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Tittel

Molybdenite in Ødemark Area, Hurdal. Project Mo in the Oslo Region

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Sammendrag

This is a preliminary report on the geology of the Ødemark (claim) area in Hurdal. (NM-217-1987-ØB)
Attention is paid to the result of the drilling, the nature of mineralzation, and the geochemical and geohysical work which have been done. Futher investigations are proposed.
Low grade molybdenite mineralization occur in hydrothermal veins together with quartz, pyrite, magnetite and carbonate. The veins are hosted in coarse-grained syenitic rocks which is pervasively pyrittized. Apart from bleaching of the syenite in certain parts of the cores, more intensive alteration of the silicate minerals have not been recognized.
Mineralization is cut by younger syenite and more felsic dykes.
The source rock is unknown.

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DATO: 18/9-81	**RAPPORT NR:** 1202	**KARTBLAD** NP 3132-16	**Antall sider** 22 **—"— bilag**

SAKSBEARBEIDER Ingolf J. Rui, geologist

RAPPORT VEDPØRENDE:

Molybdenite in the Ødemark Area, Hurdal.
Project Mo in the Oslo Region.

RESYMÉ:

This is a preliminary report on the geology of the Ødemark (claim) area in Hurdal. Attention is paid to the result of the drilling, the nature of mineralization, and the geochemical and geophysical work which have been done. Further investigations are proposed.

Low grade molybdenite mineralization occur in hydrothermal veins together with quartz, pyrite, magnetite and carbonate. The veins are hosted in coarse-grained syenitic rocks which is pervasively pyritized. Apart from bleaching of the syenite in certain parts of the cores, more intensive alteration of the silicate minerals have not been recognized. Mineralization is cut by younger syenite and more felsic dykes. The source rock is unknown.

FORDELING

OSLO:

- [ ] PK
- [ ] HK
- [ ] Bugge

KIRKENES:

ANDRE:

- [ ] Union

KOMMENTAR:

Content

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INTRODUCTION.

A/S Sydvaranger started exploration for molybdenum in Hurdal in the northern part of the Oslo Region in October 1979 (Fig. 1). Recognition of MoS_2-bearing boulders in the so-called Ødemark area initiated a more extensive survey in 1980 comprising : Geological mapping, soil geochemistry, and magnetic ground surveying Subsequent diamond drilling took place during the winter season 1980/81.

The target area which is heavily covered by moraine drifts and glacifluvial gravel was selected on the basis of geochemical soil anomalies and the previous findings of MoS_2-bearing boulders. The drilling (Fig. 3) indicates a rather extensive area of abundant pyrite mineralization under a 5-10 m thick cover of moraine drift. Parts of this area is underlain by low-grade Mo-mineralization. Molybdenum are mostly occurring along mm-thick veinlets together with quartz/magnetite in a reddish syenite host.

The syenite host is cut by numerous syenite porphyry dykes and rarer by aplitic, partly flow-banded felsitic dykes. The former appear to have intruded subsequent to the main phase of MoS_2-mineralization, but are clearly pyritized. The latter aplitic to felsitic dykes could be the ultimate source rock to mineralization.

The present preliminary report are dealing with the general geology of the Ødemark (claim) area and its surroundings (Fig. 2 and 3), mainly based on the work of Nystuen (1975). In addition the data from the soil geochemistry, magnetic survey, and the drilling will be presented. Finally there will be some comments and proposals on further work in this restricted area.

GENERAL GEOLOGY.

The general geology of the claim area and its surroundings may be divided in eight principal units (Fig. 2 and 3).

- VII Breccia complexes/pipes (youngest).
- VI Alkaligranite (aplitic dykes).
- V Syenite, quartz syenite, syenite porphyry, etc.
- IV Quartz-feldspar porphyry.
- III Biotitegranite.
- II Kjelsåsite (oldest Permian).
- I Precambrian blocks.

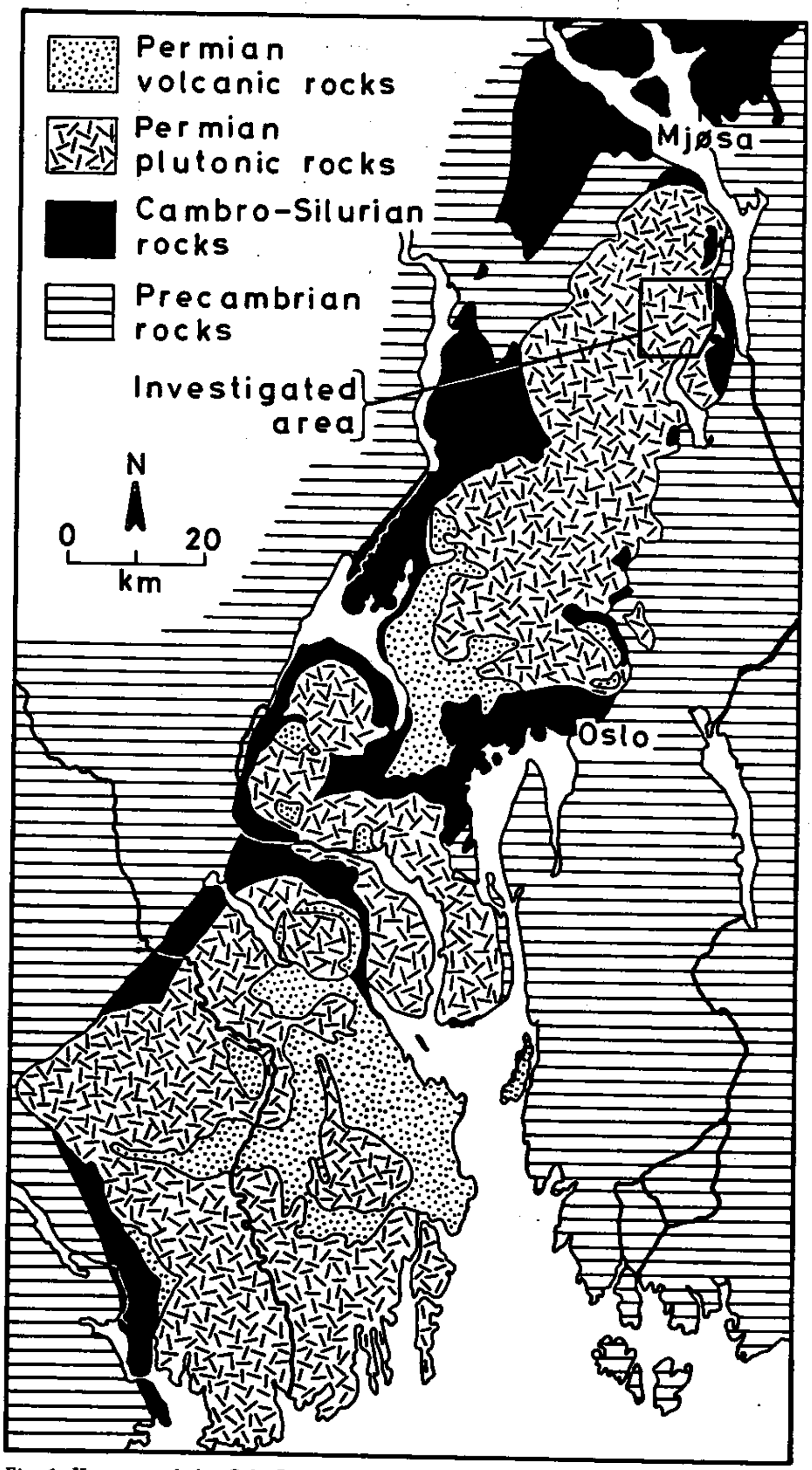


Fig. 1. Key map of the Oslo Region, simplified from Holtedahl & Dons 1960, showing the location and geological setting of the investigated area.

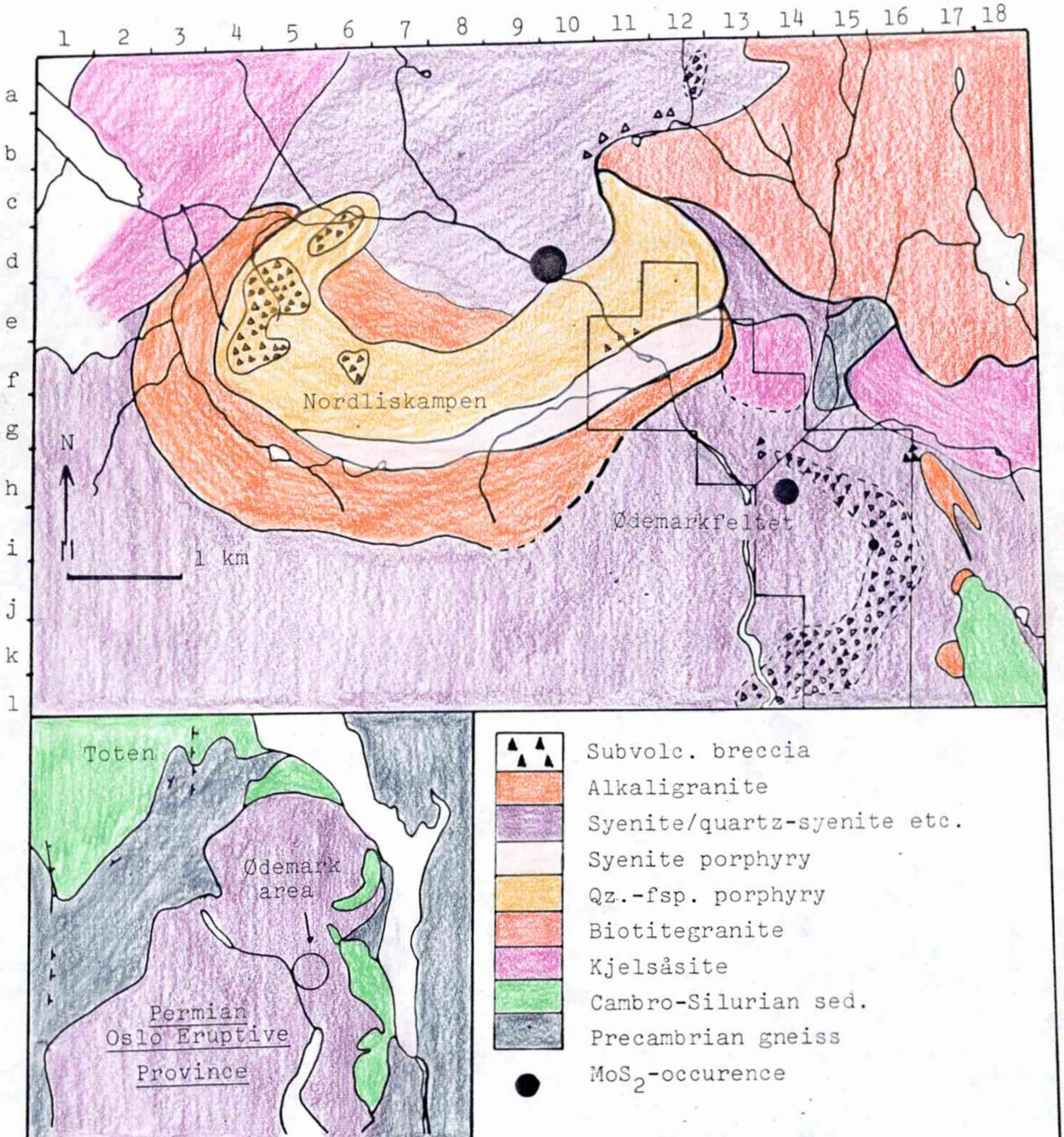


Fig. 2: Geological map of the Hurdal district with the Ødemark area (framed).
Revised after Nystuen (1975).

I. Precambrian blocks of varying size occur as frequent xenoliths within the kjelsåsite - i.e. the oldest Permian intrusion of the area. The largest of these isolated gneissous units occur along the river Steinsjøelva, between the two kjelsåsite bodies.

II. Kjelsåsite in the present area mostly corresponds to monzonite and monzodioritic rock-types.

The kjelsåsite is a light to dark grey rock, and in most of the massifs grainsize and texture vary considerably, comprising very coarse-grained facies as well as fine-grained and aplitic types. The feldspar is usually subhedral and anhedral, but plagioclase grains have rectangular outlines in some places. The plagioclase, mostly an andesine, is frequently mantled by alkali feldspar, and the ferromagnesian minerals have crystallized in the order augite, hornblende and biotite. The mafic minerals may constitute up to 30 % of the total volume.

The kjelsåsite bodies have been almost completely net-veined by all surrounding Permian rock.

Inclusions of Precambrian gneiss and Cambro-Silurian calc-silicate hornfels are especially abundant in the easternmost kjelsåsite massif (Fig. 2).

III. Biotitegranite. In the northern part of the area, a red granite forms the southern branch of a massif covering approximately 45 km^2 in the district further to the north. Within the map area (Fig. 2) the granite is mainly coarse-grained and granular, but aplitic types also occur, partly as irregular masses and partly as discrete dykes cutting the coarser-grained parent rock. Porphyric facies are also developed in the peripheral zones adjacent to older rocks. The granite corresponds petrographically to the biotite granite of the Drammen granite type further south in the Oslo Region.

The plagioclase is a zoned, acid oligoclase, usually with a turbid core and rims of microperthitic alkali feldspar. The latter feldspar also occurs as separate grains. The biotite has partly grown at the expense of hornblende.

The granite is observed to invade the adjacent kjelsåsite as numerous veins, dykes and irregular masses, thus forming an intrusion-breccia; this reaches 5-700 m in width in the area east of Høltjern (19, e-f). Inclusions of kjelsåsite in the granite are very rare north of its southern border, but they do occur within a zone at least 1 km wide in from the contact to the kjelsåsite. The xenoliths are angulare and well-defined in the marginal zones, but become more diffuse and nebulitic further into the granite.

IV. Quartz-feldspar porphyry. It is light grey or pink, and contains phenocrysts (ca. 7 %) of alkalifeldspar and quartz. The groundmass is finely crystalline, and the euhedral to subhedral phenocrysts are from 0,1 to 5 mm in diameter. In the massifs at Nordliskampen (5-6,g-f), the homogeneous porphyry rock grades into flow-banded felsites which are frequently disrupted by auto-brecciation. The flow-bands dip steeply and locally form folds and convolutions with mostly vertical fold axes.

The alkali-feldspar comprises microperthite and orthoclase and is accompanied by albite, which is predominantly of the chess-board type. Accessory minerals, including biotite, iron ore grains, zircon and apatite, never exceed 2 % of the mode in the investigated specimens.

In the Nordliskampen area the quartz-feldspar porphyry forms a ring-dyke, encompassing 270° and having a maximum width of 1200 m. The contacts are apparently subvertical. Xenoliths are practically absent, but some few inclusions of syenite, 5-50 cm in diameter, have been observed at Nordliskampen. These inclusions were probably derived from the adjacent syenite. The ring-dyke is itself cut by breccia pipes.

V. Syenite, quartz syenite, alkali-feldspar syenite and alkali-feldspar quartz syenite.

The predominant rock-type is a reddish, coarse-grained, quartz syenite which is part of a larger batholithic massif occupying extensive areas in the northern part of the Oslo Region. This rock also displays porphyric facies and may pass into syenite (with less than 5 % quartz among the leucocratic minerals), alkali-feldspar syenite and alkali-feldspar quartz syenite.

Variations in the ratios alkalifeldspar/plagioclase and total feldspar/quartz are thus considerable and the changes in composition may occur within short distances. The plagioclase, an acid oligoclase, is usually poikilitic and turbid. The microperthite may be rimmed by a thin zone of clear albite. Albite, mostly chess-board type, is abundant in the alkali-feldspar syenites and is also here a late mineral. Biotite is the dominant mafic mineral, whereas sodic amphibole and aegirine occur in rocks which are transitional to ekerite. This special type of rock has to be termed alkali syenite or alkali quartz syenite, depending on the quartz content. They correspond to normarkite according to the local terminology. The latter soda-rich rocks occur only in minor amounts in the Hurdal area.

Members of this group of plutonic rocks reveal divergent age relations to several of the other plutonic and subvolcanic rocks in the area. The body of syenite porphyry occurring within the Nordliskampen ring-dyke complex appears to be cut by the two neighbouring ring-dykes and hence could be interpreted as a screen within the plutonic structure. A dyke of syenite porphory occurs on the other hand in the quartz-feldspar porphyry in the southern slope of Garsjørøet.

Syenite, quartz syenite and alkali-feldspar quartz syenite are found to be both older and younger than the subvolcanic breccias and inclusions of alkali-feldspar syenite occur in the main quartz syenite massif in the area west of Steinsjøelva.

The extensively occurring coarse-grained quartz syenite of the massif penetrates most other rock-types, and in all places the contacts are sinuous and irregular inclusions of the country rock are common. In the northern part of the area (14,a-b), when approaching the granite contact the quartz syenite becomes increasingly porphyric and fine-grained, whereas the granite is coarse-grained right up to the border.

VI. Alkali granite. Alkali granite is red, medium- to coarse-grained rock with a homogeneous, granular texture. The alkali-feldspar granite is characterized petrographically by the absence of plagioclase (except for xenocrysts) and the presence of biotite.

Sodic amphibole occurs instead of biotite locally in the marginal zone of the body north of Rognstadkollen (9, i). This facies is thus closely related petrographically to the ekerite. The albite, including chess-board albite, is of later origin than the microperthite, filling the interstices between the larger microperthite and quartz grains.

Alkali granite has been recorded from a number of small and large bodies of varying shape and in different structural environments. The largest bodies of alkali-feldspar granite occur within the Nordliskampen ring-dyke complex. The innermost, incomplete ring-dyke has a maximum width of 500 m, and dips steeply, probably vertically. On the small-scale, the ring-dyke displays a sinuous and irregular contact against the quartz-feldspar porphyry; detached fragments of the latter, up to 50 cm across, occur within the alkali granite.

The outer ring-dyke, reaching a maximum width of 600 m, is continuously developed in an approximately 250° arc.

The alkali granite penetrates the kjelsåsite at its north-western boundary as apophyses and veins along a steep and sinuous contact surface. The massif of kjelsåsite situated at the eastern end of the ring-dyke is brecciated and partly mylonitized along the contact, but this fractured wall-rock is penetrated by the alkali granite. Along its concave side, the outer ring-dyke has intruded the syenite porphyry and carries xenoliths of this rock along a sinuous contact which dips generally outwards at 80-90°. The younger intrusion of quartz syenite on the convex side of the alkali granite appears to have only slightly modified the original shape of the ring-dyke.

VII. Breccia-complexes. The subvolcanic breccias and breccia-complexes are considered to be vertically orientated diatremes with a complicated mode of emplacement. Volcanic debris predominates among the breccia fragments, but blocks of syenite and syenite porphyry are also frequent in the largest bodies. In addition, fragments of kjelsåsite occur in the northernmost breccia, (12, a). The diatremes within the Nordliskampen ring-dyke complex have pierced through the quartz-feldspar porphyry and are enriched in fragments from this wall-rock. Abundant fragments of alkali granite occur in the breccia just to the east of the "skisenter" (16, h) adjacent to the small body of alkali granite.

THE GEOLOGY OF THE DRILLED AREA.

A total of 7 holes were drilled in the densely vegetated area to the east of the rivers Hurdalselva and Steinsjøelva (Fig. 3). The holes are between 80-150 m long and inclined either 45° NE or 45° SW to cut mineralized veinlets with an apparent preferred NW-SE, steep-dipping orientation.

The area is extensively covered by moraine drifts. One single exposure occurs between drill holes nos. 2 and 3 (close to trig. point G 33-359), showing coarse-grained red syenite. Nearest exposures showing similar rocks are found to the southwest along Hurdalselva and in some new road-cuttings to the north, close to Bekkelund. The latter exposures show strongly pyritized and rusty synenite cut by syenite porphyry dykes.

The rock types disclosed in the cores are generally the same as the one exposed in the surroundings which are described above, including (Figs. 4 and 5):

a) Syenite, quartz syenite and related hybride types.
b) Kjelsåsite blocks
c) Intrusive breccia
d) Dykes of various types

The main part of the area is underlain by the ordinary coarsegrained syenite/quartz syenite. The principal mineral constituent are sub- to anhedral, reddish K,Na- feldspars, but there are a considerable variation in content of quartz and dark silicates - the latter predominantly being biotite, and rarely a strongly pleochroitic amphibole. The quartz and biotite are usually enriched interstitially between the feldspars and are often occuring together with apatite and Fe,Ti-oxides. Rectangular aggregates of sericite probably represent altered plagioclase. Common accessories are zircon and sphene.

Hybride syenite/quartz syenite being richer in dark constituents and with frequent more or less resorbed inclusions of kjelsåsite are often recognized around the larger, floating blocks of kjelsåsite (drill holes nos. 4 and 7 B).

The breccia rock occupying the main part of drill hole no. 1 (Fig. 4) are probably a true intrusive breccia (diatreme) composed mostly

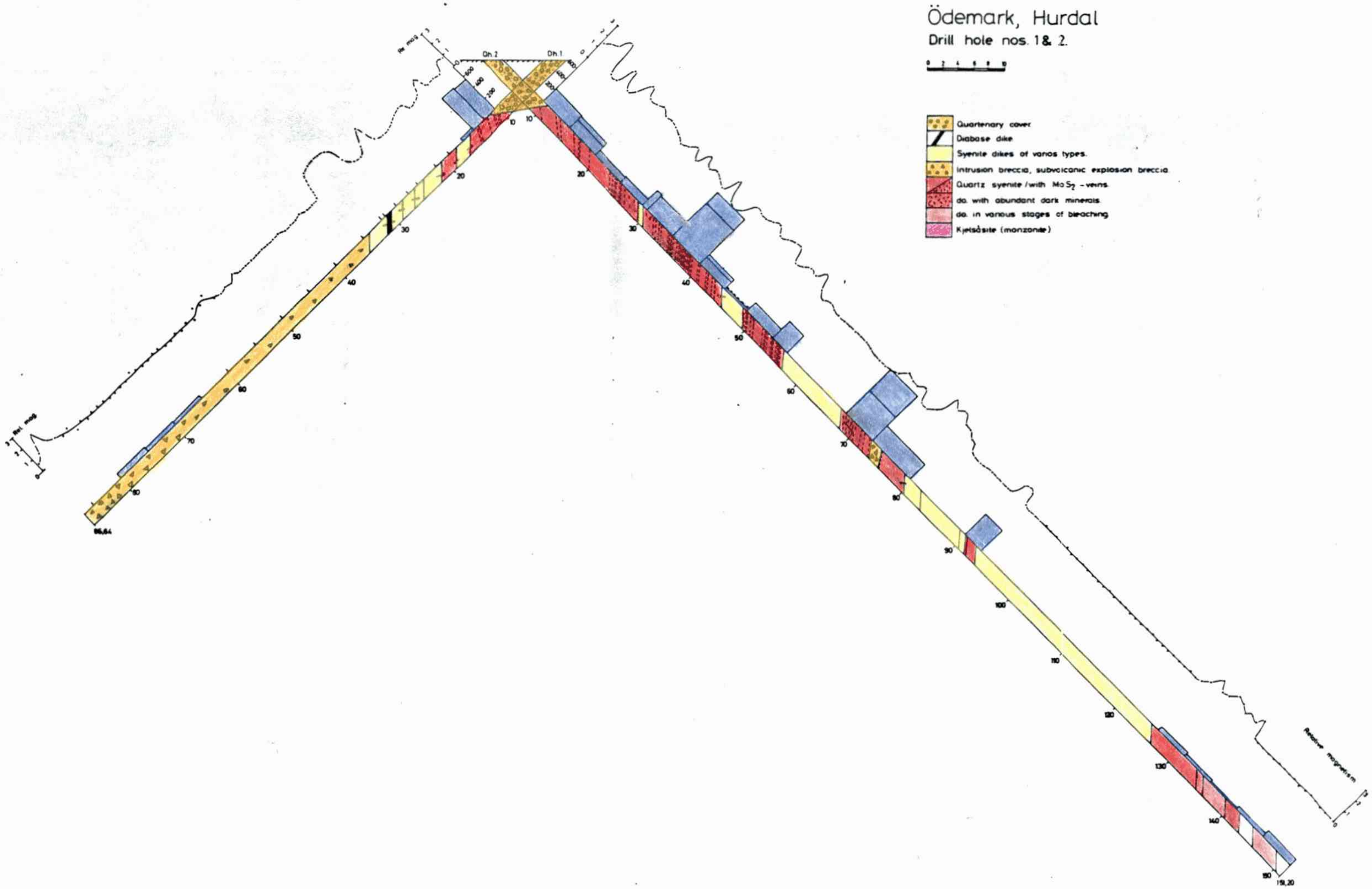

Ödemark, Hurdal
Drill hole nos. 1& 2.
Quartenary cover
Diabase dike
Syenite dikes of varios types.
Intrusion breccia, subvolcanic explosion breccia
Quartz syenite / with MoS2 - veins
do. with abundant dark minerals
do. in various stages of bleaching
Kjelsåsite (monzonite)
Dh. 2
Dh. 1
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
151,20
86,64

Fig. 4.

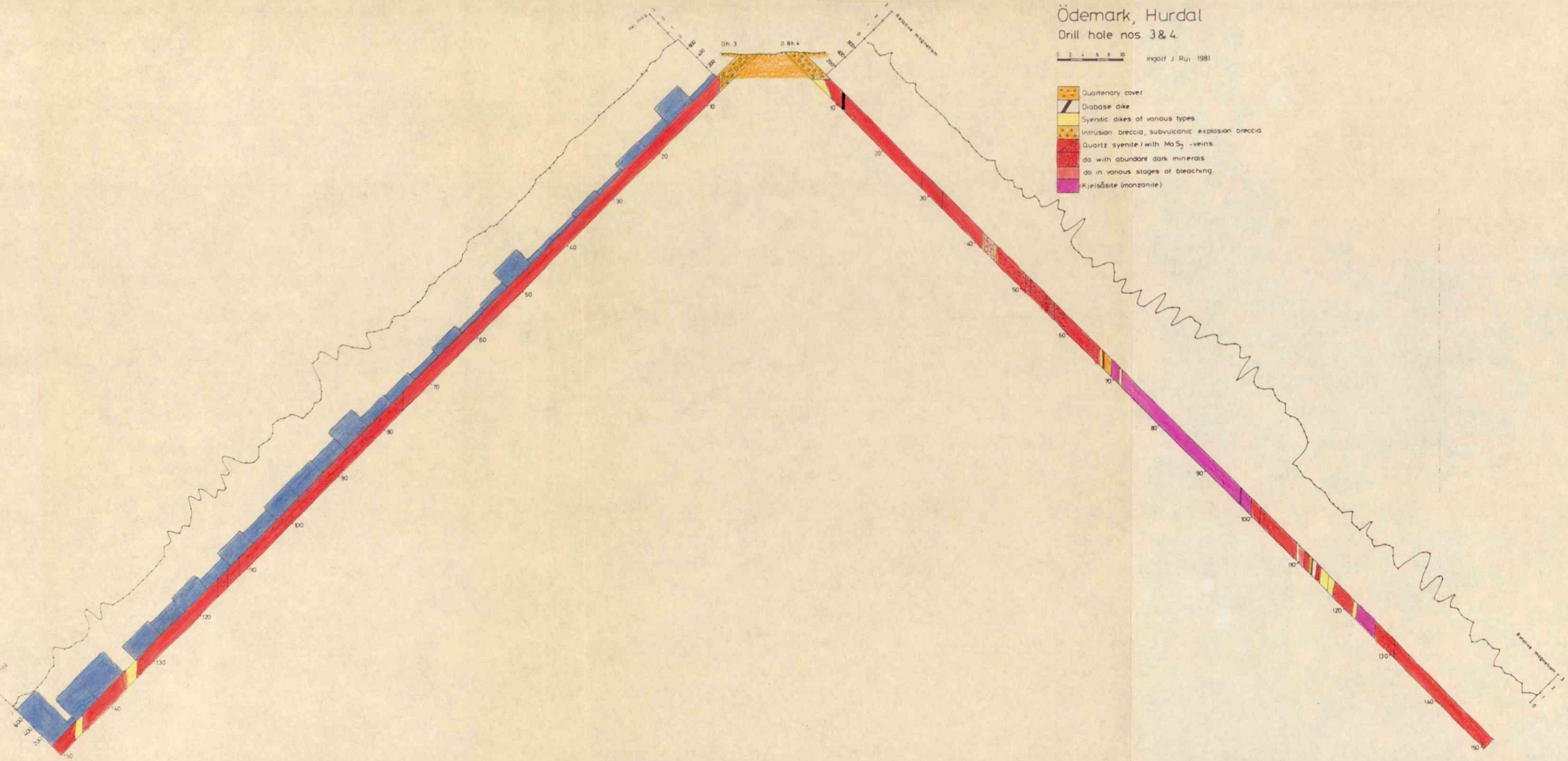

Ödemark, Hurdal
Drill hole nos. 3& 4.
0 2 4 6 8 10
Ingolf J. Rui 1981
Quartenary cover
Diabase dike
Syenitic dikes of various types
Intrusion breccia, subvulcanic explosion breccia
Quartz syenite / with MoS_2 -veins
do. with abundant dark minerals
do. in various stages of bleaching
Kjelsåsite (monzonite)
Dh 3
D.Bh.4
Relative magnetism
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

Fig. 5.

of fragmented and disintegrated syenite but also with larger inclusions of kjelsåsite, Cambro-Silurian (?) marble and hornfels and other exotic blocks.

The most common dyke rock is a syenite porphyry with zoned phenochrysts of alkali feldspar up to about 1 cm in diametre. These show different shades of colors from brownish red (fresh) through yellowish or greenish to grayish white due to alteration and bleaching.

Other dykes include red quartz-biotite syenite porphyries, brown aplitic dykes up to a few cm thick, and finally a gray, fine-grained to felsitic, partly flow-banded acidic dyke encountered in drill hole no. 7 B.

Hydrothermal minerals abundant in the system are: Pyrite, magnetite, quartz and carbonate, molybdenite, and less common fluorite.

The presence of pyrite is pervasive and it is hosted in all the above described rocks. It occurs mainly in veins and disseminated along micro-fractures.

The individual veins are usually up to about 1-2 mm thick (occationally 1-2 cm) with propable preferential subvertical NW-SE orientations. Other crossing orientations have, however, been observed - i.e. parallel to the cores, for instance.

Any of pyrite, magnetite, quartz and carbonate may occur in almost monomineralic vein-aggregates as white to bluish, fine-grained mosaic of quartz; black magnetite or brass colored pyrite. More important, however, are the polymineralic quartz veins with pyrite/magnetite/carbonate in various proportions. Carbonate is usually subordinate to the other minerals. Feldspar fragments, evidently detached from the vein walls, are also common. The latter veins are also the principal carrier of molybdenite !

The molybdenite occurs in the veins as tiny flakes, partly as radiating aggregates. The individual flakes are usually in the order of 0.05-0.15, rarely up to 0.2-0.3 mm in diametre.

Fig. 6:

Quartz-molybdenite veins in coarse syenite.
In this sample disseminated molybdenite
also occur outside veins.
Counterpart to sample shows 0,10 % Mo.

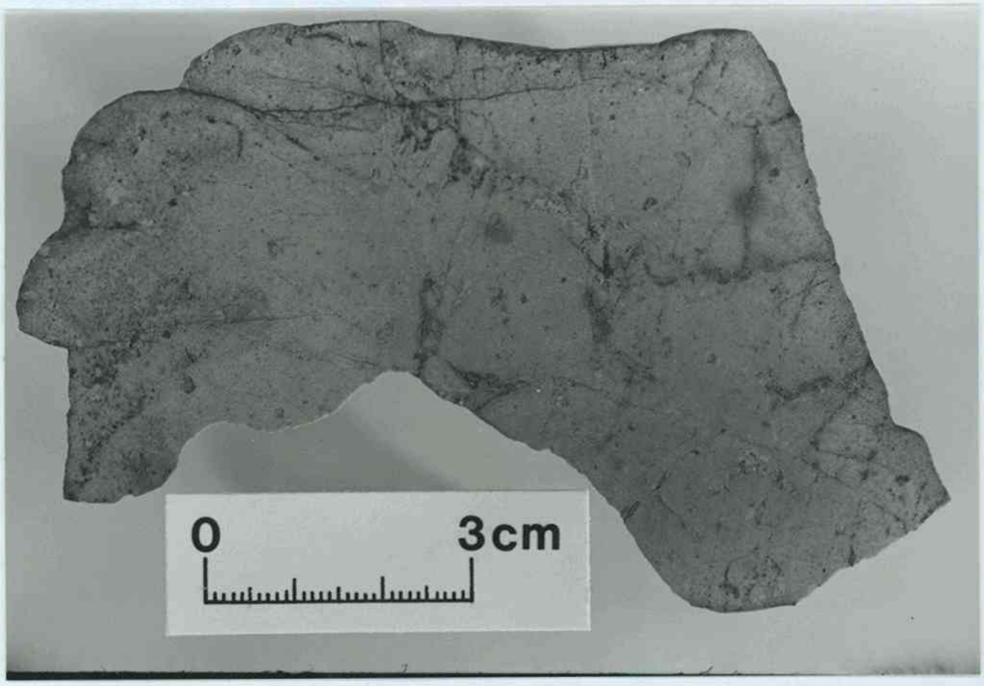


Fig. 7:

Molybdenite in stockwork.
Counterpart of sample shows 160 ppm Mo.

Fig. 8:

Quartz vein with molybdenite,
counterpart to sample shows 0,57 % Mo.

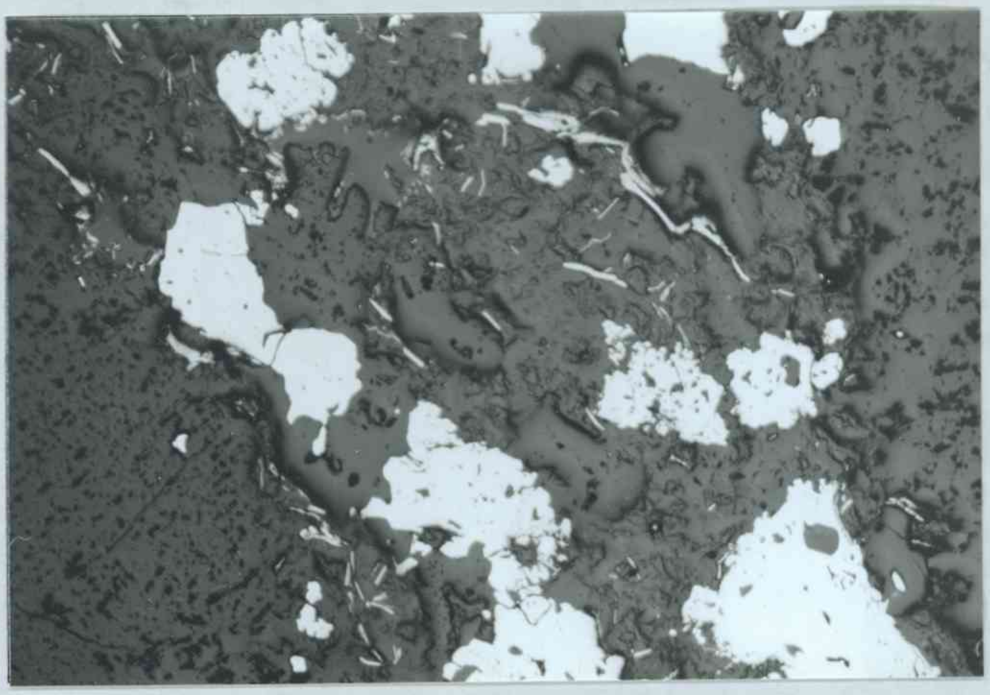


Fig. 9:

Microphoto of vein from sample shown in fig. 7.
White, flaky grains are molybdenite,
the othersare pyrite. Ca. 600 X.

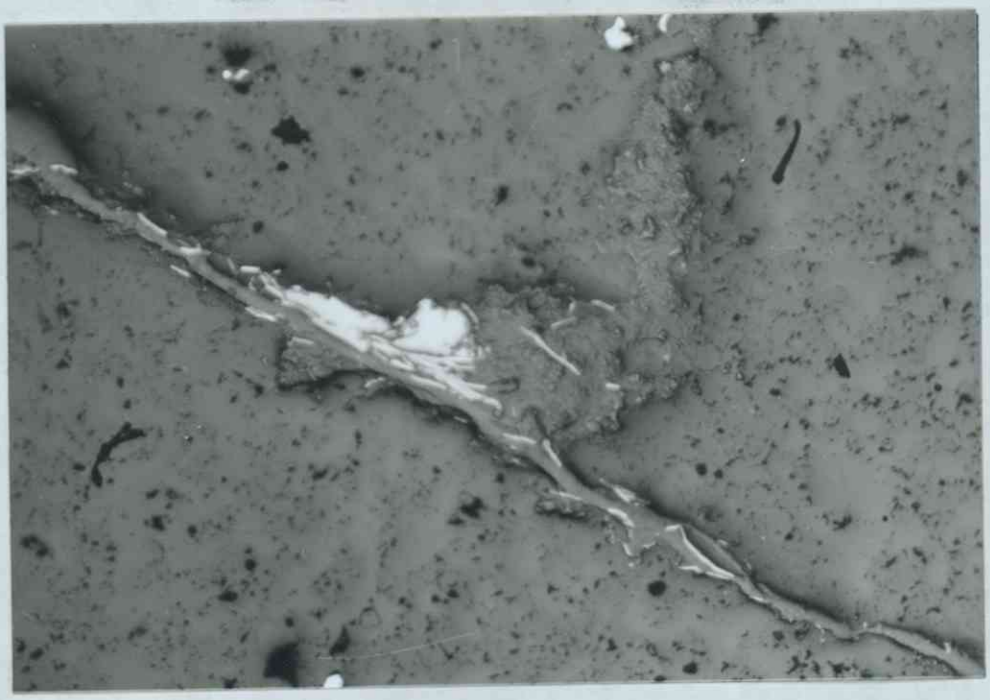


Fig. 10:

Thin veins with molybdenite.
Same sample as above. Ca. 600 X.

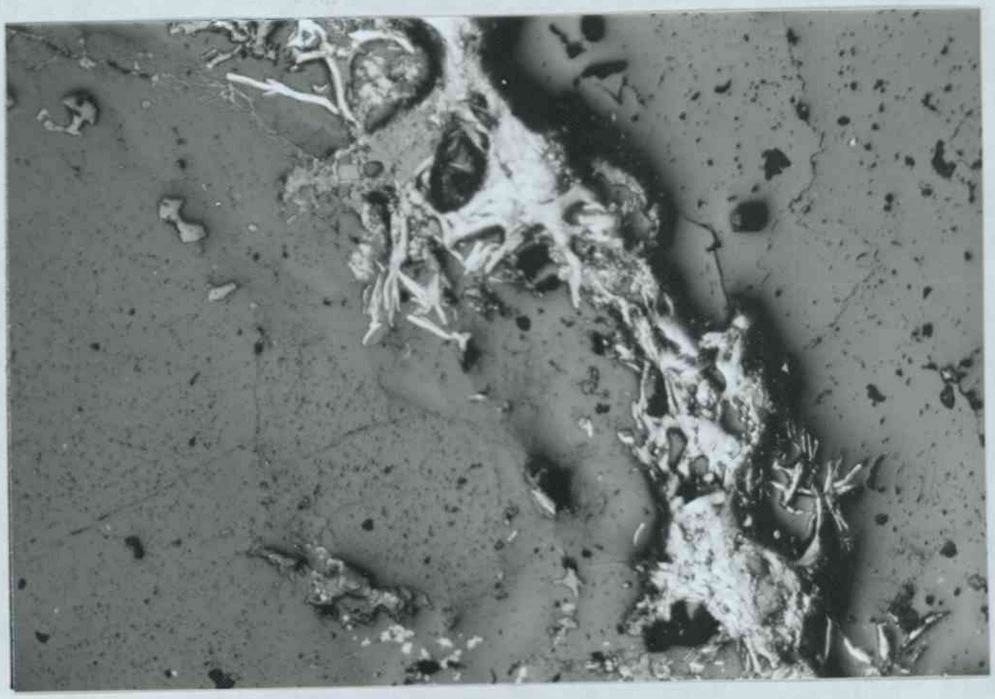


Fig. 11:

Microphoto of vein from sample shown in fig. 8.
Molybdenite is enriched along vein boundary.
Ca. 600 X.

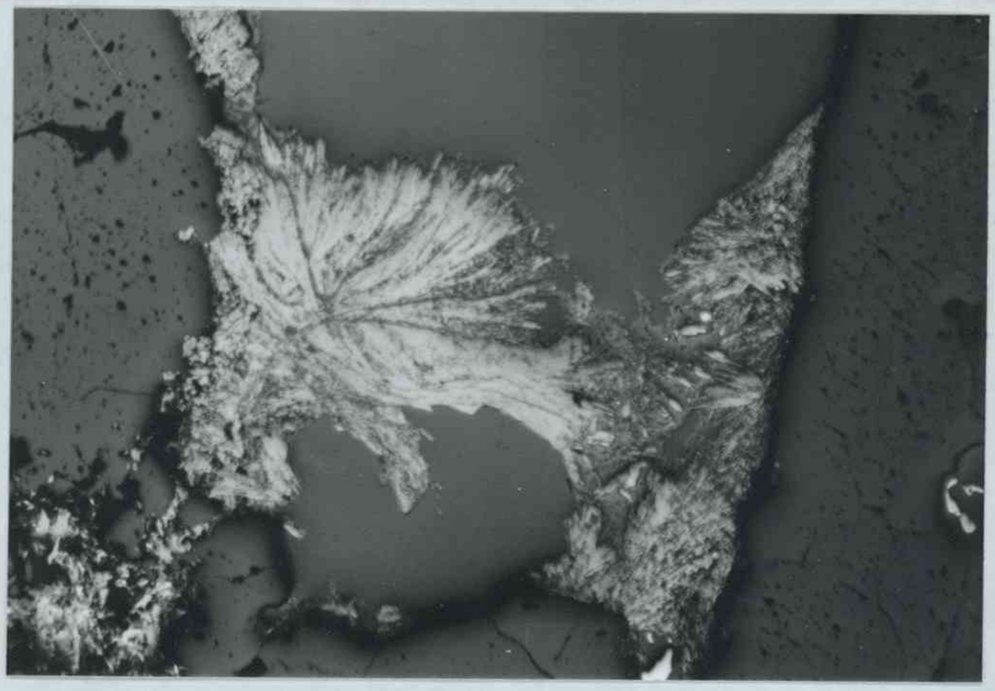


Fig. 12:

Microphoto from same sample as above showing, radiating aggregate of molybdenite in quartz. Ca. 600 X.

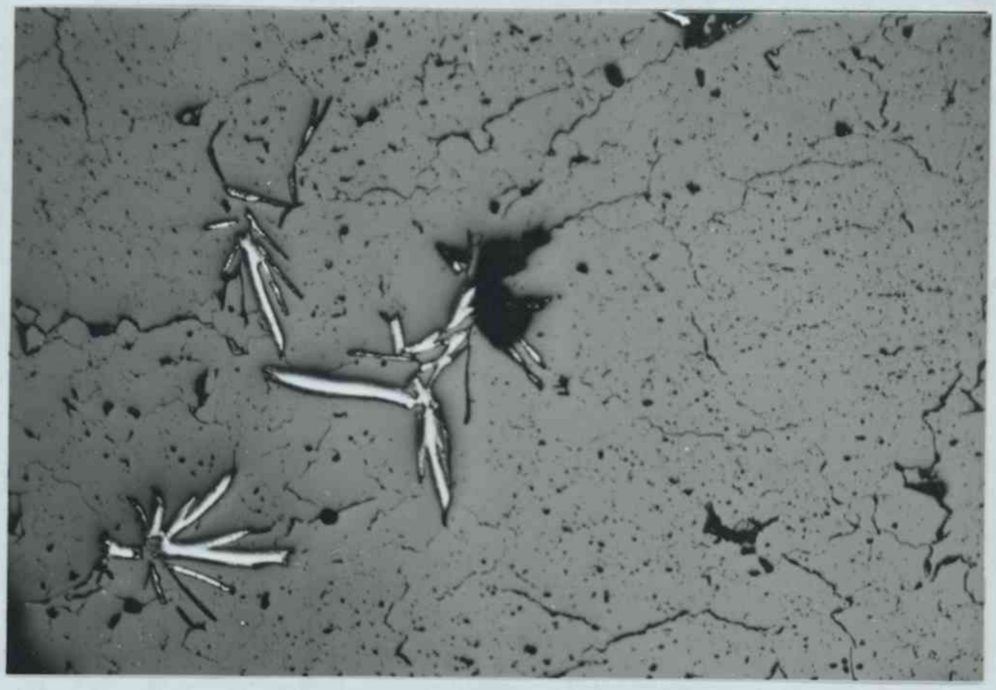


Fig. 13:

Same sample as above showing relatively large flakes of molybdenite in quartz. Ca 600 X.

Photos of cut and polished slabs of veined boulders are shown in figs 6-8, and some microphotos from the same samples are shown in figs. 9-13.

Molybdenite - bearing veins are almost exclusively hosted in the syenite/quartz syenite. This is also evident when the Mo-grades and the host rocks are compared in figs. 4 and 5. Magnetite veins are also restricted to the syenites, while pyrite veins may occur in the dykes. Carbonate-quartz veins are quite frequent and are sometimes carrying fluorite.

SOIL GEOCHEMISTRY.

Most of the claim area has been covered by geochemical soil samples in a 100x100 m grid (Fig. 14). The samples were taken by the aid of an auger drill. Sample dephts are nowhere more than 1/2 m due to the stony moraine.

Keeping in mind the thick cover in the area (Figs. 4 and 5) it is surprising to see how the 30 ppm Mo-curves apparently disclose the better part of the mineralization in drill hole nos. 1-4. In the other holes where the anomalous values are lower, the Mo-content in the cores are negligible. The only outcropping Mo-mineralization to the south of the Nedre Røsrud farm (Profile 15, sample 4 in Fig. 14) is also clearly disclosed by a soil anomaly.

Other anomalies in the area have not been tested, but there are strongly pyritized rocks to the east of the "Ski-senter" (profile 21, sample 1 and 2) and in the road-cuttings near Bekkelund (profile 23, sample 7-9). Within the elongate anomaly to the NW of Ødemarksbakken (profile 30-31) a boulder with rich Mo-mineralization has been found.

The flat farmland surrounding the Flaen farms are covered with thick glacifluvial gravel and has therefore not been sampled. This area could be of interest in light of the anomaly approaching from the N and NE.

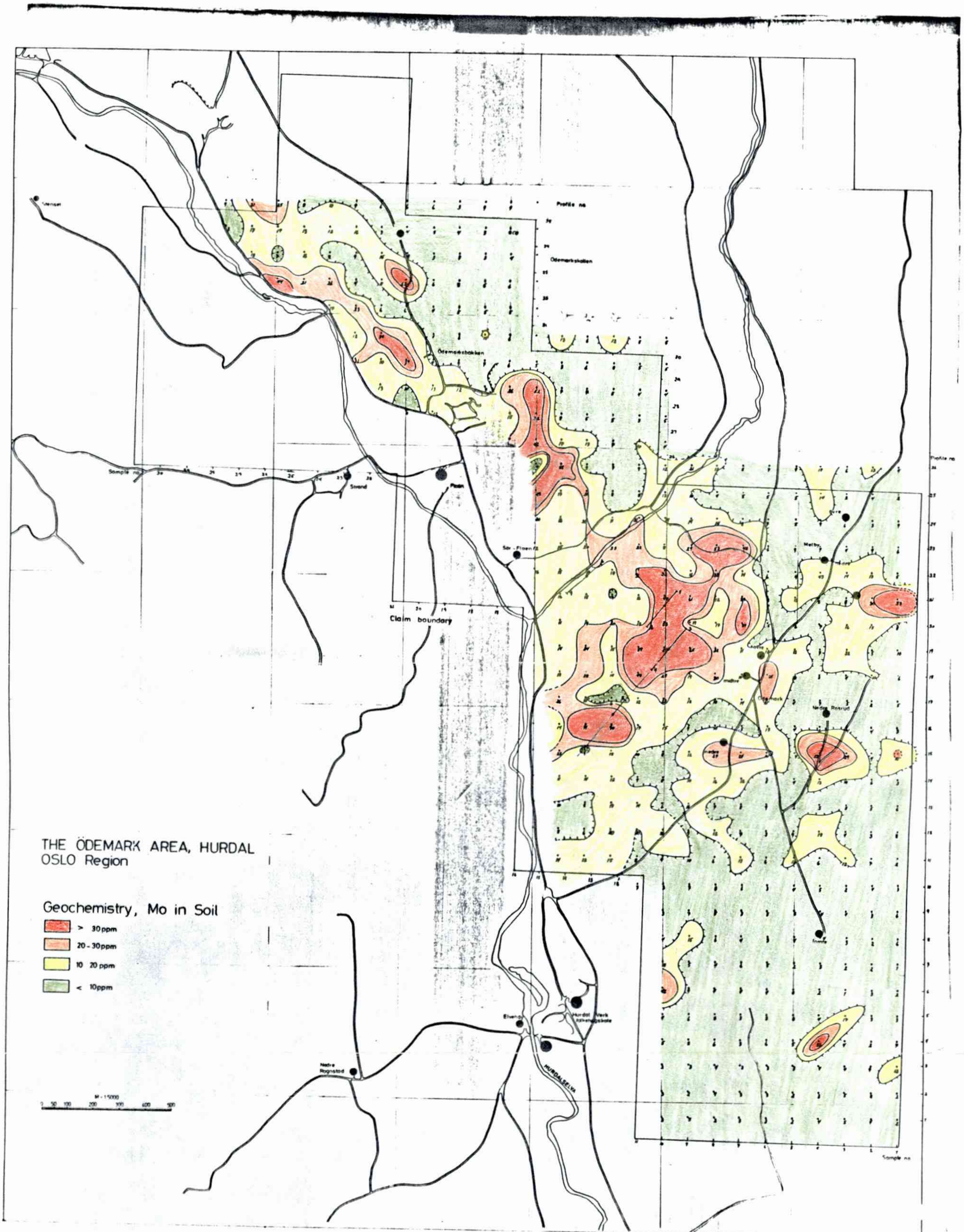

THE ÖDEMARK AREA, HURDAL
OSLO Region
Geochemistry, Mo in Soil
> 30ppm
20 - 30ppm
10 20 ppm
< 10ppm
Claim boundary
Profile no
Sample no
HURDALSELVA

Fig. 14

MAGNETIC GROUND SURVEY.

The most interesting part of the area in question has been surveyed by ground magnetic measurements (Fig. 15). A GM magnetometer was used.

The higher magnetic anomalies in the N and NE are evidently due to the Kjelsåsite which usually contains appreciable dark constituents including Fe/Ti-oxides.

The ordinary syenite in the southern part of the area shows a relatively low and even magnetic pattern. The surroundings of the drill sites where mineralization are known to occur shows, however, irregular high and low values. This is probably caused by:
1) Irregular distribution of vein magnetite and 2) Larger floating blocks of kjelsåsite.

Otherwise there appear to be a general good correspondance between the soil geochemistry and the magnetics in the area indicating a more widespread distribution of magnetite together with sulfides. This is in good accordance with the theory and experimental results of Kullerud. He has shown that sulfurization and extraction of iron from rocks and minerals with the formation of pyrite are accompanied by magnetite as an inevitable reaction product.

In the claim area there are two roughly circular fields showing magnetic lows surrounded by irregular magnetic highs - i.e. to the N and E of the drill sites and the flat farmlands around Flaen. The bedrocks are in both places hidden by extremely thick cover. The soil in the surroundings is also anomalous high in Mo. These two fields may represent hydrothermal centers which are worth closer examination. The magnetic lows in the centers may represent the most strongly leached portion of a system where original magnetic minerals have been destructed. The surrounding, irregular magnetic highs may, thus, represent roughly circular haloes where magnetite has been deposited.

SUMMARY AND CONCLUSIONS.

Drillings in the Ødemark area, Hurdal have shown that sulfide-mineralization with Mo are hosted in coarse-grained syenitic rocks.

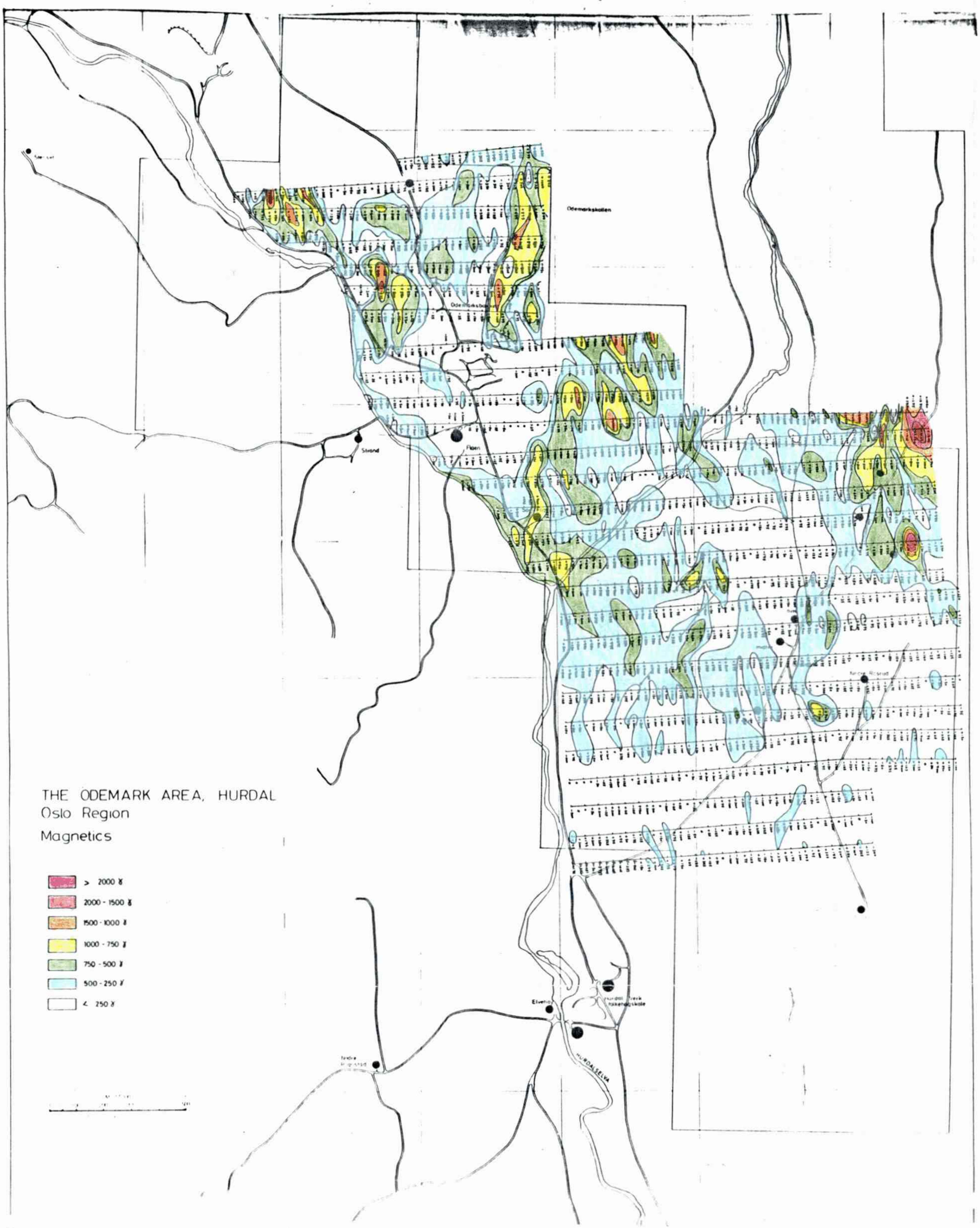

THE ODEMARK AREA, HURDAL
Oslo Region
Magnetics
> 2000 γ
2000 - 1500 γ
1500 - 1000 γ
1000 - 750 γ
750 - 500 γ
500 - 250 γ
< 250 γ

Fig. /5

So far no other metals than Mo which could be of economic interest have been found.

Molybdenite occurs in hydrothermal veins, usually about 1-2 mm thick, together with quartz, pyrite, magnetite, and usually some carbonate.

Apart from bleaching in certain portions of the cores, no extensive and pervasive alteration of the rockforming silicates have been disclosed. Wide areas of pervasive pyritization have, however, affected extensive volumes of rocks at least 1x1 km in surface extension. This proves that a large hydrothermal system was active. This system was most probably contemporaneous and connected with the system which was activ in the Hydro area, some 3 km to the NW.

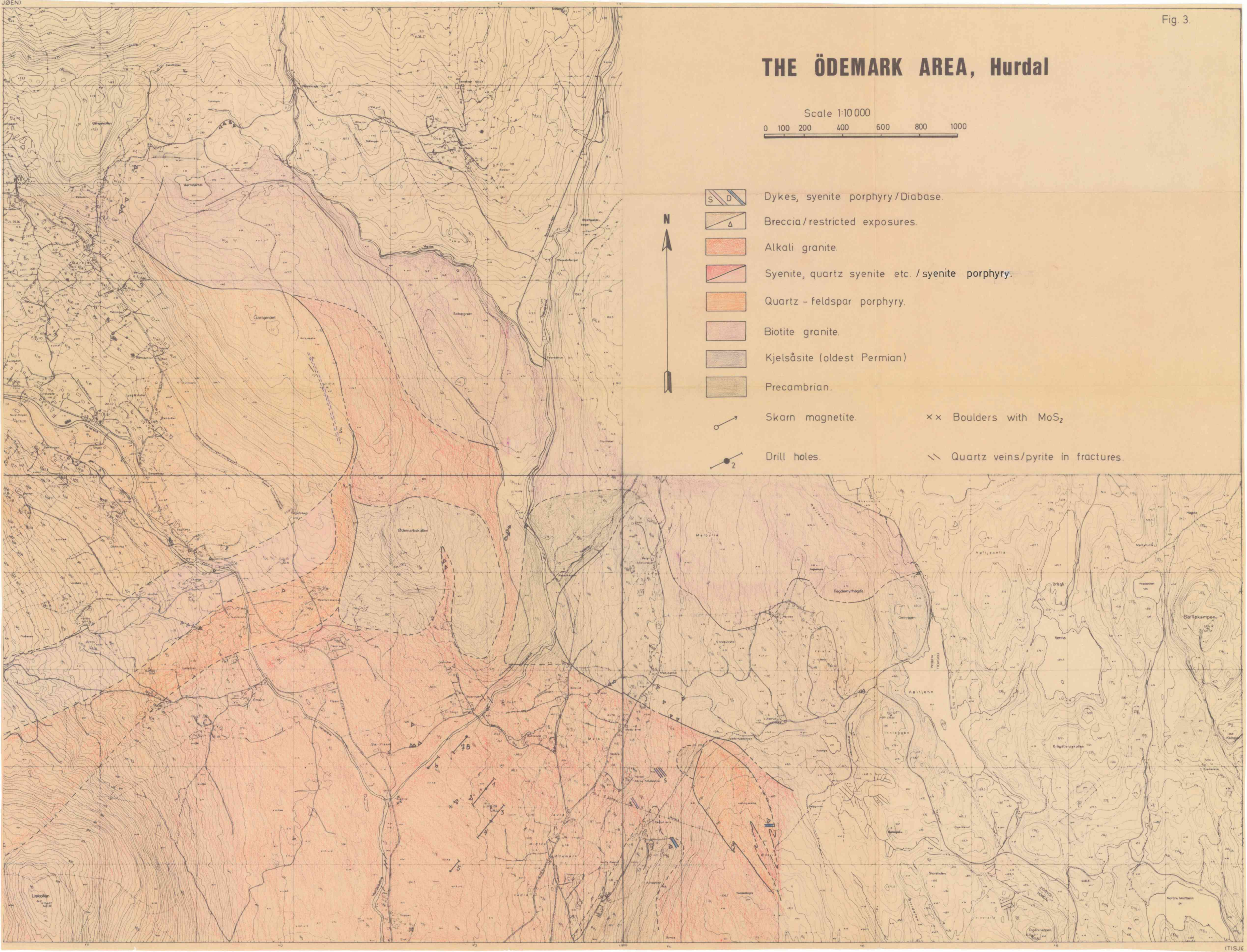
At the moment there is no conclusive prove of the complete intrusion history of the area, neither the source of the hydrothermal system. It might be the quartz-feldspar porphyry, phases of the alkali granite, or the felsic dykes seen in the cores. The intrusive breccias (diatremes) may be related to some late stages of the mineralizing events.

The next steps in the exploration should be aimed at:

1. Limit the suboutcrop entension of known low grade mineralization recognized in existing drill holes.

2. Look for possible hydrothermal centers in the two magnetic low areas to the N and E of the drill sites and in the surroundings of Flaen farms.

This steps should be carried out during 1982, aided by geophysical IP-measurements and subsequent drilling.


THE ÖDEMARK AREA, Hurdal
Scale 1:10 000
0 100 200 400 600 800 1000
N
S D
Dykes, syenite porphyry / Diabase.
Breccia / restricted exposures.
Alkali granite.
Syenite, quartz syenite etc. / syenite porphyry.
Quartz - feldspar porphyry.
Biotite granite.
Kjelsåsite (oldest Permian)
Precambrian.
Skarn magnetite.
×× Boulders with MoS_2
Drill holes.
Quartz veins/pyrite in fractures.
Fig. 3.