Bergvesenet
Postboks 3021, 7002 Trondheim

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NGU Rapport nr. 1189

# Geologien i Sanddøla - Blåmuren området. Grong, Nord-Trøndelag

18. mai - 25. september 1973

Saksbehandler: G. H. Gale.

Norges geologiske undersøkelse
Postboks 3006, 7001 Trondheim
Tlf.: (075) 20166

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Figures, Plates and Maps.

## 1. INTRODUCTION

This report is a summary of geological investigations carried out during 1973 in the Cambro-Ordovician rocks of the Sanddφla area east of Trangen and in the area between Langtjern and Gaziervann-Blåmuren areas. Several small areas have not been remapped in detail, however, the rock units involved have been observed elsewhere and the lack of information in the unmapped areas is not considered to affect the conclusions drawn here.

The description is organized on the basis of individual map sheets and detailed descriptions of each unit on a map sheet are avoided when the unit has been discussed in a previous section.

## 2. MφKLEVANN (Map 1189-01).

Gneiss: The oldest rocks in the area appear to be the acidic gneisses of the "Grong Culmination" which occur south of Sanddφla river. These have been investigated in three traverses from which it appears that the gneisses are dominantly acidic with only thin, widely scattered horizons of amphibolite. The fine-grained, layered gneisses immediately south of the river grade southwards into medium-grained gneisses with small ( $<$ 1 cm) feldspar porphyroblasts in some exposures which become progressively more abundant southwards. At (0330 1100) there is a 8-10 meter thick unit of quartz-biotite schist which was probably a semi-pelitic sediment. The medium-grained porphyroblastic gneiss becomes more porphyroblastic south of (0310 1100) in that the size and proportion of feldspar metacryst increases to such an extent that the rock is a porphyroblastic feldspar gneiss with up to 50% consisting of feldspar porphyroblasts up to 2 cm in length set in a fine to medium grained quartz-feldspar-biotite matrix.

The presence of quartzitic layers in the fine-grained, medium-grained and porphyroblastic gneisses (outside the Mφklevann sheet) and the quartz-biotitic schist layer mentioned above as well as layering/bedding in the fine-grained gneiss indicate that the gneisses are metamorphosed arkosic sediments rather than metamorphosed granitic intrusives.

Acidic intrusive rocks: The largest intrusive mass in the map area forms part of the Sanddφla trondhjemite. The trondhjemite is medium-grained and often pinkish coloured with large areas that are pale greenish due to strong epidotizion. The latter is well exposed in road cuts between Mφklevann and

Stortjern. At the extreme eastern end of Møklevann there is a small lense of fine-grained unaltered trondhjemite several tens of meters in width.

An elongated body of trondhjemite extending from Langtjern to west of Stamtjern is considered to be an apophysy of the main trondhjemite mass. Contacts with the surrounding rocks are only rarely exposed, the best example being along the road to Stamtjern. This is a fine-to medium-grained crystalline mass with a pronounced schistosity which is so well developed in some places that the rock resembles a quartzose schist. Along the Stamtjern road the northern contact is diffuse and consist of lenses of the trondhjemite intruded into basic volcanics/diabase. The contact at Langtjern and west of it appears to be strongly cleaved and is marked by a sharp escarpment which is probably a fault zone.

South of Langtjern the rocks are largely silicic and resemble a medium-grained keratophyre more than a trondhjemite. On the basis of the evidence at Stamtjern this unit is considered to be an intrusive phase related to the main trondhjemite mass.

The relationship between the main trondhjemite mass and the other rocks is difficult to establish due to the absence of observed contact relationships. Southeast of Bryntjern the diabase appears to be intruded by trondhjemite which contains rafts of basic volcanics with a well developed schistosity. This suggests that the trondhjemite may have been intruded into the greenstones after the development of the regional schistosity.

The contact between Møklevann and the eastern boundary of the map is poorly exposed and east of Setertjern it runs along a small steep valley. Several small exposures of strongly tectonized greenstone near the contact where it crosses the Møklevann road suggests that faulting has occurred along the contact in some places.

Basic intrusives: Two large bodies of basic intrusives occur at Bryntjern and Møklevann. Small basic dikes occur near Angeltjern and scattered throughout the volcano-sedimentary sequence at Møklevann. In addition, there are several small exposures of a medium-grained basic rock resembling gabbro along the northern contact of the trondhjemite body at Stamtjern. This area is shown on the map as a single mass, however, since the exposure is sparce in this area it is just as feasible to consider it as an area of basic volcanics with scattered medium-grained dikes.

The basic intrusive at Bryntjern is mainly fine-grained and holocrystalline. The rocks are metamorphosed and the original minerals have been intensely altered and it can therefore be classified as a diabase. The interior of the body has zones that are medium grained and resemble a metagabbro. This basic mass is considered to be a high-level synvolcanic intrusive which was sufficiently large to permit coarse crystallization of its center. The contact with the metasedimentary rocks in the northwest corner of the map is not exposed and could be a fault boundary running along a topographic depression. The southeastern contact is also shown as a fault since there is a strong scarp at the approximate location of the contact. (It should be noted that some of the rocks at (0460 0590) mapped as massive lava are similar to the fine grained diabase and placement of the contact along the fault zone may not be valid in detail).

The diabase body at Møklevann is fine grained and contains a number of 1 - 2 m wide lenses of basic and acidic volcanics and several small dikes of fine- to medium-grained trondhjemite. Small diabase dikes intruding the volcanosedimentary rocks in the area mapped by K. Langley indicate that the diabase is later than the regional fabric in this area.

Although age relationships of the intrusives to the other rocks in the area has not been definitely established, several features point toward a post greenstone age for the diabase and trondhjemite: (1) dikes of diabase cut the foliation in the volcanics; (2) apophyses of trondhjemite occur in the diabase; (3) xenoliths of basic rocks considered to be volcanic in origin occur within the trondhjemite; and (4) the Stamtjern trondhjemite body intrudes the basic volcanics.

Volcanic rocks: The volcanic rocks of this map area can be separated into three major divisions: (1) massive lavas; (2) Greenschists; and (3) the volcano-sedimentary sequence north of Langtjern.

The fine-grained massive lavas are basaltic flows in which lava boundaries are only rarely visible. The lavas have been intruded by basaltic dikes, up to 1,5 m thick, which are well exposed along the electricity transmission line at (0430 0735). In places, notably east of Stamtjern, the map unit contains minor pyroclastic material. West and northwest of Stamtjern the lavas, pyroclastics and tuffaceous sediments are intimately intermixed and no attempt has been made to separate them into lithological units.

The greenschist unit is a sequence consisting mainly of strongly foliated basic pyroclastics, layered tuffs and clastic basic sediments. Massive basaltic units several meters in thickness, and thin keratophyric tuffs and lavas are scattered throughout this unit. In addition, several quartzite horizons, the largest of which occurs at Stortjern, occur thorughout the unit.

Strongly deformed pyroclastics are most common adjacent to the massive lava unit. These consist of basic volcanic fragments, generally less than 10 cm in length, that have been strongly flattened within the plane of the regional folation which is generally parallel to the layering when it can be determined. Several fine-grained layered basic rocks, considered to be tuffs, west of Angeltjern have scattered pyroclastic fragments.

The tuffaceous units are dark green, fine-grained basic rocks consisting mainly of amphibole crystals. Occasionally lapilli tuff fragments can be detected. The rocks have a strong schistosity and often exhibit a well developed layering which indicates that they were water lain. Tuffaceous greenschist is most abundant adjacent to the massive lavas.

The basic sediments often contain metacrysts of calcite and have up to 50% clastic quartz. Layering is well developed in many places and is generally bedding although in many places the compositional layering appears to be a foliation and original bedding is difficult to prove e.g., along the road to Møklevann at (0450 1080). Rocks with sedimentary layering and containing clastic quartz become more prominent southwards from the massive lava unit so that the rocks immediately north of the limestone unit consist almostly entirely of basic sediments in contrast to the dominantly tuffaceous and pyroclastic rocks immediately south of the massive lavas. No contact has been placed between the pyroclastic and tuffaceous greenschist and the basic sediments since the writer considers them to be both gradational and intermixed. The basic sediments are best exposed in road cuts along the Stamtjern road where they are phyllitic and in the vicinity of Stortjern where they are a mixture of phyllites and medium grained clastic sediments.

A quartzite layer at Stortjern has a thickness of 3 - 5 m and can be traced along strike for a distance of 1,5 km. This is greyish coloured rock consisting mainly of quartz with 5 - 15% magnetite and traces of feldspar. Several thin layers at (0406 0730), (0434 0775) and (0400 0740) could not be traced beyond the immediate outcroping. A quartzite lense, 10 x 0,5 m, at (0393 0707) appears to be a continuation of the horizon at the Godejord mineral occurence.

Isolated outcrops of massive greenstone, interpreted as lava, occur within the dominantly tuffaceous and pyroclastic parts of the greenscist unit. Poorly developed pillow-like structures were observed in one small outcrop northwest of Fiskløsa.

Thin horizons of keratophyric rocks were observed at (0399 0722), (0399 0747), (0430 0997 - not shown on the map), 600 m northwest of Stamtjern at (0455 0600). Several of these e.g., that at (0455 0600), are massive and have a weak schistosity whereas others are strongly schistose and are best described as quartz-sericite schists. Primary volcanic structures have not been observed in the keratophyric rocks. The schistose keratophyres maintain their thickness along strike and are probably of tuffaceous origin. The massive keratophyres can be either lavas or dikes related to the trondhjemitic intrusive.

The volcano-sedimentary unit north of Langtjern has not been mapped in detail. The unit is similar to that of the greenschists in many respects and differs mainly in the greater abundance of keratophyre in this area. Some of the sediments observed north of Langtjern appear to be more quartz-rich than those occurring in the Greenschist unit to the south.

A limestone horizon 5 - 10 meters in thichness can be traced across the map area. Isolated blocks above Trangen has enabled the writer to extend the unit beyond the Stamtjern road to the western edge of the map area. The limestone horizon separates basic sediments of the Greenschist unit from the pelitic and psammitic rocks to the south, Map Unit 15. The pelitic and psammitic rocks are generally brownish in colour due to the presence of biotite as the chief mica present. Isolated thin horizons have a pale green colour indicating the presence of minor material derived from basic rocks. Locally this unit contains garnet porphyroblasts (2-3 cm) but these do not indicate an age difference with the greenschist and greenstones since small garnets (1-2 mm) have also been observed at Stortjern and at Godejorde.

The contact between the sediments and the gneisses of the "Grong Culmination" to the south has not been observed. Several small outcrops near the contact in the woods at (0322 0631) on the south side of the Sanddøla river have a strong vertical cleavage and are intensely mylonitized which indicate that at least locally the contact is a fault. In addition the narrow, steep walled and straight character of the Sanddøla river channel supports a fault contact however more observations of structural discordance are needed before a faulted contact can be accepted.

FINNBU (Map 1189-02).

The rock units described on the Møklevann map sheet continue into the Finnbu sheet.

At the eastern margin of the map the medium-grained trondhjemite is intruded into basic volcanics. Veins and lenses of medium-grained trondhjemite cut the greenstones and rafts of greenstone occur in the trondhjemite. This area of the trondhjemite is considered to represent its roof. The general absence of inclusions of greenstone in the trondhjemite to the west is thought to represent progressively deeper erosional levels.

Small bodies of fine grained trondhjemite and porphyritic trondhjemite are exposed in the northeastern corner of the map. The fine grained trondhjemite is schistose and pyritic (1 - 5% pyrite) and contains rafts of greenstone. A Mo-Cu mineralization occurs in fine grained trondhjemite at (0610 1660).

On the north side of Fremsttjern a fine-grained trondhjemite or keratophyre occurrence occurs adjacent to the main trondhjemite mass. It contains small lenses with disseminated pyrite. Immediately east of Fremsttjern there is a body of mixed schistose silicic and basic rocks which appear to be deformed volcanics. This body is in thrust contact with the trondhjemite. (The actual extent and origin of these rocks is not known since the area between the Kolitjern brook and Fremsttjern has not been mapped).

Between Rognhaugtjern and Piperudtjern there is a fine-grained laminated silicic rock, which resembles a silicic volcanic, lying between the trondhjemite and the greenstone. Thin sections of this rock show it to be strongly mylonitic with highly strained quartz which suggests that movement along this zone has been later than the regional metamorphism. An attempt was made to find this zone at the trondhjemite contact in Kolitjern brook however here the contact zone is a mixture of dense basic volcanics and medium grained trondhjemite. The pelitic and psammite sediments (Unit 15) on this map sheet have not been investigated.

The limestone horizon pinches out somewhere south and east of Bergtjern. The greenschist horizon on this map sheet is dominantly sedimentary west of Tverrelven and consists mainly of green phyllites and well layered greenschists some of which are probably waterlain tuffs since they consist entirely of basic material. East of Tverrelven this unit consists mainly of layered tuffaceous rocks and massive greenstones become more common eastwards.

The massive greenstones and pyroclastic greenschists north of Finnbuvann thin out rapidly in the unmapped area west of Kolitjern brook since they are represented by only a very basic volcanic unit in Kolitjern brook. This is considered to be due to thrusting along the trondhjemite margin.

Metasediments (other than Unit 15).

A thin horizon of calcareous phyllite can be traced across the map area and for a short distance into map 1189-01. West of Finnbuvann the horizon becomes very thin and is found as scattered small exposures in brooks. The lithology is highly variable from calcareous phyllites to siltstone and sandstone -in several places it resembles a phyllitic limestone. The rock is strongly tectonized with a penetrative cleavage and original layering can be seen between the cleavage planes in several places where the rocks have been folded. East of Fremsttjern both contacts of this unit are delineated by steep near vertical scarps and are considered to be fault controlled. The southern fault boundary can be traced westwards as far as (0500 1380).

Southeast of Tjernrøle and along Kolitjern brook there are approximately 200 meters of medium-grained calcareous psammite which is quite similar to unit 18 of the Nesavann mapsheet. The relationship of the calcareous psammites and calcareous phyllites is not known since both contacts run along small steep valleys.

The rocks immediately south of the greenstone occurrence in Kolitjern brook and for 400 meters soutward are well layered sediments consisting of semipelite and psammite. This unit has not been outlined but is thought to have much the same configuration as the unit of calcareous tuff (LKT) shown on Foslie's map.

Two occurrences of graded bedding were found close to section B -B$^1$. The best exposure occurs in slightly overturned metasandstones near the faulted southern boundary of unit 19. The other occurs in interbedded sandstone and siltstones about 50 m north. The latter is not so well preserved but indicates that the sequence is right way up since the folds ($F_2$) here appear to be upward facing (see Fig. 1).

A polymict conglomerate horizon (unit 23) is unconformably overlying an eroded and weathered trondhjemite surface in the eastern part of the map area. The conglomerates are interbanded with gritty and pebbly arkoses. The conglomerate consits of larger rounded blocks of medium-grained trondhjemite, keratophyre/or fine-grained trondhjemite, and minor greenstone and jasper in a chloritic sandy matrix.

The conglomerate have been folded together with the trondhjemite by open $F_2$ folds with a near vertical axial plane. The south contact of the conglomerate-arkose unit is faulted against calcareous phyllites.

## 4. LANGTJERN SHEET (Map 1189-03)

Greenstone and trondhjemite. The area of greenstone on Skarfjell shown on Foslie's 100,000 map sheet Sanddøla is a complex interfingering of greenstone with minor keratophyre and medium-grained trondhjemite. Small lenses of fine-grained trondhjemite and keratophyre, too small and irregular to be shown on the 1:20 000 map, are present in both the trondhjemite and greenstone units.

The greenstone is generally massive, fine-grained, and lacking primary volcanic structures. Locally, epidotized subrounded blocks (knots) are considered to be tectonic breccia fragments.

The greenstone body lying between arkose and phyllite near the top of the map contain pyroclastics at (0642 1775) and several tuffaceous horizons in the immediate vicinity. Although this block of greenstones has not been investigated in detail it resembles the Blåmuren greenstone unit on the Nesåvann map sheet rather than massive lavas of nearby Skarfjell and the layered greenstones to the south.

The intrusion of the trondhjemite into the greenstones can easily be demostrated in this area: medium-grained trondhjemite lenses and veins cut the greenstone and small stocks of trondhjemite contain xenoliths of basic volcanics.

The layered greenschists (map unit 12) are a continuation of the rocks on the Finnbu map. This unit is poorly exposed and small outcrops of pyroclastics and lava appear to be more abundant than on the Finnbu sheet to the west.

In the brook running from Langtjern at (0559, 1700). there is a short section of calcareous sedimentary rocks which are similar to the calcareous phyllites at Langtjern (unit 19). These rocks are however considered to represent minor calcareous sedimentation within the greenschist unit (because of the sparcity of exposure a correlation with unit 19 or unit 17 is equally plausable). The greenschists are in direct contact with unit 17 at (0639 1863) and although folations are parallel in both rock units the actual contact shows evidence of late shearing. The contact with unit 15 is not exposed in the brook draining Langtjern and the rocks of unit 12 nearest the contact are lavas.

Several small bodies of trondhjemitic rocks occur in layered greenschists in the eastern part of the map.

Metasediments: Map unit 15, observed only in a short section of the brook running from Langtjern, is mainly psammite with interlayered semi-pelite. The highly calcareous siltstones and phyllites of unit 19 are a continuation of the rocks on the Finnbu sheet. The relationship between the thin horizon of these rocks at the west end of Langtjern and the faulted block northeast of Langtjern is best explained as a prefaulting isocline although evidence for such a fold has not been found in the area. The south contact is strongly mylonitized at (0662 1827).

Arkose and conglomeratic arkose of unit 23 are definitely in fault contact with the greenschist and calcareous phyllites along the south boundary and are also faulted against greenstone and trondhjemite to the north. At (0588 1702) local movements have sheared and mylonitized conglomerate at the north contact. Conglomerates are most common in the western part of this unit and have been "cut out" by late faulting in the northeast.

A small body of a calcareous silicic rock occurs in the eastern part of the map area (unit 9). This rock has a strong folation and abundant quartz phenocrysts/porphyroblasts. The unit is in fault thrust contact with the calcareous phyllites. The north contact with the greenstone is a zone of thrusting and is marked by remobilized carbonate with about 20% quartz and mica. A small body of this carbonate has been outlined at (0663 1836). This rock was probably a volcanic however it is difficult to account for the high carbonate content other than by remobilization.

## 5. NESÅVANN (Map 1189-04)

Trondhjemite: A medium-to coarse-grained massif with small lenses of fine-grained trondhjemite occupies the south western corner of the map. Small bodies of gabbro have been observed within the massif at vann 630 and on Nesåpiggen.

Veins and lenses of medium-grained trondhjemite intrude greenstone southwest and northeast of Gaiz-javre.

Fine-grained trondhjemite, often porphyritic, is the dominant rock type in several places southwest of Gaiz-javre (unit 11). These have been intruded by medium-grained trondhjemites and the small bodies of unit 11 are often a mixture of both rock types.

A body of silicic volcanics (unit 10) occurs in the southern part of the map. These are fine-grained, and fine-grained quartz-porphyritic rocks in which individual units. probably flows, can be followed for short distances. Along the south boundary they are interlayered with thin greenstone horizons while the north boundary is unconformally overlain by, and folded together with, the arkose and conglomerate of unit 23. Part of the south boundary is faulted/ thrusted against the greenstones.

The greenstones between Skarfjell and Gaiz-javre are massive, fine grained basaltic volcanics which rarely exhibit primary volcanic structures. Thin horizons of chloritic silicic lavas occurs in several places throughout this unit.

The Blåmurvann greenstone unit is probably a continuation of the layered greenschist and greenstones on the Langtjern map. These greenstones have been investigated only briefly. There appears to be an abundance of fragmental and tuffaceous basaltic volcanics in this unit (see Plates 1A, 1B) however there is too much basic lava to warrant describing it as 'basaltic tuffs' since it is a mixture of lava, pyroclastics and tuff. A thin horizon of keratophyre agglomerate in a basic matrix occurs just off the southwestern corner of this unit on the Langtjern map.

Metasediments: A thin unit of calcareous phyllite marks the thrust/fault boundary between the arkose (unit 23) and the Blåmurvann greenstones. This unit is strongly tectonized and appears to be massive dirty limestone at (0700 1888) and (0878 2105) (se Plate 1C).

A phyllitic unit occurs southwest of Gaziervann. This unit consist of calcareous phyllite and siltstone with scattered beds of arkose sandstones up to 10m thick. The contact, if any, with the limestone conglomerate(unit 20) has not been delineated. A small body of calcareous phyllite occurring within the greenstones at (0849 1935) is faulted along both contacts.

A limestone conglomerate, unit 20, is gently westward to vertical dipping in the area west of Gazier vann. Thin horizons of greenstone conglomerate and thin arkose beds occur throughout the unit. In several places the rock is obviously a pseudo-conglomerate since only the limestone 'fragments' have a rounded form and the siltstone and phyllite fragments have definite angular and elongated shapes. Unit 20 is thrusted upon and over the arkoses of unit 23 at (0991 2028) but appears to have a vertical contact (probably faulted) against unit 23 in the northeast at (1135 2187).

Map unit 21 is quite similar to unit 19 and differs mainly in the presence of a basal conglomerate horizon which lies unconformably upon the greenstones. This unit has been preserved in late downfaulted blocks in the Blåmurvann antiform. Several lenses of this rock, without the basal conglomerate, less than 10 meters in thickness occur at the contact between the greenstones and unit 17 northeast of Holmtjern.

A greenstone conglomerate with a steep westerly dip occurs west of Gaiz-javre and northeast of øvre Nesåvann. The unit has been mapped on only one traverse and is not greatly dissimilar to the basal conglomerate of unit 23 except for its much greater thickness in that it is a layered pebble to boulder conglomerate with basic and acidic rock fragments in a basic matrix. Definite stratigraphic correlation between the two units cannot be attempted at this time due to lack of detailed tectonic observations in this area.

Arkose and conglomerates of unit 23 are a thick sequence of sedimentary rocks with abundant cut and fill structures (Plate 2A, 2B), graded bedding in the arkosic layers and an absence of layering in conglomerate units that are up to several hundred meters thick. The well-rounded fragments range in size from pebbles up to boulders one meter in length and have been derived largely from a medium-grained trondhjemite similar to the massif to the west. Basic fragments are rare in the conglomerate although jasper fragments are commonly present.

Cut and fill structures and graded bedding in arkosic sandstones indicate that both parts of this unit are right way up.

A small body of unit 23 northeast of Blåmurvann can be shown to be folded about the greenstones on the basis of the intermediate axes of deformed pebbles. It is quite obvious from the map that unit 23 has been "cut out" by faulting along its contact with unit 18 in the area north of Holmtjern.

All of the boundaries of unit 23 are controlled by a late, brittle deformation. A traverse was made over the entire width of the arkose-conglomerate unit where the two parts are in contact (between Gaiz-javre and Havdalsvann in an effort to study the contact relationships between them. A brief examination of the area where the two parts of the unit should meet did not reveal any obvious structural discontinuity.

The calcareous psammites of unit 18 are a thick sequence of uniform highly calcareous sediments. In many places in this unit bedding has been destroyed by a regional schistosity along which carbonate weathers out to give an impression of layering, however, when fold hinges can be discerned it is possible to recognize the original layering since it is at a high angle to the schistosity (see Fig. 2). The bedding becomes indiscipherable from the schistosity when there is an angle of less than 30 degrees between them.

## 6. KLINGERVATN (map 1189-05)

Only limited geological observations have been made on this map sheet. The most important of these was recognition of the folded character of the arkose and conglomerates in the area immediately south of Havdalsvann; the main tectonic features of this area have been outlined by an airphoto interpretation made by Fred Haarbrink at NGU. Calcareous brown phyllites with complex fold patterns overlie conglomeratic arkose with graded bedding at (1203 2386). To the southwest of this locality the calcareous phyllites overlie the arkose-comglomerate unit which is also right-way-up (see Plate 1A) and thus the calcareous phyllite is probably right way up and younger than the conglomerates of unit 23. Faulting along the contact may have complicated the relationships of the two units.

The calcareous phyllite is itself overlain by calcareous grits which appear to grade southeastwards into the calcareous psammites of unit 18. In the area west and northwest of Klingervann the minor folds are more open and the folation less pronounced than in the Holmtjern area (map 1189-04) and thus it should be possible to determine the facing directions of $F_2$ minor structures in the calcareous psammites.

The rocks exposed in Klingervasselven are mainly black phyllites and siltstones with occassional horizons of very fine grained quartzites interbanded with black phyllite. These rocks are similar to those of the 'Eastern Cambro-Silurian rocks' observed at Joma. The thin 2 - 10 cm continuous layers in the quartzite and their very fine grain size suggests that they may originally have been chemically precipitated sediments (cherts). These phyllitic rocks are separated by a fault at (0944 2426) from the more steeply dipping unit of sandstones with minor black phyllite and fine grained quartzite. The rocks north of the contact are similar to those of unit 17 observed south of Holmtjern.

## 7. STRUCTURE

Sanddøla - Langtjern.

The dominant structural feature of the Sanddøla area is the westerly strike and steep northerly dips of the penetrative regional folation ($S_1$). In the area immediately west and southwest of Møklevann this folation has a variable but generally northeasterly strike due to post $S_1$ folding. In several places in the Sanddøla area early isoclinal folds have axial planes parallel to $S_1$ and these, the earliest folds recogonized in the area, are similar to the early folds found on Tømmerås (see Report 1122 A). Several excellent examples of this fold type were observed in both greenstones and quartzites near the western end of Møklevann by K. Langley in 1973. In several places, e.g. north of Trangen and Stamtjern, mineral and particle lineations as well as $F_1$ minor fold axes have a general E-W strike and gentle dips. This data is consistent with the interpretation of the Tømmerås area as a major east-west trending isocline of $F_1$ age (NGU Report 1122A), but does not prove the existence of this structure in the area east of Trangen. Several isolated occurrences of possible early folds ($F_1$) and lineations ($L_1$) have steep northerly dips. In the absence of mapable marker horizons it is not possible to prove the existence of a major $F_1$ isoclinal structure in the Sanddøla area even though minor structures point toward such a conclusion.

In several places within map units 15 and 12 an early mica fabric can be seen to predate the regional folation (see Fig. 3). The near parallelism of $S_1$ and $S_2$ in some places makes if difficult to interpret these observations, i,e, they may represent an early pre $S_1$ schistosity or a strong disruption of $S_1$ by $S_2$ since bedding was not found in the rocks where this 'early' schistosity occurs.

A steep penetrative second foliation ($S_2$) has been superimposed on $S_1$. This fabric can be recognized as a distinct cleavage/schistosity axial planar to $F_2$ folds and as a crenulation on $S_1$ surfaces (see plate 2C).

Within map 1189-01 $F_2$ minor folds are abundant in the rocks of unit 15 and in phyllitic layers of unit 12, especially along the road to Stamtjern. These are generally Z-type folds (see fig. 4). S-type folds of $F_2$ age (Fig. 5) are present in the area north of Langtjern (0500 0910). There is present in this vicinity a large $F_2$ fold with a short limb at least several hundred meters in length. One of the hinges of this fold occurs near (0505 0865) where $S_2$ - $S_1$

intersections have produced a particle lineation that is elongated parallel to the $F_2$ minor fold axes in the area (see fig. 6). On the basis of this observation it is possible that a major $F_2$ synformal structure occurs in this part of the Sanddøla area. Further studies in the Møklevann area are needed in order to determine the actual form of this structure.

Open folds of $F_2$ age, found in the area west of Møklevann, fold the $S_1$ into a large scale $F_3$ synform with a northwesterly plunge. The variations in $S_1$ from northeasterly to easterly in the area south of Stamtjern are probably due to the presence of a large open $F_3$ antiform.

Several small scale conjugate folds were observed in basic schists immediately west of the bridge over Finnbuelven (Fig. 8).

A number of lineaments can be seen on the airphotos of the Sanddøla area. The majority of those with a northeasterly strike are vertical fractures along which there is little displacement. The E-W fault shown on map 1189-01 is probably a continutation of the mylonite zone (unit 9a of map 1189-02). Faults of unknown but considerable displacement occur along both boundaries of map unit 19b in the Fremstjern area (see cross-sections $B-B^1$ and $C-C^1$ of map 1189-02).

Langtjern - Blåmuren area (maps 1189-03, 04, 05).

The westerly strike of the regional foliation continues eastward into map 1189-03 and -05 on map units 12 and 15, however, the dominant regional strike in this area is northeastward which reflects the more strongly developed $F_2$ structures in this area. The regional foliation $S_1$ is well developed in the greenstones and in the phyllites of unit 17.

The presence of $S_1$ in the arkoses and conglomerates has yet to be verified by thin section studies. Its apparent absence in these rocks is due to their low mica content since a $S_1$ (?) fabric has been observed at several localities where thin silty layers are present.

The crenulation cleavage of the Sanddøla area develops into a steep to vertical regional cleavage/folation ($S_2$) in the area northeast of Langtjern. This cleavage is axial planar to $F_2$ folds. In some rocks, notably the calcareous psammites of map unit 18, it is the dominant fabric and is so strongly developed that the original bedding is generally not decipherable.

An horizontal to gently dipping cleavage associated with open late folds is found in the calcareous phyllites when the foliation/bedding is steeply inclined. These folds are younger than the $F_2$ folds, and are most common in the calcareous phyllites southwest of Gaziervann.

No folds of definite $F_1$ age were found in rocks outside of map units 12 and 15.

Folds of $F_2$ age have a general northeasterly plunge with some hinges plunging gently to the southwest. The fold styles vary from open structures in the arkose-conglomerate unit to tight and isoclinal structures in the calcareous psammites. In general the $F_2$ folds have vertical axial planes; in the areas around Holmtjern they tend to be overturned towards the southeast (Fig. 9).

Boulders in the conglomerates of unit 23 have a northeasterly elongation (see Plates 3 ) and this elongation must be a result of a deformation predating the $F_2$ folds; in the Blåmurvann area the intermediate axes of conglomerate blocks can be used to trace out a major $F_2$ antiform.

Steep scarps and the unusually straight geological boundaries on map 1189-04 attest to the abundance of faults in this area. These faults are especially prominent along the margins of map unit 23. In the Gaiz-javre area vertical northeasterly striking faults bound a wedge of volcanics and trondhjemite that has been uplifted between the two blocks of unit 23. Vertical faults with a NE strike parallel the bedding in unit 23 at Blåmuren. A large part of unit 23 has been cut out along a fault/slide zone north of Holmtjern.

## 8 Mineralization

Sulfide occurrences in the Sanddøla area have not been investigated as these were studied in detail by Øystein Petterson of Grong Gruber A/S .

A molybdenum-copper occurrence was discovered in fine grained porphyritic trondhjemite north of Langtjern (map 1189-02). A quartz vein containing molybdenum was found in fine grained trondhjemite as (0927 2049). A description of these occurrences along with a minor occurrence of scheelite has been described in a short report by Gale and Kvien (a modified version of this report is included here as Appendix A).

A large body of disseminated pyrite on Skarfjell at (0700 1770) occurs in a silicic lava surrounded by basic volcanics. The sulfides account for 5 - 10%

of the rock. Only pyrite was observed in the hand specimens. Several small lenses of pyrite were also noted in greenstones on Skarfjell; these were generally less than 20 cm thick and 1 - 2 meters in length.

Small lenses of disseminated pyrite occur in greenstones at (0764 1773) and (0766 1845). These occurrences of disseminated pyrite are not considered to be of economic importance.

Trondheim den 7/5/74

George H Gale

# APPENDIX A

Til Grongprosjektets styringsgruppe
fra G.H. Gale og R. Kvien.

Note on the significance of samples 1189/110, 1189/144A and the molybdenite occurrence at Grønndalsdam.

1. In view of what we consider to be a rather warm response to the NGU proposal for further prospecting of the Sanddøla trondhjemites we feel that an elaboration of the ideas behind the proposal should be set down in order to aquaint the styringsgruppe with the full implications of the economic significance of the Mo-Cu occurrence.

Sample 1189/110 is a hand specimen of a fine grained porphyritic trondhjemite zone approximately 200 m wide and more than 300 m long just north of Langtjern. The rock is schistose, and strongly altered. 5-10% pyrite occurs as disseminated grains ( 1 mm in diameter) and along microfractures. Tiny molybdenite grains are visible with the naked eye and up to 10 grains have been seen on a cut surface of approximately 8 $cm^2$. Chemical analysis give 0,03% Mo. Minor chalcopyrite has been seen in polished sections but not in economic quantities. Disseminated Mo was observed in four places from the zone of pyritized, fine grained trondhjemite (Fig. 1).

Sample 1189/144A is a medium grained trondhjemite with a 1 cm grey quartz vein containing 0,06% Mo. Molybdenite occurs within and along the margins of the quartz vein as well as along fractures in the altered trondhjemite alongside of the quartz vein. The alteration is less intense than in sample 1189/110 and only a few grains of pyrite are visible. Although the rocks in the vicinity of sample 1189/144A and to the northwest of it are fine-medium grained, pyritized (<10%) trondhjemite, molybdenite was not observed - probably because it was not looked for. It may also be significant that the quartz vein in sample 1189/144A was not detected on the weathered outcrop surface so that we are unable to evaluate the extent of quartz veining in the area. (The significance of the quartz vein was not realized at the time).

In addition an angular erratic approx. 40x30x20 cm with a chalcopyrite-pyrite vein, with an estimated 2% Cu, occurring in a fine-medium grained trondhjemite was found about 200 meters south of sample 1189/144A (Fig. 4).

A 1 cm quartz vein with molybdenite was collected in 1969 from a locality near Grønndalsdam - Tunnsjø. The quartz vein occurs in a medium grained, strongly epidotized, trondhjemite (Fig. 3).

2. It can be seen from Fig. 2 that there are significant Mo and Cu anomalies in the Langtjern area both within the area from which sample 1189/110 was collected and outside in unmapped areas.

3. Although we do not contend that all trondhjemites in the Grong area are intrusive, mapping in the Sanddøla area has clearly demonstrated that the Sanddøla trondhjemite massif is clearly intruded into greenstones (late orogenic faulting /thrusting has produced tectonic contacts in several places along Sanddøla). In fact the whole or most of the sequences in the Grong area are allochthonous (Oftedahl, 1955; Gale and Roberts, in preparation).

We interpret the Cu-Mo mineralization occurring near the roof of an intruded trondhjemite as a porphyry Mo type of deposit.

Gale and Roberts (in prep.) have shown on the basis of greenstone petrochemistry that the volcanics and associated intrusives are part of an island arc sequence which has been obducted onto the continental margin during the end stages of the Caledonian orogeny.

4. In a paper (in prep.) on "Porphyry copper type mineralization of the Northern Part of the Appalachian orogen" Hollister, Potter and Barker describe the occurrence of Appalachian porphyry Cu and Mo deposits and relevant sections of their paper are attached. The association of Mo and tungsten mineralization may be of some interest in view of its previously known occurrences in the Grong area and the discovery of scheelite in sample 1189/145 by Harald Elstad.

5. We cannot stipulate or even guess at the economic potential of Mo and Cu mineralization in the trondhjemites of the Grong area. The majority of the known porphyry Mo and Cu deposits are located in island arc terrains of Recent to Palaeozoic age. Thus in view of the occurrence of a possible porphyry type deposit in the Grong area and the interpretation of the area as an island arc sequence (Gale & Roberts, 1972 in Nature; and in prep.) it would be a pity to allow the area to pass out of control of Grong Gruber A/S without a proper investigation being made.

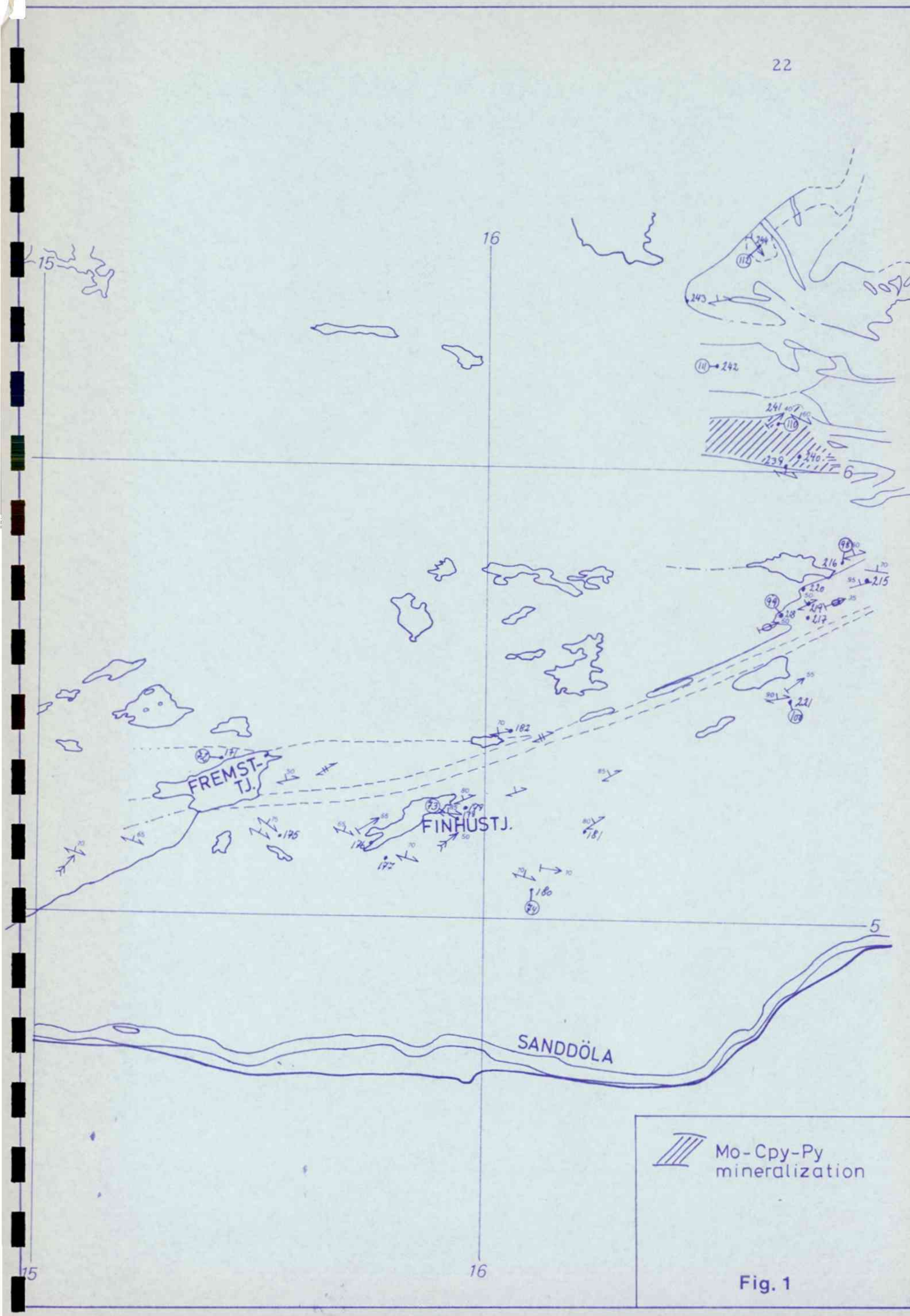
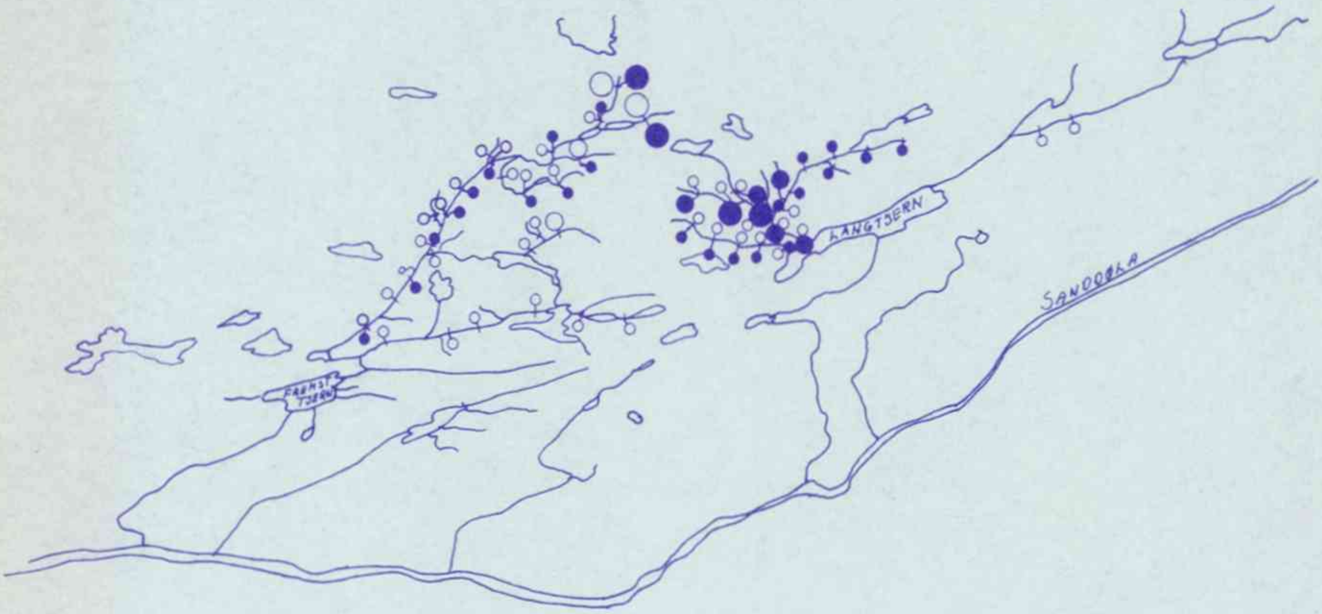



Fig. 1



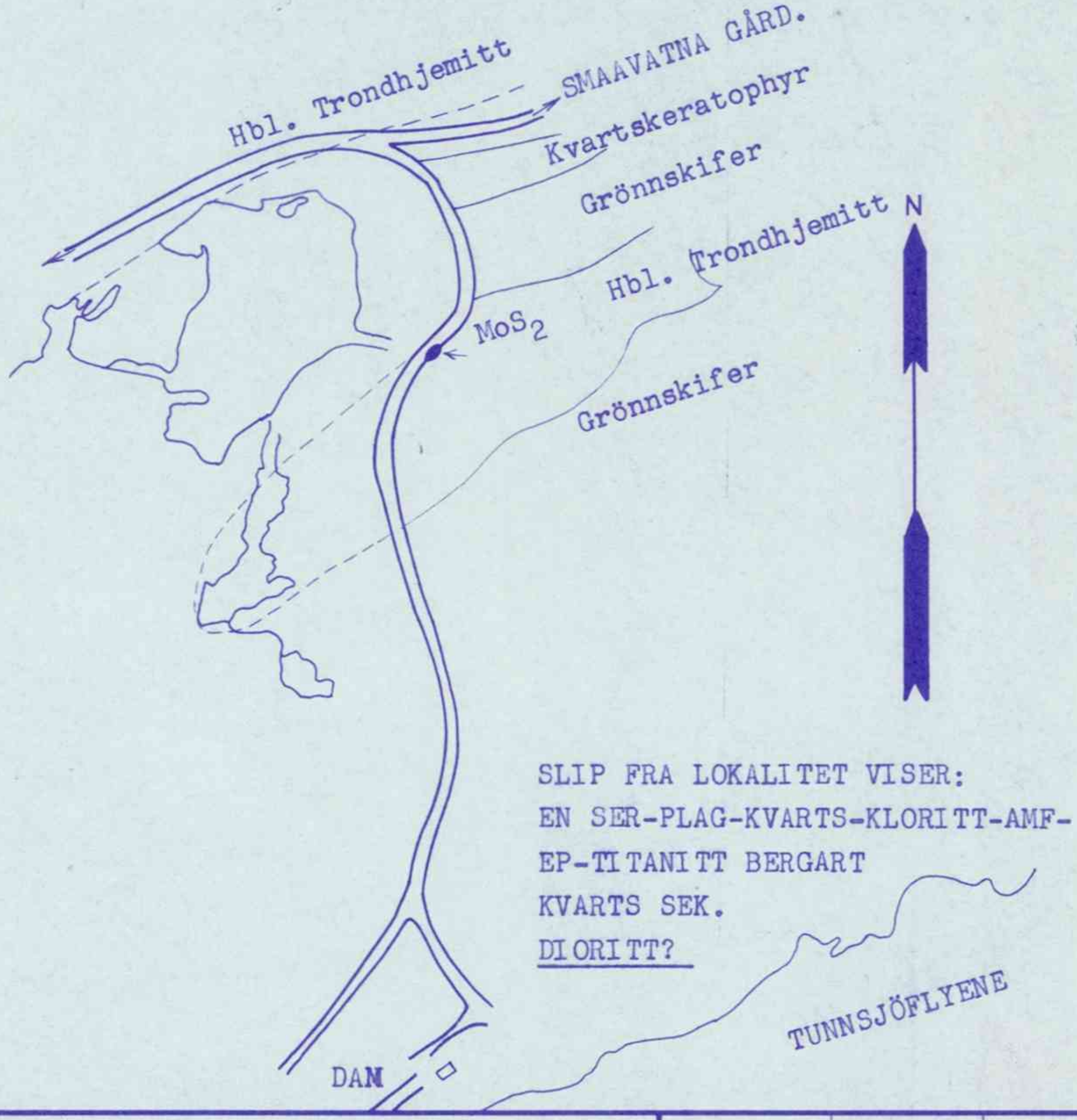

*Mo - innhold*
- o 10 - 50 ppm
- O 50 - 100 ppm
- O > 100 ppm

*Cu - innhold*
- • 30 - 100 ppm
- ● 100 - 200 ppm
- ● > 200 ppm

| | | |
|---|---|---|
| GRONGPROSJEKTET 1973<br>Cu-Mo I BEKKESEDIMENTER<br>( ikke kontrollerte pröver) | MALESTOKK<br>1 : 50.000 | |
| NORGES GEOLOGISKE UNDERSÖKELSE<br>TRONDHEIM | Fig. 2 | KARTBLAD<br>1823 I |

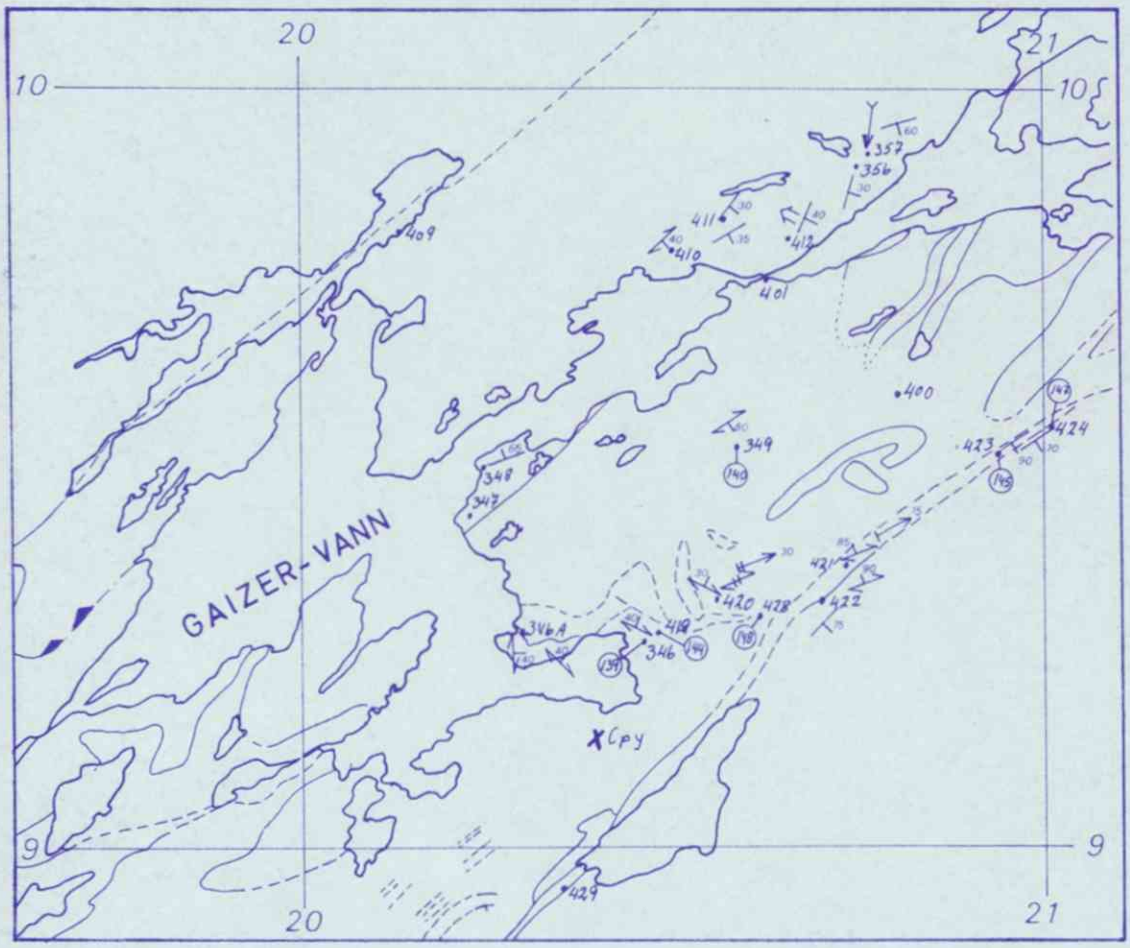
$MoS_2$ ER PÅVIST. OPPTRER SOM EN TYNN FILM I SPREKKER I KVARTSRIKE PARTIER I EN AMFIBOLFÖRENDE TRONDHJEMITT, TRONDHJEMITTEN VIRKER INTRUSIV.

7 stk. PRÖVER(SLITS) 905/400-407 BLE TATT. VÅTVEISANALYSE VAR NEGATIV. PRÖVENE BLE KONTROLLERT PÅ RÖNTGEN. D.V.S. IKKE PÅVIST MENGDER OPPTIL 0,003% Mo...............




SLIP FRA LOKALITET VISER:
EN SER-PLAG-KVARTS-KLORITT-AMF-EP-TITANITT BERGART
KVARTS SEK.
<u>DIORITT?</u>

| | | | |
|---|---|---|---|
| $MoS_2$ - LOKALITET<br>VED GRÖNNDALSDAMMEN-TUNNSJÖFLYENE | M 1:5000 | Obs. Kv.<br>Tegn.Kv.<br>Trac.H.E. | 1969<br>1974<br>1974 |
| NORGES GEOLOGISKE UNDERSÖKELSE<br>TRONDHEIM | Fig. 3 | | |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GAIZER-VANN
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346A
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X Cpy
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Fig. 4

From Hollister et. al. (in prep.).

Exploration Geochemistry: Nearly all porphyry copper prospects have been detected by stream sediment sampling. Possibly the weakest expression is at Alma, where the Cu anomaly in the streams cutting the intrusion is just barely above background. The most confusing is at Maringer where copper mineralization occurs both in the stock and in Carboniferous strata nearby. Geochemical results over the Attean pluton have been placed on the USGS open file (Chafee, M.A., et al, 1972).

## CHARACTERISTICS OF APPALACHIAN PORPHYRY MOLYBDENUM DEPOSITS

Petrology: Most of the porphyry molybdenum deposits of the Appalachian orogen occur spatially associated with a granite porphyry, as noted on Table 1. The granite is not always porphyritic, but where this is the case, it usually has characteristic large subhedral quartz phenocrysts. The quartz monzonite and and rhyolite at Mt. Pleasant are close chemical relatives of the granites found in other deposits. Orthoclase is the predominant feldspar, and biotite the most common mafic mineral.

Sulfides may occur as apparent magmatic constituents and pyrite does so most frequently. Molybdenite is a constituent of some granites, and chalcopyrite very rarely has been identified. Molybdenum, tungsten, tin minerals and other lithophiles are most abundant in pegmatitic zones, dikes, or veinlets in these intrusions, however.....

The potassic zone in some deposits, such as the Cooper and Catrine, consists of a strong metasomatic replacement of the original silicates with orthoclase, minor biotite, and muscovite. In these deposits vugs in and near veins are lined with orthoclase, mica, quartz and sulfide.

In all deposits pegmatitic phases exist which are characterized by coarse mixtures of orthoclase, quartz and other silicates. Based on experience in the Cordilleran orogen, it seems logical to group these in with alteration phenomena. The silicates occur as veins or dikes, and the ore minerals occur in them as crystal clusters, pods or fracture fillings. Fluorite and fluo-silicates are common minerals in the pegmatite facies.

Mineralization and Structure: Both stockwork and breccia pipe type structures are controlling features for mineralization in porphyry molybdenum deposits. The outstanding example of a breccia pipe type is the description presented by Petruk (1972) for the Mt. Pleasant pipe. Here, fragments of igneous rocks are cemented with fluorite, quartz, silicates and ore minerals. The Cooper and Catherine intrusions in Maine were described previously by Emmoms (1910) as being locally miariolitic and have what may be interpreted to be small breccia pipes. These two deposits are, however, predominantly stockwork types. ......

METALLOGENIC EVOLUTION IN PORPHYRY TYPE DEPOSITS

Taken together, porphyry type deposits of the Appalachian orogen appear, on the basis of present data, to form early as porphyry copper, then evolve through a period where both porphyry copper and porphyry molybdenum deposits formed separately but simultaneously; finally ending with porphyry molybdenum province are not geographically coincident. As can be seen on Fig. 2, however, the area from the Cooper deposit in Maine north-east to Square Lake in New Brunswick, the two can be found in the same general terrain. In this area molybdenum deposits generally appear to be younger and post-tectonic.

.....

...... He states, "The intensity of fracturing increases inward toward the granite and culminates in a mass of thoroughly jumbled breccia. The breccia consists of angular to rounded blocks of hornfelds, generally up to a few feet across...". A second striking feature is the change in dip of the country rock near the "granite contacts". On the Cadillac Mountain pluton the centripetal dip pattern extends completely around the intrusion.

Molybdenum and other lithophile element mineralization accompanying late Devonian intrusions may appear in linear trends as shown in Fig. 3. This figure also shows radiometrically determined age dates where known. Distribution of molybdenum in this figure is from Chafee, et al (1972). The trend of these particular anomalies is N-E, paralleling tectonic fabric in the Appalachian orogen. Bedrock exposures in each deposit usually contain a set of veinlets or mineralized joints which also parallels the trend. Young (1962 and 1963) Wright (1940), Victor (1957) and Poitevin (1932) each show joint sets supporting this conclusion.

Generally, an additional set trending nearly N-S also exists. The N-S trend may be dominant, as at Cooper (Hess, 1908) or Gabarus Bay (Vokes, 1963). It may vary from deposit to deposit but ranges from N 15 W to N 10E.

All of the porphyry molybdenum deposits carry varying amounts of fluorite as vein constituents with the molybdenite. Tungsten minerals, usually the wolframite family, also occur, and cassiterite has also been found in some deposits. Sulfide tin minerals are much rarer. Beryllium minerals have been detected in a number of deposits

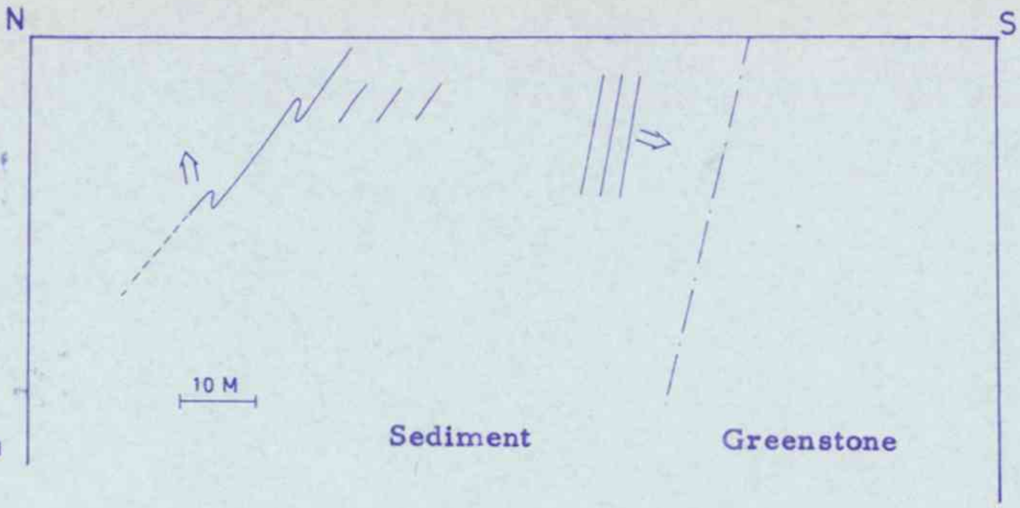



Fig 1a

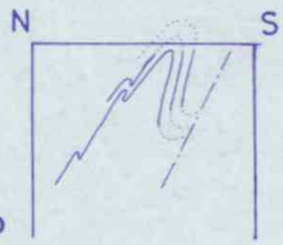



Fig 1b

Fig. 1a Minor folds in sediments near profile B-B[1] of Map 1189-02. The arrow shows younging direction.

Fig. 1b Large scale structure inferred from minor folds.

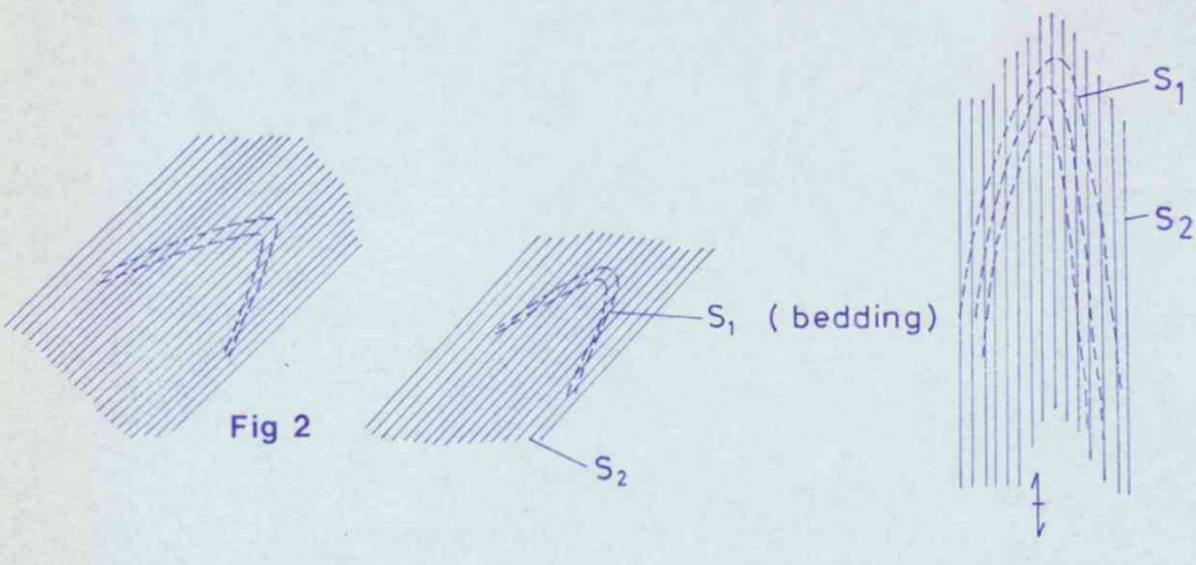



Fig 2

Fig. 2. Minor folds in calcareous psammite (Map unit 18) northeast of Holmtjern.

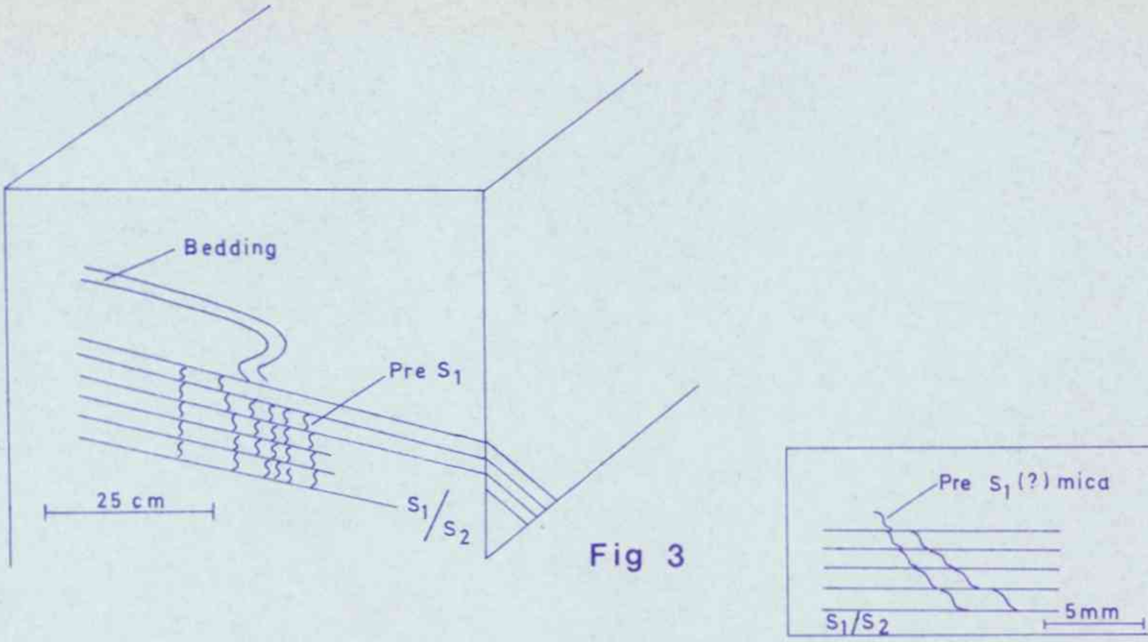



Fig 3

Fig. 3. Possible Pre $S_1$ mica fabrics in semipelites of map unit 15 near Trangen.

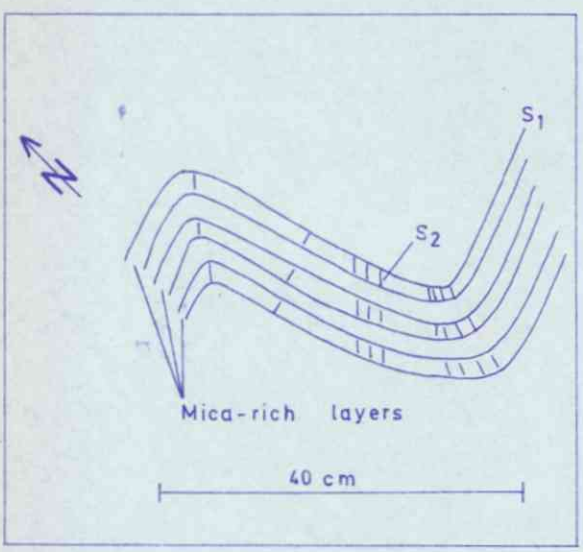



Fig 4a

Fig. 4a. $F_2$ minor fold at (0378 0648) with vertical $S_2$ schistosity developed in micaceous layers but not in the quartzitic layers. Plunge 040/45.

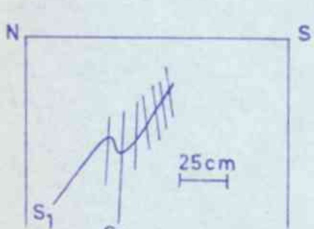



Fig 4b

Fig. 4b. $F_2$ minor fold in greenschists 20 meters west of the structure shown in 4b.

Fig 5

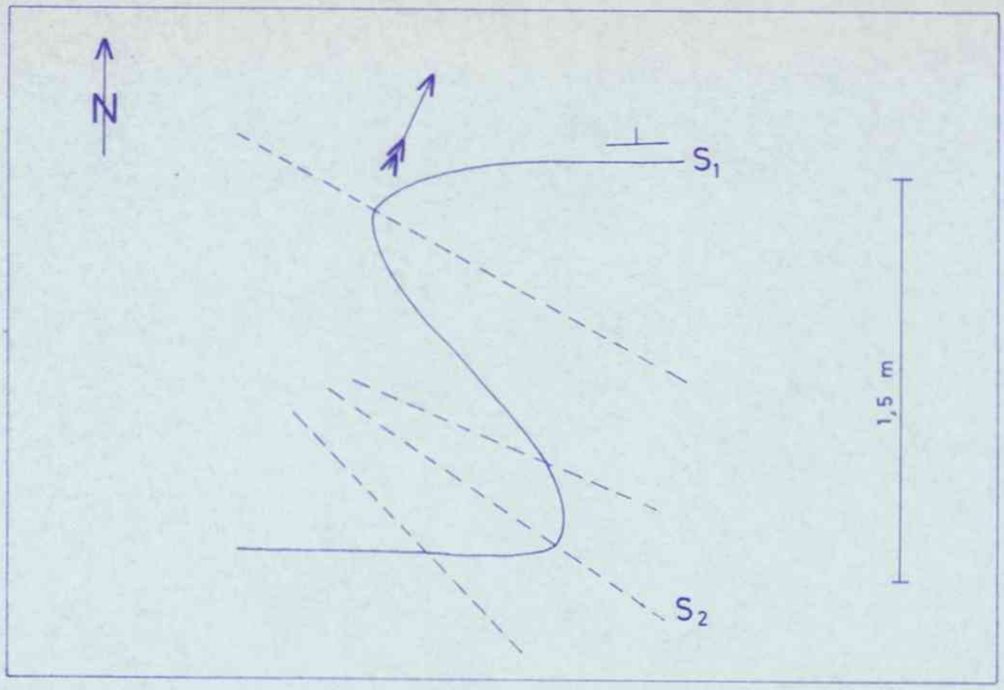



Fig. 5. $F_2$ S-type fold in basic tuffs at (0500 0910). Fold hinge plunges 010/80. Axial plane 320/80 strike of regional fabric ($S_1$) 290/80. Note cleavage fan.

Fig 6

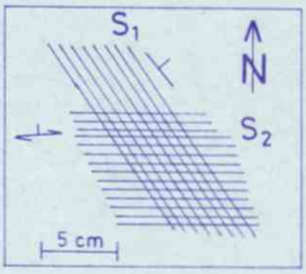
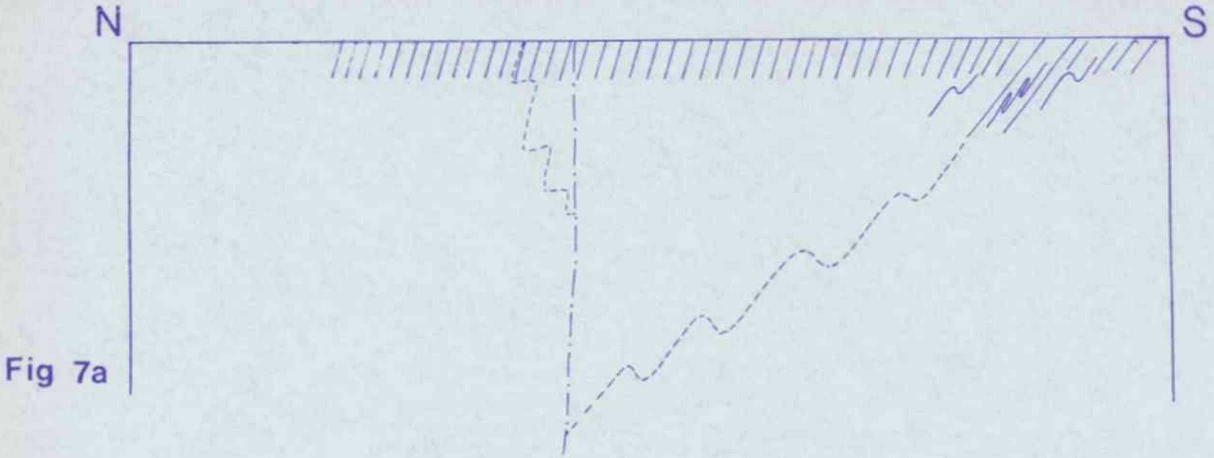



Fig. 6. Particle lineation (pseudo-conglomerate) produced by $S_2$-$S_1$ intersection at (0505 0865).



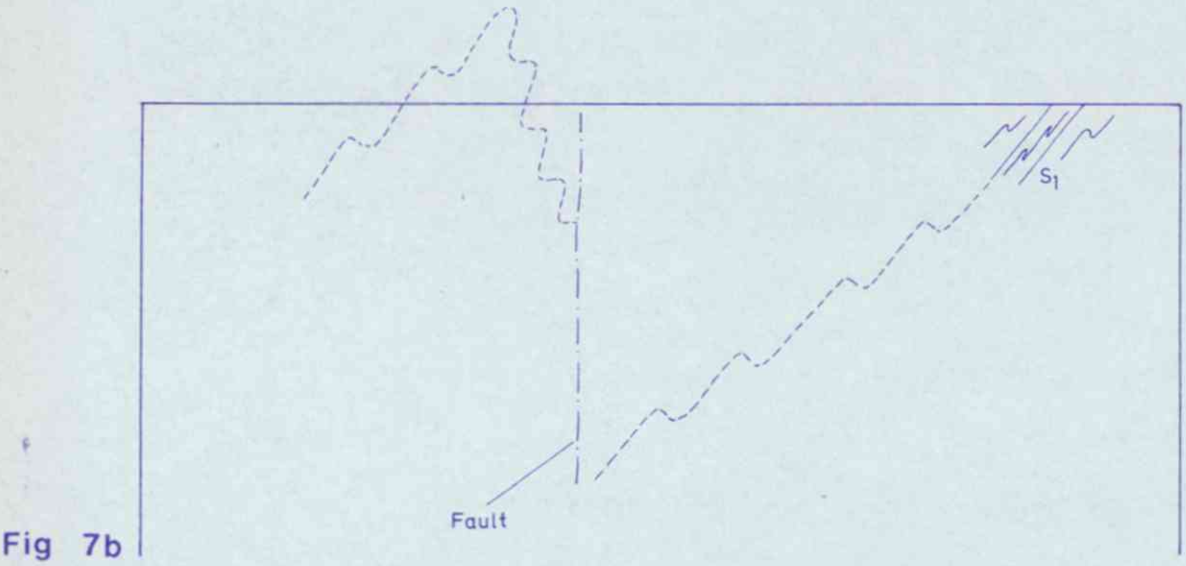




Fig. 7a. Schematic cross-section of Sanddøla area showing interpretation as a major $F_2$ synform.

Fig. 7b. Interpretation of the same area as a major $F_2$ antiform.

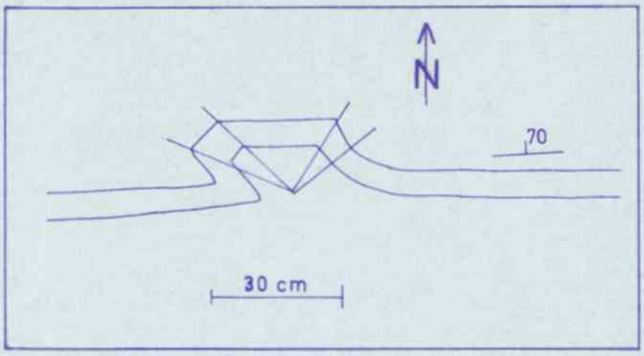



Fig 8

Fig. 8 Congugate Fold in greenschists south of Finnbuvann.

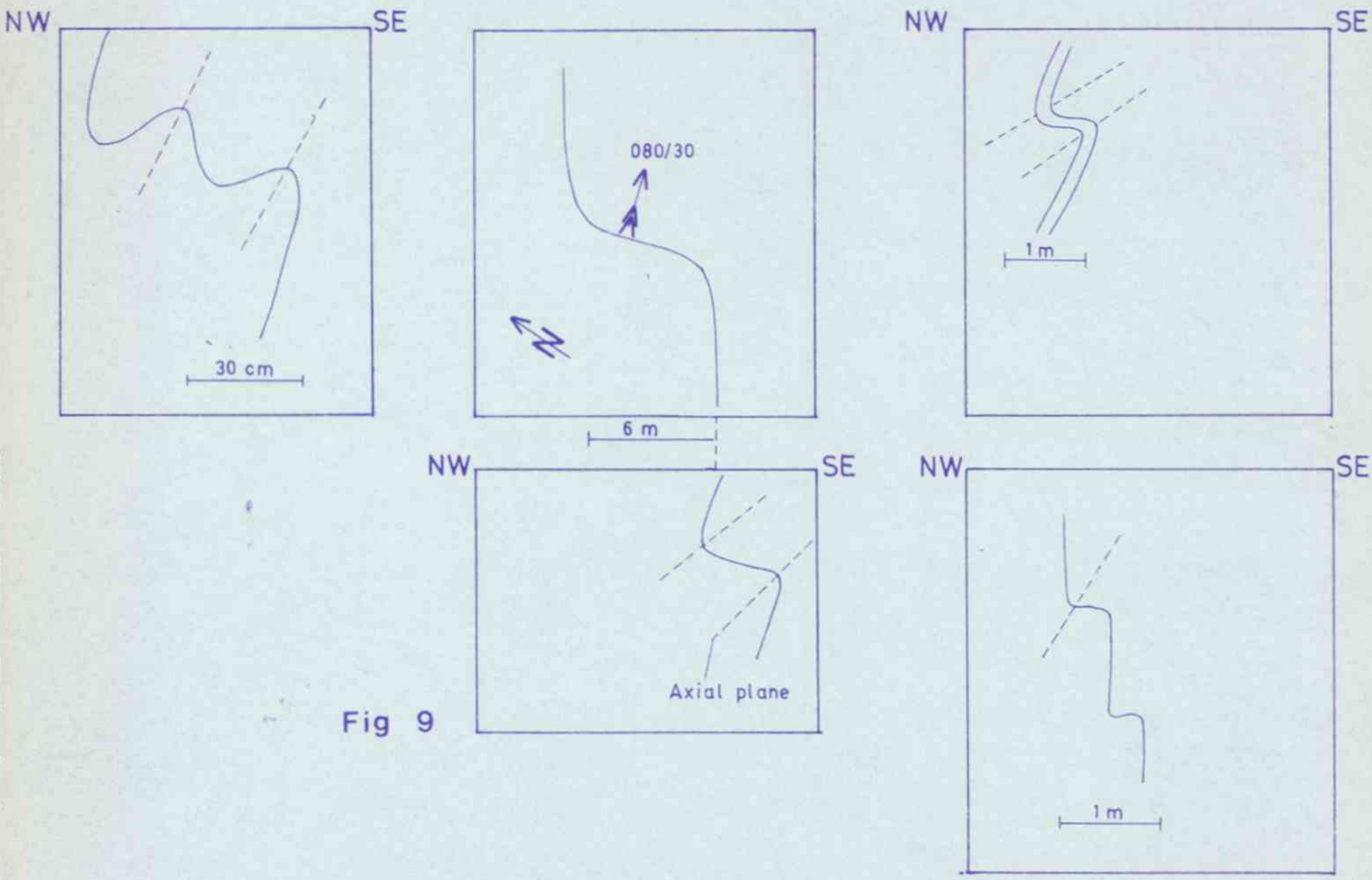



Fig 9

Fig. 9. $F_2$ folds in semipelites and psammites near the soutwest corner of Holmtjern.

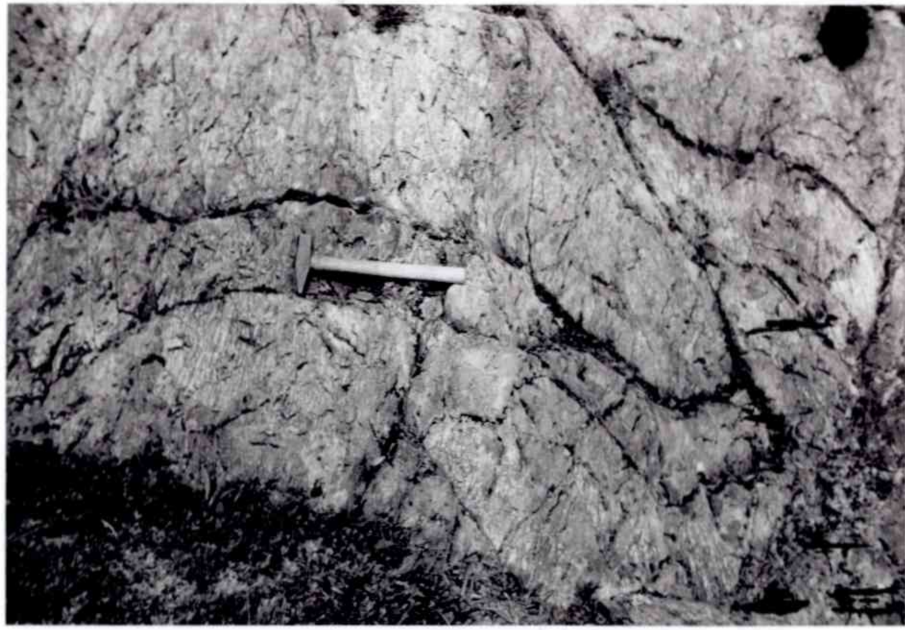
Plate 1

1A. Folded Basaltic lavas. Note vertical $S_2$. (0737 1998) Map 1189-04.

1B. Pillow lava (Left of hammer) folded by $F_2$ (above hammer) at (0730 1996). Map 1189-04.

1C. Carbonate layer (C) in calcareous phyllites (vertical unit in center of picture). Conglomerates on the left, greenstones on the right. Looking NE at (0704 1892). Map 1189-04.

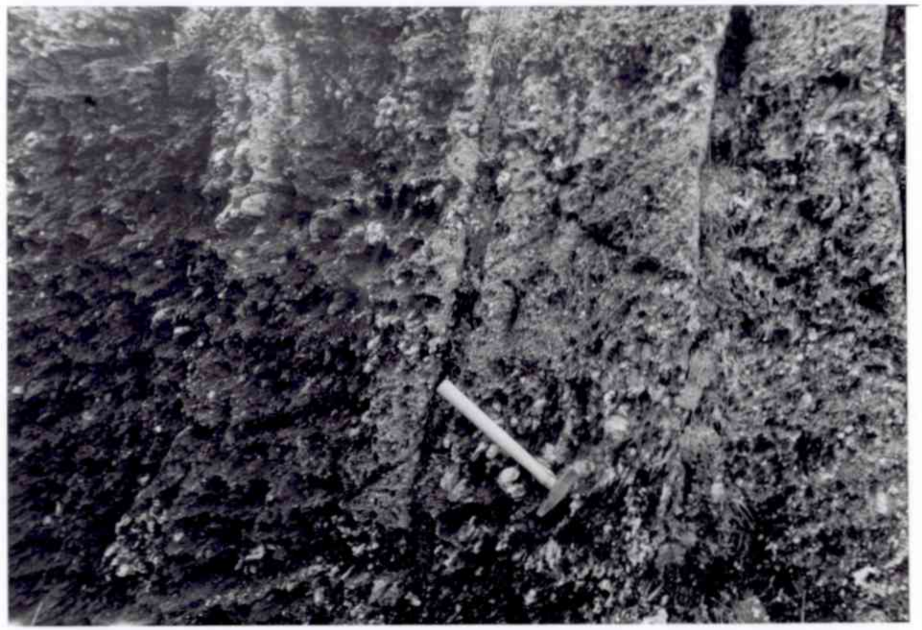
1D. Limestone conglomerate (?) in phyllitic schists, with a well -developed particle lineation produced by $S_2$ (vertical) and $S_1$ (dipping approx. 50 degrees to the right). Carbonate fragments are spherical whereas sandstone fragments are angular (0903 1943). Map. 1189-04.



1A.

1C.

1B.



1D.

Plate 2

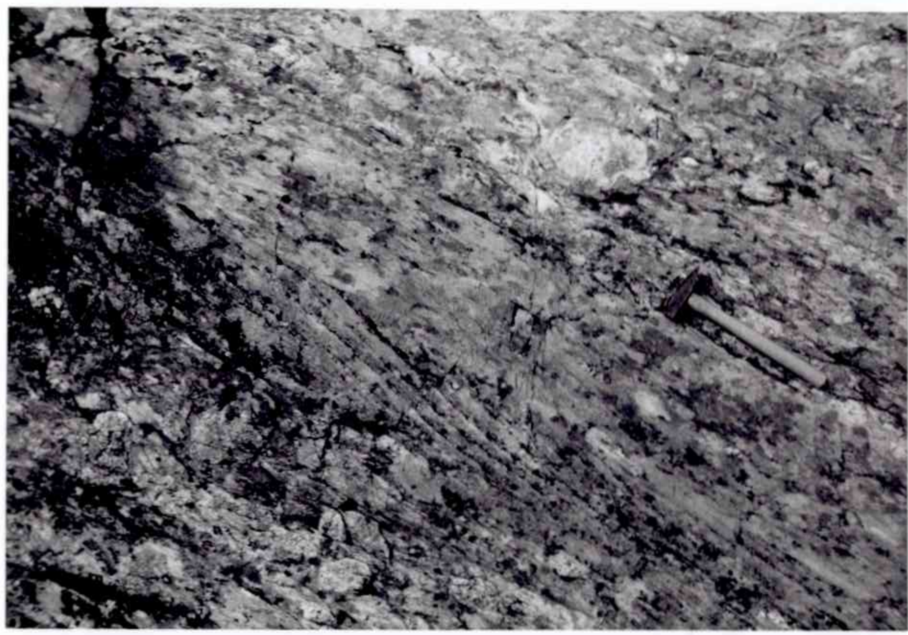
2A., & 2 B. Cut and fill structures in arkoses interbedded with conglomerate. 2A (1055 2556); 2B (0740 1927). Both indicate that the arkose - conglomerate unit is "right-way up". Maps 1189-04, 1189-05.

2C. Crenulation produced by $S_2$ strain-slip cleavage on $S_1$ (0405 0896). Map 1189-01.

2D. Foliation ($S_1$) in tuffaceous greenstones. Note folded quartz vein near the coin. Discontinuity of compositional layering suggests that the original bedding has been destroyed. (0439 0990 ). Map 1189-01.

2A.

2C.



2B.

2D.

Plate 3

Deformed trondhjemitic fragments in Map unit 23. (Map 1189-04).

2A & 2B. Sections normal to (2A) and parallel to (2B) elongation directions of particles in the same exposure (0747 0948).

2C. Elongated trondhjemite boulders in arkosic matrix. Section parallel to elongation. (Locality approximately mid-way between 2A and 2D.

2D. Deformed trondhjemite boulders. Section normal to elongation. Intermediate axes of pebbles are parallel to layering in arkose layers. (0773 1992).

3A.

3C.

3B.

3D.

LEGEND FOR GEOLOGICAL MAPS

| Unit | Description |
|---|---|
| 24. | Quartzite: |
| 23. | Arkose, conglomeratic arkose and conglomerate: Fragments derived mainly from medium grained trondhjemite. |
| 23a. | Conglomerate derived from basic and acidic volcanics, and trondhjemite, gradational to 23. |
| 22. | Conglomerate: derived mainly from basic volcanics. |
| 21. | Calcareous sediments: siltstones and sandstones. Underlain by thin basal conglomerates and grits in the Blåmuren area. |
| 20. | Calcareous conglomerate: contains fragments of basic volcanics, limestones and fine grained sediment. Locally this unit is strongly tectonized and resembles a pseudo-conglomerate. |
| 19. | Calcareous brown siltstone and phyllite: 19A. psammite; 19B. Calcareous psammite. May be equivalent to unit 21. |
| 18. | Highly calcareous psammite: locally gritty. |
| 17. | Dark green to black phyllite and siltstone, with minor arkose and quartzite. |
| 16. | Limestones/marble: 16A. remobilized carbonate. |
| 15. | Psammitic and pelitic metasediments: 15A. garnetiferous. |
| 14. | Undivided basic pyroclastics and lava, silicic tuffs and lava, clastic basic sediments and phyllite. |
| 13. | Massive basic lava and minor tuffaceous greenschist. |
| 12. | Greenshist: 12A. quartzite horizon. |
| 11. | Silicic volcanics: aphanitic to fine grained, chloritic, occassionally with undivided trondhjemite, lenses. |
| 10. | Silicic volcanics: massive, often porphyritic. |
| 9. | Silicic volcanics: schistose, origin uncertain. 9A. mylonitic. |
| 8. | Basic intrusive: 8A. fine grained diabase; 8B. medium grained gabbro. |
| 7. | Trondhjemite: medium grained with rafts of basic volcanics. |
| 6. | Trondhjemite: fine grained, in part aphanitic. |
| 5. | Trondhjemite: porphyritic; 5A schistose. |
| 4. | Trondhjemite: medium grained; 4A. fine to medium grained. |
| 3. | Layered gneiss: fine to medium grained. |
| 2. | Gneiss: fine to medium grained, often porphyroblastic. |
| 1. | Gneiss: medium to coarse grained, porphyroblastic; 1A. Augen gneiss. |

Massive basic lava.

Massive basic lava with basic dikes.

Pyroclastic basic volcanics.

Pillow lava.

Basic pyroclastic with fragments of acidic volcanics.

Basic volcanics with trondhjemitic veins.

Schistose layered greenstone, generally tuffaceous.

Clastic basic sediments.

Phyllitic basic sediments.

Conglomerate.

Strike and dip of bedding (So).

Strike and dip of foliation ($S_1$).

Strike and dip of cleavage ($S_2$).

Strike and dip of cleavage ($S_3$).

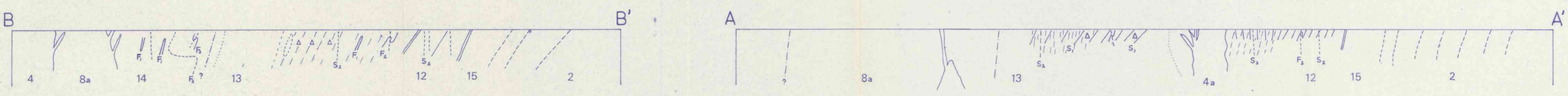
Particle lineation ($L_1$).

Lineation produced by So/$S_2$ intersection ($L_2$).

Fold axis ($F_1$).

Fold axis ($F_2$).

Axial plane to fold.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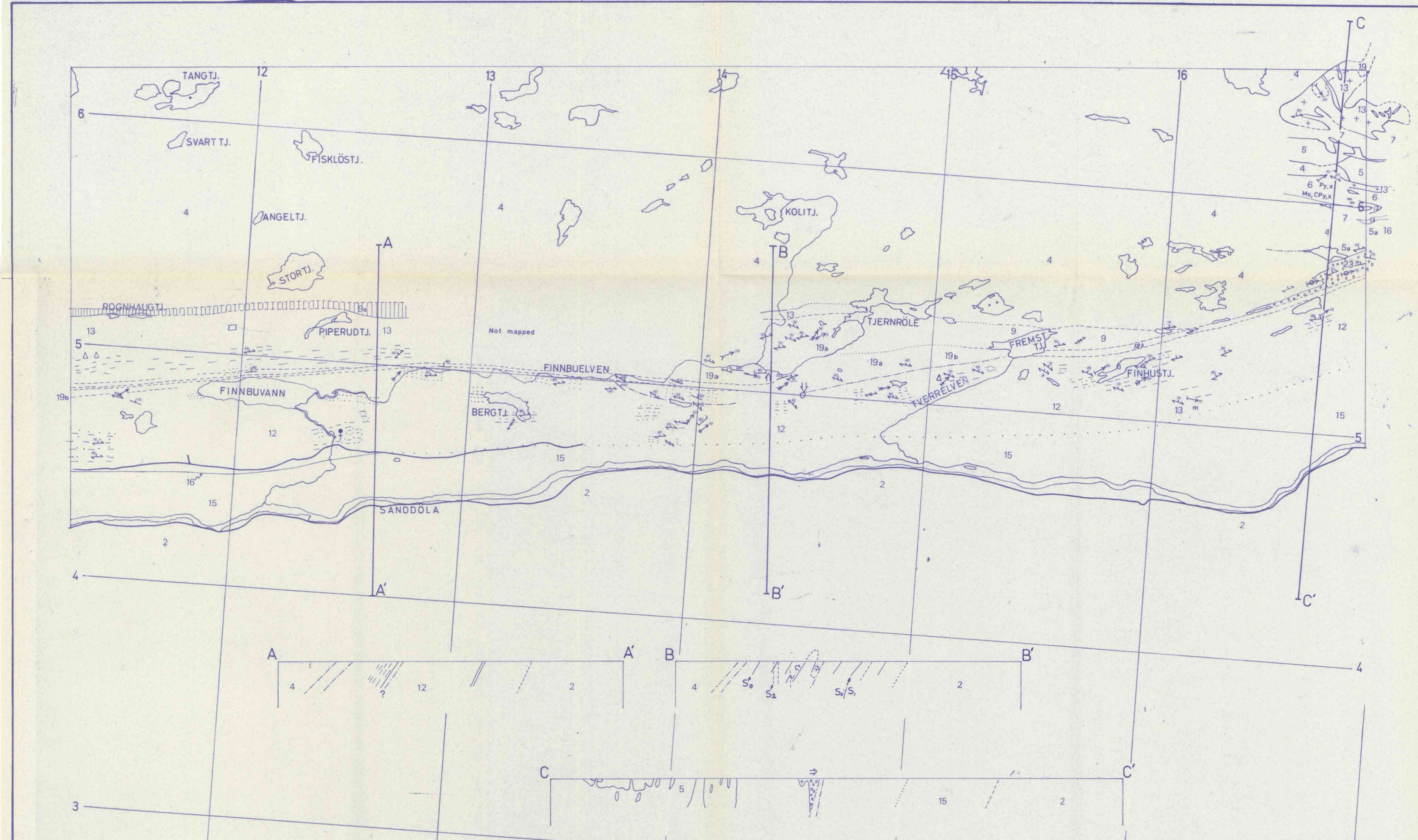
| GEOLOGICAL MAP | | TEGN: " | 1974 |
| MÖKLEVANN | 1:20.000 | TRAC: H.E | 1974 |
| | | KFR. | |
| NORGES GEOLOGISKE UNDERSÖKELSE TRONDHEIM | TEGNING NR. 1189 - 01 | KARTBLAD (AMS) 1823 IV A | |




GRONGPROSJEKTET 1973

GEOLOGICAL MAP

FINNBUVANN

| MÅLESTOKK | OBS. G.GALE | 1973 |
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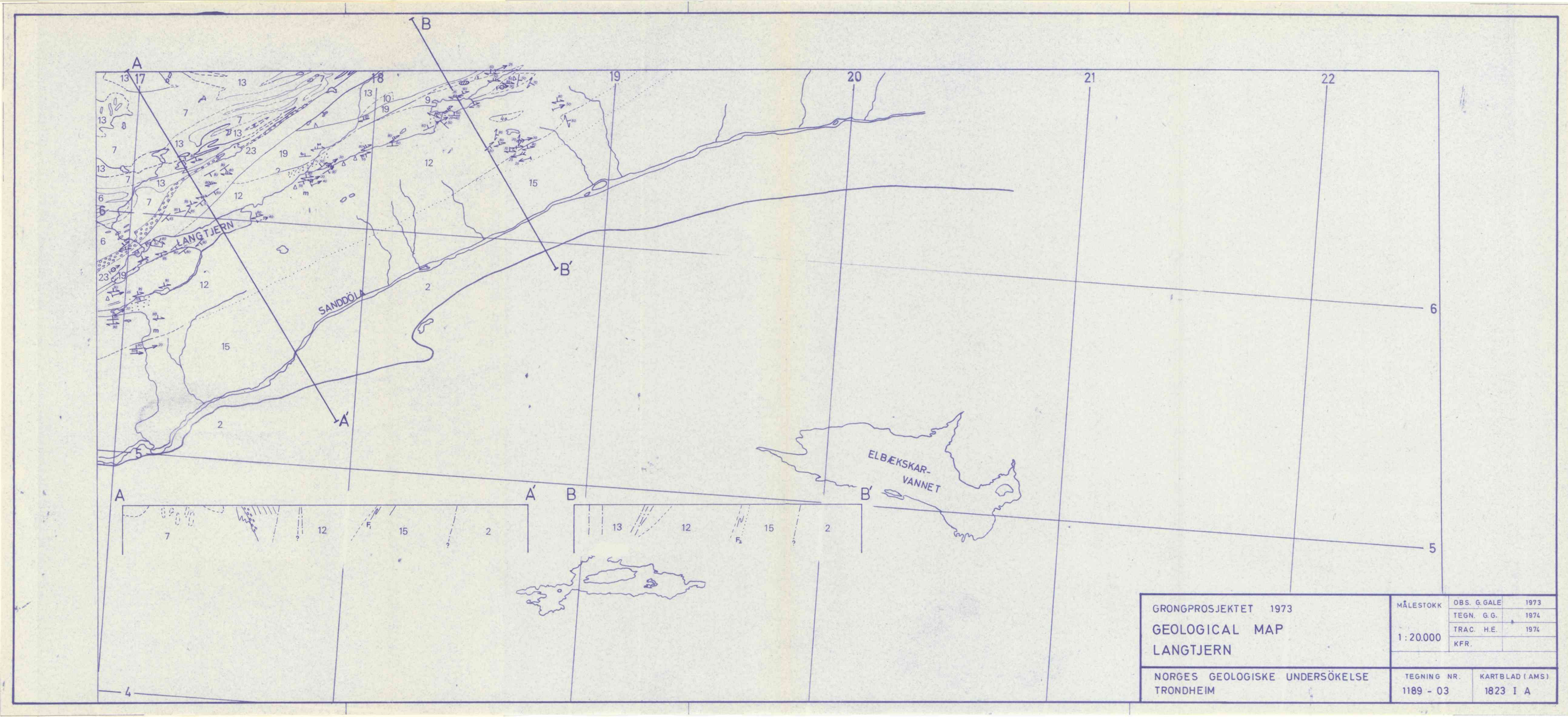

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LANGTJERN
SANDDÖLA
ELBÆKSKAR-
VANNET
GRONGPROSJEKTET 1973
GEOLOGICAL MAP
LANGTJERN
MÅLESTOKK
1 : 20.000
OBS. G. GALE 1973
TEGN. G.G. 1974
TRAC. H.E. 1974
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NORGES GEOLOGISKE UNDERSÖKELSE
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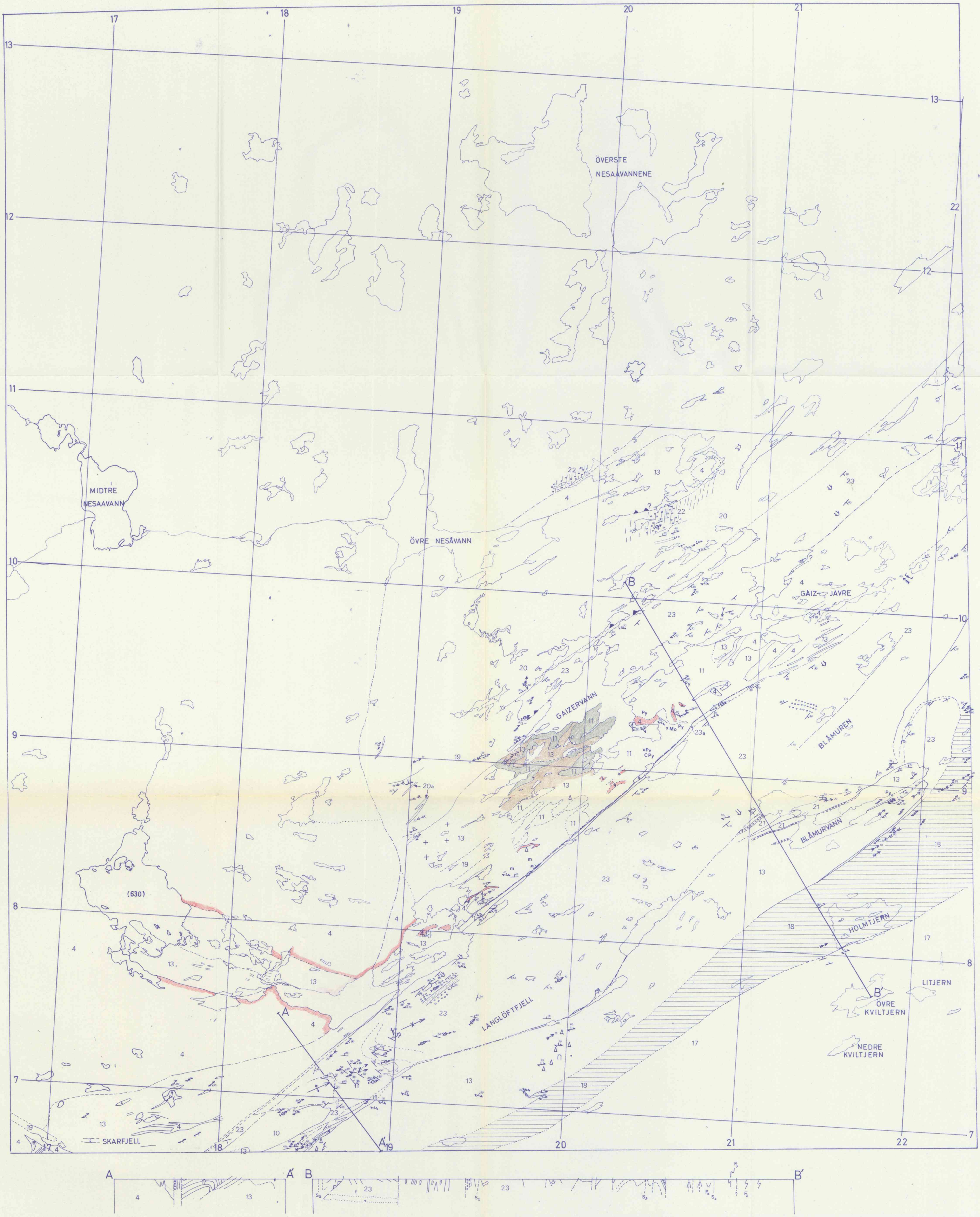


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| NESÅVANN | | TRAC H.E 1974 |
| NORGES GEOLOGISKE UNDERSÖKELSE TRONDHEIM | TEGNING NR. 1189 - 04 | KARTBLAD (AMS) 1824 II B |


LOCALITY AND SAMPLE NUMBER

AIRPHOTO INTERPRETATION

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| GEOLOGICAL MAP KLINGERVANN | 1: 20.000 | TEGN. G. G. | 1974 |
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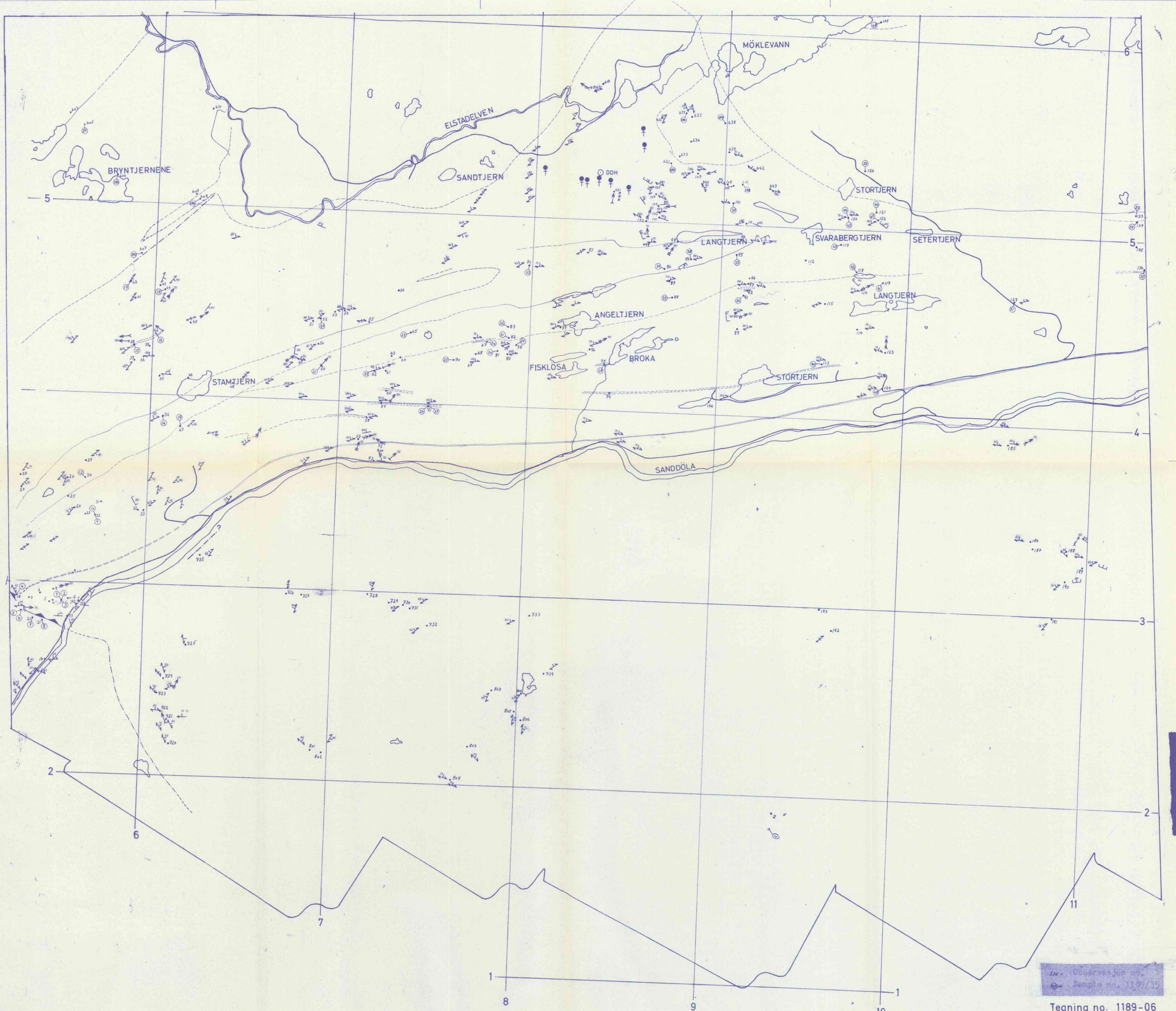


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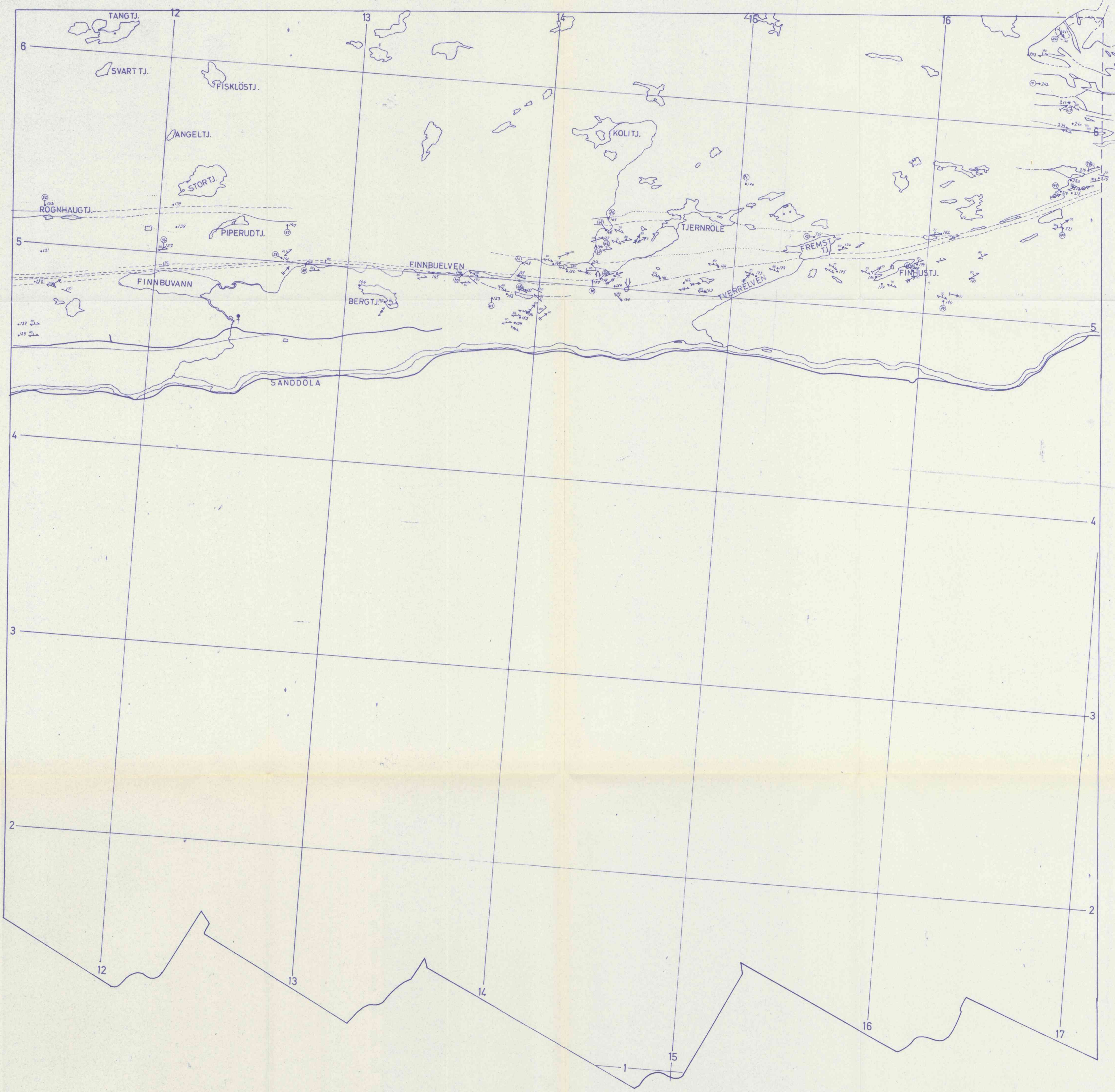
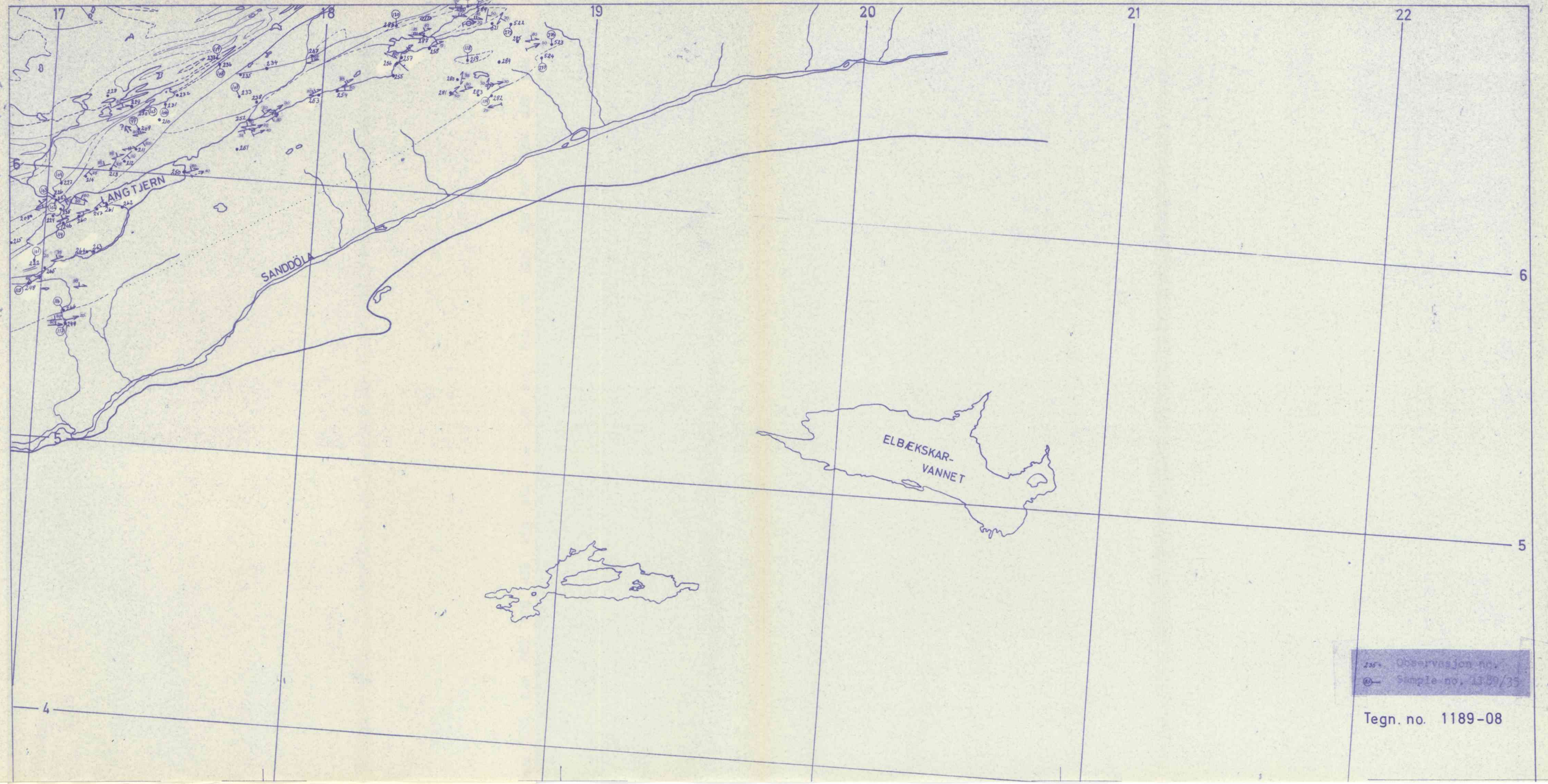



235 · Observasjon no.
(55)— Sample no. 1139/35

Tegning no. 1189-07

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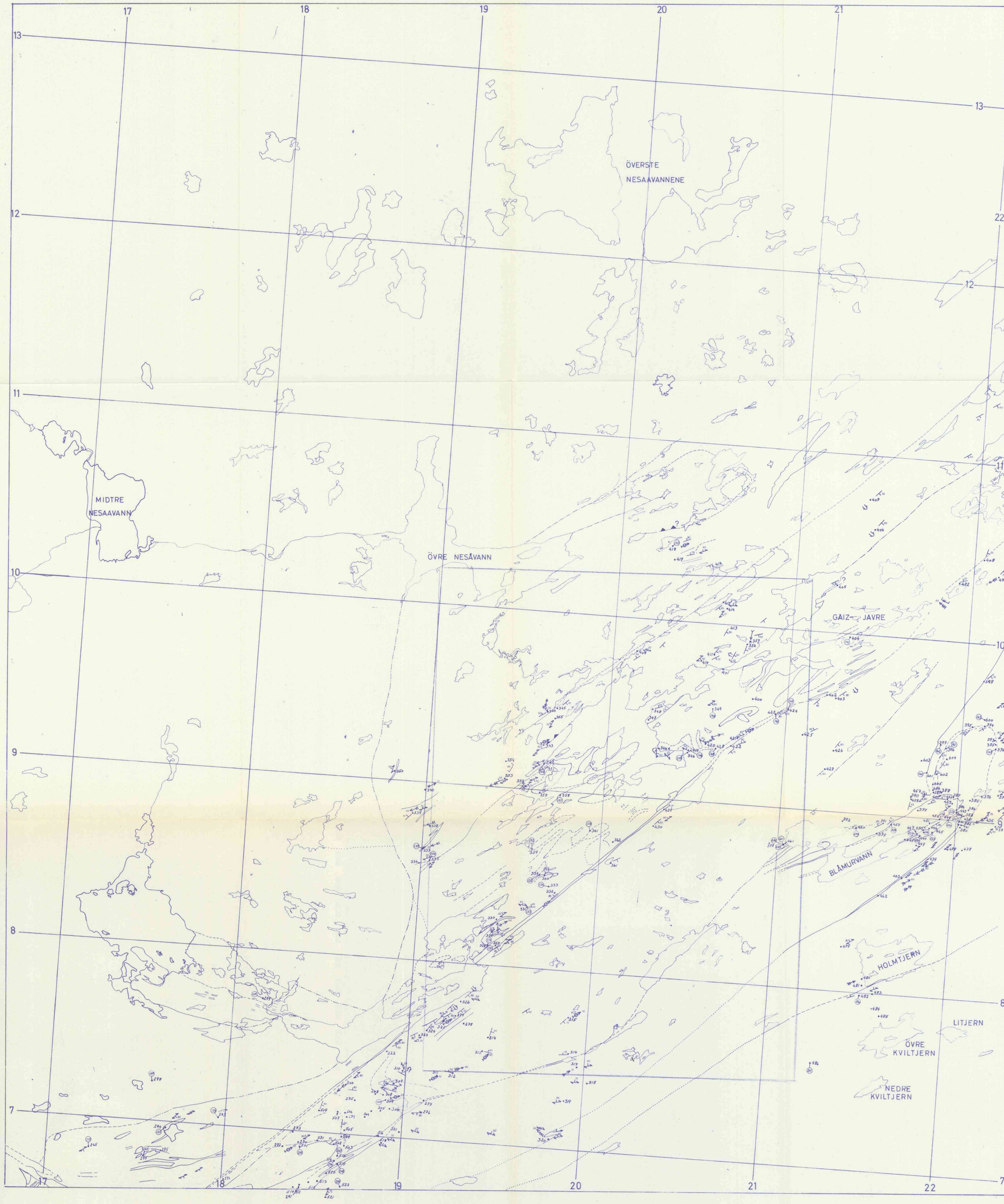


235• Observasjon no.
(35)— Sample no. 1189/35

Tegning no. 1189 - 09

NORGES GEOLOGISKE UNDERSØKELSE

| | |
|---|---|
| m | Massive basic lava. |
| | Massive basic lava with basic dikes. |
| Δ | Pyroclastic basic volcanics. |
| ∩ | Pillow lava. |
| ▲ | Basic pyroclastic with fragments of acidic volcanics. |
| + + | Basic volcanics with trondhjemitic veins. |
| | Schistose layered greenstone, generally tuffaceous. |
| | Clastic basic sediments. |
| | Phyllitic basic sediments. |
| oooo | Conglomerate. |
| | Strike and dip of bedding (So). |
| | Strike and dip of foliation ($S_1$). |
| | Strike and dip of cleavage ($S_2$). |
| | Strike and dip of cleavage ($S_3$). |
| | Particle lineation ($L_1$). |
| | Lineation produced by So/$S_2$ intersation ($L_2$). |
| | Fold axis ($F_1$). |
| | Fold axis ($F_2$). |
| | Axialplane to fold. |

| MAP Unit | Description |
|---|---|
| 24. | Quartzite: |
| 23. | Arkose, conglomeratic arkose and conglomerate: Fragments derived mainly from medium grained trondhjemite. |
| 23a. | Conglomerate derived from basic and acidic volcanics, and trondhjemite, gradational to 23. |
| 22. | Conglomerate: derived mainly from basic volcanics. |
| 21. | Calcareous sediments: siltstones and sandstones. Underlain by thin basal conglomerates and grits in the Blåmuren area. |
| 20. | Calcareaous conglomerate: contains fragments of basic volcanics, limestones and fine grained sediment. Locally this unit is strongly tectonized and resembles a pseudo-conglomerate. |
| 19. | Calcareous brown siltstone and phyllite: 19A. psammite; 19B. Calcareous psammite. May be equivalent to unit 21. |
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| 17. | Dark green to black phyllite and siltstone, with minor arkose and quartzite. |
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| 15. | Psammitic and pelitic metasediments: 15 A. garnetiferous. |
| 14. | Undivided basic pyroclastics and lava, silicic tuffs and lava, clastic basic sediments and phyllite. |
| 13. | Massive basic lava and minor tuffaceous greenschist |
| 12. | Greenshist: 12 A. quartzite horizon |
| 11. | Silicic volcanics: aphanitic to fine grained, chloritic, occassionally with undivided trondhjemite, lenses. |
| 10. | Silicic volcanics: massive, often porphyritic. |
| 9. | Silicic volcanics: schistose, origin uncertain. 9A. mylonitic. |
| 8. | Basic intrusive: 8A. fine grained diabase; 8B. medium grained gabbro. |
| 7. | Trondhjemite: medium grained with rafts of basic volcanics |
| 6. | Trondhjemite: fine grained, in part aphanitic |
| 5. | Trondhjemite: porphyritic; 5 A schistose. |
| 4. | Trondhjemite: medium grained; 4A. fine to medium grained. |
| 3. | Layered gneiss: fine to medium grained. |
| 2. | Gneiss: fine to medium grained, often porphyroblastic |
| 1. | Gneiss: medium to coarse grained, porphyroblastic; 1A. Augen gneiss. |

Summary ~~synopsis~~ of the Geology of the Sanddøla-Nesåvann area:

## A. INTRODUCTION

This report is a summary of geological investigations carried out in 1973 in the Cambro-Ordovician rocks of Sanddøla east of Trången and extending northeastwards as far as Gaziervann and Blåmurvann. This report is not a final account of the geology, since not all of the structural data has been synthesised, and is designed primarily as a basis for discussion and interpretation of the accompanying geological maps.

The description is organized on the basis of individual map sheets and detailed descriptions of each unit on a map sheet are avoided when the unit has been discussed in a previous section.

## B. MØKLEVANN. Map 1189-01.

Gneiss: The oldest rock in the area appears to be the acidic gneisses of the "Grong Culmination" which occur south of Sanddøla river. These have been investigated in three traverses from which it appears that the genisses are dominantly acidic with only thin, widely scattered horizons of amphibolite. The fine-grained, layered gneisses immediately south of the river grade southwards into medium-grained gneisses with small ( $< 1$ cm) feldspar porphyroblasts in some exposures which become progressively more abundant southwards. At (0330 1100) there is a 8-10 meter thick unit of quartz-biotite schist which was probably a pelitic sediment originally. The medium-grained porphyroblastic gneiss becomes more porphyroblastic south of (0310 1100) in that the size and proportion of feldspar metacryst increases to such an extent that the rock is a porphyroblastic feldspar gneiss with up to 50 % of the rock consisting of feldspar porphyroblasts up to 2 cm in length set in a fine to medium grained quartz-feldspar-biotite matrix.

The presence of quartzitic layers in the fine grained, medium grained and porphroblastic gneiss (outside the Møklevann sheet) and the quartz-biotitic schist layer mentioned above as well as layering/bedding in the fine grained gneiss indicate that the gneisses are metamorphosed arkosic sediments rather than metamorphosed granitic intrusives.

Acidic Intrusive rocks: The largest intrusive mass in the map area forms part of the Sanddøla trondhjemite. The trondhjemite is medium-grained and often pinkish coloured with large areas that are pale greenish due to strong epidotizion. The latter is well exposed in road cuts between Møklevann and Stortjern. At the extreme eastern end of Møklevann there is a small lense of fine-grained trondhjemite several tens of meters in width.

An elongated body of trondhjemite extending from Langtjern to west of Stamtjern is considered to be an apophysy of the main trondhjemite mass. Contacts with the surrounding rocks are only rarely exposed, the best example being along the road to Stamtjern. This is a fine to medium grained crystalline mass with a pronounced schistosity which is well developed in some places so that the rock resembles a quartz-rich schist. Along the Stamtjern road the northern contact is diffuse and consists of ~~bases~~ lenses of the trondhjemite intruded into basic volcanics/diabase. The contact at Langtjern and west of it appears to be strongly cleaved and is marked by a sharp escarpment which is probably a fault zone.

South of Langtjern the rocks are largely silicic and resemble a medium grained keratophyre more than the trondhjemite. On the basis of the evidence at Stamtjern this unit is considered to be an ~~interime~~ intrusive phase related to the main trondhjemite mass.

The relationship between the main trondhjemite mass and the other rocks is difficult to establish due to the absence of observed contact relationships. Southeast of Bryntjern the diabase appears to be intruded by trondhjemite which contains rafts of basic volcanics which have a well developed schistosity. This suggests that the trondhjemite may have been intruded into greenstones after the development of the regional scistosity.

The contact between Møklevann and the eastern boundary of the map is poorly exposed and east of Setertjern it runs along a small steep valley. Several small exposures of strongly tectonized greenstone near the contact where it crosses the Møklevann road suggests that faulting ~~bars~~ has occurred along the contact in some places.

Basic intrusives: Two large bodies of basic intrusives occur at Bryntjern and Møklevann. ~~In addition,~~ Small basic dikes occur near Angeltjern and scattered throughout the volcano-sedimentary sequence at Møklevann. In addition, there are several small exposures of a medium-grained basic rock resembling gabbro along the northern contact of the trondhjemite body at Stamtjern. This area is shown on the map as a single mass, however, since the exposure is sparce in this area it just a feasible to consider it as an area of basic volcanics with scattered medium grained dikes.

The basic intrusive at Bryntjern is mainly fine-grained and holocrystalline. The rocks are metamorphosed and the original minerals have been intensely altered and is therefore classified as a diabase. The interior of the body has zones that are medium-grained and is best classified as a meta-gabbro. This basic mass is considered to be a high-level synvolcanic intrusive which was sufficiently large to permit coarse crystallization of its center. The contact with the metasedimentary rocks in the northwest corner of the map is not exposed but appears to be a fault boundary running along a topographic depression. The southeastern contact is shown as a fault since there is a strong scarp at the approximate location of the contact (It should be noted that some of the rocks at (0460 0590) mapped as massive lava are similar to the fine grained diabas so that placement of the contact along the fault zone may not be valid in detail).

The diabase body at Møklevann is fine grained and contains a number of 1-2 m wide lenses of basic and acidic volcanics and several small dikes of fine-to medium-grained trondhjemite. Small diabase dikes intruding the volcano-sedimentary rocks in the area mapped by K. Langley indicate that the diabase is later than the regional fabric in this area

Although age relationships of the intrusives to the other rocks in the area has not been definitely established, several features point toward a post greenstone age for the diabase and trondhjemite: (1) dikes of diabase cut the foliation in the volcanics; (2) apophyses of trondhjemite occur in the diabase; (3) xenoliths of basic rocks considered to be volcanic in origin occurs within the trondhjemite; and (4) the Stamtjern trondhjemite body intrudes the basic volcanics,

Volcanic rocks: The volcanic rocks of this map area can be separated into three major divisions: (1) massive lavas; (2) Greenschists, and (3) the volcano-sedimentary sequence north of Langtjern.

The fine grained massive lavas are basaltic flows in which lava boundaries are only rarely visible. The lavas have been intruded by basaltic dikes, up to 1.5 m thick, which are well exposed along the electricity transmission line at (0430 0735). In places, notably east of Stamtjern, the map unit contains minor pyroclastic material. West and northwest of Stamtjern the lavas, pyroclastics and tuffaceous sediments are intimately intermixed and no attempt has been made to separate them into lithological units.

The greenschist unit is a sequence consisting mainly of strongly foliated basic pyroclastics, layered tuffs and clastic basic sediments. Massive basaltic units several meters in thickness, and thin keratophyric tuffs and lavas are scattered throughout this unit. In addition, several quartzite horizons, the largest of which occurs at Stortjern, occur throughout the unit.

Strongly deformed pyroclastics are most common adjacent to the massive lava unit. These consist of basic volcanic fragments, generally less than 10 cm in length, that have been strongly flattened within the plane of the regional foliation which is generally parallel to the layering when it can be determined. Several fine-grained layered basic rocks, considered to be tuffs, west of Angeltjern have scattered pyroclastic fragments.

The tuffaceous units are dark green, fine-grained basic rocks consisting mainly of amphibole crystals. Occasionally lapilli tuff fragments can be detected. The rocks have a strong schistosity and often exhibit a well developed layering which indicates that they were water lain. Tuffaceous greenschist is most abundant adjacent to the massive lavas.

The basic sediments often contain metacrysts of calcite and have up to 50 % clastic quartz. Layering is well developed in many places and is generally bedding although in many places the compositional layering appears to be a foliation and sedimentary layering is difficult to prove e.g., along the road to Møklevann at (0450 1080). Rocks with sedimentary layering and containing clastic quartz become more prominent southwards from the massive lava unit so that the rocks immediately north of the limestone unit consist almostly entirely of basic sediments in contrast to the dominantly tuffaceous and pyroclastic rocks immediately south of the massive lavas. No contact has been placed between the pyroclastic and tuffaceous greenschis and the basic sediments since the writer considers them to be both gradational and intermixed. The basic sediments are best exposed in road cuts along the Stamtjern road where they are phyllitic and in the vicinity of Stortjern where they are a mixture of phyllites and medium grained clastic basic sediments.

A Quartzite layer at Stortjern has a thickness of 3 - 5 m and can be traced along strike for a distance of 1.5 km. This is a greyish coloured rock consisting mainly of quartz with 5-15 % magnetite and traces of feldspars.

Several thin layers at (0406 0730) (0434 0775) and (0400 0740) could not be traced beyond the immediate outcroping. A quartzite lense, 10 x 0.5 m, at (0393 0707) appears to be a continuation of the horizon at the Godejord mineral occurrence.

Isolated outcrops of massive greenstone, interpreted as lava, occur within the dominantly tuffaceous and pyroclastic parts of the greenschists unit. Poorly developed pillow-like structures were observed in one small outcrop northwest of Fiskløsa.

Thin horizons of keratophyric rocks were observed at (0399 0722) (0399 0747), (0430 0997 – not shown on the map), 600 m northwest of Stamtjern and (0455 0600). Several of these e.g., that at (0455 0600), are massive and have only a weak schistosity whereas others are strongly schistose and are best described as quartz-sericite schists. Primary volcanic structures have not been observed in the keratophyric rocks. The schistose keratophyres maintain their thickness along strike and were probably of tuffaceous origin. The massive keratophyres are either lavas or dikes related to the trondhjemitic intrusive.

The volcano-sedimentary unit north of Langtjern has not been mapped in detail. The unit is similar to that of the greenschists in many respects and differs mainly in the greater abundance of keratophyric in this area. Some of the sediments observed north of Langtjern appear to be more quartz-rich than those occurring in the Greenschist unit to the south.

A limestone horizon 5-10 meters in thickness can be traced across the map area. Isolated blocks above Trangen has enabled the writer to extend the unit beyond the Stamtjern road to the western edge of the map area. The limestone horizon separates basic sediments of the Greenschist unit from the pelitic and psammitic rocks to the south, Map Unit 15. The pelitic and psammitic rocks are generally brownish in colour due to the presence of biotite as the chief mica present. Isolated thin horizons have a pale green colour indicating the presence of minor material derived from basic rocks. Locally this unit has garnet porphyroblasts (2-3 cm) but these do not indicat an age difference with the greenschist and greenstones since small garnets (1-2 mm) have been observed at Stortjern and at Godejorde.

The contact between the sediments and the gneisses to the south has not been observed. Several small outcrops near the contact in the woods at (0322 0631) on the south side of the Sanddøla river have a strong vertical cleavage and are intensely mylonitized which indicate that at least locally the contact is a fault. In addition the narrow, steep walled and straight character of the Sanddøla river channel supports a fault contact however more observations of structural discordance are needed before a faulted contact can be accepted.

Finnbu (Map 1189-02).
The rock units described on the Møklevann map sheet continue into the Finnbu sheet.

At the eastern margin of the map the medium-grained trondhjemite is intruded into basic volcanics. Veins and lenses of medium grained trondhjemite cut the greenstones and rafts of greenstone occur in the Trondhjemite. This area of the trondhjemite is considered to represent its roof. The general absence of inclusions of greenstone in the trondhjemite to the west is thought to represent progressively deeper erosional levels.

Small bodies of fine grained trondhjemite and porphyritic trondhjemite are exposed in the northeastern corner of the map. The fine grained trondhjemite is schistose and pyritic (1-5 % pyrite) and contains rafts of greenstone. A Mo-Cu mineralization occurs in fine grained trondhjemite at (0610 1660).

On the north side of Fremsttjern a fine grained trondhjemite or keratophyre occurrence occurs adjacent to the main trondhjemite mass. It contains small lenses with disseminated pyrite. Immediately east of Fremsttjern there is a small body of mixed schistose silicic and basic rocks which appear to be deformed volcanics. This body is in thrust contact with the trondhjemite. (The actual extent and origin of these rocks is not known since the area between the Kolitjern brook and Fremsttjern has not been mapped.

Between Rognhaugtjern and Piperudtjern there is a fine grained laminated silicic rock, which resembles a silicic volcanic, lying between the trondhjemite and the greenstone. Thin sections of this rock show it to be strongly mylonitic with highly strained quartz which suggests that movement along this zone has been later than the regional metamorphism. An attempt was made to find this zone at the trondhjemite contact in Kolitjern brook however here the contact zone is a mixture of dense basic volcanics and medium grained trondhjemite.

The pelitic and psammite sediments (Unit 15) on this map sheet have not been investigated.

The limestone horizon pinches out somewhere south and east of Bergtjern.

The greenschist horizon on this map sheet is dominantly sedimentary west of Tverrelven and consists mainly of green phyllites and well layered greenschists some of which are probably waterlain tuffs since they consist entirely of basic material. East of Tverrelven this unit consists mainly of layered tuffaceous rocks and massive greenstones become more dominant eastwards.

The massive greenstones and pyroclastic greenschists north of Finnbuvann thin out rapidly in the unmapped area west of Kolitjern brook since they are represented by only a very thin basic volcanic unit in Kolitjern brook. This is considered to be due to thrusting along the trondhjemite margin.

Metasediments (other than Unit 15).

A thin horizon of calcareous phyllite can be traced across the map area and for a short distance into map 1189-02. West of Finnbuvann the horizon becomes very thin and is found as scattered small exposures in brooks. The lithology is highly variable from the calcareous phyllites to siltstone and sandstone. In several places it resembles a phyllitic limestone. The rock is strongly tectonized with a penetrative cleavage and original layering can be seen between the cleavage planes in several places where the rocks have been folded. East of Fremsttjern both contacts of this unit are delineated by steep near vertical scarps and are considered to be fault controlled. The southern fault boundary can be traced westwards as far as (0500 1380).

Southeast of Tjernrøle and along Kolitjern brook there is 200 meters of medium grained calcareous psammite which are quite similar to unit 18 of the Nesåvann mapsheet. The relationship of the calcareous psammites and calcareous phyllites is not known since both contacts run along small steep valleys.

The rocks immediately south of the greenstone occurrence in Kolitjern brook and for 400 meters southward are well layered sediments consisting of semipelite and psammite. This unit has not been outlined but is thought to have much the same configuration as the unit of calcareous tuff (LKT) shown on Foslies map.

Two occurrences of graded bedding were found close to section B - B[1]. The best exposure occurs in slightly overturned metasandstones near the faulted southern boundary of unit 19. The other occurs in interbended [illegible] siltstones about 50 m north. The latter [illegible] preserved but indicate that the sequence is right way up since the folds ($F_2$) here have the style shown in the diagram below.


(2) position of way up criteria at the southern locality in relation to folds 50 meters north.

A Polymict conglomerate horizon (unit 23) is unconformably overlying an eroded trondhjemite surface in the eastern part of the map area. The conglomerates are interbanded with gritty and pebbly arkoses. The conglomerate consists of larger rounded blocks of medium grained trondhjemite, keratophyre/or fine grained trondhjemite, and minor greenstone and jasper in a chloritic sandy matrix.

The conglomerate have been folded together with the trondhjemite by open $F_2$ folds with a near vertical axial plane. The south contact of the conglomerate-arkose unit is faulted against calcareous phyllites.

D. LANGTJERN SHEET- map 1189-03

Greenstone and trondhjemite. The area of greenstone on Skarfjell shown on Foslie's 100.000 map sheet Sanddøla is a complex interfingering of greenstone with minor keratophyre and medium grained trondhjemite. Small ~~bases~~ lenses of fine-grained trondhjemite and keratophyre, too small and irregular to be shown on the 1:20 000 map, are present in the trondhjemite and greenstone units.

The greenstone is generally massive, fine grained and generally lack primary volcanic structures. Locally, epidotized subrounded blocks (knots) are considered to be tectonic breccia fragments.

The greenstone body lying between arkose and phyllite near the top of the map contain pyroclastics at (0642 1775) and several tuffaceous horizons in the immediate vicinity. Although this block of greenstones has not been investigated in detail it resembles the Blåmuren greenstone unit on the Nesåvann map sheet rather than massive lavas of nearby Skarfjell and the layered greenstones to the south.

The intrusion of the trondhjemite into the greenstones can easily be demonstrated in this area: medium grained trondhjemite lenses and veins cut the greenstone and small stocks of trondhjemite contain xenoliths of basic volcanics.

The layered greenschists, map unit 12, are a continuation of the rocks on the Finbu map. This unit is poorly exposed and small outcrops of pyroclastics and lava appear to be more abundant than on the Finnbu sheet to the west.

In the brook running from Langtjern at (0559, 1700) there is a short section of calcareous sedimentary rocks which are similar to the calcareous phyllites at Langtjern (unit 19). These rocks are however considered to represent minor calcareous sedimentation within the greenschist unit (because of the sparcity of exposure a correlation with unit 19 or unit 17 is equally plausible).

The greenschists are in direct contact with unit 17 at (0639 1863) and although foliations are parallel in both rock units the actual contact shows evidence of late shearing. The contact with unit 15 is not exposed in the brook draining Langtjern and the rocks of unit 12 nearest the contact are lavas. Several small bodies of trondhjemitic rocks occur in layered greenschists in the eastern part of the map.

Metasediments: Map unit 15, observed only in a short section the brook running from Langtjern, is mainly psammite with interlayered semi-pelite. The highly calcareous siltstones and phyllites of unit 19 are a continuation of the rocks on the Finnbu sheet. The relationship between the thin horizon of these rocks at the west end of Langtjern and the faulted block northeast of Langtjern is best explained as a prefaulting isocline although evidence for such a fold has not been found in the area. The south contact is strongly mylonitized at (0662 1827).

Arkose and conglomeratic arkose of unit 23 are definitely in fault contact with the greenschist and calcareous phyllites along the south boundary and are also faulted against greenstone and trondhjemite to the north. At (0588 1702) local movements have sheared and mylonitized conglomerate at the north contact. Conglomerates are most common in the western part of this unit and have been "cut out" by late faulting in the northeast.

A small body of a calcareous silicic rock occurs in the eastern part of the map area (unit 9). This rock has a strong foliation and abundant quartz phenocrysts/porphyroblasts. The unit is in fault contact with the calcareous phyllites. The north contact with greenstone is a zone of thrusting and is marked by remobilized carbonate with about 20 % quartz and mica a small body of this carbonate has been outlined at (0663 1836). This rock was probably a volcanic however it is difficult to account for the high carbonate content other than by remobilization from elsewhere.

E. NESÅVANN - map 1189-04

Trondhjemite: A medium-to coarse-grained massif with small lenses of fine grained trondhjemite occupies the south western corner of the map. Small bodies of gabbro have been observed within the massif at vann 630 and on Nesåpiggen.

Veins and lenses of medium grained trondhjemite intrude greenstone south-west ~~og~~ and northeast of Gaiz-javre.

Fine-grained trondhjemite, often porphyritic, is the dominant rock type in several places southwest of Gaiz-javre (unit 11). These have been intruded by medium-grained trondhjemites and the small bodies of unit 11 are a mixture of both rock types.

A small body of silicic volcanics (unit 10) occurs in the southern part of the map. These are fine-grained, and fine-grained quartz-porphyritic rocks in which individual units, probably flows, can be followed for short distances. Along the south boundary they are interlayered with thin greenstone horizons while the north boundary is unconformably overlain by and folded together with the arkoses and conglomerate of unit 23. Part of the south boundary is faulted/thrusted against the greenstones.

The greenstones between Skarfjell and Gaiz-javre are massive, fine grained basaltic volcanics which rarely exhibit primary volcanic structures. Thin horizons of chloritic silicic lavas occurs in several places throughout this unit.

The Blåmurvann greenstone unit is probably a continuation of the layered greenschist and greenstones on the Langtjern map. These greenstones have been investigated only briefly. There appears to be an abundance of fragmental and tuffaceous basaltic volcanics in this unit however there is too much basic lava to warrant describing it as 'basic tuffs' since it is a mixture of lava, pyroclastics and tuff. A thin horizon of keratophyre agglomerate in a basic matrix occurs just off the southwestern corner of this unit on the Langtjern map.

Metasediments: A thin unit of calcareous phyllite marks the thrust/fault boundary between the arkoses (unit 23) and the Blåmurvann greenstones. This unit is strongly tectonized and appears to be massive dirty limestone at (0700 1888) and (0378 2105).

Less tectonized phyllites occurs southwest of Gaziervann. The rocks consist of calcareous phyllite, siltstone and several beds of arkosic sandstones up to 10 m thick. The contact, if any, with the limestone conglomerate unit 20 has not been delineated. A small body of calcareous phyllite occurring within the greenstones at (0840 1935) is fault bounded on both contacts.

The limestone conglomerate, unit 20, is westward dipping to vertical in the area west of Gazier vann. Thin horizons of greenstone conglomerate occur throughout the unit in addition to thin arkosic ~~sandstone~~ beds. In several places the rock is obviously a pseudo-conglomerate since only the limestone 'fragments' have a rounded form and the siltstone and phyllite fragments have definite angular and elongated shapes. Unit 20 is thrusted upon and over the arkoses of unit 23 at (0991 2028) but appears to be faulted against unit 23 in the northeast at (1135 2187).

Map unit 21 is quite similar to unit 19 and differs mainly in the presence of a basal conglomerate horizon underlying the calcareous siltstones and phyllites and lying unconformably upon the greenstones. This unit has been preserved in late downfaulted blocks in the Blåmurvann antiform. Several small bodies of this rock, without the basal conglomerate, less than 10 meters in thickness occur at the contact between the greenstones and unit 17 northeast of Holmtjern.

Greenstone conglomerate with a steep westerly dip occur west of Gaiz-javre and northeast of Øvre Nesåvann. The unit has been mapped on only one traverse and is not greatly dissimilar to the basal conglomerate of unit 23 in that it is a layered pebble to boulder conglomerate with basic and acidic rock fragments in a basic matrix. Definite stratigraphic correlation between the two units cannot be attempted at this time due to lack of detailed tectonic observations in this area.

Arkose and conglomerates of unit 23 are a thick sequence of sedimentary rocks with abundant cut and fill structures, graded bedding in the arkosic layers and an absence of layering in conglomerate units that are up to several hundred meters thick. The well-rounded fragments range in size from pebbles up to boulders one meter in length and have been derived largely from a medium grained trondhjemite similar to the massif to the west. Basic fragments are rare in the conglomerate although jasper fragments are commonly present.

Cut and fill structures and graded bedding in arkosic sandstones indicate that both parts of this unit are right way up.

A small body of this unit northeast of Blåmurvann can be shown to be folded about the greenstones on the basis of the intermediate axes of deformed pebbles. It is quite obvious from the map that the unit 23 has been "cut out" by faulting along its contact with unit 18 in the area north of Holmtjern.

All of the boundaries of unit 23 are controlled by a late brittle tectonic deformation. A traverse was made over the entire width of the arkose-conglomerate unit where the two parts are in contact (between Gaiz-javre and Handalsvann in an effort to study the contact relationships between them. A brief examination of the area where the two bodies should meet did not reveal any obvious structural discontinuity.

The calcareous psammites of unit 18 are a thick sequence of uniform highly calcareous sediments. In many places in this unit bedding has been destroyed by a regional schistosity along which carbonate weathers out to give an impression of layering, however, when fold hinges can be discerned it is possible to recognize the original layering when it is at a high angle to the schistosity. The bedding becomes indiscipherable from the schistosity where there is an angle of less than 30 degrees between the two.