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Field Season 1975

GEOLOGICAL REPORT ON THE NEVERFJORD DISTRICT, KOMAGFJORD TECTONIC WINDOW, FINNMARK, NORWAY.

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Geological report on the Neverfjord District, Komagfjord Window.

I. Introduction.

This field report is based on mapping of the Komagfjord Tectonic Window carried out during the summer of 1975. The stratigraphical nomenclature used herein closely follows that of Reitan (1963), though closer investigation of the greenstone sequence has enabled a more detailed stratigraphy to be established for this unit.

The oldest rocks in the area are those of Reitan's Holmvann Formation, here given the status of a Group, in view of the variety of lithologies which it contains, and its thickness. It has been informally divided into four formations by Ramsay (Fig. I). The Högfjell Formation is composed of pillow lavas, breccias, agglomerates and conglomerates, forming the volcanic supracrustal sequence in this district. It is overlain by the Vargsund Formation, dominated by carbonate lithologies, particularly dolomite, and the Skinnfjell and Langorvann Formations, mostly composed of pelites with subsidiary volcaniclastic horizons.

The outcrop pattern of the Kvalsund Formation in other parts of the Komagfjord Window suggests that it rests unconformably on the above formations. These carbonaceous slates are however tectonically involved with the rest of the Raipas

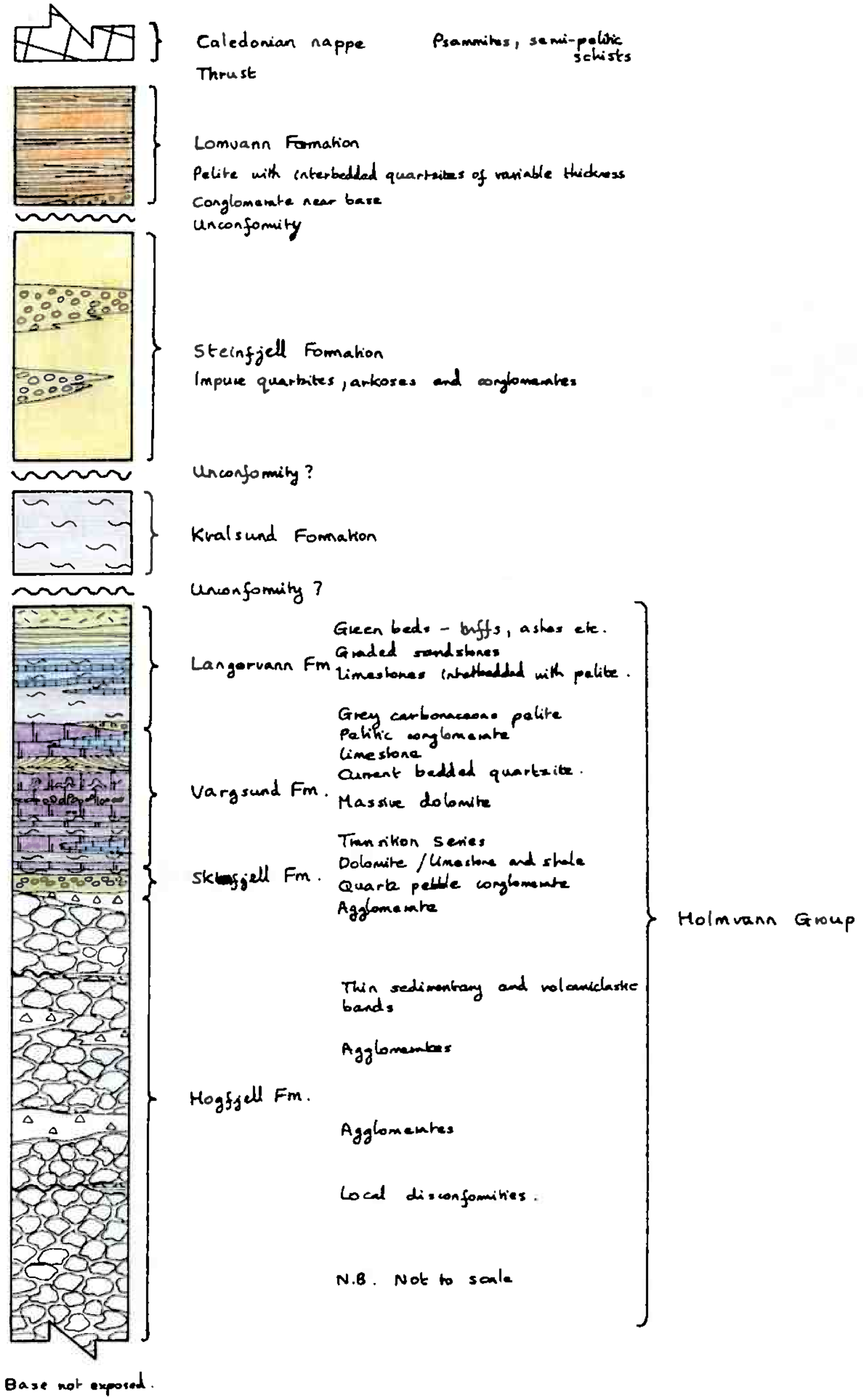


Fig. I. Stratigraphic Column

formations, sharing the same steeply north-west dipping first cleavage.

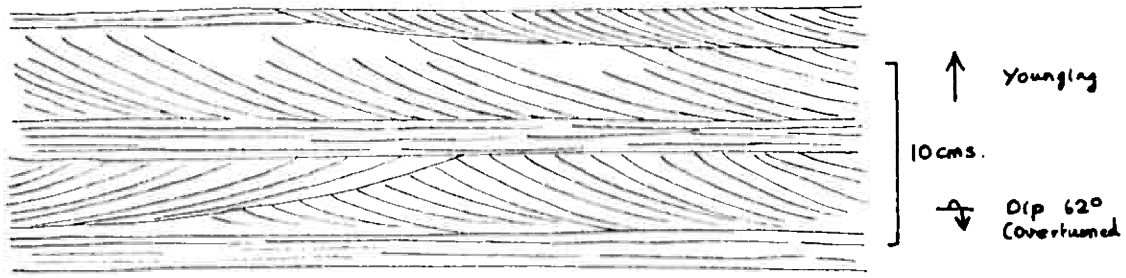
The relationship of the Steinfjell Formation (arkoses, conglomerates and impure quartzites) to the above suite is far from clear. However, for reasons which will be outlined, these rocks are thought to be younger than those of the Holmvann Group. The other formations in Reitan's Saltvann Group (the Djupelv and Fiskevann Formations) have not yet been recognised in this district.

The Lomvann Formation has a narrow outcrop (less than one kilometre wide) and is an autochthonous sequence unconformably on the Pre-cambrian basement around the margin of the tectonic window in the region of Porsavann and Hermanvann. The style of deformation in this unit is very different from that displayed by the basement and is clearly related to the Caledonian orogeny, during which the overthrusting of the Caledonian nappes occurred.

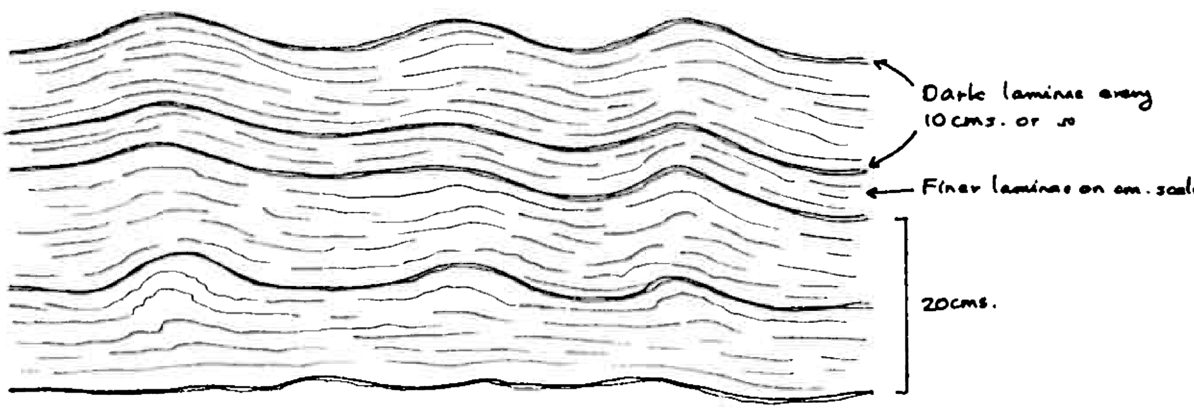
II. The Holmvann Group

Stratigraphy and palaeogeography

It is noticeable how different the Holmvann Group is on either side of the outcrop of the Steinfjell Formation. To the south the rocks are all greenstone lithologies, while to the north a more varied sequence of sediments and volcaniclastics is present above the greenstones. It is not certain whether this contrast is due to original facies variation within a complex volcanic environment, or simply due to the level of exposure, the rocks to the south representing a lower level in



a. Current-bedding in a quartzite interbedded with massive Vargsund Formation dolomites. Current directions were from North and North-East at time of deposition.



b. Low amplitude mounds produced by stromatolitic algae.

Fig. 2. Sedimentary structures in the Vargsund Formation.

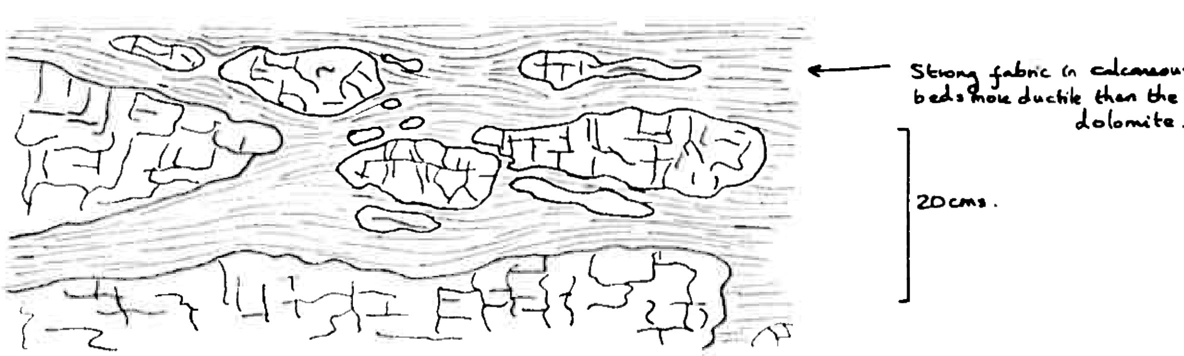


Fig. 3. Boudinage of competent dolomite beds within more ductile calcareous horizons.

the volcanic pile. This latter hypothesis is borne out by the rise in metamorphic grade southwards (Reitan, 1963). It is expected that a number of disconformities are present within this sequence, as well as rapid facies changes.

1. Högfjell Formation

The base of this greenstone formation is not seen, and it must be at least 2 kilometres thick. The formation is dominated by spilitic basalts (with pillow texture clearly visible at a number of localities), recrystallised under very low greenschist facies metamorphic conditions. Interbedded with these lavas at a number of levels are units of basaltic agglomerate (some blocks strongly flattened in the cleavage), conglomerate, and volcaniclastic sediments of tuffaceous and ashy aspect. As would be expected, considerable facies variation is present, and these probably do not represent chronostratigraphical units thoughout the area.

2. Skinnfjell Formation

This formation is poorly represented or absent in the area mapped so far. It comprises a unit of conglomerate (with vein quartz pebbles) and grey pelite with ashy bands, a few metres in all, underlying the dolomite of the Vargsund Formation.

3. Vargsund Formation

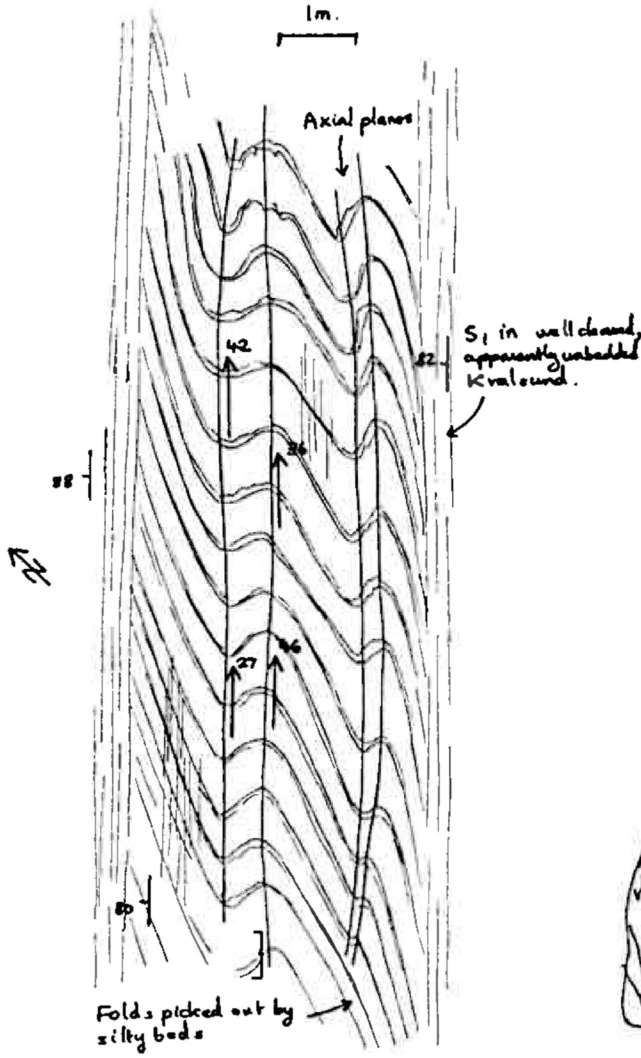
A sequence of carbonate-rich sediments, dominantly dolomitic, but with some limestones, together with interbedded pure quartzites (frequently current-bedded e.g. Fig. 2). At the base grey shales intercalated with thin beds of dolomite form a transition series with the Skinnfjell Formation. At higher levels the dolomite is more massive and contains in places domal structures produced by stromatolitic algae. Certain horizons are rich in cherty nodules. At least 100 metres of dolomite is present locally, but this has been thinned, or even cut out altogether, by folding and faulting. These sediments were clearly deposited in a warm shallow marine environment. Current-bedding in the quartzites indicates a north-easterly source for these mature sediments.

4. Langørvann Formation

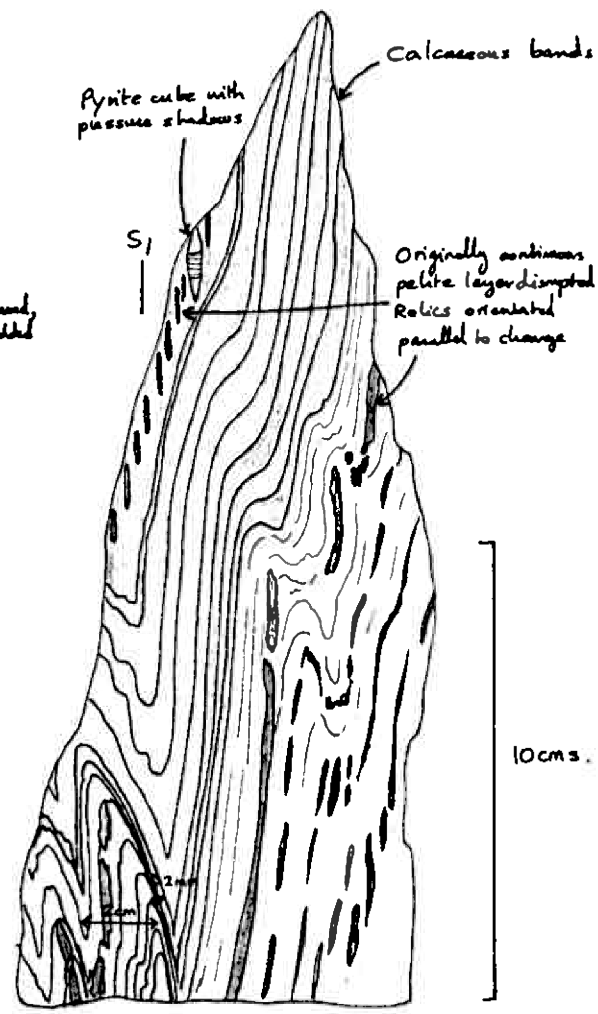
At the base, immediately overlying the Vargsund Formation, a thin conglomerate horizon is sporadically developed. Sub-rounded pebbles of greenstone lithologies with subsidiary clasts of shale and vein quartz pebbles are set in a greyish-green pelitic matrix. This is followed by a much thicker sequence of dark, slightly graphitic shales, which become increasingly calcareous until eventually micritic limestone bands appear in the sequence (some up to 25cms. thick). In addition, beds of coarser-grained clastic sediment appear, giving the sequence a turbiditic aspect. At one locality grading and sharp bases in some of these sandstone beds enable determination of the way-up of the sediments and the facing direction of the tectonic structure (section IV).

III. The Kvalsund Formation

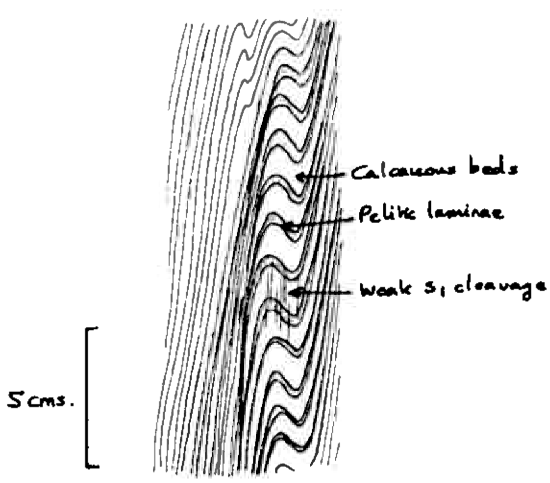
These are black, highly graphitic pelites, only found so far in the region of Kvalsundal lakes. Throughout most of the outcrop they are a well cleaved, monotonous lithology. Locally however, pale beds of silty sediment reveal that they



a. Fold in silty laminae in Kvalsund Fomation carbonaceous slates — outcrop plan.



b. Folds in carbonate rich horizon of Langervann Fm, with marked thinning of limbs — section of hand specimen.



c. Similar to b.

Fig. 4. Fold styles typical of pelitic lithologies in the Holmvann Group and Kvalsund Fomation.

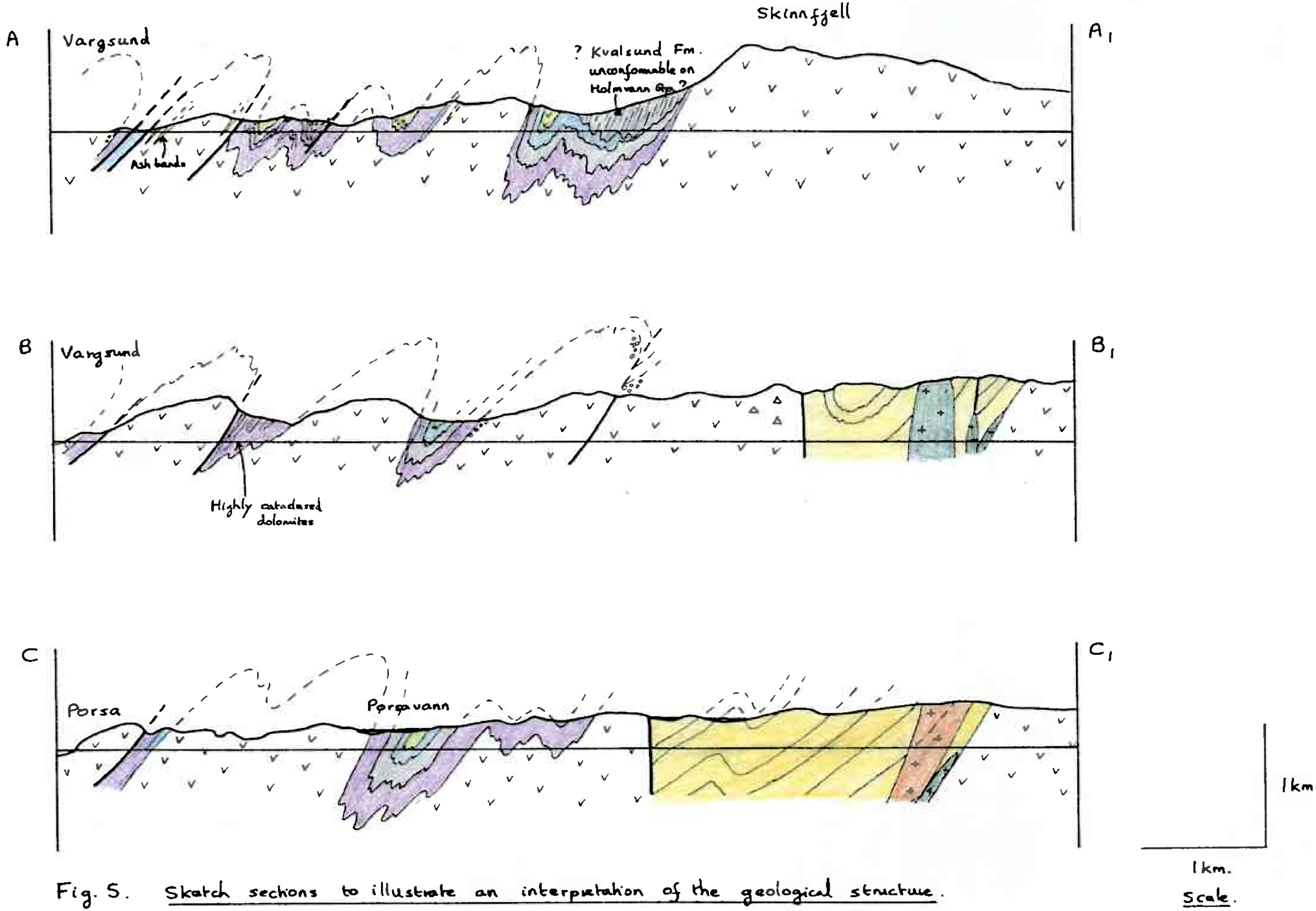


Fig. 5. Sketch sections to illustrate an interpretation of the geological structure.

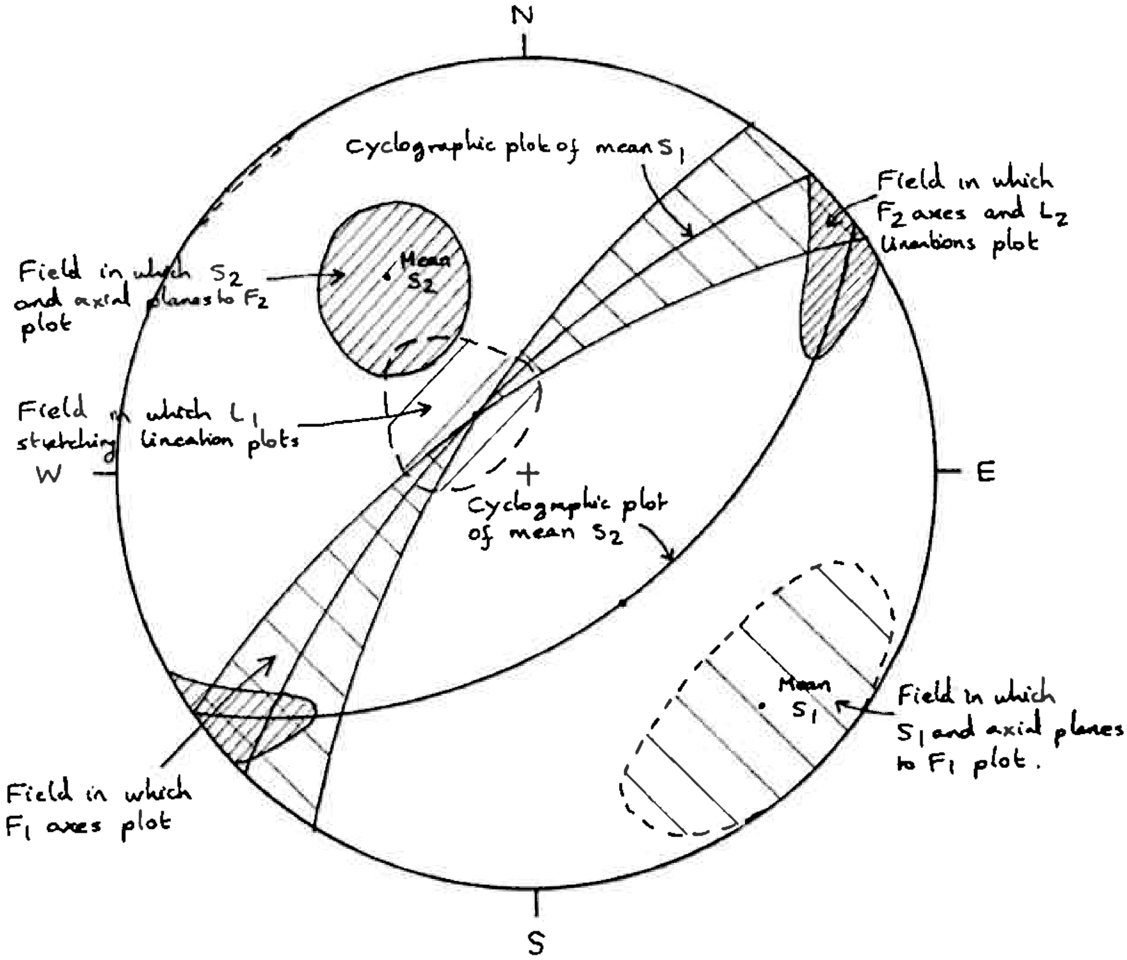


Fig. 6. Synoptic Stereonet.
Fields in which D_1 structural elements plot have open shading, those with D_2 plots have denser shading.

exhibit a style of deformation very similar to that of the Holmvann Group (Fig. 4.) They have the same strong penetrative cleavage present in the pelitic units of the latter, which dips steeply to the north-west, though cleavage fanning occasionally give rise to a vertical cleavage or very steep dip to the south-east. Structurally, therefore, they may be regarded as being involved with the Holmvann Group, the Kvalsund Formation clearly being interfolded with the latter. Reitan (1963) regards the Kvalsund Formation as being stratigraphically distinct too, lying unconformably on the Holmvann Group, but there is no evidence for this in this district. It is difficult to estimate the thickness present.

IV. The Structure of the Holmvann Group and Kvalsund Formation

The interpreted structure of the stratigraphic units described above is as illustrated in the accompanying geological sections (Fig. 5). In general, the upper formations of the Holmvann Group form pinched-in synclines between anticlinal cores of the Högfjell Formation greenstones. The axial planes of these asymmetric folds dip steeply to the north-west, while fold axes plunge at variable angles to south-west and north-east (synoptic stereonet, Fig. 6) reflecting the gross noncylindrism of the major structure, readily visible from the map. The first cleavage (S_1) is penetrative in the fine-grained sediments of the Langervann and Kvalsund Formations and dips steeply to the north-west, with some fanning. In steeply dipping fold limbs, flattening deformation has been most intense, with partial completion of transposition of the

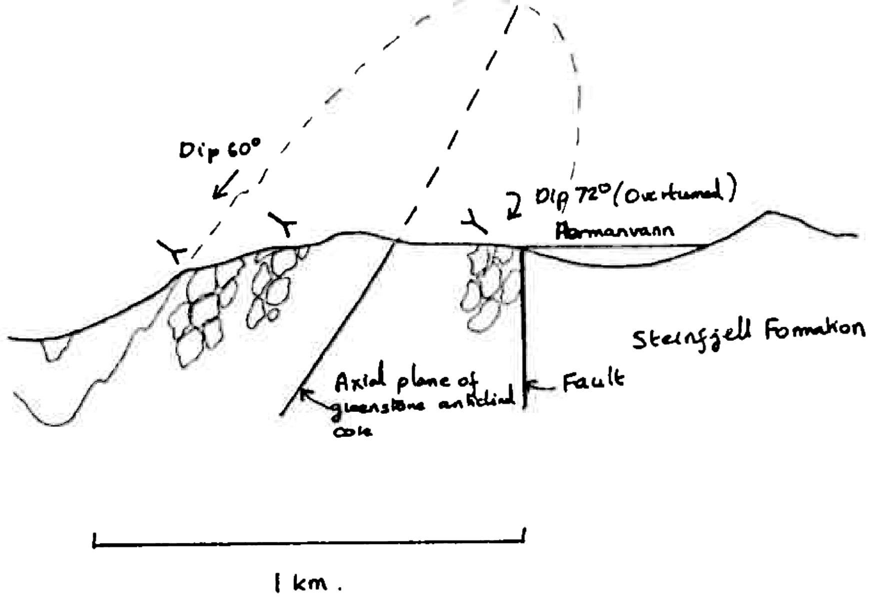


Fig. 7. Demonstration of folding in greenstones by the use of pillow structures for way-up evidence.

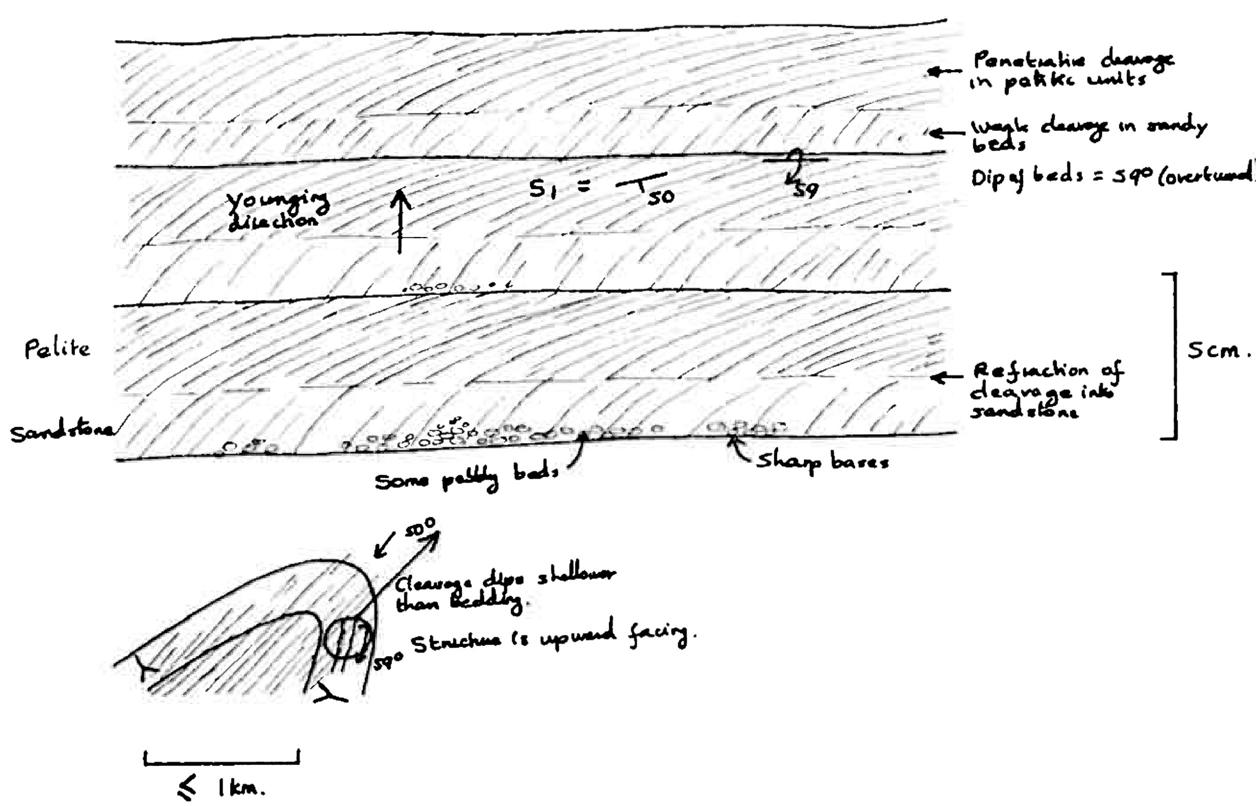


Fig. 8. Demonstration that the structure consists of recumbent folding with local inversion of the stratigraphy, but upward facing.

Sketch of graded sandstones of the Langevann Formation on the west shore of Hermanvann.

sedimentary layering to a completely new metamorphic fabric. In this situation there is considerable variation in angle of plunge of fold axes, the minor structures displaying an incongruous relationship to the major folds, particularly in the more ductile lithologies, e.g. those of the Langcrvann Formation. In the more competent units, such as the quartzites and dolomites, folds are of concentric style and larger wavelength, closely resembling simple buckle folds. Carbonate units frequently display pressure-solution cleavages. Little folding is apparent within the pillow lavas, largely due to the absence of suitable marker horizons, but when the shape of pillows is used to indicate way-up it is possible to show that the volcanics are deployed in anticlinal cores (Fig. 7) of asymmetric folds with wavelengths of > 1km. Some of the blocks in the volcanic agglomerates have been flattened in the cleavage plane, as have the amygdales found in some of the lavas. Another feature of the first episode of deformation to affect the Holmvann Group is a fibre lineation (L_1) plunging steeply to the north-west in the plane of the cleavage. It is a stretching lineation, produced by extension in the X-direction of the principal strain ellipsoid, and is deformed by folds of a second generation.

On the western shore of Porsavann is an outcrop of graded sandstone within the Langorvann Formation. The S_1 cleavage is refracted in the sandy layers and the relationship of younging direction and cleavage are such that the structure is deduced to be upward-facing, even though bedding is overturned (Fig. 8.).

Further complication to this structure was caused by

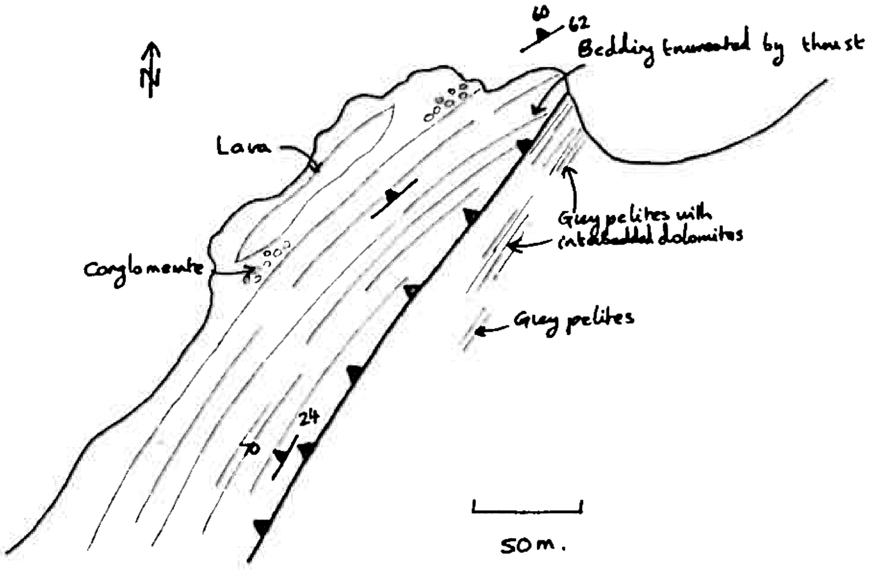


Fig 9. Marked truncation of bedding in Vargsund Formation dolomite on the coast just west of Neverfjord.

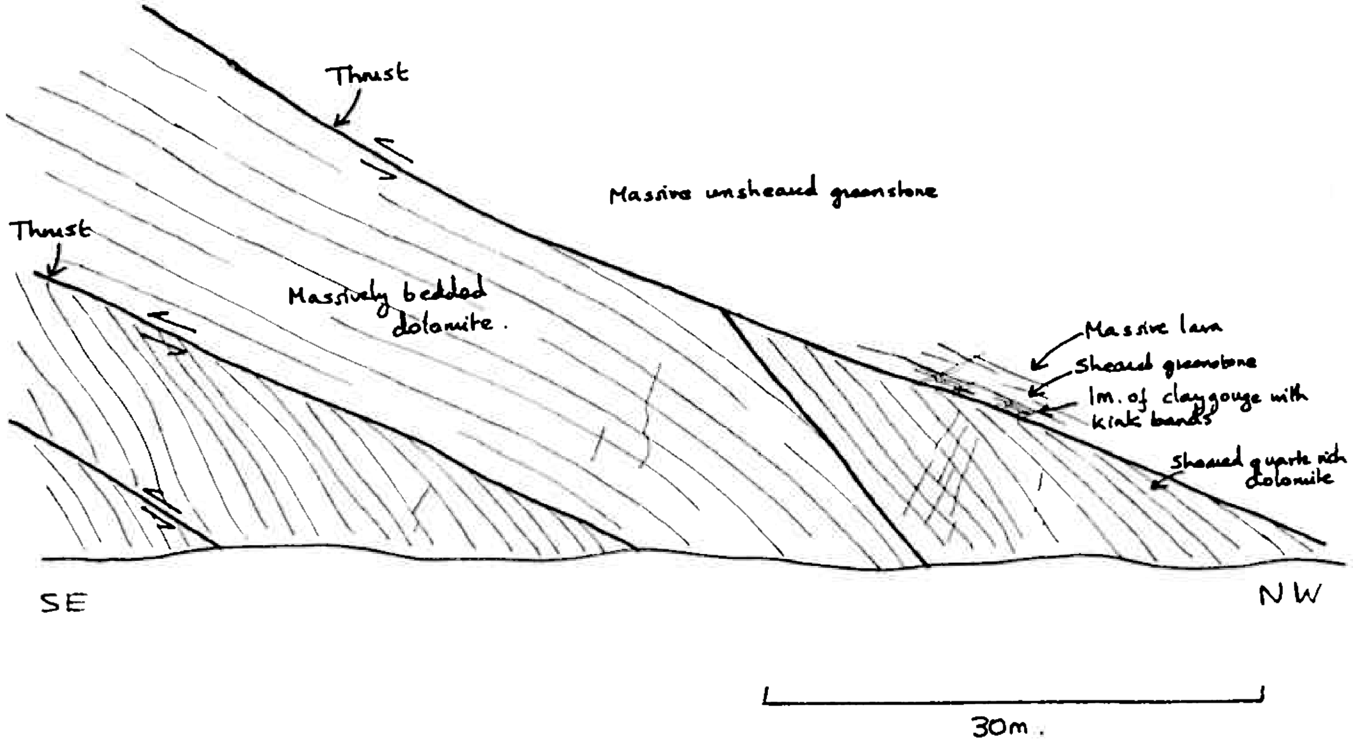


Fig 10. Section in the cliff behind the fish factory and quay at Kremkluben showing the complexity of the thrusting in dolomite which has been overthrust by greenstone.

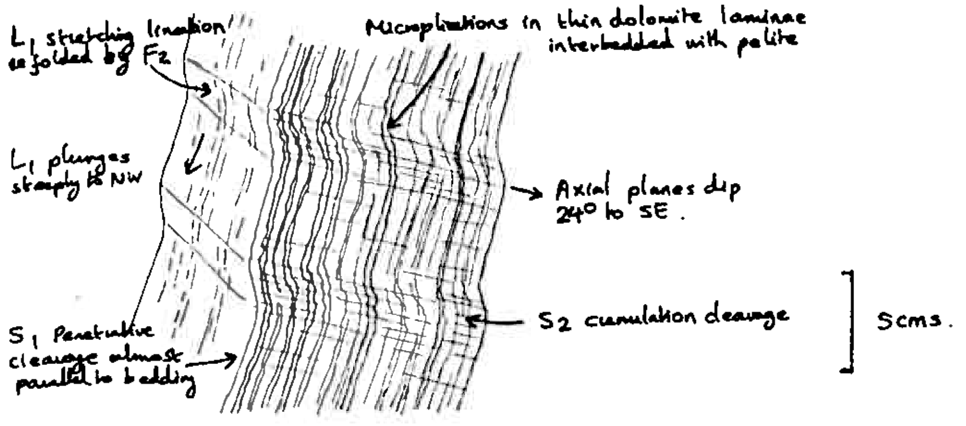


Fig. 11. Small scale F2 folds with associated crenulation cleavage refolding S1 cleavage and bedding in a striped unit of dolomite and pelite.

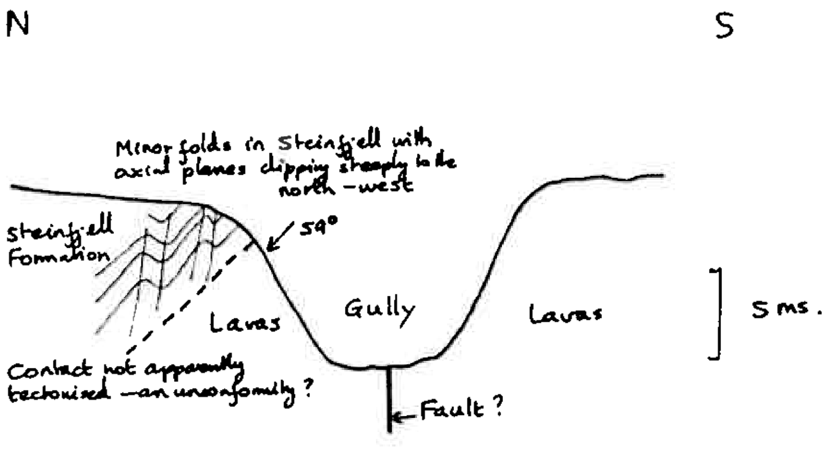


Fig. 12. Relationship of greenstones to the Steinfjell Formation in the gully due south of Hemanvann.

shearing along less competent stratigraphical layers producing thrusts (Fig. 9 and 10) and cataclasis of more competent units, particularly the dolomites. It remains uncertain as to whether this thrusting occurred as a consequence of continued tightening of the structure established in the first phase of deformation, or perhaps due to imbrication below the Caledonian basal thrust as Reitan has suggested.

At a number of localities the first penetrative cleavage (S_1) is folded by small scale open folds (Fig. 11). These F_2 folds have axial planes dipping at low angles (typically 20-30^{o}) to south-east, and fold axes plunge at shallow angles to south-west and north-east. Axial planar to these folds is a crenulation cleavage (S_2) and the intersection of these discrete cleavage planes with the S_1 cleavage produces a prominent lineation (L_2).

The grade of metamorphism in the Holmvann Group and Kvalsund Formation in this district is low, and does not appear to exceed the quartz-albite-muscovite-chlorite-sub-facies of the greenschist facies.

V. The Steinfjell Formation

The Steinfjell Formation appears to be the only formation of Reitan's Saltvann Group present in the Neverfjord district. It is a sequence of coarse-grained arkoses, impure quartzites and conglomerates. The former are frequently cross-bedded, enabling determination of way-up, while the latter are useful indicators of true bedding. Over much of the outcrop bedding can only be recognised with difficulty, especially in the impure quartzites. Current bedding indicates that the formation was laid down in a sedimentary basin with the provenance of materials to the west or north-west. Most of the pebbles in the conglomerates are of vein quartz.

The relationship of the Steinfjell Formation to the rocks of the Holmvann Group is far from clear, unfortunately. The north-western boundary of the formation is in faulted contact with the Holmvann Group for much of its length. The south-eastern contact is more poorly exposed, but appears to dip at about 70-80^{o} to the north-west. Near the southern extremity of Hermanvann the contact is exposed on the upper slopes of a gorge, which may itself be eroded along a fault (Fig.12). The contact itself is not faulted and where it crosses the gorge it can be closely examined. Greenstones of the Hogfjell Formation approach to within 5cms of the Steinfjell impure quartzite. There is not sign of any crushing or brecciation as might be expected along a faulted contact, neither is there any sign of a basal conglomerate in the Steinfjell. Pending further evidence, it is suggested that the Steinfjell Formation is unconformable on the Holmvann Group, the original contacts having been modified by folding and faulting.

Other evidence for the relative age of the Steinfjell formation includes the following. Firstly, bedding (where it can be observed) is consistently dipping to the north-west, though steep dips to the south-east occur near the faulted contact in the north-west. Current-bedding everywhere indicates that the rocks are the right way-up, so the Steinfjell Formation appears to sit on rocks of the Holmvann Group. Secondly, the tectonic style of the Steinfjell formation is very different to that of the Holmvann Group. Observable folds on any scale are very rare, and there is no sign of a cleavage. This might be a consequence of the difficulty in recognition of bedding, or possibly due to the competence of the massive quartzite beds. If the Steinfjell Formation had undergone the same deformation as the Holmvann Group surely it would have been buckled to a much greater extent than is apparently the case, the basalts of the Hogfjell Formation being equally competent (if not more so) to the Steinfjell quartzites.

In conclusion, it is suggested that the Steinfjell Formation is infilling a complex basin within the basement greenstone assemblage, and may be of Eocambrian or earlier age. The possibility that these impure quartzites and arkoses could be lateral equivalents of the Doggelv Formation, found along southern margin of the tectonic window, cannot be ruled out.

VI. The Lomvann Formation

This formation outcrops as a narrow strip no more than about a kilometre wide adjacent to the Caledonian basal thrust. It is dominantly a striped sequence of dark pelites interbedded with thin quartzitic stringers, though more massive quartzite beds (a few metres thick) are developed. At the base is a thin discontinuous layer of conglomerate, containing small rounded pebbles of vein quartz in a grey fine-grained matrix. The formation is probably no more than 100 metres thick in this area.

Although the contact with the underlying formations described above has not yet been found, the relationship of the

Lomvann Formation to these can confidently be stated as being unconformable. The outcrop of the Lomvann Formation transgresses the structure and stratigraphical boundaries of both the Holmvann Group and the Steinfjell Formation. There is no evidence for displacement of the Lomvann Formation at either the north-west or south-east margin of the Steinfjell outcrop, suggesting that the faulting in these areas is pre-Caledonian in age. From the map the angular discordance between bedding in the autochthonous Lomvann and the basement upon which it sits unconformably, is clearly visible.

VII. Effects of the Caledonian Orogeny.

The top of the Lomvann Formation is truncated by the Caledonian basal thrust plane, and the deformation of the autochthonous sediments appears to be closely related to the thrusting movements. In places the Lomvann Formation looks undeformed, in others the strike is normal to the outcrop of the thrust plane and clearly considerable folding has taken place. The wavelength of folding is controlled to a large extent by the lithology involved. The more massive quartzites are buckled in large concentric folds, while finely striped pelite/quartzite units buckle in folds of amplitudes of only 2cms and slightly greater wavelength. Axial planes are nearly always upright, and pelitic units are characterised by a non-penetrative cleavage of fracture or crenulation type. The grade of metamorphism in the Lomvann Formation appears to be very low.

VIII. Intrusions into the basement rocks

Numerous bodies of intrusive igneous rock are present in the area, of basic and ultrabasic composition. They frequently cross-cut the structure in the supracrustal sequences and are often irregular in shape. Their intrusion appears to have been controlled by planes of weakness such as faults, joints and bedding plane anisotropies present in the basement rocks. Considerable retrogression is apparent in thin sections from all the intrusions. Rocks of ultrabasic composition have been thoroughly serpentinised, while those of gabbroic composition may contain the occasional relict pyroxene phenocryst set in a groundmass of alteration minerals such as serpentine, chlorite, sericite and amphibole. In one or two intrusions ultrabasic serpentinites pass into gabbroic rocks at their margins. The contacts between these bodies and the country rocks into which they were intruded are exposed at a number of places. The contact is always sharp and regular, and the intrusions are free of xenoliths. The country rocks are either greenstones or impure quartzites, neither lithology facilitating determination of the thermal effects associated with the emplacement of the intrusions. The greenstones adjacent to the intrusions are rich in pyrite, suggesting some redistribution of Fe at least.

It is hoped that further mapping and geochemical analysis will enable the elucidation of the relationship between the basic/ultrabasic suite inside the Komagfjord Window and the rocks intrusive into the Caledonides outside it, e.g. the Seiland Igneous Province. It is not yet possible to give an absolute date for the intrusions within the window.

IX. Mineralisation

Investigation of the mineralisation was limited during the 1975 field season and was concentrated on known vein type deposits of the 'pyritic paragenesis' (Vokes 1957). The veins at Porsa Mine, and in the valley opening into Neverfjord in the north, are all developed in the greenstone sequences of the Hogfjell Formation transverse to the regional structure, i.e. folds and cleavage. The main minerals present are pyrite and chalcopyrite, with a gangue of calcite, quartz and chlorite. In addition, disseminated sulphides are found as accessory minerals in rocks throughout the area, especially carbonate horizons of the Vargsund Formation, but also in the greenstones. In places magnetite is a very important accessory mineral in the lavas and the matrix of volcanic agglomerates.

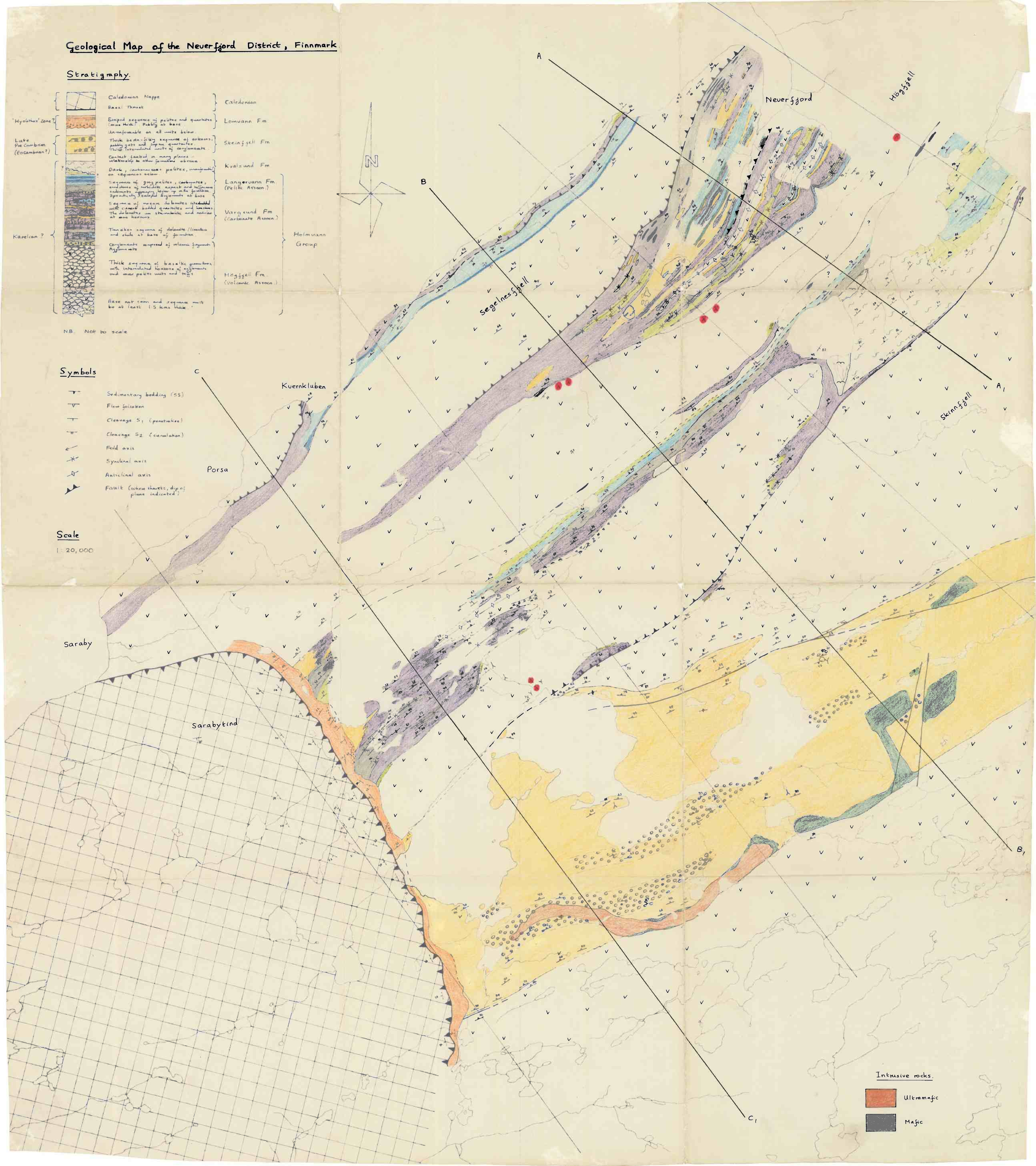
It has not been possible so far to determine the age of mineralisation, or the origin of the sulphide bearing hydrothermal fluids. The following modes of formation are considered possible:-

a. Flushing of elements such as Cu, Fe and Zn contained in the volcanic sequences in trace quantities and their concentration in veins, the basic/ultrabasic intrusive suite possibly providing the heat and volatiles necessary for flushing the greenstone pile.

b. Hydrothermal ore-bearing fluids emanating from the basic/ ultrabasic suite and deposited in the greenstones as discrete vein type deposits and in the Steinfjell Formation as a disseminated sulphide. However, there is no obvious relationship between the intrusions and the mineralisation.

c. Hydrothermal fluids rising from granitic intrusions at depth (trondhjemitic bodies have been described by Reitan from the southern area of the Komagfjord tectonic window), or from fractures in remobilised granitic crust.

It is hoped that geochemical analysis will help in solving these problems.


Geological Map of the Neverfjord District, Finnmark
Stratigraphy.
Caledonian Nappe
Basal Thrust
Caledonian
'Hyolithus' Zone?
Lomvann Fm
Unconformable on all units below
Late Pre Cambrian (Eocambrian?)
Thick basin-filling sequence of arkoses, pebbly grits and impure quartzites.
Steinfjell Fm
Kvalsund Fm
Dark, carbonaceous pelites, unconformable on sequences below
Langorvann Fm (Pelitic Assocn.)
Vargsund Fm (Carbonate Assocn.)
Karelian ?
Holmvann Group
Thick sequence of basaltic greenstones with intercalated horizons of agglomerate and minor pelitic units and tuffs
Høgfjell Fm (Volcanic Assocn.)
Base not seen and sequence must be at least 1.5 kms thick.
NB. Not to scale
Symbols
Sedimentary bedding (SS)
Flow foliation
Cleavage S1 (penetrative)
Cleavage S2 (crenulation)
Fold axis
Synclinal axis
Anticlinal axis
Fault (where thrusts, dip of plane indicated)
Scale
1 : 20,000
N
A
A1
B
B1
C
C1
Neverfjord
Høgfjell
Segelnesfjell
Kvernkluben
Skinnfjell
Porsa
Saraby
Sarabytind
Intrusive rocks.
Ultramafic
Mafic