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Precambrian structures of the Ikorfat peninsula, Agto region, West Greenland

by

Lilian Skjernaa

KØBENHAVN 1973

Grønlands Geologiske Undersøgelse

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Reports

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Abstract

A supracrustal sequence of biotite gneisses, light coloured garnet-biotite gneisses (metasediments) and metabasite rocks is bounded to the north-west and south-east by basement rocks of biotite (± hornblende) gneisses and metabasites. The supracrustal sequence lies in the core of a major F_3 synform. Metabasite horizons are used as marker horizons to elucidate the structure of the area.

Hornblende-granulite subfacies metamorphism accompanied the F_3 folding; later retrograde metamorphism only affected the rocks along master joints and thrusts.
Structural analysis of the basement rocks indicates at least two folding phases older than the F_3 folding of the supracrustal sequence; the supracrustals also show minor folds of a fourth phase.

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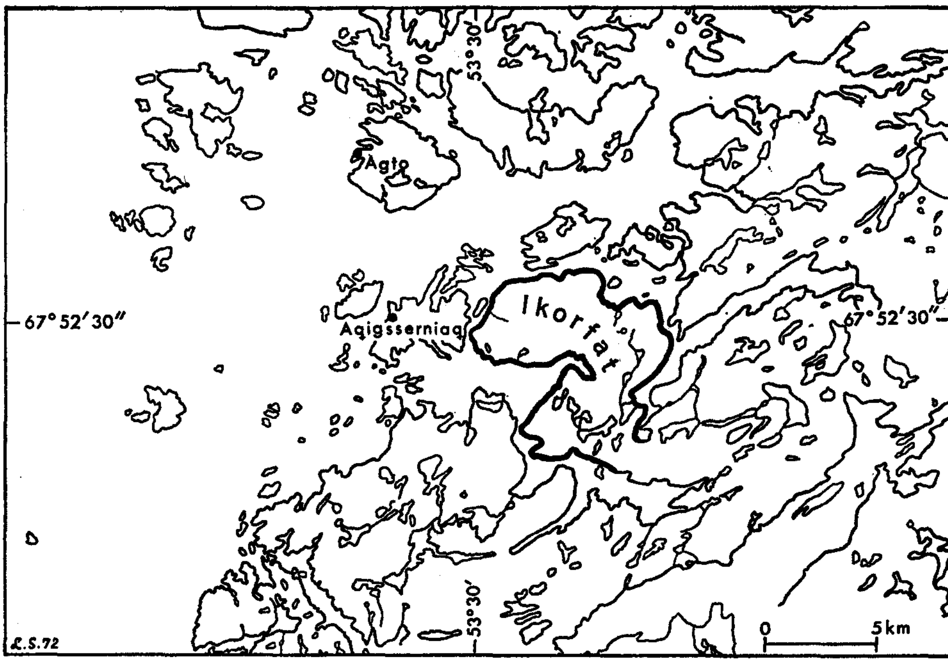


Fig. 1 Map showing location of the Ikorfat area.

INTRODUCTION

In the summer of 1966 detailed mapping was started in the Agto area of western Greenland under the leadership of Erling Bondensen (Bondesen, 1966, 1968). The work was a university research project but also formed a part of the mapping programme carried out by the Geological Survey of Greenland (Grønlands Geologiske Undersøgelse).

During a few weeks in the summers of 1966 and 1967 the author mapped the peninsula Ikorfat (fig. 1), an area of about 50 km^2 situated south-east of Agto at about 67°50'N and 53°25'W.

The dominant topografic features are rounded ice-eroded ridges with intervening valleys; the valley floors are covered by moraine and talus and, in the lower parts, by Quaternary marine deposits. The area is generally well exposed, in particular the western part.

Ikorfat lies within the Isortoq complex of the Nagssugtoqidian fold belt, a name proposed by Ramberg (1948) and later discussed by Noe-Nygaard (1952) and Pulvertaft (1968). Pulvertaft considers the whole complex, from Søndre Strømfjord as far north as 72°30', to be reactivated pre-Nagssugtoqidian basement.

Ikorfat can geologically be divided into three areas; two of the areas are essentially similar, but are separated by a synformal area which differs structurally and lithologically from the two others.

The major task during the short field seasons was to prepare the geological map and less attention was given to the mesoscopic structures. During the mapping it was found that the dark metabasite horizons formed suitable key horizons for a structural analyses.

LITHOLOGICAL UNITS AND METAMORPHIC FACIES

Lithological units

The rocks of Ikorfat may be roughly divided into various types of metabasites and gneisses.

The metabasites comprise amphibolites, pyroxene amphibolites, pyribolites and hornblende pyriclasites (see fig. 2 for nomenclature usage). In addition there are dark coloured rocks in which the amount of diopside exceeds that of hornblende, and which do not contain hypersthene.

The metabasites are homogeneous or heterogeneous banded rocks, the thickness of the bands varying from a few centimetres to a few decimetres. Most metabasites are concordant, but two discordant examples are known; one is described below, while the second was noted in the north-west area by E. Bondesen (personal communication) subsequent to the mapping described here.

In places, especially near the macroscopic fold closures, the metabasites are boudinaged, folded or agmatised. In some places in the north-eastern part of the south-east area there are some large lens-shaped bodies of ultramafic rocks which contain large amounts of hypersthene (map 1).

There are no essential petrological differences between the metabasites from the three areas, except that in the area of the synform some show retrograde alteration of pyroxenes to uralite. (For quantitative mineral contents see table 1).

The discordant metabasite found by the author on Ikorfat is a dyke up to 8 m wide trending NE-SW through the easternmost part of the north-west area. To the north-east the dyke is folded and broken up, and to the south-west it splits into several branches only a few centimetres broad and finally disappears. This dyke differs from all other metabasites in the area by its intrusive character and marked homogeneity. The dyke itself is slightly discordant to the gneiss foliation (10 to 20°), while some apophyses are strongly discordant. The metadyke is a pyribolite; no relics of magmatic textures have been found.

The gneisses on Ikorfat were termed hypersthene gneisses by Noe-Nygaard & Ramberg (1961) probably because of their olive-green colour on fresh surfaces, and the orange-brown colour on weathered surfaces. However, hypersthene is only rarely present and when present only in very small amounts.

In the north-west and south-east areas the gneisses are hornblende-biotite gneisses and biotite gneisses, a few of them containing a little hypersthene. They may be foliated, with homogeneous or heterogeneous banding. The composition ranges

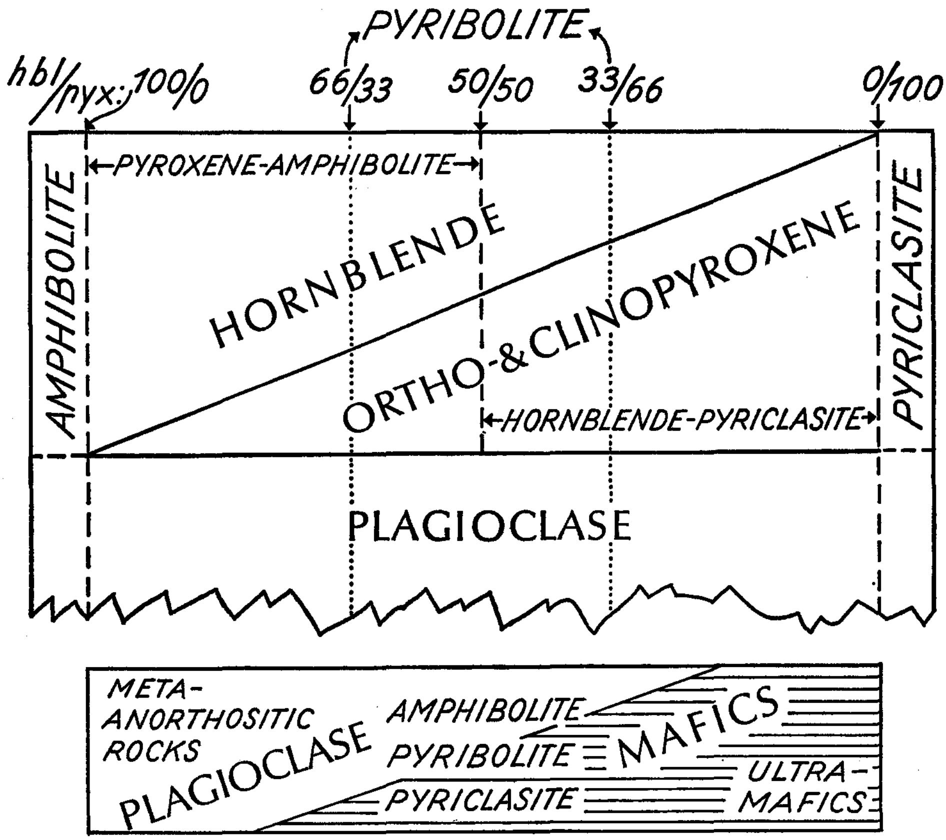


Fig. 2 Diagram showing the possible variations in mineral composition of pyribolite and pyriclasite rocks (after Berthelsen, 1960, fig. 2).

from quartz dioritic to granodioritic or even granitic. A granitic composition has been found in some zones where the gneiss contains large amounts of potassium feldspar schlieren (see table 2).

The gneisses of the synformal area are very characteristic rocks which are thought to be metasediments. They differ greatly from the other gneisses by their light colour, the presence of rusty horizons and their garnet content. In places they contain sillimanite. The composition of these gneisses is quartz dioritic to granodioritic (see table 3). Similar rocks have been described by Sørensen (1970) from the neighbouring area. Noe-Nygaard & Ramberg (1961) termed them granulite *sensu stricto* but because of the different meanings of this term (cf. Berthelsen, 1960) the more descriptive term light coloured garnet-biotite gneiss is preferred.

In addition to these gneisses there are some banded or foliated biotite gneisses present in the synformal area. They generally contain more microcline than those in the adjacent areas and are totally lacking hypersthene.

Table 1. Mineral contents of six metabasites (vol. %)

GGU sample numbers	Rock type	Number of points	Plagioclase	Microline	Quartz	Hornblende	Hypersthene	Diopside	Biotite	Garnet	Opaques	Calcite	Titanite	Apatite	Zircon	Chlorite	Unidentified alteration products	Uralite
89584	Amphibolite	2435	39.2	<0.1	1.7	46.0					0.9	2.0		0.4	<0.1	<0.1		9.7
89548	Diopside-amphibolite	1896	35.2			54.3		9.7	0.3		0.5							
89564	Hypersthene-amphibolite	2397	37.6			54.8	6.8		0.1		<0.1	<0.1		<0.1				
88726	Pyribolite	2676	29.5			42.8	12.7	13.6	0.1	0.1	0.9	0.1		<0.1		<0.1	0.4	
89502	Hornblende-pyriclastie	2320	62.9		2.1	3.5	12.8	11.6	0.1		7.4			0.1	<0.1			
89586	Diopside hornblende metabasite	3580	63.0			12.2		22.4	0.8		0.3	0.7	0.4	0.1	<0.1			

Table 2. Mineral contents of three gneisses from the north-west and south-east areas (vol. %)

GGU sample numbers	Rock type	Number of points	Plagioclase	Microcline	Quartz	Hornblende	Hypersthene	Biotite	Opaques	Calcite	Apatite	Zircon	Muscovite	Chlorite	Zoisite	Epidote	Unidentified alteration products
89515	Hornblendegneiss	1275	71.0		15.3	10.5	<0.1	1.3	0.8	0.8	0.2	<0.1					0.8
89565	Hornblendebiotite gneiss	2161	66.2	0.5	20.2	3.2		7.4	0.4	0.1	0.3	<0.1	0.2		0.1	0.2	0.2
88764	Biotite gneiss	1822	63.3	1.6	24.4			5.5	0.6		0.1	<0.1	0.5	0.5			1.7

Table 3. Mineral contents of two gneisses from the synformal area (vol. %)

GGU sample numbers	Rock type	Number of points	Plagioclase	Microcline	Quartz	Biotite	Garnet	Opaques	Calcite	Apatite	Zircon	Chlorite	Muscovite	Zoisite	Unidentified alteration products
89534	Biotite gneiss	2196	61.1	1.4	29.7	6.2		<0.1	0.6	0.1	<0.1		1.0		<0.1
89588	Garnet biotite gneiss	2418	56.1	3.9	30.1	5.7	1.0			0.3	<0.1	0.4	1.3	1.0	<0.1

Metamorphic facies

From the mineral parageneses in the samples examined under the microscope it is clear that the rocks from Ikorfat were formed under high grade metamorphic conditions of the hornblende-granulite subfacies and sillimanite-almandine-orthoclase-amphibolite subfacies (Winkler, 1967). Winkler considers that granulite facies parageneses can only arise in polymetamorphic rock complexes, or in dry intrusions; the latter may be the case for many of the metabasites. The reason that some of the rocks of Ikorfat preserve sillimanite-almandine-orthoclase-amphibolite subfacies assemblages and others hornblende-granulite subfacies assemblages may be due to contrasting water contents in the different horizons during metamorphism; this view is supported by the fact that the metamorphic grade of the rocks does not have a regional variation but differs from one horizon to the next.

The rocks of Ikorfat have also been affected by retrograde metamorphism. The greater part of the rock mass shows only slight signs of retrogression in the form of small amounts of secondary muscovite, chlorite, epidote and zoisite. Where the rocks have suffered later crushing the retrograde metamorphism is more evident. In the synformal area crushing accompanied the formation of thrusts (see page 19) and here uralitisation of the pyroxenes is conspicuous. In zones of master joints the mineral parageneses indicate quartz-albite-muscovite-chlorite-greenschist subfacies conditions (Winkler, 1967).

ANALYSIS OF THE STRUCTURES

The stratigraphic relations between the various rocks are not known, and no primary structures indicative of "way up" have been found. Structural data (e. g. minor fold axes) are somewhat sparse and only in the area of the major synform do fold axes show a simple pattern. However, Ikorfat is sufficiently well exposed that it was possible to map the macroscopic structures by tracing the various metabasite horizons almost continuously.

Analysis of the mapped macroscopic structures in combination with the measurements of foliation, banding, measured and constructed fold axes, has permitted the establishment of a structural model. It has not been possible to confirm or invalidate the proposed interpretation by further field work, which should therefore be taken as a working hypothesis.

GEOMETRICAL DESCRIPTION OF THE STRUCTURES

The south-east area

The metabasite horizons in the south-western part of the south-east area can be connected to give the comprehensive structural pattern seen on fig. 3 and map 2. The analysis of this pattern may act as a key to the understanding of the structural development of the whole of the south-east area.

A number of constructed fold axes for the closures of the key structures are shown on fig. 3. They plunge rather steeply in directions varying from WNW to N, and seem all to be related to the same fold phase with axial planes striking NNE-SSW and dipping steeply to the WNW.

Interference patterns and minor folds plunging at low angles suggest the presence of other, older structures, as do some vertical foliations striking at high angles to the main trend of the NNE-SSW fold system. The structural pattern of the south-western part of the south-east area (fig. 3) can probably best be explained as formed by two fold phases termed here F_1 and F_2.

The F_1 folds, even where they are not apparently disturbed by later folding, have axes plunging at various angles to the NNE and SSW. Within the key area

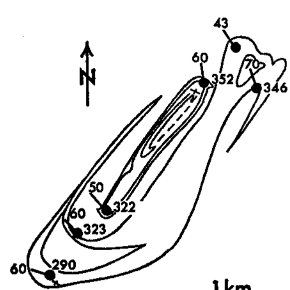


Fig. 3 Sketch of the key structures in the south-western part of the south-east area with the constructed F_2 axes for the closures in the metabasite horizons.

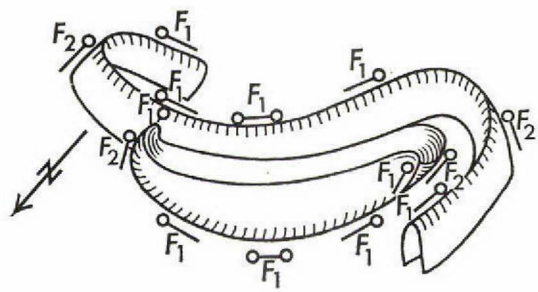


Fig. 4 A three-dimensional model of the key structures in the south-east area.

shown in figs 3 & 4 one antiform and one synform or basin are recognised, and these are deformed by an F_2 structure; these are the key structures of the region.

There is some doubt as to whether the F_1 structures are antiforms or synforms

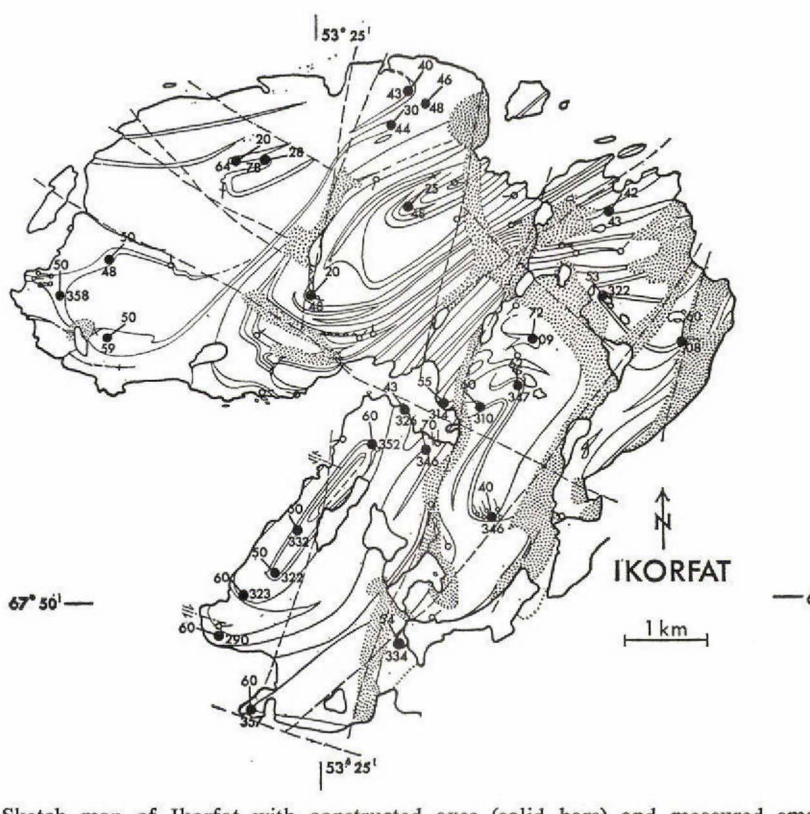


Fig. 5 Sketch map of Ikorfat with constructed axes (solid bars) and measured small-fold axes (open heads). Major joints and faults (dashed lines) drawn from aerial photographs. Dotted areas are unexposed.

since all the measured foliations are steep (map 1); the selected interpretation is the best fit to the available data.

On extending the structural interpretation to the remainder of the south-east area it is possible to recognise the same two fold phases. In the central part of the south-east area, however, the metabasite horizons in some places wedge out in a way which cannot easily be explained as interference patterns. These features could be explained if the metabasite rocks are regarded as being originally sills.

In all there can be recognised in the south-east area two F_1 antiforms and one F_1 synform which have been refolded about F_2 axes (fig. 5). On the structural map (map 2) it is seen how the F_1 folds in places have been tightened during F_2 folding and that the F_2 folding is disharmonic; the strike of the axial planes varies from the "normal" NNE-SSW to NW-SE in the northern part of the south-east area. These variations might alternatively be a consequence of post-F_2 deformation. Sections along the lines A-A and B-B on map 2 are shown in figure 6.

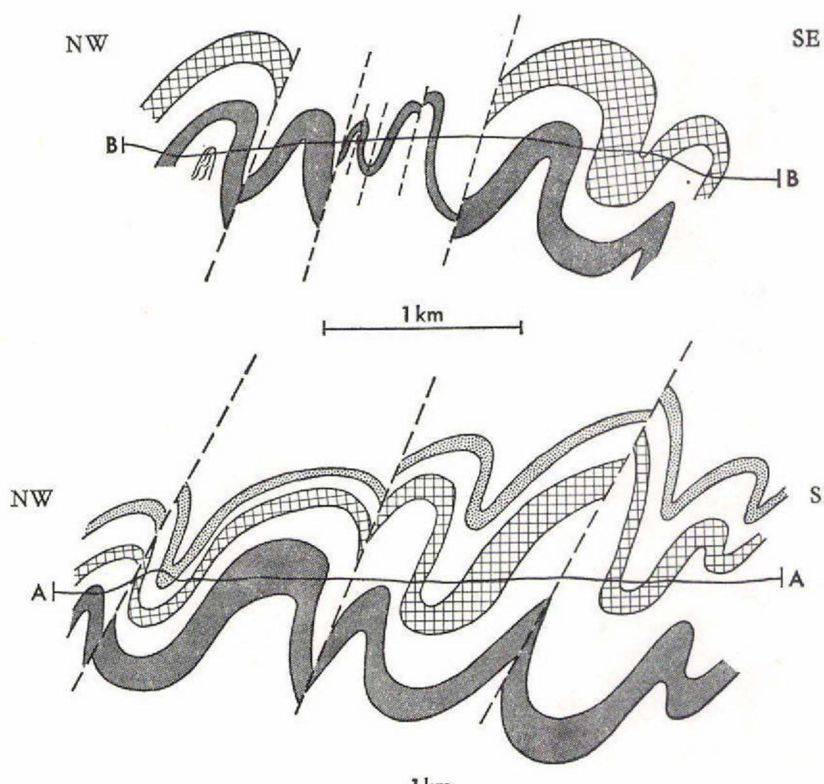


Fig. 6 Sections along the line A-A and B-B on map 2. The folds are F_1 folds; the dashed lines are the traces of F_2 axial planes.

The north-west area

In the north-west area, to the west of the synformal area, one single metabasite in the central part of the area (the uppermost metabasite of the stratigraphic column of map 2) outlines the key structures (map 1 and 2, fig. 5). Again it seems possible to explain the fold pattern in terms of two fold phases, which seem to be correlatable with the two distinguished in the south-east area.

Within the key area the F_1 fold phase is represented by a synform and an antiform, which are refolded about a steep north-plunging F_2 fold axis (indicated by vertical foliation on map 1 and Fig. 5); the axial plane strikes ENE-WSW and dips to the NNW. On the north flank of the F_2 fold the F_1 fold axes plunge at moderate angles to the ENE; on the south flank of the F_2 fold they plunge to the WSW. The F_1 closures in the metabasite here lie above the present land-surface (see the central part of section D-D on fig. 9).

A special feature of the south-western part of the north-west area is an F_1 antiform (map 2 and fig. 7) which to the north-east has a NE-SW trend, but to the south-west has an E-W trend and broadens out as a dome structure overturned to the south and west; further west it abruptly resumes its normal antiformal shape. On the south flank of the dome an isoclinal fold with an amplitude of about 1 km occurs and on the north flank a corresponding gentle undulation is present. The two features can be connected over the crest of the dome as shown in fig. 7 and the three successive sections of fig. 8 along the lines 1-3 on fig. 7.

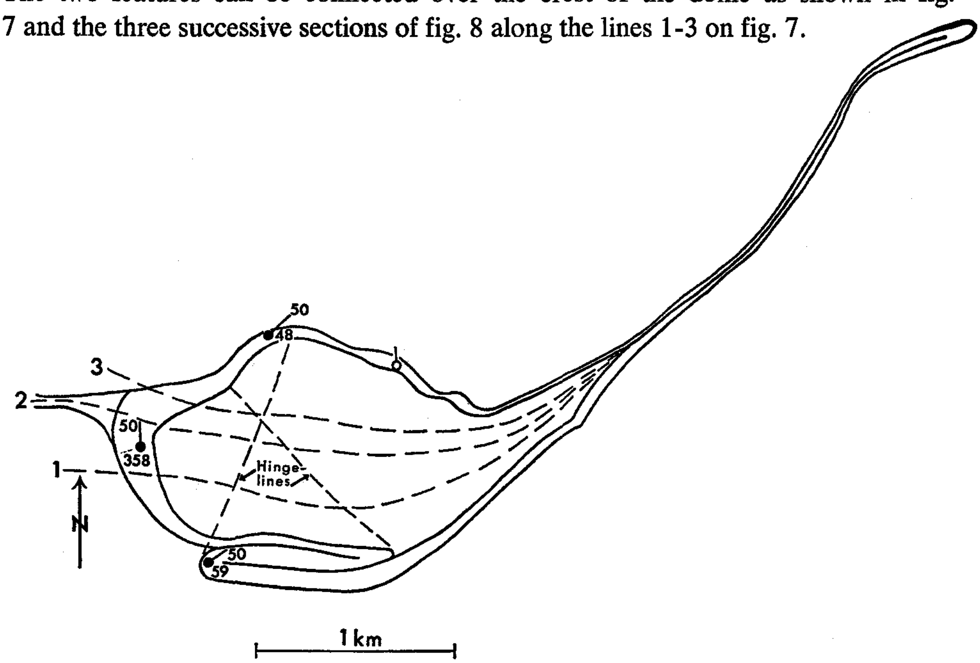


Fig. 7 Structure from the south-western and eastern part of the north-west area. For explanation see text.

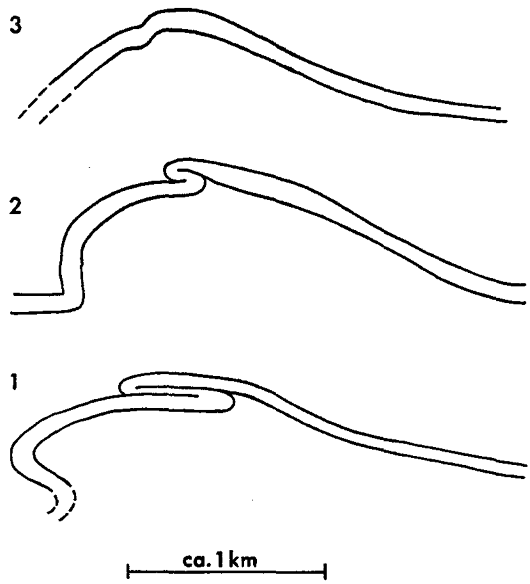


Fig. 8 Longitudinal sections through the dome along the lines 1, 2 and 3 on fig. 7.

As in the south-east area some of the metabasite horizons of the north-west area may wedge out, a feature supporting the interpretation of the horizons as sills.

The metabasite horizons of the north-west area in general appear to be interrelated as shown on map 2. The interference pattern depicted can, with the exception of the dome, be explained as three F_1 antiforms and two F_1 synforms refolded around a major F_2 fold; the latter has a closure to the west with a steep north-plunging axis. To the north-east the flanks of the F_2 fold are pressed together, forming a fan fold, the axial plane of which strikes ENE-WSW and dips steeply to the NNW; see map 2 and three successive cross-sections on fig. 9.

The orientations of the F_1 fold axes are naturally distorted as a result of the later folding. Two F_1 fold axes (043°/40° and 044°/30°) have been constructed for fold closures in the metabasite horizons in the north-eastern part of the area; these are shown on fig. 5.

The two principal fold phases of the south-east area and the north-west areas appear to be correlatable. However, the origin of the dome structure of the north-west area is uncertain.

The dyke found in the north-east of the north-west area has a general NE-SW trend, and generally is only slightly discordant to the gneiss foliation. To the north-west it curves about an axis which, by construction, has been found to plunge 048°/46°, i. e. almost parallel to the F_1 fold axis constructed for the

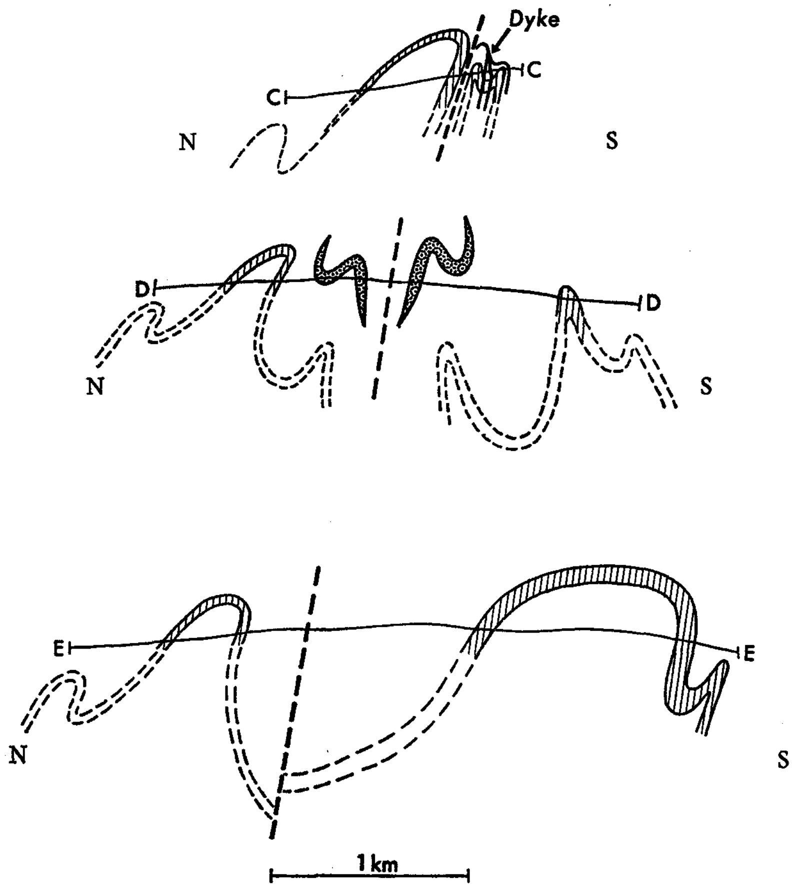


Fig. 9 Sections through the north-west area along the lines C-C, D-D and E-E on map 2.

metabasite horizons in the same area (see fig. 5). In the zone of the closure the dyke is disrupted, and it abruptly stops at the inferred location of the F_2 axial plane (see fig. 9, section C-C). At its southern end the dyke splits up into a horsetail structure and thins out. However, a further dyke has been located in the west of the north-west area by E. Bondesen (personal communication). It seems probable that the dyke was emplaced prior to the F_1 folding.

Sørensen (1970) describes some metadykes north and north-east of Agto which are deformed by his F_4 and F_5 fold phases into folds with the Nagssugtoqidian ENE trend. He assumes that they were intruded in a cratogenic phase which marked the interval between the Nagssugtoqidian and an earlier orogenic phase. On Ikorfat the F_1 fold phase, which apparently deforms a metadyke, is considered to be pre-Nagssugtoqidian although it too has a general ENE "Nagssugtoqidian" trend; the coincidence in trend is fortuitous.

The gneiss foliation and the dyke itself pre-date the F_1 fold phase and the foliation may be interpreted as original bedding or as a pre-F_1 structural development. Evidence from neighbouring areas favours the latter interpretation.

The synformal area

The synformal area which makes up the central part of Ikorfat, differs lithologically and structurally from the north-west and south-east areas.

The core of the synform is built up of the light coloured garnet-biotite gneisses and biotite gneisses with associated metabasites, and these are flanked by an older basement of biotite gneisses and hornblende-biotite gneisses with their associated metabasites.

Structurally this central area is much simpler than the two adjacent areas, and only one major fold phase, represented by a major synform, appears to have affected the rocks. However, some of the minor folds do not correspond to the general axis of the major synform that plunges 20° to the NE in the south-western part of the synform, increasing to 25° in the north-eastern part.

When all the measured and constructed axes from the synformal area are plotted (fig. 10) they seem to lie on two great circles defining two planes with orientation 048°/90° and 086°/55°N. The vertical plane corresponds to the axial plane of the major synform.

A pattern of lineations defining two great circles on a Wulff net can appear in two ways, namely if minor early folds are deformed by simple shear about a major similar fold. or if minor folds are overprinted on a major fold.

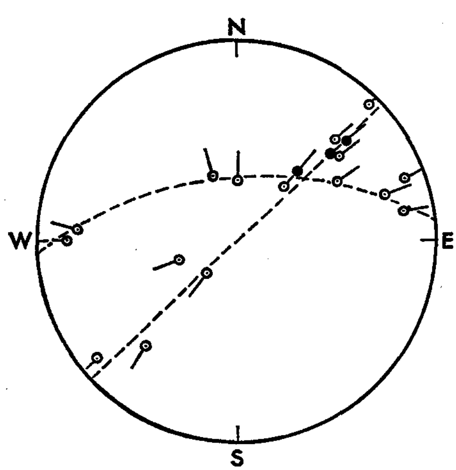


Fig. 10 Stereographic projection with all fold axes from the synformal area. Measured minor fold axes (open heads), constructed axes (solid heads).

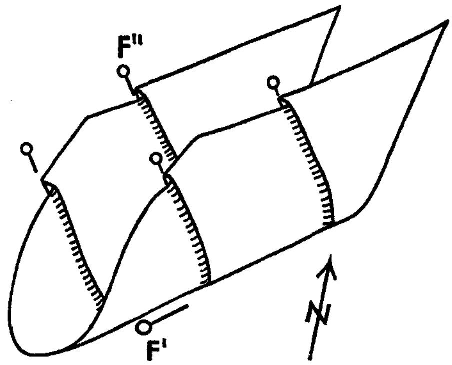


Fig. 11 Three-dimensional sketch of the major F' synform with minor F'' folds overprinted.

An explanation by simple shear folding could be accomodated if a first folding gave rise to minor recumbent folds, and a second simple shear folding formed the major synform. The direction of movement (the kinematic *a* direction) would be 048°/42° which is the intersection line of the two great circles. However, if the major synform was formed by simple shear some axial plane foliation might be expected to be present; but none has been recognised. Also simple shear folding normally results in a marked thinning of the limbs, particularly pronounced when the fold is isoclinal. The near isoclinal major synform lacks also this feature.

If the second possible explanation is considered the major synform may be considered to have been formed by a first fold phase which may be termed F'. A later overprinting by minor-folds with axial planes 086°/55°N may be termed F'' (fig. 11). This explanation in the author's view best fits the facts.

Some of the metabasite horizons within the area of the major synform split up into branches and others wedge out. As in the adjacent areas these features are also thought to indicate that at least some of the metabasites are former sills. However, the presence of some thrusts within the synform provides a partial explanation of the wedging out.

FOLD CHRONOLOGY

The first impression of the structure of Ikorfat was that the major synform preserved a metasedimentary sequence bordered on both sides by older basement rocks. Although no discordance has been established between the "basement" and the "supracrustals", the much simpler fold pattern within the synformal area supports this interpretation.

As described above two fold phases F_1 and F_2 can be distinguished from an analysis of the structures of the north-west and south-east areas.

The two fold phases F′ and F″ of the central synformal area are thought to be younger than F_2, and may be termed F_3 and F_4 fold phases. This implies that the two later fold phases should also be visible in the older rocks of the north-west and south-east areas, but this speculation has not been confirmed.

The minor F″ folds overprinting the major synform may very well be present in the adjacent areas, but because of the complex structural pattern already present any examples present have not been distinguished as formed by an independent fold phase.

Structures of the F′ fold phase have not been noted in the north-west or south-east areas, but the basement areas may simply be considered as the flanks of the major synform. Thus the only result of the F′ fold phase in the north-west and south-east areas might be a body rotation. Unfolding about the F′ axis such that the metasediments attain a horizontal position does, in fact, more or less, bring into conformity the orientation of the axes and axial planes of both F_1 and F_2 folds of the two basement areas.

STRUCTURAL CONCLUSION

To conclude the following model can be established.

One or more deformational phases may pre-date the F_1 fold phase and may have given rise to the foliation in the rocks of the north-west and south-east areas.

F_1: Represented by folds with an amplitude up to about 1 km (figs 6 and 9) with originally subhorizontal axial planes and variable axial directions.

F_2: These are several very large recumbent folds of nappe-type with digitations and involutions (fig. 12). The axial planes were originally subhorizontal.

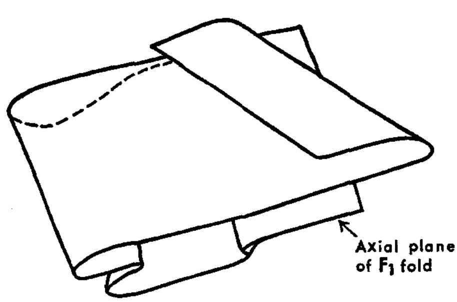


Fig. 12 The style of the F_2 folds of Ikorfat. The upper closure is outside the area. Complications due to F_1 and F′ and F″ foldings are neglected.

$F_3=F'$: A major, nearly isoclinal synform with an axis plunging 20 to 25°NE is the only certain F_3 fold. The axial plane has a NE strike and is vertical, except in the upper levels of the synform where it has a north-westerly dip.

$F_4=F''$: Minor folds with axial planes 086°/55°N and axes varying in direction within the axial plane.

LATE TECTONIC EVENTS

Thrusts in the major synform

Within the major synform of the central area of Ikorfat some of the supposed supracrustal horizons have been overthrust to the south-west. Two thrust planes are directly seen in the field (fig. 13), and it is likely that a third thrust is responsible for the duplication of a distinctive garnet-biotite gneiss horizon. A marked rusty zone occurs near the top of the two identical horizons.

The alteration of pyroxene to uralite in many of the metabasite horizons, which is representative of a retrogressive metamorphic phase preferentially developed along water-bearing crush zones, may indicate the presence of thrust planes.

Minor planes of movement may be of the same age or later than the principal thrusts.

Major joints and faults

The Ikorfat area is cut by joints with trends in three directions, parallel to the fjords and valleys; these are about 010°, about 037° and about 120°. A few strike slip faults with movements of less than 25 m are also distinguished (fig. 5).

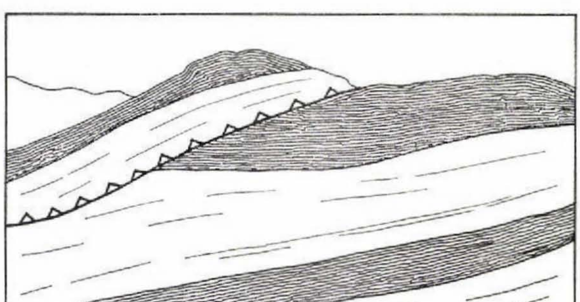


Fig. 13 Thrust in the major synform.

A distinctive red and green rock type associated with the joints in the north-west area has been formed by retrogressive metamorphism of the originally high-grade metamorphosed gneisses which have been crushed. Where they are most altered the rocks have mineral parageneses typical of the quartz-albite-muscovite-chlorite-greenschist subfacies (Winkler, 1967).

RELATIONS OF FOLDING AND METAMORPHISM

In the preceding discussion the fold chronology has been considered, but there remains the problem of the metamorphic grade associated with the various tectonic events.

The gneisses from the north-west and south-east areas have a small hypersthene content which implies that they have been at some time or other metamorphosed under hornblende-granulite subfacies conditions.

In the area of the major synform the gneisses show mineral parageneses of sillimanite-almandine-orthoclase-amphibolite subfacies. The parageneses may have developed under "wetter" conditions, than in the flanking areas, and this idea is supported by the fact that hypersthene is also present in many of the metabasites from the area of the synform as well as in those from the north-west and south-east areas.

Hypersthene could have been an original constituent of the sills, but the total lack of magmatic textures implying complete recrystallisation, and the fresh nature of the hypersthene in the metabasites suggests that metamorphic recrystallisation took place under granulite facies conditions. The mineral parageneses indicate hornblende-granulite subfacies conditions. The occurrence of bands with parageneses of silliminite-almandine-orthoclase-amphibolite subfacies alternating with those with hornblende-granulite subfacies parageneses suggests perhaps that *P-T* conditions were close to the lower boundary of the hornblende-granulite subfacies.

This high-grade metamorphism, which has affected not only the old rocks of the north-west and south-west areas, but also the younger rocks of the central synformal area, must be correlated with one of the younger folding phases, in all probability F_3. Nothing is known of the metamorphic conditions associated with the pre-F_3 folding phases due to intensity of later high-grade metamorphism. Retrograde metamorphism followed.

Synchronous with, or following the formation of the main joints, metamorphism took place under quartz-albite-muscovite-chlorite-greenschist subfacies conditions. It cannot be said whether the uralitisation of pyroxene along thrust planes in the area of the major synform took place under this metamorphic phase or under higher *P-T* conditions, possibly synchronous with the F_4 folding.

The various events are summarised in the chronological scheme of fig. 14.

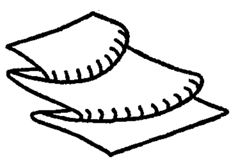
	Major jointing		Quartz-albite-muscovite-chlorite-greenschist subfacies metamorphism
Small folds	$F_4 = F''$ folding	Axial plane 086°/55°N	Possible retrograde metamorphism resulting in uralitization along thrust planes
		Thrusting in the synformal area	
	$F_3 = F'$ folding	Axial plane strike 048° dip from vertical to steep NW, axis 048°/20° to 048°/25°	*P-T* conditions of lowermost hornblende-granulite subfacies
		Sedimentation and sills	
	Formation of dome F_2 folding	Subhorizontal axial planes. Axes varying from about N-S to WNW-ESE	?
	F_1 folding	Subhorizontal axial planes. Axes mostly about NE-SW but variable Intrusion of dyke	?
	? Early foldings ?	Foliation and banding	?
		Sedimentation and sills	

Fig. 14 Scheme of fold chronology in the Ikorfat area.

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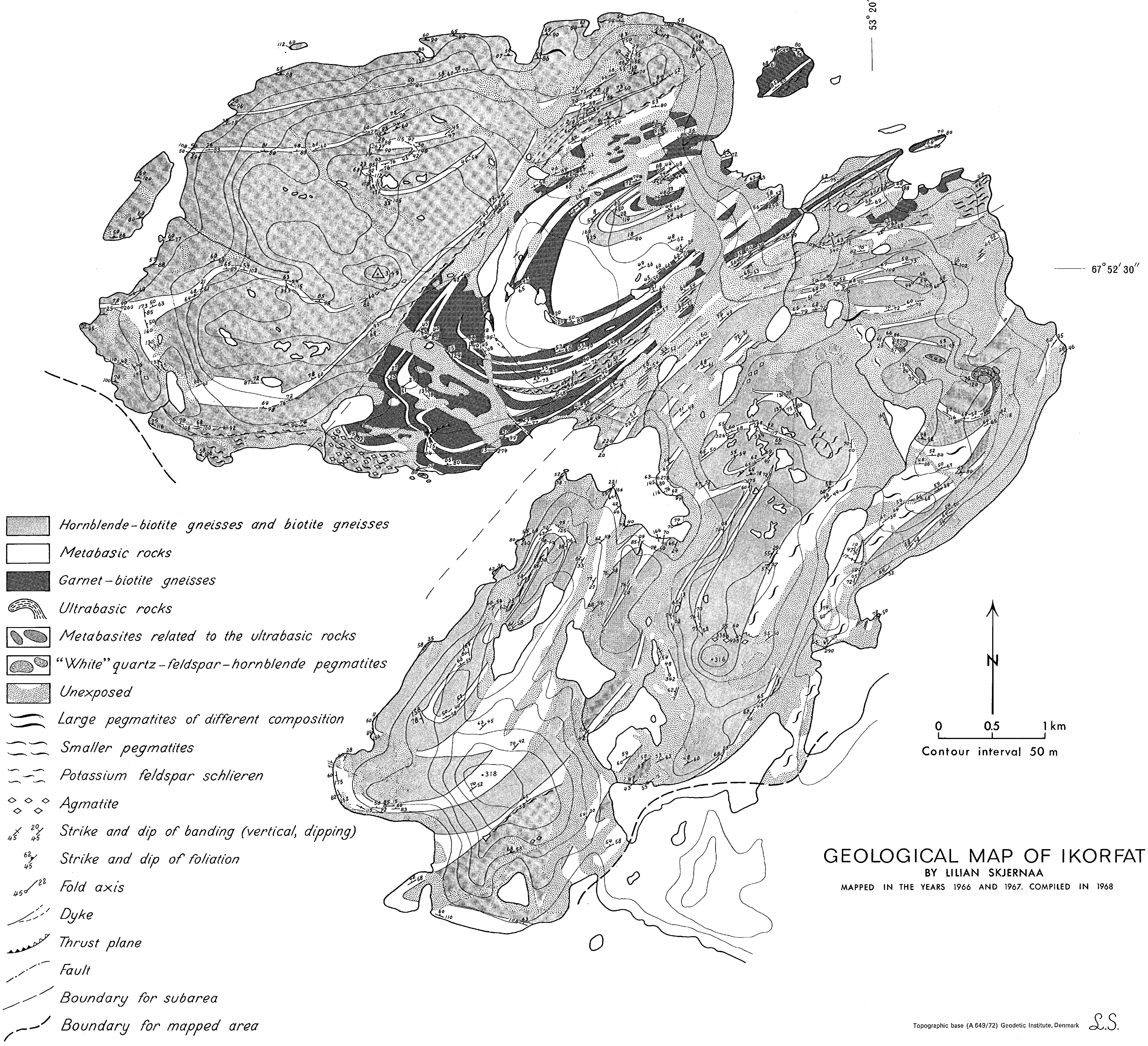
GRØNLANDS GEOLOGISKE UNDERSØGELSE

THE GEOLOGICAL SURVEY OF GREENLAND

Map 1



GEOLOGICAL MAP OF IKORFAT

BY LILIAN SKJERNAA

MAPPED IN THE YEARS 1966 AND 1967. COMPILED IN 1968

Topographic base (A 649/72) Geodetic Institute, Denmark

L.S.

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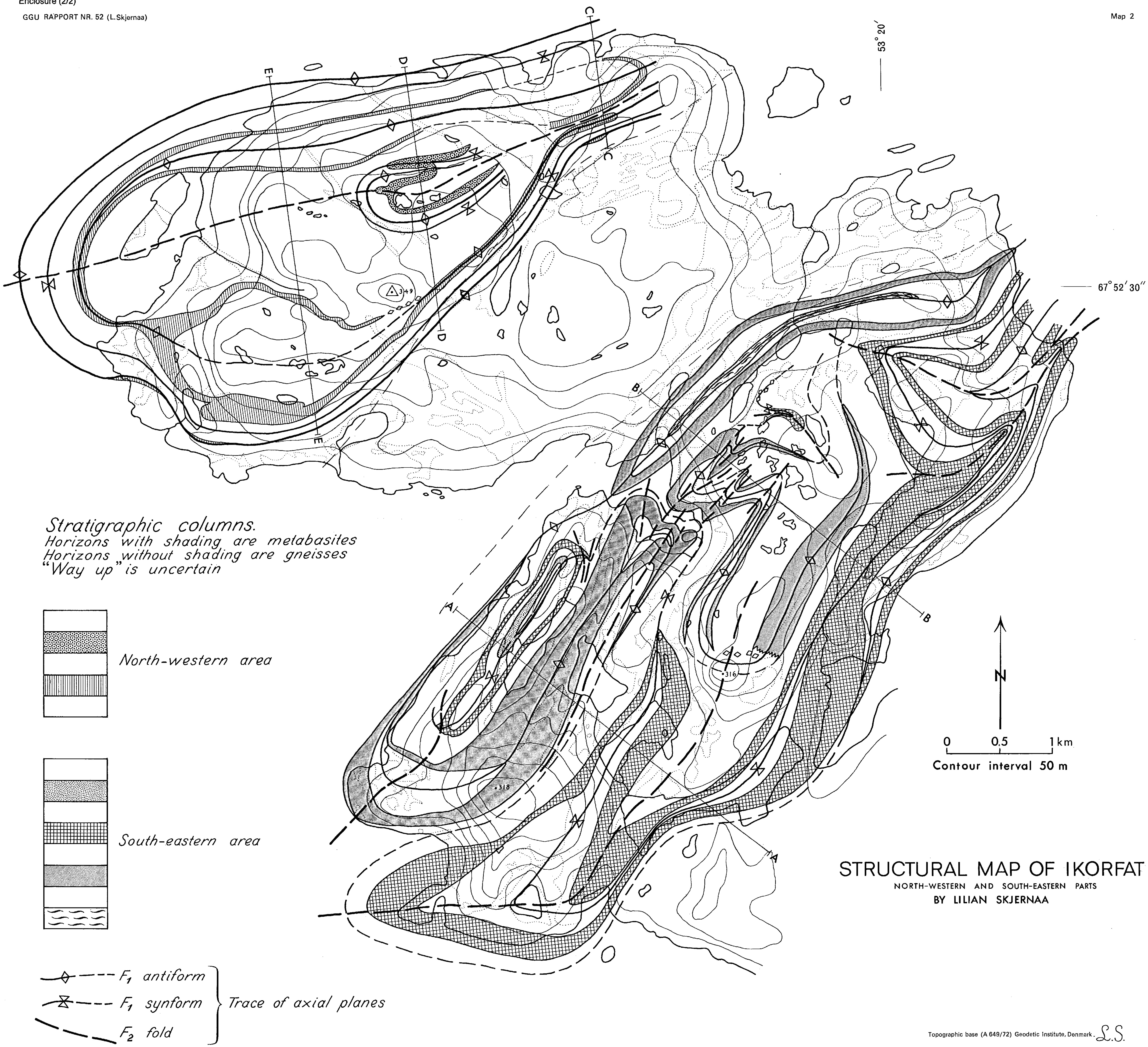
GRØNLANDS GEOLOGISKE UNDERSØGELSE
THE GEOLOGICAL SURVEY OF GREENLAND

Map 2



STRUCTURAL MAP OF IKORFAT
NORTH-WESTERN AND SOUTH-EASTERN PARTS
BY LILIAN SKJERNAA

Topographic base (A 649/72) Geodetic Institute, Denmark. L.S.