II. Geology of the Meråker area as a key to the eastern part of the Trondheim region

by F. Chr. Wolff.

Abstract

The present paper deals with a discussion of the main tectono-stratigraphical problems of the eastern Trondheim region. Based on detailed studies made in the Meråker area in the last three summers and available manuscript maps and personal communications from geologists working in the southern parts of the region, it has been possible to establish a general stratigraphy for this eastern region and revise the stratigraphical nomenclature, distinguishing the Gula Schist Group from the Røros Schist. It is also pointed out that on evidence principally from the northern half of the region, the former 'Trondheim synclinorium' has to be regarded as an anticlinorium. It is shown that a major thrust plane occurs along the larger part of the border of the Trondheim region and the term 'Trondheim nappe' is suggested for the allochtonous metasedimentary sequence above this plane. The occurence of serpentinite bodies along the thrust plane is discussed, as is the distribution of the pyritic and chalcopyritic ores over the entire Trondheim region.

Introduction

In the last decade a good deal of mapping has been carried out in different parts of the eastern Trondheim region, from the Sel area in the south to the Jævsjø area in the north. No attempts to compile all this data have been made until now.

The present writer is fully aware of the difficulties involved in performing such a compilation and while he accepts the risk of making errors on a small scale, the conviction that such work would be of considerable value to those pursuing studies in this field has tended to outweigh all the risks involved. It may well be that certain of the conclusions which here will be drawn from the different observations made over this broad region will later be proved to be incorrect, but on the basis of present-day knowledge the writer is of the opinion that an attempt to put all this data together will point out the main problems and assist in determining where and how to start the most fruitful investigations in the years to come.

Previous investigations

In this chapter mainly the investigations made previous to the last decade will be mentioned.

In 1838, 1844 and 1850 B. M. Keilhau published his revue of Norwegian geology, "Gæa Norvegica", in three volumes. In part four of the last one he gives a description of the area which is today known as the Trondheim region. Keilhau shows a general knowledge of the principal rock types and the broad outlines of the strike and dip of the schists of the area. Although he expresses himself in a rather vague manner with regard to the question of the tectonic development of the area the principle conclusion to be drawn is that he considers the Trondheim area as folded in a large syncline. This can be seen from the following statement, "Zwischen Vaage und Læssøe (Vågå and Lesja) fängt mit nördlichem und nordwestlichem Fallen eine Schichtenzone an, welche mit nordwestlichem Fallen über Foldalen (Folldal) im Tønset (Tynset) hinein fortsetzt, in dem H a n g e n d e n (present writer's italics) derselben folgt eine eben so lange vertikale Zone, und jenseits dieser wieder Schicten, die südlich- und südöstlich einschiessen, dann aber in der Gegend am Stu-See und um Bubakken in Qvikne sich gegen Norden mit östlichem Fallen schwingen, und noch nördlicher sogar umbiegen, um beinahe nord-nordwestlisches Streichen mit Fallen gegen ONO anzunehmen. Eine Art Regelmässigkeit in der Schichtenstellung findet sich also in dieser besonders im Süden und Osten an Dovrefjeld angeschlossenen Gegend, und die Regel führt zu einem Streichen ganz quer über die Kette, die man sich hier zu denken pflegt."

After Keilhau Th. Kjerulf worked in the Trondheim region, from 1866 with K. Hauan as his assistant. The results of this work was published in two papers; "Om Trondhjems stifts geologi", 1871 and 1872, which gave a lot of descriptive information about the Trondheim region. With regard to the stratigraphical and tectonic problems Kjerulf also favoured the idea that the whole sequence was folded in a syncline. He published a stratigraphical table suggesting the "Gulaschists" as the youngest, Støren, claystone and schists, conglomerate and sandstone layers as the middle and Røros and Trondheim schists as the oldest part of the sequence. Later in his paper, "Udsigt over det sydlige Norges geologi" (1878), he still held the same opinions about both stratigraphy and tectonics, though he then discussed (p. 176) the possibilities of an inverted system with the oldest rocks in the middle of an anticlinal structure. However, since he was not able to locate the thrust planes necessary for such an interpretation, he abandoned this alternative. Largely the same view is also found as a basis for Kjerulf's interpretation in his next paper, the "Merakerprofilet" (1882).

In contrast to this opinion are the views of the Swedish geologist A. E. Tørnebohm (1872) and his countryman F. Svenonius (1885). Svenonius discusses the opinions of Th. Kjerulf and Tørnebohm and concluded that the Meråker profile must be interpreted as an anticlinal structure with the youngest rocks in overturned synclines on either side of an older central core zone, an opinion which seemed to be accepted by the head of the Norwegian Geological Survey, Hans Reusch, in his paper of 1890. At this time Reusch was able to involve A. Getz's discovery of graptolites at Kjølhaugene in Meråker in the same discussion.

A. E. Tørnebohm in his memoir on Central Scandinavian geology (1896) discussed his ideas for the general geological structure of the Trondheim region. He pointed out the NNE — SSW trend of the mountain chain and declared that amongst all the synclines and anticlines in the region there are two "nuclear lines", the syncline in the east along the Swedish—Norwegian border and the syncline along the Trondhjemsfjord. But as his picture of the stratigraphy is partly misleading he was not able to clear up the overall tectonic picture of this broad district.

Carl Bugge (1912) rejected the views of the Swedish geologists and supported Kjerulf's old opinion that the "Gula Schists" must be the youngest stratigraphical group. Bugge drew a profile across the mountain chain which indicates a syncline with the "Gula-schists" in the middle (fig. 50). Gunnar Holmsen (1915) held the same view.

C. W. Carstens (1920) revived the opinion of Svenonius, Reusch and Tørnebohm but repeated the interpretation of all previous authors in placing the Røros schists in the lower part of the sequence. C. W. Wegmann (1925) regarded the central Gula schist zone as a "grand lambeau de recouvrement", while Gunnar Aasgaard (1927) again stuck to the old opinion of Kjerulf.

Th. Vogt (1940) emplyed a revised study of an old find (by the late J. H. L. Vogt, his father (1888)) of *Dictyonema flabelliforme* at Nordaunevold to try to strengthen the idea of a synclinal structure for the Trondheim region. He also supported the opinion that the Røros schists were older than the Gula schists by mistaking the schists at Nordaunevold as belonging to the Røros schist division. In this attempt he succeeded so well that no one working

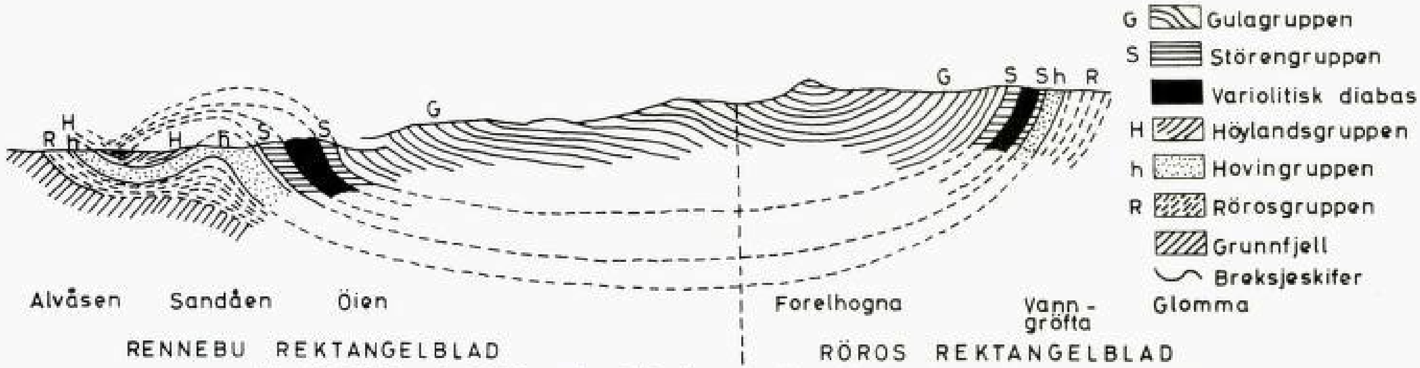

Fig. 50. C. Bugge's (1912) section indicating a syncline with the Gula Schists as the youngest beds.
C. Bugge's (1912) profil som antyder en synklinal med Gulaskifrene som de yngtse lag.

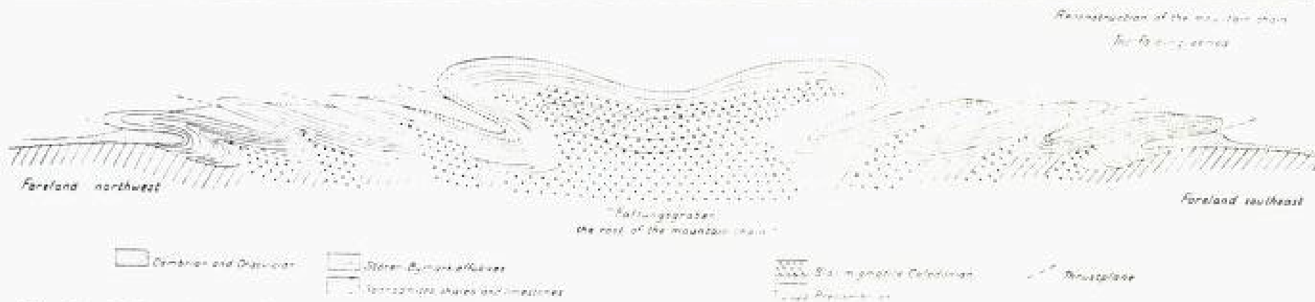

Fig. 51. C. Bugge's (1954) section across the Norwegian Caledonian mountain chain from NW to SE with reconstruction of the folding. The section also tends to show that the "Faltungsgraben" (the root of the mountain chain) to a certain extens is a depressed geanticline.
C. Bugge's (1954) profil gjennom fjellkjeden fra nordvest til sydøst med rekonstruksjoner av foldingene. Profilet skal også vise hvorledes foldingsgrøften kan tydes som en delvis sammensunket geantiklinal.

in this area opposed him until Carl Bugge did in 1954. Bugge published a profile across the mountain chain (Fig. 51) and a map demonstrating his idea that this eastern part of the Trondheim region is analogous to the western part. He correlated the greenstone of the Folldal — Haltdal area with the Støren greenstones and concluded that the greenstones are overlain in a syncline by the Røros schists, which are equivalent to the Hovin — Hølonda Group in the western Trondheim region. He also stated that although the greenstones overlie the Røros schists, in his opinion this is only a tectonic feature and in reality the Røros schists are younger than the greenstones. Unluckily Bugge's views were never accepted (this is demonstrated by the fact that his ideas were never lectured nor cited) before the present writer (1964) arrived at a similar, but better established stratigraphical and tectonic picture based on accurate field observations from detailed studies in the northern half of the Trondheim region.

Using the evidence from these northern areas the present writer was able to re-analyse the available data from the southern half of the region, based mainly on manuscript maps from his former colleague state geologist Johs. Færden, who had worked for a period of 10 years in the Røros district (Quadrangles: Stuesjø, Aursunden, Røros, Haltdal, Tynset and Kvikne).

Acknowledgements

Thanks are first of all due to my former colleague Johs. Færden for permission to use his manuscript maps and report on the Røros area, and to Hans Heim, Folldal, for similar reasons.

A student group under the guidance of Professor J. A. W. Bugge is carrying out a programme of ore research in the Killingdal area. The present writer is indebted for data obtained from members of this group.

Discussion based on recent investigations

We shall now turn to the discussion of the broad tectono-stratigraphical picture in the eastern Trondheim region, see table I, a picture which can be constructed from the studies made over this region in the last ten years.

The Stjørdal - Meråker area

As this area has been so thoroughly described earlier in this NGU volume, it is necessary here only to sum up what the writer considers to be the main results of these studies with regard to the present discussion.

As the present writer points out in an earlier paper (1964) he regards the profile across the Caledonian mountain chain from Stjørdal to the Swedish border as a fan-shaped anticline with the oldest rocks, the Gula Schist Group in the central part and the younger Støren and Hovin rocks in overturned synclines on either side. In view of the resulting controversy surrounding this statement, it was felt that certain more specialised and detailed studies in the area would help to clarify various points and perhaps settle the main arguments. The results of the small scale tectonic studies are given by D. Roberts in his article. He has been able to support the anticlinal interpretation by much stronger arguments based on a better and detailed knowledge of the structure. The finding of the Lille Fundsjø conglomerate by F. Fediuk proved the inversion of the sequence in the eastern area as did the detailed study of the sedimentary structures by A. Siedlecka. The views of the present writer are therefore more firmly established today than in 1964.

The extension of the thrust-plane

As pointed out by the present writer (1960 and 1964) and by Peacey (1964) there is a thrust plane separating the basement from the Cambro-Silurian rocks in the northern part of the Trondheim region. Peacey (1964) moreover was able to interpret the rocks resting on this thrust plane as constituting an upper nappe above the Seve nappe. Oftedahl (1966) states that, "As yet it remains to be seen if this upper nappe can be compared with the Rødingfjell nappe farther north and if this new nappe can be traced into the central parts of the Trondheim district".

Our mapping over the last two summers has shown that this thrust plane is traceable southwards as far as half-way down the quadrangle Essandsjø (Pl. IV). On Quadrangle Stuesjø it coincides with the thrust plane marked on Schaar's (1961) map, although this writer interprets the rocks overlying the thrust-plane as belonging to the Seve nappe. Færden (personal communication*) regards the augen gneiss zone extending from the lake Langen on quadrangle Stuesjø to Brekken on quadrangle Aursunden, as being derived from metamorphosed mylonites belonging to a thrustplane. This zone, which links up with the above-mentioned thrust plane of Schaar, extends southwestwards across the quadrangles Aursunden and Røros and joins up with the augen gneiss zone of P. Holmsen (1950) on the quadrangle Tynset. Heim (1966) also marked this augen gneiss zone on his map, quadrangle Folldal, and as the thrustplane is overlain bye the Røros Schists and underlain by the

*) Hereafter personal communication will be cited as p.c.

Eocambrian Sparagmites it is possible to extend the trace of the thrust plane along the border between these two rock-types across the map sheet Dovrefjell (Heim 1966 p.c. on manuscript map). This takes the thrust plane into the Sel and Vågå map area of Strand (1951) where it links with the northern part of his Otta nappe. In this southern area the trace of the thrust plane swings round and proceeds northwards across the western part of the map-sheet Dovrefjell (Heim's manuscript map) and then links up with the augen gneiss zone of P. Holmsen (1960) on the quadrangle Oppdal map-sheet.

At the moment it is not possible to trace it further northwards but it is quite probable that this will be achieved by more detailed mapping in the future.

As can be seen from the map (Pl. IV) the thrust plane surrounds what for a long time has been called the Trondheim region and the present writer therefore suggests the *Trondheim nappe* as a suitable name for the metasedimentary pile occuring above this major thrust plane. This will include the upper nappe of Peacey (1964) in the north and the northern part of the Otta nappe of Strand (1961) in the southwest.

It then remains to be proved whether or not the Trondheim nappe is equivalent to the Rødingfjell nappe in the north (Oftedahl 1966) or the Lower Jotun Nappe in the south (Strand 1951).

The Gula Schist Group

The rocks of this group are characterised by different types of mica schists often containing garnet or hornblende. Some horizons also contain staurolite, kyanite or sillimanite (Roberts present volume).

Kjerulf (1871) uses the term Gula Schists for this rock series and Røros Schists for the rocks appearing in this paper as belonging to the Røros Group. As the studies of the Trondheim region proceeded the term Gula Schist lost ground in preference to the latter, and in the recent papers rocks of both groups appear as one, namely the Røros Group. As it has now been possible to distinguish between the two, the olds terms should be re-established. The Gula Schist Group then refers to the mica schists described above and the Røros Group to the metagraywackes of the Røros — Meråker zone in the east which are equivalent to the Upper Hovin Group of the Hølonda — Horg area in the west.

In the northern part of the Trondheim region these rocks contrast markedly with rocks of the Røros Group, the latter containing phyllites and graywackes of the lower part of the greenschist mineral facies. As the degree of metamorphism increases southwards and the rocks of the Røros Group, often contain porphyroblasts of biotite, garnet and hornblende in the Haltdal — Røros area, it becomes increasingly difficult to distinguish between the two groups. For this reason the mapping of these rocks has been problematical in these southern areas. Færden (p.c., manuscript maps 1965) for example, designates the metasediments of both these groups as mica schists.

As it is clearly much easier to distinguish between these two types of schist further north in the vicinity of Meråker, this obvious difference has proved advantageous to the present writer in his examination of the rock-types occurring in the Haltdal — Røros area. Consequently it has been possible to follow the two metasedimentary groups along the strike between the Meråker and Røros areas, despite their changing metamorphic condition.

As already pointed out by Strand (1960), "Objections can be raised to the validity of the term Røros Group..." taken as a group name for the oldest Cambro-Silurian beds of the Trondheim region. As discussed later in the present paper the schist of Røros Group type is almost certainly equivalent in age to the rocks of the Upper Hovin Group in the Hølonda — Horg area (Vogt 1945). The term Røros Group is therefore invalid for the schists below the lower greenstone (Støren Group) in the central zone of the Trondheim Caledonides.

The schists typical of this group outcrop all along the Gauldalen valley from Ålen to Støren and the term *Gula Schist Group* is therefore quite appropriate.

Since the northern distribution of the Gula Schists (then called the Røros Group) has already been outlined in an earlier paper, Wolff (1964), it is only necessary to discuss their distribution south of the Tydalen valley in this chapter.

South of Gauldalen valley Birkeland (p.c. 1966) report rocks of the Gula Schist Group as far southwards as the area east of Dalsjøhøgda, quadrangle Røros. In the western half of the same quadrangle Færden (p.c. manuscript map 1965) has indicated the presence of mica schists. On quadrangle Folldal Heim (manuscript map 1966) indicates that the different mica schists of the "Storhøschieferserien" most likely represent the Gula Schist Group in this area. By comparison with the Sel Micaschist to the west, Strand (1951) Heim interprets this rock series as belonging to the Hovin Group. In the present writers opinion while the comparison with the Sel Micaschist is valid as the Storhø Series continues across the map-sheet Dovrefjell and links up with the Sel Micaschist on quadrangle Sel (Strand 1951), the interpretation of the stratigraphical position is incorrect since the Storhø Series is almost certainly equivalent to the Gula Schist Group.

In the western part of the southern Trondheim region, rocks of this group are also known from quadrangle Oppdal (Holmsen 1960) and Kvikne (manuscript map Færden 1965).

The extension of the Gudå conglomerate zone

In an earlier paper, Wolff (1964) the present writer interpreted the Gudå conglomerate zone, represented at different localities in the central part of the northern Trondheim region as lying near the base of the lower greenstone. The distribution of these localities is shown on the map (Pl. IV). These quartzite conglomerates are often accompanied by a band of crystalline limestone. This limestone occurs in the southernmost part of the previous map at Bukkhammeren and is also known south of this locality, on Vollfjell (Volfjell limestone, Vogt 1941). Sørbye (p.c. 1967) reports a deformed, discus-shaped polygenous conglomerate near Vårhus in Hesjedalen. A similar conglomerate is also reported from Harsjøfjell and Øvstubekken on quadrangle Røros (Birkeland p.c. 1966).

A conglomerate of similar type (the Husum conglomerate) appears on Heim's manuscript map Folldal together with a crystalline limestone. As will be seen from the map (Pl. IV) it's stratigraphical situation is indicative of the position of the Gudå conglomerate zone.

A conglomerate located at Buåi in Grimsdalen on map-sheet Dovrefjell has been correlated with the Husum conglomerate (Heim p.c. 1966). The present writer also believes thatt he Skardshø quartzite conglomerate, appearing on quadrangles Sel and Vågå (Strand 1951), belongs to this zone.

No definite reports are known of any conglomerate which could be interpreted as belonging to this zone in the southwestern part of the Trondheim region. A conglomerate near Hjerkinn, quadrangle Dovrefjell (Heim p.c. on manuscript map 1966) is somewhat dubious since it contains boulders of both quartzites and greenstones.

The lower greenstones — the Fundsjø Group

The rocks oft this group have been correlated with the Støren Group (Wolff 1964) of the Hølonda — Horg area (Vogt 1945). This zone consisting of basic and acid volcanics as well as gabbroic intrusive bodies, is very easy to trace north and south of the Meråker area. It's extension to the north has already been pointed out in an earlier paper (Wolff 1964). The map accompanying this paper depicts its extension towards Tydal south of the Meråker area, where it links up with the amphibolite group of Kisch (1962). This zone proceeds southwards on the manuscript maps Haltdal, Røros and Tynset of Færden (p.c. 1965). Færden reports pillow structure at Lille Øyebekken near Nygjeltvold on the quadrangle Røros.

The rocks of this group are also met with on Heim's manuscript maps Folldal and Dovrefjell (p.c. 1966). Heim also regards these rocks as belonging to the Støren Group, an intepretation favoured by Strand (1963) in the adjacent Sel area, where a similar zone of greenstone links up with the greenstones of the southern part of the map sheet Dovrefjell.

The greenstones appears repeatedly possibly due to the folding in this area.

The western limb of this greenstone fan disappears in the northwestern part of the quadrangle. Vågå, but reappears on the map-sheet Dovrefjell (Heim manuscript map 1966) and then continues northwards on to quadrangle Oppdal (Holmsen 1960). The exact borders of the lower greenstone are not properly given on Holmsen's map, but the existence of such rocks is undubitable since rock-types such as pillow lavas, chert, greenstones and greenstones conglomerate appear on the map.

The Lille Fundsjø conglomerate zone

The best demonstration of the inversion of the beds at Meråker is provided by the Lille Fundsjø conglomerate discovered by Fediuk (Fediuk and Chaloupsky this volume). Grammeltvedt (p.c. 1966) reports a similar conglomerate from the same stratigraphical position on map-sheet Essandsjø. A polygenous conglomerate is also reported from quadrangle Haltdal by Rui (p.c. 1966) but it's stratigraphical position is not quite clear. It might be equivalent to the Lille Fundsjø conglomerate but it is more likely to represent the position of the Brenna conglomerate stratigraphically above the first one.

Birkeland (p.c. 1966) reports polygenous conglomerates containing boulders of trondhjemite and greenstone at Rensjøen and at Grøtåa near Hesjedalen quadrangle Haltdal. These conglomerates are bordered by the lower greenstone Fundsjø (Støren Group) to the west, and are thus in a comparable position to the Lille Fundsjø conglomerate.

The same holds for the Grimsa conglomerate (Heim, p.c. 1966) on quadrangle Folldal although Heim interprets this conglomerate as underlying the lower greenstone thus representing the Gudå conglomerate zone (Wolff 1964). Heim's interpretation is due to his belief in the assumption of the Trondheim *synclinorium*, (Strand 1951). As to the age of the greenstone conglomerate on quadrangle Sel (Strand 1951), there is no doubt that this conglomerate is overlying the greenstone of this area interpreted as being equivalent to the

Støren Group by Strand (1964). Moreover this conglomerate is overlain by the serpentine conglomerate dated by fossils to the lower part of the Lower Hovin Group, (Yochelson 1963).

From the west side of the anticlinorium a conglomerate of a similar type and position is known from the Grønbakken area, Holmsen (1960). Some of the "various polygenous conglomerates" depicted on Holmsen's map (1960) might also occupy this position.

A serpentine conglomerate is also found near Brekkebekk, quadrangle Folldal (Marlow 1936). The most obvious assumption is to correlate this conglomerate with the serpentine conglomerate near Sel, but as it occupies a position which seems to be the same as the upper greenstone this parallelization is still somewhat doubtful. The extension of the Brekkebekk serpentine conglomerate was reported by Törnebohm (1896) who claimed that it continues northwards for 80 km to Sætersjøen, on quadrangle Røros, as a quartzitic conglomerate. Near Sætersjøen the conglomerate is overlain to the east by the zone of an upper greenstone. The present writer is therefore inclined to correlate this conglomerate with the Brenna conglomerate at Meråker.

The extension of the Sulâmo-Group

The rocks of the Sulâmo-Group have been correlated with the rocks of the Lower Hovin Group (Fediuk and Chaloupsky, present volume). Their extension to the north is clear (Wolff 1964), but to the south their presence is still somewhat dubious. Grammeltvedt (manuscript map 1966) has been able to trace the beds of this group to the lakes Lødølja on the quadrangle Essandsjø. South of this lake a limestone is reported by K. M. Hauan (diary 1870) together with a grey to black phyllite, rocks typical of the sequence in question.

On quadrangle Haltdal, Rui (p.c. 1966) holds that the sandstone to the west of the upper greenstone belongs to the Sulâmo Group. Because of the thrust plane mentioned in the next paragraph, there is no mappable connection between these two localities (Pl. IV) which in effect represent the same zone. Birkeland (p.c. 1966) reports phyllites, partly graphitic, and graywackes south of the Gauldalen valley on map-sheets Haltdal and Røros, which also may belong to this same horizon.

Færden (manuscript map Røros 1965) describes these rocks as mica schists, but as they occur between the upper greenstone in the east and the lower greenstone (Fundsjø — Støren-Group) in the west it is most probable that these mica schists are equivalents of the Sulâmo-Group.

On P. Holmsen's map Tynset (1950) this zone is depicted as phyllites;

there can therefore be no arguments against including them in the same group.

On an excellent map of the quadrangle Folldal, Heim (stensil, Diplomarbeit University of Mainz, F.G. 1966) notes the occurrence of a "Graue phyllitische Glimmerschiefer" in this zone. Heim's sketch map Dovrefjell (p.c. 1966) shows this same rock continuing across the map sheet towards the west where it links up with the schists indicated as the Heidal Series on Strand's map Sel and Vågå (1951). Strand's interpretation of the Heidal Series, in this part of the map, as being situated beneath the greenstone (Støren Group) is contrary to the fact that according to his map the schists in the area in question are obviously overlying the greenstone while the border between the two is occupied by a double greenstone-serpentine conglomerate which is proved to be younger than the greenstone. The serpentine conglomerate is dated by fossils to 3cβ—3cγ of the Oslo region (Yochelson 1963) a position equivalent to the Venna conglomerate of the Hølonda — Horg area (Vogt 1945). This questionable point is due to the fact that Strand (1951) with the information then available had to assume that, "In the northern part of the Vågå map area a synclinorium widening towards the north forms the southern end of the large synclinorium of the Trondheim Region", while today, working with the present knowledge of the northern Trondheim region, one has to accept the possibility that the main structure of this area is similar to that in the northern parts i.e. anticlinal. This leads to the assumption that the schists in the western part of this area, indicated as the Heidal Series with a question-mark on Strand's map, belong to the Sulåmo (Lower Hovin) Group.

The upper greenstone

At several localities in the eastern Trondheim region a greenstone of minor thickness is found to the west of the rocks of the Røros Group (Upper Hovin). This greenstone was found by Foslie (Foslie and Oftedahl 1959) during his mapping of quadrangles Jævsjø and Bjørkvassklumpen and followed across the quadrangle Verdal by the present writer (1960). Stratigraphically it has been placed near the horizon of the Volla conglomerate (Wolff 1964). As mentioned in Fediuk's and Chaloupsky's article (this volume) it has also been traced across the quadrangle Meråker. Grammeltvedt (p.c. 1966) has only been able to follow this greenstone for a short distance southwards on the quadrangle Essandsjø where it thins out. U. Bjørlykke's (1963) map indicates that this greenstone reappears along the river Lødølja. Rui (p.c. 1966) reports a similar greenstone horizon further to the south on the quadrangles Stuesjø and Haltdal, the inversion of which is demonstrated by well-preserved flame structures in a tectonically overlying sandstone to the west. To the east of this greenstone Færden (examination thesis 1949) and Rui (p.c. 1966) report the presence of a thrust plane. This thrust plane is probably sub-parallel to the main one but of a minor order. Its extension both northwards and southwards is not properly mapped at the moment; until this mapping has been completed several questions must remain unanswered. Although several manuscript maps by Færden and others indicate the extension of an easterly greenstone, most likely belonging to this zone it is impossible at present to give an exact picture of it on the map. Færden (p.c.) also reports this green stone from Branumshøgda west of Kongens grube quadrangle Røros and from a drill hole at Lergruebakken east of this mine. This observation is particularly noteworthy as it is a strong indication that the upper greenstone underlies the Røros schists in an inverted anticline in this area. (Færden p.c. profile (fig. 52).). It should be pointed out here that an accurate mapping of this greenstone, in the present writer's opinion, would be of great value to the stratigraphical understanding of this region since it is most likely equivalent to the Volla conglomerate in the Hølonda — Horg are (Vogt 1945), thus marking the border between the Lower and the Upper Hovin Groups. Carstens 1919 reports a similar greenstone niveau in the western Trondheim region, the Jonsvann greenstone. Heim (p.c. 1966) reports an "untere grünschieferzone" on Bukletten, quadrangle Folldal, which may belong to the upper greenstone since he is not aware of the inversion of the sequence. Farther to the west there are no reports of this greenstone horizon.

The Røros Schists

Since Kjerulf (1876) introduced the name "Røros-skifer" this rock series has been regarded as the oldest part of the Trondheim suite. As mentioned previously C. Bugge (1954) was alone in opposing this opinion although T. Strand (1960) pointed out that, "The Røros Group consists of mica schists and can be defined as a stratigraphical unit only by its position below the greenstones of the Støren group and above the underlying sparagmitic schists, which may perhaps be an original basement". Strand also states that, "objections can be raised to the validity of the term Røros Group as the mica schists in the surroundings of Røros, which ought to be the type area of the group, are of undetermined stratigraphic position". It must be kept in mind that the Røros Group as mentioned here, is taken as a group name which includes both the Røros Schists and the Gula Schists.

As the studies in the Meråker area proceeded the present writer became

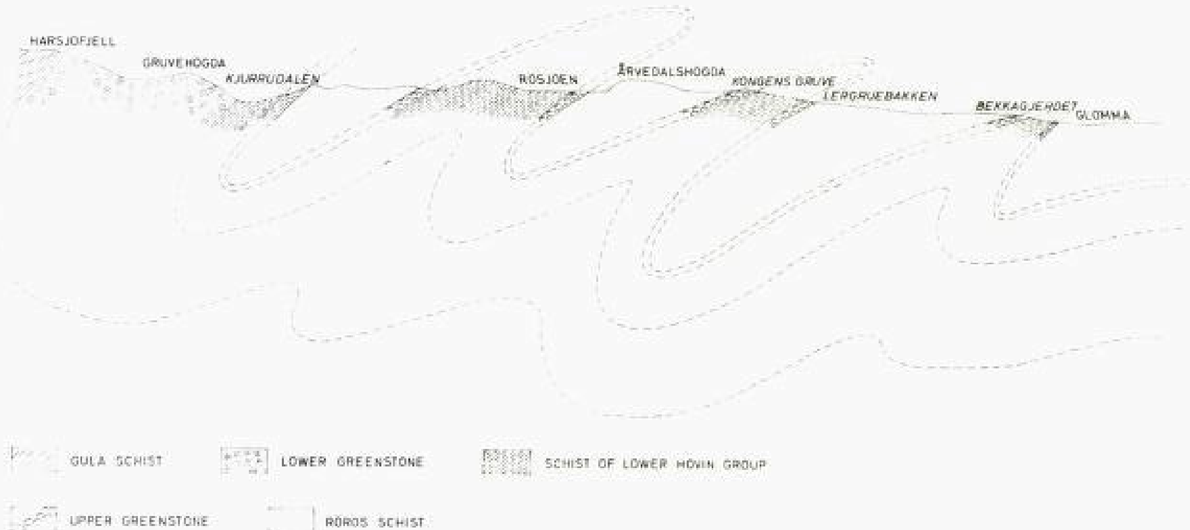

Fig. 52. Section from Harsjøfjell to Glomma (the western part redrawn after Færden (p.c.) showing the present writer's interpretation of the fold structures in this area.

Profil fra Harsjøfjell til Glomma. (Den vestlige delen er omtegnet etter et manuskriptprofil av Færden) som viser det nærværende arbeids tolkning av foldestrukturen i området.

more and more suspicious about the character of the Røros Schists as they were described in the literature. It appeared from the more detailed description that the schists mentioned by several authors (Reusch (1890), Carstens (1920), Bryn (1961) and others) as "Stuedalsskifer" and "garbenskifer" were, because of their containing porphyroblasts of biotite and amphibole, being designated as mica schists or garben-schists; this served merely to camouflage their primary sedimentary character. A couple of short visits to Tydal (in 1965) and Røros and Folldal (in 1966) demonstrated that the Røros Schists (Stuedal Schists and garben-schists) are slightly higher metamorphic equivalents of the metagraywackes and slates met with in the Meråker area, as they almost everywhere showed more or less well-preserved sedimentary structures of the Meråker type. The most convincing example was found in a stone quarry be a sideroad to Storvarts east of Røros where gritty graywacke of the Meråker type was observed.

The present writer is therefore convinced that Bugge was correct in suggesting the Røros schists to be equivalent to the Hovin — Hølonda rocks of the western Trondheim region and that a more detailed study of the Røros area in the future will provide additional data in support of this conception.

This view is based on the assumption that the Kjølhaugen Group is equivalent to the Upper Hovis Group, thus placing the Røros Schists also within this latter group.

Silurian and Devonian sediments

The Silurian beds encountered in the Meråker area (Siedlecka and Chaloupský presentv olume) proceed southwards and are traced along the strike to midway down the quadrangle Essandsjø. Their extension further south is also probable, but the area is not yet properly mapped.

The present writer is of the opinion that in the easternmost part of the region near the large thrust zone there is a fair chance of finding beds younger than the Røros Schists. R. Falck-Muus (Map 1936) indicates bituminous alum-shale at the two localities Dalvola and Tronsmyren on map-sheet Aursunden. At Dalvola a dark limestone also occurs. These beds might be of Silurian age.

Strata of Devonian age are well known from the locality near Røragen (Goldschmidt 1913). A short visit to this locality convinced the present writer that there is an undoubtable sedimentary succession from the Røros Shists in the west to the Devonian beds in the east, although the contact shows a clear discordance between them. Goldschmidt described the border in this way, "Das Basalkonglomerat wird hier fast ausschliesslich von ausgewitterten

Quarzlinsen des Rørosschiefers zusammengesetzt, es liegt auch direkt auf Rørosschiefer: die unmittelbare Grenze is gut aufgeschlossen. Man erkennt deutlich die Diskordanz, indem der Rørosschiefer nach Nordwesten fällt, das Konglomerat hingegen nach Südosten." This statement is repeated by Holmsen (1962) who found that the Devonian beds were also folded.

The location of the different serpentinite bodies

Ultrabasic peridotitic bodies are known from a long series of localities in the Trondheim region. They are usually metamorphosed into serpentinites and occasionally even to soapstone.

Strand (1960) states that, "In all parts of the Scandinavian Caledonides where the stratigraphic relations are known, the peridotites occur in the older part of the stratigraphic sequence only corresponding to the Røros and Støren Groups of the Trondheim region. This seems well enough established to enbale one to take the occurrence of peridotites as a strong indication of an old age of the sediments enclosing them". Interpreting the Røros Schists as equivalent to the Upper Hovin Group, the present writer is forced to oppose this statement. As seen from the map (Pl. IV), the distribution of the serpentinite bodies is closely related to the large thrust plane of the Trondheim nappe or to smaller thrust zones such as the zone of Færden and Rui (p.c.) at Kjøliskarvene, quadrangle Haltdal. As the ultrabasic bodies are intruded into beds of different age, the occurrence of such rocks can hardly be taken as a "strong indication" of an old age for the surrounding beds.

The present writer regards it as more probable that the emplacement of these rocks was associated with the development of the larger trust planes in this region, thus permitting their emplacement into beds of different age. As to the question of the mechanism of the emplacement it might be possible that the fissures of the thrust plane caused pressure to be released at great depts and opened up transport channels up which the relatively viscous ultrabasic magma has been squeezed. This idea for the origin of some of the serpentinite bodies in the Trondheim region is supported by the statement of Turner & Verhoogen (1960) that, "It is not surprising, therefore, to find that major intrusions of peridotite and serpentinite tend to be located along zones of strong dislocation or at least to be bounded by faults of great magnitude."

Another strong support for this idea is the fact that the lower part of the Devonian beds at Røragen contains no boulders of serpentinite while such boulders dominate in the upper part, indicating that the serpentinite masses did not exist in early and middle Devonian time. Consequently the serpentinite bodies were most likely emplaced just before the deposition of the upper Devonian beds.

There is, moreover a distinct difference in the particle size of the sediments in this niveau indicating an abrupt change in sedimentation conditions. This is thought to have been brought about by an uplift of the land block in the east caused by a movement along the thrustplane also at the end of middle Devonian time (Svalbardian fold phase).

The distribution of the ore deposites

Mines and smaller occurrences of ore are scattered throughout the Trondheim region and several places have been established as mining districts since the middle of the 17th century. Much data has been gathered from all these deposits, but very little has been done to systematize the available data. This chapter will therefore be devoted to an attempt at correlating the data obtained from the studies of ores with the geology of the regtion.

By plotting the mines on the geological map it is manifest that the various ore occurrences are connected with different rock zones. From Foslie's (1925) list of the South-Norway mines and ore occurrences, it is clear that there is a certain difference in the ore mineral assemblages of the different deposits, a difference which is connected with the surrounding geology. This trend will be seen from the following lists, Tables II, III and IV, compiled both from Foslie's list and NGU archive reports, wherein the prevailing mineral occurs to the left and the secondary mineral to the right. The numbers before the names of the mines refer to the numbers on Foslie's list.

A. Mines situated in the lower greenstone

The trend of this group is very clear as 98 of the 126 occurrences are dominated by pyrite and another 13 by iron-quartzites, hæmatite- and magnetite layers. See Table II. Only 9 are dominated by chalcopyrite and 6 by pyrrhotite. According to Vokes (1962) the two latter can be regarded as one group since there is a marked tendency in the sulphide ore bodies of the Norwegian Caledonides for these to occur together. Thus 111 of the 126 occurrences in this group are dominated by noncuprous sulphides while only 15 are dominated by sulphides containing copper: moreover there are several among the 15 where the genetical connection with the lower greenstone is dubious as bodies of hornblende gabbro may occur nearby. This point will have to be investigated more closely by the mining geologists working in this region.

B. Mines situated in the upper greenstone

The trend in this group is not so marked as that in the lower greenstone as only 12 of the 20 occurrences are pyrite-dominated, 2 being dominated by chalcopyrite and 6 by pyrrhotite. See Table III. This will need a more thorough explanation. On quadrangle Meråker the upper greenstone is often found to be intruded by bodies of hornblende gabbro. This might be the reason why some of the occurrences are deviating from the main trend.

C. Mines situated in the Røros Schists near bodies of the hornblende gabbro

The trend within this group is quite clear as 28 of the 31 occurences are dominated by chalcopyrite, see Table IV.

D. Final remarks

The result of the plotting of the ore occurrences shows a marked tendency for pyrite to be concentrated along zones of greenstone and for chalcopyrite to be concentrated near bodies of hornblende gabbro intruded as sills mainly in the sediments of the Røros Group but also in older sediments and volcanics.

A discussion of the genesis of the ores is beyond the scope of this paper, but as the greenstones are known to contain layers of acid volcanics the theory of exhalative-sedimentary ores of Oftedahl (1958) should be kept in mind when studying the occurrences.

A connection between the hornblende gabbro and chalcopyrite seems to be so close that the present writer is inclined to believe that the genesis is associated with the existence of the gabbro sheets.

Sammendrag

I denne artikkelen diskuteres de tektono-stratigrafiske hovedproblemer i det østlige Trondheimsfeltet. Basert på detaljerte studier i Meråker-området de tre siste somrene og på tilgjengelige manuskripskart og personlige meddelelser fra geologer som arbeider i de sydligere deler av feltet, har det vært mulig å bygge opp en generell stratigrafi for det østlige Trondheimsfelt tilsvarende stratigrafien for det vestlige. Det er også foretatt en revisjon av den stratigrafiske nomenklaturen slik at Gulaskifergruppen brukes om de deler av Rørosgruppen som ikke innbefatter Røros-skifrene.

Med utgangspunkt i hva som er påvist i den nordlige del av Trondheimsfeltet pekes det videre på at den eldre oppfatningen av et 'Trondheim synklinorium' må endres til et antiklinorium. Det vises også at det fins et hovedskyveplan langs størsteparten av grensen for Trondheimsfeltet, og betegnelsen

'Trondheimsdekket' foreslåes for den alloktone metasedimentpakke over skyveplanet. Forekomstene av serpentinlegemer langs skyveplanet diskuteres. Til slutt blir fordelingen av svovel- og kopperkisforekomstene i Trondheimsfeltet diskutert med hensyn på geologien.

References

Bjørlykke, U., 1963: Foreløpig meddelelser fra kartbladet Essandsjø. A. prelimiminary report on the Essandsjø map area. NGU 223, Årbok 1962.

Bryn, K. Ø., 1959: Geologien på søndre del av kartblad Essandsjø. NGU 205, Årb. 1958.

Bugge, C.: 1912: Lagfølgen i Trondhjemsfeltet. NGU 61. Årbok 1912.

— 1954: Den kaledonske fjellkjede i Norge. NGU 189.

Carstens, C. W., 1919: Oversikt over Trondhjemsfeltets bergbygning. Det Kgl. norske Vid. Selsk. Skr., 1919, no. 1.

— 1919: Geologiske undersøkelser i Trondhjems omegn. NGU 83. Årbok 1918 og 19.

Chaloupský, J. and *Fediuk, F.*, 1967: Geology of the area between Meråker and Kjølhaugene (Trondheim Region) present volume.

Falch-Muus, R., 1936: Kartbladet Aursunden. NGU 147.

Foslie, S., 1925: Syd-Norges gruber og malmforekomster. NGU 126.

Foslie, S. and *Oftedahl, Chr.*, 1959: Kartbladet Jævsjø.

Getz, A., 1890: Graptolitførende skiferzoner i det Trondhjemske. Nyt Mag. for Nat Vid. XXXI.

Goldschmidt, V. M., 1913: Das Devongebiet am Røragen bei Røros. Mit einem palæobotanischen Beitrage. Die Pflanzenreste der Røragen - Ablagerung von A. G. Nathorst. Vidensk. Selsk. i Chr. Skrifter 1913. Bd. 2.

Holmsen, G., 1918: Fortsættelsen av Trondhjemsfeltets kisdrag mot Nord. N.G.T. 5, Hft. 2.

Holmsen, P. and *G.*, 1950: Tynset. Beskrivelse til det geologiske rektangelkart. NGU 175.

Holmsen, P., 1955: Trekk av Oppdalsfeltets geologi. N.G.T. Bd. 35.

Holmsen P. and *Strand, T.*, 1960: Stratigraphy, Petrology and Caledonian Nappe Tectonics of Central Southern Norway; Caledonized Basal Gneisses in a Northwestern area (Oppdal—Sunndal). NGU 212.

Holmsen, P., 1962: On the tectonic relations of the Devonian complex of the Røragen area, East Central Norway. NGU 223, Årbok 1962.

Keilhau, B. M., 1850: Gæa Norvegica, Chra. (J. Dahl).

Kjerulf, Th., 1871: Om Trondhjems Stifts geologi. Chra. Nyt Mag. for Naturv. Bd. 18.

— 1875: Om Trondhjems Stifts geologi. Chra. Nyt Mag. for Naturv. Bd. 21.

— 1879: Udsigt over det sydlige Norges Geologi. Chra.

— 1882: Merakerprofilet. Kgl. N. Vid. Selsk. Skr. 1882.

Kisch, H. J., 1962: Petrographical and geological investigations in the South-western Tydal Region, Sør-Trøndelag, Norway. Acad. Profsch. Amsterdam, 1962.

Marlow, W., 1935: Foldal, Beskrivelse til det geologiske rektangelkart. NGU 145.

Oftedahl, Chr., 1966: Note on the Caledonian Thrusting in Northern Scandinavia. N.G.T., Bd. 46, Hft. 2.

— 1958: A theory of exhalative-sedimentary ores G.F.F., Bd. 80, Hft. 1.

Peacey, J. S., 1964: Reconnaissance of the Tømmerås Anticline. NGU 227.

Reusch, H., 1890: Geologiske iagttagelser fra Trondhjems stift. Det Kgl. N. Vidensk. Selsk. Forh. No. 7.

Roberts, D., 1967: Structural observations from the Kopperå—Riksgrense Area and Discussion of the Tectonics of Stjørdalen and the N.E. Trondheim region. Present volume.

Schaar, G., 1961: Petrological and geological investigation in the Sylene — Skardølsfjell Region (Sør-Trøndelag, Norway). Acad. Profsch. Amsterdam, 1962.

Siedlecka, A., 1967: Geological investigations in the Meråker Vicinity (Trondheim Region), Present volume.

Svenonius, F., 1885: Några profiler inom mellersta Skandinaviens skifferområde. G.F.F. no. 95. Bd. VII, Hft. 11.

Strand: T., 1951: The Sel and Vågå Map Areas. Geology and petrology of a part of the caledonides of Central Southern Norway. NGU nr. 178.

— 1960: Geology of Norway. NGU nr. 208.

— 1964: Geology and structure of the Prestberget area. NGU nr. 228.

Turner, F. J. and *Verhoogen, J.*, 1960: Ignous and Metamorphic Petrology. Int. Ser. in the Earth. Sc., N. York 1960.

Törnebohm. A. E., 1872: En geognostisk profil öfver den skandinaviska fjällryggen mellan Östersund och Levanger. Öf. K.V.A. 1872.

— 1896: Grunddragen af Det Centrala Scandinaviens Bergbyggnad. Kgl. Sv. Vet.-Ak. Handl. Bd. 28, no. 5.

Vogt, Th., 1940: Geological notes on the dictyonema locality and the upper Guldal District in the Trondheim Area. N.G.T. Bd. 20, Hft. 3-4.

— 1945: The geology of part of the Hølonda—Horg District, a type area in the Trondheim region. N.G.T. Bd. 25.

Vokes, F. M., 1962: Mineral paragenesis of massive sulphide ore bodies of the Caledonides of Norway. Econ. Geol. Vol. 57.

Wegmann, C. E., 1925: Sur le lambeu de recouvrement de la Gula (Chain Calédonnienne Scandinavie). C.r. somm. des siénces de la Soc. géol. de France, 1925.

Wolff, F. Chr., 1960: Foreløpige meddelelser fra kartbladet Verdal. NGU 211.

— 1964: Stratigraphical position of the Gudå conglomerate zone. NGU 227.

Yochelsen, E. L., 1963: Gastropods from the Otta conglomerate. N.G.T. 43.

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Table I. *Correlation table for beds discussed in this paper.*

	Sworkmo — Lundamo Carstens 1954 · Vogt 1945.	Stjørdal — Meråker (West) Carstens 1960, Wolff 1964	— Getz 1890, Wolff 1966 (East)	Ålen I. J. Rui 1966 (p.c.)
Horg Group	Shale and sandstone (The Sandå beds)	Absent	Dark shale and sandstone	Absent
	Quartzite conglomerate (Lyngstein)		Quartzite conglomerate (Kjølhaugene)	
Upper Hovin and Røros Group	Rhyolite (Grimås)	Polygenous conglomerate		Graywackes — often with biotite or amphibole
		Rhyolite tuff		
	Sandstone	Polygenous conglomerate and sandstone alternating	Graywackes	Phyllites
	Polygenous conglomerate (Volla)	Polygenous conglomerate (Hopla)	Absent	- - - - Thrust plane - - - -
Lower Hovin Group	Dicranograptus black shale	Dark shale		Dark biotite schist
	Rhyolite tuff (Esphaug, Hareklett)	Rhyolite tuff (Muruvik)	Amphibolite (Turifoss)	Amphibolite (Kjøliskarvene)
	Sandstone and shale (Krokstad)	Sandstone	Sandstone and conglomerate	Limestone
	Limestone (Hølonda)	Limestone (Tautra, Forbordfj., Flora)	Limestone (Brenna)	Polygenous conglomerate Sandstone
	Fossiliferous shale (Langeland)	Fossiliferous shale (Leksdal)	Shale	Dark phyllite
	Greenstone conglomerate (Venna)	Greenstone breccia (Stokvola)	Polygenous conglomerate (Lille Fundsjø)	Conglomerate (Rensjøen)
Støren Group	Greenstones	Greenstones	Greenstones	Greenstones, with some sediments
Gula Schist Group	Mica schist	Mica schist	Mica schist	Black-shale (Dictyonema 2eα)
	Quartzite conglomerate (Svorkmo)	Absent	Quartzite conglomerate (Hegsjøfjell, Skjækerstøtene Gudå and Bukkhammer — Usmadam)	Quartzite conglomerate (Øvstubekken)
	Crystalline limestone	Absent	Crystalline limestone	Crystalline limestone (Vollfjell)
	Mica schist	Mica schist	Mica schist	Mica schist

Table II. *Mines situated in the Lower greenstone.*
Py = pyrite. Cpy = chalcopyrite. Po = pyrrhotite. Sph = sphalerite.

Quadrangle Dovrefjell, western part.

150.	Elgsjøbækk occurence	Py
152.	Vårstigfjeld (with Skålebekk occurrence)	Py
152a.	Drivdalen occurrence	Py
148.	Fundberget occurrence	Py
149.	Elgsjøtangen occurrence	Py
	Tverrfjellet	Py

Quadrangle Vågå.

80.	Vasenden mine	Py

Quadrangle Dovrefjell, southeastern part.

180.	Værkensdalen field	Py
	Gåshovda occurrence	Py
	Tværliseter occurrence	Py
	Grimsa occurrence	Py

Quadrangle Folldal.

	Einundalens occurrence	Py
175.	Grimsdalen mine	Py Cpy
176.	Grev Moltke mine	Py Cpy
177.	Folldal main mine	Py Cpy
179.	Juliane Marie & Godthåb mine	Py Cpy

Quadrangle Tynset.

201.	Nebyvoll occurrence (St. Olaf's mine)	Py Cpy
202.	Hvaltjernåsen mine	Py
203.	Nonsvola occurrence	Py

Quadrangle Røros.

204.	Kvitstein mine	Py
205.	Vingelen mine	Py Cpy
	Vingelsvola occurrence	Py
208.	Åseng mine	Py
209.	Vandgrøften occurrense	Cpy Po Py
210.	Fredrik IV mine	Cpy Py
233.	Harsjø mine	Py Cpy

Quadrangle Haltdal.

249.	Rognså occurrence	Py Cpy
247.	Storvold mine	Cpy Po Py
248.	Hesjedalen mine	Py Cpy
245.	From mine	Py
246.	Rogn mine	Py Cpy
251.	Lillerena occurrence	Po Cpy
269.	Rødhammer mine	Py
	Grønfj. occurrence	Py
270.	Hultrå mine	Py
268.	Skjellåfjell mine	Po Cpy
252.	Kårslått mine	Cpy Po

Quadrangle Essandsjø.

349.	Torsbjørk mine	Py

Quadrangle Meråker.

350.	Mandfjell mine	Py Cpy
351.	Gruvbekk and Bakbekk occurrence	Py Cpy
352.	Fondfj. mine and Løvlibekk occurrence	Py Cpy
353.	Finskar occurrence	Py Cpy
355.	Lillesætervold occurrence	Cpy
356.	Krogstad occurrence	Po Cpy Sph

Quadrangle Verdal.

372.	Årstad occurrence	Py Po
373.	Storstad occurrence	Py Po
375.	Åkervold mine	Py Cpy Po
376.	Malså mine	Py Cpy
377.	Vetringshallen mine	Py Cpy
378.	Gulstad & Mok mines	Py Cpy

Quadrangle Selbu, south-east.

266.	Rokne occurrence	Py
265.	Selbu mines	Py Cpy Po

Quadrangle Selbu, north-west.

298.	Renå occurrence	Py
299.	Dragsten mine	Py
301.	(Nonsh. & Venen mines)	Fe
302.	Viken (Løvådal) mine	Py
303.	Sandoret occurrence	Py Cpy
304.	Grøttemsvold field with Kirkelid mine	Py
305.	Engvold occurrence	Py
306.	Fuglemvold field with Langjon mine	Py
307.	Ingridvold occurrence	Py
319.	Vottafjell occurrence	Py
320.	Damtjern occurrence	Py
321.	Røsbæk occurrence	Py Fe
322.	Sesåsvold occurrence	Py

Trondheim.

282.	Leinum (or Mo) occurrence	Py
283.	Leinstrand mine	Fe-quartzite
293.	Bratsberg occurrence	Py
292.	Lien occurrence	Py
290.	Vikåsen occurrence	Py
291.	Stene occurrence	Fe
288.	Kobberdammen occurrence	Py
284.	Klefstadåsen occurrence	Py Cpy
285.	Flåkahaugen occurrence	Py

286.	Svartdalsbæk (or Klemets-aunet) occurrence	Py
287.	Holstvolden — Bratløfta occurrence	Py
289.	Fagerli (or Ilsviken) occurrence	Py

Melhus.

97.	Åmot mine	Cpy Py
98.	Stor-Næve occurrence	Py Cpy
275.	Leberg occurrence	Py
276.	Kvål og Skjerdingstad mine	Py Po
277.	Flå (or Vasfjeld) mine	Py
278.	Lerli and Løvset occurrence	Py
279.	Havdøl occurrence	Py
294.	Bratstigen occurrence	Fe - quartzite
295.	Viken occurrence	Py
296.	Lervik occurrence	Py
297.	Tangvoldodden occurrence	Py

Rennebu.

105.	Gorset occurrence	Py
106.	Jordfjeldets mine	Py
107.	Lillevandåsen	Po
111.	Mærk occurrence	Py

Rindal.

81.	Solås - Midtgård occurrence	Py
82.	Nergårdsmo occurrence	Py
83.	Trøkna mine	Py
84.	Lommunda mine	Py
95.	Dragset mine	Py Cpy
103.	Holum occurrence	Py

96.	Skjøtskift—Jordhus occurrence	Py
100.	Løkken mine	Py Cpy
99.	Høidal mine	Py Cpy
101.	Grefstad mines	Py Cpy

Stjørdal.

309.	Brandåsen occurrence	Fe & Py
310.	Flensberg mine	Fe
311.	Næverå mine	Fe
312.	Hinberg occurrence	Fe
313.	Kleptjern occurrence	Fe
314.	Bjørn mine	Fe
315.	Næver mine	Py
316.	Vikvold mines	Py
317.	Klep mine	Fe
318.	Grønli mine	Fe
323.	Rangåvold & Vinds-myren occurrence	Py Po
348.	Sonvandets mine	Cpy Po
358.	Renåbolet occurrence	Po Cpy

Levanger.

364.	Tingstad mine	Cpy Py
366.	Rokne occurrence	Py
367.	Kolberg occurrence	Cpy Py
389.	Nordvik occurrence	Py
388.	Jørstad mine	Py
386.	Falstad, Eines, Stanger-holt mines	Py
387.	Ytterøens mines	Py Cpy
390.	Sundsetnes occurrence	Po
380.	Hø occurrence	Py Po

Trollhetta.

104.	Reisfjeld occurrense	Py

Table III. *Mines situated in the upper greenstone.*

Quadrangle Tynset.

200.	Nyberg occurrence	Py
	Storbekken occurrence	Py

Quadrangle Røros.

213.	Oscar II mine	Py Cpy
222.	Salå mine	Po Cpy
223.	Lomtjøn mine	Py
230.	Kongens and Årvdals mine	Py Cpy
231.	Sekstus mine (Christian VI)	Po Cpy
232.	Muggruben	Py Cpy

Quadrangle Haltdal.

243.	Skar (Skårdals) mine	Py
242.	Killingdals mine	Py Cpy
255.	Svensk - Menna mine	Py Cpy
256.	Røros - Menna mine	Po Py Cpy
257.	Guldals mine	Po Cpy
254.	Folldals occurrence	Po Cpy

Quadrangle Stuesjø.

258.	Kjøli mine	Py Cpy
260.	Midt (Jens) mine	Py Cpy

Quadrangle Meråker.

340.	Sag and Røsås occurrence	Py Cpy
342.	Dalemo occurrence	Cpy
344.	Stadsås mine	Po Cpy
345.	Vægterhaug mine and Angeli occurrence	Cpy Po

Table IV. *Mines situated in the Røros Schists near bodies of hornblende gabbro.*

Quadrangle Røros.

214.	Kvernskal mine	Cpy
255.	Isak occurrence	Cpy
226.	Storvarts mine	Cpy Po
227.	Hestkletten, Quintus, Nyberg, Solskinn mine	Cpy Po
228.	Klasberget mine	Cpy Po
229.	Sletmo occurrence	Cpy Po
235.	Skarv (Ole Iversa) mine	Cpy Po

Quadrangle Haltdal.

241.	Sørosen occurrence	Cpy

Quadrangle Aursunden.

218.	Lossius and Sara mines	Cpy Po
238.	Klinkenberg occurrense	Cpy Po? Py

Quadrangle Stuesjø.

239.	Sødals mine	Cpy
237.	Mads (Mathis) mine	Cpy Py
236.	Fjeldgjelt occurrence	Cpy Po
240.	Bønskneppen occurrence	Cpy
259.	Lillegula occurrence	Cpy

Quadrangle Essandsjø.

263.	Esna mine	Cpy
264.	Vorrevik occurrence	Cpy Py
331.	Ramfjell mine	Cpy Po
332.	Gilså mine	Cpy Po
333.	Bjørneggen occurrence	Cpy
334.	Dronningen mine	Cpy Po
336.	Lillefjell mine	Py Cpy
337.	Storhusmannsberget (Dudu) mine	Cpy Py Po
338.	Væråsvold occurrence	Cpy Po

Quadrangle Meråker.

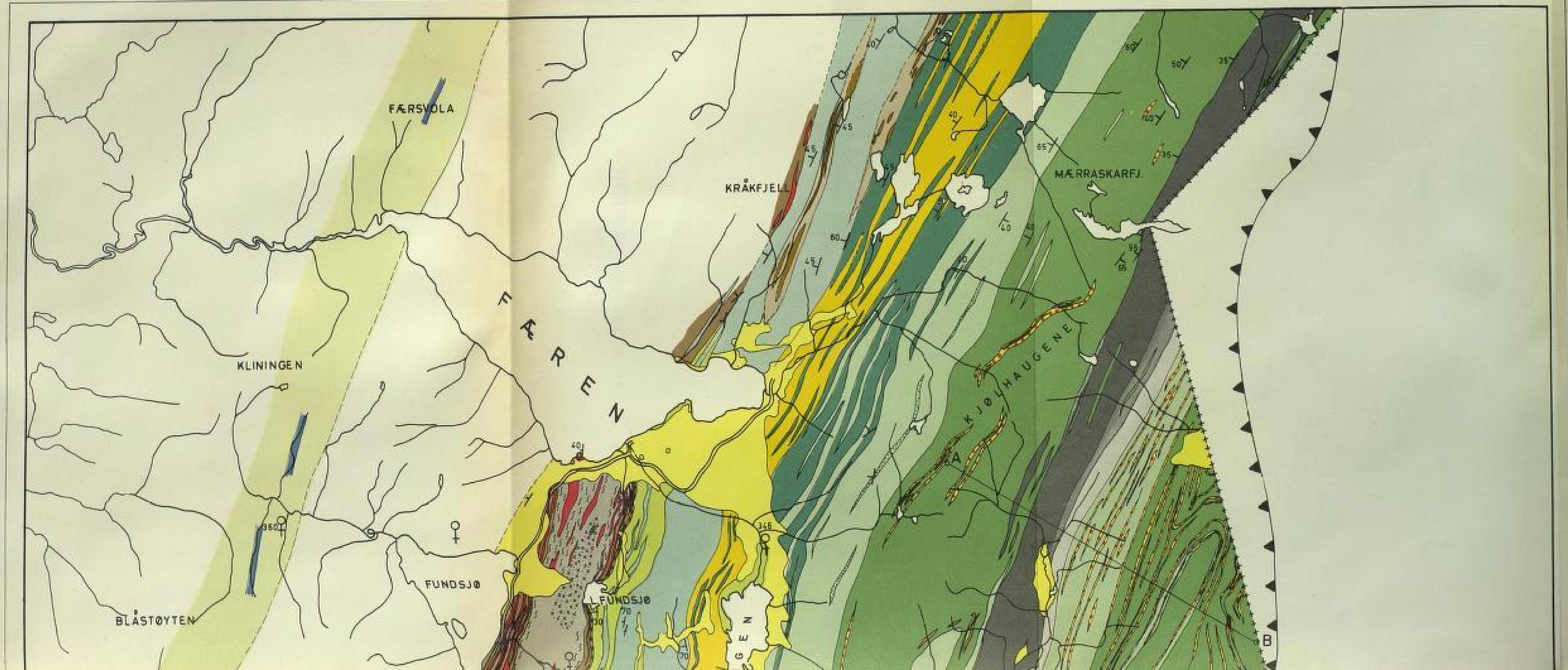
339.	Langsund	Cpy Po
	Davola occurrence	Cpy
	Dalvolavollen occurence	Cpy
	Brenthaug occurrence	Cpy Py
	Navelhaug occurrence	Cpy
	Langen occurrence	Cpy
	Hammerskallen occurrence	Cpy


KJØLHAUGENE

GEOLOGICAL MAP OF THE MERÅKER AREA

GEOLOGISK KART OVER MERÅKER

Scale 1:100 000



LEGEND

Quaternary.

Slågån Group (Silurian).

Grey to grey-black phyllite, slate and metasiltstone.

Grey slates with intercalations of metasandstone.

Grey metasandstone with intercalations of slate.

Kjølhaugen Group (Upper Ordovician).

Grey-green slates and phyllites with intercalations of metagraywacke.

The Kjølhaugene quartzite conglomerate.

Grey-green metagraywackes with intercalations of slate (dotted: thicker beds of subgraywacke).

Grey phyllite.

Sulåmo Group (Middle Ordovician).

Metabasite with banded structure.

Metabasite of massive structure.

Grey phyllite.

Grey calcareous metasandstone.

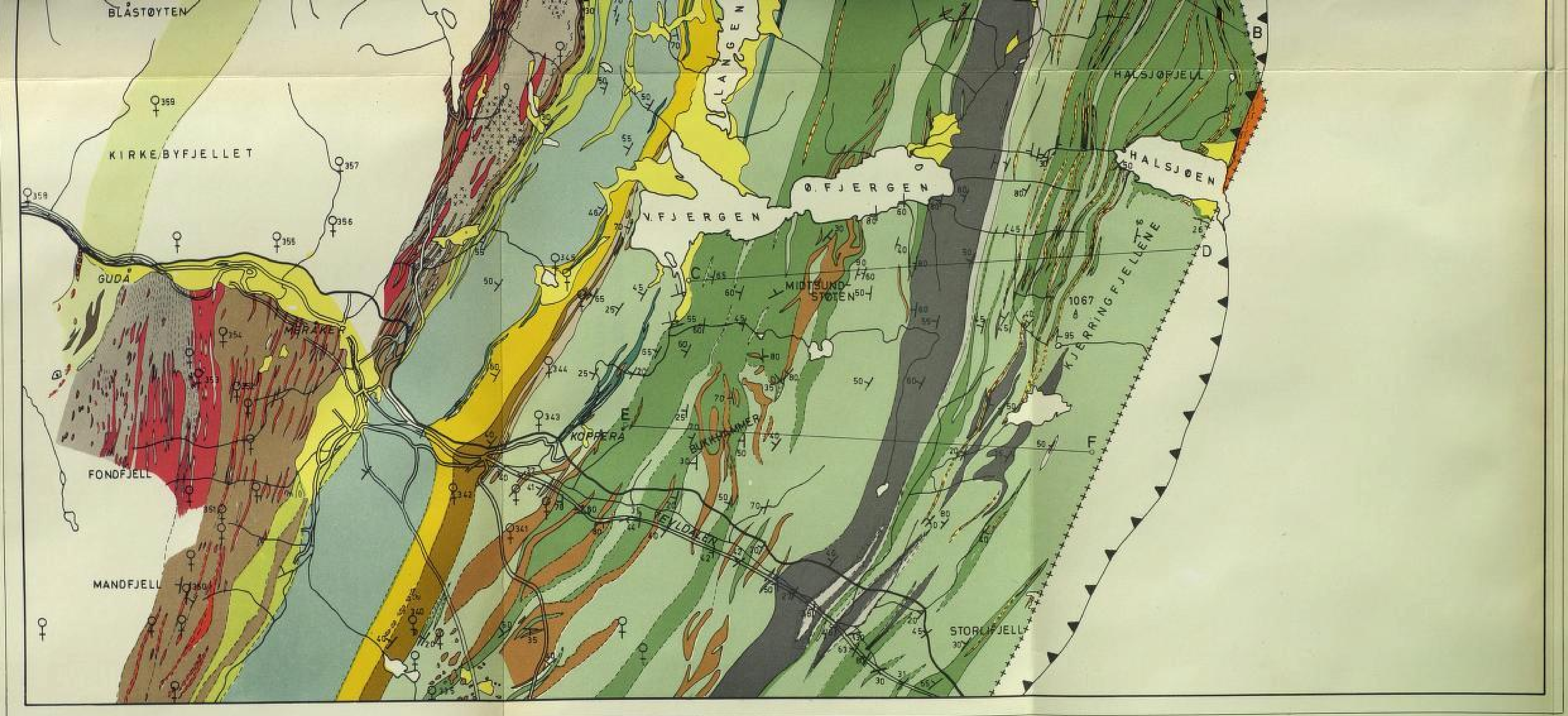
The Brenna conglomerate.

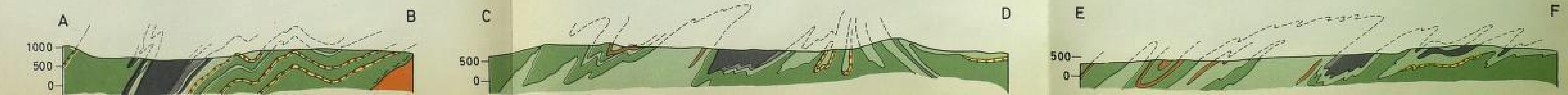
The Brenna limestone.

Grey and black phyllite.

Grey phyllites and graywackes.

The Lille Fundsjø conglomerate.





Grey phyllites and graywackes.

The Lille Fundsjø conglomerate.

Fundsjø Group (Lower Ordovician).

Metabasites.

Quartz-keratophyre.

Sonvatn Group (Cambrian)

Mica schists, often with garnet.

Alternating amphibolites and schists.

The Gudå quartzite conglomerate.

Limestone.

?Eocambrian.

Schists and gneisses.

Caledonian intrusives.

Granitic rocks.

Fine- to medium-grained gabbro.

Fine- to medium-grained gabbro, without preferred orientation.

Fine- to medium-grained gabbro, strongly schistose.

Hornblende gabbro.

Structures.

Strike and dip.

Lines of section.

Foliation, lineation.

Mylonite zone.

Thrust plane.

Occurrences of pyritic and chalcopyritic ore.

GEOLOGICAL MAP OF THE TRONDHEIM REGION

GEOLOGISK KART OVER TRONDHEIMSFELTET

1: 500000

COMPILED BY FR. CHR. WOLFF AFTER:
SAMMENTEGNET AV FR. CHR. WOLFF ETTER:

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LEGEND
TEGNFORKLARING

RÖRAGEN BEDS (DEVONIAN)
RÖRAGENFELTET (DEVON)

CONGLOMERATE AND SHALE
KONGLOMERAT OG SKIFER

SLÅGÅN GROUP – HORG GROUP (SILURIAN)
SLÅGÅNGRUPPEN – HORGGRUPPEN (SILUR)

DARK SHALE AND SANDSTONE
MÖRK SKIFER OG SANDSTEIN

KJÖLHAUGEN GROUP – RÖROS GROUP – UPPER HOVIN GROUP (UPPER ORDOVICIAN)
KJÖLHAUGGRUPPEN RÖROSGRUPPEN ÖVRE HOVINGRUPPEN (ÖVRE ORDOVICIUM)

PHYLLITE, METAGRAYWACKES, WITH INCREASING AMOUNTS OF BIOTITE, HORNBLEND AND GARNET TOWARDS THE SOUTHEAST, PARTLY CONGLOMERATIC
FYLLITT, METAGRÅVAKKER MED ÖKENDE MENGDER AV BIOTITT, HORNBLENDE OG GRANAT MOT SYDÖST, DELVIS KONGLOMERATISK

POLYGENOUS CONGLOMERATE
POLYMIKT KONGLOMERAT

SULÅMO GROUP – LOWER HOVIN GROUP (MIDDLE ORDOVICIAN)
SULÅMOGRUPPEN UNDRE HOVINGRUPPEN (MIDTRE ORDOVICIUM)

DARK SHALE AND RHYOLITE TUFF IN WEST, GREENSTONE IN EAST
MÖRK SKIFER OG RHYOLITT TUFF I VEST, GRÖNNSTEN I ÖST

GREY CALCAROUS SANDSTONE AND GREY TO DARK PHYLLITE
GRÅ KALKHOLDIG SANDSTEIN OG GRÅ TIL MÖRK FYLLITT

HÖLONDA, TROMSDALEN, BRENNA AND SIMILAR LIMESTONES
HÖLONDA, TROMSDALEN, BRENNA OG LIGNENDE KALKSTEINER

VENNA, STOKKVOLA, LILLE FUNDSJÖ AND SIMILAR CONGLOMERATES
VENNA, STOKKVOLA, LILLE FUNDSJÖ OG LIGNENDE KONGLOMERATER

FUNDSJÖ GROUP – STÖREN GROUP (LOWER ORDOVICIAN)
FUNDSJÖGRUPPEN – STÖRENGRUPPEN (UNDRE ORDOVICIUM)

GREENSTONES AND QUARTZKERATOPHYRES
GRÖNNSTENER OG KVARTSKERATOFYRER

GRANODIORITIC GNEISS
GRANODIORITTISK GNEISS


GRANODIORITIC GNEISS
GRANODIORITTISK GNEISS
SONVATN GROUP – GULA SCHIST GROUP (CAMBRIAN)
SONVATNGRUPPEN – GULASKIFERGRUPPEN (KAMBRIUM)
MICA SCHISTS, OFTEN WITH GARNET
GLIMMERSKIFER, OFTE MED GRANAT
CONGLOMERATES OF THE GUDÅ CONGLOMERATE ZONE
KONGLOMERATER TILHÖRENDE GUDÅKONGLOMERATSONEN
LIMESTONE
KALKSTEIN
CALEDONIAN INTRUSIVES
KALEDONSKE INTRUSIVER
LARGER BODIES OF TRONDHJEMITE
STÖRRE LEGEMER AV TRONDHJEMITT
LARGER BODIES OF GABBRO
STÖRRE LEGEMER AV GABBRO
NORITE
NORITT (DYRHAUGEN)
SERPENTINITES
SERPENTINER
UNDIFFERENTIATED ROCKS BELOW THE TRONDHEIM NAPPE
UDIFFERENSIERTE BERGARTER UNDER TRONDHEIMSDEKKET
STRIKE AND DIP
STRÖK OG FALL
TRONDHEIM NAPPE THRUST PLANE
TRONDHEIMSDEKKETS SKYVEPLAN
MINOR THRUST PLANES
MINDRE SKYVEPLAN
SUPPOSED THRUST PLANE
ANTATT SKYVEPLAN
SVORKMO
LUNDAMO
SELBUSJØEN
GAULA
BUKKHAMMER
USMADAM
HYLLINGEN
HALTDALEN
AURSUNDEN
RØROS
FOLLDAL
GRIMSDALEN