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Geplogical Report of the area of Rauvatnet

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Geological Report

of the area

of

RAUVATNET

(Sheet Nevernes , No.2027 IV)

P.H.BEEKMAN

MO-I-RANA, Sep.1966

1. Introduction

The fieldwork was carried out during the summerseason from 21/6 till 3/9/66, for Bleikvassli Gruber A/S in Mo-I-RANA.

The area is located circa 20 km east from Mo and includes the eastern Mo-fjell, the Reinfjell and a small part of the Röd-fjell.

It can be reached by the road to Umbukta.

The main purpose of the work was to make a geological map of an area in which geochemical Cu-anomalies were discovered recently.

The geological investigations extend over an area of circa 12x7 km.

Studies of air-photos resulted in the structural map. A sample-map was made of the most important Cu-anomaly (No.4).

2. Geology and Petrography

The regional metamorphic rocks have metamorphosed in the garnet-amphibolite facies for the greater part.

They can be classified into three groups:

1. Garnet-mica-gneisses (partly pyrite-bearing)
2. Amphibolites
3. Mica-schists (partly with calcite and/or limestone/dolomite bands)

The succession is from old to young, as can be observed rather well on the central parts of the Reinfjell. From its summit, which is the gneissic core of the anticline of the Reinfjell, to the north, first an amphibolite zone is traversed and still lower the mica-schists with limestone/dolomite bands and lenses can be seen. In this direction' in view of the dip of the schistosity, we enter in higher stratigraphic units, as the north limb of the anticline is normal. (See: Tectonics).

South of the Reinfjell the mica schists with the intercalated limestone- and dolomite bands are not developed in this area. This can be explained by lateral facies change so that the calc-mica schists change to more quartz-fedspar rich sediments towards the south. Here, Bjõrndalen has been mainly built up of gneisses and migmatites. The pyrite-bearing gneisses are not so important as in the Reinfjell area and are narrow scattered zones between the gneisses(with the red garnet and biotite and/or muscovite). The migmatitic character of many gneissic rocks is probably due to a process of differentiation during the regional metamorphism of the rock complex.

On the Reinfjell gradual transitions from gneiss to more schistose zones with muscovite ,calcite or/and graphite is common, probably due to variations in metamorphism-degree, caused by original rock composition. So, for instance, intercalated graphite schists and calc-mica-schists occur here and there, intercalated in the gneiss, indicating to a variation in lithology and to a variable resistance to metamorphism.

A distinction has been made on the map between the pyrite-bearing and ore-free gneisses. In both garnet, biotite, muscovite, quartz and feldspar occur, but in the pyrite-gneisses we find also pyrite and chlorite as common constituents. Also they show, except on the fresh surface, brown (limonite), red(goethiet?) and yellow(sulphur) weathering surfaces, giving typical weathering surfaces and pulverizing of the rock. This can be seen on an extensive scale on the Rödfjell -summit and its marked south-scarp, north-east of Rauvatnet. The pyrite-bearing, brown coloured gneisses are also common in the northern slope of the Mo-fjell. This zone is splitting up towards the east, near Utsikten, in two separate zones,which continue on the northern and southern flanks of the Reinfjell. The strongly coloured rock show finely dipersed tiny pyrite cubes and -grains.The ore is secundary weathered into limonite,sulphur,etc.The garnet also is often changed into limonite grains.The biotite changes into chlorite,which on its turn can be converted into muscovite flakes. The rock composition ,probably leads to easy and thorough desintegration by such processes as chloritization and limonitization.

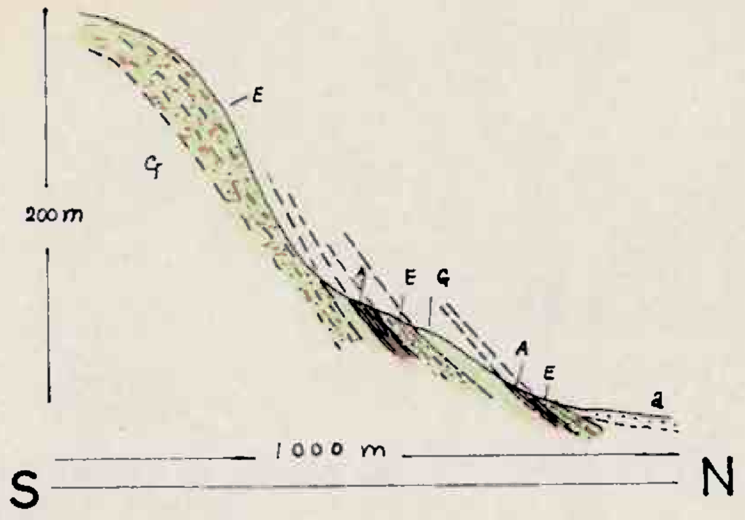
The feldspar-quartz lenses ,the garnet and the pyritegrains form more resistant bands than the biotite-chlorite-muscovite-pyrite-limonite bands. Pyrite is the only ore mineral found in these gneisses,besides traces of Zn and Cu,as can be stated from the analyses of the Mosgruben-mine ore(see Economic Geology).The dipesed pyrite may here and there concentrate in massive ore-bodies(Mosgruben).

A striking feature is the association of these ore-bearing zones in the gneiss with the commonly long(till 5 km) and thin(some meters till 50 m) amphibolite bands,which run concordantly with the schistosity of the gneisscomplex.These amphibolite bands are generally understood as former basic tuff layers or deposits.Their boundaries must coincide therefore with the general bedding plane or plane of deposition.The dark green hornblende is the main constituent of the bands.In shearzones biotite-chlorite concentrations occur(17) or the amphibolite show pyrite-bearing zones(32) as can be seen in the description of section 2,below.

The amphibolite bands below Utsikten are responsible for the ore-bearing gneiss zone in this area(see section 1).Outcrops in the waterfall tract and along the hairpin road were a great help in making the situation clear,as the fjell-slope is heavily vegetated here.

The pyrite-bearing zone on the southern flank of the Reinfjell is associ-

SECTION 1 Tveraaen waterfall



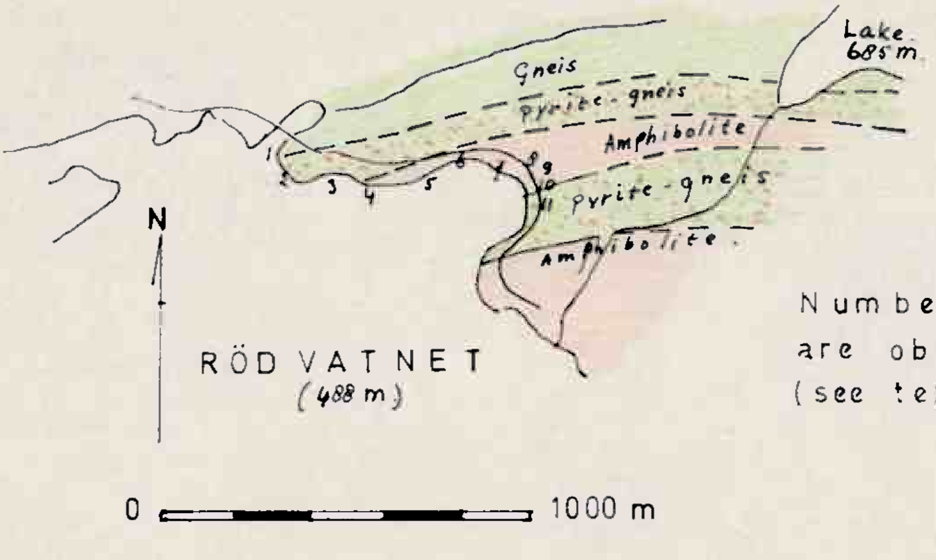
A = Amphibolite

a = Alluvium

E = Pyrite bearing gneiss

G = Garnet mica gneiss

SECTION 2 (along „svenske veien")



Numbers are observation points (see text)

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ated with some three or four amphibolite bands, running parallel with the schistosity and with the east-west folding axes. On one of the bands Øvre Reinfjeldet is situated and parts of this band outcrop in exposures on the roadside short east and west of this settlement.
The other bands here are ,e.g. crossing the transportroad to the Mosgruben-mineor are cut off by the mainroad towards Utsikten.
Also on top of the Mofjell an amphibolite band could be traced over a short distance, probably wedging out in the strike by tectonic squeesing. With this amphibolite(636 m top) an ore bearing gneiss zone is associated, which concentration of the pyrite (two work-pits were made here).
Also the amphibolitebands on the Reinfjell may be thinning out or splitting up in still thinner streaks on some places(e.g. the thick amphibolite band 1 km north of Rauvatnet is quickly thinning out towards the Rødfjell, but returnes in a small lens in the same strike north-east of the fjell summit. This wedging out is ascribed to differential movement and squeezing out of the band. One of the amphibolitebands at Øvre Reinfjell shows from east to west between the mine-road and the Umbukta-road a splitting up into thin streaks as can be seen at a roadoutcrop in the road bend west of the settlement.
The following rock discription is from a section along the road from N-S through the thick amphibolite band ,1 km north of Rauvatnet:(Section 2)
1. Garnet-mica-gneiss, bordering the amphibolite band to the north with a steep northern dip(70°N).
The gneiss becomes more chloritic towards the amphibolite with the same dip and strike. The chlorite sometimes is segregated in streaks and bended lamellae(sample 14). In the chlorite the pyritegrains are abundant but finely dispersed, while limonitization occurs(pit on the road-verge).

The gneiss has a kind of "Augengneiss" texture:white feldspar-quartz-rich zones around the red garnet or garnet-clusters proceeded from the growth of the latter mineral.The almandine garnet was formed at the cost of the immediate surrounding dark minerals in a certain metamorphic facies Here also an intensive isoclinal folding can be seen and the migrated quartz has concentrated into "pressure-shadows",as the hinges of these folds.

Streaks of biotite-chlorite-pyrite-garnet separate more feldspar-quartz rich streaks,which contain some biotite and garnet.Limonitization occurs in some of the mentioned minerals,as the pyrite,causing a rusty aspect.

3.Quartz-feldspar-bands are impregnated by limonite,supplied by the biotite and chlorite.

4.Mica and pyrite are finely dispersed in the gneiss.No garnet.Biotite and quartz-feldspar lenses,1 m thick zone.(15)

5.Increase of quartz-feldspar in quantity as well as in thickness.The garnet is well developed again in this zone.

6.Thin concordant with the schistosity running amphibolite bands and streaks of some cms thick with red garnet.These amphibolite bands are splitting up in thin lamellae ,which often change in a chloritic composition,by the alteration of the amphibole.The quartz-feldspar lenses contain often brown calcite.

7.Thick coarse grained and discordant feldspar-quartz-mica veins in the gneiss and amphibolite.

8.The amphibolite forms the major rock component.An amphibolite zone(16) with pyrite finely dispersed and in thin lamellae(32).Isoclinal folding with the quartz migrated in hinges of folds.The dip is variable between 40° and 70° North.Alternation of strong folding and straight layers suggests strong differential movements in the amphibolite.

9. Ptygmatic veins are abundant. Sideway disruption of a small gneiss band over some cms and vague "boudinage" structure can be seen in this gneiss.

10. Thin chlorite-biotite zones, probably reflecting former shear zones, in which the amphibolite locally altered into the mentioned minerals by a process of retrogressive metamorphism(17). In a 4 meters thick zone the amphibolite is pyrite-bearing. Finely dispersed pyrite or in thin lamellae, (18,32).

11. The garnet-mica gneiss again is represented, alternating in thin bands with amphibolite. Differential movements in the rockscaused a migmatic appearance. Isoclinal folding border to straight unfolded layers, alternating irregularly. The wedging out of the two rock types is also irregularly. Quartz segregations in "pressure-shadows" as the hinges of the folds here. The schistosity is dipping north (40-70°N).

Section F-F'

From a small mining pit("Thermos",420) towards the Rödfjell, the following rock types were found, perpendicular to the strike:

1. Pyrite-bearing gneiss, in which pyrite-concentrations in a certain zone to massive small lenses, concordant the schistosity(some small trenches and "Thermos"-pit)(22).

2. A small amphibolite band.

3. Fine grained mica gneiss, partly schistose with abundant muscovite and a brown weathering(limonitization).

4. Garnet biotite gneiss with limonitization of its dark minerals

5. Thin amphibolite bands and biotite rich zones in this gneiss. One of the amphibolite bands is associated with a pyrite bearing gneiss with intensive brown and yellow weathering colours. Sample (10) is a hornblende-schist occurring in the amphibolite band, with biotite and small garnets.

6.Chlorite-muscovite gneiss with calcite,forming conspicuous broad,hard almost white banks in the general strike of the rock complex.Plastic folding is common.No pyrite.The zone is about 20-30 m wide.

7.Garnet bearing calcareous mica gneiss with thin pyrite bearing zones of some meters wide .

8.A thin zone of garnet mica gneiss,with irregular concentraions of biotite in bands.

9.Calcareous muscovite-chlorite schist with biotite.The latter is limonitized and therefore the schist has a brown colour.

10.Weathered gneisses with moderate pyrite which are intercalated in these schists.

11.Calcite-chlorite-muscovite gneiss with harder bands of garnet-mica gneiss and microfolding conspicuous by the pronounced hard quartz-feldsparstreaks in the gneiss.

12.Pyrite-bearing gneiss with local enrichment in a small sheet ,This ore has been mined in a small pit.Abundant red,yellow and brown colours.

13.A broad zone of white garnet mica gneiss along the northern lake-shore.

14.Garnet-biotite gneiss and biotite-gneiss with pyrite impregnations on the southern shore of the fjell-lake with a to the east rapidly outwedging of an amphibolite band(the same which forms the road outcrop 1 km north of Rauvatnet).This pyrite bearing gneiss occupies the whole high fjell-area south of the lake and has very conspicuous red and brown colours. The gneiss is partly chlorite rich as in the great escarpment N.E.of Rauvatnet(12).

3.Tectonics

Different folding phases can be distinguished:

1.Isoclinal folding on a small scale(some cms-some m.)

2.Macrofolding by a compressional stress in a NNW-SSE direction.

3.Macrofolding with a compressional stress acting in a NE-SW direction.

Ad.1)

The intensive folding,observed in the whole rock complex,has contributed to the schistosity of the gneisses and amphibolite bands.
This small scale folding shoul not be considered as a mere intensive bending by compression.Such bending would destroy ,for instance,the long,straight and relatively thin amphibolite bands,running parallel the schistosity(till a length of about 5 kilometer and a width of some meter). The folds,therefore,may be better explained as the result of cleavage-foldingor a combination of this and a process of flow,as the elastic properties of the rockmass start to loose their influence and become viscous.The cleavage-planes run in the schistosity-plane.They must be considered ascthe places of intensive close-spaced differential movements and evidently are running about parallel with the outer borders of the amphibolite bands(that is the deposition plane of these metamorphosed basic tufflayers),wich are not much discontorted by the intensive folding.These differential movements can be studied in the fresh road-outcrops 1 km north of Rauvatnet and also in a road-outcrop 1½ km south of this settlement.Irregular foldingpatterns alternate closely with straight layers,which only can be explained by these differential movements These folding phase is considered contemporaneous with the general metamorphism and differentiation(segregation-)processes in the rocks.

Ad.2)(See Profiles A,B,C,D,E)

Macrofolding in a later stage by compression in a NNW-SSE direction, caused the more or less parallel axes of the Reinfjell anticline in the north and the Mo-fjell-Rödfjell anticline in the south of the area. Just beyond the south-boundary of the map the Sloikvold-Snauryggen synclinal runs also in the same trend ,but turns sharply to the S-E in the Tvervatnet area.This syncline is a normal wide structure in the Sloikvold area,but merges into a compressed and overturned structure in the Tvervatnet area and Snauryggen,the axial plane dipping ca.40° N. Still further south,but not detailed investigated,the anticlinal axes of the Stangfjell runs in about the same direction,with a sharp plunge in the Umskar area,where the plunge seems almost vertical.

North of the Tvervatnet area the incumbent Rödfjell anticline is somewhat thrusted upon the Tvervatnet syncline with the thrustplane of a ca.40° N.dipping,probably represented by the road outcrop,1½ km south of Rauvatnet.This incumbent structure turns to the west into the normal wide anticline of the Mofjell.The Björndalen is the transition area between the two anticlinal forms just mentioned.The anticline is still overturned to the south here.

The Reinfjell anticline shows also an gradually increase of the intensity of folding from west-east,as the anticline gradually becomes overturned and more compressed.To the west this anticline is flattening and merges into a flexure and eventually in the north limb of the Mo-fjell anticline.Also the Reinfjell syncline turns from a highly compressed structure in the east(between Rein-and Rödfjell)into a shallow form and eventually into a monocline in the west.The axial plunge of the Reinfjell anticline is to the west,whereas the plunge of the Reinfjell syncline is to the east.The Mofjell axes plunges east and west from a structural culmination point,which lies close to ~~to~~ the topographic culmination. The Rödvand forms a structural depression,as does the Tvervand.The Rödfjell anticlinal axes plunges westward.The amount of the plunge in all cases is not more than ca.20°.An exception forms the stark plunge of the Stangfjell anticlinal axes in the Umskar area,and Klubben. This area however is not sufficient investigated yet.

In the thrust-zone of the incumbent Rodfjell anticline,of which a part is exposed over 50 m. in a road outcrop,1½ km south of Rauvatnet,there are highly distorted,folded and faultet amphibolite,quartz-feldspar rock lenses and a strongly pyritised gneiss zone as an intercalation in the amphibolite. The outcrop show a close identity to the zone of differential movement 1 km north of Rauvatnet-settlement with also mainly amphibolitic rocks. However,unsufficient examination of the area east of the present one, makes it not certain if the two zones are stratigraphically the same,as the profile A suggests,but it seems not improbable.

Ad.3

The plunging axes form structural culminations and depressions ,which suggests another folding approximately perpendicular to the first,with a compressional force in a NE-SW direction.A certain interference of the t two folding stages can be deduced probably from the deviation of the ENE-WSW axes into a more E-W direction(e.g.Mo fjell anticlinal axes),(De Sitter, p.314-317).Also the general bending of the axes in a south-east direction more to the east can be ascribed to this folding stage probably.

The wrench- and thrust-faulting,shown by the structural map,drawn from aerial photos ,are also possible effects of this compressional stress. In the Fuglen area parts of the north limb of the Reinfjell anticline seem to have been distorted,becoming reversed(with a southward dip) by this folding.

As a consequence the mapped amphibolitebands in the hairpin road area (Utsikten) will have a more complicated continuation to the east,than is indicated on the map.The direction was deduced from scattered creek-outcrops in a heavy vegetation area.This makes it difficulty to check the trends accurately here.

4. Economic Geology

In the area the pyrite ore is dispersed in some zones of the garnet-mica gneiss and in the amphibolite bands. On some places the pyrite have segregated in coarsegrained massive ore-bodies(Mosgruben-423, Thermos-420, Areens-423, Bertelberg-426, Selaaen-425 , and still smaller pits, e.g. on the Reinfjell) . All the pits in the area have been abandoned. The Mosgruben mine, at the south flank of the Reinfjell is the most important of them all. The pyrite here is coarse grained(½-1 cm) and forms massive layer, concordant the schistosity and at the foot of an amphibolite band. The dip is about 70° North. The remnant ore is 1 meter thick and probably not longer than 1 or 2 m. The pyrite (24) is the main ore. For S, Cu, Zn and SiO2 are given resp. 49%, 0.2%, 1% and 1½%. As in traces, (N.G.U. Bergarkivet Rapport, No.1134). The ore-body was 150-200 m long and 2-5 m wide, according to this report.

On the Mofjell(Bertelberg, Selaaen) smaller workpits were made and here the ore must have been of less importance than at Mosgruben, so far as the dimensions are concerned. Some piles of ore-rock outside the mine say something of the composition and size of the orebody(25, 26). In the mine itself very little ore was left, in the gneissic country rock.

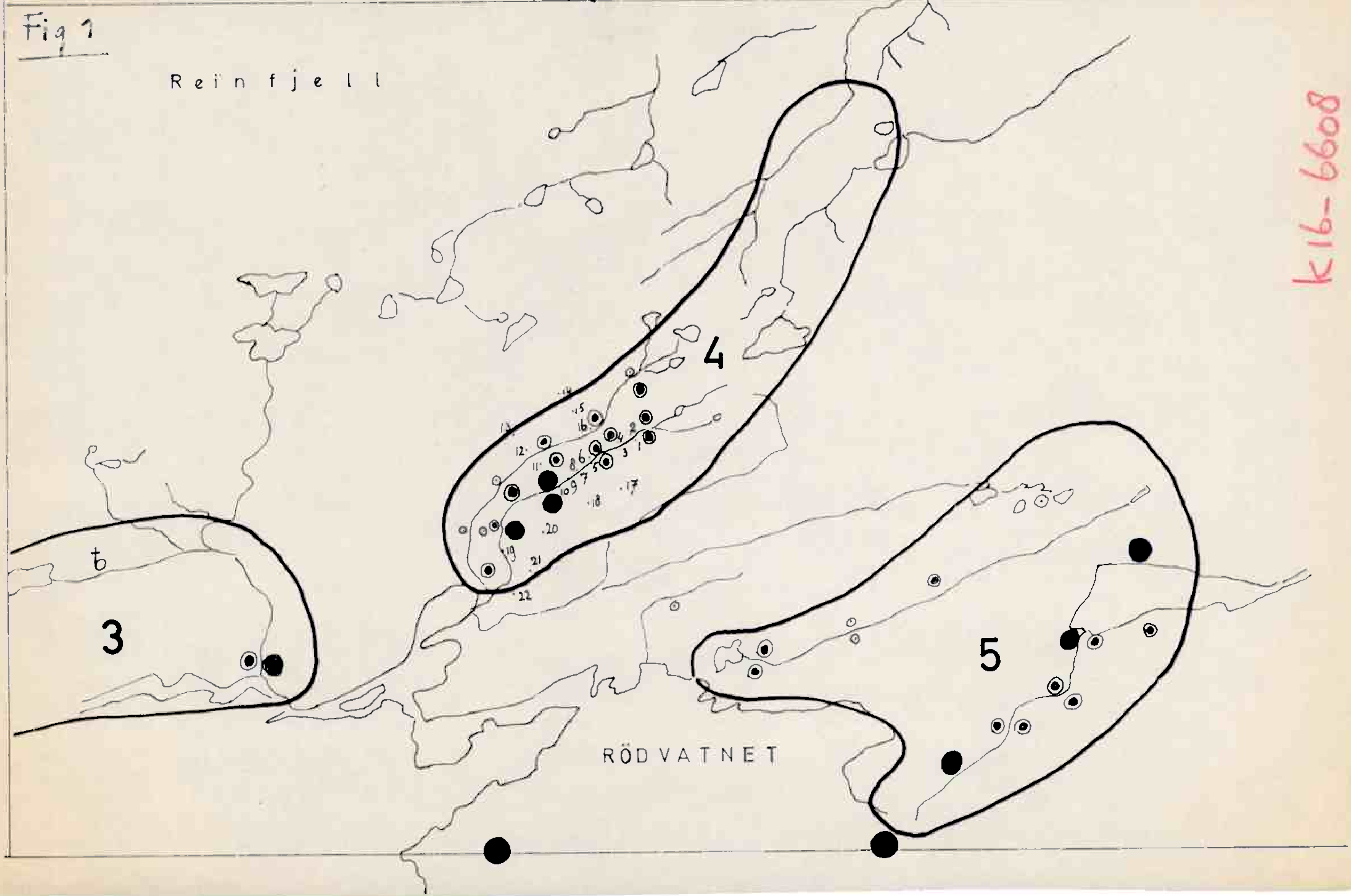
At the 495 m top(Sølgruben) small concentrations of pyrite were found in a shallow trench and immediate surrounding of a pyrite gneiss, the roof of a significant amphiboliteband, plunching ca. 20° NW(the general plunche direction of the Mofjell anticlinal axes here). Sample 31. This ore-bearing zone in the northern limb of the Mofjell continues further to the west and may be connected with the ore-bearing zone of large Mo-mine at Mo-i-Rana.

The topographically highest amphibolite band is stratigraphically the lowest It is not certain if the two bands can be structurally connected by isoclinal folding or that redoubling by a process of imbrication had taken place.

No signs of such processes could be observed in the area and therefore

Geochemical anomaly no. 4 (COPPER) RÖDVATNET (Umbukta road)	Small numbers refer to rock samples	SCALE 1: 15.000

Fig 1



the bands are here considered as stratigraphically different levels in the northern limb of the Mo-fjell anticline.

The Mosgruben ore zone, in the reversed southern limb of the Reinfjell-anticline, shows another enrichment on a much smaller scale in the north-east continuation, just beyond the topographicallgulmination of the Reinfjell, 3 km N.E. of the Mosgruben mine. Here a deep pit was made("Thermos") No ore was left in the visible part of the pit, which was filled up with water. However, some piles of wastematerial show much of the pyritic ore coming from the pit(sample 22). It is quite well possible that the Mosgruben ore-bearing gneiss zone contains still more enrichments between the two mines. Close north of the pit several trenches delivered unsignificant quantities of pyrite-ore. The gneiss is strongly limonitized in parts.

The geochemical anomaly no.4(see fig.1) is a Cu-anomaly in a ore-bearing gneiss zone running parallel and south of the Mosgruben ore-bearing gneiss-zone. The anomaly was detailed examined upon possible Cu-minerals, however with negative result. A close spaced rock sampling was made for further chemical analyses(numbers 1-22).

No significant Zn-Pb orefications occur in the area.

For genetical reflections is here referred to the thesis of R. Saager(1966, p.125).

Prospects

It mightd be advisable that a further geophysical research of the mentioned Cu-anomaly should be made. Previous to this electro-magnetic surveys across more or less well known ore-bodies(Mosgruben)and ore bearing gneisses bordering the ore-mass, may be useful to learn if there is any significant contrast between the ore-bearing gneiss and the ore-less gneiss and between the ore-bearing gneiss and the ore-mass itself.

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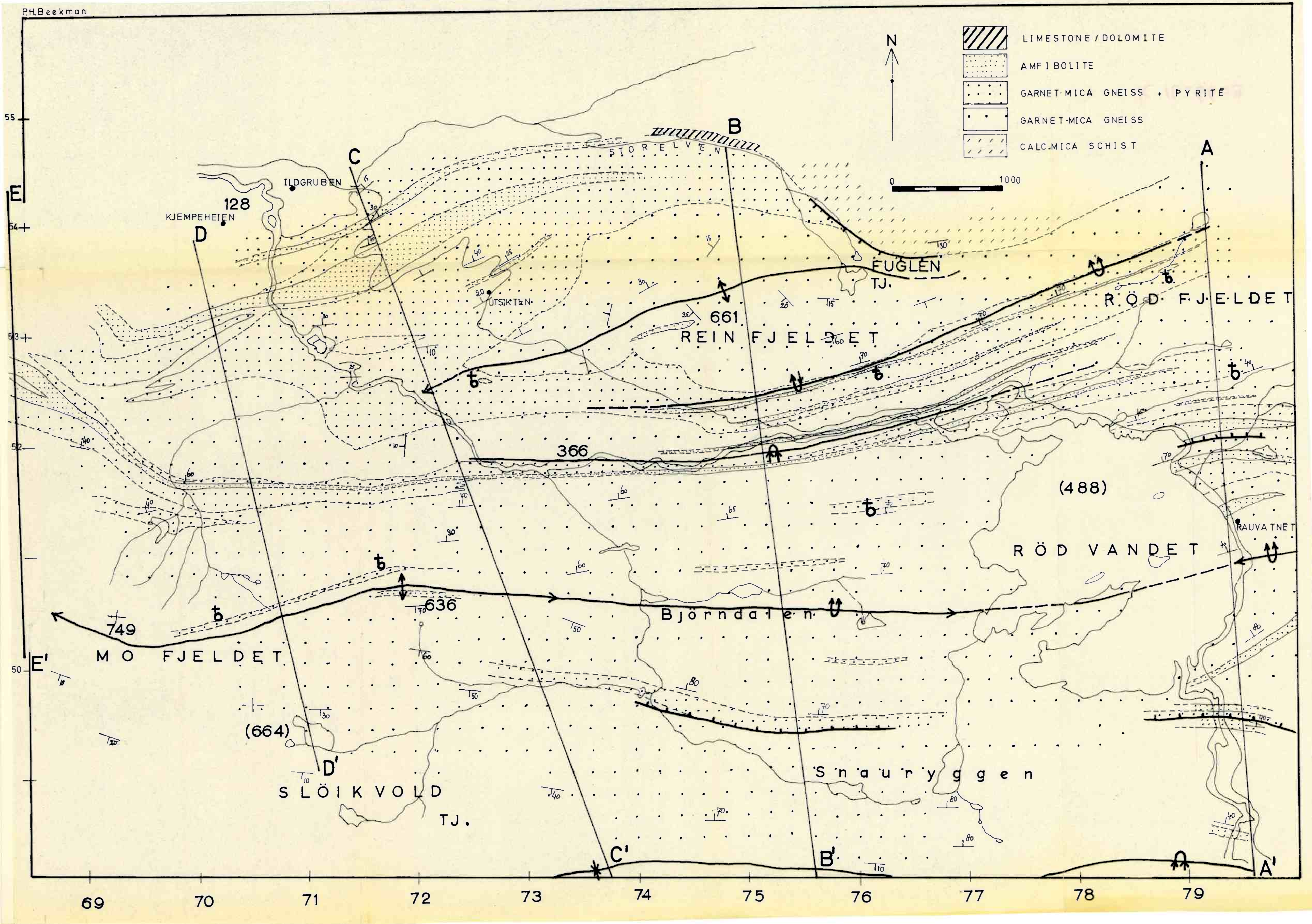
Drs. P.H. BEEKMAN
No-1-Rana, 13/9/1966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LIMESTONE / DOLOMITE
AMFIBOLITE
GARNET-MICA GNEISS + PYRITE
GARNET-MICA GNEISS
CALC.MICA SCHIST
N
0
1000
A
B
C
D
E
A'
B'
C'
D'
E'
STORELVEN
ILDGRUBEN
KJEMPEHEIEN
128
UTSIKTEN
FUGLEN
TJ.
661
REIN FJELDET
RÖD FJELDET
366
(488)
RAUVATNET
RÖD VANDET
636
749
Bjorndalen
MO FJELDET
(664)
SLÖIKVOLD
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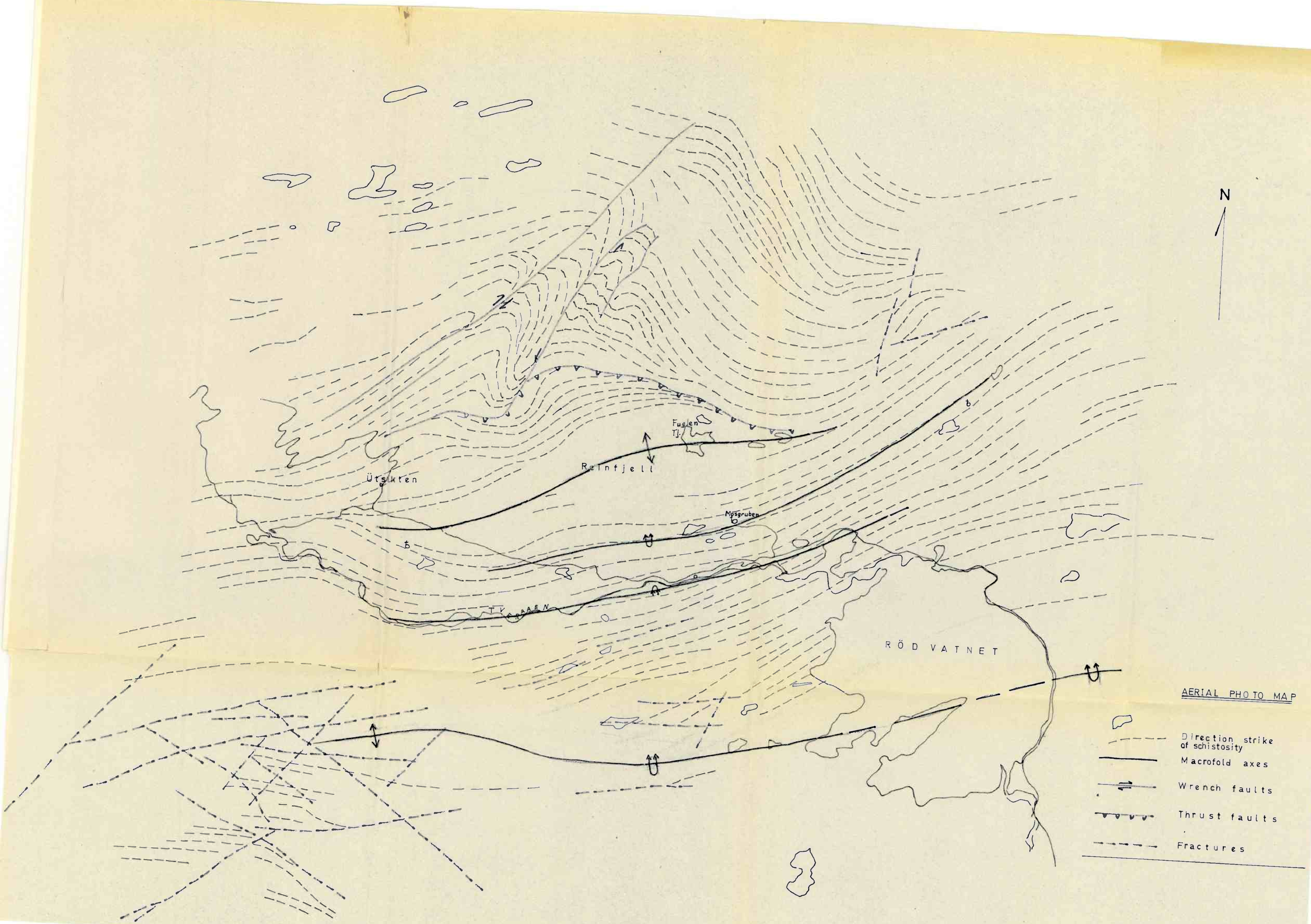

N
Fuglen
Tj.
Reinfjell
Ütsikten
Mosgruben
RÖD VATNET
AERIAL PHOTO MAP
Direction strike of schistosity
Macrofold axes
Wrench faults
Thrust faults
Fractures

6x

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