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GRONGPROSJEKTET

NGU Rapport nr. 1293

GEOLOGY AND SULPHIDE MINERALIZATION

in the

SANDDØLA-GAIZERVANN AREA,

Grong, Nord-Trøndelag (engelsk utgave)

Geologi og sulfidmineralisering i
Sanddøla-Gaizervann området
Grong, Nord-Trøndelag

1972–1974

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GEOLOGY AND SULPHIDE MINERALIZATION IN THE SANDDØLA - GAIZERVANN AREA, TRØNDELAG (engelsk utgave)

Geologi og sulfidmineralisering i Sanddøla - Gaizervann området, Grong, Nord-Trøndelag

Tidsrom:
1972 - 1974

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1. INTRODUCTION:

In this report the results of the past three summers' field work will be synthesized. Previous reports 1122A and 1189 have dealt with various aspects of the geology of the area. During the 1974 field season the writer concentrated mainly on filling in gaps in the 1973 mapping and detailed mapping of areas of economic interest. The maps included in this report are updated versions of the 1972 and 1973 maps.

The area investigated occupies the southernmost part of the old Grong Concession Area and forms part of five 1:5o.ooo map sheets (see fig. 1). Reconnaisance mapping on a scale of 1:5o.ooo has been carried out in the gneissic terrain of the Grong Map Sheet (1823 IV); this mapping is not included on the enclosed maps but will be presented on the preliminary map sheet now in preparation.

In this report the geology will be described in 5 major sections corresponding to the mapped portions of the 1:5o.ooo map sheets shown in Fig. 1. Map references, coordinates and names refer to the 1:2o.ooo maps.

The location of fieldnotes, observation points, samples, sample location maps, and original overlays for the 1:2o.ooo airphotos are given in Appendix A.

Appendix B is the section of NGU rapport 1228 A which deals specifically with the geochemistry of volcanic rocks in the Grong area.

2. HARRAN MAP SHEET (1824 III).

The geology of the mapped portions of this map sheet is presented on the 1:2o.ooo maps 1293-01 and 1293-02. In addition some reconnaissance mapping has been carried out along the roads between Gartland station and Høylandet.

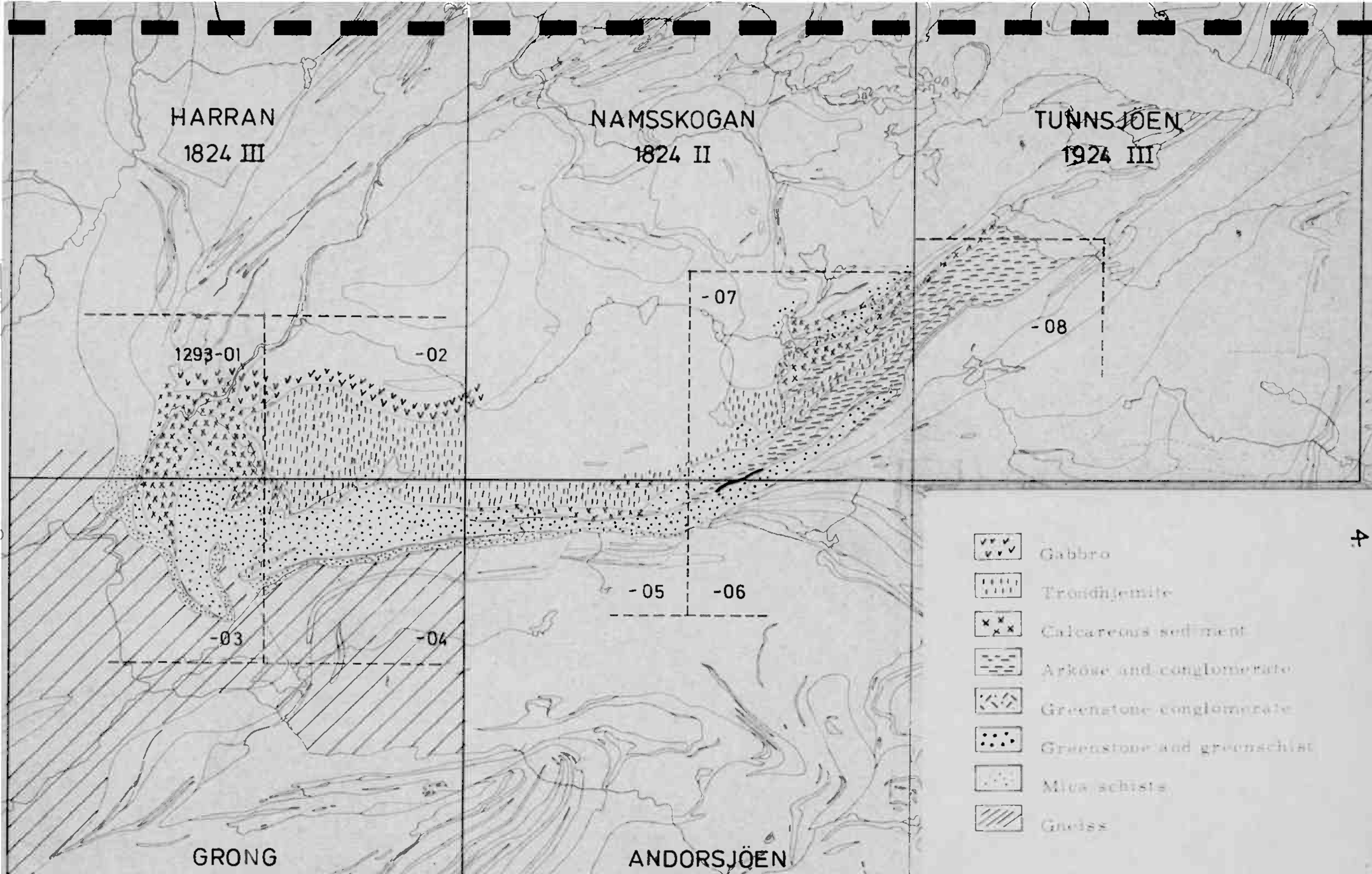


Fig. 1. General geology of Sanddøla area.

Gneissic rocks.

The oldest rocks in this area appear to be the feldspar-rich gneisses in the western part of Map 1293-01. These include strongly foliated medium grained red and grey gneiss and augen gneiss. In the areas where mapping has been carried out to date the augen gneiss is the most dominant rock type. In the area northwest of Fosland both fine-to-medium-grained (1-2mm.) reddish gneiss and augen gneiss occur in close proximity to each other. The augen gneiss has reddish subhedral feldspar porphyroblasts 2-3 cm. in length enclosed in a finer grained (1-2 mm.) matrix of quartz, feldspar and biotite.

On the eastern side of Grungstadvann, southwest of Høylandet, road cuttings in the gneisses are dominantly grey augen gneiss with white feldspar porphyroblasts with an average length of 3 cm. A small outcrop at the northeast end of Grungstadvann has reddish coloured feldspar porphyroblasts but has a quartz-feldspar-biotite groundmass identical to that of the grey gneiss.

Amphibolite layers, approx. 1m. thick, can be found in the grey gneiss. These lie roughly parallel to the regional foliation and are folded together with the regional fabric into late open folds with vertical axial planes.

Garnet mica schist.

Rocks of the garnet mica schist unit should occur between the lower greenstone and the gneisses in the area west of Fosland farm on Map 1293-01, when projected along strike from the exposures north of Grong Station. This area is, however, covered by thick glacio-fluvial deposits and no exposures of this unit have been found in the Fosland area. The unit does occur in the northern parts of Map 1293-01, northwest of Gartland Station, and should be continuous southwards towards Grong Station. A small road cutting at (701 251) consists of mica schist but these are considered to represent the mica schist layers in the upper levels of the gneissic unit similar to those found immediately under the garnet mica schist unit in road cuttings north of Grong Station and elsewhere on Map 1293-03 (cf. Section 3 and NGU rapport 1122A.).

Lower amphibolite.

This unit,which overlies the garnet mica schist on Map 1293-03 and presumably occupies the same position on Map 1293-01, is found on both sides of the Namsen river in the southern part of Map 1293-01. The thin units of amphibolite observed along the Gartland-Høylandet road are considered to belong to this unit but have not been followed along strike.

This amphibolite is well exposed along the railway track on the north side of the Namsen river and in a small brook, Miganbekken, on the south side of the river. This rock is medium grained and strongly foliated. Amphibole and feldspar are the main minerals and garnet, 1-2 mm in diameter, is often present as an accessory mineral. In several places this unit has an indistinct layering defined by layers consisting of 90% hornblende alternating with layers of hornblende and plagioclase. Keratophyric layers have not been observed in this unit. In the absence of primary volcanic structures it is only possible to state that this unit has been derived from a basic volcanic terrain and consists of intensely deformed basic lavas and/or tuffs.

The relationship of this unit with other units in the immediate vicinity is not readily apparent. In the road exposure on the NW side of the river (600 280) the amphibolites dip steeply westward and the sediments underlying the amphibolite here are not typical of either the garnet mica schist unit or the metasediments(calcareous arkoses and semipelites) which overlie gently southward dipping amphibolite at the base of the cliff in Miganbekken. The exposures at (600 280) and at the entrance to the railway tunnel immediately north of that locality contain a number of Z - type minor folds which fold the foliation and can be interpreted as part of a larger Z - type fold (see cross section A-A'). This interpretation indicates that the approx. 50 m thickness of medium grained amphibole-rich sediments tectonically underlying the amphibolite unit in this locality must belong to the same unit as the calcareous arkoses and semipelites which overlie the amphibolites in Miganbekken.

Amphibolite layers, 10 to 40 cm. thick, in quartzites along the northern shore of the Namsen river i.e. NE of (600 280) support the above interpretation since these quartzites can be correlated with similar quartzites overlying the lower amphibolite immediately south of the railway bridge over the Namsen river (see Map 1293-03, and section on Map 1122A-01 of report 1122A). The quartzites are discontinuous along strike and do not occur at the Miganbekken contact. Calcareous metasediments identical to those in the "metasediment Unit" overlying the lower amphibolite elsewhere, e.g. Map 1293-03, are also found interbedded with, or infolded with, amphibolites along the shores of the Namsen northeast of (600 280).

A roadcutting, 100m^2, at (666 306) north of the Miganbekken amphibolite exposure was earlier correlated with the amphibolites (rapport 1122A). On reexamination it is quite obvious that this rock is not an amphibolite but a basic gneiss consisting of amphibole (actinolite), abundant epidote and red porphyroblastic feldspar. This rock has a tectonized appearance and cannot be followed beyond this particular outcrop which probably represents a tectonized basic layer in the sediments since there are several small exposures of tectonized sediment approx. 100m. northeastwards along the road.

Metasediments.

There are two major units of metasediments on Map 1293-01 which continue southwards and southeastwards on Maps 1293-02, 1293-04 and 1293-05. These shall be referred to as the Namsen sediments which are found between the lower and upper amphibolite units and the Rosset sediments which are found in the area between the trondhjemite gabbro complex in the east and the upper amphibolite in the west. The Rosset sediments tectonically overlie the upper greenstone at Killingberget but underlie thin unit of basic volcanics at Elstad farm which can probably be correlated with the upper greenstone. The two sedimentary units have similar lithologies and probably represent one formation which has been faulted/thrusted against the amphibolites. The area SE of Gartland, where the two units are in contact, is covered with thick glacial deposits.

The thickness of the Namsen section is estimated to be about 400m while the Rosset section has an apparent minimum thickness of 800m, which can be considerably inflated due to folding and faulting.

The Namsen section is exposed along the railway track and between the two amphibolite units in Miganbekken.

The base of this unit is exposed in Miganbekken near the top of the cliff and possibly in the roadside exposures at (600 280) (if the interpretation of that exposure as a Z-type fold is correct). The contact between sediments and amphibolite in Miganbekken is a mylonite zone 10-15 cm. thick; quartz boudins and scattered subrounded 5-10cm. diameter blocks of a reddish coloured feldspar-quartz rock occur in the sediments within 5 meters of the contact. It is not clear whether these blocks represent tectonized sediments or boulders.

The dominant lithology exposed in Miganbekken and along the roadside and railroad on the NW side of the river is calcareous meta-arkose. These rocks are generally biotitic and have free carbonate (calcite) as individual grains and as segregations in lenses and boudinaged veinlets within the regional tectonic fabric which is defined by biotite and muscovite.

Brown-weathering calcareous semipelites are found near the top of the Miganbekken section, in the vicinity of(620 338) and southwards as well as along the shores of the river northeast of (600 280). The calcareous semipelite is less abundant in the Namsen metasediment unit on Map 1293-01 than in the continuation of this unit to the south on Map 1293-03 where it can be followed as a distinct unit overlying the psammites.

A 10 - 50 m. thick zone of fragmental rocks occurs near the top of the Namsen sediment unit. This is a marked stratigraphic unit which is generally found within a few meters of the base of the upper greenstone but is separated from it by metasediment. At (640 438) the conglomerate was not found. (A 1 meter thick mylonite zone occurs at the steeply-dipping contact.) The presence of the "conglomerate" on this contact could not be confirmed in the area to the SW of (648 438); that area is however poorly exposed. The presence of the "conglomerate" on the hills SSW of (648 438) supports the interpretation of this area as the core of an antiform (Rapport 1122A).

In the exposures on the north side of the Namsen river this fragmental rock resembles a pseudoconglomerate. The rock fragments are plate-shaped and of variable size; fragments 50 x 15 x 40 cm. have been noted. In several cases the "fragments" are less than 10 cm. thick and have a length of 2m., e.g. (770 355). The fragments in this area consist of quartz, reddish-coloured feldspar and minor biotite (1-2%) and muscovite and are embedded in a similar matrix which differs mainly in that it has a higher mica content (5-10%). In some instances it is not possible to distinguish between the matrix and the fragments in hand specimens. Both the fragments and the matrix can have a gneissic appearance. Along the railway line immediately SW of the outcrops of fragmental rocks the underlying sediments are quartz-feldspar-muscovite-chlorite roks which in some respects resemble the fine grained (1 mm.) gneisses more so than the metasediments.

The writer has seen nothing in the outcrops on the NW side of the river that would indicate a conglomeratic origin for these fragmented rocks; however, these rocks could be extremely deformed conglomerates.

On the south side of the river the same unit is well exposed in fresh road cuttings at (706 342). (see Plate 1A, 1B). These outcrops were earlier considered to be a deformed conglomerate (Rapport 1122A). A re-examination of these outcrops and other exposures in the same unit has revealed that there are layers in the matrix that are quite similar to the fragments and, although the fragments are generally different in composition than the matrix in that there is a smaller proportion of dark minerals, the texture and grain size are similar.

The origin of this fragmental zone is of considerable importance to the regional interpretation of the geology in this area and although I have been aware of the problems involved it has not been possible to date to devote time to a detailed study of this rock unit. If this unit is a true conglomerate it can be used as a stratigraphic marker horizon; the flattening in these rocks then represents a strong S-tectonite fabric. On the other hand, if these are pseudo-conglomerates then this represents a zone of tectonic translation, and the sediments occurring between the fragmental rock unit and the upper greenstone are probably a recrystallized mylonite (this would also explain why garnets are generally found in the sediments nearest the amphibolite contact but does not explain why they occur at both the contact with the upper amphibolite and the lower amphibolite; the upper amphibolite would then not necessarily have any correlation with the lower amphibolite.)

The Rosset metasediment unit is poorly exposed. The good exposures along the E6, Elstad river and the Rosset road (the road through Rosset farm) represent a limited stratigraphic thickness since these roads and the river follow the strike.

The contact of this unit with the upper amphibolite is not exposed. In a small valley behind the rock quarry at (0732 0372) the amphibolite is interbanded with metasediments (psammites). The metasediments tectonically overlie the amphibolite and although a fault zone is suspected to lie near this contact there is no marked difference in the attitude of the regional schistosity in the two units.

The rocks in the western part of this unit are dominantly psammite and semi-pelite. Pelitic layers are often found interbedded with the other two. In the eastern part of the area, i.e. in the tectonically higher parts of the unit, semipelitic to pelitic rocks are most common (e.g. along Elstad river and the E6 at (0820 0440) On the NE side of Elstad river the semipelitic rocks are overlain by massive meta-arkose in which thin pelitic layers rarely occur. A thin zone of conglomerate/pseudo-conglomerate occurring at the top of the meta-arkose has been observed at(0723 0525) near Elstad farm. The conglomerate/pseudo-conglomerate is directly overlain by amphibolite. (Plate/1).

The sediments in the quarry at (0732 0372) are very close to the contact with underlying amphibolites. These rocks appear to represent the lowest structural level of the Rosset metasediment unit but resemble in hand specimen the mica schist underlying the lower amphibolite in that they are garnetiferous and contain the reddish brown biotite that is typical of the mica schists. Garnetiferous sediments have not been found elsewhere in the Rosset metasediment unit but this could merely reflect a difference in composition (e. g. a lower carbonate content)..

The dominant rocks in the Rosset metasediment unit are psammite and semi-pelite. These have a brownish colour on weathered surfaces due to their carbonate content. The main minerals are quartz, biotite (black and brown), calcite, and feldspar; muscovite is also present in psammitic layers that are poor in carbonate. The semipelitic rocks are generally higher in carbonate and often consist of alternating quartz + calcite layers (0. 5 - 1. 5 cm. thick) and quartz + biotite + calcite layers (0. 5 - 2 cm. thick).

Pelitic rocks in Elstad river at (0600 0587) have a distinct green colour while those along the E6 are dark grey to black in colour. The pelites outcropping in Elstad river were considered by Foslie to be a separate rock unit,"Highly calcareous phyllite". These rocks were metamorphosed during the first regional metamorphism under at least biotite grade conditions and have since undergone retrograde chlorite grade metamorphism since biotite porphyroblasts have been partly broken down to chlorite. Since only 3 exposures of this green-coloured pelite have been found and a similar rock is found interlayered with calcareous semipelite elsewhere in Elstad river, it is considered to belong to the Rosset metasediment unit. The pelites along the E6 at (0820 0440) are interlayered with psammite and semi-pelite but have not undergone a retrograde metamorphisn.

A fine-to medium-grained psammite unit is exposed in several places NE of Elstad river on Maps 1293-01, 1293-02. This is a massive quartz (80%)-biotite (10%)-feldspar rock in which distinct layering is rarely observed,but does occur along the edge of a forestry road at (0649 0560) where several beds of black phyllite 1-5cm. thick are interlayered with psammite. The thickness of this unit is difficult to estimate due to poor exposure but it appears to be a lense-shaped unit which has its greatest thickness along section C-C' (Map 1293-01) and thins along strike – probably as a result of thrusting.

At (0723 0525) the psammite is overlain by a conglomerate/ pseudoconglomerate zone at least 15m. thick. The relationship between the psammite and the "conglomerate" is not known. The exposure of psammite nearest the "conglomerate" (less than 10 m below the inferred contact) has no distinctive layering but does have a 15 cm wide zone with several subrounded "cobbles" of a medium-grained quartz-feldspar rock which resemble trondhjemite fragments. The enclosing matrix and the remainder of the rock in the rest of this 2 m. high exposure has pinkish-coloured feldspar metacrysts (5mm. in diameter): evidence of metacryst development has not been observed elsewhere in this unit.

The "conglomerate" zone can be traced along strike for a distance of approx. 100m. It consists of fine-grained (1-2mm.) pinkish coloured fragments, which resemble a fine-grained trondhejmite or keratophyre, in an arkosic matrix. (see Plates 1 C); less than 1% of the fragments are strongly epidotized basic material. The small (less than 5cm.) "fragments" in these exposures consist of medium - to coarse-grained quartz and feldspar and resemble blastomylonite rather than clastic fragments. The rock fragments in this "conglomerate" zone are flattened within the first regional fabric and resemble compositionally and texturally the "conglomerate" zone at the top of the Namsen sedimentary unit; the greatest difference between the two occurrenses is the extremely low calcite content of the underlying psammites in comparison to the calcareous arkoses which form the matrix to and underlie "conglomerate" zone of the Namsen sediments. The two "conglomerate" zones must be stratigraphical equivalents by virtue of their marked similarities in fragment composition, deformation and structural position, since both occur at the top of a sedimentary sequence and underlie an amphibolite unit. Whether these "conglomerates" are true clastic rocks or a tectonic melange is not readily apparent.

The upper amphibolite refers to the amphibolite unit at Killingberget (Map 1293-01) and its continuation to the south into Map 1293-03. This unit is comprised of massive amphibolites (lavas), minor pillow lavas, pyroclastics, banded amphibolites (tuffs) and quartz-rich amphibolites (probably tuffites).

The contact of this unit with the underlying Namsen sedimentary unit appears to be sharp in most places but where the contact is well exposed, e.g. at (704 352), there is a 1 m. zone of interbanded amphibolite and sediment. In several places (e.g. 640 331) there are small lenses, 1 to 2 m. in length and 10 - 30 cm. in width, of fine - to medium-grained quartz and feldspar; these lenses are generally slightly discordant to the regional foliation which they predate, and have been found only in the amphibolites and adjacent to its lower contact. The contact is concordant with the regional fabric in both the amphibolite and the metasediment.

At (648 438) the amphibolite appears to be in fault contact with the Namsen sediments and separated from them by a 1 m.-thick acidic mylonite. The contact SW of this locality is not exposed and the regional fabric in both the sediments and the amphibolites has a steep to vertical dip except where it has been modified by later, post-S_1, folding. The contact in this area runs along a small valley which probably represents a fault zone (? supporting evidence for such an interpretation appears to be contained in the aeromagnetic map from this area which shows a disruption in the magnetic anomalies at the approximate location of the contact).

The northern termination of this amphibolite unit appears to occur at approximately the location of the Namsen river; however, since there are no exposures or aeromagnetic data in this area it is possible that a thin horizon of amphibolite continues northwards. (this question could easily be solved by several short magnetic profiles.)

The southward extension of the upper amphibolite can be seen as a wall cap of amphibolite at (410 325) on Map 1293-01 and further to the SW on Map 1293-03. These rocks are preserved in the core of an open synform.

The gabbroic rocks on Maps 1293-01 and 02 are part of an extensive gabbroid complex (see Foslie's maps Sanddøla and Trones) that underlies part of the Harran and Namskogan map sheets. This mass is generally medium-grained (2-3 mm.) and consists mainly of plagioclase and amphibole. In several places, e.g. north of Elstad farm,there are large areas of fine-to medium-grained (1-2 mm.) gabbro containing plagioclase, hornblende, epidote, and minor chlorite. The plagioclase contains abundant submicroscopic crystals with a high relief (epidote?). In many places, especially near the margins, the rock is a mixture of fine-and medium-grained lenses which have diffuse and irregular contacts with each other.

The gabbro mass in the northern part of Map 1293-02 is a composite body in which some areas are dominated by hornblende-plagioclase gabbro, and others by plagioclase-hornblende gabbro. An exposure of plagioclase-hornblende gabbro at Rongbuvann (0950 1064) contains about 30% hornblende and has a distinctive greyish colour in contrast to the dark green-coloured gabbro present along the E6 at Fiskumfoss. The Rongbuvann 'gabbro' contains in addition to plagioclase about 2% microcline (specimen 1293/160); any Rb/Sr dating studies of the igneous rocks in this area should include samples of this gabbro.

Trondhjemite dikes have been noted in road cuts at (864 598). The presence of dikes and larger bodies (see Foslie's maps of trondhjemite in the gabbro) suggests that the gabbro is younger than the trondhjemite.

Along the E6 west of Fiskumfoss the gabbro is exposed within a few tens of meters of its contact with greenstones. Near the contact the gabbro has a strong foliation defined in hand specimen by 1-4 mm. flattened white feldspar grains in a matrix of very fine-grained amphibole (0.1 - 0,5mm.) with a preferred orientation. The feldspar grains are an aggregate of anhedral crystals with inclusions of microcrystalline epidote. In other words, the rock appears in both hand specimen and thin section to be a strongly tectonised gabbro and is interpreted here as a likely candidate for a "pre-or-syn-metamorphic mylonite". (see specimen 1122/69).

The trondhjemite on Maps 1293-01 and 1293-02 is part of the Sanddøla trondhjemite complex. The trondhjemite has not been investigated in detail and the following observations are based mainly on observations around the contact and several traverses across the pluton. The trondhjemite is generally medium-grained (2-3 mm.) but finer and coarser grained sections have been noted. The colour is variable from deep to pale epidote green in epidotized areas, e.g. east of Møklevann, to greyish white in areas that have not been affected by epidotization. Sodic-plagioclase, quartz, hornblende and epidote (where the rock is epidotized) are the main minerals. Accessory minerals are sphene, chlorite, pyrite and zircon.

The area northeast of Elstad farm (Map 1293-02) is a hybrid zone in which a large raft of metasediment with crosscutting trondhjemite dikes occurs within, and appears to be surrounded by, trondhjemite. These metasediments are now quartz-biotite schists with a strong regional fabric and a distrupted but distinct compositional layering (see Plate 2A). Small outcrops of fine-grained gabbro are also present in this area. Immediately south of the above metasediments there is a zone of basic volcanics and trondhjemite in which the trondhjemite varies locally from 20 to 80%; this area probably represents the roof zone of the trondhjemite.

The intrusion of the trondhjemite predates the development of the regional fabric in the area since the foliation and schistosity in the metasediments and the basic volcanics is parallel to the schistosity in the trondhjemite. Small trondhjemitic veins, 10cm. thick, cut across and appear to postdate the regional fabric in several places in the greenstone + trondhjemite area — these are post-S_1 and are considered to represent a mobilization of the trondhjemite during later, post-S_1, deformational events.

The contact between the trondhjemite and greenstones in the area NE of Elstadelven appears to be a thrust which has been modified by post-metamorphic faulting. Mylonitized trondhjemite occurs at the base of the cliff (771 482) north of Elstad farm, at (608 585) and in Elstadelven immediately south of Map 1293-02. Quartz-sericite schists at (815 479) and (669 576) appear to be strongly mylonitized trondhjemite. In addition the trondhjemite near the greenstone contact in the vicinity of (608 585) is more schistose and finer grained than that found several hundred meters from the contact. This suggests that the trondhjemite has a pre-or-syn-metamorphic thrust contact with the greenstone. In other places, e.g. (728 531) and along this contact to the SE, the trondhjemite can be seen to have a vertical, post-metamorphic contact with the greenstone due to late faulting. The presence of outcrops of trondhjemite overlying calcareous semipelites along the road to Møklevann immediately south of Map 1293-02 lends further support to the interpretation of the trondhjemite as part of a major thrust sheet that has been emplaced over the metasediments and metavolcanics prior to the development of the regional schistosity since there is no evidence of pre-S_1 contact metamorphism in the sediments. Modification by late faulting has resulted in confusing contact relationships elsewhere along the contact which can be followed as far as Langtjern (Map 1293-06).

Structures:

Primary structures:

These include pillow lavas and agglomerates in the amphibolites south of Hotjern and bedding which has been observed in a number of places within the calcareous sediments. No primary structures have been observed in the trondhjemites. The gabbros have not been investigated in detail but primary structures other than veins of fine-grained gabbro cutting medium-grained gabbro have not been observed in the exposures examined.

Secondary structures.

The earliest deformational episode recognized on the Harran map sheet is that associated with the problematical pseudo-conglomerate underlying amphibolite at Killingberget and at (0720 0525). A thrust plane has not been placed at the position of this conglomerate since as mentioned earlier there are some exposures which do have the characteristics of flattened conglomerates; it is best to await a detailed examination of this unit before establishing such an important thrust plane in the area since the tectonically induced fragmentation observed could be merely local movements. The mylonitic zone observed in the road cuts near the gabbro contact SW of Fiskumfoss also predates the earliest penetrative regional fabric and lends considerable weight to the interpretation that the earliest deformational episode in this area was large-scale low-angle thrusting.

The first deformational event (D_1) has produced tight to isoclinal folds, F_1, a mineral lineation and a penetrative regional schistosity, S1, which is developed throughout the Grong area and has affected most, if not all, of the rocks including the gabbro and trondhjemite (small dikes of diabase do, however, post-date this regional deformation, e.g. in the Møklevann area).

In general the S_1 is axial planar to F_1. Examples of the S_1 - F_1 relationship can be seen along the banks of the Namsen river, south of section B-B[1] on Map 1293-01, when the water level of the river is low (see Fig. 2).

One of the difficulties in mapping in this area is the pervasive nature of S_1. In many instances, especially in the calcareous sediments and the amphibolites, it is not possible to determine whether the layering in the rocks is primary (bedding) or tectonically induced. Layering that appears to be bedding has been observed in the sandstones along the road south of Rosset, in the arkosic unit at (0640 0566), and along the E6 to the east of Gartland. Elsewhere, especially within the metasediments, the layering is probably tectonically induced. This is quite clearly demonstrated in exposures of metasediment in Elstadelven at the south boundary of Map 1293-02 (see fig. 3).

F_1 folds are rarely distinguishable but have been recognised in the amphibolites, calcareous sediments and the arkoses. Generally only the tight to isoclinal hinges are preserved and the limbs are sheared out. Complete folds with extremely attenuated limbs are to be found in the river bed (when the river is low) at approximately the location of section $A-A^1$ where a thin amphibolite layer has been folded together with calcareous psammites. Where discernible the F_1 folds have east-west striking hinges. Although a major F_1 structure is thought to be present (NGU Rapport 1122A), there is little concrete evidence to prove the existence of this structure even though it has considerable merits for the regional interpretation.

Asymmetric S- and Z-type folds are present in a number of places (in amphibolites at section $A-A^1$, along the shore of the Namsen, at (0638 0567) and in the area south of Miganbekken). These structures fold S_1 and almost invariably have an axial plane cleavage which has gentle to moderate dips (40^o-50^o). The axial plane cleavage of these folds does not appear to have been deformed, but their age relationship to the F_3 folds is not known since the two have not been observed in the same exposure. These folds probably represent a phase of folding which postdates F_1 but predates F_3 since a major post-F_2 folding to produce the minor structures would have affected the F_3 axial plane cleavage to greater extent than the open warps observed on the F_3 cleavage. In addition it is reasonable to expect that if the F_3 postdated these assymmetric folds then its open to close folding should only perceptably affect an earlier phase when the earlier structure occurs in the hinge of F_3. This episode of folding is tentatively assigned to a second deformation, D_2.

The third deformation, D_3, produced open to close folds with a northeast-southwest strike. A vertical to steeply dipping axial plane cleavage is usually associated with these folds. A major synform and antiform of F_3 age is present in the Killingberget area. Smaller scale F_3 folds with wavelengths of 50 - 100m. are present in the metasediments southeast of Rosset and along the forestry road east of Hotjern.

Small open folds with northwest-southeast striking hinges and vertical axial planes are developed in metasediments along the railway line at (0603 0281) and along the shoreline of the Namsen between profile A-A[1] and B-B[1]. These folds are also developed elsewhere (Map 1293-03) and produce eye-folds where they interfere with F_3 structures,and although they post-date the F_3 structures they are considered by the writer to represent the same deformational episode as that producing F_3. These structures are referred to here as F_4 folds of D_3 age. The development of the F_3 and F_4 structures was probably related to differential basement uplifts during the end stages of the Caledonian orogeny.

The final stage of the non-brittle folding observed in the area is the development of small-scale recumbent folds, F_5, with amplitudes of a few tens of cms. These folds are characterized by the presence of a sub-horizontal cleavage. These folds are only present on the flanks of major F_3/F_4 structures. They are well developed in the "conglomeratic" rocks in the vicinity of (0655 0405). (see fig. 4).

Faults and thrusts.

Vertical to steeply dipping fault planes are common in the area and these structures commonly control the drainage patterns. In most cases the measureable displacement on these structures is in the order of a few meters.

The essentially straight boundary of the amphibolites against the sediments on the east side of Killingberget is difficult to reconcile with the presence of F_3 major fold structures in the amphibolite. Furthermore there does not appear to be a continuation of the amphibolites across the Namsen river to the NE of Hotjern; the area where a possible extension could lie is,however,extensively covered by marine clay. An interpretation favoured by the writer is that there is a major fault along the amphibolite border – this postulated fault would be the extension of the Trangen thrust zone (see later).

The structural relationship of the rocks in the area south of Rosset at the end of profile B-B[1] is not clear. The amphibolites are obviously folded into an F_3 antiform and the area has been disturbed by faulting. The structural development of the poorly exposed sedimentary "embayment" is not clear.

The boundary between the trondhjemite and greenstones is clearly a fault contact and can easily be observed in a number of places,e. g. on profile C-C[1] and in a small brook at (0632 0579). This is a late tectonic feature since the fault zone is marked by gouge. Both east and north of Elstad farm the trondhjemite has a distinct foliation and has been brecciated prior to the regional metamorphism. This was orginally interpreted as a volcanic phenomena; however, a reexamination of the area and further observations elsewhere along the contact have revealed that these rocks represent an early, pre-S_1, thrust zone.

Mineral occurrences.

The main mineral occurrence on Map 1293-01 and 02 is the Hotjern deposit. This deposit consists of a thin zone of disseminated and massive sulfides associated with keratophyre and minor volcanic sediment which structurally underlie a zone of pillow lavas and agglomerate that can be followed along strike to the southeast.

A small deposit of pyrite with a trace of chalcopyrite occurs as small veins and lenses in amphibolites approximately half way up the waterfall on Miganbekken.

Massive and disseminated pyrrhotite mineralization is to be found in a 5 cm long road cut about 4 km. north of Gartland. Several massive pyrrhotite bands are over 30 cm. wide and the total width of the mineralization is about 15m. Only pyrrhotite and pyrite have been observed in the exposures and in hand specimens. Specimens analysed for Ni and Cu contained less than 0.1% of the metals. The host rock to this mineralization appears to be an amphibolite derived from a basic volcanic rock. Metamorphic grade of both the mineralization and the amphibolite is at least garnet amphibolite and although the sulfide could have been introduced as a result of metamorphic mobilization the presence of garnet porphyroblasts indicates that it has been metamorphosed and predates at least the end stage of the metamorphism.

Despite the absence of Ni or Cu in the sulfide the writer considers this occurrence worth further investigation by geophysical methods (VLF??) since the sulfides are probably related to the pre-metamorphic intrusion of the large gabbro mass situated about 150m. to the east.

Although a definite relationship between the gabbro and the pyrrhotite has not been established the gabbro should be seriously considered as the source of the sulfide mineralization.

3 GRONG MAP SHEET (1823 IV)

The geological maps 1293-03 and 04 cover the northern part of the 1 : 50,000 map sheet. Additional reconnaissance mapping carried out in the previously unmapped gneissic terrain outside the area covered by these 1 : 20,000 maps will be presented on the 1 : 50,000 preliminary map sheet now in preparation.

The gneissic rocks which structurally underlie the metasediments and metavolcanics are considered to be the oldest rocks in the area under discussion; they do, however, overlie the granitic gneisses observed on the north side of the Luru river (i.e. south of Map 1293-04). With the exception of widely scattered 1-2m thick amphibolitic layers which could represent basic dikes, the gneisses are of acidic composition with feldspar (Na-and K-varieties), quartz, biotite and/or muscovite as the main mineral constituents. Garnet and hornblende are minor constituents in several places.

The gneisses can be separated into two poorly defined units - a " layered gneiss" and an "augen gneiss" - which grade into each other. The augen gneiss is a medium to coarse-grained reddish- or greyish coloured gneiss with albite and K-feldspar porphyroblasts that are generally 2-3cm. , but can be up to 10 cm in diameter. The size of the porphyroblasts decreases gradually as the contact with the meta-sediments is approached. Distinct compositional layering, considered to represent bedding, includes a quartz-biotite schist (0330 1100 on Map 1293-04) and quartzite layers (0431 0212) at Grong village and along the E6 about 1 km. south of the new bridge at Formofoss.

"Layered gneisses" structurally overlie the augen gneisses and are found directly underlying the garnetiferous quartz-mica schist. They form the upper 200 - 300 meters of the gneissic unit. In the upper parts the layered gneisses have a distinct compositional banding which varies from less than 1 cm. to several tens of meters in thickness. The layers include greyish quartzite, micaceous quartzite, reddish fine-grained quartzite/leptite, medium-grained massive arkose, mica schists (generally only a few tens of cm. in thickness) as well as fine to medium-grained quartz-feldspar schists, with 5-20% feldspar porphyroblasts 0,5 to 1 cm. in diameter, which are often interlayered with the other rock-types.

The presence of quartzite layers in coarse-grained porphyroblastic gneiss, the increase in quartz in the upper levels of the gneissic unit,i.e. the "layered gneiss", and the marked increase in the mica schist layers near the contact with the garnetiferous quartz-biotite schist unit suggests that most of these gneisses are strongly deformed arkosic sediments.

The writer has observed that the size of feldspar "augen" increases steadily southwards from Nyneset (Map 1293-04) as far as the Medøla river valley but south of this valley the acidic gneisses change abruptly to non-porphyroblastic medium grained-gneiss which structurally underlie the porphyroblastic gneisses and thus form the basement in this area. These basement gneisses form part of "Olden nappe and lower units" (Gee, 1974 NGT) or "Oldendekket" of Oftedahl (1956). Although I have not studied the boundary between the "augen gneisses" and the "granitic gneisses", it is clear that this boundary represents either the contact between a Precambrian granitic basement and its Eocambrian (?) sedimentary cover,or a major structural contact. The latter interpretation would be consistent with the interpretation of Oftedahl (1956) and Gee (1974) who place the boundary of the "Seve Nappe" in the gneisses rocks south of Sanddøla,but differs in detail in that if the boundary in question is a structural one then the nappe boundary must be placed farther south than shown by Oftedahl (1956),i.e. the northern contact must lie along the valley of the Medøla river in the area south of Nyneset and at the contact between the "augen gneiss" and "granite gneiss" elsewhere.

A unit of metasediments comprised mainly of quartz-biotite schists in which the biotite has a characteristic reddish brown colour overlies the basement gneisses with which they appear to have a gradational contact. (see above). The metasediments have a gradational contact (over a few meters) with the overlying "lower amphibolite". Since these schists are always found overlying the gneisses and underlying amphibolites or greenschists, can be traced northwards into the Harran map sheet (Birkeland, 1958), and occupy the same stratigraphic position as the "mica schist, often with garnet" mapped by Roberts (1968),this unit is tentatively named the Namsen formation since the best exposures are to be found in road cuts along the Namsen river immediately north of Grong railway station. The base of this formation and most of the estimated 200m. thickness are exposed in the road cuts beginning at (0510 0295):, the upper contact is not well exposed but can be closely approached in a brook at (0238 0578) and elsewhere along the contact with the lower amphibolite to the west and northwest of this locality.

The quartz-mica schists are variable in that they consist mainly of interbanded quartz-rich biotite schists (75% quartz, 25% biotite) and quartz-poor biotite schists (25% quartz, 75% biotite). Impure quartzite horizons are present in exposures along the Namsen river north of Grong station. Amphibolite horizons up to one meter thick, and amphibole porphyroblasts are present near the contact with the overlying lower amphibolite.

Quartz and biotite are the main minerals present and together constitute more than 95% of the rock. Garnet, kyanite and hornblende porphyroblasts are present at a number of localities. In general the garnet and kyanite porphyroblasts occur mainly near the base, while hornblende, which is most abundant adjacent to the amphibolite contact, also occurs throughout the formation. The garnets are usually 2-3 mm in diameter but crystals greater than 1 cm. are common. Kyanite crystals are commonly acicular(0, 1 x 1 x 5 cm.) and exhibit radiating star-like crystal forms nucleated on earlier garnet porphyroblasts. Garnet, kyanite and hornblende porphyroblasts overgrow the schistosity.

Quartz segregations and boudins are common but are most profuse in the lower part of the unit north of Grong station. They are aligned within the regional schistosity and often resemble deformed quartz veins. (see Plate 3A, Rapport 1122A).

The distribution of the Namsen formation in the vicinity of Rossettjern is not clear due to the extensive coverings of marsh in the area between Aanestjern and Rossettjern. Outcrops of garnetiferous mica schists were found at (0295 495), in the brook north of Rossettjern and at (0390 0463). R. Kvien (pers. comm. 1972) found a small outcrop of marble at (0348 0453) which suggests that the metasediments continue uninteruptedly between Aanestjern and Rossettjern. The micaschists south of Aanestjern appear to be in fault contact with the gneisses which must pinch out somewhere near Rossettjern. No exposures of mica schist were observed between the north-south striking gneisses and the east-west striking amphibolites in the area east of Aanestjern and Rossettjern. The existence of a fold structure as suggested in Rapport 1122A mapping is unfounded both from the attitudes of layering and the distribution of outcrops. Furthermore,it cannot be demonstrated that there is a continuation between the mica schists in the brook north of Rossettjern and the metasediments to the east of Tangen (map 1293-04) – indeed a direct continuation is highly unlikely since the metasediments underlying the limestones to the east of Tangen are of lower metamorphic grade.

The metasediments underlying the limestone horizon (Map 1293-04) can be followed continuously along the Sanddøla valley. These rocks probably overlie the gneisses, although the contact is not exposed anywhere along the valley which has a thick cover of glacio-fluvial deposits. Strongly disturbed metasediments at (0322 0631) indicate that at least locally this contact is faulted.

A striking feature of the metasediments on Map 1293-04 is the lower metamorphic grade in comparison to that on Map 1293-03 even though they are found at the same stratigraphic level, i.e. below a limestone, and should therefore belong to the Namsen formation. East of Tangen this unit consists mainly of semi-pelites in which psammites and phyllites are common. Phyllites appear to be more abundant eastwards especially near Nyneset.

Kyanite has not been found east of Tangen. Small garnets (2-3mm.) are found in several places but these are extremely rare east of the road to Stamtjern. Biotite is the chief metamorphic mineral. Quartz-lenses and boudinaged quartz veins have not been found in the metasediments east of Tangen. A mylonitic zone marks the contact between the northerly striking gneisses and the westerly striking metasediments (0276 0554) and translation on this fault zone probably accounts for the marked difference in metamorphism found over a distance of about 2 km. in the vicinity of Tangen.

A 5-10m. thick limestone horizon occurring at the boundary between the semipelites and the volcanic rocks can be traced all the way across Map 1293-04 and can be followed intermittently along the contact between the Namsen formation and the amphibolites on Map 1293-03 where it occurs a few meters inside the amphibolite unit. The thickness of the limestone is fairly uniform. The limestone is often banded, recrystallized and has a poorly defined schistosity defined by the alignment of mica and quartz grains. The colour varies from white to blue-grey, the latter colour being imparted by fine-grained disseminated phyllite.

The dominant volcanic rocks on Map 1293-03 are amphibolites. These are dark green, often schistose and generally have a fairly well-defined compositional layering. Undoubted volcanic structures have not been found in these rocks and in many places the continuity of layering suggests a largely volcano-sedimentary origin (tuffaceous?). In many places quartz-rich amphibolite layers are abundant and most likely represent clastic detritus, while in others the layers are composed almost entirely of hornblende and thus could represent basic tuffs, lavas or even sediments. In general the layering in these amphibolites is less than 0,5 m. thick and massive amphibolite layers (several meters in thickness) typical of metamorphosed lava flows have not been observed.

Thin quartz-keratophyre bands, 0,1 to 1 m. thick, occur west of Kultjern, at (0300 0400), and in the brook north of Rossettjern. Keratophyric rocks are also present in the vicinity of the Rosset mine and a number of thin horizons were intersected in boreholes there. A 10 to 15 m. thick keratophyric horizon is present at (0527 0424). These keratophyric layers are parallel to the layering and/or foliation in the enclosing amphibolites and maintain a uniform thickness along strike; these rocks are probably of tuffaceous origin since acidic lavas tend to form thick domes with a limited lateral extension.

As mentioned above, the amphibolite appears to be gradational with the underlying metasediments of the Namsen formation although the actual contact has not been observed. The "upper" contact of the amphibolite, i. e. its relationship with the calcareous psammites is more complicated and confusing.

South of Fosland the "lower amphibolite" (see section 2) is overlain by about 25 m. of impure grey to greyish white quartzite with minor interbanded semipelite. A 5 m. thick quartzite layer at the same stratigraphic layer occurs at (0482 0305) south west of Renslitjern. Thin quartzite horizons are present on the NW bank of the Namsen river to the NNE of Fosland on the Map 1293-01 but do not occur above the "lower amphibolite" exposures at Miganbekken. Quartzites have not been found at any other places where the amphibolite is in contact with the calcareous metasediments.

The relationship between the amphibolites and the conglomerates and psammites at Renslitjern are not clear. South of Renslitjern the amphibolite appears to be folded into the metasediments. Both the upper and lower contacts between the metasediments and amphibolites east of Tømmeråsseter are unexposed. Strikes of foliations in the sediments and amphibolites are parallel, although the eastern of these contacts runs along a small valley which could represent a small fault zone. Northeast of Renslitjern the contact is probably steeply dipping since strikes and dips are similar on both sides of the contact which runs along a small ravine 5 - 10 meters in width. The apparent conformity of strike and dips along the contact is not consistent since in a good exposure at (0470 0355) the foliation in the amphibolite strikes into the sediments (this outcrop is,however,about 40 meters away from the actual contact).

The two small isolated occurrences of amphibolite NW of Renslitjern are caps of amphibolite on small hills. These are underlain by thin "conglomerate" horizons and occupy the same position as the "upper amphibolite" at Killingberget (Harran Map sheet).

Relationships between the calcareous sediments and the amphibolites in the Rosset area is extremely uncertain, despite the detailed mapping carried out there in 1972 by R. Kvein, due largely to the presence of considerable overburden in the area.

The most westerly contact of the Rosset sediments,i.e. that which runs through (0500 0434), is easily followed both to the north and to the south this locality. The contact is steeply dipping and foliations in both the sediments and the amphibolites are more or less parallel,and since there is no evidence of layering adjacent to this contact it is quite possible that it is a tectonic contact. The contact at the West Rosset mineral occurrences is regionally parallel to the strike in the sediments and amphibolites; however,this contact was observed at (0430 0440) where it is clearly disjunctive. The nature of the contact in the vicinity of (0531 0463) is not known. The presence of sediments with "conglomeratic" blocks along this part of the contact suggests that the amphibolite, which appears to be relatively flat-lying in the few exposures present, is overlying the sediment — this area is, however, so poorly known that this "suggestion" is little more than speculation.

The tongue of sediment extending southwards towards Rosset grube is exposed in a small valley. The west side of this valley is completely covered so that the relationship between the sediments and amphibolites on the west contact of this "tongue" has not been observed. On the eastern contact of this "tongue" the sediments appear from a number of exposures to underlie the amphibolites and a thin "conglomerate" is found close to the contact. The sediments here are exposed in the bottom of the valley and the amphibolites on the hillside to the east. Both rock types dip at about 40 degrees to the east and thus there is little doubt that the amphibolites in which the Rosset deposit occurs are overlying the sediments. The amphibolite unit in which the Rosset deposit occurs can be followed northwards and appears to be continuous with the amphibolites which are shown on the map as swinging around from north striking to west striking. The contact position is based on the presence of several isolated outcrops and no hinge zone has been observed in the field. In addition, the best exposures of this unit, in a small brook are strongly tectonized and bear more resemblance to a tectonized gabbro than an amphibolite. It should therefore be borne in mind that the representation of a fold closure in the area (0574 0476) may not be correct.

The relationship of the amphibolite to the sediments and conglomerates occurring to the NE of the Rosset mine is not clear. The calcareous semipelites and psammites have an overall easterly dip. The sediments in the vicinity of the contact are tectonized and in several places there is a clear discordance of schistosity across the contact.

The strike and dips in the sediments could be interpreted as an indication that the sediments and conglomerate overlie the amphibolite. This interpretation would appear to be conformed by the presence of several meters of sedimentary rocks at the top of a diamond drill hole (DDH 2) which penetrated the amphibolites below the sediments.

A fault can be traced along this contact; this is,however, a late deformational event. A small outcrop near DDH 2 indicates the presence of a possible slide zone/mylonite zone at the sediment-amphibolite contact.

The metasediments occurring to the NE of the Rosset mine are a continuation of those occurring on Maps 1293-01 and -02, i.e. they are calcareous psammites and semipelites. The sediments adjacent to the amphibolite contact in some places, especially near DDH3, contain hornblende crystals and garnets — these minerals have not,however, been observed in the calcareous sediments away from the contact. The relationship between the sediments and the Brynntjern gabbro is not known since the contact is not exposed and small outcrops of amphibolitic rock near the contact could be either metavolcanics or metagabbro.

The westerly striking volcanic sequence on Map 1293-04 is separated from the northerly striking basic volcanics of the Rosset area by the Trangen-Rossettjern gneisses. The contact between the westerly striking metavolcanics and northerly striking gneisses is not exposed but is assumed to lie along the northwards continuation of the thrust plane observed at Trangen. The volcanics are bounded by the limestone horizon to the south and gabbro and trondhjemite to the north.

The volcanic rocks consist predominatly of greenstones, greenschists and amphibolites. Acidic tuffs and lavas are scattered throughout the sequence but are a common rock-type only in the vicinity of the Skiftesmyr mineral deposits, southwest of Møklevann. Quartzite horizons, generally discontinuous, are present in the dominantly greenschist terrain in the area around Angeltjern and Stortjern.

Fine-grained basaltic lavas in which flow boundaries can occasionally be observed, occur mainly in a narrow belt which can be traced from near Stamtjern eastwards to the eastern boundary of Map 1293-04. The best exposures of these lavas are to be found in the areas west and east of Angeltjern. Isolated, fine-medium-grained,massive greenstones are present in the dominantly greenschist terrain to the south of this belt of lavas. Massive greenstone lavas are common in the area west and northwest of Stamtjern but are most abundant near the contact with the gabbro south of Bryntjern, where they are mixed with tuffaceous greenschists. Poorly developed "pillow-like" structures were observed in one small outcrop northwest of Fiskløsa.

Acidic rocks outside of the Skiftesmyr area are generally less than 2 m. thick, strongly schistose and are best described as quartz-sericite schists. Since primary volcanic structures have not been observed in these rocks and they maintain a uniform thickness along strike — usually they can only be followed for a few tens of meters — they are considered to be of tuffaceous origin. Massive keratophyritic rocks with a weak schistosity, e.g. at (0455 0600), are rare and could be either lavas or fine-grained trondhjemitic dikes.

Acidic rocks which locally attain thickness of several tens of meters are common in the vicinity of the Skiftesmyr sulfide deposit. Horizons of schistose acidic rocks, 1 - 2 m. thick, are more common in the volcanic rocks occurring north of the Stamtjern trondhjemite than in those to the south of that intrusive body. The acidic rocks near the Skiftesmyr deposit appear to be thicker than those which occur along strike to the NE towards Møklevann and along strike to the SW towards Stamtjern — exposures are sparse and generally only 1 - 2 m. in this area even where the trees have been harvested and it is usually difficult to estimate the true thickness of an acidic rock observed in small exposures under blownover trees. The writer considers this decrease in thickness as well as the more schistose nature of the acidic rocks away from the Skiftesmyr area to imply that the Skiftesmyr area acidic rocks are mainly lavas while those to the NE and SW are probably largely of a tuffaceous origin. This would,furthermore,imply that the Skiftesmyr area is probably close to the volcanic vent producing these acidic rocks.

The volcanic rocks NW of Stamtjern contain a number of exposures of acidic rocks; one of these is at least 10 m thick and appears to be a lava — others that are schistose and probably of tuffaceous origin are too small to show on the map. This area may also represent a vent environment and should be closely considered as a potential mineralized area.

The basic volcanic rocks north of the Stamtjern trondhejmite differ from those to the south mainly in that they contain less clastic material (basic volcanic sediment) and as noted earlier have relatively more acidic lava. Volcanic sediments do, however, occur in the area south of Sandtjern and north of Langtjern. In the area south of Sandtjern these sediments are mainly interbanded, greyish-coloured, quartz-rich and amphibolitic layers. The quartz-rich layers are usually 1 - 4 cm. thick while the amphibolite layers are from 1 - 30 cm. thick. Sandstone layers have been observed only at (0507 0768), a 1 $m.^2$ exposure, in the area south and southwest of Sandtjern.

Sandstones and sandy phyllites are also present in several exposures near (0507 0768) on Map 1293-04. The other rocks in the immediate vicinity are a mixture of clastic sediment derived from a basic volcanic source and schistose basic rocks that are interpreted as basic tuffs.

The majority of the basic volcanic rocks north of the Stamtjern trondhjemite are banded and/or schistose, are generally low in quartz and consist mainly of amphibole; These rocks are considered to be mainly basic tuffs deposited in an aqueous environment. Well-banded, quartz-rich amphibolitic rocks interlayered with light green phyllitic rocks, e.g. in the brook at (0351 0658) and immediately north and west of Langtjern, are basic volcanic sediments. Attempts to map out individual horizons of volcanic sediment and tuffs have not been successful due to the sparsity of outcrop and the impossibility of distinguishing between different units of tuffs and between different units of sediments.

In the area north of Langtjern (0525 0862) it could be seen from several small exposures that the volcanism in this area was cyclical. At this locality a sequence from east to west consisted of massive amphibolite (lava) - basic pyroclastic - basic tuff - acidic tuff (40 cm. thick) - massive amphibolite (lava) - basic tuff. In several other exposures in this area it was noted that the acidic lavas-tuffs were often underlain by schistose, fine-grained, basic rocks (tuffs). This relationship could have a direct bearing on prospecting in the area since the tuff horizon underlying the acidic tuff at (0525 0862) contains 10 - 15% pyrite and about 2% chalcopyrite over a thickness of about one meter; the rocks underlying the other acidic rocks do not contain visible mineralization.

The rocks bounded by the limestone, and the Stamtjern trondhjemite or the unit of massive lavas are mainly schistose layered tuffs and volcanic sediments – these are referred to collectively here as greenschists; however,they do contain hornblendic rocks, amphibolites, in several places,e.g. north of Trangen and north of Godejorde. Massive basaltic lavas several meters in thickness as well as 1 - 2 m. thick schistose keratophyric layers are scattered throughout this unit of greenshists. Basaltic fragmental rocks and quartzitic layers are also present.

Strongly deformed fragmental rocks (pyroclastics?) occur adjacent to the unit of massive lavas and in several small exposures about 50 m. north of the Godejorde deposit. These rocks consist of basic volcanic fragments, approximately 10 cm. in length, that have been flattened in the plane of the regional foliation. In the area west of Fiskløsatjern, fine-grained layered tuffs have widely scattered fragments – pillow-like structures were also observed in this area.

The tuffaceous rocks are dark green to green in colour, comprised mainly of amphibole (tremolite and/or hornblende), have a strong schistosity and are usually layered but only rarely exhibit distinct compositional banding. These rocks are most abundant in the northern part of the greenschist unit but are also found throughout the southern part of the unit where they are less abundant than the volcanic sediments.

The volcanic sediments are generally well layered where they are quartz-rich and medium-grained, e.g. at the west end of Stortjern. The green-coloured phyllitic rocks contain thin (2 - 5 cm.) layers of quartz-rich sediment which enhances the recognition of their sedimentary character (e.g. along the forestry road to Stamtjern). The separation of the greenshists into clearly tuffaceous and clearly sedimentary units has not been possible since, as one can reasonably expect, there is no reliable criteria for the separation of poorly layered, deformed waterlain tuffs and clastic sediments derived from the same basaltic volcano when the rock is fine-grained, devoid of fragments and low in quartz. With the recognition of both tuffs and sediments throughout the greenschist unit the best that can be done with these rocks is to separate them into a northerly tuff-dominant zone and a southerly sediment-dominant zone. The placement of a contact between the two zones would be a misrepresentation of the geology in this area. Thin keratophyric layers (tuffs?) are present throughout the greenschist unit and occur within 50 meters of the limestone horizon north of Nyneset.

In the vicinity of the Godejorde sulfide horizon, especially immediately south of it, there are several horizons of "garben schiefer" which can be up to 50 m. thick. These are layered calcareous sediments consisting mainly of quartz, randomly oriented hornblende porphyroblasts, calcite and occasional garnet.

The quartzite is a greyish, fine-to medium-grained rock containing quartz, minor feldspar, and magnetite (5 - 15%). A unit at Stortjern with a thickness of 3 - 5 m. can be followed for a distance of about 1,5 km. along strike. Thin layers at (0406 0730), (0434 0775) and (0400 0740) could not be followed beyond the immediate exposure. A quartzite lense, 10 x 0,5 m., at (0393 0707) appears to be a continuation of the horizon overlying the Godejorde mineral occurrence.

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 near Møklevann. Several small exposures of a medium-grained basic rock resembling gabbro occur along the northern contact of the trondhjemite body at Stamtjern. This area was previously considered to contain a single gabbro body (Rapport 1189); however, a reexamination of the area revealed that it is underlain by basic lava and tuffs which have been intruded by gabbroic dikes.

The basic intrusive at Bryntjern is mainly fine-grained and holocrystalline. The rocks are metamorphosed and the original minerals have been intensely altered. The interior of the body has zones that are medium-grained and so it 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 centre. The contact with the metasedimentary rocks in the northwest corner of Map 1293-04 is not exposed but there appears to be a fault boundary running along a topographic depression. The southeastern corner of the gabbro appears to be intruded into the basic lavas and tuffs. Further southwest the contact is situated close to a cliff and is probably a fault.

The gabbro 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 at least some of the diabase is later than the regional fabric in this area.

Although age relationships of the intrusives to the other rocks in the area have not been definitely established, several features point towards a post-greenstone age for the gabbro and trondhjemite: (1) dikes of gabbro cut the volcanics; (2) dikes of trondhjemite intrude the gabbro; (3) rafts of basic rocks considered to be volcanic in origin occur within the trondhjemite; and (4) the Stamtjern trondhjemite intrudes the basic volcanics.

The largest intrusive mass in the map area forms part of the Sanddøla trondhjemite. The trondhjemite is medium-grained and often pinkish coloured but with large areas that are pale greenish due to strong epidotization. The rock consists mainly of quartz, albite, biotite, hornblende and epidote. Calcite, zircon, apatite, sericite and pyrite are minor constituents. The greenish areas are 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 holocrystalline mass with a pronounced schistosity which is so well developed in some places that the rock resembles a quartz-rich schist. Along the Stamtjern road the northern contact is diffuse and consists of lenses of trondhjemite intruded into basic volcanics. The contact at Langtjern and west of it is strongly cleaved and is marked by a sharp escarpment which represents a fault zone.

South of Langtjern this rock resembles 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 gabbro is intruded by the trondhjemite.

The south 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 tectonised greenstone near the contact where it crosses the Møklevann road indicate that faulting has occurred along this contact.

Both the trondhjemite and the gabbro were deformed by the regional foliation and thus must have been intruded prior to the onset of the first regional deformational event which is dated as occurring in the Early Silurian (Wilson et al. 1973 NGU). Priem et al. (1968, Second Progress-report on the isotopic dating project in Norway) report an age of 504 ± 30 m. yrs. for the Sanddøla trondhjemite obtained on biotite using the Rb-Sr method. This age, if true, would make the Sanddøla trondhjemite considerably older than the trondhjemites in the Trondheim area and would thereby place the minimum age of the volcanism as being earliest Ordovician. This age is, however suspect (Råheim, pers. comm. 1975) since it was calculated using an assumed initial $^{87}Sr/^{86}Sr$ ratio.

Structures

No undisputed primary structures have been found on Maps 1293-03 and 1293-04. Interbanded quartz and phyllitic layers in the basic sediments at the west end of Stortjern (1293-04) are thought to represent graded bedding but the strong schistosity in this area makes the recognition of "cut-offs" in these rocks very uncertain.

Minor structures on Map 1293-03 have the same styles and age relationships as those on Maps 1293-01 and -02. D_1 structures include rotated garnets in layered gneisses at (0500 0200) and boudinage structures in layered amphibolites on Tømmeråsfjellet (see Rapport 1122A).

The correlation of minor structures between Maps 1293-03 and 1293-04 is complicated by the abrupt change in the strike of S_1 from N-S on most of Map 1293-03 to E-W east of the gneissic rocks at Aanestjern and on Map 1293-04.

F_1 folds have been recognized in several places on Map 1293-04; the best examples are at (0577 0862), Møklevann, where layered greenschists and a "blåkvarts" layer are folded into isoclines.

F_2-type minor folds are present on Map 1293-04 but are not as common as on maps 1293-01 and -03. One of the difficulties in recognizing F_2 structures on Map 1293-04 (and the area to the east) is the rotation of F_2 folds into an attitude similar to that of the later F_3 structures so that S-type F_2 structures have vertical axial plane cleavage. The best, yet usually unsatisfactory, criterion for distinguishing F_2 folds is the tendency for their hinges to plunge more towards north than the F_3 folds which almost invariably plunge toward the NE. Z-type F_2 folds are easier to identify since their axial planes, although also vertical to steeply dipping, have a westerly or northwesterly strike — these folds are not F_4 structures since they are quite different in style.

F_2 minor structures are most common in the vicinity of Skiftesmyr and north of Langtjern. It has not been possible to establish a major fold structure.

On the basis of the prevalence of S-type folds at Langtjern (0500 0910, see page 30 of Rapport 1189) with an axial plane subparallel to the folded S_1, and along the road to Berg on Map 1293-05 where the axial plane is less steeply dipping than S_1, it is possible to conclude that the rocks south of Skiftesmyr on Maps 1293-04 and -05 occupy the lower limb of a major N-to NE-trending F_2 antiform — the closure of this structure is unknown.

F_2 minor folds with northerly plunging hinges are common in both the amphibolites and the sediments on Map 1293-03; however, no major F_2 structures have been identified.

F_3-type minor folds similar to those described for Maps 1293-01 and -02 are present on Map 1293-03. The change in the strike of S_1 from NW south of Aanestjern to north in the area west of Rossettjern is attributed to the presence of a major open F_3 fold with a northeasterly trending axis. Other examples are to be found at
Stamtjern and in a small outcrop near the western extension of the Godejorde sulfide horizon at (0625 0380). In the latter example where the fold is developed in banded (2-5 cm) quartz-rich and pelitic schists, there has been a growth of biotite porphyroblasts along the axial plane within the pelitic layers.

Open,northwest-trending,F_4 minor folds and a major structure are well-developed in the vicinity of Renslitjern (1293-03). The change in attitude of S_1 from westerly striking southwest of Skiftesmyr to southwesterly striking at Møklevann is attributed to a major F_4 synform since small F_4 folds are common in the area west of Møklevann and in the vicinity of Skiftesmyr near the hinge of the fold. A complementary open F_4 antiform is present in the Stamtjern area where the S_1 again becomes more southwesterly striking.

Late faults along which there has been relatively little displacement are common. They are commonly marked by topographic depressions which are partially filled with alluvium. These structures have a NW to NE or a westerly strike and are commonly associated with lithological boundaries, e.g. the trondhjemite at Langtjern, the Bryntjern gabbro contact.

Two zones of thrusting have been located within Maps 1293-03 and -04. A mylonite zone is present in Elstad-elven (0556 0629) at the contact between the trondhjemite and the underlying gabbro. The trondhjemite passes upwards from a completely brecciated basal 2-3 meters into strongly cleaved and partly brecciated trondhjemite which is followed by cleaved and non-brecciated trondhjemite. It has not been possible to follow this thrust zone along strike due to lack of exposures; however, its presence to the northwest of the above locality has been confirmed by the occurrence, within approximately 75 meters of the suspected contact, of strongly cleaved and schistose trondhjemite. This thrust is not related to emplacement of the trondhjemite since it postdates the regional scistosity, S_1, and is considered to be related to late tectonic movements; the amount of displacement involved is unknown and could be only a few tens of meters or more than several hundred meters.

Another zone of mylonitization, which is associated with the major fault in the gneisses south of Trangen (1293-04) that is plainly marked by a major nearly vertical cliff, is located at the contact between sediments + amphibolites and gneisses immediately north of Trangen. Although there are no exposures along the mylon ite zone between Trangen and Rossettjern the extrapolation of the thrust in this area is warranted since it satisfactorily explains the discrepancy between the northerly striking gneisses at Aanestjern and the westerly striking greenstones to the East. The thrust zone probably continues along the west boundary of the gabbro and some indication of this is present in strongly fractured garnet-mica schists in the brook north of Rosset about 50 meters from the gabbro. The northward extension of this thrust is very uncertain. It is possible that it runs along the northwest contact of the gabbro – this contact is covered and follows a small valley as far as Elstadelven. The most reasonable interpretation is that the brecciated rocks at the amphibolite - "conglomerate" contact immediately north of Rosset Grube represent the northward extension of this thrust and that the thrust zone itself follows the amphibolite sediment contact. The thrust zone is then lost north of Map 1293-03 in the poorly exposed sediments and has two equally plausible positions;(1) along the amphibolite-sediment contact on the east side of Killingberget;or (2) it passes through the sediments at some distance from the above contact and continues northwards towards Gartland.

Structural details in both of the economically important areas, Rosset and Skiftesmyr, are not fully understood. At Rosset the ore deposit appears to lie in the upper limb of a tight isocline with sediments in the core of the fold since the geophysical measurements indicate that the amphibolites at the west Rosset sulfide occurrence dip under the sediments (Director I. Aalstad, pers. comm. 1975).

This is also consistent with the intersection of a short section of sediments in Rosset Borehole. The interpretation necessitates that the amphibolites on both sides of the tongue sediment at Rosset Grube are the same horizon but occupy different limbs of the isocline; the geophysical anomalies under the sediment-covered area are then relatable to the amphibolites on the lower limb of the fold and worthy of further investigation by drilling. A further interpretation in view of the outcrop pattern is that the sediments at the west Rosset occurrence are continuous beneath the amphibolites on Tømmeråsfjell with those at Renslitjern,and the sediments east of Rosset Grube, if of the same age as those outcropping between the amphibolites, must be thrusted over the amphibolite containing Rosset Grube. The interpretation outlined above is consistent in general with the writer's earlier ideas on the structure of the area (see Rapport 1122 A) but differ in relative position of the amphibolite found between Rosset Grube and the west Rosset occurrence. It also reconciles a number of apparently conflicting observations (e.g. age of sediments, sediments entirely surrounded by amphibolite).

Although there is an abundance of small-scale structures in the Skiftesmyr area, the only major structure that can be outlined with any certainty is the open F_4 synform. The implications of the structures for understanding the ore deposit will be mentioned in the next section.

Sulfide occurrences

On the basis of the present structural interpretation the Rosset west and Rosset Grube occurrences represent the same stratigraphic horizon and the horizon should be traceable southwards into a fold hinge and northwards from Rosset Grube until cut out by the thrust along the east contact of the amphibolite. If the amphibolites are continuous beneath the sediments to the northeast then this also has ore potential but will be difficult to evaluate until the thickness of the sediments is determined by drilling.

The mineralogically interesting (see Bergstøl and Vokes (1974), Mineralium Deposita) Godejorde deposit has a strike length of approx. 2 km. This stratabound deposit occurs in calc-rich basic lava and tuffs. In the western part of the deposit the host rock is a quartz-sericite schist which may have originially been an acidic tuff. The western part of the deposit which contains pyrite and chalcopyrite can be considered as a typical exhalative deposit, whereas the Zn, Pb, Au and Ag-bearing eastern part is atypical of sulfide mineralization in the Grong area; mineralogically complex exhalative deposits are well known from the Canadian Shield areas. Another anomalous feature of the deposit is the extremely iron-poor sphalerite (pale straw yellow in colour) which indicates deposition in an iron-poor environment. The complex mineralogy of the deposits seems to rule out a remobilizate origin for the Cu, Zn, Pb, Au and Ag ore. Since there is no evidence to support a vein-deposit theory, an origin as a metal-rich exhalative deposited in calcareous, iron-poor sediment is suggested. Such a deposit could have fairly large lateral dimensions without ever attaining mineable thicknesses except in fold hinges.

The Skiftesmyr area contains a number of small chalcopyrite-bearing pyrite occurrences in addition to the main, presently known, Skiftesmyr Cu-Zn-bearing massive sulfide deposit. The minor sulfide occurrences are commonly associated with, or occur in close proximity to, acidic lavas and/or tuffs. The cyclical nature of the volcanism with periodic ejection of acidic lava, basic tuffs and basic lava often with associated exhalative sulfides indicates that this area has considerable metal potential. Attempts to establish the main sulfide-bearing stratigraphic horizon have been frustrated by the absence of traceable marker horizons and the presence of several distinctive metal-bearing horizons.

On the basis of the presently known minor structures in the area several broad generalizations can be made. The only phase of folding which could have seriously affected the sulfide deposit sufficiently to impose a structural control on the ore body was the F_1 isoclinal folding which could have reoriented and boudinaged the sulfide mass to give it an east-west orientation. F_1 folds can also be expected to produce a repetition of the ore body; thus, several drill holes should eventually be allowed to penetrate the footwall for 150-200 meters even though no evidence has yet been found to prove a major F_1 structure in the vicinity of Skiftesmyr.

It has been suggested to the writer that the Skiftesmyr deposit is elongated in a northerly direction (Ø. Pettersen, Pers. comm. 1974). The F_2 structures in the area do in fact have a northerly trend; however, I estimate the deformation associated with this folding to be of insufficient intensity to produce a realignment of a major sulfide mass, and therefore suggest that if a northerly trend for the sulfide deposit is substantiated by further drilling, then this is probably the original attitude of the deposit and not the result of D_2 or later deformation.

It is clear from Map 1293-04 that the geophysical anomaly (EM) at Skiftesmyr does not follow the structural trends and must reflect either a non-strata bound mineralization, a composite anomaly resulting from superimposed conductors, or an F_1 fold hinge at depth.

A 25 cm-wide horizon of pyrrhotite at (0423 0990) occurs at approximately the same stratigraphical level as the Godejorde deposit and may be related to the same episode of exhalative activity.

IV. ANDERSSJØEN MAP SHEET (1823 I)

Only the northern part of this map sheet has been remapped, since the area south of Sanddøla consists mainly of acidic gneisses and lay outside the boundaries of the "Grong Concession Area". The mapped areas are shown on Maps 1293-05 and 1293-06.

Most of the rock units occurring in this area are a continuation of units present on Map 1293-04.

The gneissic rocks of the Grong Culmination generally occur only on the south side of the Sanddøla river and the contact with the overlying semipelitic sediments occurs in the bed of that river. Gneissic rocks do, however, occur on the north side of the river near where the brook draining Langtjern meets the Sanddøla river. These rocks have not been investigated.

The "mica schist" unit which can be followed across both map sheets occurs between the gneisses and the limestone or the greenschists throughout most of the map sheet. East of Langtjern they are separated from the greenschists by a unit of calcareous psammite. The mica schist unit,which is generally a semi-pelite in the west,contains also psammite interbedded with green-coloured phyllitic rocks in the upper parts of the unit south of Langtjern. These greenish psammites and phyllites are similar to the rocks occurring south of the calcareous psammite on Map 1293-07 and described later. The lower parts of this unit have not been investigated in detail but appear to contain considerable black schists. Therefore it would appear that this unit of schists changes character eastwards and both the Økl and Øvf units on Foslie's Map, Sanddøla, continue farther west than shown on this map so that they either overlie the mica schists south of Langtjern or else they are the lower metamorphic grade facies equivalents. An elucidation of this problem must await remapping of these rocks to the east of Map 1293-05).

The Sanddøla limestone unit can be followed eastwards to within a few hundred meters of Berg farm. Ø. Pettersen (pers. comm. 1974) reported that isolated outcrops have been located several hundred meters east of Berg farm. There is no record of this unit being found east of Tverrelven; however, the calcareous psammites may represent a facies equivalent.

The basic volcanic rocks consist mainly of green phyllites, basic tuffs, minor keratophyric tuffs, clastic basic sediments and massive lava.

The phyllites, basic sediments and poorly layered tuffs are intimately intermixed and difficult to separate into map units because of the poor exposure and the thinness of the individual units which are often only a few tens of meters thick.

Magnetite horizons up to 30 cm thick have been observed in road cuts south of Finnbuvann. Keratophyric layers are scattered throughout the reasonably well exposed section in Finnbuelven. These vary from about 15 cm to 1 m in thickness, are parallel to the layering in the surrounding rocks and thus appear to be of tuffaceous origin.

Massive greenstones which appear to be lavas are only rarely found within the greenschist areas but are abundant in several areas, i.e. north of Finnbuvann and SE and E of Finhustjern. In the area east of Finhustjern individual lava units can be recognized in several places by the presence of thin tuff and jasper layers between the massive lavas.

Basaltic pyroclastics, tuffs and pillow/coarse pyroclastics constitute the wedge of volcanics NE of Langtjern and NW of Fisktjern. The volcanics north of Langtjern that are intruded by trondhjemite consist predominantly of basaltic lava and tuffs with several thin horizons of keratophyre.

A small body of medium-grained trondhjemite occurs within layered greenschists at (0650 1854). Several 1-2 m thick units of acidic rock approximately a hundred meters east of this body are either trondhjemite dikes or acidic volcanics.

The presence of sedimentary rocks within the greenschist unit on Map 1293-06 can easily be seen in the brook draining Fisktjern where there are abundant green phyllites. In addition there is a 100 m-thick section of calcareous basic sediments at (0559 1700) in the brook draining Langtjern.

Acidic rocks of unknown origin occur in a small body east of Fremsttjern and on the north side of Fisktjern.

The Fremsttjern rocks appear to be in thrust contact with the trondhjemite to the north and are probably in fault/thrust contact with calcareous sediments to the south on the east side of Fremsttjern; however,they appear to underlie the calcareous sediments at the west end of Fremsttjern where the silicic rocks occur in a small valley between two small hills of calcareous sediment. The nature of the contact between these rocks is unknown but could be conformable since the layering is more or less conformable in both rock-types at this locality.

The silicic rocks are very fine-grained and have strong schistosity even though the mica content is low. Thin (50 cm) horizons of basic rocks are scattered throughout the outcrop area and basic volcanics occupy the southern part of the outcrop area. Weathered sulfide veinlets (1-2 mm thick) are abundant in the eastern part of this area. These rocks could have been acidic volcanics, silica-rich sediments (chert ?) or even trondhjemite that has been intensely mylonitized; the absence of rocks with visible feldspar or quartz crystals would tend to rule out an origin as mylonitized trondhjemite. The writer considers a silicic volcanic origin most likely for these rocks. The silicic rocks at Fisktjern (Map 1293-06) are quite different from those at Fremsttjern in that they are highly calcareous, are strongly schistose with abundant mica, and have 1-2 mm quartz and feldspar grains. These rocks are in thrust contact with the calcareous phyllites to the north and a small body, 100 x 20 m, of impure carbonate occurs close to this contact. A poorly defined layering is present in several places. This rock probably originated as a calcareous sediment since it is difficult to envisage a silicic volcanic with 10-15 % free carbonate.

Calcareous phyllites, siltstones and sandstones form a unit which can be traced across both maps 1293-05 and 1293-06. These rocks are well-layered except where strongly tectonized,e.g. west of Piperudtjern and north of Fisktjern. In some places, e.g. (0643 1792), the rocks are so calcareous that they can be considered dirty limestone (70 % or more carbonate). These rocks are typically brownish weathering and consist mainly of quartz and carbonate. Light green beds indicating derivation from a basic terrain are rare.

Two occurrences of graded bedding were noted in these rocks close to section B-B[1] of Map 1293-05.

Two other occurrences of similar calcareous rocks can be found northeast of Kolitjern and in the extreme NE corner of Map 1293-05. The rocks near Kolitjern have a pale green colour and are cut by trondhjemite dikes. Basic rocks occur near the southern contact of this area and rafts of basic rocks, probably greenstones, occur in the trondhjemite to the north of this area. The rocks NE of Kolitjern are fault-bounded so that it is not clear if there are basic lavas underlying the sediments. These rocks are considered to represent an undigested raft of the Tjernrøle sediments within the trondhjemite.

A smaller body of calcareous sediments which overlie volcanic rafts in the NE corner of Map 1293-05 are also cut by dikes of trondhjemite.

The relationship of the calcareous phyllite unit to the other rocks is defined in detail by regional faults/thrusts (Plate 2 B). The contact with the trondhjemite is a high-angle fault. The sediments in the Tjernrøle area dip moderately northwards and thus appear to dip under the trondhjemite. The south boundary of these rocks is characterized by a narrow belt of steeply dipping to vertical calcareous sediments that are fault-bounded on both sides east of Fremsttjern and are fault-bounded along at least their south boundary between Fremsttjern and Piperudtjern — they are also overturned towards the south in this area. West of Piperudtjern the narrow band of fine-grained laminated rocks considered earlier (Rapport 1189) to be a mylonitized silicic rock was found on reexamination to be continuous with the calcareous sediments and to be mylonitized calcareous sediment.

The disjunctive nature of the contact between the calcareous sediments and the greenschists to the south is also substantiated by the discordance between the strike and dip of foliation in the greenschists and the contact with the sediments.

The unit of calcareous siltstones and phyllites NE of Langtjern is lithologically similar to those found in the Fremsttjern area and is considered to belong to the same stratigraphic horizon. These sediments are displaced along a fault which marks the south boundary of the arkoses and occurs between two greenstone units. The contact with the northern greenstone unit is faulted; however, the south contact is not exposed but the bedding in layered greenschists immediately to the south appears to be parallel to bedding in the siltstones. These calcareous sediments thin rapidly eastwards but can be followed as a thin fault-bounded unit as far as Blåmuren (see Map 1293-07).

The medium-grained trondhjemite is similar to the trondhjemite described from the Møklevann area and is a continuation of the same intrusive. North of Langtjern veins and stocks of trondhjemite intrude and often surround the greenstones which are considered to be the remnants of a thick volcanic pile.

The occurrence of greenstone and sediment rafts in this part of the trondhjemite suggests that it represents the roof of the intrusive. Small areas of fine-grained and porphyritic trondhjemite occur near the eastern margin of Map 1293-05 and the rocks in this area, especially near the southern margin of the trondhjemite, are often strongly schistose.

The trondhjemite is in direct contact with a polymict conglomerate (Plate 2 C) west of Langtjern in what appears to be an old erosional and weathering surface. The trondhjemite adjacent to the contact often has a stronger schistosity than trondhjemite a few meters away from the contact. The conglomerate fragments nearest the contact consist predominantly of trondhjemite blocks identical to the main trondhjemite mass. In several places north of Langtjern the trondhjemite and the conglomerate are separated by a few meters of a clastic "trondhjemitic sediment" which has a pale epidote-green colour, contains abundant clastic feldspar and quartz and appears to grade into the trondhjemite. The writer interprets this to be evidence for preservation of the in situ weathered surface of the trondhjemite.

The polymict conglomerates overlying the trondhjemite form the basal unit of a thick sequence of conglomeratic arkose occurring to the NE on Map 1293-07; however, only a narrow belt of these southerly dipping arkosic rocks is preserved in the Langtjern area. A steep late tectonic fault zone occurs along the south boundary of the southerly dipping arkoses and a similar fault zone occurring along the north contact at the northern edge of Map 1293-06 can be traced southwards in several places along small steep ravines.

The conglomeratic rocks forming the base of these sediments directly overlie trondhjemite or greenstone rafts in the trondhjemite except where they have been cut out by late faulting, e.g. at (0660 1783). Rock fragments in this conglomerate range from boulder to pebble size and exhibit varying degrees of deformation. Discontinous lenses of arkose are scattered throughout the conglomerate. The rocks closest to the contact with the trondhjemite and greenstone exhibit the least deformation and the original elliptical shape of the fragments leaves little doubt that these are water-worn fragments. Elsewhere within the conglomerate zone — the best exposures are to be found in the brook running into Langtjern at (0587 1702) — the fragments are intensely elongated and could easily be mistaken for a pseudo-conglomerate. The development of these intensely deformed zones which predate or accompany the regional penetrative deformation probably represent thrust zones within the sedimentary sequence.

The arkosic rocks are well-bedded medium-grained sediments with occasional thin conglomerate horizons. Siltstone horizons are occasionally present. These rocks generally contain free carbonate which varies from trace amounts in the medium-grained arkose to distinct calcareous horizons (20-40 % carbonate) a few centimetres thick in the siltstones. These southward-facing sediments are right way up.

Note: In Rapport 1189 the writer reported that the calcareous phyllite unit could be traced westwards in a narrow belt which ran north of Finnbuvann at about the same position as that shown on Foslie's Sanddøla map. This interpretation was based on the observation of two small exposures of sediments in the area west of Finnbuvann. This area was reinvestigated in 1974 and this interpretation is now considered invalid since the meta sediments found in 1973 are not calcareous; the postulated position of this narrow unit runs along a small marsh-covered valley in the area west of Finnbuvann and the exposure located to the north of Bergtjern. A 10 m^2 outcrop of acidic fragmental rocks in a basic matrix was located at (0481 1139). The fragments (10x15 cm) are fine-to medium-grained keratophyric rocks with 3-5 mm quartz grains embedded in a 1-2 mm chlorite-quartz-feldspar matrix. A few meters away from this outcrop a 1 m^2 exposure contained basic fragments in a greenschist matrix. It is not clear whether the fragmentation of these rocks was tectonically induced or if they were pyroclastics.

Structures

The prominant structural feature in the greenstones on Maps 1293-05 and -06 is the west-striking S_1 which has locally been folded into large open structures of probably F_3 age,e.g. near Fremsttjern and Berg. These structures are defined by slight changes in the attitudes of S_1. A northeast-trending cleavage and/or crenulation appears to be related to this phase of folding. Minor folds in the metasediments northeast of Berg appear to be related to the same phase of F_3 folding.

First deformation structures include a minor fold in metasediments south of Langtjern, and elongated pebbles in the conglomerates west of Langtjern on Map 1293-05.

Faulting and thrusting are common on both maps and in many instances the lithological boundaries are tectonic contacts. The two most dominant faults on Map 1293-05 are the westerly striking fault that marks the contact between the calcareous sediments and the greenstones, and the contact between the trondhjemite and the calcareous sediments. The former is a steeply northwards dipping late tectonic feature that is locally at a high angle to S_1 in the greenstones but is usually subparallel to bedding attitudes in the sediments. The trondhjemite-sediment contact is also a steeply northwards dipping fault/thrust plane. East of Fremsttjern this fault has a vertical attitude where it separates conglomerates and calcareous sediments. West of Piperudtjern the two faults which are probably of the same age come together to produce a zone of strongly mylonitized calcareous sediments. At Fremsttjern a related faultforms the north boundary of the sediments to the east until it passes into the fault marking the boundary of the trondhjemite, e.g. NE of Kolitjern.

The calcareous sediments NE of Langtjern on Map 1293-06 are bounded on at least the north side by a zone of thrusting. Immediately north of Fisktjern the north contact appears to have a dip of 50-60 degrees, but to the west and east the contact is vertical (see Plate 3 B).

Vertical faults mark both boundaries of the unit of arkose and conglomerate at the north boundary of Map 1293-06. The northwesternmost of this fault pair appears to cut through the trondhjemites and greenstones north of Langtjern while the southernmost fault can be followed to Langtjern where it can pass into the greenstones to the south or become a part of the fault forming the contact between the trondhjemite and calcareous sediments. Both of these faults appear to have mainly vertical displacements.

Mineralization

The largest known massive sulfide deposits are those at Finnbuvann. The south deposit is a stratabound pyrite-chalcopyrite-sphalerite deposit within greenschists (tuffs and tuffites). The north deposit is massive pyrite (+ sphalerite) which is closely associated with a fine-grained silicic layer (probably an acid tuff) and is parallel to the layering in the surrounding basic tuffites.

Small lenses of pyrite several tens of cms thick and a few meters in length are present at Finnhustjern and in the trondhjemite-intruded greenstone north of Langtjern. These deposits have only traces of chalcopyrite and sphalerite and are not considered to be economically significant.

A forgotten occurrence of chalcopyrite (a small trench was cut on the deposit many years ago) was rediscovered at (0501 1630) in 1974. The deposit which covers an area of approximately 50 m by 10 m consists of both mineralized trondhjemite and greenstone. The greenstone, which is a small block within the trondhjemite, contains chalcopyrite as massive lenses and as closely spaced 0.1 to 1 cm thick veins. A vein network of pure chalcopyrite, 1-3 cm thick, occurs in trondhjemite adjacent to the greenstone raft at the edge of the lake. This deposit is probably a result of chalcopyrite remobilized from the greenstone during intrusion and injected into the trondhjemite along fractures as it cooled. However, in view of the occurrence of traces of chalcopyrite in the molybdenite-bearing trondhjemite, in a small quartz vein at Fremsttjern and as discrete grains in the pyritized silicic rocks immediately east of Fremsttjern, these areas, as well as the trondhjemite mass, should be carefully prospected for disseminated Cu-mineralization.

The zone of Mo-bearing pyritic trondhjemite discovered in 1973 was investigated further in 1974. The pyritic zone was found to have a length of approximately 1200 m and to pinch out gradually westwards. Molybdenite films on fractures are scattered throughout the zone. Attempts to evaluate this interesting mineral occurrence were frustrated by the inability to obtain unweathered samples for analysis.

Pyritized trondhjemite also occurs in several small lenses associated with faults/ shear zones. A number of these were found to contain films of molybdenite.

5. NAMSSKOGAN MAP SHEET (1824 II)

Geological observations which have been confined to the southeast corner of the Namsskogan Map sheet are presented on Map 1293-07.

Since the sediments in the extreme southeast corner of Map 1293-07, near Kviltjern, have not been mapped it is not certain if these are all younger than the calcareous psammites at Holmtjern or if they contain some stratigraphic equivalents of the micaschists structurally underlying the limestone horizon on the Anderssjøen map sheet.

The oldest rocks in that part of Map 1293-07 investigated by the writer are the volcanics. These rocks form three main linear belts on Map 1293-07 (a) the Nesaavann belt, (b) the Gaizervann belt and (c) the Blåmurvann belt.

(a) The Nesaavann volcanics consist dominantly of basaltic lavas and tuffs that have been intruded by gabbros and trondhjemite. These rocks have not been investigated in detail by the writer since they are being remapped in detail by Dr. C. Halls and co-workers. My own observations have been limited to brief examinations of the relationship between the volcanics and younger sedimentary rocks and to a check on the mapping carried out by Dag Huseby in the Øvre Nesaavann area. Huseby's mapping was found to be in general correct and to be accurate enough for inclusion into the 1:50 000 Namsskogan map.

(b) The Gaizervann belt of volcanics are a mixture of greenstones and greenschists which can be traced from Skarfjell in the SW to Storgaizervann in the NE. Primary volcanic structures have not been observed in the belt and the majority of the basic volcanics are massive with a weak schistosity which suggests that they are probably lavas. In several places the rocks are well-foliated with scattered rock fragments which suggests a tuffaceous origin.

The Gaizervann volcanics have been severely dissected by trondhjemitic intrusions related to the main trondhjemite mass. In view of the presence of molybdenite mineralization in fine grained trondhjemitic rocks at Gaizervann, an attempt was made to map in detail the whole of the Gaizervann volcanic belt. Only the major units of trondhjemite and volcanics are outlined on Map 1293-07 since the trondhjemite and basic volcanics are occasionally so thoroughly mixed that it was not possible to show them on the 1:20 000 map. Thus the greenstone areas in this belt often contain many small veins of trondhjemite and the trondhjemite areas contain abundant rafts of basic volcanic material. (The complexity of lithological distributions in this area can be seen from the air-photo overlays used in the field since the units were mapped out by using coloured pencils; the overlays are deposited in the NGU archives.)

Thin horizons of chloritic acidic lavas/tuffs are present on Skarfjell. The fine- to medium-grained pyritic acidic rocks at Gaizervann which contain molybdenite mineralization may be volcanic lavas but in the absence of definite volcanic textures these are considered to be related to the trondhjemite.

(c) The Blåmurvann greenstone unit is comprised mainly of fine-grained greenschists although lavas and agglomerate are common locally. Acidic rocks have been observed only in the southwest extension of this belt onto Map 1293-06 near Fisktjern. Adjacent to the contact with the calcareous psammites there are a number of brown-weathering calcareous phyllites, several to several tens of meters in thickness, which can be followed along the strike of the foliation and layering in the greenschists.

A small body of acidic rocks (lavas?) occurs at the southwest end of Langløftfjell. These rocks overlie greenstones and greenschists which structurally overlie calcareous phyllites north of Fisktjern on Map 1293-06 but are separated from the Blåmurvann greenstone belt by the strongly tectonized greenstones and calcareous phyllites in a fault zone along the southeast edge of the arkoses (Plate 3 B). The occurrence of a thin acidic volcanic unit and acidic pyroclastics in the Blåmuren belt immediately NE of Fisktjern on Map 1293-06 suggests a correlation between the two volcanic units. The writer's interpretation of the structural geology of the Langløftfjell area favours a correlation of the Skarfjell, Fisktjern and Blåmurvann volcanics as the same stratigraphic unit.

Conglomerate containing fragments of basalt, keratophyre and trondhjemite and often containing thin beds of arkose overlie the Nesaavann greenstone belt in the area NW of Gaizervann. These conglomeratic fragments (2-50 cm in diameter) and their fine-grained quartz-chlorite matrix are considered to be derived from the volcanic rocks which they overlie. These conglomerates are coarsest adjacent to the underlying volcanics and pass upwards into a finer grained pebble conglomerate (<5 cm) with scattered fragments embedded in a calcareous basic matrix; fragments greater than 30 cm maximum length are rare in the upper parts of this conglomerate unit but 1-2 m thick horizons with cobble-size fragments are common in several places (Plates 3 C & 4 A).

Graded bedding in arkosic layers interbedded with these conglomerates indicate that they are "right-way-up".

A thin unit of conglomerate with pebble to cobble-sized fragments of basalt and keratophyre in a basic matrix occurs along the southwest edge of the Gaizervann "greenstone" belt. These rocks are generally steeply dipping but can be seen in several places, e.g. (0910 2043) and (1000 2152) to be flat-lying and unconformably overlying the greenstone and trondhjemite. This unit, which is in fault contact with the younger arkoses and has been cut out by that fault in several places, can be followed southwestwards as far as Langtjern on Map 1293-06. On the basis of the lithology of the fragments, the basic matrix and the stratigraphic position, this conglomerate is considered to be a stratigraphic equivalent of the conglomerate overlying the Nesaavann greenstones; the small thickness encountered here is the result of faulting/thrusting.

Pebble conglomerates and grits with fragments of greenstone, trondhjemite and jasper overlie the greenstones in the vicinity of Blåmurvann. These conglomerates have a thickness of 10-15 m and are conformally overlain by calcareous siltstones west and north of Blåmurvann.

The calcareous sediments occurring west of Gaizervann consist of phyllite, silts, sandstone and limestone-conglomerate. These sediments overlie the "greenstone-trondhjemite" conglomerate and may be gradational into them; however, the contacts are poorly exposed in the Gaizervann area and the area has not yet been mapped in detail.

Both the calcareous sediments and the underlying conglomerate are older than the Blåmuren arkoses since dikes of trondhjemite and gabbro are intruded into them but are absent in the Blåmuren arkoses (Plate 5 A).

A thick sequence of arkosic and conglomeratic rocks occurs on both sides of the Gaizervann greenstone belt. The two blocks merge northeast of Storgaizervann (see Map 1293-08) into one unit referred to here as the Havdalsvannn formation. The Havdalsvann formation conformably overlies the calcareous sediments.

The contacts between the Havdalsvann formation and the rocks in the Gaizervann greenstone belt are clearly steeply to vertically dipping faults. The west contact of the Gaizervann arkosic block occurs along a small ravine but this is considered to be an erosional feature since the calcareous sediments in several places grade into siltstones which in turn pass into arkose without any change in attitude of bedding. Disjunctive relationships are, however, to be found along this contact, e.g. at (0986 2019) the calcareous sediments have been thrusted for 10-20 m over the arkose by a late thrust.

At the SW corner of Gaizervann, coarse conglomerate (20-30 cm) directly overlies schistose calcareous sediments. The absence of identifiable bedding in the conglomerate does not permit establishment of the nature of this contact without further studies in the area and a thrust contact relationship cannot be ruled out at this time.

The east contact of the Blåmuren block of arkose and conglomerate is faulted in the areas southwest of Blåmurvann; however, the relationship with sedimentary rocks to the north east of Blåmurvann is probably conformable since the minor schistose zone at the contact between the arkoses and the calcareous psammite is considered by the writer to reflect differing competencies between the two lithologies during regional deformation.

The thin wedge of conglomerate at the east contact of the Blåmurvann greenstone wedges out completely southwestwards. North of Holmtjern the conglomerate is separated from the greenstone by a thin layer (10 m thick) of calcareous phyllite; but the phyllites are not present in the vicinity of (0900 2202) where the conglomerate rests unconformably on the greenstone. The eastern contact of this conglomerate wedge is a major thrust which has cut out most of the conglomerate and brought the calcareous psammites against the greenstones west of Holmtjern.

The Havdalsvann formation is a thick sequence of interbedded arkose and poorly sorted conglomerate with a matrix of arkose. Along the western margin of this formation, e.g. west of Pervatn, the base of the formation is a 20-30 m thick calcareous siltstone unit which appears to grade upwards into arkoses. Similar siltstones occur interbedded with the arkoses in several places e.g. (0954 2014), (0984 2025), and (0740 1927).

The arkose is a medium-grained quartz feldspar rock with 5-10 % calcite and minor muscovite. The arkose is well layered with individual beds up to 10 m thick. Graded bedding, often with pebble conglomerate at the base is present in many places. Cut-and-fill structures are common (Plates 4 B & 4 C).

The conglomerate consists mainly of ellipsoidal fragments of trondhjemite which range in size from pebbles to boulders one meter in length. Fragments of red jasper are common in some beds but clasts of basic volcanics are rare except in the conglomerate block at (0930 2200) which also has a more basic matrix than the other conglomerates. Beds and lenses of arkose are commonly found within the thick conglomerate layers. (Several photographs of the conglomerates are to be found in Rapport 1189).

Brown-weathering calcareous psammites structurally overlie the Havdalsvann formation and the greenstones with which they have a tectonic contact. Bedding is often difficult to recognize in this unit due to the presence of a strong penetrative regional second schistosity which has often destroyed the primary layering. Weathering of carbonate along the schistosity planes often gives an impression of layering in these rocks; however, relics of the original bedding can be observed in fold hinges when it is at a high angle to the schistosity. (See Fig. 2, Rapport 1189).

The rocks structurally overlying the calcareous psammites are greenish-coloured siltstones, sandstones and phyllite with minor pebble conglomerate. These rocks have not been studied in detail since the extreme SW corner of Map 1293-07 has not been remapped.

The oldest intrusive rocks in the area are gabbroic rocks which cut the greenstones,e.g. NW of Pervatn,and are in turn intruded by trondhjemite (e.g. Nesaapiggen and south of (0800 1800). Dikes of an hornblendic rock with minor feldspar intrude the calcareous sediments at (1000 2021) and (0997 2029).

The trondhjemite is dominantly medium-grained but can contain small zones that are fine-grained and pyritized, e.g. south of Nesaapiggen. The trondhjemite intrudes the greenstone and can completely engulf large blocks of greenstone which now remain as isolated rafts in the trondhjemite,e.g. the raft at (0760 1800). Elsewhere the trondhjemite occurs as veins and small stocks cutting the greenstone. The Gaizervann greenstone belt is essentially a body of greenstone that has been intruded by a small stock of trondhjemite. The centre of this stock is located between Gaizervann and Gaizjavre where the basic volcanics occur as rafts within the trondhjemite. To the south and north of this centre the trondhjemite occurs as veins and small bodies within the greenstone.

Two ages (phases) of trondhjemite are clearly present in this area. The earliest phase of intrusion is fine-to medium-grained, porphyritic and pyritized. This was intruded by a later medium-grained non-pyritic trondhjemite. These rocks were eroded and the polymict greenstone-trondhjemite conglomerate was laid down on top of them. There is no evidence of the age relationship between the later phase of trondhjemite and the conglomerate along the east contact of the

Gaizervann greenstone belt; however, this conglomerate is equated with the polymict conglomerate overlying greenstones northwest of Pervatn where trondhjemite dikes clearly post-date the deposition of the conglomerate and the calcareous sediments overlying them. If the medium-grained trondhjemite of the Gaizervann greenstone belt can be shown to be older than the polymict conglomerate then there must be at least three phases of trondhjemitic intrusions in the area. This does not necessarily imply that there are three ages of intrusion since the fine-grained porphyritic and pyritized trondhjemite body in the southwestern part of the map is considered to be the initial phase of the intrusive episode.

Structures

Graded bedding and cut-and-fill structures are the main primary structures on Map 1293-07. These structures are quite common in the conglomerate arkose unit and in some of the sandstone layers in the basal conglomerate overlying greenstones at the northwestern margin of the mapped area. Pillow lavas and agglomerates are present in the Blåmurvann greenstone but have not been positively identified in the Gaizervann greenstones.

The earliest tectonic structures are a schistosity S_1, and a particle lineation, L_1. The schistosity is present in all of the rocks of the map area while the lineation, which appears slightly to predate the S_1, is best developed in the conglomerate (see Plate 3 of Rapport 1189). This particle lineation approximates the hinge of an upward-facing F_1 isocline in arkose and conglomerate at the north end of Pervatn; this is the only F_1 fold identified in the mapped area; however, the metasedimentary rocks have not been mapped in detail.

The dominant fold phase to have affected the rocks has northeast-southwest trends and a vertical to steeply dipping axial plane which is often defined by an axial plane cleavage. A synform-antiform pair occurs at the southwest end of Langløftfjell and an antiform is present in the greenstones at Blåmurvann. Small-scale folds of the same style are abundant in the calcareous sediments west of Gaizervann and in the calcareous psammites near Holmtjern. Although an antiform is suspected in the Gaizjavre greenstone belt it has not been possible to prove the existence of this structure in either the greenstones or the arkoses and conglomerates at the northeast end of Storgaizervann (Map 1293-08). These folds are similar in style and attitude with the F_3 folds on Map 1293-01 and are considered to belong to the same deformational episode.

Northwest trending open folds, F_4, have locally produced a gentle warping of bedding in the metasediments.

Flat-lying to gently westward dipping thrusts are common on Map 1293-07. A well-defined thrust with a mylonite zone 10-30 m thick occurs at the base of the trondhjemites south of Øvre Nesaavann (0961 1897). Calcareous sediments have been thrusted over arkose at (0987 2020); at (0927 1966) the arkose is thrusted over the calcareous sediments. These thrusts are late tectonic features but predate the N-S and NE-SW steeply to vertically dipping faults.

A pre-F_3 fault/thrust has cut out the arkose and conglomerates north of Holmtjern; the arkose and conglomerate unit thins gradually southwestwards and the F_3 cleavage has the same attitude in both the greenstone and the calc-psammites.

The contact between the greenstone and the Langløftfjell-Blåmuren arkose is a tectonic boundary. It is not clear whether this boundary is entirely controlled by the late steeply dipping faults or if there has also been some thrusting along this contact; a steeply dipping fault along the contact and passing into the arkose and conglomerate to the west of Blåmurvann offers the best explanation for the observed lithological relationships.

Mineralization

Small deposits of pyrite occur at (0764 1771), (065 1841), (0895 2182),(1040 2172), (1114 2091), (0810 2054), and (0700 1770). The first three of these occurrences are weak impregnations of pyrite in greenschists and keratophyric tuffs. The occurrence at (1040 2172) is a semimassive pyrite and quartz lense 25 cm wide by approx. 5 m long in greenstone. The occurrence at (0700 1770) on Skarfjell consists of 5-10 % disseminated pyrite in a keratophyre or silicified greenschist. Although chalcopyrite and molybdenite were not observed in this deposit, in view of its close proximity to the molybdenite mineralization at Langtjern fresh samples of this deposit should be obtained for Cu and Mo analyses.

The deposits at (0810 2054) and (1114 2091) were investigated briefly by O. Minsaas in 1974. These deposits occur within greenstones and contain 10-25 % disseminated pyrite; the deposit at (0810 2054) has a width of 10-15 m and a length of approx. 50 m.

An area of pyritized silicic rock considered to be an early intrusive phase of the trondhjemite contains small rafts of greenstone and is intruded by post-mineralization medium-grained trondhjemite. The pyritic area is shown by dots on Map 1293-07. Molybdenite-bearing quartz veins were discovered in the pyrite zone in 1973. A reexamination of the area in 1974 revealed that molybdenite in quartz veins, 1 cm wide, and as thin films along fractures, was widely scattered over the pyritized area; however, no intensive vein networks were found. Several soil samples collected over the poorly exposed parts of the pyritic area yielded anomalous high values of Mo (D. Smith,pers.comm.). A greyish quartz vein, 5-10 m wide by 150 m long, locally contains visible molybdenite (identified by X-ray diffractometer. Small occurrences of pyrite and chalcopyrite occur along the margins of this quartz vein. Although the whole of the trondhjemite and greenstone zone both northeast and southwest of the Gaizervann pyritic zone was mapped in detail no other extensive pyritic areas were located.

6. TUNNSJØEN MAP SHEET (1924 III)

In view of the recognition of early isoclinal folds in the Havdalsvann formation north of Pervatn a one-day traverse was made across this formation in the area south of Havdalsvann to see if a major isoclinal fold existed in the area and also to investigate the airphoto interpretation of structures in the area. Way-up criteria indicated a regionally normal sequence with only local inversions due to small-scale folding. Observations are shown on Map 1293-08.

7. FURTHER INVESTIGATIONS

Poorly understood stratigraphical and structural relationships have been pointed out throughout this report. A number of the most important of these that are considered to be crucial to an understanding of the geology are outlined below.

1. The nature of the conglomerate/pseudo-conglomerate underlying the greenstones on the south side of the Namsen river.

2. The structural relationship between the sediments and amphibolites at Rosset, since this will have a direct bearing on the search for ore at Rosset.

3. The extension of the Trangen thrust zone and the Killingberget amphibolites on the north side of the Namsen river.

4. Stratigraphical relationship between the arkose and conglomerate unit and the calcareous sediments to the east of it at Blåmuren.

5. Internal structures within the arkoses and conglomerates, i.e. detailed mapping of the individual conglomerate units to see if there are any major F_1 isoclines in the unit.

6. Structural relationships between the conglomerate and the other sediments immediately northeast of Blåmurvann.

7. Do the sedimentary rocks underlying the volcanic unit at Berg belong to the same unit as the black shales and quartzites occurring in the extreme southwestern corner of Map 1293-07 or is there an unidentified major thrust/slide zone of the contact between the sediments near Nedre Kviltjern as is indicated by the strongly tectonized zone in the Klingervann river several hundred meters south of Klingervann?

8. Is the trondhjemite an homogeneous mass or is it a complex intrusive in which only certain zones are mineralized?

Trondheim, June 1975

George H. Gale
geolog

Summary of Structural Events

D_6 — Faulting and thrusting: high-and low-angle displacements, e.g. Trangen thrust, Gaizervann thrust and faults. (High-angle faults post-date thrusts).

D_5 — Kink bands and box folds. Kink bands on south side of Namsen 2 km north of Grong; box folds at Finnbuvann.

D_4 — F_5 folds with flat-lying cleavage ravity folds),e.g. conglomerate zone south side of Namsen.

D_3 — F_4,NW-SE-trending,open to close folds with vertical axial planes, often with an axial plane cleavage. Also eye-folds in Namsen river.

F_3,NE-SW-trending,close to tight folds with vertical axial planes, axial plane cleavage usually well developed.
e. g. throughout the area.

D_2 — F_2 Asymmetric folds with axial plane cleavage, e.g. Large Z-fold in amphibolites north of railway tunnel over Namsen.

D_1 — F_1 Tight to isoclinal folds, development of regional schistosity. Post-dates intrusion of gabbro and trondhjemite (see Rapport 1122 A for examples and locations).

Pre-D_1 — Development of pseudo-conglomerate and slide zones. Rotated garnets in gneisses 1 km north of Grong. Emplacement of island arc intrusives, volcanics and associated sediments onto the Baltic foreland.

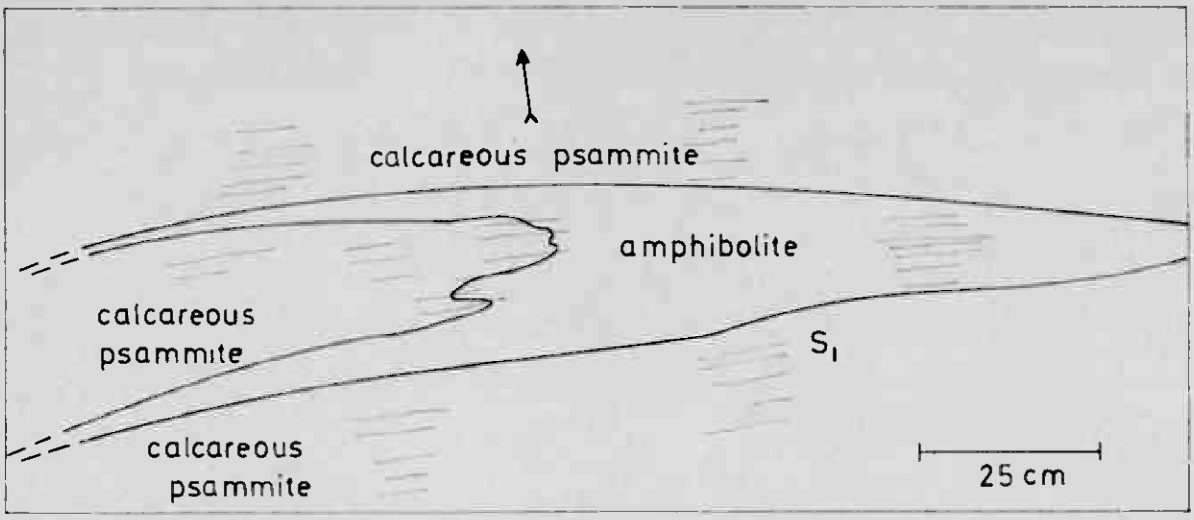


Fig. 2 F_1 Fold (plunging westwards) in Namsen river

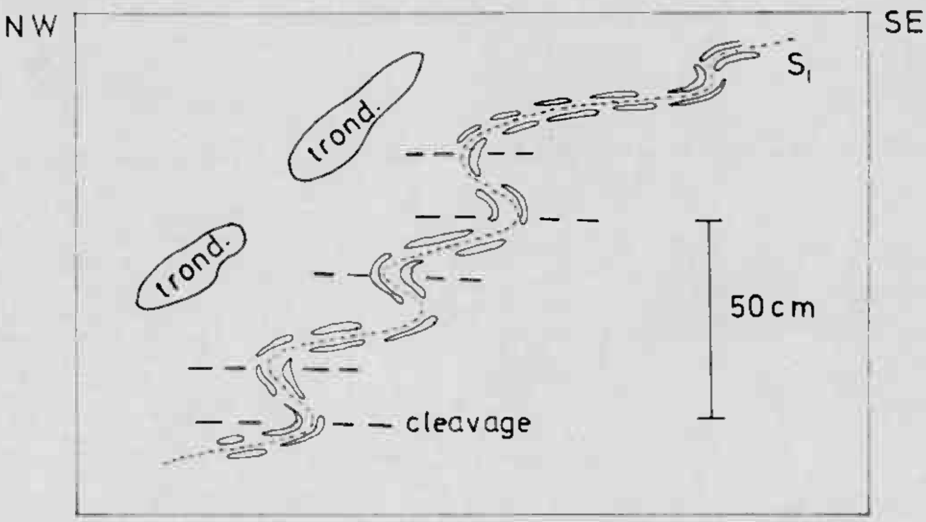


Fig. 4 F_5 structures in pseudo-conglomerate at (0655 0405)

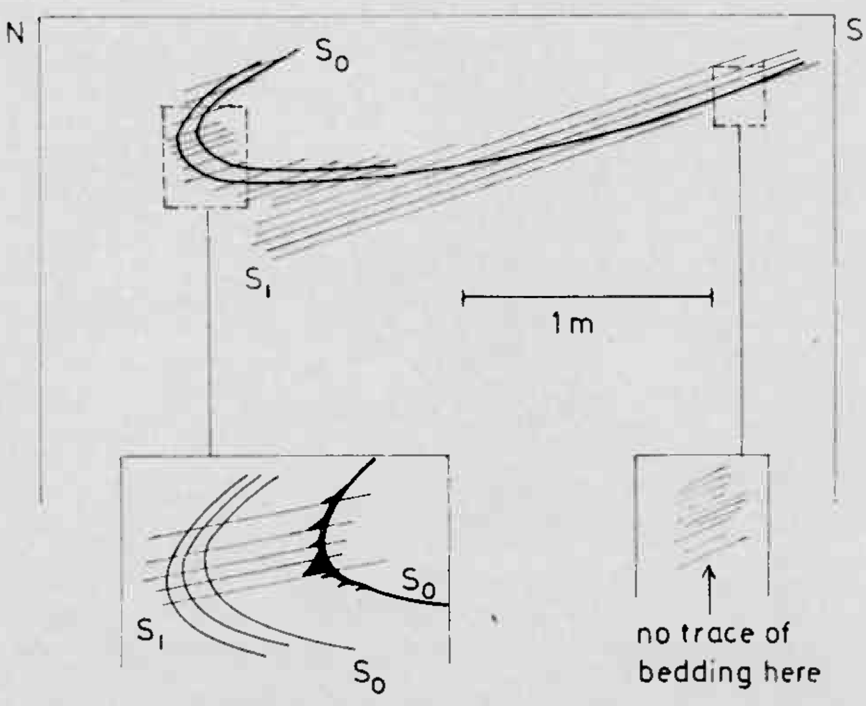


Fig. 3 Transposed bedding in calcareous psammite with a phyllite layer (black). Elstadelven (0603 0583)

Captions to plates

Plate 1. A. & B. Pseudo-conglomerate on south side of Namsen river at (0342 0707). Looking south (A), looking east (B).

C. Pseudo-conglomerate and arkose underlying amphibolite at (0719 0525).

Plate 2. A. Meta-sediment (biotite-quartz schist) raft within trondhjemite on north side of Elstadfjell at (0789 0589).

B. Trondhjemite (T), conglomerate (C), calcareous phyllite (P) and greenstone (G) near (0544 1631). Looking west from south of Langtjern.

C. Trondhjemite (left) and conglomerate (right). Contact at (0570 1666) near Langtjern.

Plate 3. A. Sandstone layer in conglomerate about 200 m west of Langtjern.

B. Distribution of rock types in the tectonic zone at Fisktjern (Map 1293-06). Looking northeast.
A - Agglomerate, C - Conglomerate, G - Greenstone, S - Calcareous silicic rock, K - Keratophyre.

C. Deformed keratophyric block in basic pebble conglomerate at Nesaavann (1026 2002). Note elongation of block by separation along open fractures.

Plate 4. A. Gently westward dipping greenstone and keratophyre pebble conglomerate in a calcareous basic matrix at (1069 2085).

B. Cut-and-fill structure in arkose about 150 m from east contact of the arkose at (0996 2218), Blåmuren. Looking north.

C. Graded bedding in arkose northwest of Pervatn. Bedding strikes northeast. (1035 2108).

D. Mylonitized basic rocks (M) underlying trondhjemite at Nesaavann (0950 1891).

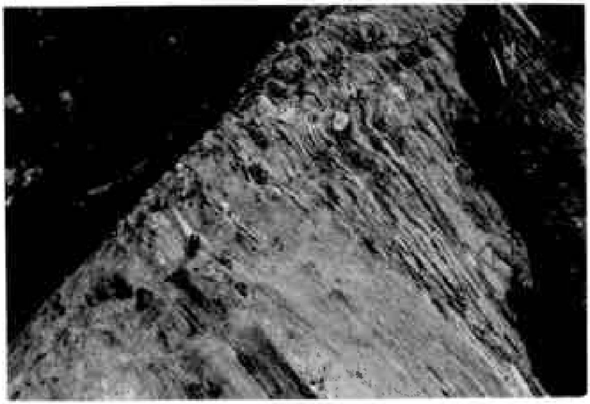
Plate 5. A. Trondhjemite dike intruded into calcareous phyllites and siltstones at (0911 1881).

B. Bedded calcareous siltstones with bedding transposed into the regional schistosity on the left limb of the fold.

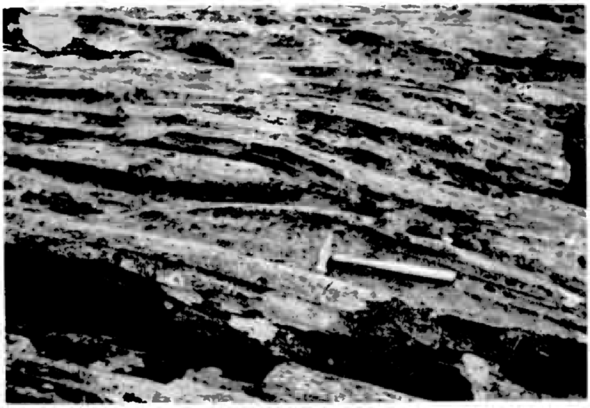
C. Close-up of 5 B. (0988 2116).

1A

1B



1C



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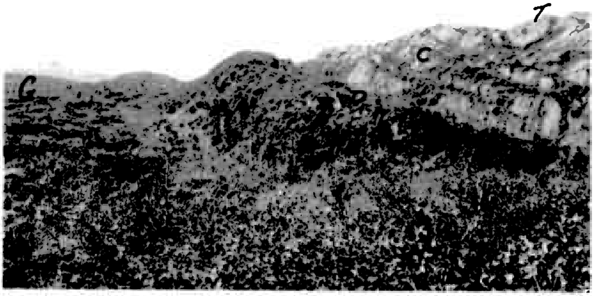
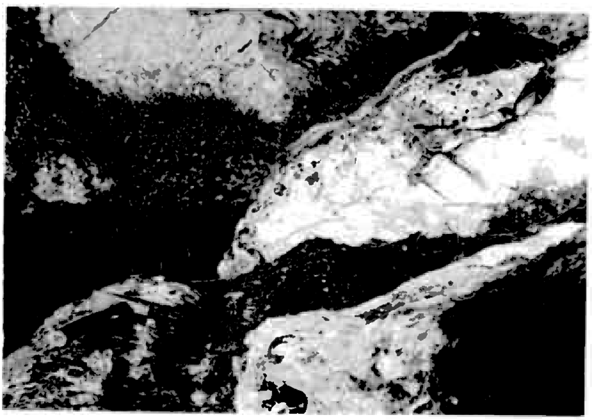


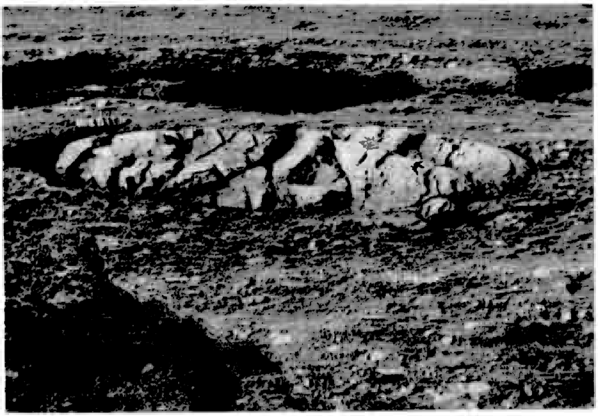
2B



2C

3A

3B



3C

4A

4B

4C

4D

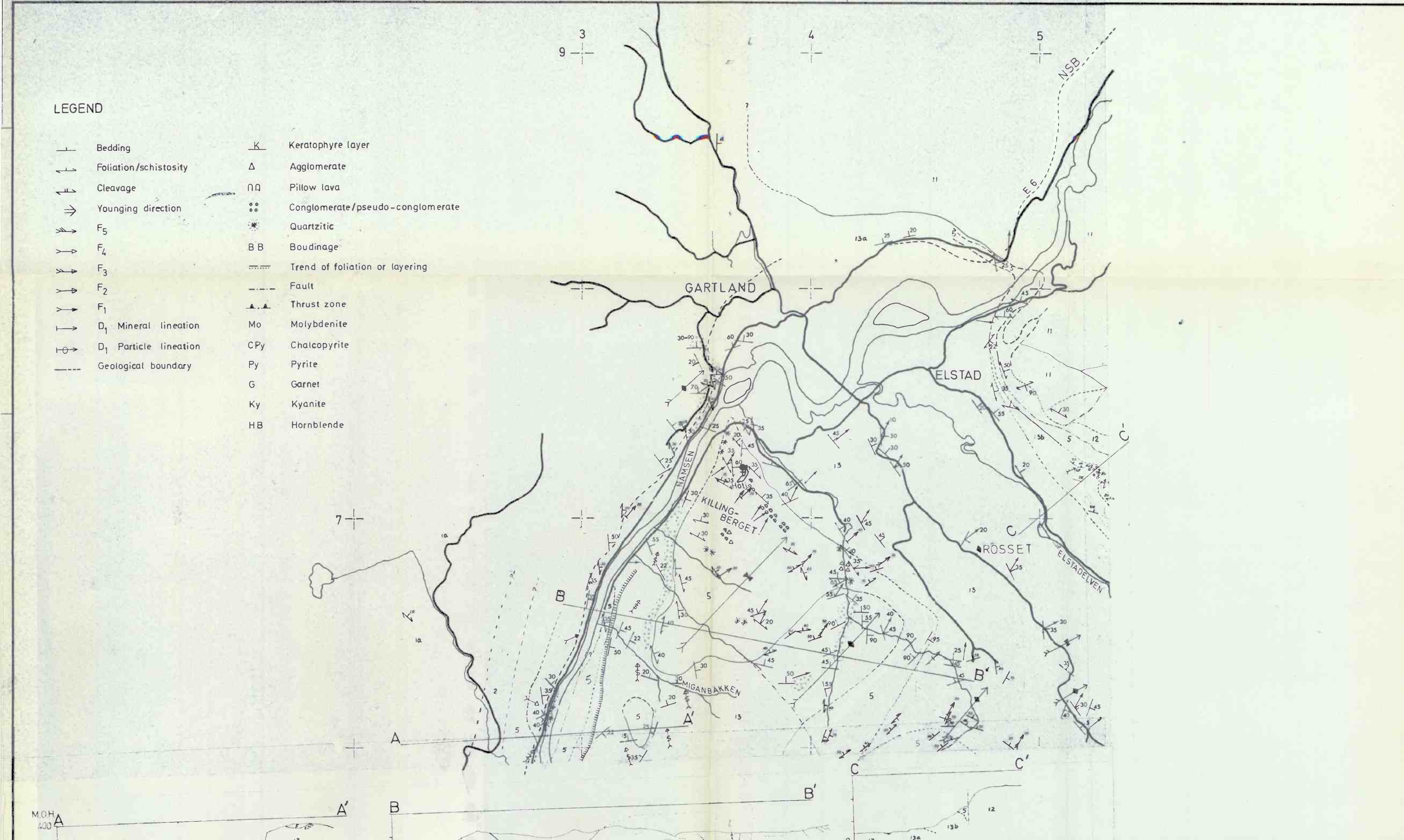
5A

5B

5C

LEGEND

16	Green-coloured phyllite, siltstone and sandstone on map 1293-07.
15	Calcareous psammite
14	Arkose and conglomerate derived from trondhjemite.
13	13. Meta-sediments; calcareous semi-pelite and arkose. 13a. Calcareous pelites, semi-pelite and phyllites in Elstadelven. 13b. Non-calcareous arkose, sandstone and minor phyllite north of Elstadelven.
12	12. Trondhjemite, medium-grained; 12a. Fine- to medium-grained; 12b. Fine-medium grained with disseminated pyrite; 12c. Trondhjemite intruded into greenstones.
11	11. Gabbro, medium-grained; 11a. fine-grained.
10	10. Calcareous sediments (phyllite, siltstone, conglomerate and sandstone). 10a. Mylonite.
9	Conglomerate derived from greenstone and keratophyre; with minor sandstone west of Gaizervann.
8	8. Quartzite horizons; 8a. Silicic rocks of unknown origin in Fremsttjern area; 8b. Calcareous silicic rocks of unknown origin (map 1293-06).
7	Keratophyre.
6	Basic volcanic rocks: 6a. Greenstone; 6b. Tuffs and volcanic sediment; 6c. Mainly volcanic sediment. Contains minor keratophyre.
5	Basic volcanic rocks: amphibolitic, generally layered; contains minor keratophyre.
4	Limestone/marble.
3	Pelitic and psammitic rocks, phyllitic in part. Probably equivalent to 2.
2	Mica schists with garnet and kyanite.
1	Gneiss, undifferentiated. 1a. Medium- to coarse-grained; 1b. Fine- to medium-grained. 1c. Layered gneiss.



GRONGPROSJEKTET 1974

GEOLOGICAL MAP

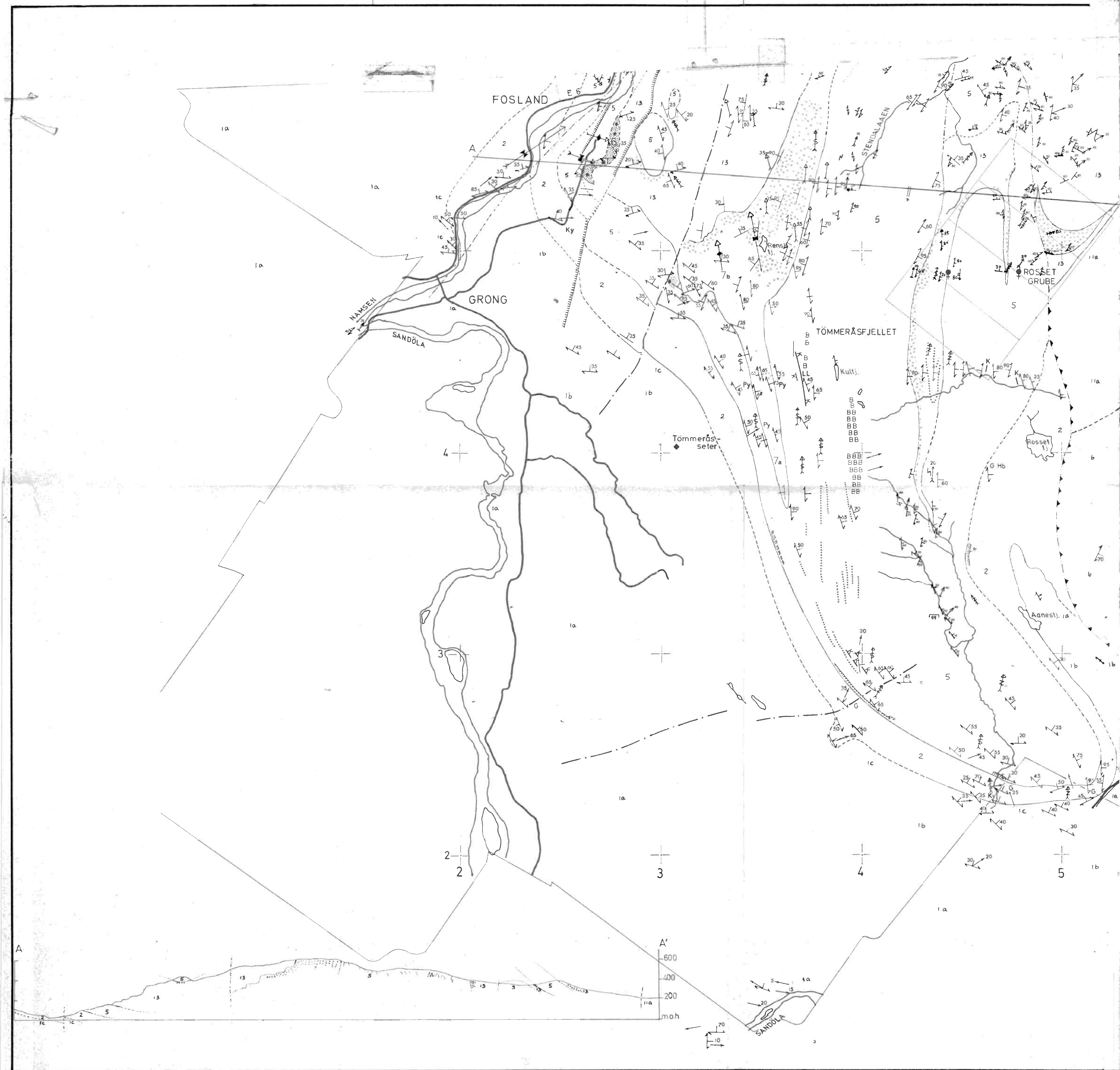
GARTLAND

NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM

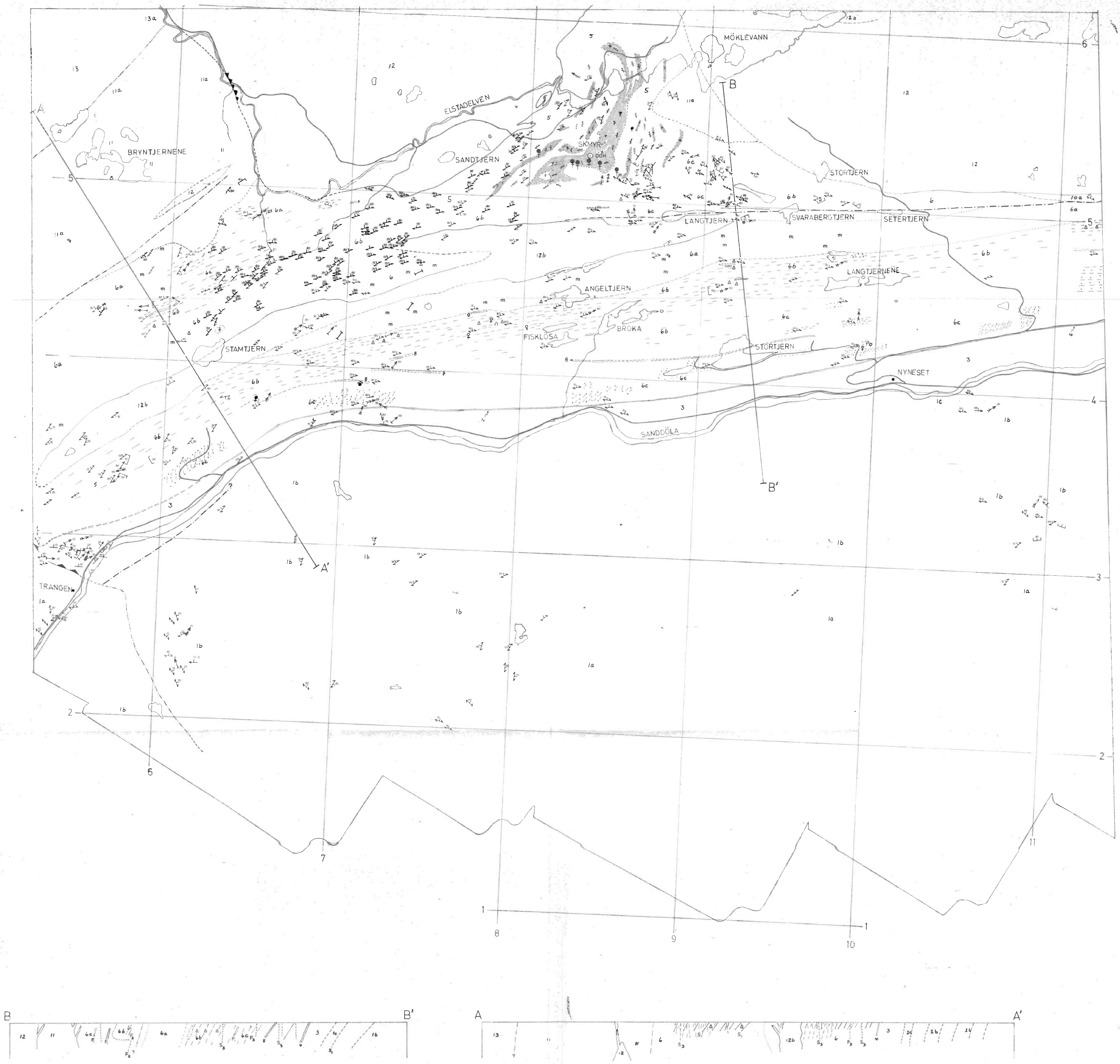
MÅLESTOKK	OBS	G.G.	1972
1 : 20.000	TEGN.	GG	1975
	TRAC.	G. Ø.	Febr. 1975

TEGNING NR.	KARTBLAD (AMS)
1293 - 01	1824 III C

GRONGPROSJEKTET 1974 GEOLOGICAL MAP RAMSJØEN	MÅLESTOKK 1:20.000	OBS GG,ØP 1973/74 TEGN GG 1975 TRAC. Jan. 1975
NORGES GEOLOGISKE UNDERSÖKELSE TRONDHEIM	TEGNING NR. 1293-02	KARTBLAD (AMS) 1824 III B

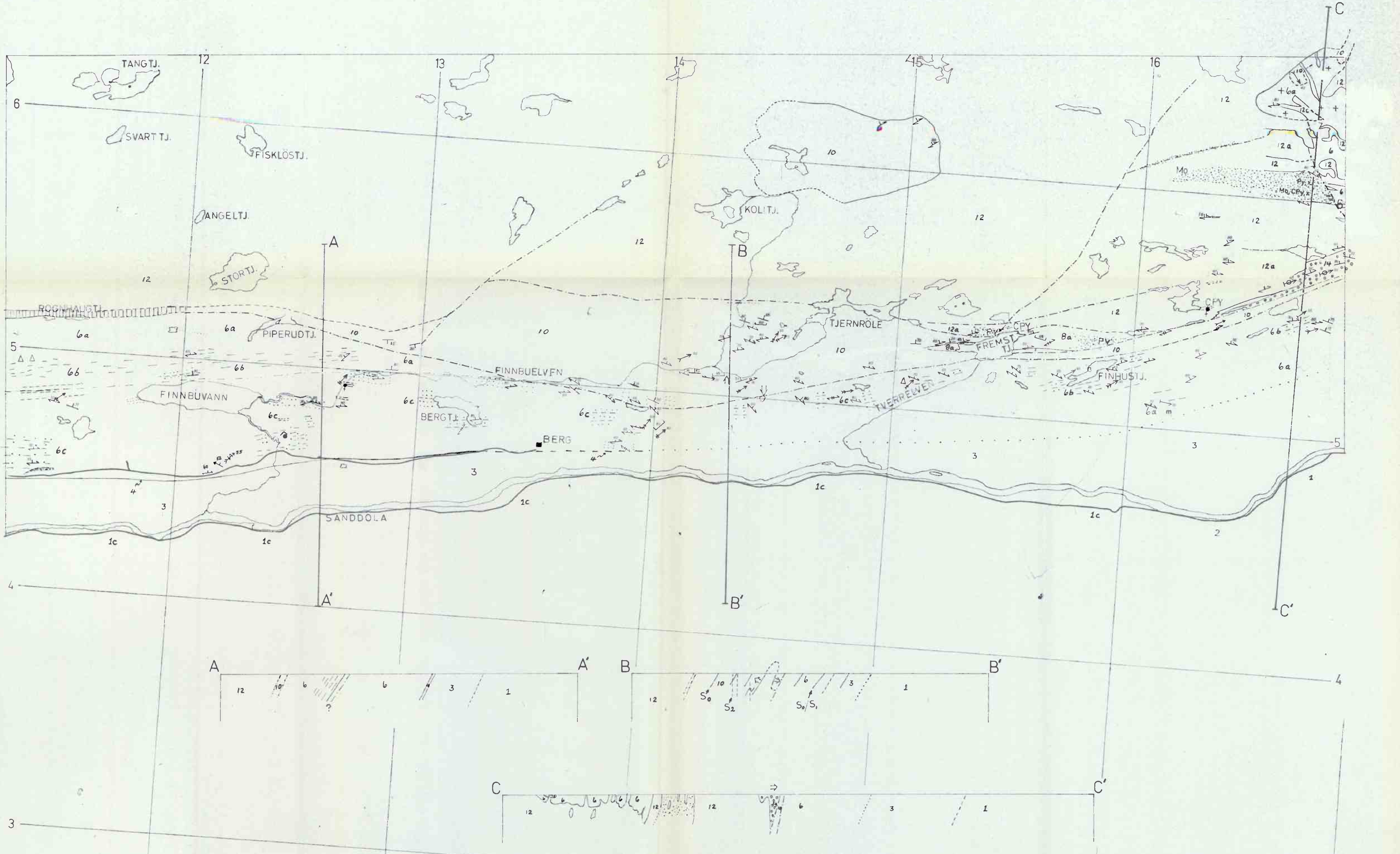


GRONGPROSJEKTET 1974	MÅLESTOKK 1 : 20.000	OBS G.G. 1972
GEOLOGICAL MAP		TEGN. G.G. 1975
TØMMERÅSFJELLET		TRAC
		KFR.
NORGES GEOLOGISKE UNDERSÖKELSE TRONDHEIM	TEGNING NR. 1293-03	KARTBLAD (AMS) 1823 IV D



SKMYR = SKIFTESMYR

GRONGPROSJEKTET 1974	MÅLESTOKK	OBS: G. Gale	1973/74
GEOLOGICAL MAP		TEGN: "	1975
MÖKLEVANN	1:20.000	TRAC: H.E	1975
		KFR.	
NORGES GEOLOGISKE UNDERSÖKELSE TRONDHEIM	TEGNING NR. 1293 - 04	KARTBLAD (AMS) 1823 IV A	



GRONGPROSJEKTET 1974

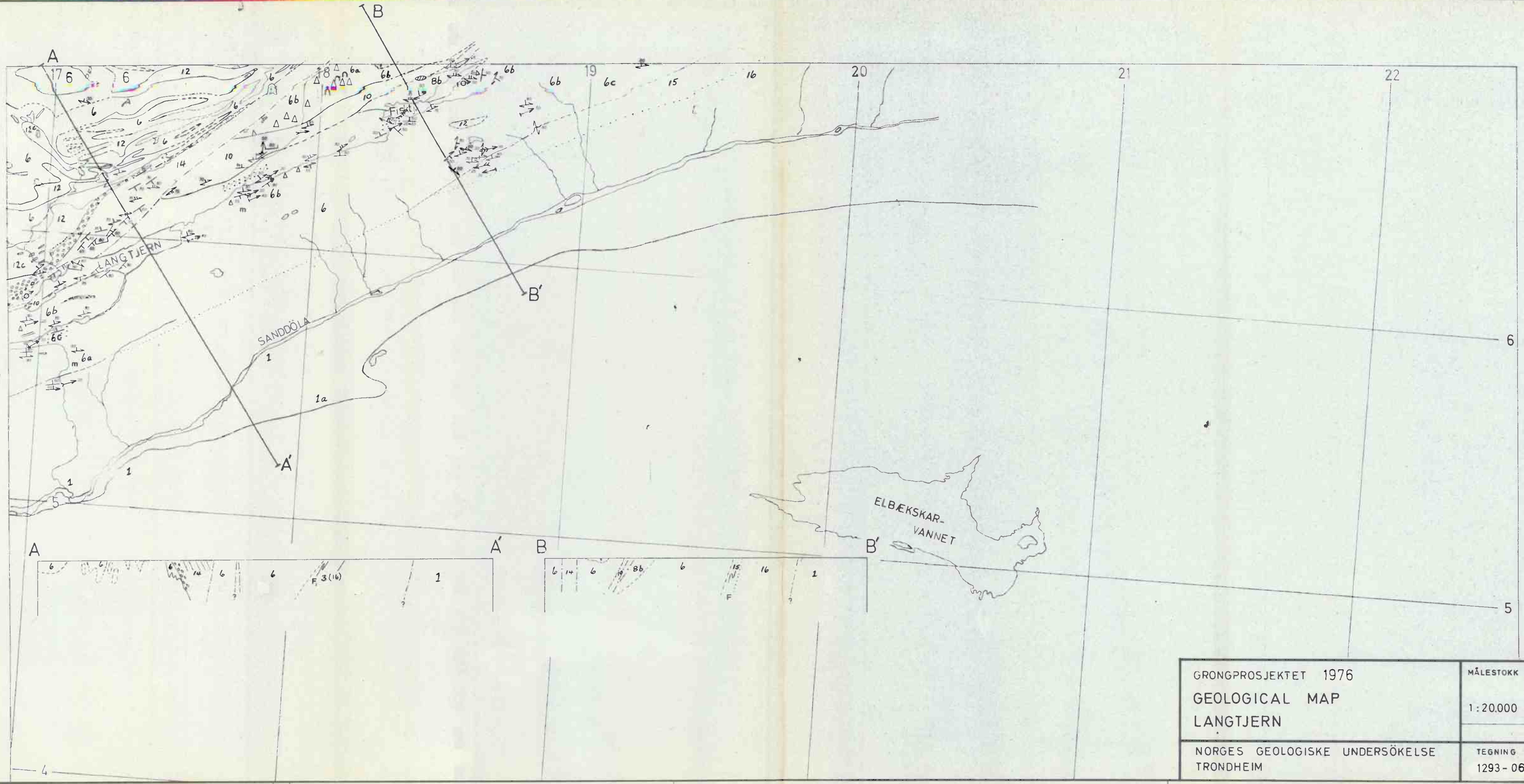
GEOLOGICAL MAP

FINNBUVANN

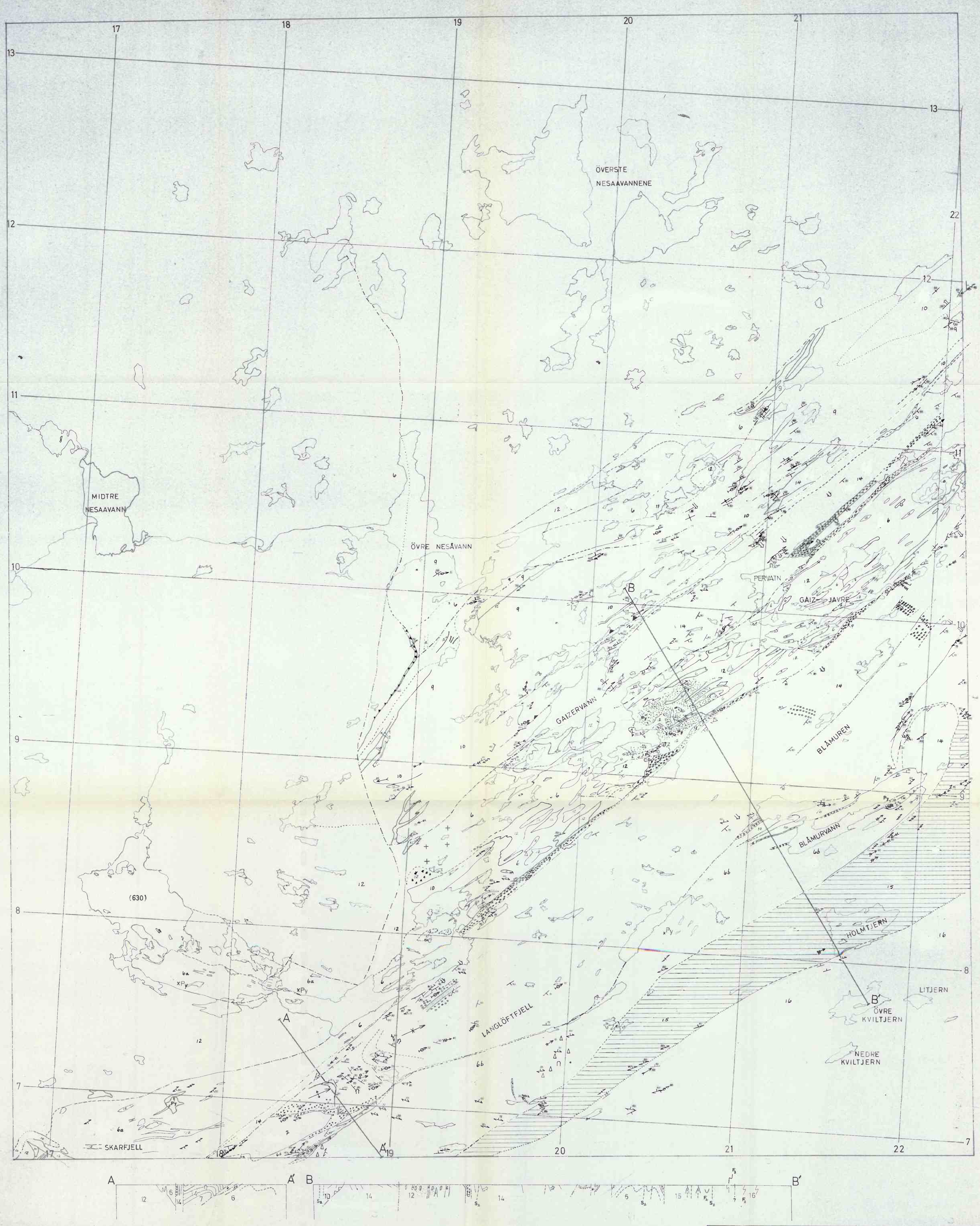
MÅLESTOKK	OBS. G.GALE	1973/74
1 : 20.000	TEGN. G.G.	1975
	TRAC. H.E.	1975

NORGES GEOLOGISKE UNDERSÖKELSE
TRONDHEIM

TEGNING NR.	KARTBLAD (AMS)
1293 - 05	1823 I D



GRONGPROSJEKTET 1976 GEOLOGICAL MAP LANGTJERN	MÅLESTOKK 1:20.000	OBS. G.GALE 1973/'74 TEGN. G.G. 1975 TRAC. H.E. 1975 KFR.
NORGES GEOLOGISKE UNDERSÖKELSE TRONDHEIM	TEGNING NR. 1293-06	KARTBLAD (AMS) 1823 I A



GRONGPROSJEKTET 1974

GEOLOGICAL MAP
NESÅVANN

NORGES GEOLOGISKE UNDERSÖKELSE
TRONDHEIM

MÅLESTOKK	OBS	G. GALE	1973/74
1:20.000	TEGN	G.G	1975
	TRAC	H.E	1975

TEGNING NR.	KARTBLAD (AMS)
1293 - 07	1824 II B

LAYERING (airphoto interpretation by F.H.)

GRONGPROSJEKTET 1974

GEOLOGICAL MAP KLINGERVANN

NORGES GEOLOGISKE UNDERSÖKELSE
TRONDHEIM

MÅLESTOKK 1:20.000	OBS. G. GALE	1973/74
	TEGN. G.G.	1975
	TRAC. H.E.	1975
TEGNING NR. 1293-08	KARTBLAD (AMS) 1924 III C	

APPENDIX A

Location of samples, etc., collected in 1972, 1973 and 1974.

1. Field notes:

1972 Notes were recorded on Geomap sheets. A card deck for these sheets has been placed on file at NGU. The originals with sketches of structures have been placed in the NGU map archives.

1973 Notes recorded on both Geomap sheets and in standard field notebooks; both are on file in the map archives. Geomap sheets have not been punched.

1974 Notes were recorded in standard field books; two of the books contain the notes taken by assistant O. Minsaas.

2. Localities:

Field observations are numbered and the location of each observation point is shown on 1:20 000 maps. For 1972 and 1974 these are filed in the map archives. The 1973 location maps are included in Rapport 1189.

3. Samples:

Samples are numbered consecutively as:

1972: 1122/1 ... 1122/n
1973: 1189/1 ... 1189/n
1974: 1293/1 ... 1293/n

The sample numbers are shown inside a ring on the observation locality maps.

A list of samples with the numbers of the observation locality and a short description is on file together with the locality maps in the map archives.

Hopefully, the samples will be separated according to 1:50 000 map sheets prior to storage in the NGU rock archives.

4. Air photo overlays:

Field observations were conducted with the aid of 1:20 000 airphotos. The original observation data were recorded on transparant overlays. These overlays are stored together with the field notebooks.

APPENDIX B

Geochemistry of volcanic rocks in the Grong area.

NB. This Appendix is chapter 4 of NGU Rapport nr. 1228 A, pp. 11-30.