On the Precambrian structures of the Sandbukta-Mølen inlier in the Oslo graben, SE Norway

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The gneisses in the Precambrian exposures of the Sandbukta-Mølen inlier are cut by a dense swarm of basic dykes – the Kattsund dykes. These dykes separate two phases of orogenic deformation in the basement, but only the effects of the younger, post-dyke deformation (D_2) can be properly studied. During D_2 each layer in the interlayered gneiss-dyke 'sandwich' structure was subjected to homogeneous deformation. Pronounced stretching resulted in reorientation of all previous structures into parallelism with the strain X-direction. The folding and boudinage seen in a belt comprising Mølen and parts of Østnestangen are thought to have been produced at a relatively late stage by a clockwise ductile shear deformation.

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Systematic mapping of the Precambrian basement complex in Østfold, SE Norway, has been carried out since 1972 by a group of geologists from Institut for almen Geologi, Københavns Universitet, working under the auspices of Norges Geologiske Undersøkelse. As a member of this group the author has been engaged in the study of the basement area along the eastern margin of the Oslo graben, including the basement exposed on southern Hurum and the island Mølen within the Permian graben itself. This area has previously been described by Gleditsch (1952).

The exposures on southern Hurum and Mølen (Fig. 1) form parts of a probably westward-tilted fault block which is limited to the west and east by down-faulted Palaeozoic strata, while to the north it is cut by the presumably Permian Drammen granite which also separates it from the Precambrian of eastern Hurum. This fault block is of great importance to the Precambrian because its Precambrian exposures constitute the westernmost exposures of a strongly ductile deformed belt running N-S in the eastern part of Oslofjorden.

The recent investigations in Østfold have revealed an important anorogenic event in the Precambrian evolution of the area, marked by the intrusion of numerous gabbroic and doleritic bodies into an older gneiss complex containing gneisses older than 1800 m.y. (preliminary Rb/Sr whole-rock age determination by S. Pedersen, pers.comm. 1975). After intrusion of these basic bodies, the anorogenic interval was succeeded by a new orogenic episode which caused amphibolite facies metamorphism and the intense deformation in the above-mentioned N-S trending belt in the eastern part of the Oslofjorden region. Rb/Sr whole-rock age determinations in this area indicate a metamorphic event at 1016 m.y., which is thought to be related to the formation of the N-S belt (Hageskov & Pedersen, in prep.).

At Sandbukta and on Mølen there is a dense swarm of deformed dykes – the Kattsund dykes – which possibly corresponds to the anorogenic basic intrusives in Østfold. The general N-S trending swarm comprises at least 600 dykes and major apophyses in an area 2.5 km wide. The dykes were intruded into homogeneous gneisses and together with these gneisses form a composite 'sandwich' structure with alternating dyke and gneiss layers. During the formation of the N-S belt each layer underwent strong homogeneous deformation and the dykes recrystallized throughout to amphibolites.

In the following description deformation structures formed prior to the injection of the Kattsund dykes are referred to as belonging to D_1-deformation, whereas D_2-deformation relates to the post-dyke deformation.

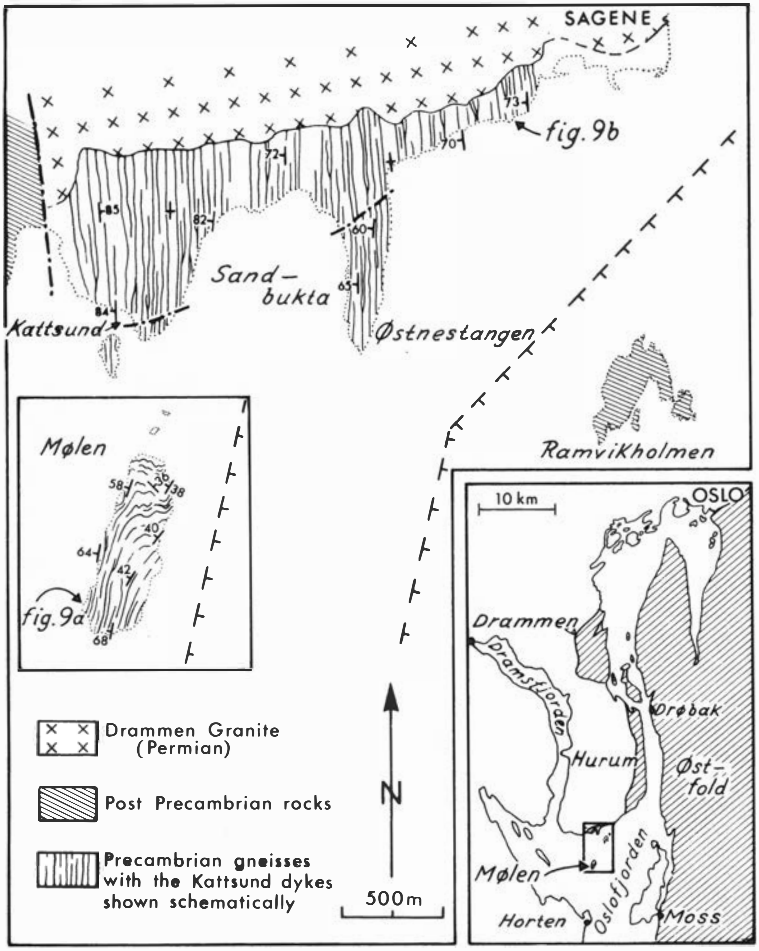


Fig. 1. Geological map of the Sandbukta-Mølen area. Index map shows the Precambrian areas (lined) in the eastern part of the Oslofjorden region.

The rocks in the basement sandwich

The gneiss layers

In the sandwich the gneiss layers between the dykes are formed of homogeneous granitic gneisses of simple mineralogy. In the field these gneisses are divided into a Sandbukta type, which is the only gneiss in the Sandbukta area, and a Mølen type known only from Mølen. While the Sandbukta gneiss is believed to be derived from a pre-D_1 granite, the origin of the Mølen gneiss is unknown.

The Sandbukta gneiss is a leucocratic, pale reddish grey rock which is extremely homogeneous and has a grain size varying in the interval 0.2–0.5 mm. Scattered biotite flakes cause the foliation and may locally also define a lineation, but more commonly the lineation is formed by up to 1 cm long and 1–2 mm wide ellipsoidal quartz aggregates. These quartz aggregates possibly represent deformed quartz phenocrysts.

The homogeneous gneiss on Mølen is distinguished from the Sandbukta gneiss by its colour, coarser texture, higher biotite content, and lack of quartz aggregates. In the gneiss fabric a lineation defined by biotite clusters is the dominant element. In the southern part of Mølen this homogeneous gneiss is interbanded with less than 1 m wide layers of a muscovite-plagioclase schist (S' surfaces).

In the gneiss layers there occur locally a few remnants of fine- to medium-grained, lineated and foliated amphibolitic rocks which have been exposed to deformation (D_1) prior to the injection of the Kattsund dykes. Their preserved sharp contacts, bifurcation structures, and the occurrence of gneiss xenoliths suggest an intrusive origin for these metabasites (the pre-D_1 dykes).

The dyke layers

The Kattsund dykes form the second type of layers in the basement sandwich; although they have been exposed to strong deformation and amphibolitization they display their intrusive structures very well. These structures in their present deformed state are best seen on the clean coastal exposures, but may also be recognized in the forest where the degree of exposure is fairly good.

Intrusive structures. – In its present deformed state the Kattsund dyke swarm consists of N-S trending, steep to subvertical westward-dipping dykes which generally are 0.5–2 m wide. Only a few dykes reach or exceed 10 m in width. The dykes amount on estimate to 35% of the total rock mass; no systematic variation in dyke spacing can be detected. East of Sagene on southern Hurum the dyke intensity decreases abruptly and only a few dykes have been observed in the gneisses from Sagene to Tofte and in the augen gneisses of eastern Hurum.

The Kattsund dykes appear as branched dilation dykes bounded by sharp planar or slightly curviplanar contact surfaces. Branching is a very pronounced structure and it is not unusual for a dyke to show several orders of repeated bifurcation. The branches are parallel to the main dyke trend; only occasionally does a branch or apophysis at a narrow angle to the dyke trend connect two neighbouring dykes. Intersection relations between dykes and their branches/apophyses have never been observed, but a few multiple dykes were found. Based on these relations it is believed that the dykes were injected at about the same time into mainly parallel joints. Thus a multiple gneiss/dyke layered system existed already prior to the D_2 deformation; this is referred to as the pre-D_2 sandwich structure.

Textural relations. – In the dyke rocks nearly all primary textural relations have been destroyed and the dyke rocks appear now as fine- to medium-grained strongly lineated amphibolites. Elongated plagioclase aggregates and hornblende nematoblasts define the lineation, and a weak foliation formed by parallel orientation of

Fig. 2. A thin Kattsund dyke cuts a D_1-folded pre-D_1 dyke. The leucocratic vein in the Kattsund dyke is folded and stretched.

the longest and intermediate axes of the plagioclase aggregates is usually developed. Otherwise foliation is restricted to the dyke margins and to the thin dykes and apophyses. In the central part of the dykes, the plagioclase aggregates are usually 2–3 cm long, but in section normal to the lineation they are only 1–2 mm across; their size, however, depends on the amount of strain as well as the primary grain size. Towards the dyke margins, the size of both the plagioclase aggregates and hornblende nematoblasts may diminish, and since this relation is found in both the interior dyke and the outer dyke shell of multiple dykes it is suggested that the size reduction of the plagioclase aggregates and hornblende nematoblasts reflects a primary chilling effect.

In Østfold, metabasites that are the possible equivalents of the Kattsund dykes commonly show preserved intersertal textures (Berthelsen 1970, 1972, Hageskov 1971, Graversen & Hageskov 1971). Even though it is likely that the textures in the Kattsund dykes were of intersertal types, no convincing relics were found. Most probably the plagioclase aggregates represent stretched primary plagioclase crystals which acquired their present aggregate texture

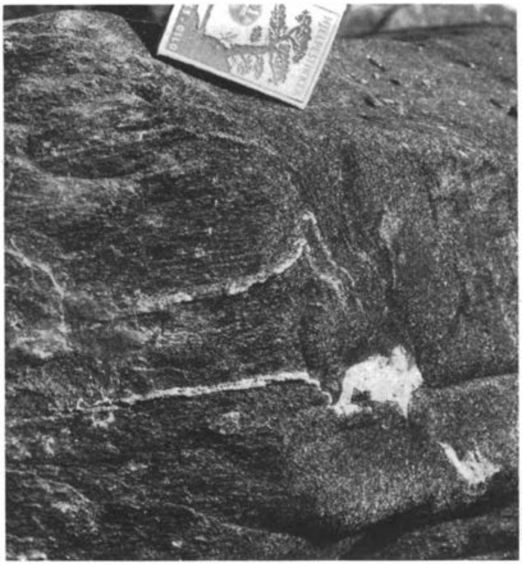


Fig. 3. Folded leucocratic veins in a Kattsund dyke, fold axis parallel to the fabric x direction.

Fig. 4. Elongated gneiss xenolith and folded leucocratic veins in a Kattsund dyke. Section oblique to fabric x.

as a result of the recrystallization accompanying the stretching. The hornblende nematoblasts on the other hand grew synkinematically, mainly at the expense of the mafic minerals.

The structures in the basement sandwich

The Kattsund dykes separate two phases of orogenic deformation of which the younger (D_2) is responsible for the pre-Permian (pre-faulting) orientation of all structural elements. Evidence of the pre-Kattsund dyke deformation (D_1) is only found in a few of the gneiss layers; this deformation is of no importance in the major structural pattern.

In the Sandbukta area the very regular sandwich structure completely dominates, but on Mølen the situation is more complex with the layers folded into a z-shaped fold structure. The structural evolution in the eastern part of Østnestangen seems to agree with that on Mølen, so that Mølen and Østnestangen may belong to one and the same structure. This structure will be considered independently of the sandwich structure.

The multilayered sandwich in Sandbukta

Before dealing with the structural details some general remarks on the sandwich is necessary. In the pre-D_2 sandwich structure the layer thickness was directly related to dyke spacing and dyke thickness. The D_2 deformation has left this sandwich structure as still parallel layers with only few indications of folding and boudinage, but in the deformed sandwich the layer thickness depends on the amount of strain as well as on the primary dyke spacing and dyke thickness. The rare fold structures appear singly and represent most likely dyke branches which had a suitable orientation. The scarcity of D_2 folds means that the layering in the pre-D_2 sandwich formed a high angle to the shortening direction during D_2, and that the effect of D_2 deformation has to be studied within the layers. Since the major structure both prior to and after the D_2 deformation was that of a sandwich, and any variation in layer thickness that occurs along the strike seems to be due to the primary dyke structures, it is believed that each layer was largely homogeneously deformed.

D_2-structures of the Kattsund dykes

Internal structures. – The tectonite fabric, deformed leucocratic veins, and xenoliths form deformation markers in the dykes as shown in Fig. 10.

From the description of the dyke rock it appears that the strong lineation and much less pronounced foliation are interrelated; the axes of the plagioclase aggregates define the linear as well as the planar fabric component. The longest axis of the plagioclase aggregates thus defines the fabric x-axis, while the longest and intermediate axes define the fabric xy-plane, which with very few exceptions parallels the dyke contacts. The general orientation of the x-axis is 354/21 (Fig. 12A).

In the dykes thin leucocratic veins deformed by folding and/or stretching are commonly found (Fig. 2, 3, 4, 5). In dykes with a pronounced planar fabric these veins either form tight or isoclinal folds with axial surfaces parallel to the xy-plane, or they are stretched towards parallelism to that plane. In dykes with a less pronounced planar fabric, the folds are less compressed and the axial surfaces show a higher degree of freedom in relation to the xy-plane although usually these planes are not far from being parallel. Fold axes and lineations measured on these deformed veins are almost perfectly parallel to the fabric x-axis of the enclosing amphibolite. Stereographic plots of measured linear structures and axial surfaces are presented in Fig. 12D.

Where a three-dimensional study of the xenoliths is possible, it is seen that the xenoliths are strongly elongated in a direction parallel to x.

Structures of the dyke layers and dyke contacts. – It appears that the dykes due to their orientation escaped deformation by folding, but it is to be expected that some branches and irregularities in the contacts formed a high angle to the dyke trend and should therefore have been exposed to folding. Very few examples of folded dyke layers are in fact found, and these form generally thight or isoclinal structures with axial surfaces parallel to xy and fold axes parallel to x. It is likely that these folded layers represent dyke branches, but the available exposures provided no proof of this. Fig. 6 shows one of the only two known examples of fold deformation of interconnecting apophyses. In Fig. 6 the contact of the interconnecting apophysis shows cuspate folding with cusps of the basic material extending into the gneiss; as already pointed out by Holmquist (1928), this indicates that the basic material was more ductile than the gneiss.

Folding of minor irregularities in the dyke contacts is, however, more common. Fig. 7

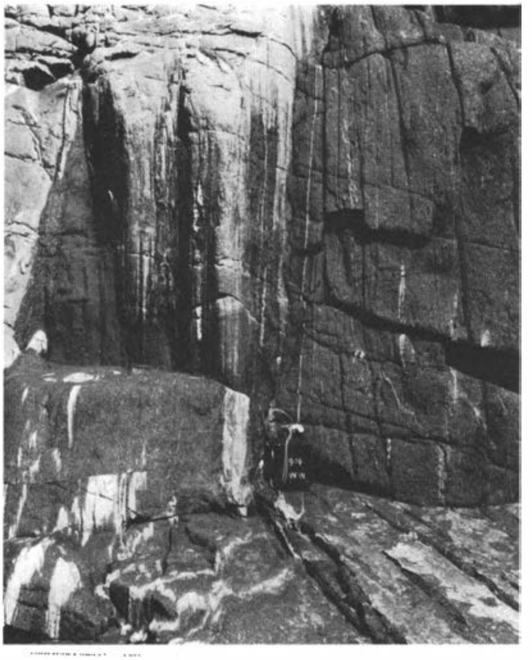


Fig. 5. Folded Kattsund dyke border with pinched-in basic material forming a lineation in fabric x direction. The deformed leucocratic veins and quartz-feldspar rods parallels this direction.

Fig. 6. Apophysis interconnecting two Kattsund dykes. The contacts of the apophysis show cuspate folding. Mølen, west shore.

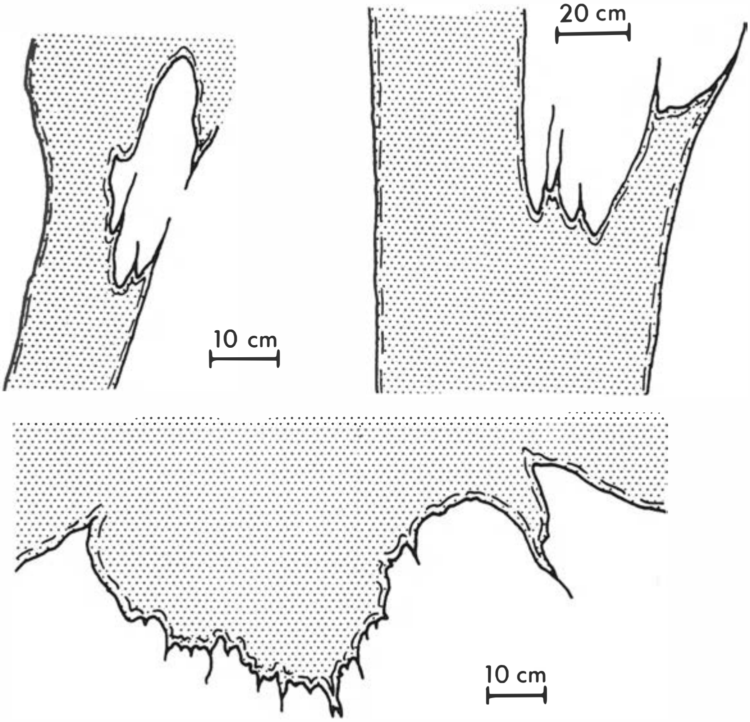


Fig. 7. Cuspate folding of irregular dyke contacts.

shows some examples of these folds, and it is always the case that the dyke margins react in a more ductile manner than the gneiss forming the cuspate folds.

At the margins of most dykes a distinct striation parallel or sub-parallel to the x-direction is seen (Fig. 8). Close inspection of sections normal to x reveals that this lineation is formed by minute pinched cusps of the basic material folded into asymmetric 'micro'-folds along the contacts. It is likely that these asymmetric 'micro'-folds indicate shear movements along the contacts normal to the lineation direction. In horizontal sections both dextral and sinistral shearing are found, but usually the sense of movement is dextral (clockwise).

Fig. 8. Contact lineation formed by minute pinched cusps of basic material.

D_2 and D_1 structures in the gneiss layers

The lithological homogeneity of the gneiss layers imposes rather strict limits as to how far the structural analysis can be extended into these rocks, but a few passive and second order structures caused by small scale inhomogeneities provide some information.

The orientation of the tectonite fabric axes in the gneiss layers shows perfect agreement with the D_2 tectonite fabric in the dykes. Scattered elongate quartz aggregates (relic phenocrysts ?) define the fabric x-axis, while the xy-plane is marked by the foliation. Thin basic schlieren and leucocratic veins and bands form inhomogeneities in the gneiss, and since these materials occur as limb remnants and rootless folds with-

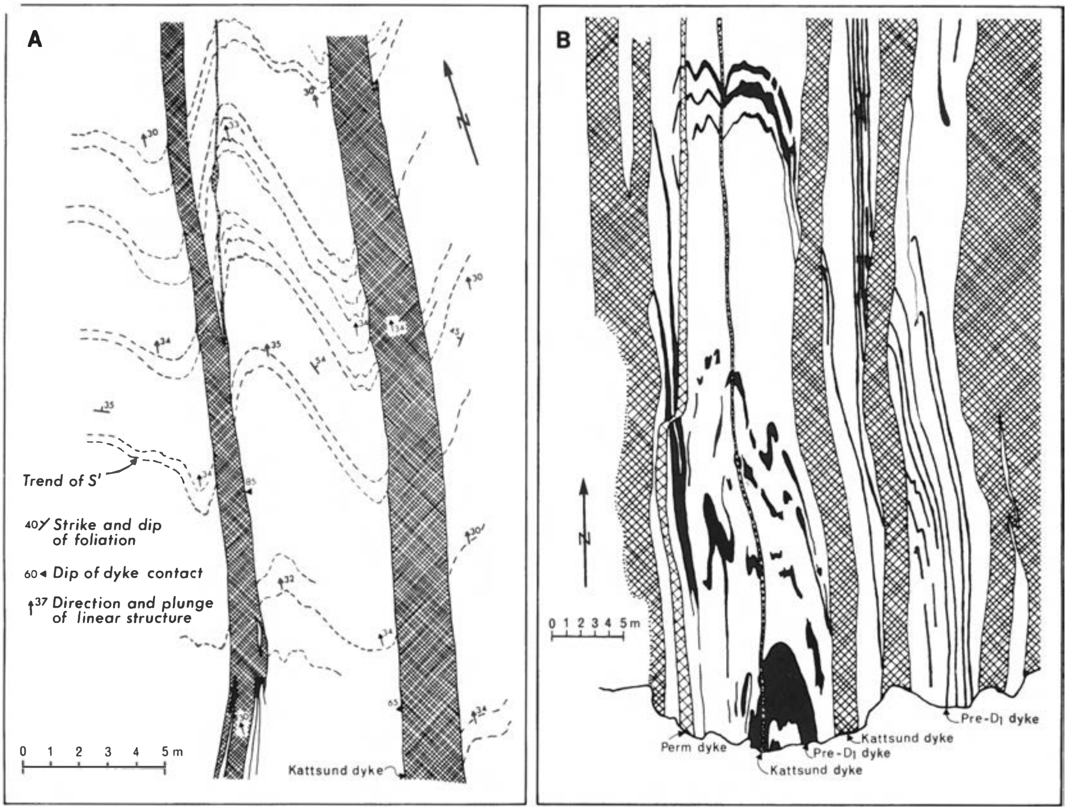


Fig. 9. A. D_1-folded S'-surfaces in the Mølen gneiss layers cut by Kattsund dykes. Mølen, west shore.
B. D_1-folded and boudinées pre-D_1 dykes in the Sandbukta gneiss layers cut by Kattsund dykes. The D_1 fold structure belongs to an isoclinal antiform. Sandbukta just south of Sagene football pitch.

in the foliation surface, it is likely that the basic schlieren and probably most of the leucocratic veins have undergone transposition towards the foliation surfaces.

Under these circumstances one might expect that it was not possible to distinguish D_1- and D_2-generated structures in the gneiss layers. Nevertheless D_1-folds have been recognized in a few very favourable localities, of which two are shown in sketch maps (Fig. 9A and B). In Fig. 9A from Mølen the Kattsund dykes cut folded S'-surfaces, while the Kattsund dykes in Fig. 9B cut folded and boudinées pre-D_1 dykes. These fold structures have an overall harmony which could hardly have arisen if they were D_2-generated in gneiss lamellae separated by dykes. The folds need to be D_1 structures, but a D_2 tightening can have taken place.

In both localities it is obvious that the D_1 fold axes are very close to fabric x and that the axial surfaces parallel the Kattsund dykes (and fabric xy-plane). The parallelism between the D_1 axial surfaces and the Kattsund dykes indicates that the latter were intruded into fractures containing at least the strike of the D_1 axial surfaces. It cannot be proved that the D_1 axial surfaces guided the dyking because of D_2 stretching (see p. 77). An extensive three-dimensional section is necessary if proof is to be found. In Sandbukta the pre-D_1 dykes are foliated parallel to the axial surfaces of the folds (like the Kattsund dykes), but it is not known whether this foliation was developed during D_1 or D_2.

The Mølen-Østnestangen structure

In the southern and western part of Mølen the layered complex has a general orientation 12/62W, but following the layers towards north a

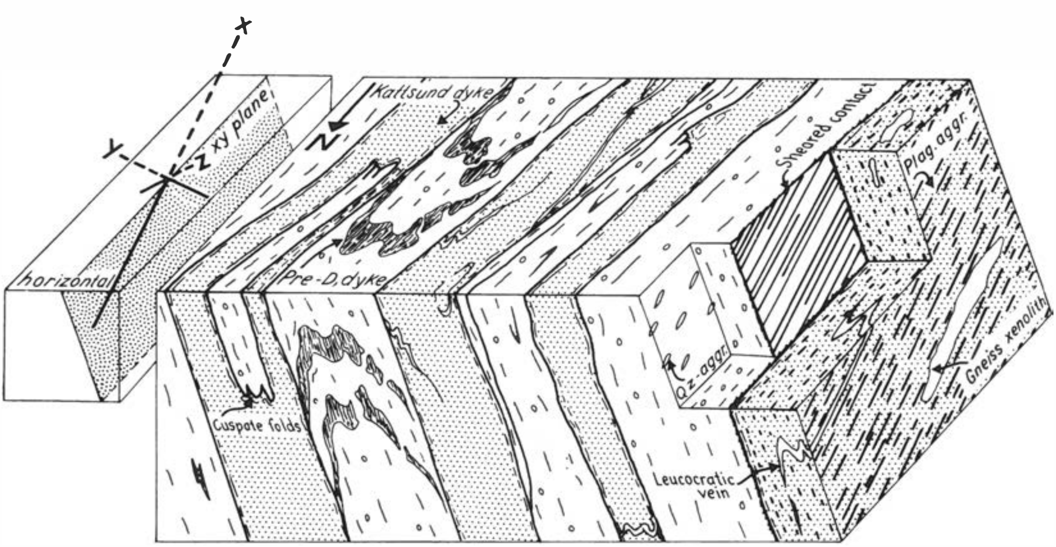


Fig. 10. Synoptic block diagram showing the prominent structural features.

remarkable NE turn appears in the central eastern part of the island. Further to the north, the layers are folded into a highly irregular z-like fold structure which dominates the northern part of the island. In this structure the axial surfaces strike almost N-S, and the fold axes, like all other linear structures, plunge to the north at a moderate angle (Fig. 12B). Minor disharmonic buckle folds and boudinage of the originally branched dykes cause the irregularity in this major structure. Both the asymmetry of the fold structure and the NE rotation of the dykes in the central eastern part of Mølen indicate that the rock mass has been rotated clockwise around a moderately northward plunging axis. Several minor shear zones parallel to the layers show dextral (clockwise) movements.

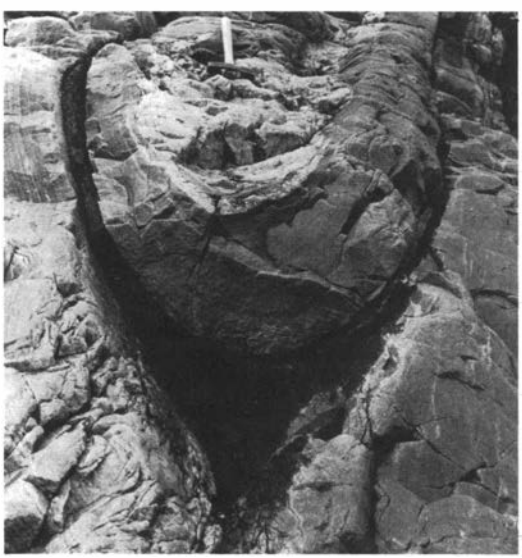


Fig. 11. Folding of a Kattsund dyke and D_2 foliation in the gneiss, indicating that the folding took place late in the D_2 deformation. East shore of Østnestangen.

In the Sandbukta area only in the eastern part of Østnestangen is there seen a structural evolution somewhat similar to that on Mølen. Z-shaped asymmetric folding of the layers and dyke margins on both a moderate and very small scale indicates clockwise rotation and shearing, but in contrast to Mølen the general N-S orientation of the layers is almost unaltered. Both on Mølen and on Østnestangen the fold and boudinage structures appear to have developed later in the D_2 deformation, postdating the formation of the main tectonite fabric (Fig. 11).

The structural relations on Mølen and on Østnestangen could probably be readily correlated if Mølen was not situated 3.5 km south of Østnestangen in an area of block faulting. Nevertheless the author believes that the structures in Østnestangen are a continuation of those on Mølen; this belief is based on the following:

The general orientation of the structural elements in Mølen fits very well with those from Sandbukta.

The structural development in the two localities is very similar.

Mølen is no more than an elevation of a shallow submarine ridge, which runs parallel to the structural trend and links Mølen to the mainland at Østnestangen.

If this correlation is correct, it implies, together with the orientation of the structural elements in both parts of the Sandbukta-Mølen inlier, that neither of the two parts of the inlier should have been moved singly by tilting or by strike slip movement along a fault cutting across the Mølen–Østnestangen ridge.

Interpretation and conclusion

When a rock mass with randomly oriented competent planar material elements (dykes, veins) is exposed to deformation, those planar elements forming an angle less than 45° to the shortening direction of the initial deformation will be folded, while all other planar elements become stretched. The initial orientation of the axes in folds initially formed by buckling of competent materials is determined by the orientation of the planar material elements and by the compression direction in them (Ramberg 1959, Biot 1961), while the axial surfaces initially develop normal to the planar material elements (Ramberg 1959). These initial orientations of fold axes and axial surfaces will have no direct relation to the axes of the strain ellipsoid, but as the progressive deformation proceeds they will move towards the longest axis of the ellipsoid (Flinn 1962).

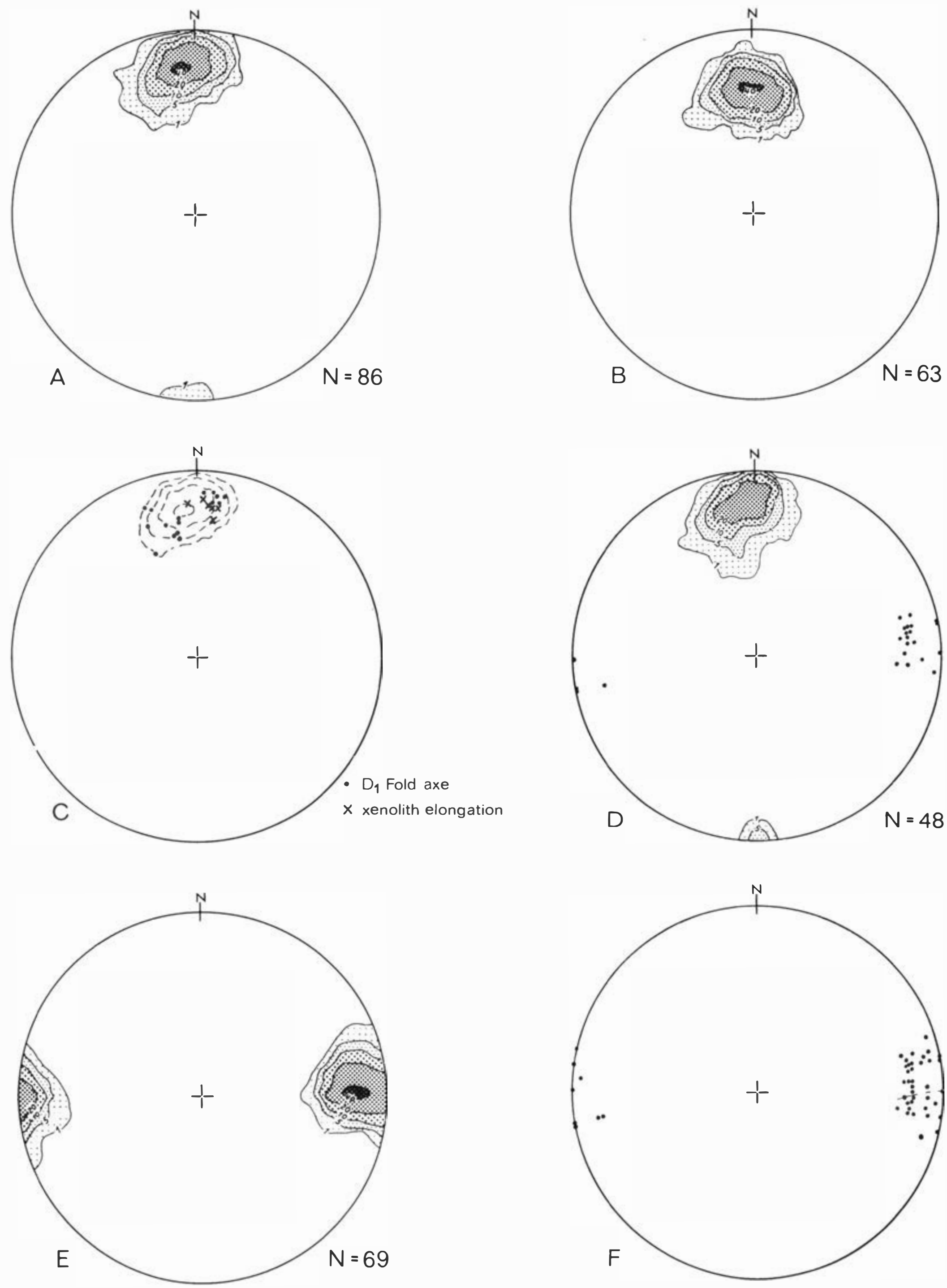
In the Sandbukta-Mølen rock mass the layers in the pre-D_2 multiple two-layer sandwich constitute first order planar material elements, while the thin leucocratic veins, the pre-D_1 dykes, and the S'layers in the Mølen gneiss are second order elements. The second order elements together with the tectonite fabric may be used as indicators of the internal homogeneous deformation of the gneiss/dyke layers. Even if these second order elements have undergone inhomogeneous deformation, they may be regarded as passive in relation to the total layered rock mass.

Within the Kattsund dykes the leucocratic veins are folded and/or stretched and are now almost perfectly parallel to the fabric x direction. This parallelism is remarkable because it requires that the leucocratic veins either contained the fabric x direction prior to the main deformation or became reorientated to the present parallelism in the way suggested by Flinn (1962). It is more likely that the deformed veins did not initially contain the fabric x direction. If this is assumed, some information on the D_2 deformation may be obtained by studying the folded veins. The geometry of the folded veins (class 1b, 1c, according to Ramsay 1967) and lack of penetrative shear/flow planes suggest that most of the folds were initially generated by buckling; however, even if the folds were formed by this process or by shear/flow, the fold axes of differently orientated veins should not be parallel. If the above assumption is correct, the marked parallelism of fold axes and stretched veins to the fabric x direction must be due to a pronounced stretching of the veins in the direction of fabric x.

Both the elongation of the xenoliths and the tectonite fabric of dyke rocks indicate stretching in this direction. In the homogeneously deformed Kattsund dykes the gradation between the lineation and foliation defined by the plagioclase aggregates shows that the fabric is that of a S-L tectonite as defined by Flinn (1965). Flinn suggests that the symmetry of the S-L tectonite fabric in a rock is directly related to the axis of the strain ellipsoid. This means that an originally isotropic rock (here the dyke rock) will develop an anisotropy reflecting the kind of homogeneous deformation.

In the Kattsund dykes the fabric x direction corresponds to the longest axis (X) in the finite strain ellipsoid, while the fabric xy-plane becomes the XY-plane of the ellipsoid. Furthermore, boudinage of the leucocratic veins with boudin axes parallel to X and the presence of foliation caused by the plagioclase aggregates indicate some degree of stretching in the Y direction. The generalised finite strain ellipsoid in the Kattsund dykes has thus the shape of an oblate cigar.

In the gneiss layers the second order planar material elements cannot be used in the same way because a distinction between D_1 and D_2 structures cannot be made except in those few situations where D_1 folds have been pulled apart during the intrusion of the Kattsund dykes. Nevertheless, the fabric and all observed fold axes (including D_1 fold axes) parallel the longest strain axis in the dykes, and the fabric xy-plane


N
A
N = 86
B
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D
N = 48
E
N = 69
F

and axial surfaces parallel the XY-plane of the D_2 strain ellipsoid. The fabric of the gneiss layers can hence be regarded as D_2 fabric. Intense stretching in the X direction can then account for the parallel orientation of fold axes, since it is improbable that the D_1 fold axes happened to have the same orientation as the much later superimposed X direction of the D_2 deformation. The occurrence of rootless folds and limb remnants in the foliation surfaces suggests that stretching also took place in the Y direction.

The D_2 deformation thus appears to have given rise to a general strain ellipsoid with the shape of an oblate cigar in the sandwich as a whole, with similar orientation in both types of layers. The pronounced stretching in the X direction explains the fact that all linear and planar structures are almost perfectly parallel to that direction.

Everywhere except in the Mølen-Østnestangen structure the first order planar material elements form a regular sandwich with parallel layers after the D_2 deformation, during which the layers have been exposed to stretching. The alternating granitic gneiss and basic dyke layers of varying thickness in the pre-D_2 sandwich structure should immediately offer suitable conditions for boudinage, because when deformed a difference in ductility is set up not only between gneiss and dyke layers, but also between layers of equal composition due to the dependence of ductility on layer thickness (Ramberg 1955).

Nevertheless, real boudinage and necking structures are rare and are only shown by the dyke material. The boudins appear to be late in the D_2 deformation postdating the main tectonite fabric since the fabric is disrupted. Both the internal structures in the layers and the lack of boudinage during the main deformation indicate the almost uniform thinning of the individual layers. Factors such as a low ductility contrast between the layers and (probably more likely) a slow strain rate may be important in explaining the lack of boudinage.

Determinations of the boudin axes have only been possible in a few of the rare boudin structures. These few boudin axes are close to the X direction. Even if the number of determinations is small, the observed direction suggests that a late stretching took place at least in the Y direction; this stretching should not be confused with the earlier stretching in Y shown by some leucocratic veins.

The Mølen-Østnestangen structure may be interpretated in different ways, but with so much information hidden beneath the sea any discussion will be highly speculative. The author suggests that the clockwise rotation and corresponding shearing indicate that the structure was formed by a clockwise ductile shear deformation with the shear movement almost parallel to the Y direction. If the layers in the sandwiched basement were originally orientated oblique to the D_2 shortening direction, it is possible that the suggested shear deformation in the Mølen-Østnestangen zone resulted from an anticlockwise rotation of the sandwich towards the finite XY-plane.

Outside the Mølen-Østnestangen structure such a rotation of sandwich may explain the shearing along dyke contacts where minor asymmetric cuspate folds were formed. Further, it may be a model for the late boudinage formation because a rotation will create an increase in the tensile stress within the layer boundaries, until these become parallel to the XY plane where the tensile stress obtains its maximum value. If it is true that all the late boundin axes are close to the X direction, such an increase in the tensile stress parallel to Y may explain boudins with axes in the X direction.

Similar situations with reorientation of fold axes towards parallelism with the stretching direction and formation of stretch fabrics of S-L type have recently been discussed by Escher & Watterson (1974). On the basis of their investigations on the southern boundary of the Nagssugtoqidian belt in West Greenland (Escher et al.

Fig. 12. Equal-area projections. Contours drawn at 1%, 5%, 10%, 20% and 40%.

A. 86 D_2 fabric x-directions measured in the Kattsund dykes. Sandbukta area.

B. 63 D_2 fabric x-directions and D_2 fold axes measured in the Kattsund dykes on Mølen.

C. D_1 fold axes (·) and xenolith elongations (x) measured in Sandbukta area and on Mølen. The curves are the 5%, 10%, 20% and 40% contours from A.

D. 48 fold axes measured on leucocratic veins in the Kattsund dykes. Dots represent poles to axial surfaces of these folds. Measurements from Sandbukta area.

E. Poles to 69 dyke contact surfaces. Sandbukta area.

F. Poles to all measured axial surfaces in different kinds of folded material.

1975), these authors propose a simple shear model to explain the geometric relations; it appears that the reorientation of fold axes towards the stretching direction is a common feature consistent with the model. Stretching in the Y direction is inconsistent, because simple shear strain creates $Y = 1$.

The D_2-deformation in the Sandbukta-Mølen area seems in some ways to be like the Nagssugtoqidian example, where in order to explain a late stretching in the Y direction, the authors (Escher et al. 1975) suggest that a ductile simple shear deformation was accompanied late in the deformation by pure shear strain. The geological conditions in the Sandbukta-Mølen area do not allow an interpretaion of the main mechanism of the D_2 deformation, but a model involving simple shear strain with the 'transport' direction parallel to the direction of the X axis may be useful as a working hypothesis.

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