (the terms are used indiscriminately by Koch) should be sought elsewhere. As Koch himself originally stated, they may come from acid, intrusive bodies, which does not become improbable by finds of acid intrusives in the southern, unfolded part of Peary Land. Another, though perhaps less likely possibility is offered by the structure of the folding range. With the probable northward increase of metamorphism the position of the Caledonian gneiss core may well be in the Arctic Ocean north of Peary Land. In connection herewith a possible overthrusting of a gneiss nappe across north Peary Land cannot be disregarded as nothing is as yet known of the structure of that area. The type of structure has become well-known from Caledonian folding ranges. In that case the blocks may have their origin in such nappes and do not tell anything of conditions of metamorphism in the part of Peary Land which to-day rises above the sea, but of conditions in another part of the folding range.

BRIEF DESCRIPTION OF MATERIAL COLLECTED ON THE DANMARK EXPEDITION

In 1907 two members of the Danmark Expedition collected some rock samples from north-east Peary Land. The samples were deposited in the Mineralogical Museum. Medd. o. Gr., Vol. 46, 1917, pp. 337, 343 and 345, contains brief descriptions of conditions at the time of collection. In the present description Arabic numerals in brackets correspond to J. P. Koch's numbers. Apart from the labels attached, J. P. Koch's diary contains little information. The rock samples have only been mentioned once in literature, viz. by O. B. Bøggild, 1917. He says: "Zusammen mit diesen gehören wohl auch die von der Danmarksexpedition untersuchten Gegenden im westlichen und nordlichen Teile von Peary-Land wo auch stark umgewandelte Sedimente gesammelt worden sind". The sediments, however, are not always transformed as will also be proved by the following descriptions of samples:

Label X. (1). 106. North side of Hyde Fjord. Rock sample 100 metres. Marble.
Determination: Bituminous marble with veins of calcite and quartz.

Label XI. (2). 107. South side of Hyde Fjord. Numerous loose blocks, probably stationary.
Determination: Dark gray sedimentary rock with much calcite, quartz, and a little chlorite.

Label XII. (3). 108. South side of Hyde Fjord. Rock sample 200 metres. Determination: Fine-grained, dark gray (almost black) rock. Cataclastic structure. Completely crushed plagioclases and pyroxenes. Primary material undoubtedly dolerite. Composition of plagioclase ab. $50\,^{0}/_{0}$ An.

Label XIII. (4). 109. South side of Hyde Fjord. Solid conglomerate. 320 metres.
Determination: Purple cementing substance of the conglomerate grains which consist of quartz, flint and other highly weathered rock fragments. Veins of quartz are frequent.

Label XIV. (5). 110. South side of Hyde Fjord. Conglomerate.
Determination: Light gray coarse-grained quartzitic sandstone which has recrystallized. A few grains are rounded but angular grains are the most frequent. Tectonic slickensides on the surface.

Label XV. (6). 111. North side of Schley Fjord. Quartzite. From talus. Occasionally *in situ.* Pos. 83°5′.
Determination: Light gray quartzite. Fine-grained, partly recrystallized. On and between the quartz grains are thin mantles of a highly birefringent fine-grained medium, probably mica scales.

The only block to attract attention is XII. (3). It may be a pre-orogenic dyke or sill which has been crushed during the folding movement. Pre-orogenic intrusives would naturally be present in the folding range although they have not yet been demonstrated. There are pre-orogenic intrusives in the southern, unfolded part of Peary Land. It would be absurd to assume that the intrusives of the pre-Cambrian rock only extend to the southern half of Peary Land.

GENERAL REMARKS ON THE FOLDING RANGE AND ITS POSSIBLE CONNECTION WITH THE SVALBARD CALEDONIDES

Since L. KOCH published his results during the years following the Bicentenary Expedition 1921, no new material from observations of the Peary Land folding range has been forthcoming, though much has been written, and guesses have been made about it. On this slight foundation its age has been discussed. Attempts have been made at correlating structure and development to the rest of the Franklinian geosyncline. Material has been wanted to support the theory of a continental displacement between Svalbard on one side and Peary Land on the other.

An attempt to quote the many contributions, large and small, to the present problem will serve no purpose. Common to them all is the fact that they build on L. KOCH's observations and publications which, as far as the Peary Land range is concerned, have been discussed in the preceding pages. With the present, more documentary material in hand, all misinterpretations (apart from those of the writer) may be disregarded.

For one side of Peary Land—the western—J. TROELSEN (1950, pp. 25—29) has given a fairly satisfactory account of the data available from the folding range of Ellesmere Land. His work contains the necessary references, particularly to points regarding the Peary Land folding range. The present writer joins with TROELSEN (pp. 28—29) in dissociating himself from the theory of Archaean gneiss maintained by SCHUCHERT (1923, p. 193). TROELSEN believes that "Archaean" should be understood as Caledonian intrusive or metamorphosed core. TROELSEN is undoubtedly correct if real gneiss occurs in Peary Land at all. That remains of a Caledonian metamorphosed complex should exist in the Polar basin is quite consistent with the similarity as to structure and metamorphism between Peary Land and Spitzbergen. This also supports TROELSEN's view on SCHUCHERT's borderland "*Pearya*" (pp. 28—29).

To the other side an attempt was made at establishing a connection between the range and the Caledonian rocks of Svalbard, all the more so after TROELSEN's recent verification of the age of the folding, as already mentioned. Regarding conditions here ORVIN's work from 1940 should be noted for its excellent references to literature on the geology of Svalbard. The correlation and possibility of connection during a continental drift which may have placed the Peary Land folding range west-southwest of Svalbard have been treated by C. E. WEGMANN (1948). By placing the "*de Geer line*" as equator on a mercator map of the Arctics WEGMANN made conditions quite clear. When dealing with unfossiliferous (not yet found) deposits in the folded rocks of Peary Land one might from a geologist's point of view have looked for a possible connection in the heavy mineral content. As far as the writer knows, quantitative analyses of heavy minerals from deposits at Svalbard are not available. In view of our knowledge to-day it would hardly pay to carry out a quantitative heavy mineral analysis in Peary Land. It has been shown in the present work that no signs of a particularly characteristic metamorphism were found. In such a connection-experiment it would have been valuable to have a highly characteristic mineral assemblage *in situ* in the Peary Land folding range.

One feature, however, might indicate a connection between the two areas, and it should once more be stressed that the inadequate profile obtained during the winter's journey is very uncertain, and particularly so when an attempt is made to compare areas far apart. The uncertainty is of course greater for the unvisited part of the folding range. Of this only the degree of metamorphism, not the structure, will be mentioned. In all samples collected the metamorphism was characterized by dynamic metamorphism with slight recrystallization. It holds good for material collected by the writer as well as by E. KNUTH. There may be an increase of metamorphism northwards at Kap Morris Jesup. At Nansen Land the structure showed unmistakable signs of overthrusting north-south. The Caledonian folded Hekla Hoek occurrence at Svalbard shows overthrusting almost due west-east.¹) Here the overthrusting is noticeably connected with a high degree of metamorphism and local granitization. This means that at this point Svalbard has conditions which, judging by the trend, should exist north of Peary Land. It should, however, not be taken as a support of the continental displacement theory. Both Peary Land in the north and Svalbard in the south-west may well lack a part of the folding range which is present in the areas in question to-day. Further, the disagreement between the rock material of the Peary Land folding range and that of Hekla Hoek, Svalbard, is against a direct comparison even when the different metamorphism are taken into account. The present remarks only show a striking conformity which with our knowledge of Peary Land should be treated with great reservation.

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¹) The reader is reminded of the circumstance that north-south at Peary Land on account of the the high northern latitude corresponds with northeast-southwest at Svalbard.

SUMMARY

The present work draws up the main features of the geology of northwest Peary Land and particularly its structure and petrography. Nansen Land with immediate surroundings was visited in the spring 1950 during a sledge journey from the winter quarters of the Danish Peary Land Expedition at Jørgen Brønlund Fjord.

The first geologist to visit Peary Land was L. Koch, member of the 2. Thule expedition, 1917. On the Bicentenary Expedition 1921 Koch revisited Peary Land. On basis of observations made during the two expeditions Koch drew up the main features of the geology of northernmost Peary Land. The country has been visited before by other expeditions, but apart from the Danmark Expedition of 1908, none of them had brought geological material home.

In the chapter on folding and structure the principal conclusion is that the folding was caused by a combination of forces with a northward direction. The south foreland, the existence of which has hitherto been assumed, i. e. the unfolded deposits in North Greenland, seems tectonically to have acted as hinterland. It is pointed out that the symmetry to the range is clearly oblique with the axial surfaces dipping southwards. The area visited at Nansen Land proved to consist of a series of very regular, slightly asymmetrical folds. The folding seems to have been quite regular although a number of complications have been obscured for many coincidental reasons. They are obvious considering the almost total lack of map material and aerial views, the fact that our compasses were unreliable, and that the country was heavily covered with snow. In the south the folding sets in in the central part of the large J. P. Koch Fjord, and is well known from existing literature. After this zone with its gentle folds comes a zone with deeply folded and very disturbed strata round the east-west direction of J. P. Koch Fjord. The latter zone is doubtless of the same type as the one described by L. Koch from areas further to the south-west. North of it follows regularly developed the sequence of folds already mentioned. In addition to the asymmetrical folds other types such as homo- and monoclinal, chevron and slightly doubtful similar folds are described. For the whole complex the regional

strike direction is very near N 80°W, and the folding axis dips from the horizontal to app. 10°W. A few faults were observed. Their main orientation coincided with that of the folding complex. In his works L. Koch mentions that the presence of thrust planes must be assumed. With the incomplete structural picture available it was not possible to determine whether the structural discordances are thrust planes or merely post-orogenic faults. On the whole, however, with its décollement tendency the structure does not seem to offer any foundation for an assumed overthrusting.

A well-developed joint net must have played an important part in forming the morphology of the rock, as many mountain sides are characterized by the intensity of the joint net. It is chiefly in the clastic parts of the graywacke series that joints were developed during the folding movement. In addition to the more regularly developed joint net, cracks also occur, apparently unsystematically. The fissures of the latter system are the seat of the hydrothermal mineral fillings of quartz and calcite. The joints presumably came into existence at a late stage of the orogenesis.

The sedimentary rocks have been divided into an incompetent shale/slate series and a competent quartzite-graywacke group. In certain places the incompetent group has been partly recrystallized and the original structure obliterated. It presents important information of the action of the mechanical forces at work during the folding. In addition to the lateral compression it makes a shear action possible. The incompetent group consists of quartz-sandstones which are graywackes to sub-graywackes and, to a great extent, orthoquartzites. The sandstones are very homogenous and compact and not well distributed according to grain size, but graded bedding is not infrequent. The content of quartz is very high, while feldspar only amounts to a few per cent. The colour is grayish-green on account of a considerable content of a clayey substance highly transformed to chlorite and mica. Highly metamorphosed shales are very frequent. Dark minerals such as hornblende, augite and biotite do not occur. Heavy minerals were seldom observed. The dynamic effect on the sandstones is very evident. Under the microscope the quartz shows highly undulating extinction, and ruptures are frequent. There is agreement between the visible form of the quartz grains as well as between the optical axes and tectonic coordinates. Petrofabric diagrams reveal transitional stages between S-and B-tectonites. Petrofabric diagrams for quartz and calcite are identical. The quartz grains may have acquired their oblong shape either by primary rounding or by mechanical flattening. The agreement between the longitudinal direction of the grains, optic axes and tectonic coordinates may thus be due to 1) rotation of originally ellipsoid grains in a clay matrix in the graywackes, or 2) mechanical deformation without rotation or neo-crystallization. The quartz grains have presumably run their course through three sedimentation cycles. The primary quartz grains are derived from gneiss-granite areas and crystalline schists. After weathering and sedimentation the grains have been cemented to secondary quartz grains which were finally broken down and "tertiarily" deposited in the Peary Land graywackes.

The magmatic, post-orogenic intrusives will be discussed together with the intrusives from the southern, unfolded part of Peary Land in a special paper.

As literature contains none, a brief description has been given of material collected by J. P. Koch and A. Bertelsen during the Danmark Expedition. Only one block deserves special attention. It is a crushed igneous rock (dolerite) which is read as an indication of pre-orogenic activity.

The main subject of the chapter on the geology of central Peary Land is the theory advanced by L. Koch (1921) of an existing gneiss core in central Peary Land. On basis of loose gneiss and granite blocks Koch assumed the existence of such a core. Morphological and glaciological considerations seemed to support the assumption that the blocks have their origin in central Peary Land. Material from the Peary Land Expedition completely disproves the existence of such a core, however. The latter material was collected by E. Knuth. It was taken at Frederick E. Hyde Fjord and consists partly of a number of blocks collected *in situ*, partly of samples of sand from river mouths. All the blocks consist of slightly metamorphosed or unmetamorphosed (strong diagenesis) material frequently showing signs of dynamic action. Qualitatively the sand samples present a very monotonous, but quantitatively very varying assemblage. Of heavy minerals only few, often doubtful "metamorphic" minerals occur, while the great majority are sure to be of magmatic origin. Accordingly, the material speaks strongly against Koch's theory of a gneiss core in central Peary Land. It is assumed that the degree of metamorphism rises south-north in the folding range and not from the east-westwards as believed by Koch. Lastly, a comparison is made between conditions at Svalbard and in Peary Land. Like that of Svalbard the Peary Land folding is most probably Caledonian. In Peary Land the structure is clearly different from Svalbard where overthrusting and granitization occur at Hekla Hoek. This, on the other hand, may be taken as sign of a connection between the two. The symmetry tendency is the same in both areas with overthrusting S-SW to N-NE. The increasing metamorphism northwards in Peary Land may call for a complex north of Peary Land of a type similar to that of Svalbard.

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Færdig fra trykkeriet den 10. marts 1955.

PLATES

Plate 1.

Fig. 1. Quartz-chlorite schist with large chlorite individuals in a transverse position. Ordinary light. X 20. (11389. Elison Ø).

Fig. 2. Fleck-schiefer structure. The elongated, regular rods are presumably epidote. Ordinary light. X 20. (Mascart Inlet).

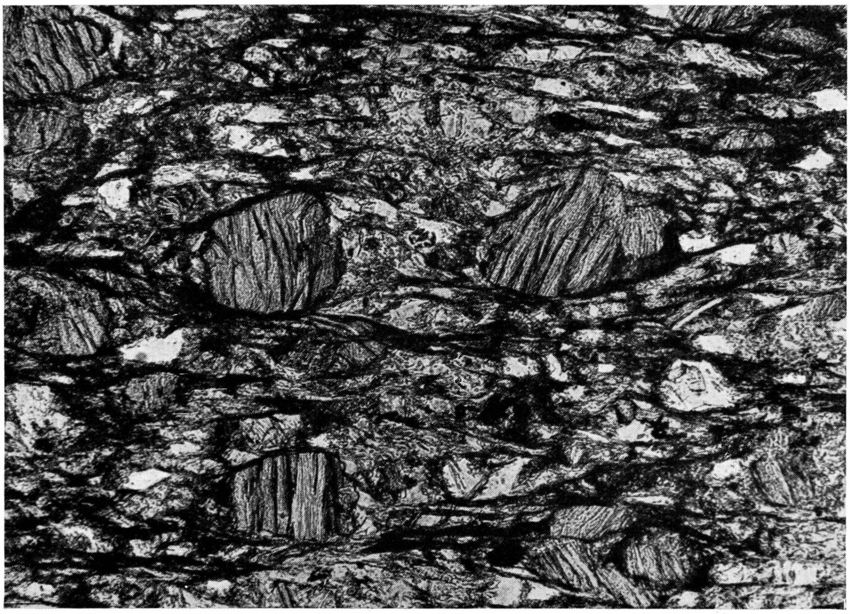

Fig. 1.

Fig. 2.

Plate 2.

Fig. 1. Folded layer of calcite. The twin lamellae of the calcite are contorted at the crest. Crossed Nicols. X 20. (11387. Elison Ø).

Fig. 2. Muscovite replacement along the surface of the quartz grains. In this section conformity after the foliation plane of the rock is very evident. Crossed Nicols. X 85. (Nansen Land).

Fig. 1.

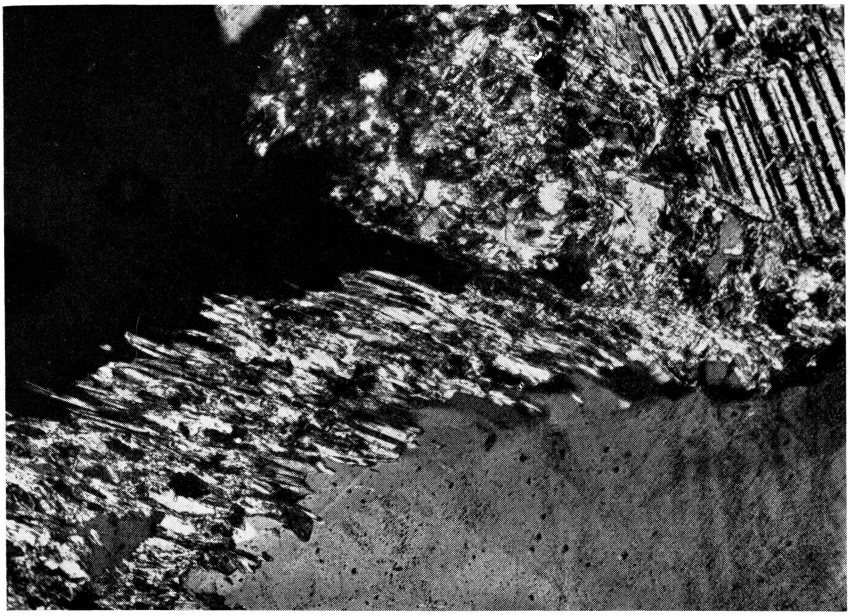

Fig. 2.

Plate 3.

Fig. 1. Quartz-sandstone. Microstylolitic intergrowth may be seen in a centrally placed grain. Areas with different refringences occur in some quartz grains. Crossed Nicols. X 80. (11337. Mascart Inlet).

Fig. 2. Quartz-sandstone. Crossed Nicols. X 8 $^1/_2$. (11383. Lemming Fjord).

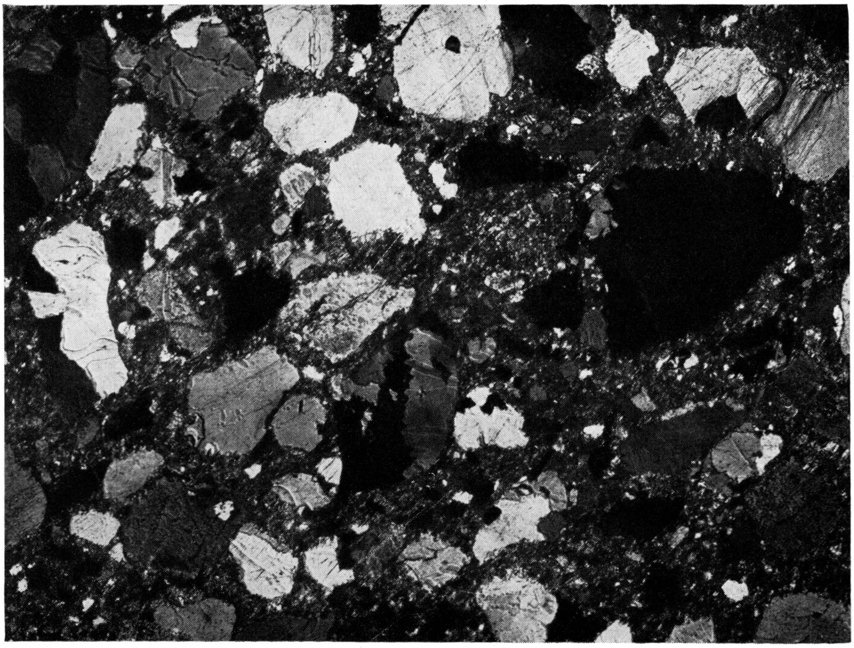

Fig. 1.

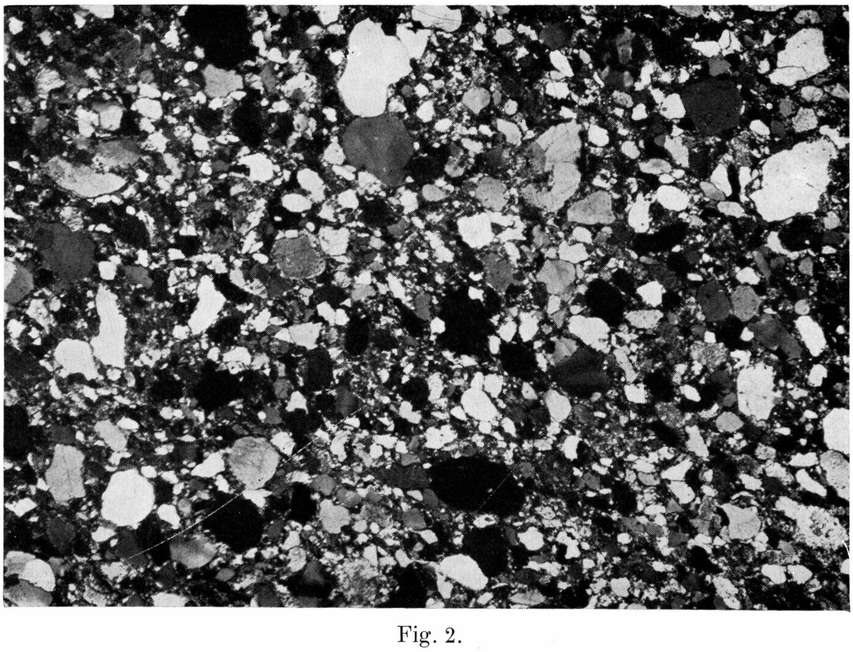

Fig. 2.

Plate 4.

Fig. 1. Quartz-sandstone, cemented by calcite. Crossed Nicols. X 85. (11340. Mascart Inlet).

Fig. 2. Rounded quartz grain in quartz-sandstone. The Becke line is seen deliminating the central, more highly refringent and contaminated core from the clear (pure) mantle. Crossed Nicols. X 85. (11340. Mascart Inlet).

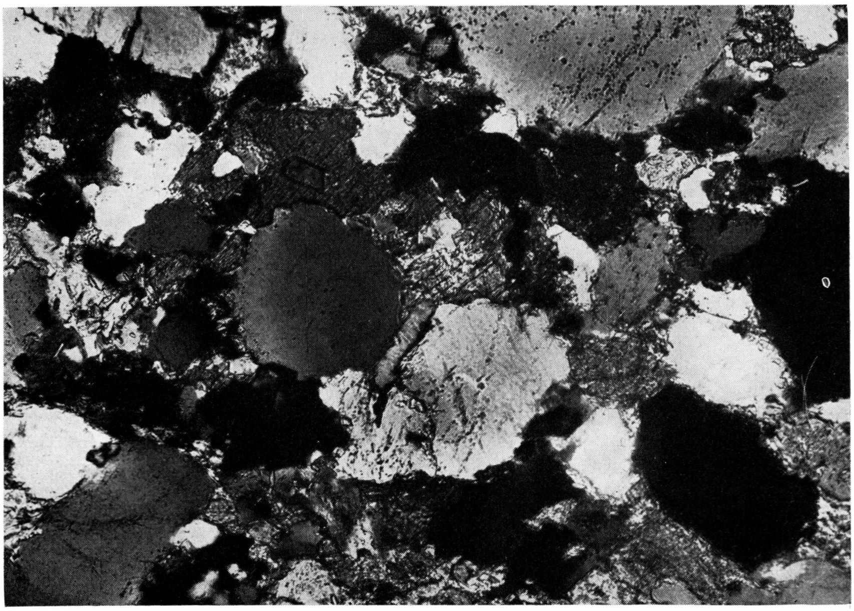

Fig. 1.

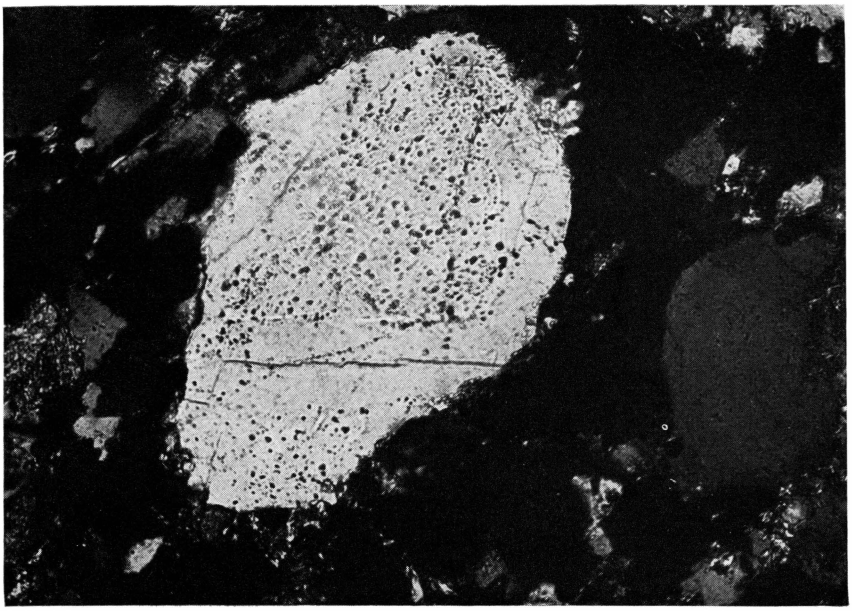

Fig. 2.

Plate 5.

Fig. 1. Vermicular chlorite crystals in quartz. Crossed Nicols. X 85. (11372. Mascart Inlet).

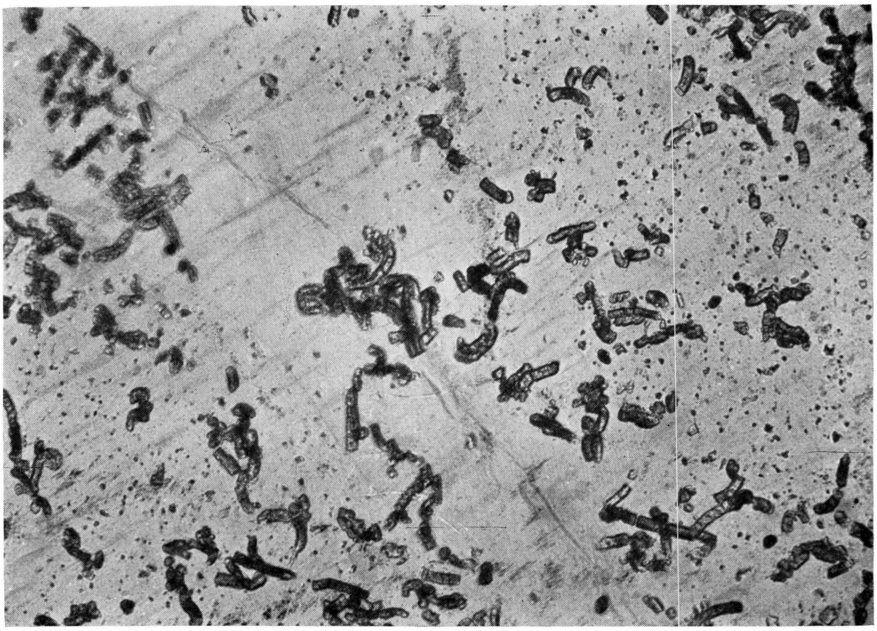

Fig. 1.