Bergvesenet

Postboks 3021, 7002 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
BV 1000			Trondheim	**Åpen**
Kommer fra ..arkiv	**Ekstern rapport nr**	**Oversendt fra**	**Fortrolig pga**	**Fortrolig fra dato:**
Falconbridge	Sul 462-77-24			

Tittel

Geological report of the Skjækerdalen - Helgådalen area with special respect to the Dyrhaugen Gabbro breccia and Ni-deposit

Forfatter	Dato	Bedrift
Bjarne Lieungh	1977	Sulfidmalm a.s.

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Verdal	Nord-Trøndelag	Trondheimske	17221 17222	Østersund Trondheim

Fagområde	Dokument type	Forekomster
Geologi geofysikk	Rapport	Dyrhaugen, Skjækerdalen gruve, Sliperen, Barbara Bachke, Anton Bachke, St Olav, Homan, Archbold.
Råstofftype	**Emneord**	
Malm/metall	Ni Cu	

Sammendrag

The Skjækerdalen area is located in the northermost part of the Trondheim region. The rocks are quartz-feldspatic schists probably belonging to the Gula schist group, the same group in which Vakkerlien and the other Kvikne Ni showings are situated.

A complex diorite-gabbro has intruded the Gula(?) schists forming a folded lenticular gabbro- ultrabasic breccia in the central part of a larger diorite mass. The breccia is composed of a hole serie of magmatic fragments and matrix types, ranging from ultramafic to dioritic, but with a clear tendency of basic fragments in a sligthly more acid matrix. Fragments of folded quartz-feldspar schist are common. Two fold phases are observed in the rocks.The first (F-1) shows tigtht isoclinal folds in the Gula schists, with an associated schistosity (S-1) which masks the original bedding (S-0). A second not well developed phold phase (F-2) has a sligthly different direction, with the axial plane hawing a 90 degree opposite dip.

The mines and showings are located in an elongated area aprox. 1700m x 300m, in the central part of the gabbro. No sulphides have been observed in the surrounding diorite.
The deposts were mined in the period 1876- 1891 producing 18 750 t of ore with 1,26% Ni and 0,63% Cu.

The comagmatic association between the gabbro and diorite, indicate that the more widespread diorites can be used to locate areas of interest, in a more regional Ni-prospecting in the Trondheim region.

FOR FALCONBRIDGE NIKKELVERK A/S
A/S SULFIDMALM

PROJECT 905-24

Geological report of the Skjækerdalen-Helgådalen area with special respect to the Dyrhaugen Gabbro breccia and Ni-deposits.

By

B. Lieungh

BV 1000

Report No. 462/77/24

View into Skjækerdalen from Rautuva

Summary

The Skjækerdalen area is located in the northernmost part of the Trondheim region. The rocks are quartz-feldspathic schists probably belonging to the Gula schist group - the same group in which Vakkerlien and the other Kvikne Ni-showings are situated.

A complex diorite-gabbro has intruded the schists forming a folded lenticular gabbroic-ultrabasic breccia in the central part of a larger diorite mass.

The breccia is composed of a whole series of magnetic fragments and matrix types ranging from ultramafic to dioritic - but with a clear tendency of basic fragments in a slightly more acid matrix. Fragments of folded quartz-feldspar schist are common.

The mines and showings are located in an elongated area approx. 1700 m x 300 m in the central part of the gabbro. No sulphides have been observed in the surrounding diorite.

The deposits were mined in the period 1876-1891 producing 18750 tonns of ore with ca. 1.26% Ni and 0.63% Cu. Two fold phases are observed in the rocks. The first (F_1) shows tight isoclinal folds with an associated (S_1) schistosity which masks the original bedding (So).

A second not so well developed fold phase F_2 has a slightly different direction, with the axial plane having a 90° opposite dip.

The comagmatic association between the gabbro and the diorite- indicate that the more wide spread diorites can be used to locate areas of interest in more regional Ni-prospecting in the Trondheim region.

../2

Location

The Dyrhaugen gabbro and old Ni-mines are situated in the Skjækerdalen valley 250-300 m above sea-level, 30 km from the small harbour town of Verdalsøra, in the northern part of the Trondheimfjord (Map 1).

The gabbro is situated in the center of the valley surrounded by mountains ranging up to 870 m above sea-level. Vegetation consists of open swamps with pine and spruce forests in the valley bottom, and heavy spruce forests on the slopes.

Tree-line occurs at approx. 450 m above sea-level. A 2 km long forest road leads from the mainroad from Verdalsøra, into the Skjækerdalen valley and stops at a point approx. 2 km from the Dyrhaugen Gabbro. The last distance is only drivable with muskeg-machines because of the swampy terrain. The owner of the forest, A/S Verdalsbruket has this year (1977) started building a road from Skjækerfossen to Dyrhaugen mainly following the western side of the Skjækra river, probably ending on the western slope of Dyrhaugen.

Geologically speaking, the Dyrhaugen gabbro is located in the Gula schist formation - in the northernmost part of the Trondheim region, approximately in the same stratigraphic position as the Vakkerlien, Olkar and Kaltberget mines.

Brief History and earlier work

(Mainly from Løvas thesis 1970)

The mining in Skjækerdalen started in 1876. During the working period 1876-1891 about 18750 tonn ore was brought out.

A total production of 250 tonn Nickel and 120 tonn Copper in the same period - gave a net average of 1.26% Ni and 0.63% Cu in the ore.

A small Ni-smelter was in 1881 built at the Skjækerfossen waterfall.

Both the mine and the smelter were closed down in 1891.

Bergmester A. S. Bachke gave in 1880 a short description of the seven different operating "mines". A similar description was made by O. A. Bachke (1910) and A. L. Rosenlund (1915).

The company A/S Prospector carried out a survey of the deposits in 1915. One of the mines was pumped free of water and short survey shafts were made. A few diamond drill holes were also put down.

H. H. Smith wrote the same year a short report about the prospecting - but the conclusion was negative. in 1934 K. M. Amdahl made his thesis work (NTH) on the Skjækerdalen Ni-occurrences with special weight on geology, mine-technical problems and the possibilities for flotating the ore. These conclusions were also negative.

The government (Geofysisk malmleting) carried out an EM and Magnetic survey (in 1949) over the main part of the gabbro. A geological map of the same area was made by Egil Sæther at the same time (GM no.67 1949). His conclusion was that the ore-deposits were restricted in size and scattered. The survey had not given any indication of new ore of importance.

H. Carstens published in 1958 an article about "Layered basic xenoliths in some Norwegian Gabbros" including the Dyrhaugen gabbro. Among other things he mentioned. "It may be worth mentioning that numerous spectrographic analyses have shown that the hypersthene - gabbro and pyroxenite inclusions possess a rather high amount of Ni and Cu compared to the hybrid gabbro of the matrix".

In 1970 L. B. Løvås made his thesis work (NTH) on the Skjækerdalen Ni-occurrences and the gabbro. Geophysical methods such as I.P., Conductivity, Mise a la masse, Magnetometric and electromagnetic methods were carried out. None of these methods gave indications of any new ore. I.P. gave a couple of new anomalies but Løvås concluded with "a possible but not large ore" (Map.6). The geological part of his thesis contains detailed descriptions of the 7 more important mines and prospects, and a microscopic description of the Dyrhaugen intrusives.

Today the mining rights are held by Værdalen kobber-nikkelverk represented by adv. Ole Skirstad, address: Thomas Angellsgt. 8, 7000 Trondheim.

This survey

The fieldwork was carried out in the period August - October 1977 mainly as a geological mapping of the Dyrhaugen area.

Some work was also carried out further south in the Rautuva - Melberget - Raufjell area, approx. 5-11 km along strike SW of Dyrhaugen.

The geological information was plotted on new topographic maps in scale 1:10 000. In addition modern regional maps in scale 1:50 000 were used.

The area around Dyrhaugen is partly well exposed, especially on the SE slope. Large swamp areas NE and SW of Dyrhaugen are a problem, and so are the heavy glacifluvial deposits in the Skjækerfossen area. Creeks and small rivers normally give well exposed geological profiles.

In this survey all the rock names are field names, microscopic work has not been carried out.

Geological description

The sediments

The Dyrhaugen intrusives are situated in a weakly banded quartz feldspathic gneiss, partly occurring as a micaschist. The colour is grey with darker bands presumably showing the original bedding (So). A sub-parallel distinct developed axial plane schistosity (S_1) is superimposed and dominating. This (S_1) schistosity is fairly constant throughout the field (fig.14 and 15) and normally it masks the original bedding.

Tight isoclinal folds (F_1) are very common but not always easy visible (fig.1) because of the dominant S_1 foliation.

Fig.1

Tight isoclinal folds F_1
Roadcut, Sæterdalsbekken
(loc 52).

A single bed of dark graphitic schist with some rusty colour is located in a roadcut west of Høgåsen. It is 4 m thick and can only be traced 100 m along strike before it disappears under the overburden. Far to the south, in the Hestå-Raufjell area (map 2) we have a similar single bed of graphite bearing schist in the same litostratigraphic position.

Amdal (1934) describes another graphite bearing schist from the Seriennavola SE of Dyrhaugen. This years mapping has not located this rock - its position is possibly further to the east.

In the easternmost part of the mapped area (Bynavola - Rundvola) we find an intraformational fold breccia zone at least 100 m wide.

The rock is a bit more pelitic in composition than the underlying gneiss - but there is no sharp border. It looks like a very open spaced conglomerate with less than 10% fragments in the mica-schist matrix (fig.2).

Fig.2

Intraformational fold breccia
loc.148 Rundvola

The rock fragments are mainly more quartz-feldspathic than the matrix and often seem to be separated fold hinges ranging from 5 cm to 150 cm in size (fig.3).

Fig.3

Separate foldhinge-fragments
in fold breccia.
loc.148 Rundvola

At location 149 we can see a partly broken up bed of quartz feldspathic rock.

This fold breccia must represent minor thrust movement - direction unknown - but possibly connected to the F_1-fold phase with movement direction approx. vertical to the axial direction i.e. a movement in E-W direction.

Similar intraformational breccia has been observed by the author in Vangrøftdalen west of Røros in approx. the same stratigraphic position.

Turner & Weiss (1963) describe this as a transportation of bedding (So) into a foliation S_1 which is virtually parallel to the compositional banding in the resulting gneiss. This is characteristic for areas of isoclinal folds or nappes.

The Dyrhaugen intrusives

The so called Dyrhaugen gabbro has been mapped several times during the last 50 years and has been described as a lenticular gabbro body of 3-4 km length and 1-1.5 km width, surrounded by a 10-50 m broad rim of diorite. The entire body is orientated with its longest axis parallel to the strike of the surrounding gneisses and mica schists.

The gabbro

The Dyrhaugen gabbro is not a uniform rock but an intrusive breccia containing fragments of gneiss schist (local types), diorite, leucogabbro, dark gabbro and ultramafics.

The size of the fragments has a wide range from less than 1 cm up to 20 m. Especially the schist fragments can have a large size which makes it difficult to decide whether they are fragments or part of the surrounding rocks. By observing the orientation and lineation of the fragments it is possible to see that they have rotated away from the uniform direction of the surrounding gneisses. The fragment number is enormous compared to the matrix.

Most of the fragments are angular, showing sharp borders towards the matrix (fig.7I) except for some few that show narrow reaction rims (fig.4). A similar reaction rim but not so sharp is observed around some of the most ultramafic rock fragments showing a slightly more acid (feldspathic) borderzone (fig.5).

Fig.4

Basic fragment with dark reaction rim.
loc.101 Slipern mine

Fig.5

Ultramafic "fragments" with an acid (feldspathic) borderzone
loc. 106 Dyrhaugen

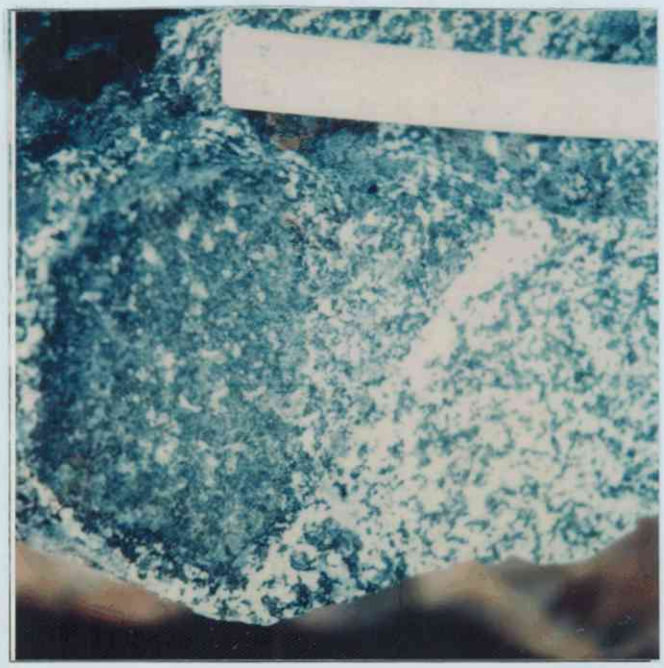
The composition of the fragments somtimes differs very little from the matrix and the fragments can only be seen as slightly darker shadows with a distinct but not sharp border (fig.6 and 7 II).

Fig.6

Ghost like fragment of gabbro in leucogabbro-matrix.
loc.92 Dyråen

Fig.7

Fragment with sharp outlines I, making an impact into a ghost like fragment II.
loc.136 Dyrhaugen



../11

On the same picture, fig.7, it is possible to see the fragment I making an impact into a more acid ghostlike fragment II. It looks like fragment II must have been more plastic than fragment I at one stage, possible during the crystallization. On the picture it is possible to see the dark minerals "flowing" around the impact.

Some few of the larger gabbro fragments show weak signs of layering. A good example is at an exposure S- and close to St. Olav mine.

H. Carstens (1958) describes such layered fragments as: partly absorbed gneiss fragments being basified. This can possibly be the case for the smaller fragments such as those in fig.8.

Fig.8

Fragment of the gabbroic borderzone or assimilated schist.
loc.122 Dyrhaugen

Rocks as shown on fig. 8 have been observed from the border zone between gabbro and schist at loc. 68 and 78. It has been concluded to be a border facies of the gabbro.

Normally the schist and gneiss fragments have sharp borders, but can show signs of partial absorbance as seen on fig. 9.

At some localities it looks like the fragmentation is of local origin and the rock can be "repaired" by moving together the single fragments situated in the most acid matrix,fig.10.

Fig.9

Partly assimilated (I) fragment of schist. loc.127 Dyrhaugen

Fig.10

"Jig-saw puzzle structure" loc.101 Slipern mine

At a single place (loc. 89) it was possible to measure the orientation of leucogabbro fragments in a dioritic groundmass. They showed orientation parallel to the L_1 and F_1 direction. See fig. 16.

Schist fragments in the breccia often show folded layers indicating that at least some of the brecciation movement must have found place during or after the first fold phase.

The ground mass of the breccia is not uniform but shows a whole range of compositions from dark gabbroic to light dioritic.

Even if there is a large variation in both matrix and fragments, it is observed that the magmatic fragments are always more basic than the local matrix they are situated in.

It is also observed that basic rocks, composing matrix in one place can exist as fragments in a more acid matrix at other localities.

It has not been possible to pull out any distribution pattern of the different rock types throughout the Dyrhaugen gabbro. The earlier reported phenomena of schist and gneiss fragment concentration along the border has shown up to be a local phenomena in the Sætertjern area.

The only field correlation is a weak one between the most basic/ultrabasic rock types and the sulphide occurrences. That means in reality that the ultramafic fragments are more numerous and locally more concentrated in the neighbourhood of many of the mines and prospects but not that the deposits are located in such rocks. Ultrabasic and dark mafic fragments are more often impregnated than the more light coloured types.

The variations in the composition of fragments and matrix combined with the fragment size that occurs makes it impossible for an accurate definition of the border to the surrounding diorite. To me it seems like the breccia is "floating in the middle of an ocean of diorite."

To the southwest, the Dyrhaugen gabbro continues as two smaller bodies. The one at Dyråen is possibly a branch which at depth is connected to the Dyrhaugen gabbro, containing the same variety of rock types including ultramafics. The second gabbrobody is located in the area of Sæterbekken close to the road end approx. 900 m south of the Dyrhaugen gabbro. Exposure in the road end shows an ecellent example of this more leuco-gabbroic type (fig.11).

Fig.11

Leucogabbro
loc.54 Road-end, Sæterbekken

The gabbro shows only a small tendency to a local brecciation as seen in loc. 76. Dark gabbroic variants also occur. Contrary to the Dyrhaugen gabbro this gabbro is partly in contact with the underlying gneiss and schist. The border zone shows up as a banded variety of the gabbro similar to the fragment shown in fig.8.

Towards the diorite there is a gradual transition in composition and colour - making it difficult to define any accurate border.

It must be mentioned that according to earlier microscopic examination of the rocks (Løvas 1970) the gabbroic rock variants contain both monocline and rombic pyroxene in different amounts. Some of the rocks must therefore be called norite or hyperite.

The Diorite

The dioritic rock occurs in the field as a light grey medium grained biotite-feldspar rock with subordinate hornblende. In some places a weak visible thick bedding can be recognized mainly as differences in grainsize. Towards the underlying gneiss-schist formation in the Dyråen river (loc. 85) there is a clear intrusive contact with the diorite cutting through the composite banding of the gneiss. This mapping also showed that the diorite surrounds the Dyrhaugen gabbro, except in the river NE of Bynasæter (loc. 128). Gabbro in contact with schist is visible here but again the question is whether the schist is a fragment or really representing the overlying gneiss-schist.

As shown on the map the diorite continues further to the south-west than previously reported. It thins out in the Sæterbekken area where it includes a small gabbro.

../16

Regional mapping showed some few exposures of the same rock type further south, down to Skjækermoen farm.

On the SW side of the Helgådalen valley the mapping reported diorite and diorite intruding schist in the Rautuva-Melberget area (see map no.2).

Small spots of rust (no visible sulphides) give the rock a rust brown colour visible from a long distance. Further south in the Raufjell mountain more of the same type of massive diorite has been mapped. Here included in the diorite there is located a gabbroic rock, with grainsize ranging from medium to extreme coarse grained variants showing amphibole aggregates up to 10 x 10 cm in size.

Mapping has not been carried out further south but there are certain possibilities that the diorite continues out in the swamp area SW of Raufjell. The continuation further south leads into the socalled Migmatite gneiss of Haver-formation in the Sonvass group (Wolff et al. 1973).

The continuation of the diorite rocks N and NE of Dyrhaugen is not so clear. The main picture is a bending eastwards of both the gabbro (with breccia) and the diorite, into the Rundvola area. On the other hand a diorite body is mapped in the Storbekken area possibly representing a branch of the intrusion.

A mineralized (?) gabbro is reported by Amdahl (1915) somewhere NE of the Åkersn. - this has not been visited.

The eastern border of the Dyrhaugen diorite is not so clear, especially on the mountain slope of Bynavola. Stream profiles here show massive diorite and diorite mixed up with schist zones showing the diorite intruding the schist. On the geological map this transition zone has been included into the diorite.

../17

Quartzdiorite (Trondhjemite)

The youngest intrusive in the area is a swarm of white fine grained quartz dioritic dykes (Trondhjemites) - cutting through the gneiss, micaschist and gabbro breccia. The dykes are not observed in diorites but this can be due to the small contrast in colour between the two rocks.

The contact conditions are variable but normally show sharp cross cutting dykes with schist fragments included in the dyke.

At one single locality a cross-cutting quartz diorite dyke in banded and foliated gneiss schist is observed showing replacement texture (fig.12).

Fig.12

Quartz-diorite (Trondhjemite) (I), showing replacement structure in micagneiss (II) loc.56 Sæterbekken

It is worth mentioning that the schistosity stops against the instrusive. Small fragments of the gneiss schist are preserved in the dyke.

Geological conclusion

The main impression of the Dyrhaugen breccia is that it is the result of a continuous or repeated brecciation of a layered gabbro during the crystallization process. The brecciation can be a result of tectonic movements indicated by the folded gneiss-schist fragments included in the breccia.

A continuous brecciation will explain the wide range of rock types represented, both as fragments and matrix- and the fact that the fragments are always more basic than the matrix.

The brecciation process must have gone on over a long period of the rock forming process based on the fact that a lot of the breccia matrix exists in other parts of the complex as fragments. Double fragments have not yet been observed.

The observation of a fragment forming an impact in another fragment and locally deforming its point to a picture of partly consolidated rocks.

The close connection and gradual transition from the more homogenous diorite into the basic breccia indicate a comagmatic formation.

Tectonics

As mentioned earlier the sediments show a weak coloured (grey) banding interpreted as a primary foliation So.

This composite banding, normally due to variation in the amount of dark minerals (hbl-mica) is often destroyed or masked by a dominant schistosity S_1 associated to an early fold phase F_1.

The F_1 folds are mainly isoclinal making the axial-schistosity subparallel to the primary foliation So (Fig.1). This axial foliation has a fairly constant orientation in the mapped area - clearly visible in fig. 14 and 15.

Fig.13

Axial plane schistosity S_1 cutting through So, creating a lineation L_1.
Strike direction So $\perp$ S_1^1
Loc.142 Dyråen

Fig.14
Poles to S_1 plane
52 observ. Schmidt equal area.
lower sphere

O S_1
Δ S_1 observed on fragment in gabbro-breccia

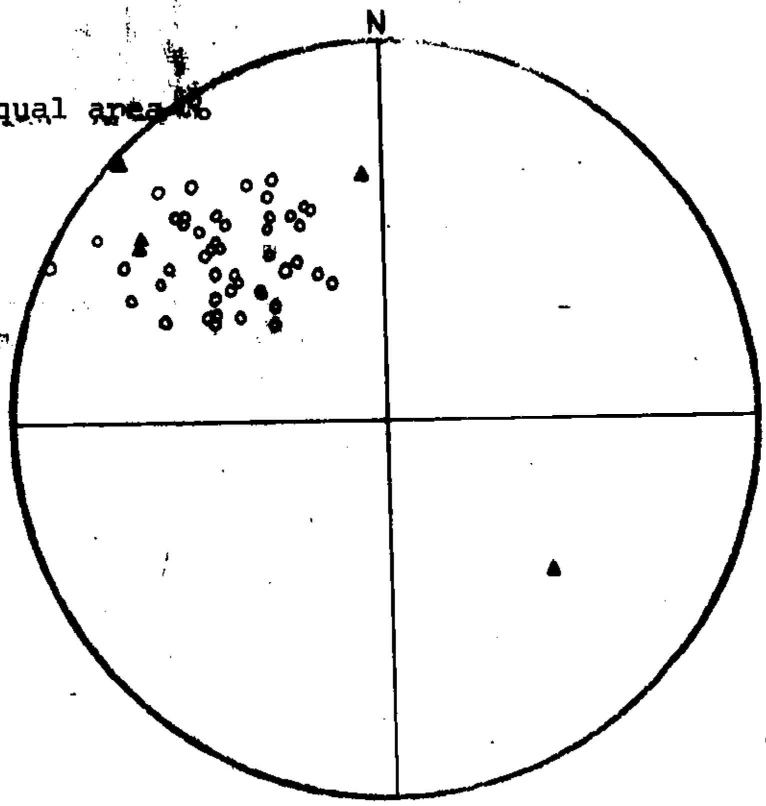
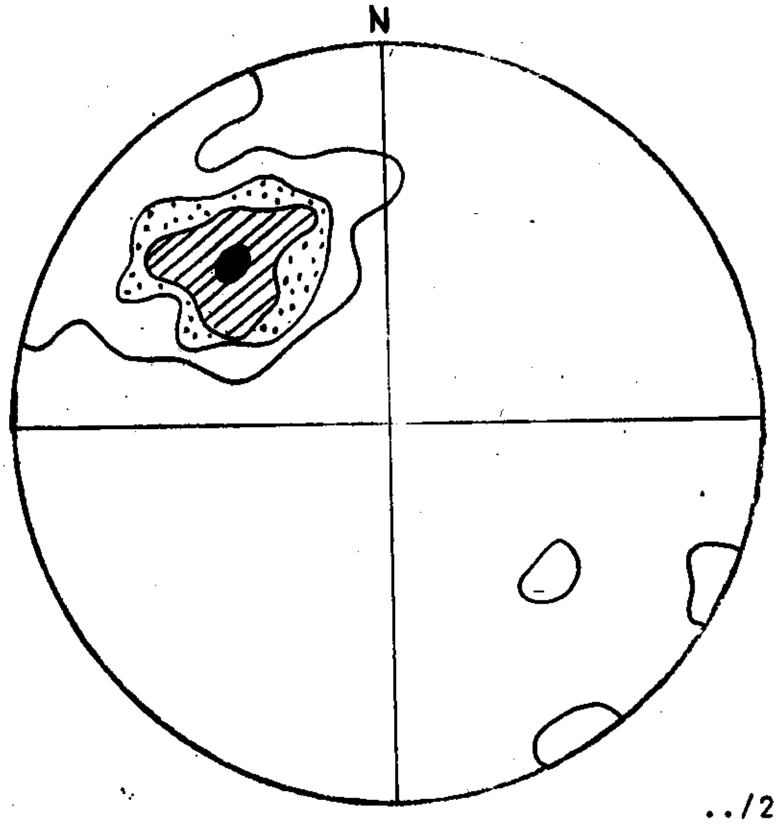


Fig.15
Poles to S_1 planes
52 observ. Schmidt equal area.
lower sphere



> 20%
13 - 20%
7 - 13%
2 - 7%

A strong lineation L_1 (fig.13) is partly well developed in the schists and is mainly a So/S_1 intersection. The orientation of F_1 and L_1 is rather constant throughout the field. This is shown in Fig. 16.

F_1 - L_1 axial dip direction is approx. SSV and the axial plane has a mean strike/dip of N135/42SE.

Folds from a second fold phase are visible at some localities, showing NE-SE striking axes with more or less horizontal dip. Axial planes are dipping approx. 45° towards northwest. Axial plane schistosity is not developed.

Fig.16

Foldaxis and lineations
● F_1
O L_1
Ø F_2
F=observ. on fragments
in gabbro breccia

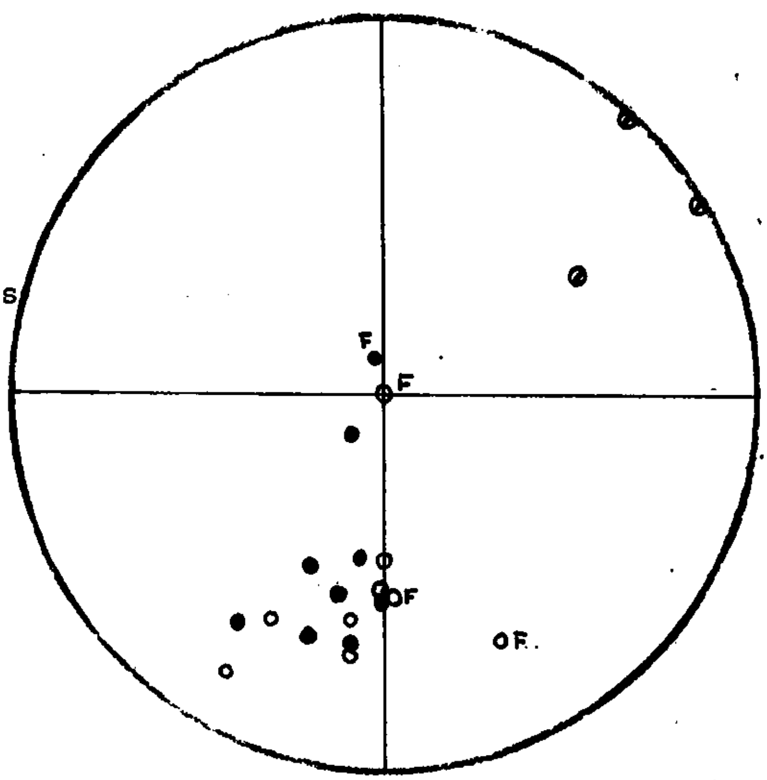
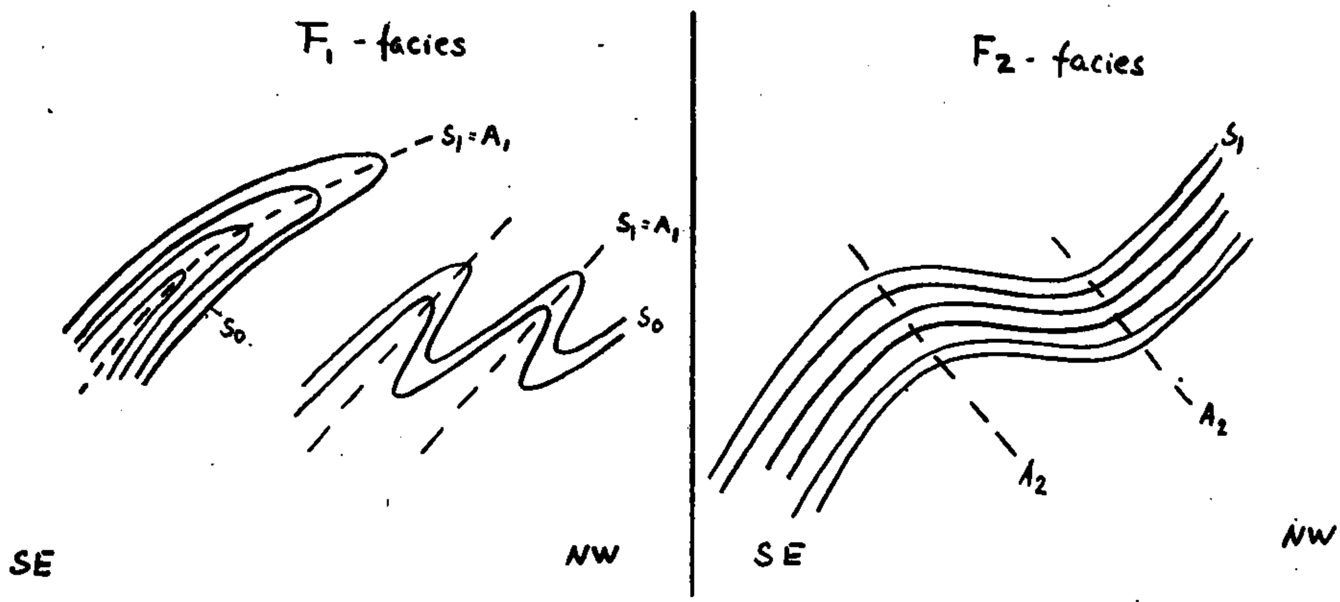


Fig. 17.

Fold style and orientation of axial plane.

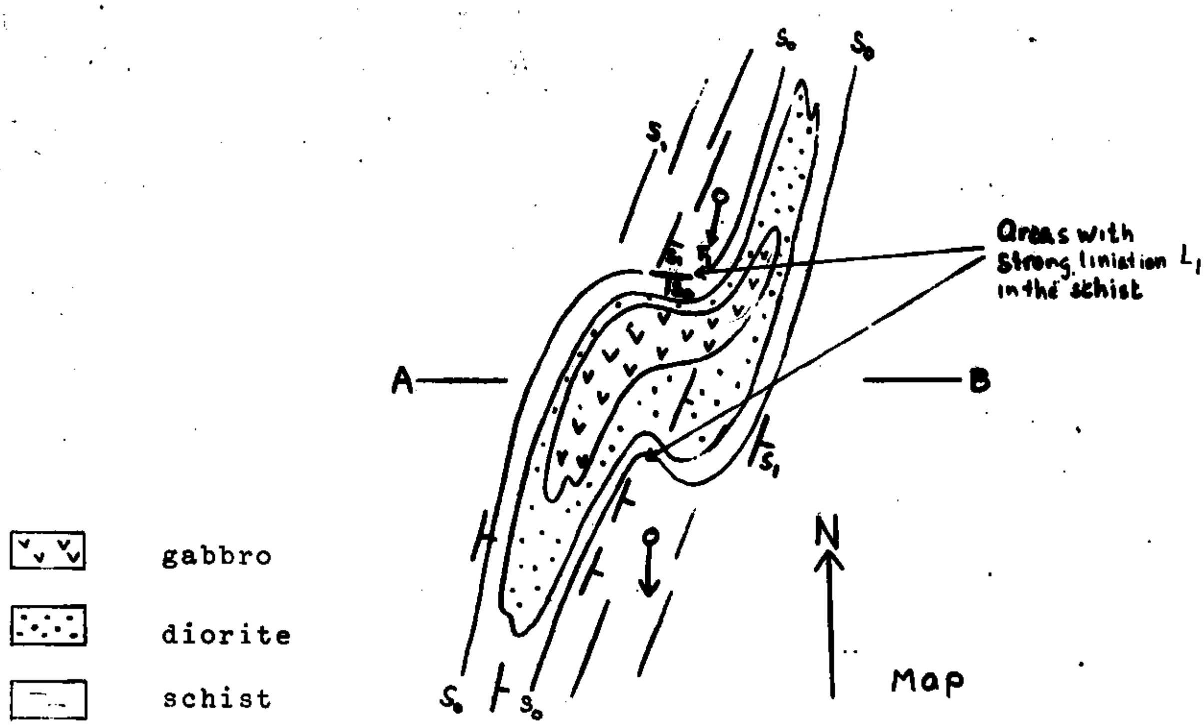


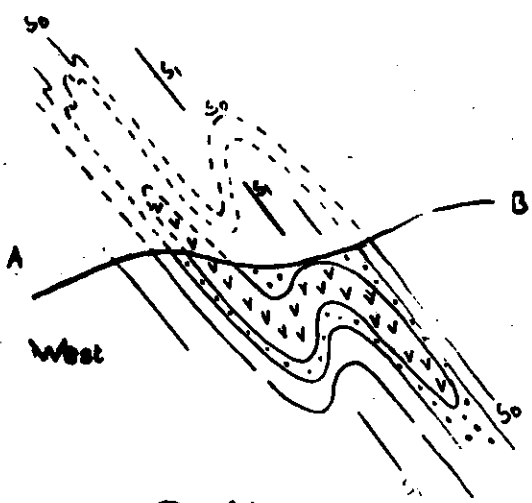
The F_2 fold phase is more often seen as a deformation of F_1 axial plane (Fig.18 & 19). The two axial planes are orientated approx. 90° to each other.

The Dyrhaugen diorite has a distinct developed schistosity visible in the Dyråen and Sæterbekken areas. This schistosity is parallel to the S_1 and must be of the same origin. It would mean that the intrusion of diorite must be older or of the same age as the F_1 phase.

The shape of the Dyrhaugen gabbro and diorite especially in the north can be explained as a result of folding the intrusion during the Γ_1 phase.

Simplified sketches





Profile

Especially in the Dyråen close to Dyrasetra, close to Åkersr. in Dyråen loc. 85/64 we have the strongest lineation L_1 with So orientated approx. E-W and S_1 NE-SW (loc. 142). This bending of So around the diorite is not easily recognisable because of the masking effect of the S_1 schistosity and the resulting lineation L_1 (Fig.13).

Fig.18

F_2 fold facies seen as deforming F_1 axial planes.
Loc. 67 Sæterdalsbekken

Fig.19
An axial plane S_1 deformed by later fold facies F_2
Loc.65 Dyråen

The Ni-sulphide deposits

There are 7 main Ni-workings in the Dyrhaugen area:

Hovedgruva (Jensen mine), Slipern, Barbara Bächke, St. Olav, Homan and Archbold mines. Only two of these (Hovedgruva and Slipern) have been put into ordinary production, with Hovedgruva as the largest and most important one. In addition 20-25 smaller showings are spread out in the basic breccia (Map no. 4).

The following is a short description ot the different mines and showings. Part of the information is from Løvas thesis work, 1970.

The numbers refer to map no.4.

THE "MINES"

1) Hovedgruva (Jensen Mine)

The ore strikes ENE with a steep inclination towards S. It is followed approx. 70 m along strike in the upper part. On the 55 m level it is followed 35 m along strike before thinning out. Thickness here is between 2.5 m and 5.5 m. The deepest working level is 60 m with an ore thickness of 2 m. No massive ore is visible on the dumps - only a heavy impregnated leuco-gabbro. The mine is filled with water.

Assayed samples from the dumps showed (A/S Sulfidmalm 1977):

Sample no.	%Ni	%Cu	%S	later checked assays Ni%	Cu%	S%
20/371	1.08	0.26	8.2	1.00	0.21	8.0
20/372	0.27	0.24				
20/373	0.97	0.21	6.5	0.87	0.27	6.8
20/374	1.20	0.90	7.8	1.00	2.60	8.9

The 1st and 2nd assay have been carried out on material from different parts of large samples.

Fig.20.
Hovedgruva

../27

2) Slipern mine

Mainly worked as an open pit mine only a couple of m deep, including 3 shafts.

The main shaft is 20 m deep,and based on reports from 1915 the ore zone is 6 m long and 0.5 m thick. Today it is difficult to say which one is the main shaft, all are waterfilled and little information is available.

A tunnel has possibly been worked from the side approx 100 m away to the SW. The opening is closed and nothing is known about the length.

Strong brecciated rock with dark gabbro and ultrabasics in leucogabbro are the main rocks around the deposit. On the dump some Cpy rich samples are visible.

Samples from the dumps show:

No.	%Ni	%Cu	%S
20/364	1.12	0.33	7.8
20/365	0.35	0.10	
20/366	0.47	0.21	3.6

A/S Sulfidmalm 1977

Fig.21

Slipern mine

../28

3) Barabara Bachke mine

An L-shaped open pit approximately 30 m long and 3-4 m wide has been mined out to 4-5 m depth. 2 shafts are located in the middle and inner part. The inner one has a SSE direction and is the deepest one. No information about the depth.

The ore zone is striking approx. SE-NE with steep dip towards SE.

The pit walls show a strong brecciated structure with different types of dark gabbro as the main fragment type.

Assays show:

Sample from small massive 70% po-ore	2.52% Ni	0.03% Cu	Løvås 1970
dark ultrabasic rock	0.32% Ni	0.13% Cu	
dark gabbro	0.20% Ni	0.14% Cu	

4) Anton Bachke mine

This is in reality a showing composed of 2 small waterfilled shafts 3 x 4 m approx. 3.5 m deep. Strike direction is NE-SW. The mineralization is mainly small lenses of compact pyrrhotite or impregnation in gabbro. Chalcopyrite shows local concentration.

Assays:

No.	%Ni	%Cu	%S
20/369	1.00	0.40	7.5
20/370	0.83	0.54	7.3

A/S Sulfidmalm 1977

5) <u>St Olav mine</u>

This is also a very small "mine" (fig.22) and is visible as a small open pit with 2 small shafts in different directions. The ore has probably been worked out of the SE one.

The sulphides occur in an ultrabasic (hornblendite) as a rich disseminations. In minor amounts as diseminations in leuco-gabbro at the dumps.

Assays:

No	%Ni	%Cu	%S
20/368	0.72	0.20	4.5
20/367	0.47	0.19	5.0

A/S Sulfidmalm 1977

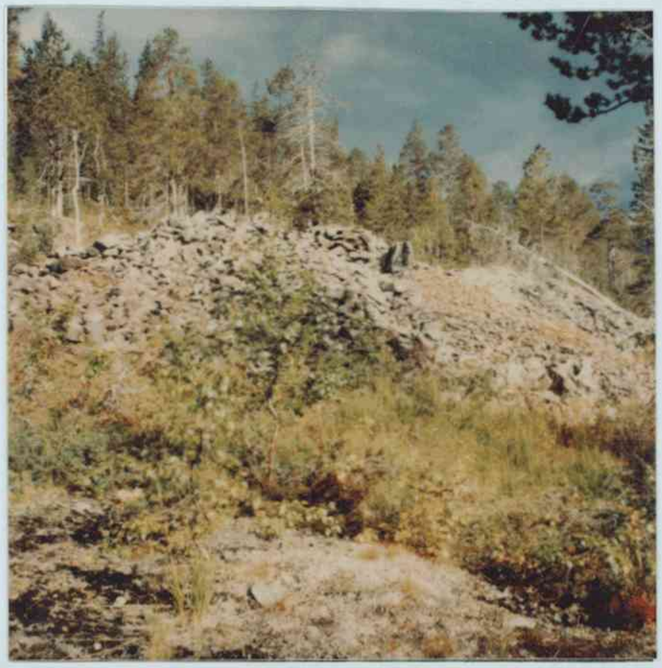


Fig.22

StOlav mine

6) Homan mine

This is mainly a showing with only a 6 m long and 1 m deep trench in dark gabbro. Under the rusty cover there are up to 20 cm thick sulphide lenses in the inner part of the trench.

Older assays:

	%Ni	%Cu	
Sample with 70% po	0.91	0.16	
Cpy-rich sample with 20% po	0.31	1.98	Løvas 1970
Fine grained gabbro with 13% po	0.13	0.14	

../32

7) Archbold mine

This is a 20 m long trench, 2-3 m wide and approx. 4 m deep. The sulphides occur in the middle part of the trench, as rich impregnation and small lenses over a 4 m length. The sulphide content decreases towards the inner part and towards depth. Leucogabbro-blocks are observed on the dumps.

Samples from the dumps:

No.	%Ni	%Cu	%S
20/363	0.78	0.09	8.9

A/S Sulfidmalm 1977

Samples from the "mine"	%Ni	%Cu
ore with 30% po	1.10	0.24
hornblendite	0.28	0.11
dark gabbro	0.20	0.16

Løvås 1970

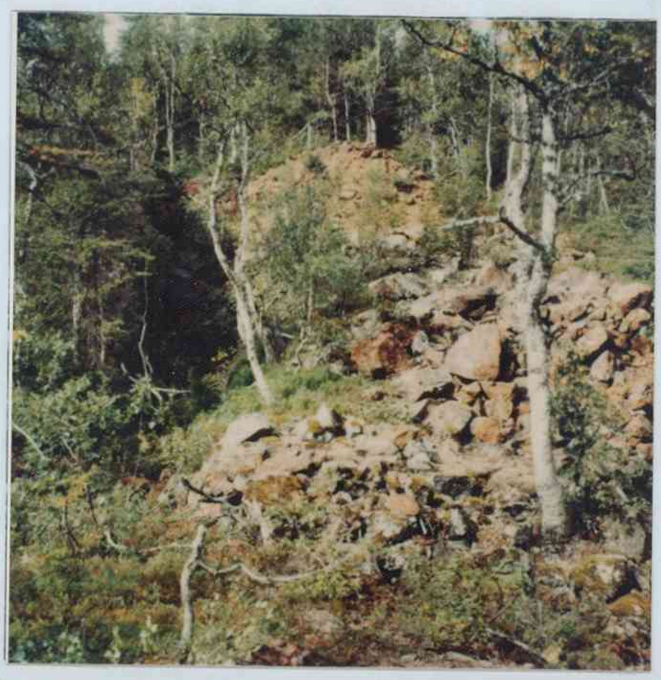


Fig.23

Archbold mine

General

According to Løvas 1970 the main ore minerals reported from polished sections are:

Pyrrhotite:	the main ore mineral grainsize 1 - 5 mm.
Pentlandite:	as 0.1 - 1 mm grains in pyrrhotite, rare as exsolution-flames
Bravoite: (Fe, Ni, Co) S_2	as alteration products of pentlandite in cracks.
Chalcopyrite:	mainly in pyrrhotite as grains of 0.1 m size or lamellar.
Linneait Co_3S_4	subhedral grains of 0.1 mm, only some few in single sections.

In addition there is observed minor amounts of:

Ilmenite
Rutile
Spahlerite
Magnetite
Marcasite
Limonite

Small grains of high reflectivity inside the bravoite grains was postulated as Pt-mineral.

At the Norwegian geological survey Au, Pt, Pd assays were carried out (Løvas 1970).

	%Ni	%Cu	ppm Au	ppm Pd	ppm Pt
Cpy-rich compact ore	0.85	3.60	0.1-0.2	0.05	no trace
Compact ore	2.85	0.02	$<$0.1	trace	no trace

The showings

8) Tunnel possible to Slipern mine or to mineralization at 9).

9) Gabbro with sulphide impregnation.

10) Ultrabasic and dark gabbro with weak po, cpy impregnation.

11) Shallow showing 3 x 3 m with sulphides in ultrabasic.

12) Weak impregnation in gabbro and ultrabasic.

13) Showing 2 x 2 m with impregnation in dark and grey gabbro.

14) Crag with sulphide impregnated dark gabbro and ultrabasic.

15) Grains and clusters of po in grey gabbro, small showing. Both 14 and 15 in strong brecciated, with folded schist fragments.

16) Showing: 1 x 4 m long in gabbro with gneiss fragments, some scattered po-grains.

17) Grey gabbro with scattered po-grains visible in small showing.

18) A 4 m long and 2.5 m trench into mainly ultrabasic rock fragments in gabbro. Some sulphides.

19) Blasting hole in crag, some sulphides in gabbro-ultrabasics.

20) Blasting hole in crag, impregnation of po in dark gabbro fragments in leucogabbro matrix.

21)

a) Dark gabbroic blocks with sulphide impregnation. Blasting hole in rusty moraine - uncertain whether it is bedrock or moraine.

b) Dark gabbro with sulphides - more sulphides in ultrabasic rocks.

c) Dark gabbro with scattered sulphides.

In the field there is a rust zone connecting these three showings.

22)

a) + b) Small crags on a line showing dark gabbro - partly with strong sulphide impregnation.

23) Elongated crag with minor sulphide impregnation in dark gabbro.

24) Crag with breccia fragments of ultrabasic and dark gabbro in leucogabbro matrix. Fine grained po-impregnation - local more cpy-"rich".

Assays:	0.16% Ni	0.28% Cu	"cpy-rich"	Løvas 1970
	0.08% Ni	0.11% Cu	weak po-impregnation	
	0.16% Ni	0.12% Cu	po + cpy impregnation	

Conclusion

All the known sulphide mineralizations are located to the breccia - none are seen in the diorite.

Throughout the breccia the mineralization is connected to dark gabbroic and ultramafic fragments mainly as impregnation, but heavier impregnation and partly massive ore has been found in more leucocratic gabbro. Looking at the different mines and showings there seems to be a concentration of ultramafic and dark mafic rocks (fragments) in the localities close to the mines - but the ore itself is often situated in the matrix rock. The distribution of the mines and showings show a weak tendency to follow the inner part of the gabbro-breccia as an elongated area more or less parallel to the strike direction of the S_1-schistosity. Information from Hovedgruva indicate a strike and dip of the ore parallel to the same S_1-schistosity.

There are several lines of evidence pointing to a formation of the ore during a magmatic crystallization process either as sulphide layers or as heavily impregnated basic - ultrabasic rocks. These rocks have at some slightly later stage been broken up into separate fragments. At some localities these basic-ultrabasic blocks have been more concentrated than elsewhere. A later process has mobilised and redistributed part of the sulphides with a following introduction into the slightly more acid gabbro around.

From a local prospecting point of view it is interesting to note the tendency for the sulphide showings to occur inside a 1700 m long and 300 m broad zone (map 5). A similar distribution is seen from the I.P. map where the strongest I.P. effect is concentrated inside the same area (map 6).

Further prospecting like drilling should be concentrated inside or along this area, and along S_1 dip towards the depth.

The regional aspect of the survey is important when thinking about following the continuation of the diorite intrusive south- (and north-) wards with the possibility of finding more of the basic rocks either as breccias or as gabbro/ultrabasic intrusives. We already know that these rocks have Ni-potential.

More regional work should look in more detail at the numerous diorites and gabbros in the southwestern part of the Trondheim region (Singsås-Kvikne-Dovre). We already know that a gabbro in the Unndal area has a brecciated structure - in part similar to the Skjækerdalen breccia.

On the other hand it is worth mentioning that the whole rock suite represented in the Dyrhaugen breccia is very similar to the rocks in the layered Hylingen gabbro complex 40 km north of Røros (O. Nilsen 1973).

The Hylingen gabbro complex is a layered intrusive sheet in the southern part of the larger Fougen intrusive and is composed of a variety of rocks ranging from ultramafic - peridotites - olivinegabbro - norite - norite gabbro - gabbro - diorite and monzonite (map no. 9 or fig.25).

Map 8 (fig.24) shows the Hylingen gabbro and the distribution of the numerous other gabbros in the area Tynset - Meråker. Some of the larger bodies contain the same variety of rocktypes as the Hylingen gabbro.

It looks like the Dyrhaugen gabbro breccia can be put into the same gabbro intrusive belt.

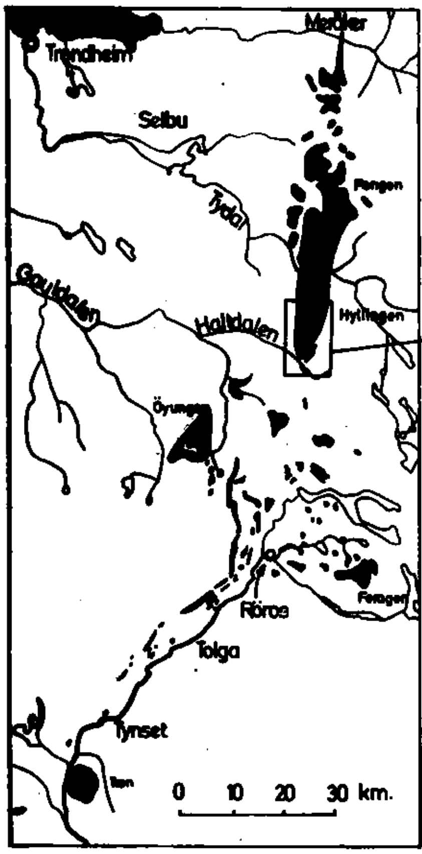
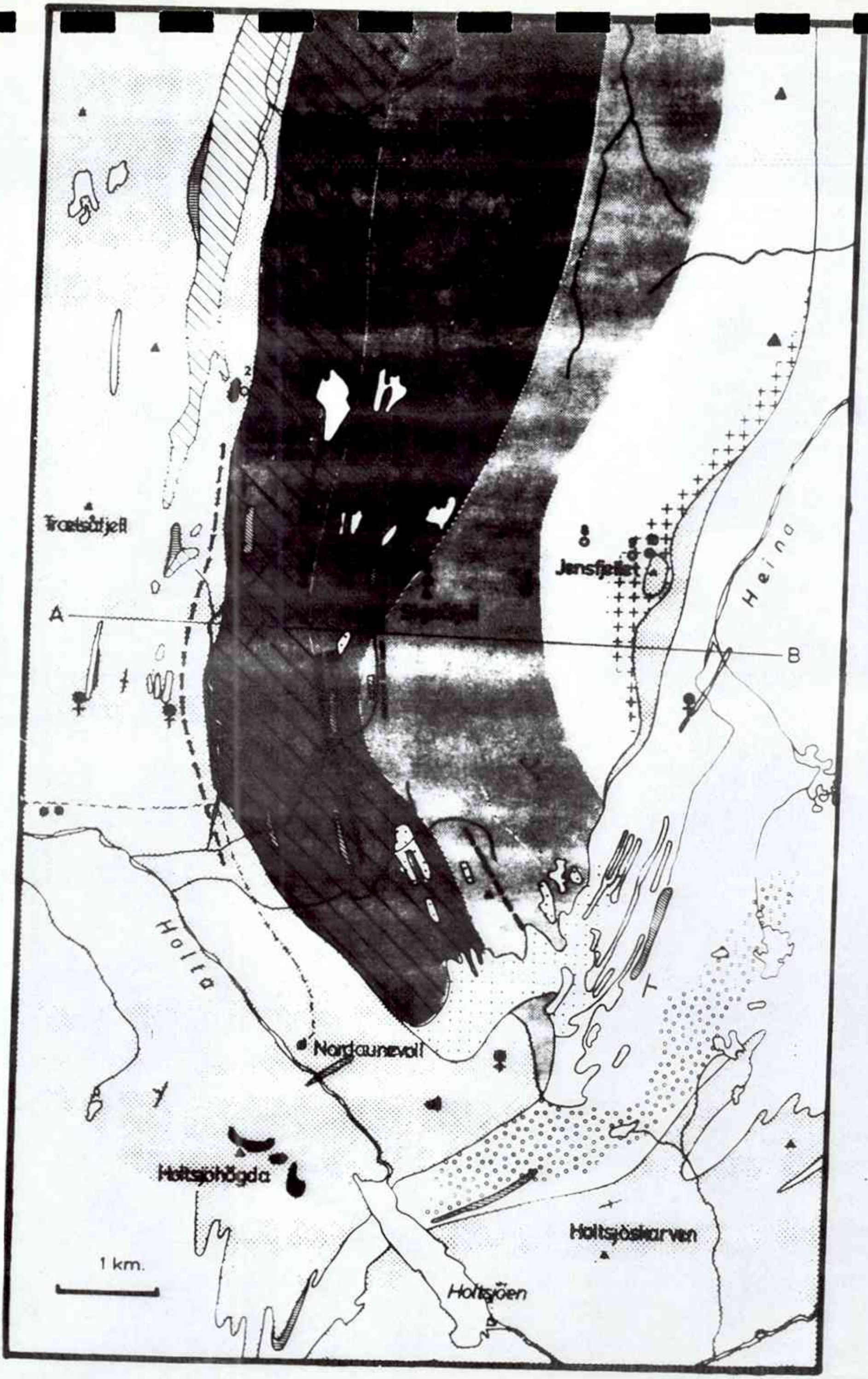
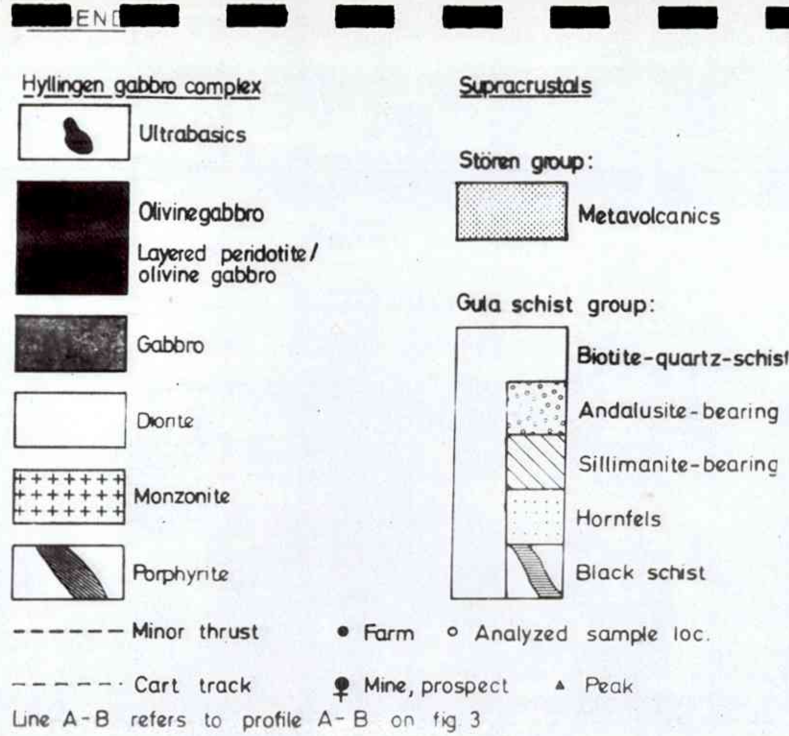


Fig. 1. Key map showing the distribution of gabbros (in black) in the eastern Trondheim region and the Hyllingen area (inset frame).

See map 9. Fig.25.

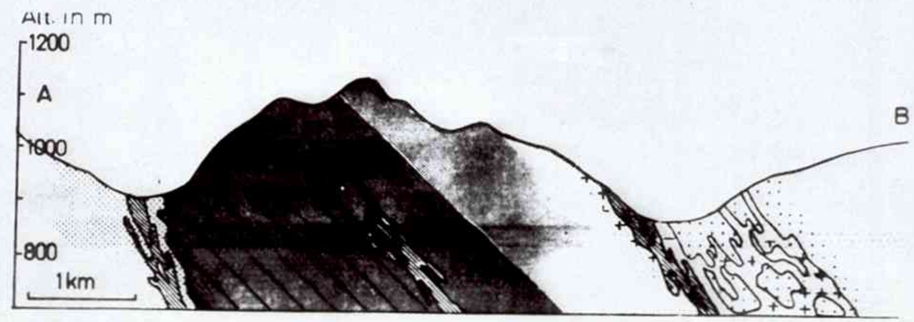
Map. no. 8 - fig. 24





Geological map of the Hyllingen gabbro complex

Map no. 9 - fig. 25



Section through the Hyllingen gabbro complex ... Skelapynten ...

References

1)	Amdahl K. M. (1934)	Thesis work NTH
2)	Bachke A.S. (1880)	The Værdals Nickel-Mines (report) "Bergarkivet" N.G.U.
3)	Bachke O. A. (1910)	Only a summary of his report exists in "Bergarkivet" N.G.U.
4)	Carstens (1958)	Layered basic xenoliths in some Norwegian gabbros. Beitrage zur Min. und Petrographie Bd.6
5)	Geofysisk Malmleting (1949)	Forsøksmålinger Skjækerdalen Nikkelforekomster, Verdal GM rapport no. 67
6)	Løvas L. B. (1970)	En malmgeologisk undersøkelse av Skjækerdalens Ni-Cu forekomst. NTH Thesis work
7)	O. Nilsen (1973)	Petrology of Hylingen gabbro Complex NGT v.53/2
8)	Rosenlund A. L, (1915)	Meddelelse vedrørende Værdalens eller Skjækerdalens gruver (report)
9)	Smidt H. H. (1915)	Rapport over Værdalens nikkelgruver
10)	Turner & Weiss (1963)	Structural analysis of Metamorphic Tectonites. Mc.Graw Hill

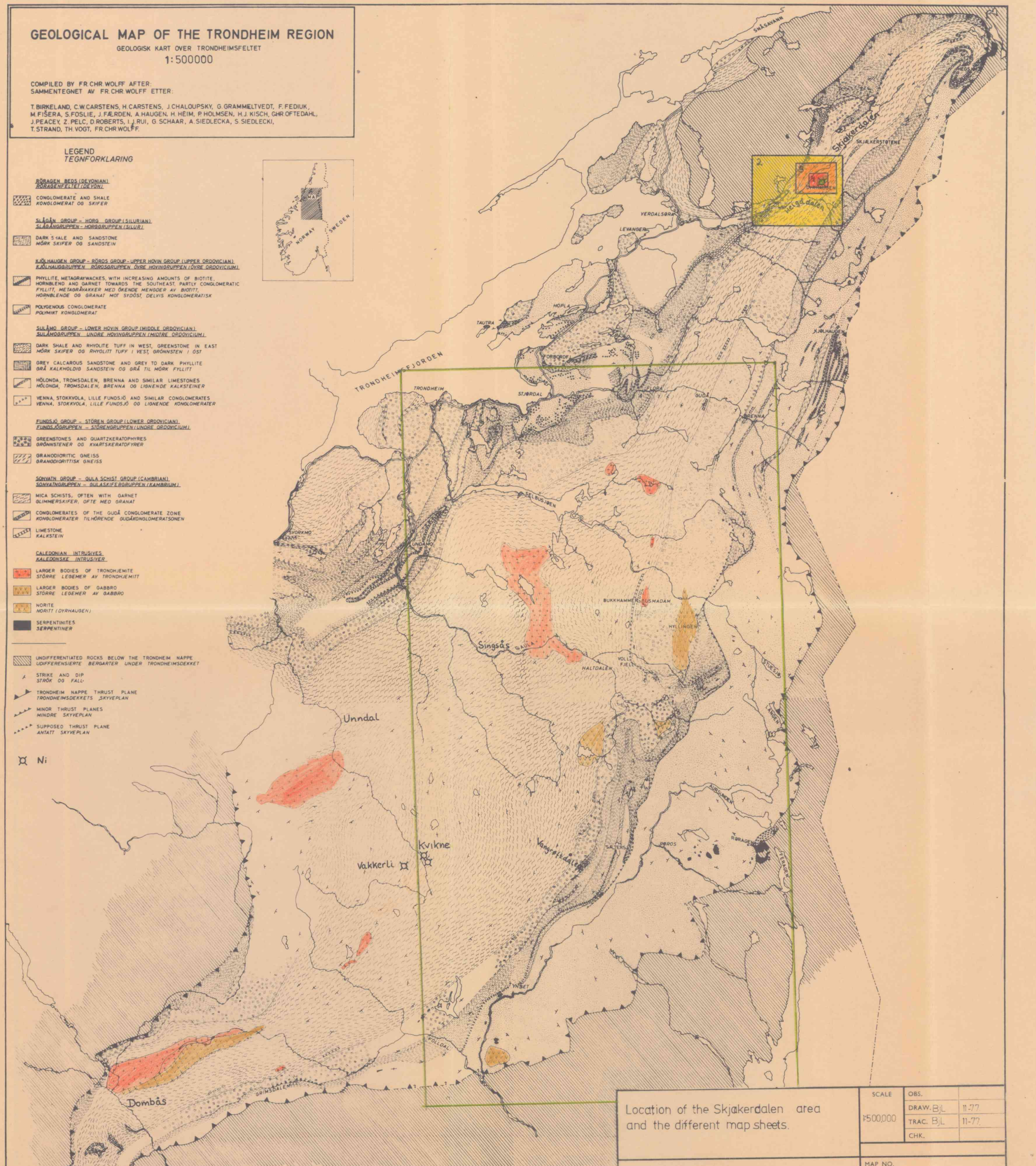
11) Wolff (1960) Foreløpig meddelelse fra kartbladet Verdal, NGU 211

12) Wolff (1973) Meråker og Færen
Beskrivelse til de bakgrunnsgeologiske kart. 1722I og 1722II

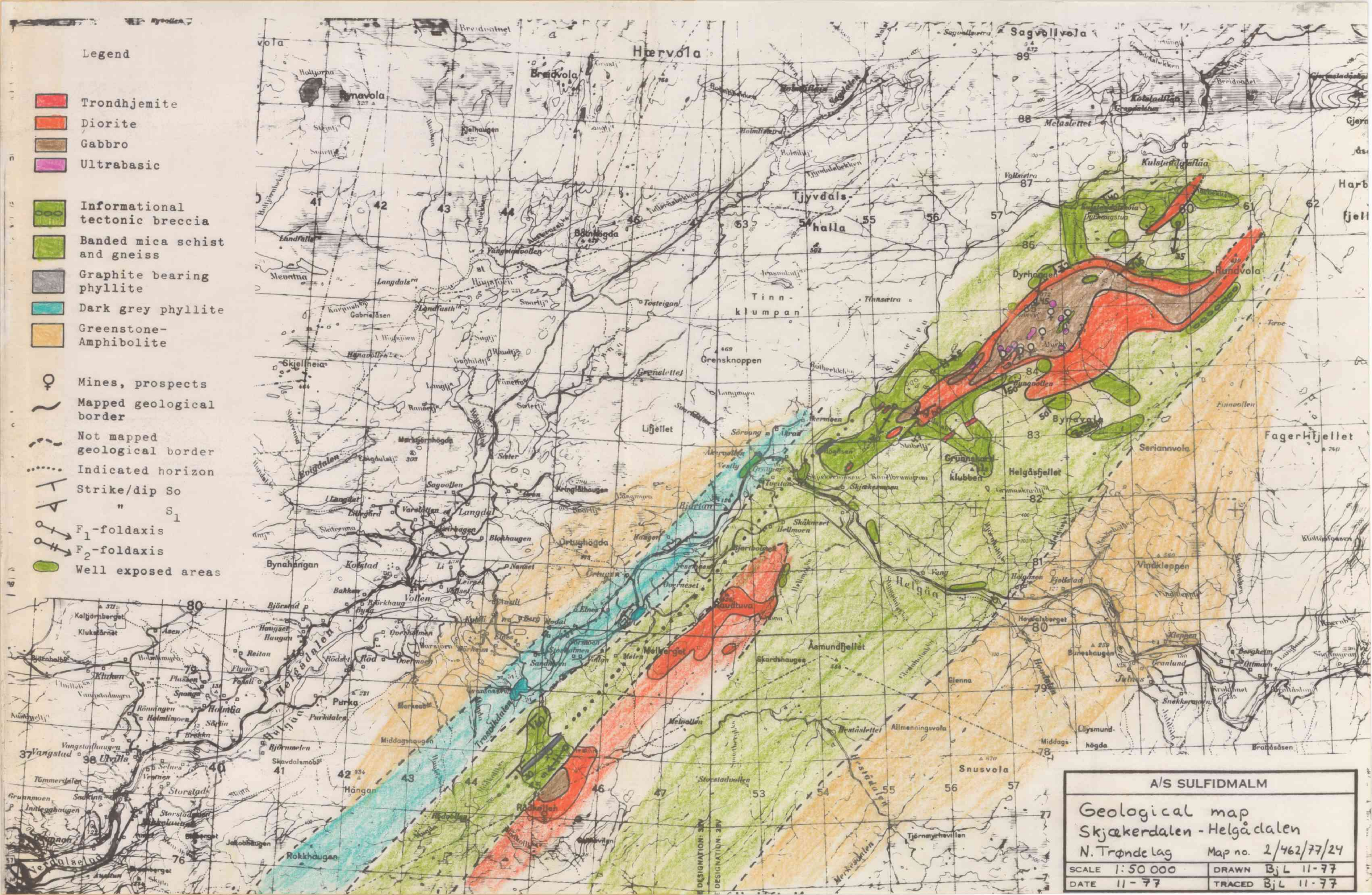
Enclosures

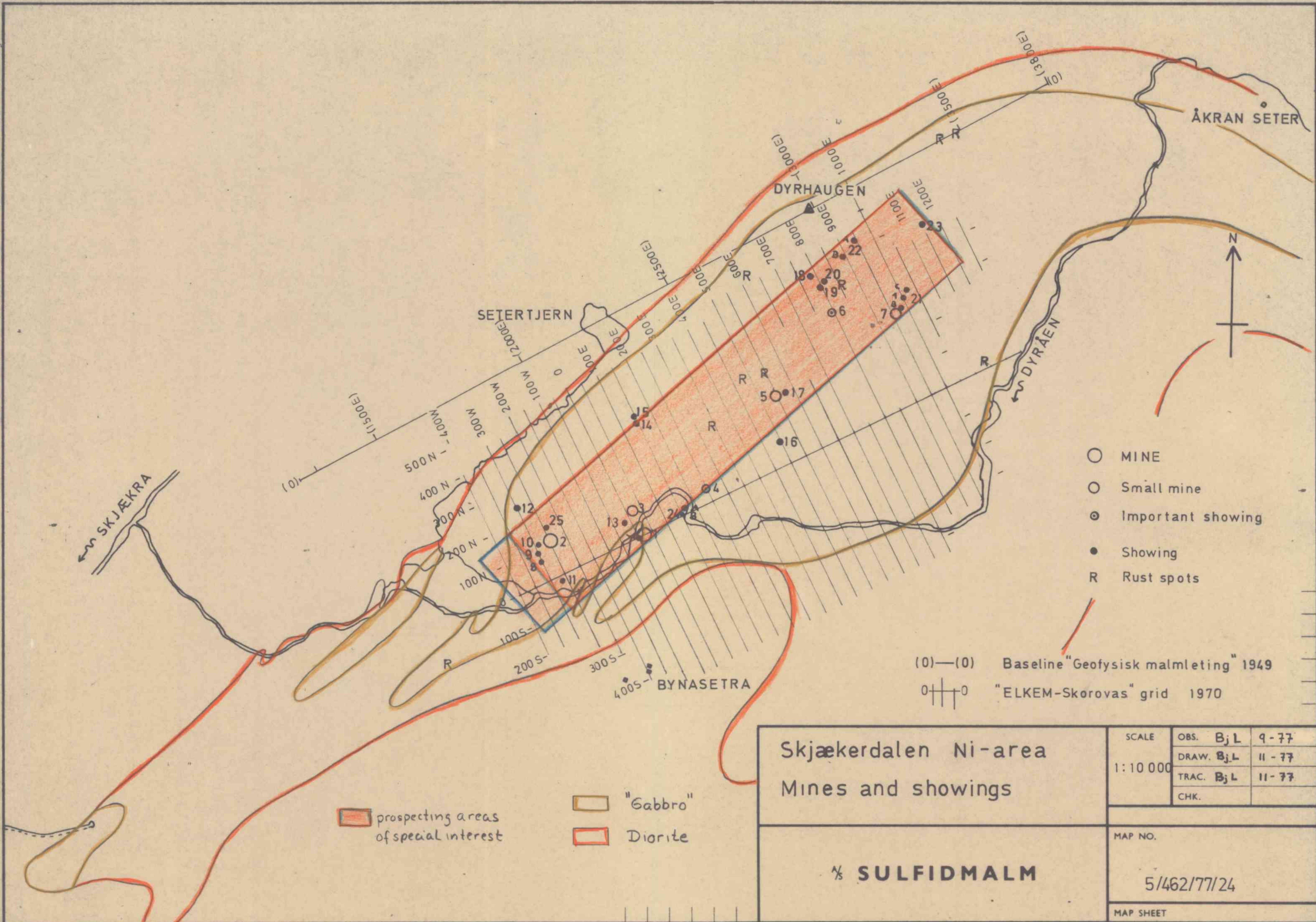
Map no. 1	Geology of the Trondheim region. Location of the Skjækerdalen with the different map sheets M 1:500 000.
Map no. 2	Geology of the Skjækerdalen - Helgådalen area M 1:50 000.
Map no. 3	Geology of the Skjækerdalen (Dyrhaugen) area M 1:10 000.
Map no. 4	Mines and showings in the Dyrhaugen area M 1:10 000.
Map no. 5	Mines and showings in the Dyrhaugen area with areas of special interest M 1:10 000
Map no. 6	Løvas I.P map Dyrhaugen area M 1:2500
Map no. 7	Geology of the Skjækerdalen Wolf. 1960 M 1:200 000.

Legend.
Ultrabasic.
Gabbro, Leucogabbro.
Diorite.
Gabbro/Diorite-breccia.
Trondhjemite dyke.
Bandet micaschist.
Intraformational fold-breccia.
Dark phyllite.
Exposed bedrock.
Strike/dip of foliation in micaschist.
Foliation in diorite.
Fold-axis.
Lineation-axis.
Mines, shafts prospects.
Rusty rock.
Location number.
Strike/dip of joints.
SKJÆKRA
STORBEKKEN
DYRHAUGEN
RUNDVOLA
ÅKER SR
HOMAN
ARCHBOLD
ST. OLAV
BARBARA BACHKE
ANTON BACHKE
SLIPERI
HOVEDGRUVA
DYRÅEN
BYNA SR
BYNAVOLA
Seterbekken
STABELS TJERN
SKJÆKERFOSSEN
SKJÆKERMOEN
HELGÅA
N
Ice-transport direction
Skjækerdalen
Norge
Sverige
Finland
USSR
0
500 km
0
500m
1000m
Geological map.
Dyrhaugen.
Skjakerdalen N-Trøndelag.
SCALE
1:10 000.
OBS. BjL 8-10-77
DRAW. BjL. 11-77
TRAC. BjL. 11-77
CHK.
A/S SULFIDMALM
MAP NO.
3-462-77-24.
MAP SHEET



Location of the Skjækerdalen area and the different map sheets.	SCALE	OBS.	
	1:500,000	DRAW. BjL	11-77
		TRAC. BjL	11-77
		CHK.	
A/S SULFIDMALM	MAP NO. 1/462/77/24		
	MAP SHEET		


Legend
Trondhjemite
Diorite
Gabbro
Ultrabasic
Informational tectonic breccia
Banded mica schist and gneiss
Graphite bearing phyllite
Dark grey phyllite
Greenstone-Amphibolite
Mines, prospects
Mapped geological border
Not mapped geological border
Indicated horizon
Strike/dip So
" S1
F1-foldaxis
F2-foldaxis
Well exposed areas
Hærvola
Sagvollvola
Tjyvdals-halla
Tinn-klumpan
Grensknoppen
Rundvola
Byrfavola
Helgåsfjellet
Åsmundfjellet
Snusvola
Fagerhjellet
Vindkleppen
Helgådalen
Helgåa
A/S SULFIDMALM
Geological map
Skjækerdalen - Helgådalen
N. Trøndelag
Map no. 2/462/77/24
SCALE 1:50 000
DRAWN BjL 11-77
DATE 11-77
TRACED BjL 11-77



Skjækerdalen Ni-area

Mines and showings

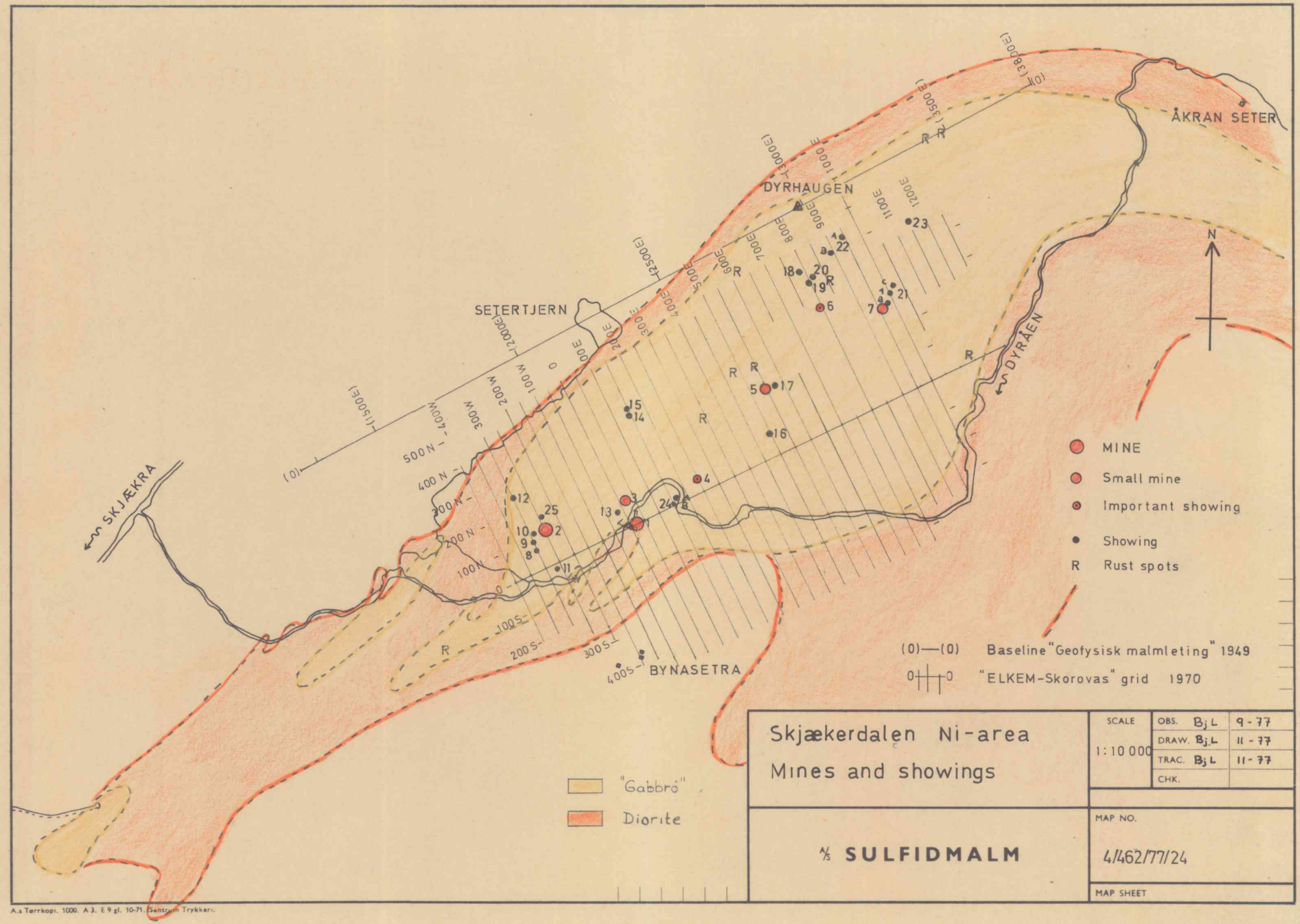
A/S SULFIDMALM

SCALE	OBS.	Bj L	9-77
1:10 000	DRAW.	Bj L	11-77
	TRAC.	Bj L	11-77
	CHK.		

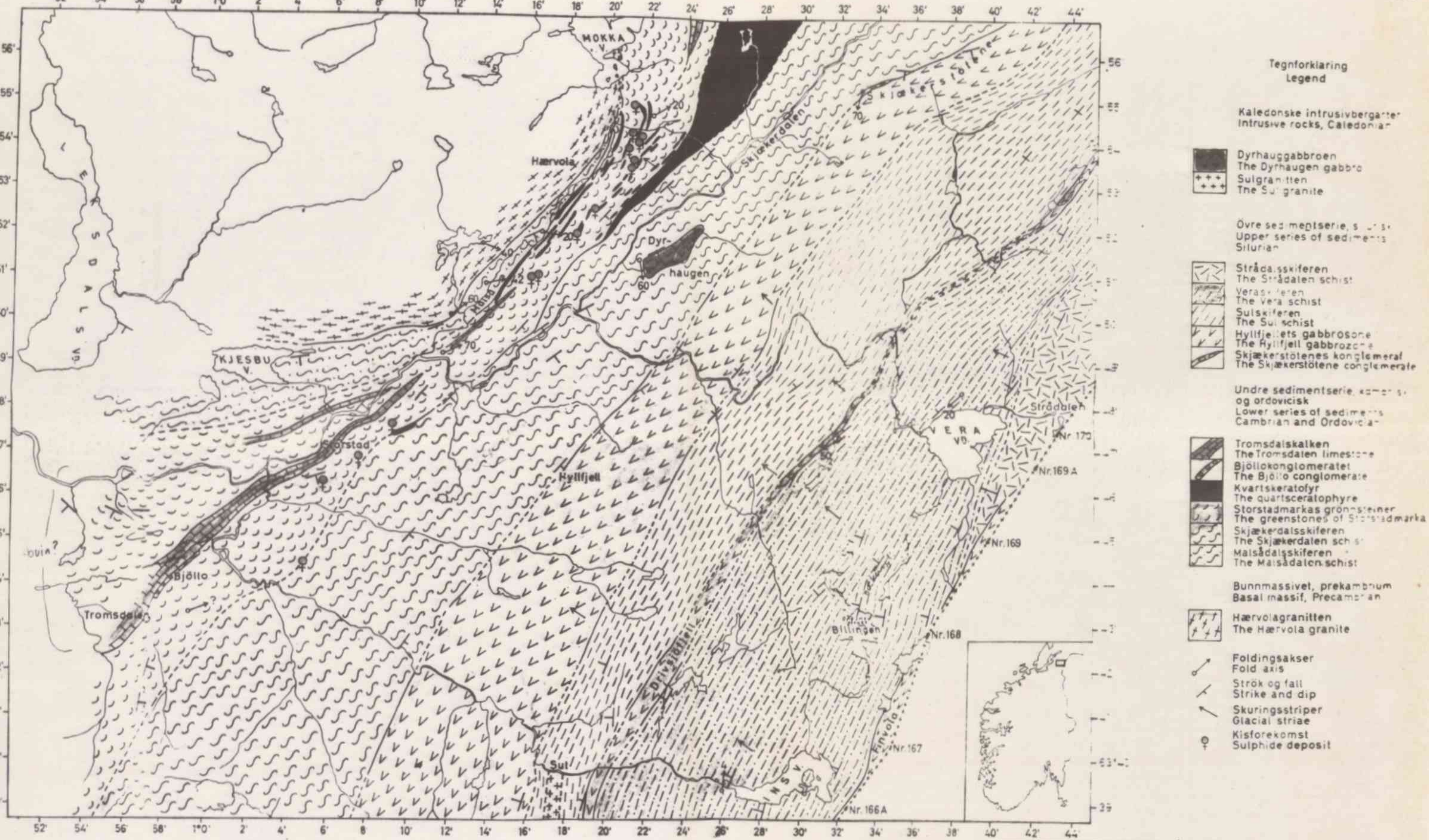
MAP NO. 5/462/77/24

MAP SHEET

A.s Tørrkopi. 1000. A 3. E 9 gl. 10-71. Sentrum Trykkeri.



A.s Tørrkopi. 1000. A 3. E 9 gl. 10-71. (Sentrum Trykkeri.



Pl. 1. Geologisk oversiktskart over Verdalen 1 : 200 000.

Geological map of Verdalen 1 : 200 000.

Map no.7/462/77/24

SKJÆKEDALEN I.P.-effekt	SCALE 1 ; 2500	OBS. LØVAS	1970
		DRAW. SULFIDMALM	
		TRAC. —"—	
		CHK.	
A/S SULFIDMALM	MAP NO. 6/462/77/24		
	MAP SHEET		