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An account of the geology of an area north east of Svorkmo

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R. Standley.

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AN ACCOUNT OF THE GEOLOGY OF

AN AREA NORTH EAST OF

SVORKMO.

FIELD MAPPING - 1969 - SVORKMO, NORWAY.

The geological mapping of an area to the east of Svorkmo was undertaken during July and August of 1969. Svorkmo lies approximately 65 kilometres south west of Trondheim on the Orkla River.

The area mapped was poorly exposed and mapping was confined to scattered exposures, stream sections, road cuttings and the edges of glint lakes.

Progress was also hampered by dense vegetation, the lack of paths, widespread glacial deposits and bogland. Because of the severe glaciation which the area had undergone, feature mapping, and especially clitter, could not be used with any degree of accuracy.

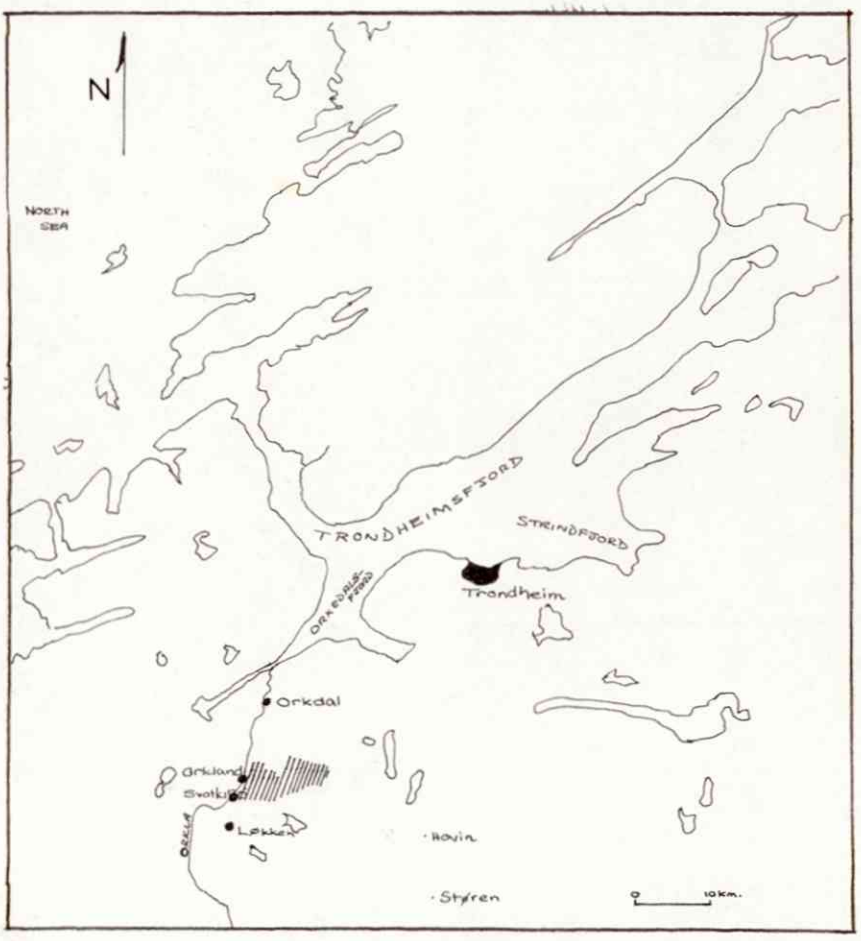
Mapping was therefore essentially confined to the recording of exposures and their structural details.

I:5,000 maps were used, except for the most southerly area, where a I:25,000 ariel photograph was used.

SUCCESSION

The rocks of this area of the Sør Trondelag province have been assigned to three groups: the Hovin, the Støren, and the Røros groups.

The Røros Group consists of mica-schists, often garnet bearing, and amphibolites which are riddled with Trondheimite dykes, (a plagioclase granodiorite with muscovite, or biotite, or hornblende, or pyroxenes).



MAP SHOWING POSITION OF
AREA MAPPED WITHIN NORWAY

The Røros Group has been given a Cambrian age and is found to outcrop five kilometres north of Svorkmo, where the rocks have a consistant south-easterly dip.

The Støren Group consists of mainly submarine spilitic pillow lavas and badly developed sediments of Upper Cambrian or Lower Ordovician age.

Lying unconformably above these is the Hovin Group. This group, of Lower and Middle Ordovician age, is made up of a basal Conglomerate, shales, sandstones and limestones.

THE STØREN GROUP.

Within the area mapped the Støren Group was represented by basic lavas, massive and pillowed, which had undergone deformation which resulted in a chlorite albite schist.

Only a few exposures show relics of former pillow structures and this is thought to be an intermediate stage in the formation of the chlorite albite schist, which may origionate from massive lava flows or from pillow lavas. Six kilometres south of Svorkmo at Løkken, this group is relatively undeformed, and one kilometre south of Svorkmo little deformation of the pillows has taken place.

In the area mapped the thickness of these "Greenstones" is many times thinner than to the south of Svorkmo and shows a cleavage, a stronger schistosity, and pillows, where present, no longer show a change of minerallogy across their diameter.

The pillows found are ellepsoidal and have a major axis up to 60 centimetres, a minor axis of 20 centimetres. The schists show variable grain size within a fine grain regime, and may contain phenoblasts of epidote.

Work on thin sections of a sample from exposure No. 224 has given the following results.

Relative abundance of minerals:-

Epidote 50%
Chlorite 20%
Amphiboles 10%
Quartz 8%
Albite 5%
Sphene
Sericite
& Opaque Ores

In hand sample this rock contains white phenoblasts in a green matrix. The white areas are concentrations of epidote, the surrounding areas being chlorite, epidote and the amphiboles. Little quartz is present but this seems to co-exist with the epidote. Albite is present as a few small crystals and has been seen to exist as a large, although much altered phenocryst.

This represents a greatly deformed pillow lava. The examination of more typical pillow lavas has shown the redistribution of minerals to a homogeneous mass, leaving the original biotite rim still present, but this may have been destroyed by metamorphism.

The sediments of the Støren have been identified from the Mellingsaeter area, where two horizons of "Greenstones" sandwich about 80 metres of grey phyllites and one localized bed of quartzite two metres thick. The Støren phyllites show no small scale folding and have no rust spots.

A basic intrusion was found in the lowest "Greenstones" of the Mellingsaeter valley. This body was confined to the "Greenstones" and was of restricted outcrop. The rock was a metagabbro which became finer grained towards its contacts with the "Greenstones".

Examination of a thin section clearly shows large phenocrysts of albite, with two different amphiboles (one primary, one secondary), calcite, sphene and a small amount of biotite and quartz.

THE HOVIN GROUP.

Unlike the Støren, this group is of sedimentary rocks, and this was used as the basic criterion to assign strata to this group.

In the area mapped the basal conglomerate was not found, but the lowest Hovin deposits belong to the Fjeldheim Beds (Chadwick et al 1964), which consist of limestones, phyllites sandstones and quartzites.

There are rapid facies changes within the siliceous sediments, however the limestone has a widespread occurance, and appears to be only absent from the Hovin south of Ryn-LiaVd.

The unconformity appears to cut across the lower Hovin. The lowest beds present are phyllites (grey) and sandstones & quartzites. These give way to the blue-grey massive limestone which typically has been totally recrystallized and is cut by white calcite veins.

The limestone may contain phyllite beds, and generally grades into, and, often from, calcite rich sandstones, phyllites and a calc-biotite schist, in which thin beds of pure limestone may be established. Where bedding is still visible, generally where limestone is interbedded with phyllites, the limestones show that they have undergone plastic deformation with recrystallization, resulting in its strongly folded form.

The phyllites are grey to charcoal in colour and are highly rust spotted and are strongly deformed and have shown F_1 folds. They are often calcic and the calcite content may be so high as to form calcite phenoblasts, and necessitate the naming of the rock as an impure limestone.

Quartzites are more abundant than sandstones. The quartzites are well bedded, the beds varying from cir. I to 30 centimetres thick, being defined by thin phyllite bands. Sedimentary structures within these quartzite-phyllite sequences, to prove a suspected density flow origin, are lacking, and thus younging data for a structural analysis is also absent.

In the Mellingsaeter Valley, stratigraphically above the limestones, structurally below, sandstones are well established. The sandstones are massive, individual beds being over 30 centimetres thick, stained by iron, and occur in a thick sequence with no phyllites present. These sandstone beds are occasionally current bedded, and near the base of the sequence may contain a large percentage of limestone detritus.

In the rest of the area mapped, structurally below the limestones, there are phyllites, sandstones, then a great thickness of chlorite schist, divided into two by grey phyllites.

Below the chlorite schist there is a thick sequence of grey phyllites, which outcrops as the core of an antiform. Within these phyllites, sandstones occur interbedded with impure limestone bands. These beds are from 1 to 2 cms thick, have a localllized outcrop, and show F_1 and F_2 folds (e.g. Exp 627).

The phyllites sequence, which lies between the chlorite schists, is of phyllites, which can be black, grey or green, and one band of a black quartzite, which is associated with grey sandstones to the west.

On the southern limb of the antiform, at Ryn-Lia Vd., the limestones have a very limited outcrop, (only found in the east), but the quartzites associated with the limestones are more developed, and with thick beds of phyllites and slates, make up a sequence about 1000 metres thick.

Above these quartzites a large outcrop of Porphyrites is present, but these were not extensively mapped. However, they appear to be concordant with the underlying quartzites but no evidence was seen to indicate either an intrusive or an extrusive origin.

To the north-east of Sosjøen, around Mulskogs Vd., phyllites, semi-pelites and immature sandstones are found. These lithologies appear to be a part of one sequence. They would seem to be placed structurally below the limestones, but this is not certain because of the thrust which is present , of which there is no knowledge of the amount of movement.

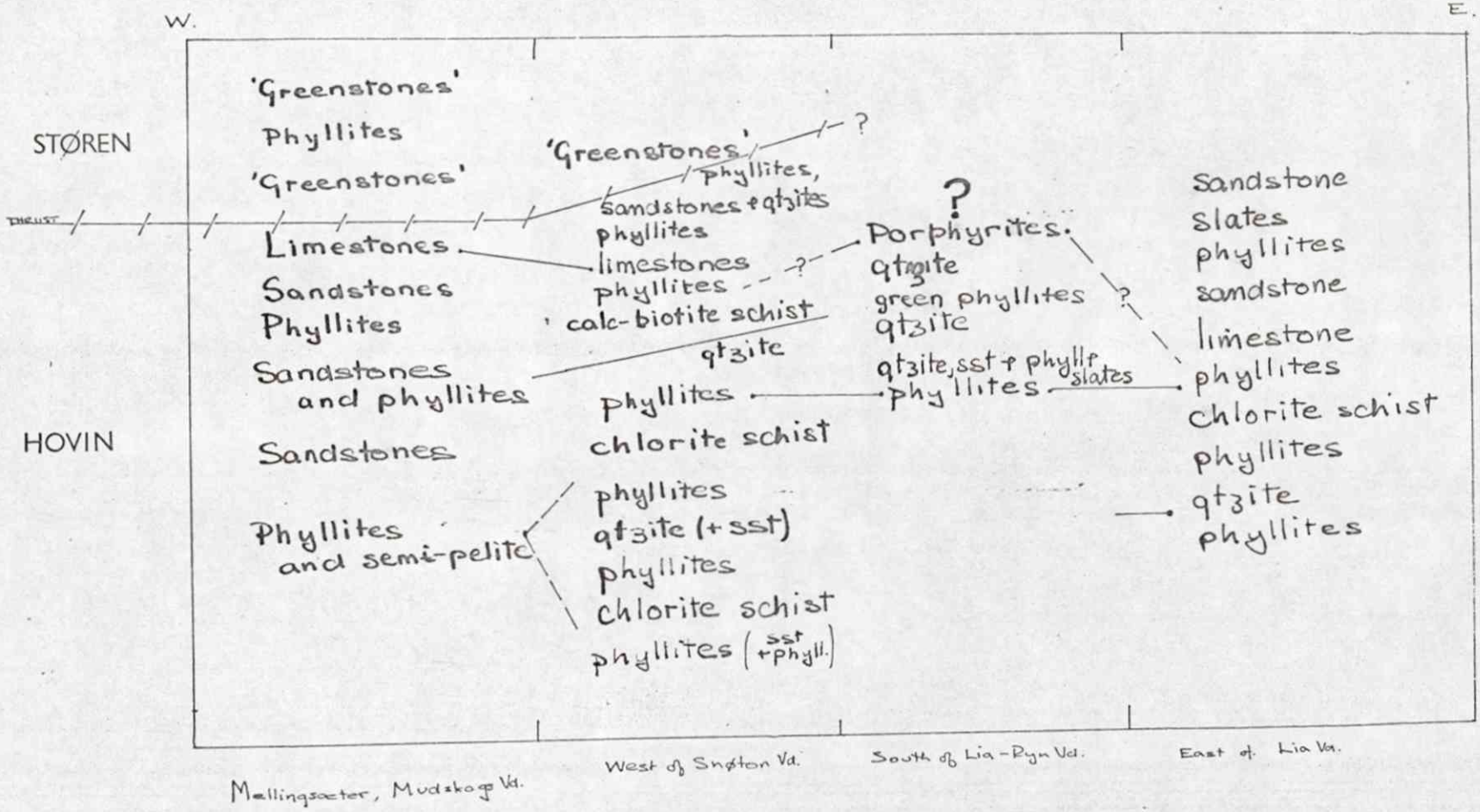
The phyllites and semi-pelites are highly rust spotted and possess a well defined cleavage, which may be crenulated. These sediments have been affected by two phases of folding, giving rise to a large-scale, isoclinal to tight, fold style (F_1), and large asymmetrical folds(F_2).

These rocks coincide with bogland, which provides little or no outcrop, and therefore correlation within these sandstones, semi-pelites and phyllites is impossible.

These rocks constitute the highest stratigraphical position, possibly equivalent to the chlorite schists, and can be compared with the Nyplassen beds of the Hølonda-Horg district to the south (Chadwick et al.)

The porphyrites was the only igneous rock found within the Hovin. The study of a thin section has shown large plagioclase crystals, up to 1·5 centimetres long, which have been sericitized, in a quartz, sericite, biotite, epidote, matrix. A very small number of small plagioclase crystals occur in the matrix. The biotite, and penninite, pervades the whole rock without any preferred orientation and are found in the plagioclase phenocrysts. They also contain a large number of pleochroic haloes.

TABLE TO SHOW CORRELATION OF AREA.



FOLDING

Three phases of folding have been recognized.

F_1

The first phase of folding is post-Hovin and has given rise to characteristic isoclinal to tight folds. Although not common, they have been found in Hovin sediments.

They range in "half wavelength" from cir.3 centimetres to 15 metres. An axial plane cleavage to these folds is very well developed over the whole area, and where the bedding is visible they are found to be parallel. The fold axes of these folds trend in an east-west direction, varying to a north east-south west trend in the east of the area.

F_2

The second phase of folding has folded the F_1 cleavage and refolded the F_1 folds.

The folding is coaxial to the first phase, and has formed large scale asymmetrical folds over the whole area. Their fold axial surface dips to the north (north west in the east), i.e., the shorter limbs are the southern limbs.

Parasitic folds are well developed and may show "S","M" and "Z" folds on folds which themselves are second generation parasitic folds.

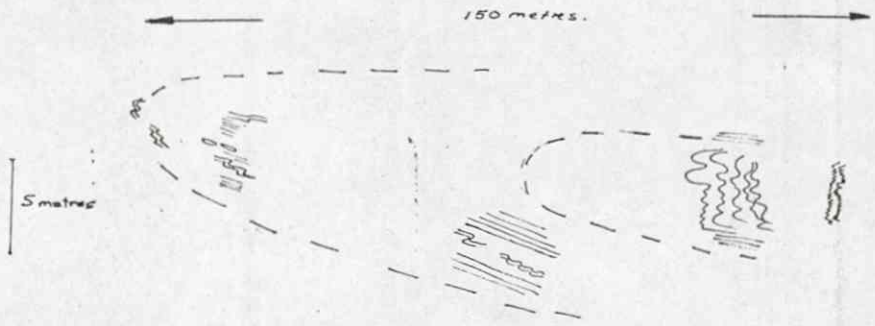
These folds have only locally formed their own axial cleavage and where present are very poorly developed and are nowhere as strong as the F_1 cleavage.

F_3

The last phase of folding has resulted in the curving of the earlier fold axes from east - west, in the west, to a north east - south west trend in the east. This phase of

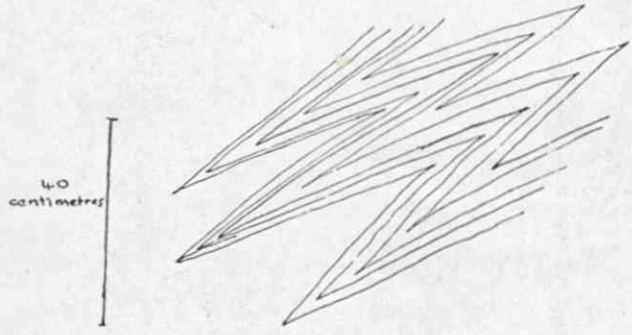
TYPICAL FOLD STYLES

F_1



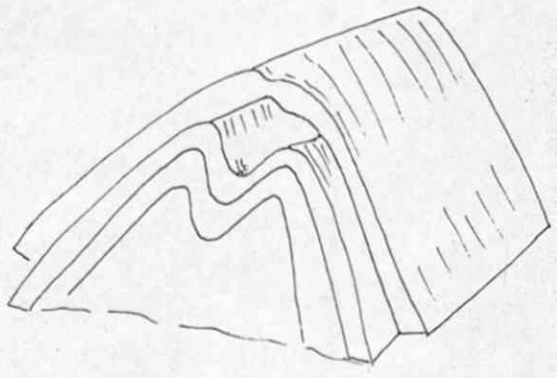
Exp. No. 575,6,7. 250 metres south east of Gjøta Vd.

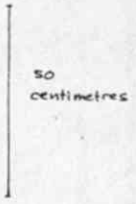
Exp. No. 211. 3 killometres west of Solsjøen.



Exp. No. 134. ½ Km. west of Solsjøen.

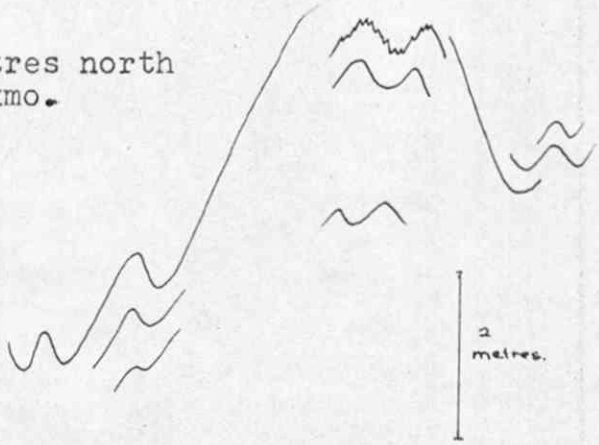
F_2





Exp. No. 47. 25 metres west of Solsjøen.

Exp. No. 626. 2 killometres north east of Svorkmo.



folding formed the Trondheim Synclinorium of which the area is a part.

The three phases of folding are all part of the Caledonian earth movements which affected the whole of Norway.

METAMORPHISM

The burial of the area has given rise to the rocks reaching the greenschist facies. The stage of metamorphism is shown especially well in the "Greenstones", and from thin sections a Barrovian quartz,albite,epidote,chlorite sub-facies has been recognised. The degree of metamorphism increases gradually to the north reaching the quartz,albite,epidote, biotite sub-facies.

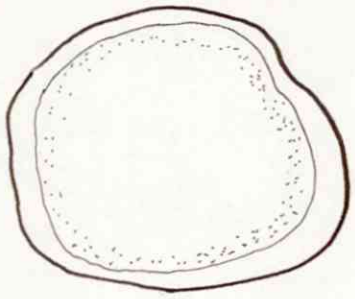
Metamorphism has caused the fusion of mature sandstones into quartzites, the recrystallization of limestones,and the formation of calcareous schists from lime rich pelites. The chlorite (biotite) schists are the result of the metamorphism of a greywacke type deposit. Their form as a rock, is made up of highly strained recrystallized quartz, which have stylolitic inter-granular boundaries, epidote, chlorite and sometimes biotite. Accessory minerals are primary albite and secondary amphibolites and penninite.

The growth of chlorite, epidote, sphene,calcite, and the alteration of primary pyroxenes to amphiboles, which are distinguishable from the primary amphiboles, has taken place in the gabbro.

The Porphyrites has been weakly affected, metamorphism causing increased sericitation of plagioclases, especially of the matrix, and the growth of epidote.

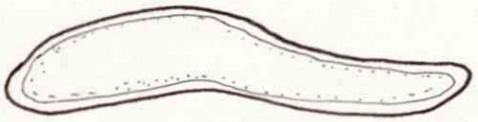
The "Greenstones" have undergone similar metamorphism as the gabbro, and the destruction of their pillow structure, as shown in Fig.1 .

1



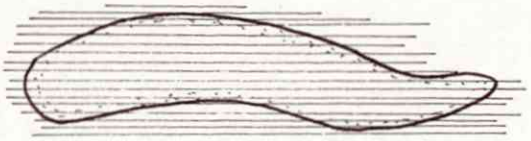
Stage I. Margins are fine grained and consist of microcrystalline aggregate of chlorite, epidote, albite and amphiboles. The core is course grained with variable textural patterns often containing phenocrysts. (Na poor, Mg rich rim).

2



Stage 2. Change of shape compared with original.

3



Stage 3. The formation of Schistosity and the beginning of a statistical homogiety.

4

Stage 4. Complete destruction of the boundary of the pillow and a homogeneous epidote chlorite albite schist with no traces of primary zoning.

Fig 1 STAGES OF DEFORMATION OF AN INDIVIDUAL PILLOW (after V. Skiba)

FAULTING

Faults which have been mapped are generally very prominent, and are marked by quartz up to five metres thick. These faults are associated with a great deal of movement. Minor faults are only obvious from individual outcrops and show very little movement.

These are normal faults and both have two distinctive trends; 1) NNE-SSW, which downthrow to the west.

2) WNW-ESE, which downthrow to the north.

and together make up a conjugate set. The NNE-SSW trending faults are more prominent and prevalent. They may appear to be more prevalent because of their conspicuousness.

The faults are definitely post F_2 , and possibly post F_3 . Whether the third phase of folding has affected the faults cannot be determined because of the difficulty of accurate mapping, and the limited affect the third phase of folding has had on the area.

A thrust was discovered in a section of the stream which drains Mulskogs Vd. However, because of the dense vegetation, and therefore the lack of exposure, it could not be traced. The thrust, where found, separated a thick series of rocks of extensive outcrop and constant dip to the south east., which are stratigraphically upside down, from an area of rocks which are extensively folded.

STRUCTURE

A study of π diagrams for the area to the east and north east of Solsjøen has shown the presence of three distinct structural areas.

A) Beds which are horizontal and have a slight dip to the south east. They are hardly affected by F_2 folding and have a large F_1 tight fold closing to the north. These beds form the lowest structural level.

B) Beds which are folded into a large asymmetrical fold, with S folds on the longer limb, and fold axes trending north east. These beds are of a higher level than A).

C) Beds which are not folded and have a constant dip to the south east. These beds are of the highest level and include the Støren "Greenstones".

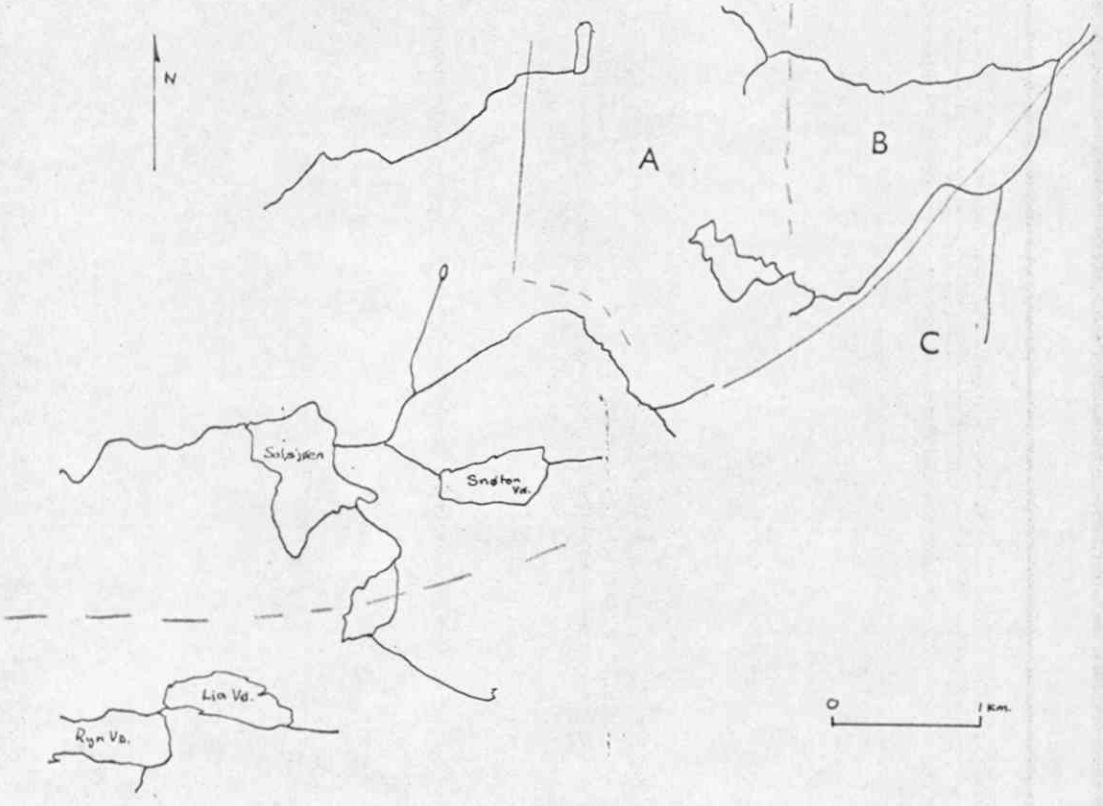
See map b

The rest of the area mapped is less easily divided, but consists of beds of area C). The northern half shows strong F_2 folds as B), while the southern area is not folded, and has a steady south to south east dip, as is found in area C).

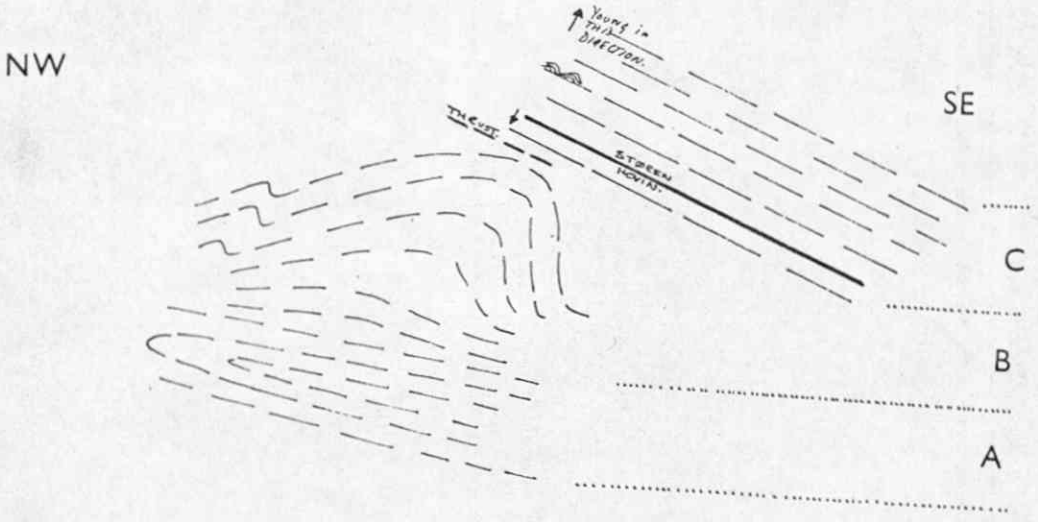
From study of maps of the area to the south, it shows that Hovin deposits lie above and below the Støren. It was also noticed that F_2 folding is more dominant in this area, where the Hovin is below the Storen.

A structural column has been constructed and appears with map b.

The evidence found leads to a suggestion of a nappe structure, possibly closing to the south and south east.



Map b to show divisions of the area north east of Solsjøen.



Diagrammatic cross-section showing relationship of divisions.

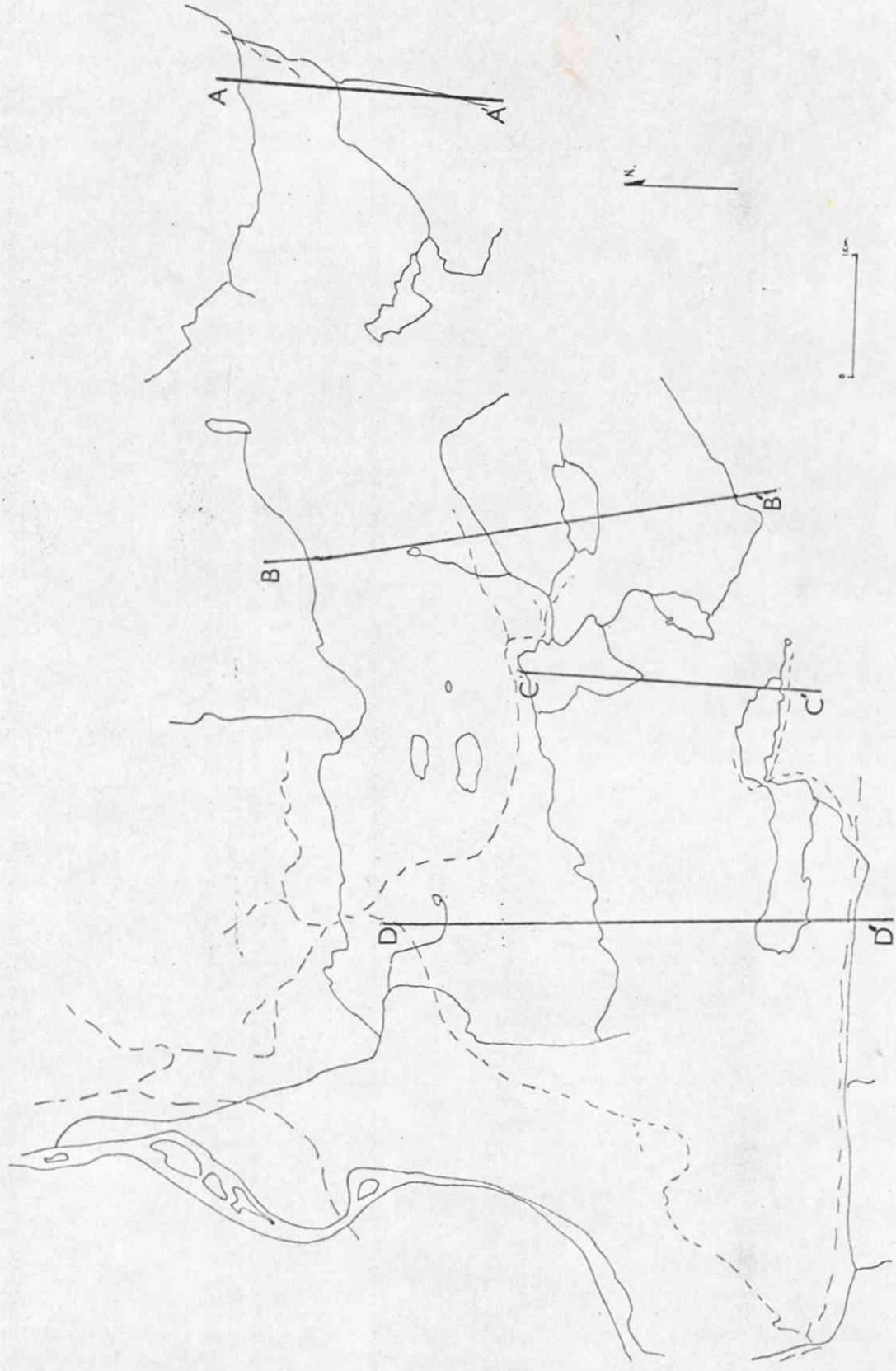
A.S. Medlycott has found Hovin sediments resting on Røros Group rocks, of a constant south east dip, about five killometres north of Svorkmo. The nature of the break between the Røros and Hovin is not known at the present time, but the Støren is absent.

Because of the complete absence of fossils in the rocks assigned to the Hovin, its age could be held in doubt. However, these sediments are conformable with the Hovin as mapped by P. Carter (1965) to the south.

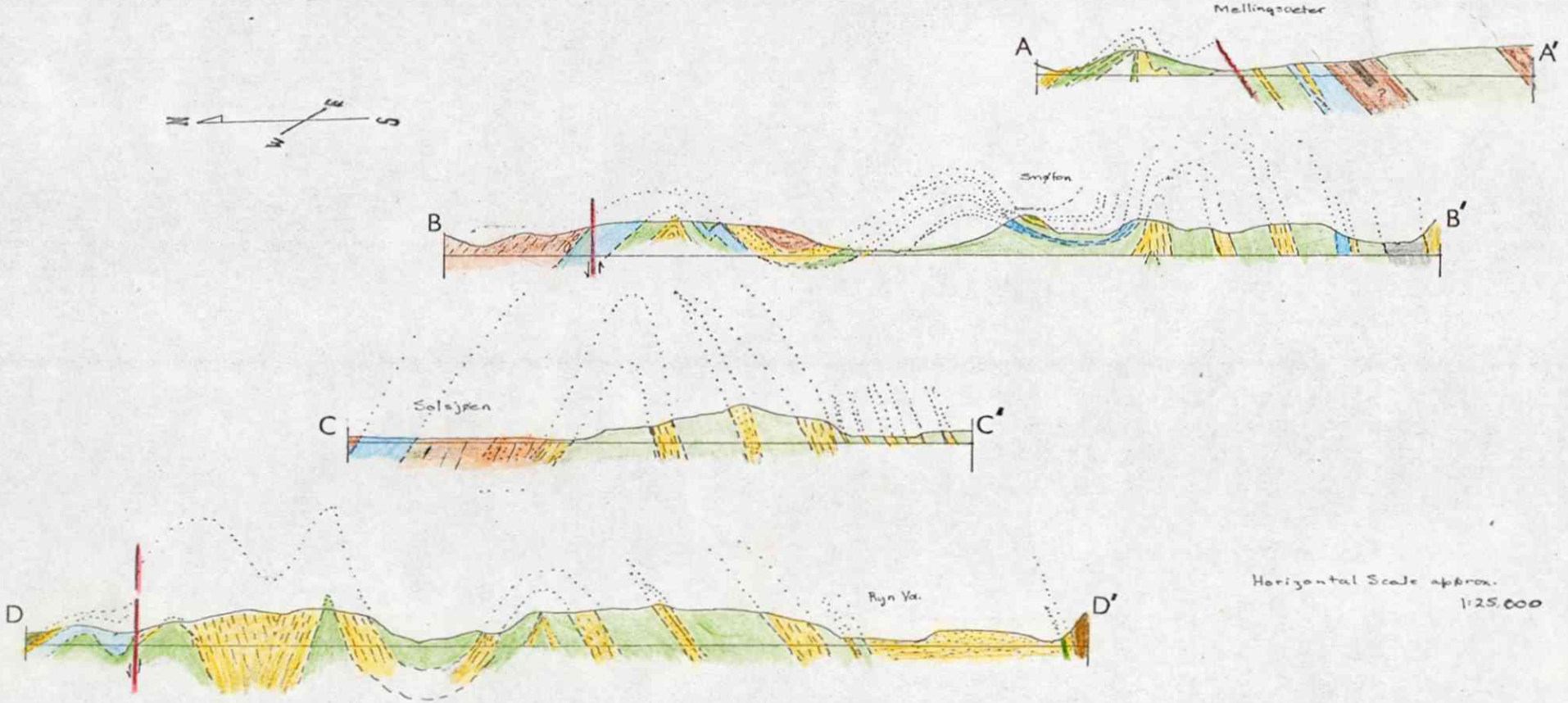
The non-existence of a basal conglomerate between the Hovin and Støren also causes the same doubt, but this conglomerate becomes increasingly thin to the north, and is only of very restricted outcrop two kilometres south of Lia Vd.

The proposal of a nappe structure for the wider area is in line with the proposals of Rutter et al (1967) about the structure of an area to the north of Løkken, and is reinforced by evidence from the mine workings at Løkken. The mine is within "Greenstones", and is worked for pyrites ore. The ore occurs in a long lenticular body tending east west within Vaskis (a black euxinic shale). This is overlaid by "Greenstones" which are the right way up, and rest upon "Greenstones" which are upside down.

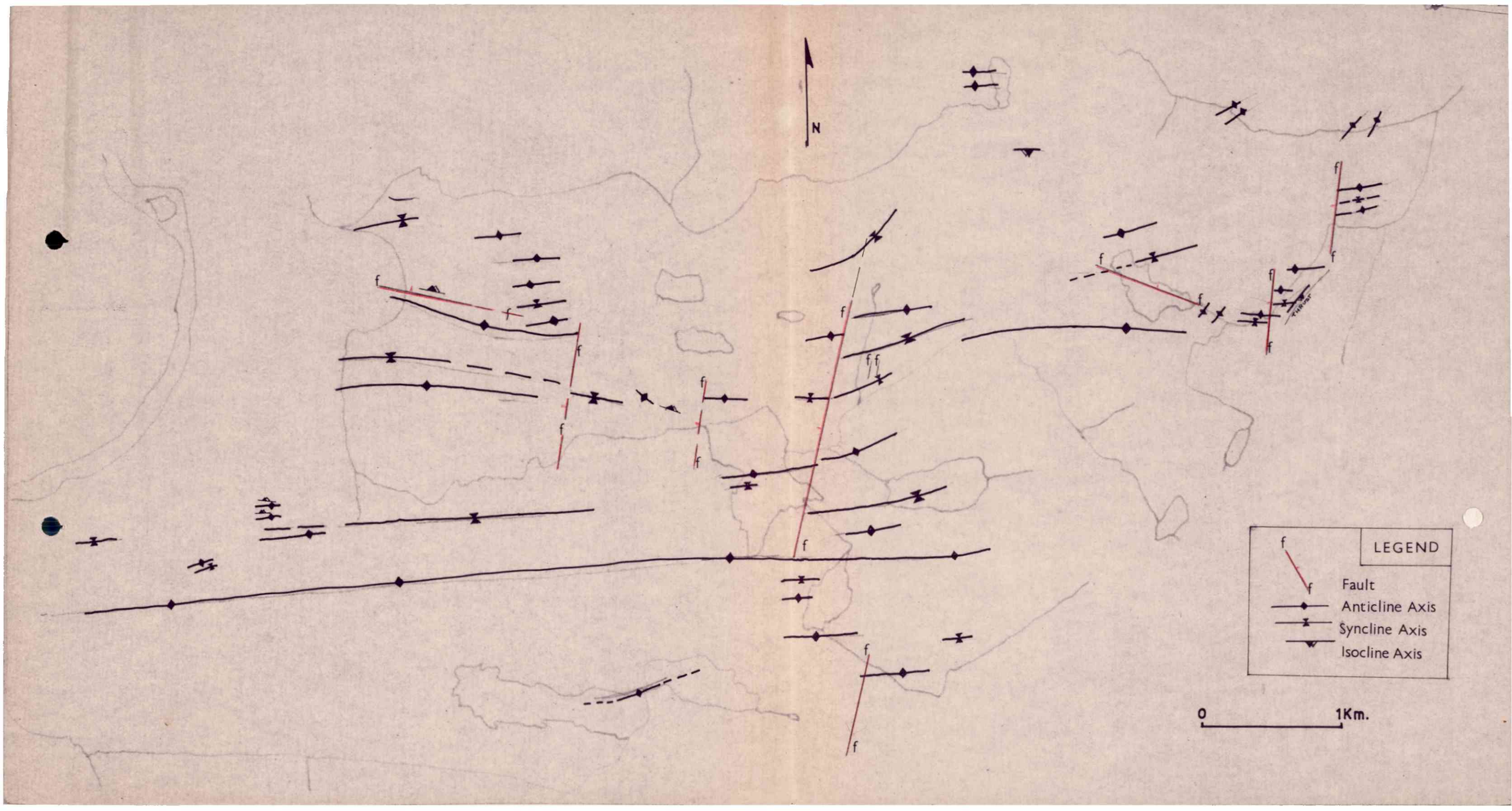
MAP TO SHOW THE POSITIONS OF CROSS SECTIONS



CROSS SECTIONS



Horizontal Scale approx.
1:25,000


N
LEGEND
Fault
Anticline Axis
Syncline Axis
Isocline Axis
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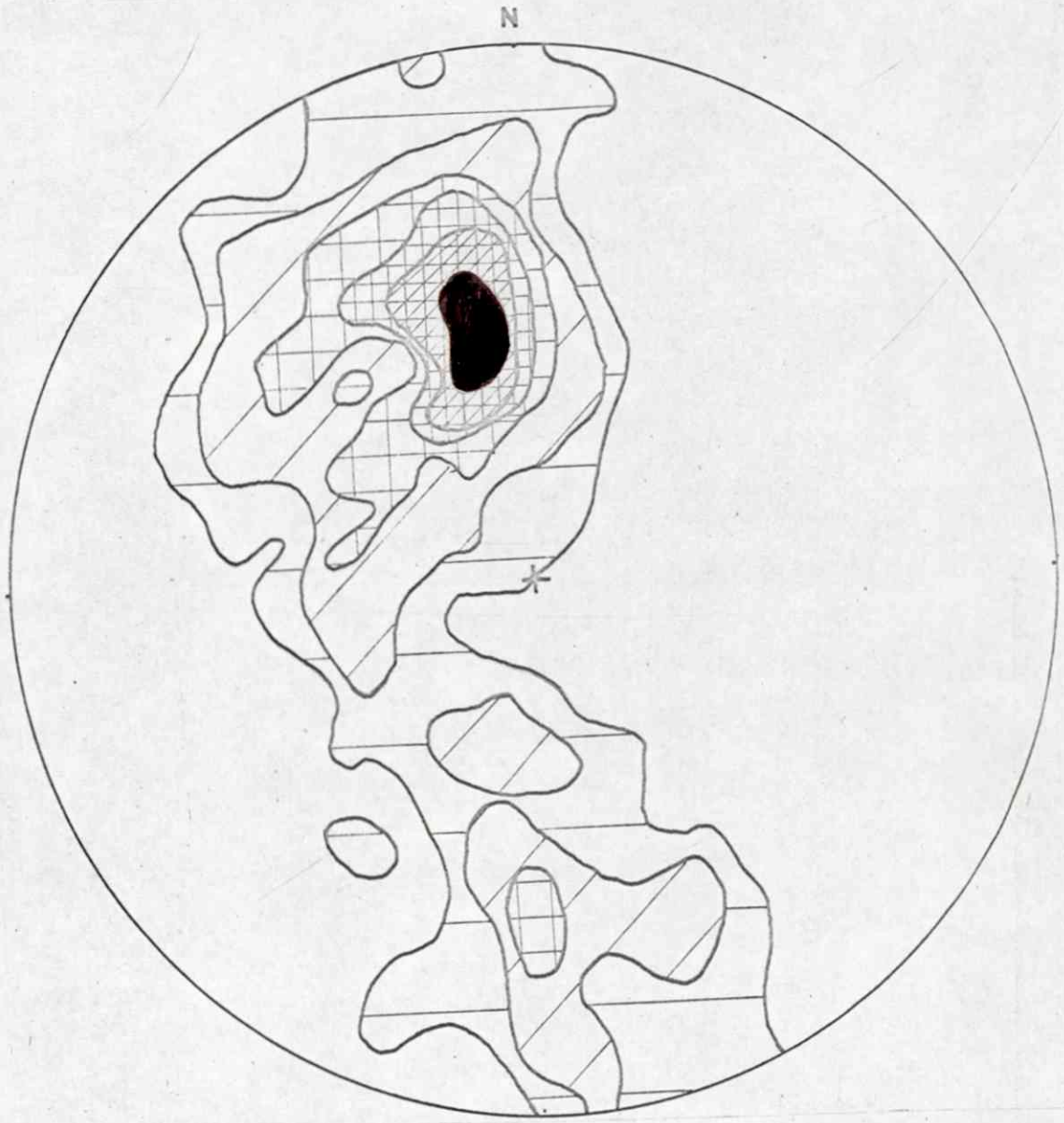

↑ Diagram for area mapped

450 readings:- bedding
cleavage
& fold axial surfaces

1 → 2%
2 → 3%
3 → 4%
4 → 5%
5 → 6%
6 → 7%

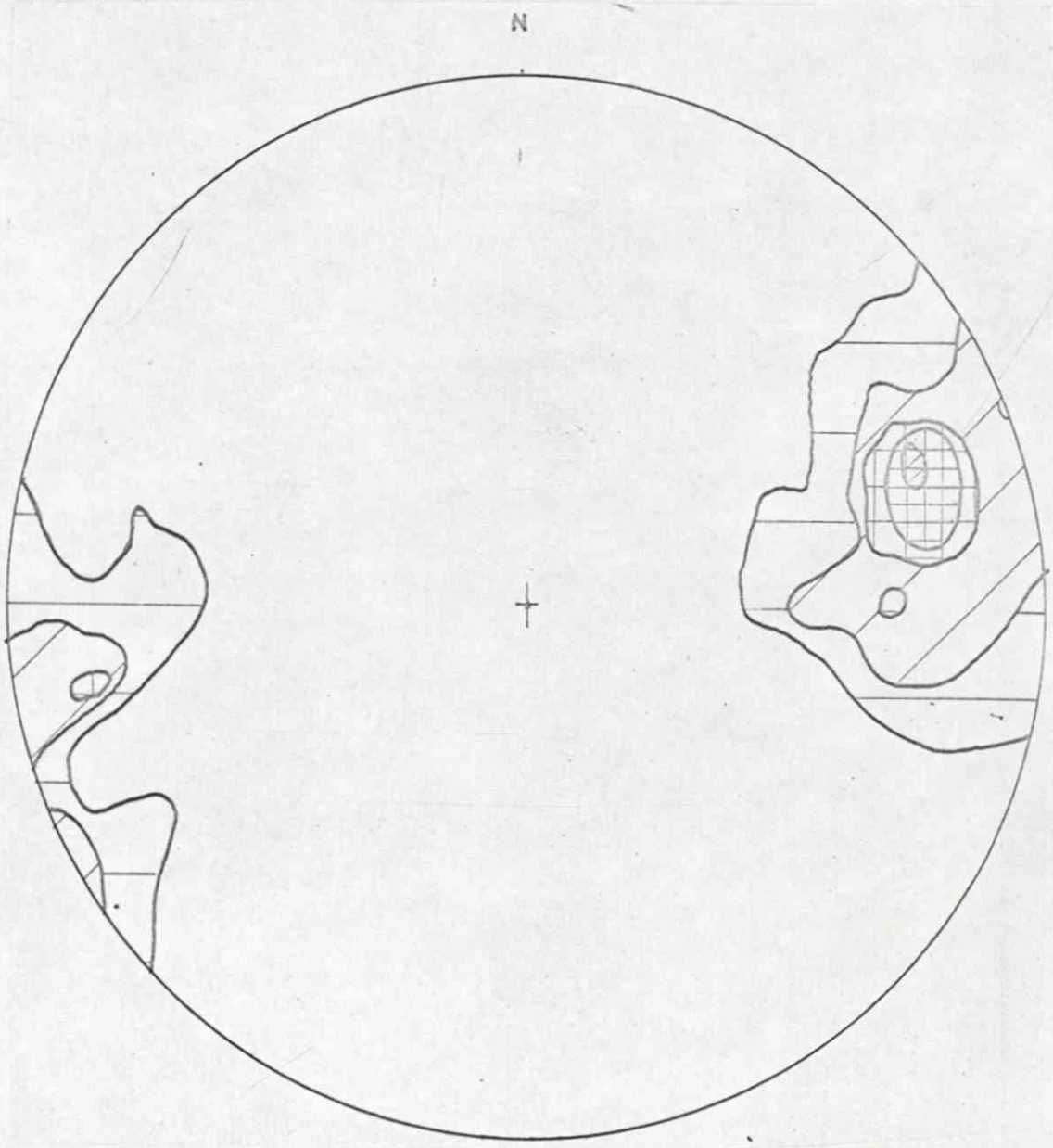

Diagram for area mapped

155 readings:- linear structures

2 → 4 %
4 → 6 %
6 → 8 %
8 → 10 %
10 → 12 %

GEOLOGICAL HISTORY

The course of events after the formation of the Røros Group, which acted upon the area around Svorkmo, and especially to the north east, are believed to be as follows.

1) The establishment of geosynclinal conditions, the centre of which was near Løkken, and the eruption of pillow lavas and massive submarine lava flows and deposition of lutites to make up the Støren Group. Svorkmo is in the position which was at the edge of volcanic activity and was of a shallower marine environment than Løkken.

2) The termination of Støren deposition by the uplift of the area and the intrusion of gabbro. The uplift causing the erosion of the Støren "Greenstones" and sediments, especially to the south of Svorkmo, and the beginning of Hovin deposition with the rise in sea level. Deposition of sediments are more complete to the south of Svorkmo and they overlap the Støren towards the north. Deposition began in shallow, near shore conditions, the limestones possibly marking the point where conditions were settled before their further gradual submergence, which changed the neritic to a bathyal environment. The latter is associated with the deposition of shales and grey-wacke type sediments.
The extrusion or intrusion of the Porphyrites occurred at this stage.

3) Sedimentation probably continued until the onset of the Caledonian Earth Movements which caused the burial of this area, its metamorphism, its folding into large isoclinal folds, and their movement to cause a second style of folding. The last effect of the Caledonian Orogeny was the third phase of folding.

4) The gradual uplift with the formation of faults and much later the formation of joints.

5) The possible Mesozoic sedimentation, after extensive erosion.

6) The severe glaciation of the area and isostatic uplift to give its present topography and height above sea level.