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Troms & Finnmark	Sydv 1149			

Tittel
Target area Raitevarre

Forfatter	Dato	Bedrift
Røsholt, Bernt	24.02 1981	Sydvaranger A/S

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Karasjok	Finnmark	Troms og Finnmark	20333 20334	

Fagområde	Dokument type	Forekomster
Geofysikk Geokjemi Boring Geologi		
Råstofftype	**Emneord**	
Malm/metall	Cu Au	

Sammendrag

The prospecting work done at Raitevarre is summarized fra 1962 ot 1980. Together 1445 m of core drilling is carried out in 8 holes.

Low grade copper-gold mineralizations are found in considerable amounts. Sections of more than 20 m of thickness with 0.44 % Cu are reported.

This type mineralization extends to the south and it is pointed on the possibilities to find favorable structures where gold or gold/copper could be deposited after remobilization.

It is belived that the extensive low grade alluvial gold deposits must have some major sources in this area.

Reduced geoghemical and geophysical maps, core log, gord report from Raitevarre by Hagen, gold prospecting model etc. are enclosed.

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SAKSBEARBEIDER Bernt Røsholt

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Target area Raitevarre.

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- Prosp. ktr.
- Bernt Røsholt
- Henriksen
- Bugge

KIRKENES:

ANDRE:

- Union Minerals
- " " Olmore
- Bergmester

RESYMÉ:

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KOMMENTAR:

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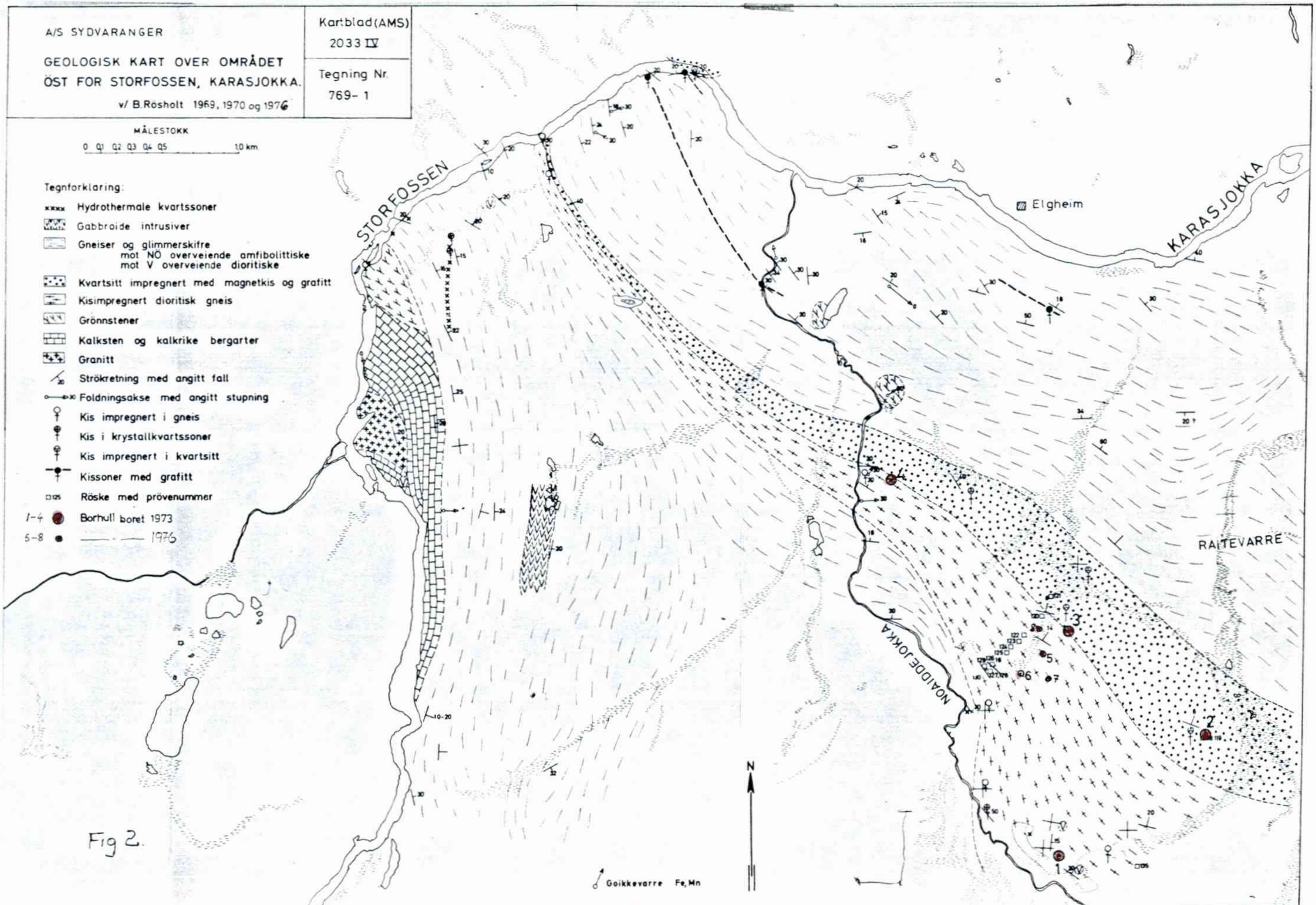

A/S SYDVARANGER
GEOLOGISK KART OVER OMRÅDET ÖST FOR STORFOSSEN, KARASJOKKA.
v/ B.Rösholt 1969, 1970 og 1976
Kartblad (AMS) 2033 IV
Tegning Nr. 769- 1
MÅLESTOKK
0 0,1 0,2 0,3 0,4 0,5 1,0 km
Tegnforklaring:
Hydrothermale kvartssoner
Gabbroide intrusiver
Gneiser og glimmerskifre mot NÖ overveiende amfibolittiske mot V overveiende dioritiske
Kvartsitt impregnert med magnetkis og grafitt
Kisimpregnert dioritisk gneis
Grönnstener
Kalksten og kalkrike bergarter
Granitt
Strökretning med angitt fall
Foldningsakse med angitt stupning
Kis impregnert i gneis
Kis i krystallkvartssoner
Kis impregnert i kvartsitt
Kissoner med grafitt
Röske med prövenummer
1-4 Borhull boret 1973
5-8 1976
STORFOSSEN
KARASJOKKA
Elgheim
NOAIDEJOKKA
RAITEVARRE
Goikkevarre Fe, Mn
N
Fig 2.

Target area Raitevarre

Introduction

The Raitevarre area is situated 69° 17' North, 25° East and lies about 40 km's SW of the village Karasjok in Finmark about 300 m above sea level. The area is mapped in detail by Røsholt. See Fig. 2.

The Karasjok area is regionally mapped by H. Wennervirta (1968). Most of the rocks in the area belong to the Karasjok group which is Svekofenno-karelian (2000 m y). The rocks are metamorphic sediments and vulcanites in the amphibolite facies. To the west and to the east the prefennokarelian basal complex (2800 m y) occurs with granodioritic and quartzdioritic gneisses with migmatites to the west and granulites (Svekofennokarelian metamorphics) to the east. H. Skålvoll (1971).
The attached map Fig. 1 shows the southern part of the Karasjok area. Several types of prospecting activities are carried out in the area with the greatest activity in the period from 1967 to 1969.

Summary of prospecting work

Geophysics

Regional aerial magnetometry and electromagnetics was measured by NGU in 1962 over a large part of Finnmark. The rather flat topography is very good for aircraft measurements.

At Raitevarre some recognizing electromagnetic slingram and magnetic profiles were done 1968. Later the same year there was done a helicopter survey by Terratest AB that covered 45 km² of the area. It was done magnetic and electromagnetic measurement in 582 profilekm's. In the center of the geochemical anomalous area see under "geochemistry", the profile distance was 50 m and outside the distance was 100 m. The profiles were flown in NE-SW direction at right angle to the general strike of the rocks.
p.15
Fig. 3 shows the electromagnetic In Phase Component over the area. It is measured in ppm of the primary field. A clear NW-SE-strike is seen on the electromagnetic anomalies due to the black schists. There are also electro-magnetic anomalies to the NE that are believed to be caused by black schist and pyrrhotite in the amphibole gneisses. Several outcrops of this type of mineralization is found. The Out of Phase Component and the magnetic anomaly map also indicates the NW-SE-strike of the rocks.
Under "enclosures" in the back of this report copies of EM and magnetic measurements are enclosed.

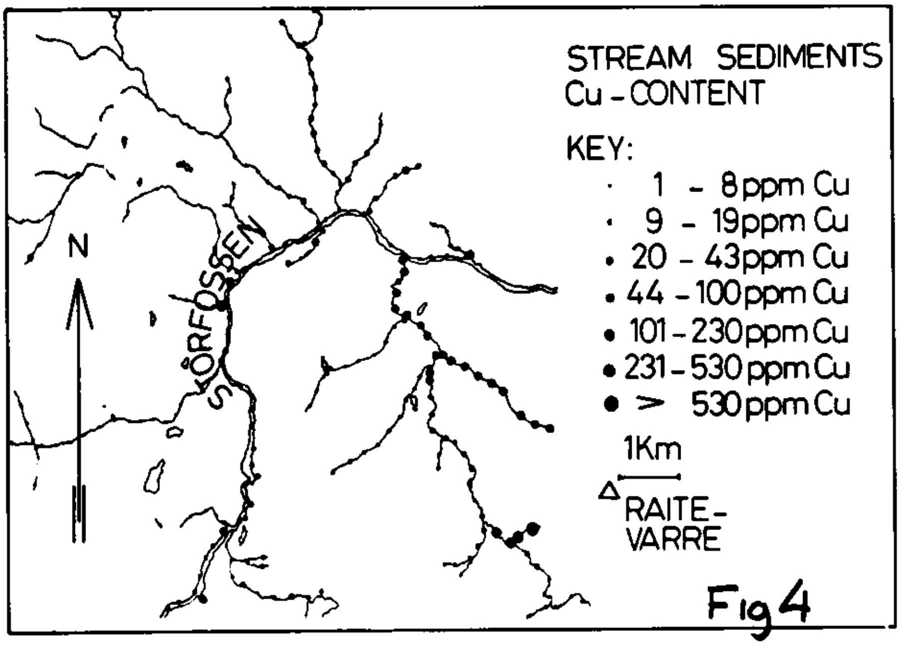

STREAM SEDIMENTS
Cu - CONTENT
KEY:
1 - 8ppm Cu
9 - 19ppm Cu
20 - 43ppm Cu
44 - 100ppm Cu
101 - 230ppm Cu
231 - 530 ppm Cu
> 530ppm Cu
1Km
RAITE-
VARRE
N
SÖRFOSSEN

Fig 4

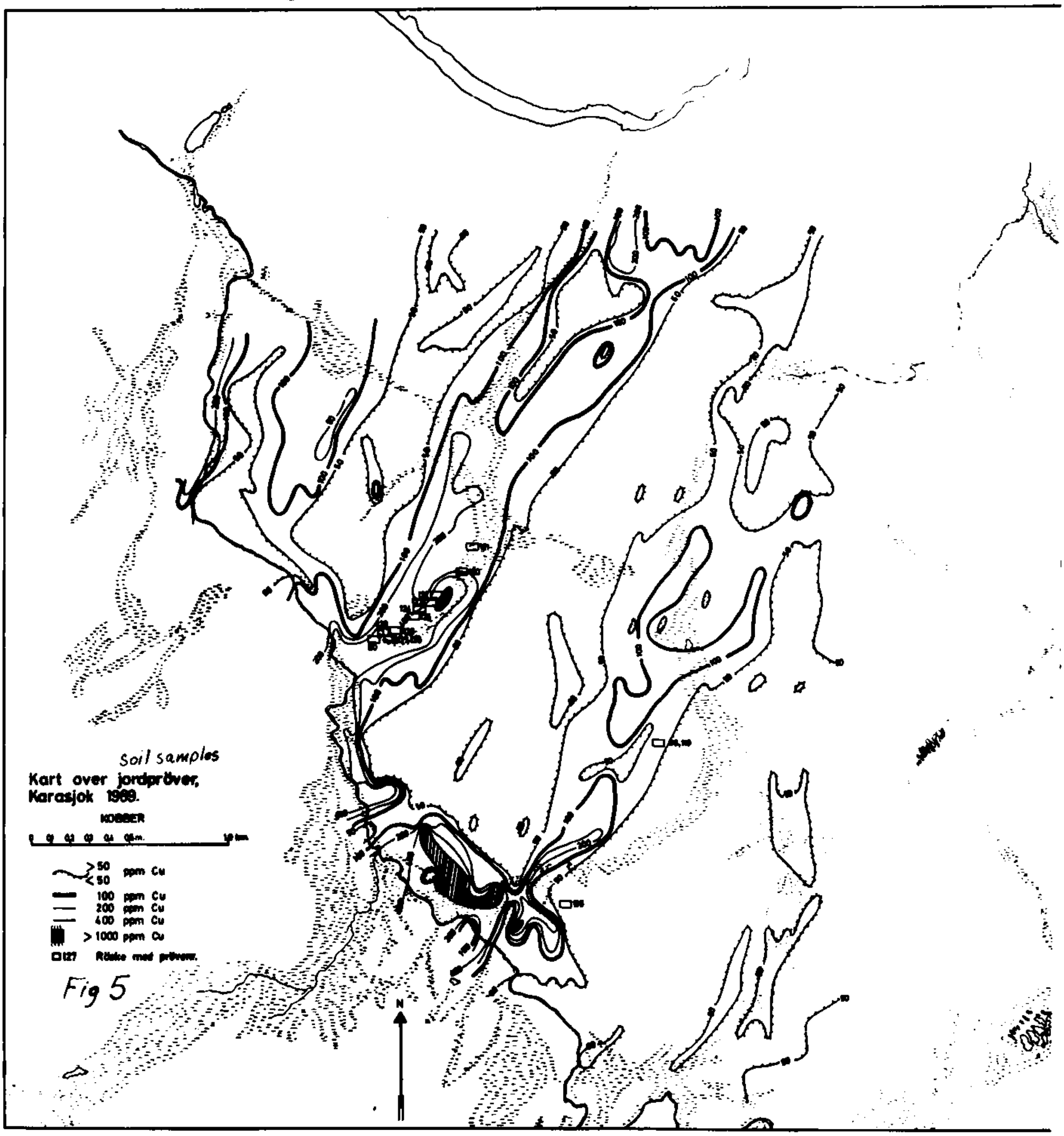

Soil samples
Kart over jordpröver,
Karasjok 1969.
KOBBER
>50
<50 ppm Cu
100 ppm Cu
200 ppm Cu
400 ppm Cu
> 1000 ppm Cu
N

Fig 5

Geochemistry

Stream sediments

In 1967 the NGU did stream sediment sampling for Sydvaranger. An area of 330 km^2 was covered with 838 samples. The samples were taken each 250 m. This geochemical investigation resulted in different anomalies. One of the anomalies was very clear with high values in copper, zinc and silver. The highest copper and zinc contents were above 600 ppm and the highest silver content was 0,9 ppm. Fig. 4 shows the copper contents in the stream sediments in the Storfossen - Raitevarre area.

Soil sampling

In the field soil samples are taken over an area of 10 km^2 in a grid of 250 x 50 m with E-W-going profiles. The distance between the profiles is 250 m and distance between each sample in the profiles is 50 m.

The samples were taken at depths from 0,5 to 1,0 m.

Fig.'s No. 5, 6, 7 and 8 shows the distribution of Cu, Ag, Zn and Ni. The copper and silver anomalies give a fairly similar pattern while the zinc and nickel distribution is more or less random with mostly background metal contents.

On Fig. 5 the copper anomalies show two areas with copper contents more than 1000 ppm. The largest anomaly has a copper content above 1000 ppm over an area of approximately 5 ha. In this area the copper bearing dioritic gneiss is cropping out. There are three distinct ridges with a NNW strike. This strike is parallell to the ice movement direction. It is not believed, however, that the ice movement has caused the shape of the anomalies. The area just NNW of the highest copper anomaly-area is definite low in copper, so it is not likely to belive that the NNW anomaly ridges are caused by the ice movement. This statement is confirmed by the silver anomalies, which have no elongations parallell to the ice movement, Fig. 6.
The areas with very high copper content are belived to be caused by at least to factors.

1. Above the copper bearing dioritic gneiss there is a black schist rich in pyrrhotite. Both the black schist and gneiss is nearly flatlying with a gentle slope to the NW and have therefore a rather large area of exposure. The weathering of the pyrrhotite results in a strong chemical action on the copper bearing gneiss with deep weathering of the rock and leaching of the copper.

2. The copper anomalies are concentrated in the lower parts of the terrain. Analyses of water that comes out the morraine in the lower parts of the

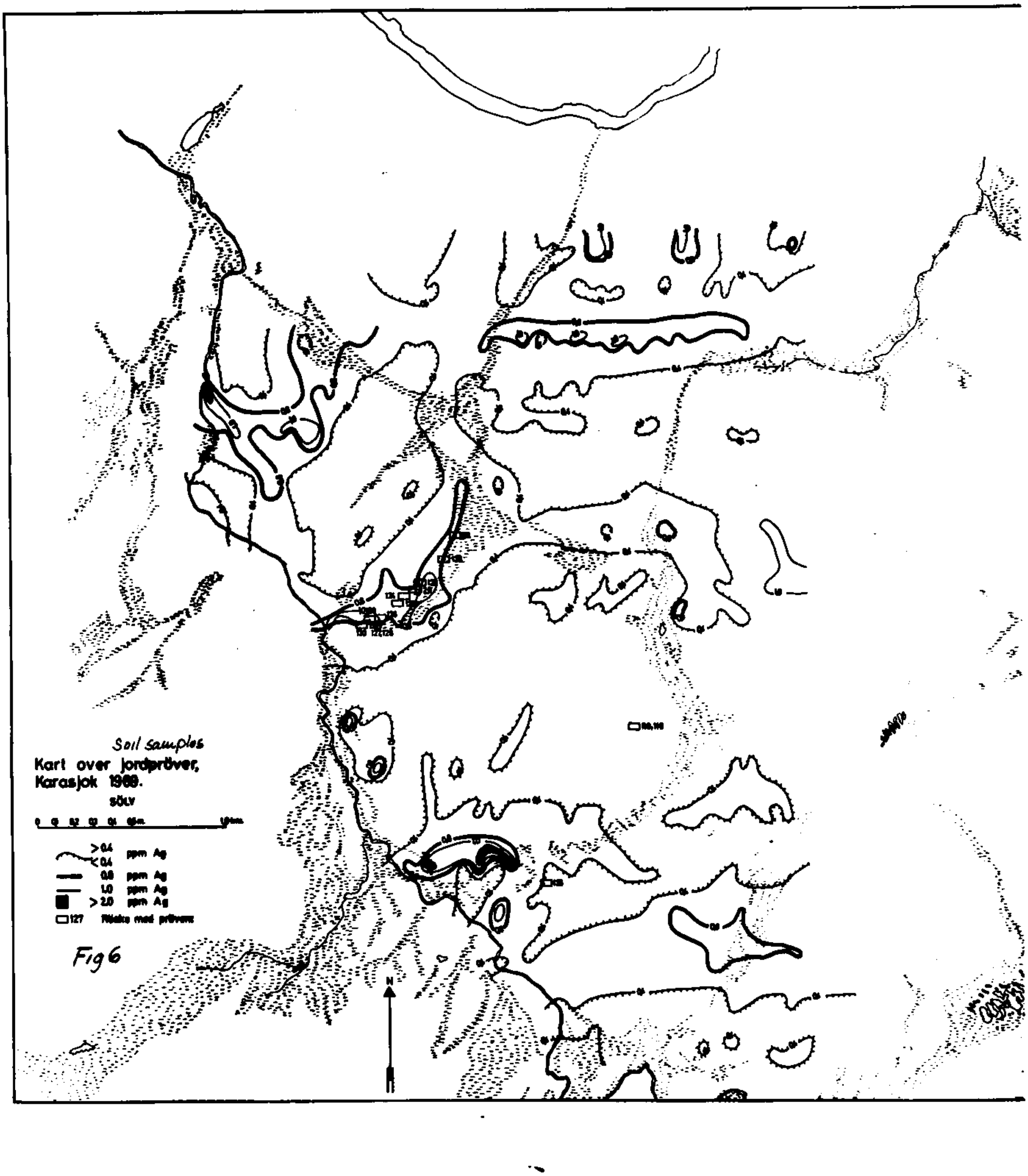

Soil samples
Kart over jordpröver,
Karasjok 1969.
SÖLV
>0.4
<0.4
ppm Ag
0.6 ppm Ag
1.0 ppm Ag
>2.0 ppm Ag
127
N

Fig 6

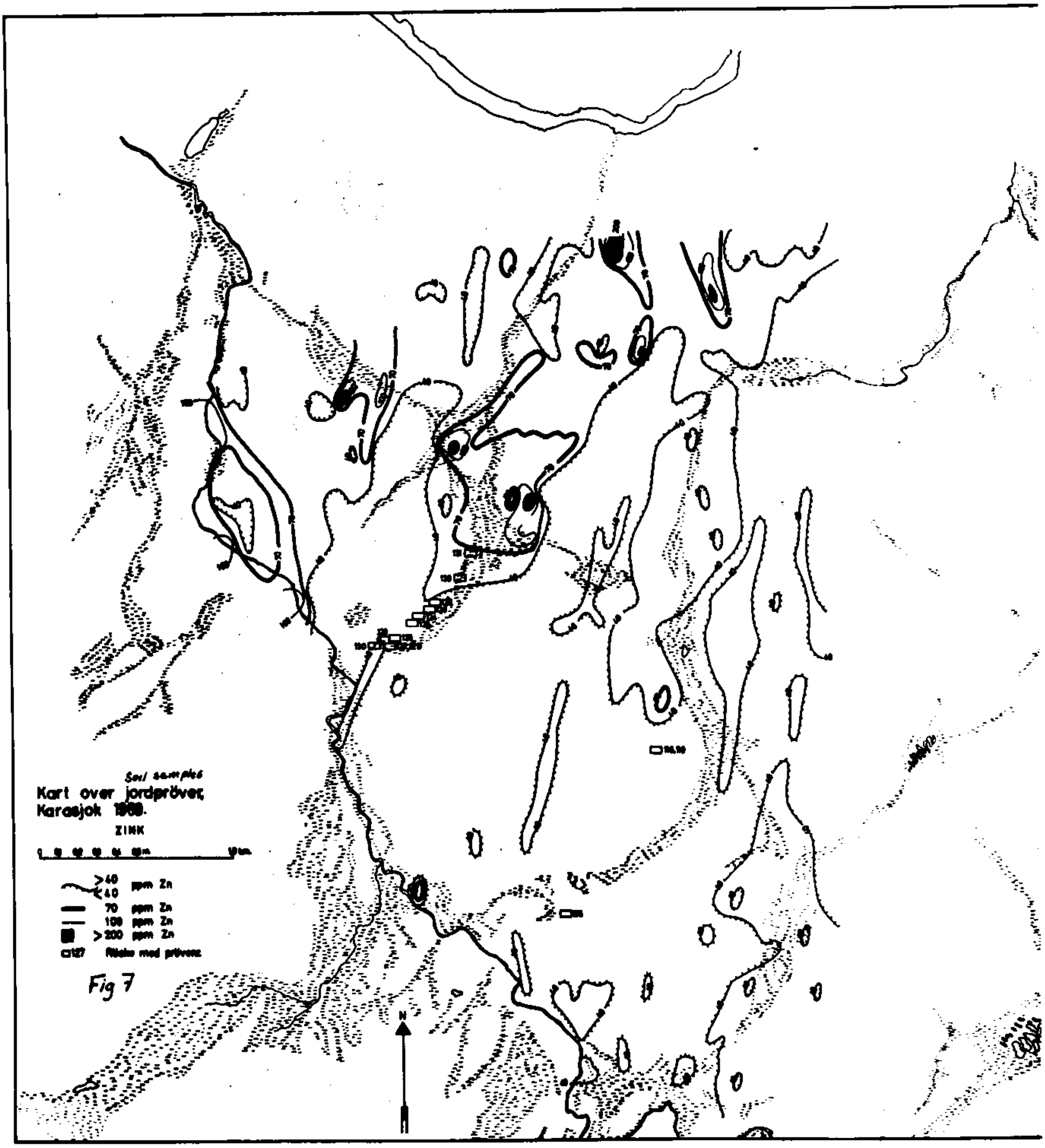

Soil samples
Kart over jordpröver,
Karasjok
ZINK
>40 ppm Zn
<40
70 ppm Zn
100 ppm Zn
>200 ppm Zn
N

Fig 7

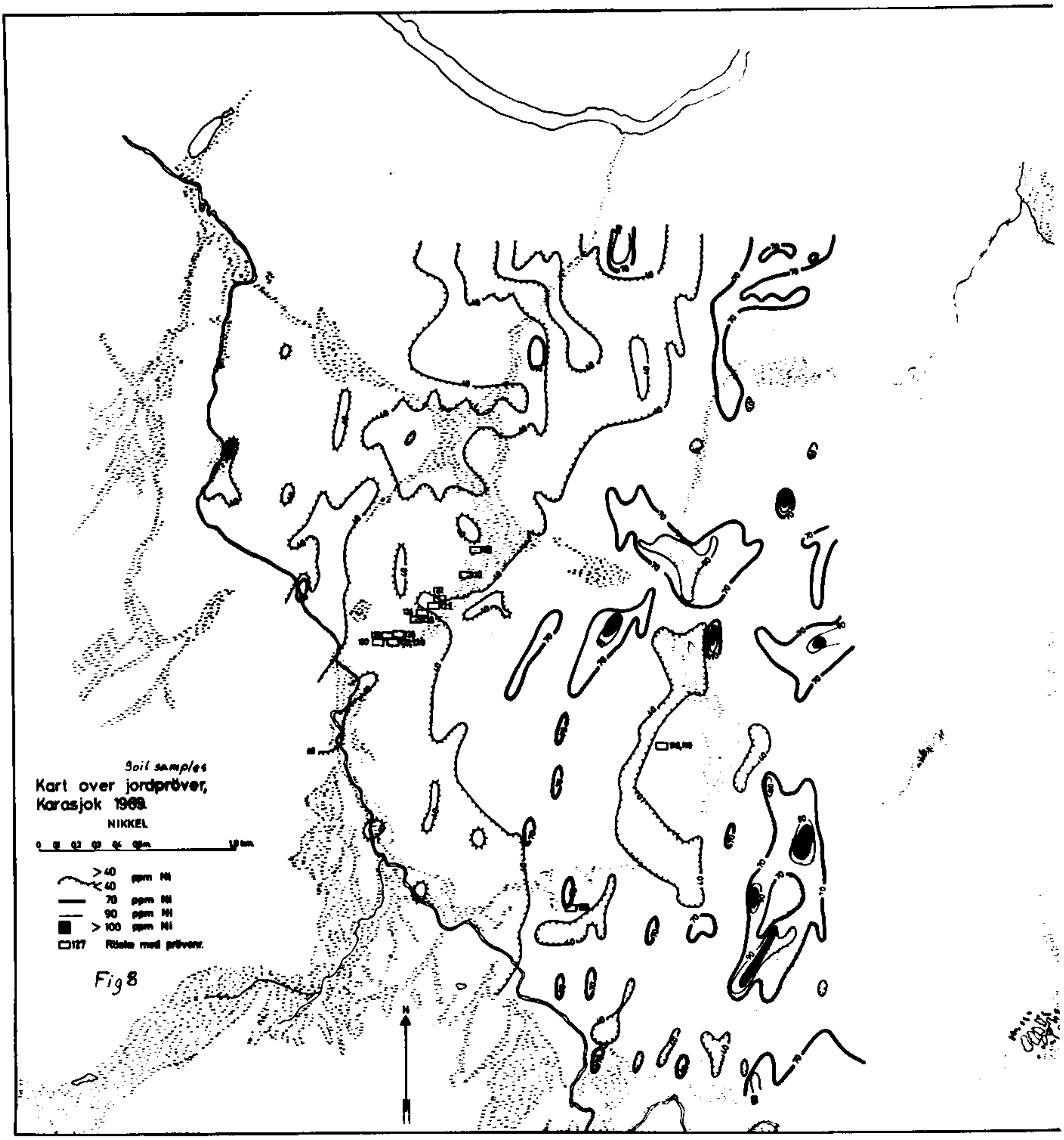

Soil samples
Kart over jordpröver,
Karasjok 1969.
NIKKEL
> 40 ppm Ni
< 40
70 ppm Ni
90 ppm Ni
> 100 ppm Ni
127 Röste med prövenr.
N

Fig 8

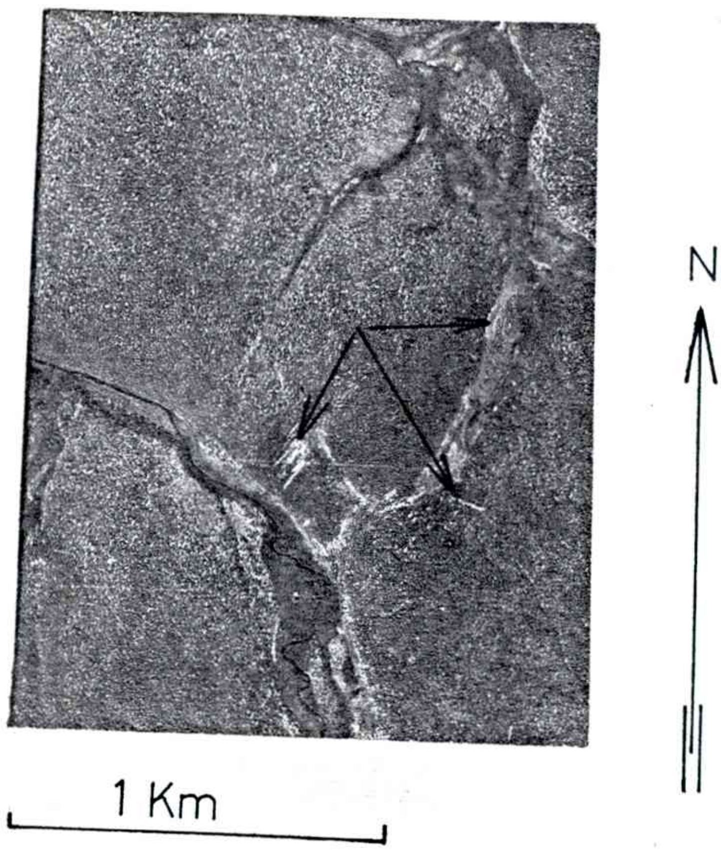


Fig. no. 9. Air photography showing copper poisoned areas at Raite- varre. See arrows.

terrain have a high copper content. The copper content in the water decreses rapidly (see below) and the copper is belived mainly to be deposited here.

In the copper anomaly area W of Raitevarre ground water is coming out. Copper analyses of the water gave 0,040 ppm in "the well", 0,025 ppm 200 m down stream and less than 0,010 ppm 600 m from "the well".

"The well" gave more than enough water to supply the drilling of one machine throughout a dry summer. We can then assume that it produces at least 5000 liters per hour 200 days a year.

With these figures approximately 1 kg of copper will be deposited pro anno from this well. If this process has been going on since the end of the last ice age, 10000 kg's of copper has been deposited. This amount of copper is of the same order what is belived to be in the anomaly area W of Raitevarre.

Copper poisoned areas

Two major copper poisoned areas can be pointed out. These areas are coinsiding with the copper anomaly areas. Early in the work of this area we became aware of the peculiar vegetation of the poisoned areas. The grass has a reddish colour throughout the whole summer. Lots of Viscaria Alpina or the "copper flower" is found in the areas and the normal ground cover vegetation is mostly replaced by Juncus trifidus, Festrica avine and Deschamps flexuoa. In the center of the areas patches of several square meters are completely free of vegetation. These patches are heavily poisoned and copper contents up to 3% is found here. Bølviken (NGU) who earlier had worked with poisoned areas in southern part of Norway was informed of this poisoning. Together with Låg he visited the area and they have described the poisoning (1974).

Fig. 9 is a air photo that shows the copper poisoning in a hill. The copper bearing gneiss is cropping out nearly on top of a hill and tongues of poisoned areas are seen from the outcrops and down the hill. This pattern is rather unique and the prospector should of course be aware of such features. NW of this unique pattern is the large poisoned area W of Raitevarre. On the black and white air photos this large poisoned area looks very much like ordinary peat bogs.

Remote sensing

Infrared air photos.

Fjellanger-Widerøe A/S has taken infrared photos from air over the area for NGU. The poisoned areas are really showing up very good on these photos. They are nearly equal to the results from the soil samples, and anomalies

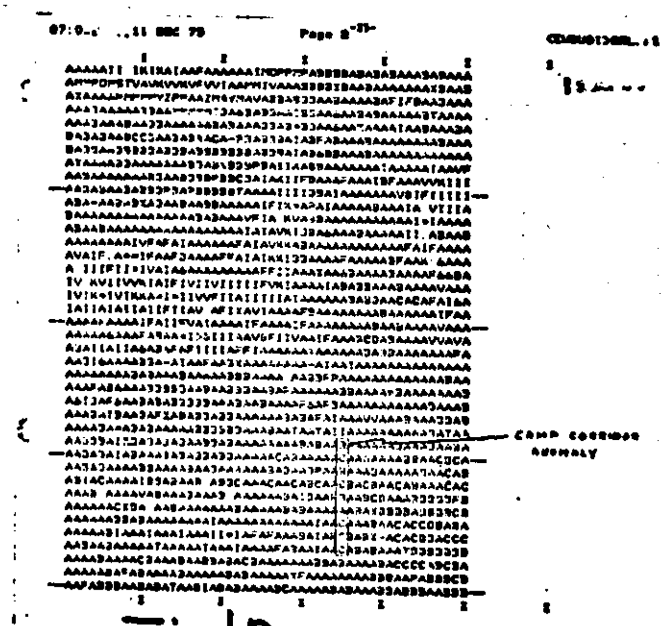


Fig 10.

with copper contents above 1000 ppm are seen very well. The areas rich in copper are getting grey blue on the infrared film while the ordinary healthy vegetation appears with a red colour.

Satellite images

Satellite images over the area from the LANDSAT-1 are studied by Lyon, Bølviken et al (1976). LANDSAT-1 images are taken from an altitude of 900 km's and each image coveres an area of 185 km in square. The camera in the LANDSAT-1 is a multispectral camera with four channels (No. 4-7) which registrates energy from waves with wavelengths from 0,5 to 1,1 microns. LANDSAT-1 resolution is limited to one pixel (0,4 hectars).

Over the actual areas a satellite image was enlarged. Close examination of this revealed a ninepixel linear bright area in channel 5 that seemed to coincide with the soil sample copper anomaly W of Raitevarre shown in the center of Fig. 5. The size of this anomaly is approximately 600 m long and 80 m wide. Two smaller anomalies just SE of this anomaly with sizes 120 m long end 12 m wide and 35 m long and 7 m wide were also studied. These two smaller anomalies could not be detected on the satellite image due to the LANDSAT resolution capability. The largest copper anomaly to the SE near Noaiddejokka (Fig. 5) was not studied due to lack of time and transport facilities.
The satellite image is computerised and this has given a model with different letters, Fig. 10. Each letter represents one pixel and the poisoned area is believed to be represented by C's. The anomaly W of Raitevarre is believed to be the N-S-groupings of C's called "camp corridor anomaly" on Fig. 10. Fig. 10 covers 800 hectars or 2000 pixels around the copper poisoned area or "camp corridor anomaly".

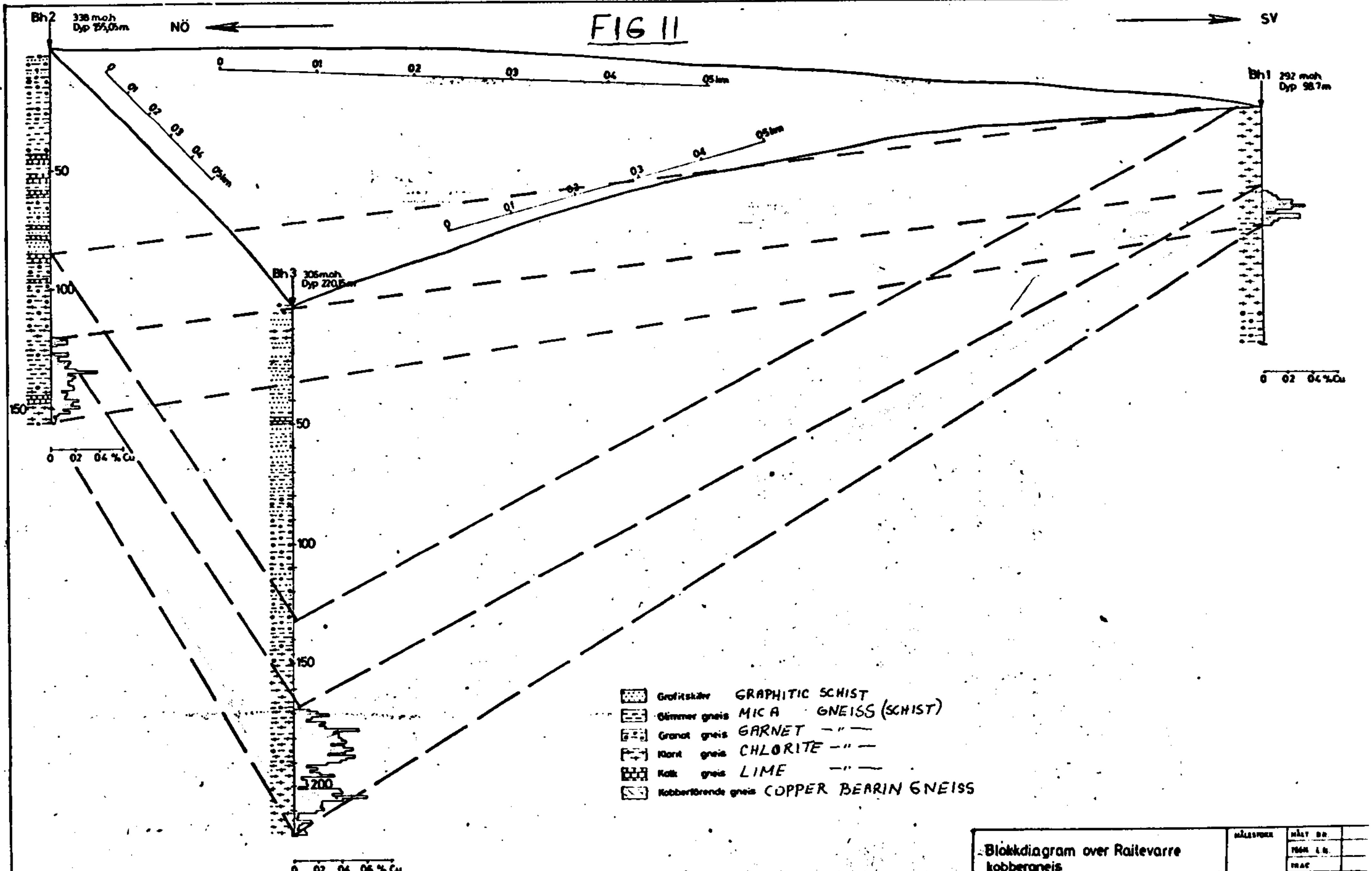
Core drilling

Diamond core drilling was carried out at Raitevarre with 558 m 1973 and 887 m 1976. As shown on map fig. 2 holes No. 1-4 were drilled in 1973 and in 1976 holes No. 5-8. In addition hole No. 3 was elongatedwith 80 m in 1976. The results from the drilling is summarized in the following tabel:

Tabel over drilling results from Raitevarre 1973 and 1976

Drill hole No.	Glacial cover m	Depth m	Analyzed zone from (m) -to(m)	Thickness of zone m	% Cu	ppm Au	ppm Ag	% S
1	3,5	98,7	37 - 48	11	0,21	0,32	2,91	
2	5,0	155	127,6 - 153	25,4	0,17	0,09	1,09	1,76
3	5,5	220	176 - 206	30	0,31	0,20	1,01	0,94
			168 - 211	43	0,28	0,368	1,03	1,16
4*	3,0	83,7		–	<0,1 *	0,17*	0,66	2,26
5	8,0	231,3	19 - 39	20,0	0,29			
			103,5 - 124	20,5	0,438			
6	5,9	196,0	5,9 - 40	34,1	0,23			
			142,7 - 150	7,3	0,19			
7	3,0	157,4	12,0 - 21,3	9,3	0,44			
			96 - 117	21,0	0,26			
8	5,0	223,5	116 - 122	6,0	0,47			
3 Elongation		219,3						
		298,5						

FIG 11



Blokkdiagram over Raitevarre kobbergneis

Finnmark

A/S SYDVARANGER

Tegning nr. 769-2

Drillhole No. 4 is the only hole which is not vertical. It is drilled with 70° inclination in direction 250^g and it has only a copper content of 0,016%. A number of 10 samples gave an average content of 0,17 ppm Au and 0,66 ppm Ag and a number of 12 samples gave an average content of 2,26% S.

In drillhole No. 5 from 146,7 - 148,0 small amounts of galena is found in a tectonic zone. The lead content was 0,72% with traces of copper and silver.

Fig. No. 11 shows drillholes No. 1, 2, 3 with the results from 1973. This figure gives an impression of the size and position of the copper bearing gneiss.

In the back of this report the anlytical results are presented graphically for copper from all drillholes, for gold, silver and sulphur from holes No. 1, 2 and 3. The core-logs are also enclosed.

Latest prospecting activity

No active prospecting is carried out by Sydvaranger since 1976 in the Raitevarre area. NGU however, has done helicopter measurements and core drilling south of Raitevarre in 1980. This work was carried out because the premining consessions owned by the norwegian government over the iron-manganese-deposits south of Raitevarre expires in April 1981.
Sydvaranger's premining consessions over Raitevarre will also expire at the same time. All results from NGU's latest activity will be free during spring 1981. This will enable us to do a much better interpretation of the geology and important structures in the vicinity of Raitevarre.

Geology

Most of the inner parts of Finnmark country is covered with glacial till from 1 to 4 m and often more,as in the bottom of the valleys,where the thickness of the overburden can go up to 20 m.
At Raitevarre the average thickness of the glacial till is 4,8 m from the 8 drillsites. The actual thickness of the glacial till is less than 4,8 m since a deep weathering from 0,2 - 1,2 m is found in the copper minera lized gneiss. The reason for this can be both chemical weathering and frost action. Stratigrafically above the copper bearing gneiss there is a black schist rich in pyrrhotite (see Fig. 2). This pyrrhotite is believed to be decomposed into sulphuric acid and limonite. Together with the frost action the sulfuric acid has acted on the underlying gneiss and this has resulted in the deep weathering. The weathered gneiss is partly very rusty even if similar unweathered gneiss is practically free of iron compounds. It is therefore reasonable to believe that the rusty colour of the weathered gneiss is limonite from the decomposed pyrrhotite.

Fig. 2 shows a geological map of the Raitevarre area. The map is based on observations from a few outcrops especially along the river Noaiddejokka, trenches, geophysics and drilling.
In the lower parts of the metasedimentary sequence, we have the copper bearing gneiss. This gneiss is mostly dioritic in composition with amphiboles altered into chlorite. Red garnets are also common in varying amounts. They are often partly altered into quartz and chlorite. In the upper parts of the gneiss there are also bands with limestone. Sections rather rich in fuchsite is found in or near to the copper bearing gneiss. Other sections with anhydrite are also found. (7-F-Davies 1980).

The contact to the mineralization seems to be rather sharp on the hanging wall, but is gradually fading out against the footwall. Chlorite is found near and in the mineralized area.

Above the gneiss there is a black schist. The contact is gradually changing from the black schist to the gneiss with alternating bands of black schist, limestone and gneiss. In the black schist sequence there are calcareous schists, micaschists, garnet-micaschists and chlorite-schists. The black schist itself has a great variation in the graphite content. In the areas with highest graphite content there are also much pyrrhotite and some pyrite. Sphalerite is also found in the black schist. Above the black schist there is a more massive amphibole gneiss. There are also bands of dioritic gneiss in this amphibole gneiss, but the amphiboles are dominating.

Copper and gold minera lizations

It should be stated that the Raitevarre minera lization today is a subeconomic deposit. Still it should be noted that sections of more than 20 m has copper contents of 0,44%. For comparison the Boliden mine Aitik in N-Sweeden is mined on 0,4% Cu with a cut off grade at 0,22% Cu. The copper-Gold-silver-sulphurcontent in the drillcores can be seen in the table under the chapter drilling, and as enclosures.

Chalcopyrite is the main copper mineral, and it is disseminated. Veinlets of chalcopyrite are also found. Chalcocite and native copper is also registered. Pyrite and a little pyrrhotite is also found in the minera lized zones, but the areas rich in copper seem to be associated only with small amounts of pyrite. In the areas with much pyrite, there is little or no copper.

Sphalerite is found as traces in the black schists.

In the copper mineral ized areas there is also found galena. The galena is not associated with the copper. Some places the galena occurs in partly brecciated zones, but it is also found in undisturbed zones.
Gold and silver is found in nearly all samples analyzed. The gold content varies from zero up to 8 ppm, while the mean gold content generally is the same in ppm as the copper content in percent.
It should be noted that a little gold also is found in copperfree zones like in drillhole No. 4. Here it is rather much pyrite (2,26% S mean content in 12 samples).

Small gold grains in a number of 28 are found in 16 polished sections from drillholes 5, 6, 7 and 8. See report by Ragnar Hagen, enclosed. Hagen reports that the gold is bound to a parageneses of dessiminated grains of pyrrhotite and chalcopyrite grown together.
This is a very important registration and will be followed up in the ore dressing tests (see next chapter) to obtain as much gold as possible.
Ore dressing test carried out on the drillcores from drillhole No. 3 the gold was enriched 24 times in the copper concentrate while the copper was enriched 40 times.
Small amounts of molybdenite is also reported by Hagen.
The silver content is relatively low compared with gold. In drillhole No. 2, 3 and 4 it is only 1 ppm Ag and in drillhole No. 1 approximately 3 ppm.

Ore dressing tests

Flotation tests are done on core samples from drillhole No. 2 and 3. The conclusions from these tests are that the chalcopyrite is very finegrained and often mixed with pyrite. It is therefore difficult to make a good copper concentrate. The best copper concentrate was obtained from the samples from drillhole No. 3 with a copper content of 10,7 % Cu. This is a concentration ratio of 40. The gold content in the copper concentrate was 6,39 ppm and the silver content 22 ppm. Compared to copper a little more than 50% of the gold and silver was concentrated in the copper concentrate.

More flotation tests are now carried out at the Technical University of Trondheim on the samples from drillhole No. 5, 6, 7 and 8. The fact that gold is found in parageneses of pyrrhotite and chalcopyrite grown together is taken into account in these tests.

Recomandations for further prospecting work

Primarily the most important factors of the prospecting work carried out should be summarized:

1. The low grade copper-gold bearing gneiss is found along the strike of the rocks from Raitevarre to Bæivasgiedde (fig. 1). This is a distance of at least 20 km. Some places the copper content is up to 0,44% over 20 m of thickness.

2. Together with the copperminera lizations it is gold with mean contents in ppm of the same order as copper in percent. Gold is also found in pyritic zones. Alluvial gold deposits along the river of Karasjokka and Bavtajokka have been worked on, in several periods since the 17th century, and alluvial gold is found all over the area.

3. The chromium mica fuchsite is found several places in the area. This can indicate that the existing sedimentary rocks partly are derived from an environment of ultramafic rocks.

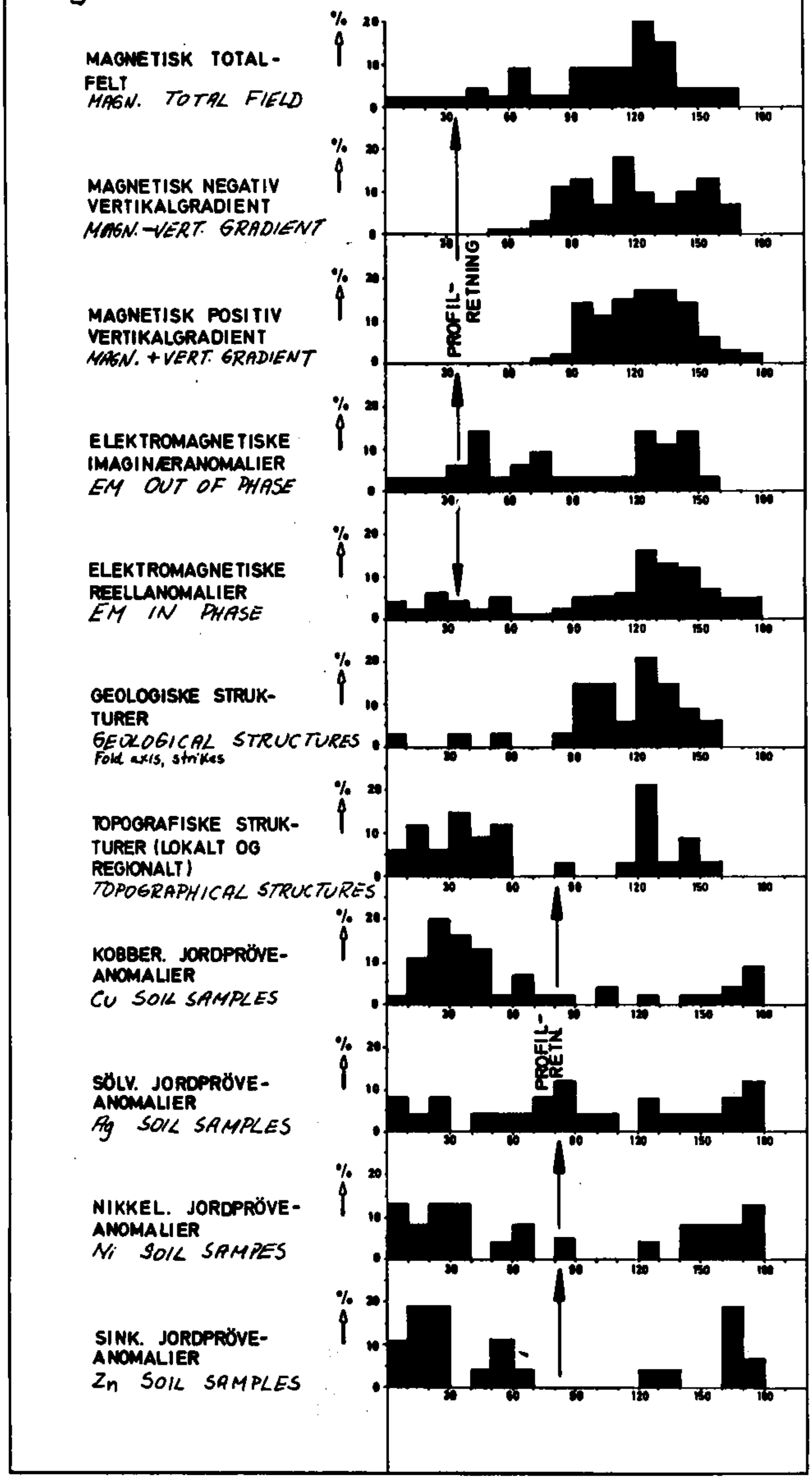
4. NGU has done geophysical measurements by helicopter 1980 over a rather large area between Raitevarre and Bæivasgiedde. The results from these measurements and from some core drillings will be given free this spring.

5. Wennervirta (1968) has mapped the Karasjok area. He also has made a tectonic map (fig. 12, transparent overlay to fig. 1).

6. It should be stated that the area is well covered by glacial till exept along the major rivers and on the highest tops.

7. The Biedjovagge copper-gold mine 90 km's W of Raitevarre is situated in the same Precambrian formation. Here it is important gold concentrations in the ore. Gold is also found in "encouraging" concentrations outside the ore, but not as alluvial gold like it is found in the Raitevarre area. Fuchsiterich sediments are reported from Biedjovagge, but they are not yet studied.
   From the Kittilä area, however, which is some 190 km's S of Raitevarre it is described an area with chromian marble (Pekkala and Puustinen 1978). The chromian marble is sulphide impregnated. Some places the sulphide content is as high as 30% and the rock is then called a sulphide schist.

Fig. 13. STRUKTURANALYSER



In a few random samples from this sulphide bearing schist the gold content is as high as 0,5 ppm.
Gold is found in quartz-ankerite veins in Finnish Lapland.

Bearing in mind the information summarized above and that the mineralogy and geology at Raitevarre is very similar to the Timmins area in Ontario Canada (Karvinen 1978*), Davies 1980, Morrison 1980, the following suggestions for a follow up work on the prospecting work can be set up:

*The Karvinen paper is so important that it is enclosed to this report.

1. Detailed structural mapping of the area to find favorable units of structure where possible remobilisation and enrichment of the gold has taken place. Fig. 13 is a compilation of the distribution of different elongation directions of all geophysical, geochemical and geological disiplines that are worked out in the Raitevarre area. In NGU-report No. 1561-02 1980,B. Rindstad describes the use and benefits of an EDB-program of digitalisation -statistics, plots and grids of lineaments red by Landsat 1, 2 and 3.
   Together with the information that will be free from NGU's work in the area, the structural analyses over Raitevarre (fig. 13), the digitalisation of the lineaments registrated by the Landsatelites and the work done by Wennervirta (fig. 12) there should be a good base for the follow up work on the structural problems.

2. Detailed geological mapping should be carried out. We should especially do follow up work on the volcanic rocks. Morrison (1980) states that association between volcanic necks and major gold fields has been observed elsewhere on the Abitibi greenstone Belt of north-eastern Ontario and north-western Quebec.
   The erosion and redeposition of soft sediments and fresh lavas, submarine fumarolic activity, and the remobilization of quartz and gold by heat from volcanic necks are believed to have been significant in this area.
   Volcanic rocks, even agglomerates, are described from the area (Wennervirta 1968). Solid rock geochemistry and analyses of several elements should guide us to find important volcanic centers or volcanic necks. Important host minerals like tourmaline and ankerite should also be looked for.

3. Prospecting techniques of geochemistry and geophysics should be considered after the geological and structural work. Boyle and Hood (1980) and Northern Miner (1979). (Enclosures).

Conclusional remarks and costs

The Raitevarre area has several similarities to other gold associated areas in the vicinity (Biedjovagge and Kittilä) and also to major gold producing districts like Timmins Ontario. No gold deposits have been found in the Raitevarre area so far exept for the lowgrade gold content in Raitevarre and 2 ppm Au in a quartz vein from Storfossen. In Finnish Lapland however narrow gold-ankerite veins are found.

Alluvial gold is found all over the inner Finnmark. The total amount of gold must therefore be of considerable magnitude. If the gold bearing rocks are not totally eroded it is believed that there must still exist some major sources to the alluvial gold. These sources are considered to be remobilised and accumulated gold from ore types like Raitevarre.

We should also prospect for mineable copper ore of Raitevarre type. The possibilities to find gold deposits of the type described above seems, however, to be at least as good as for finding economic ore of the Raite type.

Sydvaranger's premining consessions for the Raitevarre area is rather soon expiering (April 1981). The coming seasons we therefore should raise our efforts to carry throug a prospecting program which ends up with a satisfactional answer if there are any minable copper-gold deposits in the area or not.

Costs

In the field season of 1981 only geological and structural mapping will be done. Additional costs will be field transportation and analytical costs. The 1981 costs are therefore believed to be covered under the 1981 budget.

Stabekk february 24 1981

Bernt Røsholt

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HELICOPTER MEASUREMENTS

Em in phase

EM out of phase

Magnetic vertical gradient

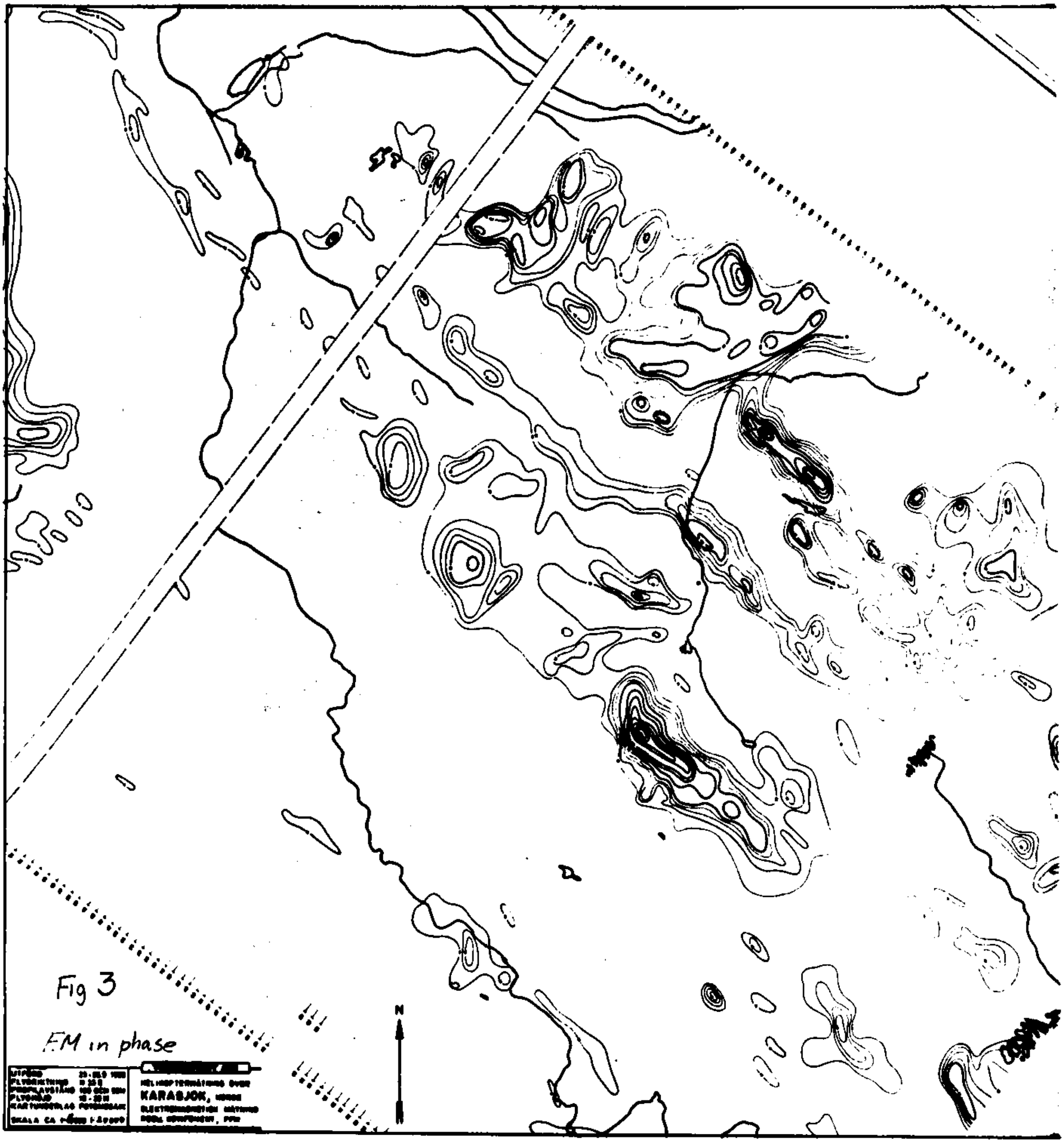
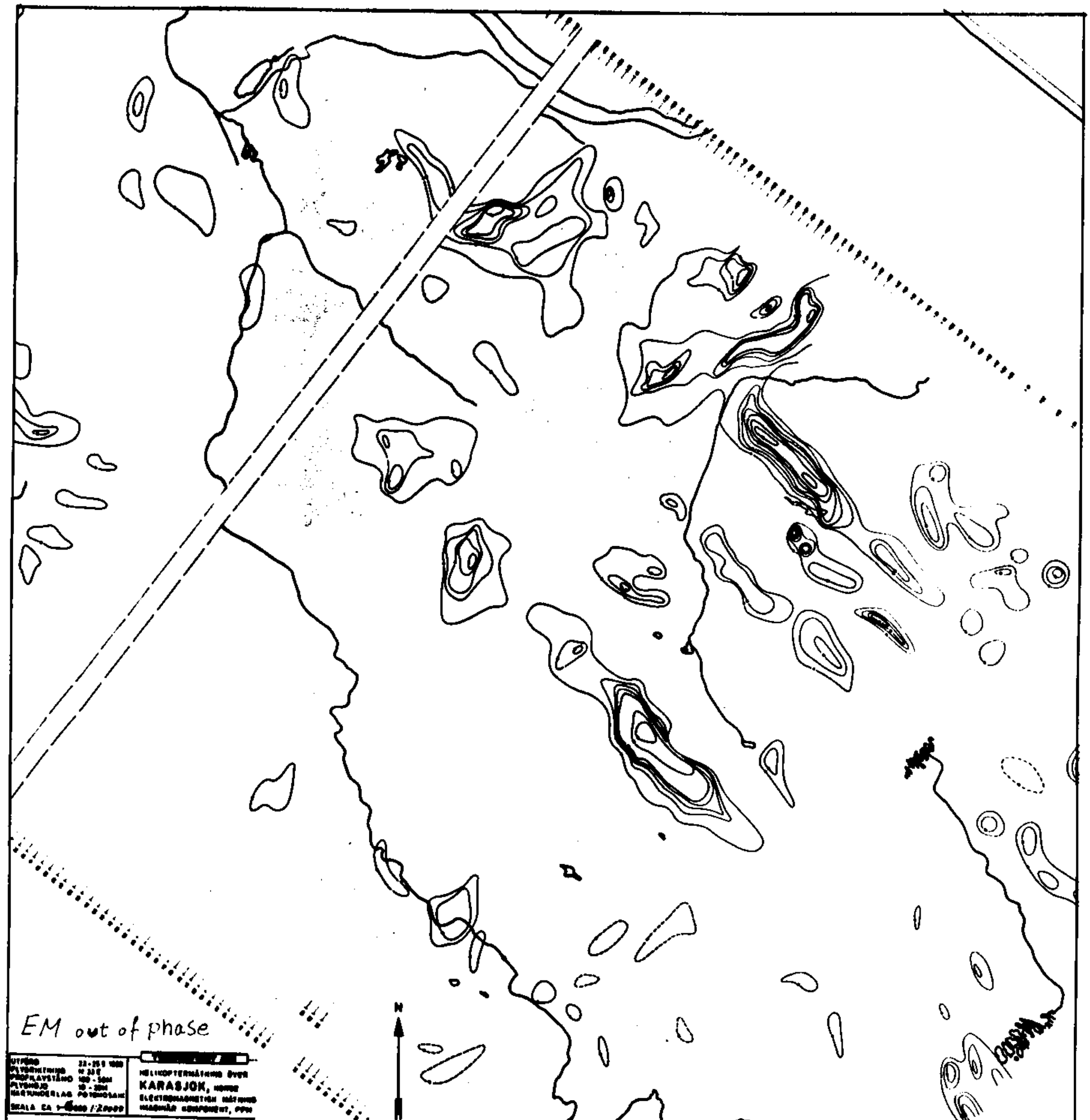
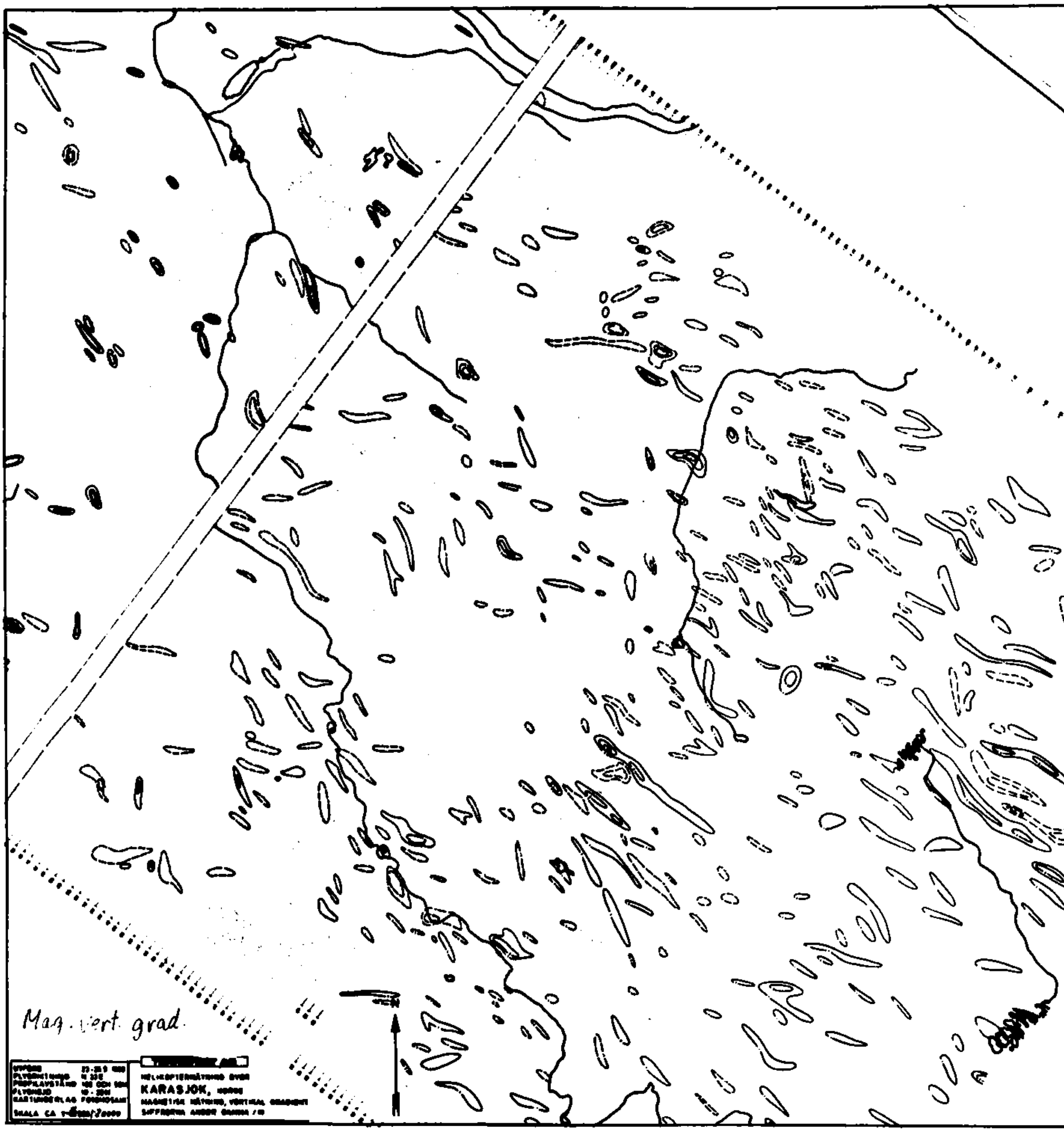


Fig 3

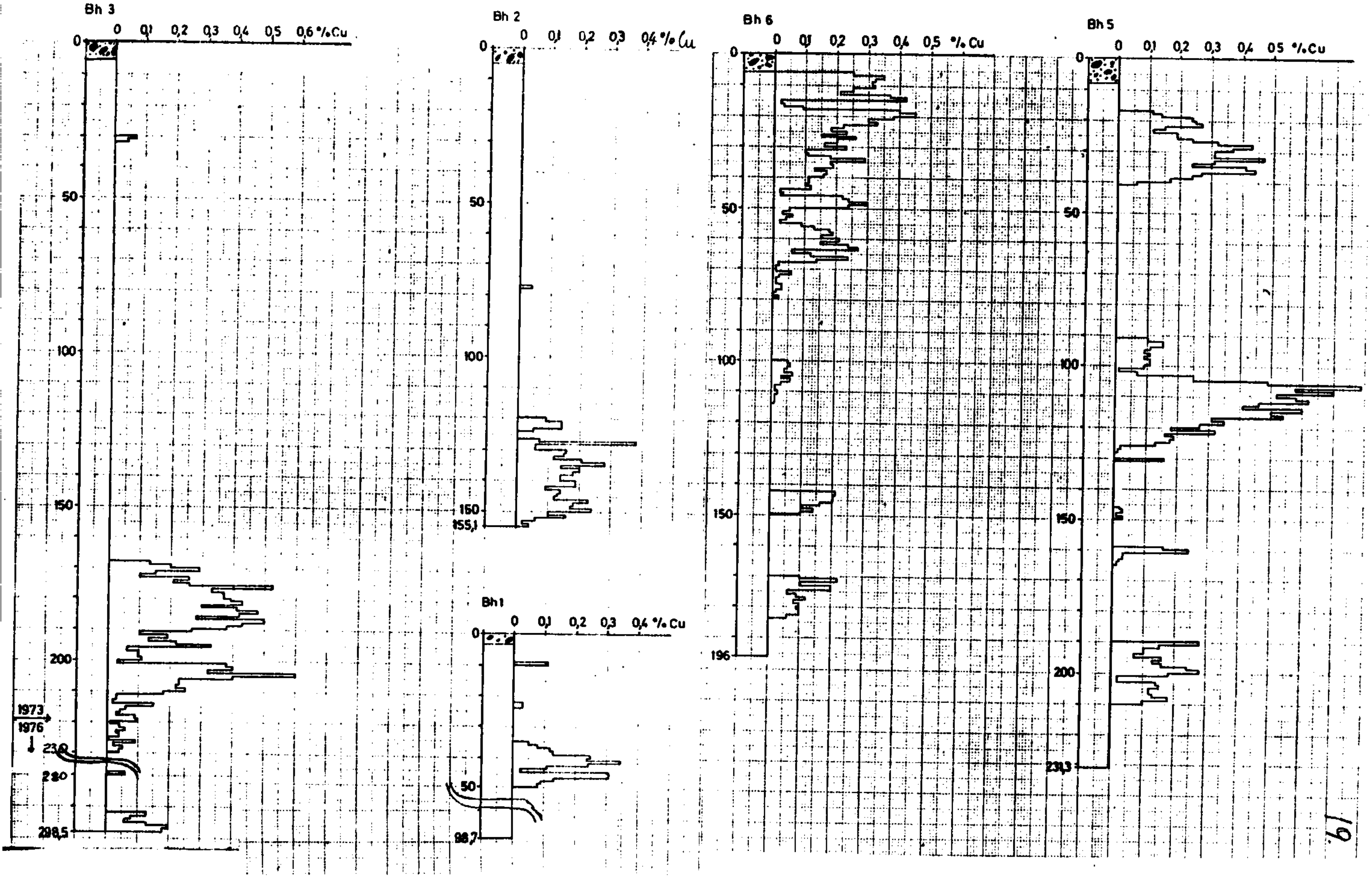
EM in phase

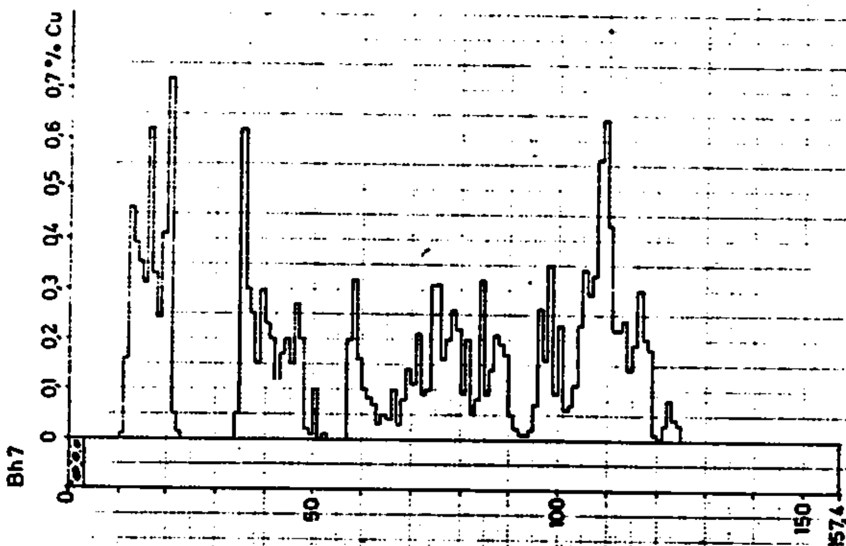

EM out of phase
KARASJOK,
N

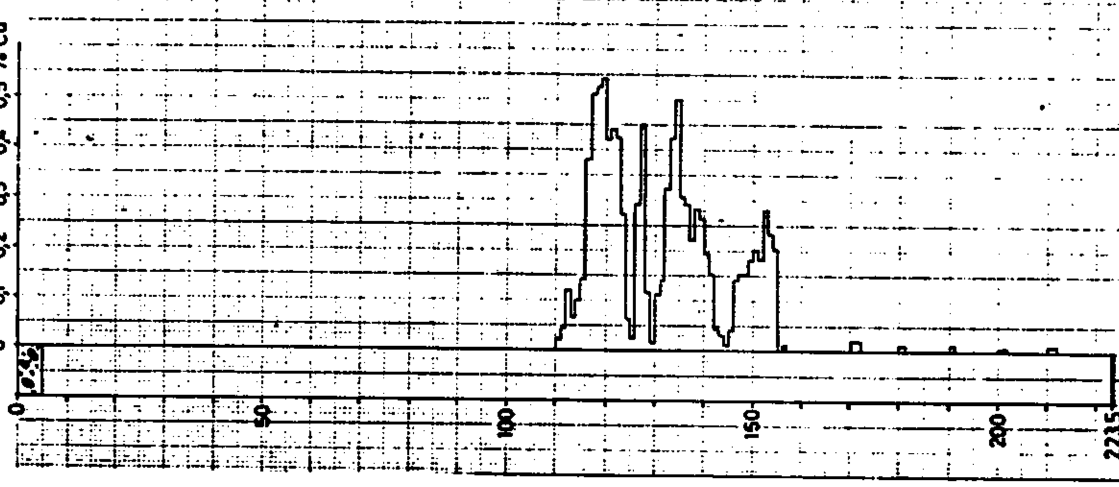

Mag. vert. grad.
KARASJOK,

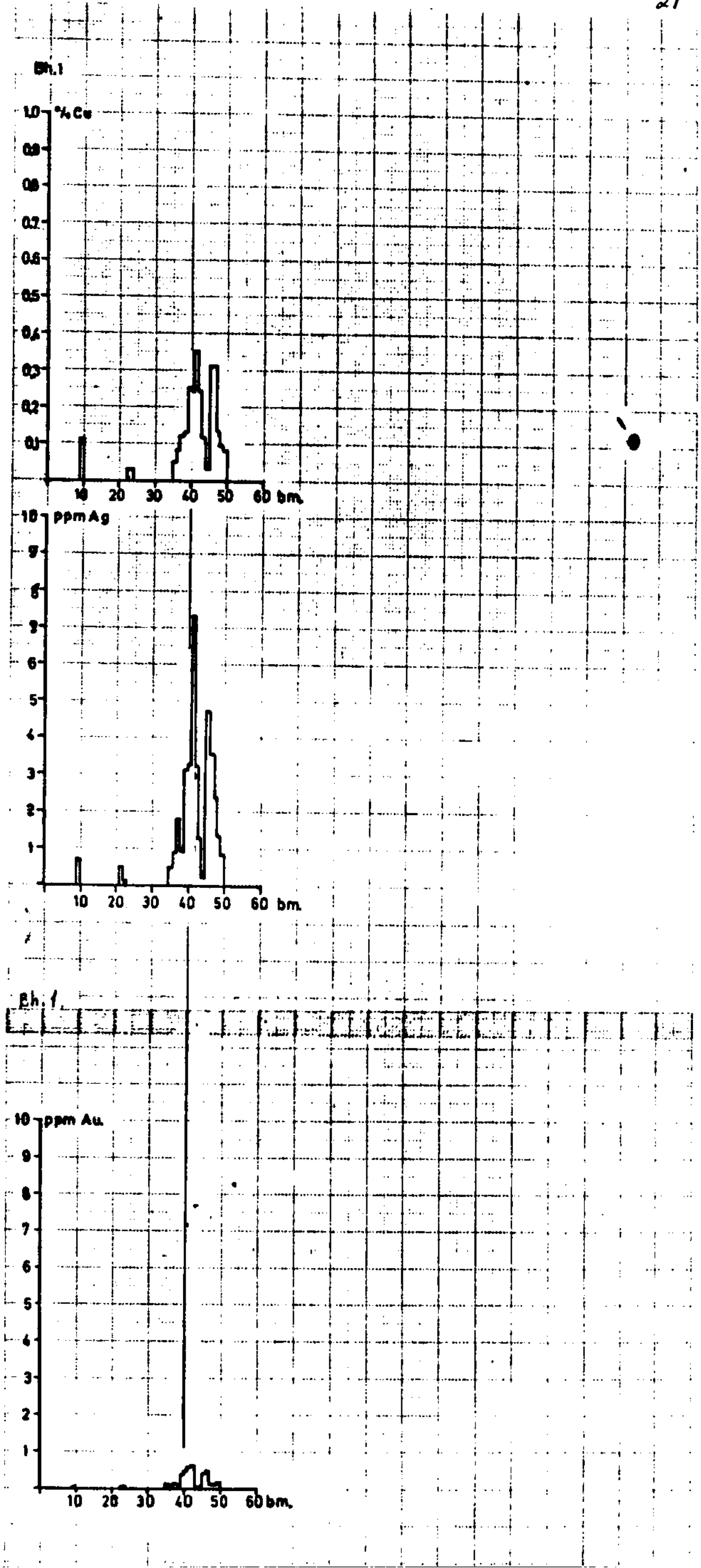
ANALYTICAL RESULTS FROM DRILLHOLES

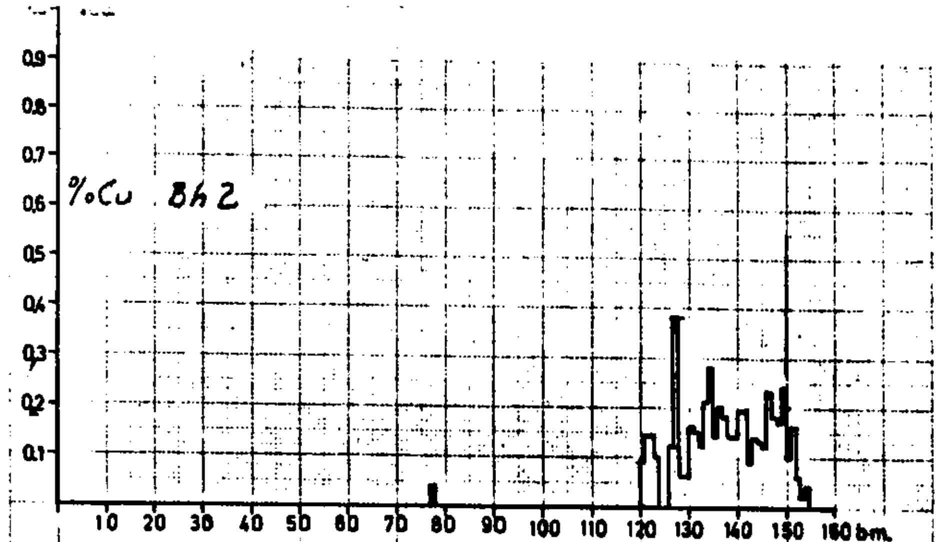
No. 1 - 8 Cu, Au, Ag, S

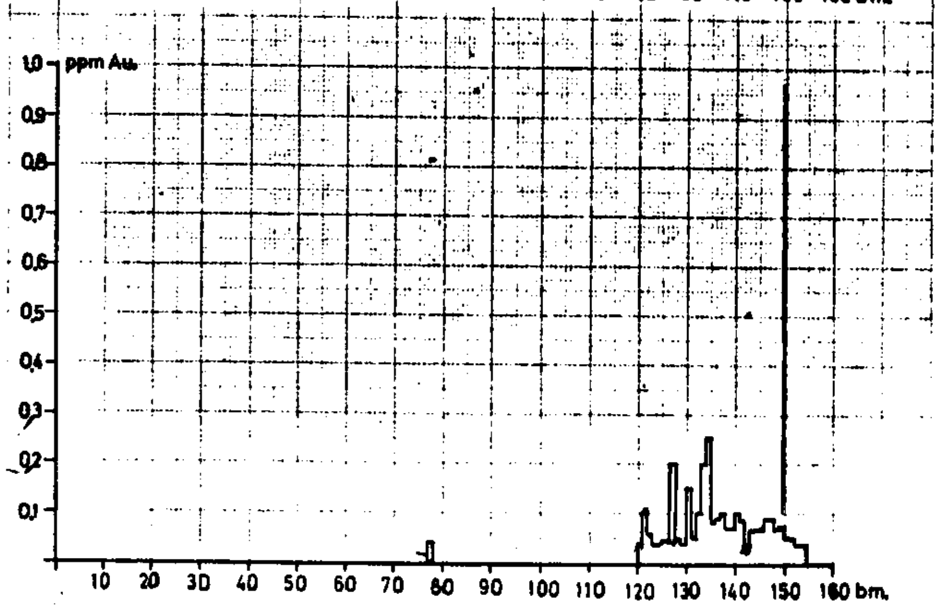

Bh 3
0 0,1 0,2 0,3 0,4 0,5 0,6 % Cu
0
50
100
150
200
1973
1976
298,5
Bh 2
0 0,1 0,2 0,3 0,4 % Cu
0
50
100
150
155,1
Bh 1
0 0,1 0,2 0,3 0,4 % Cu
0
50
98,7
Bh 6
0 0,1 0,2 0,3 0,4 0,5 % Cu
0
50
100
150
196
Bh 5
0 0,1 0,2 0,3 0,4 0,5 % Cu
0
50
100
150
200
231,3

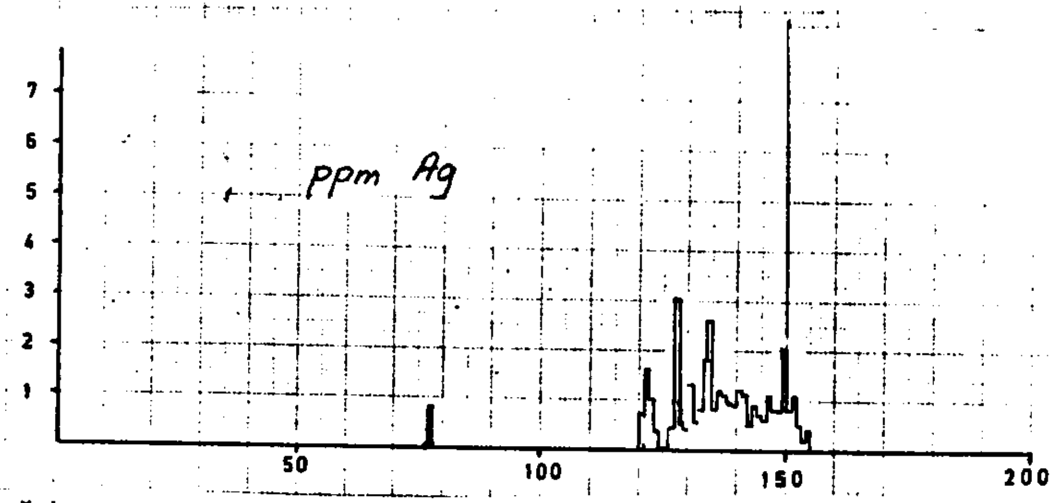

0,7 % Cu
0,6
0,5
0,4
0,3
0,2
0,1
0
Bh7
0
50
100
150
157,4

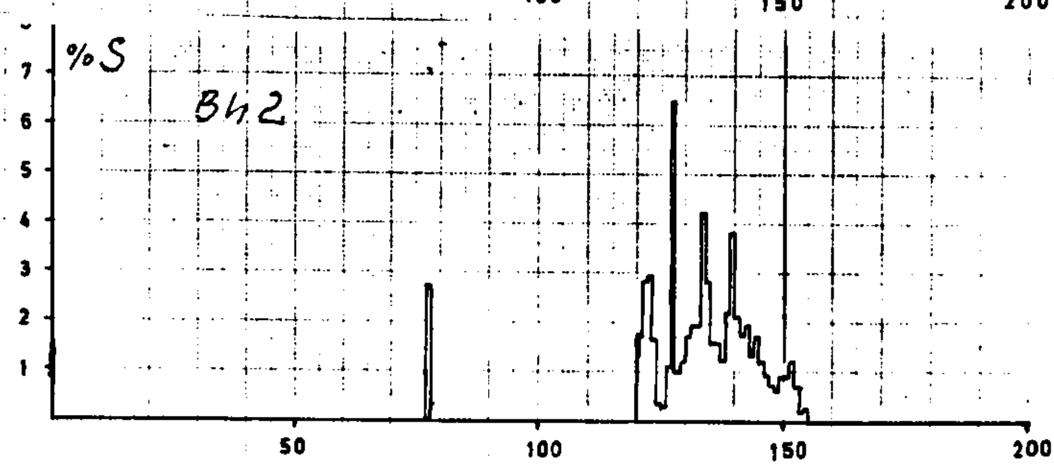

0,5 % Cu
0,4
0,3
0,2
0,1
0
Bh6
0
50
100
150
200
223,5

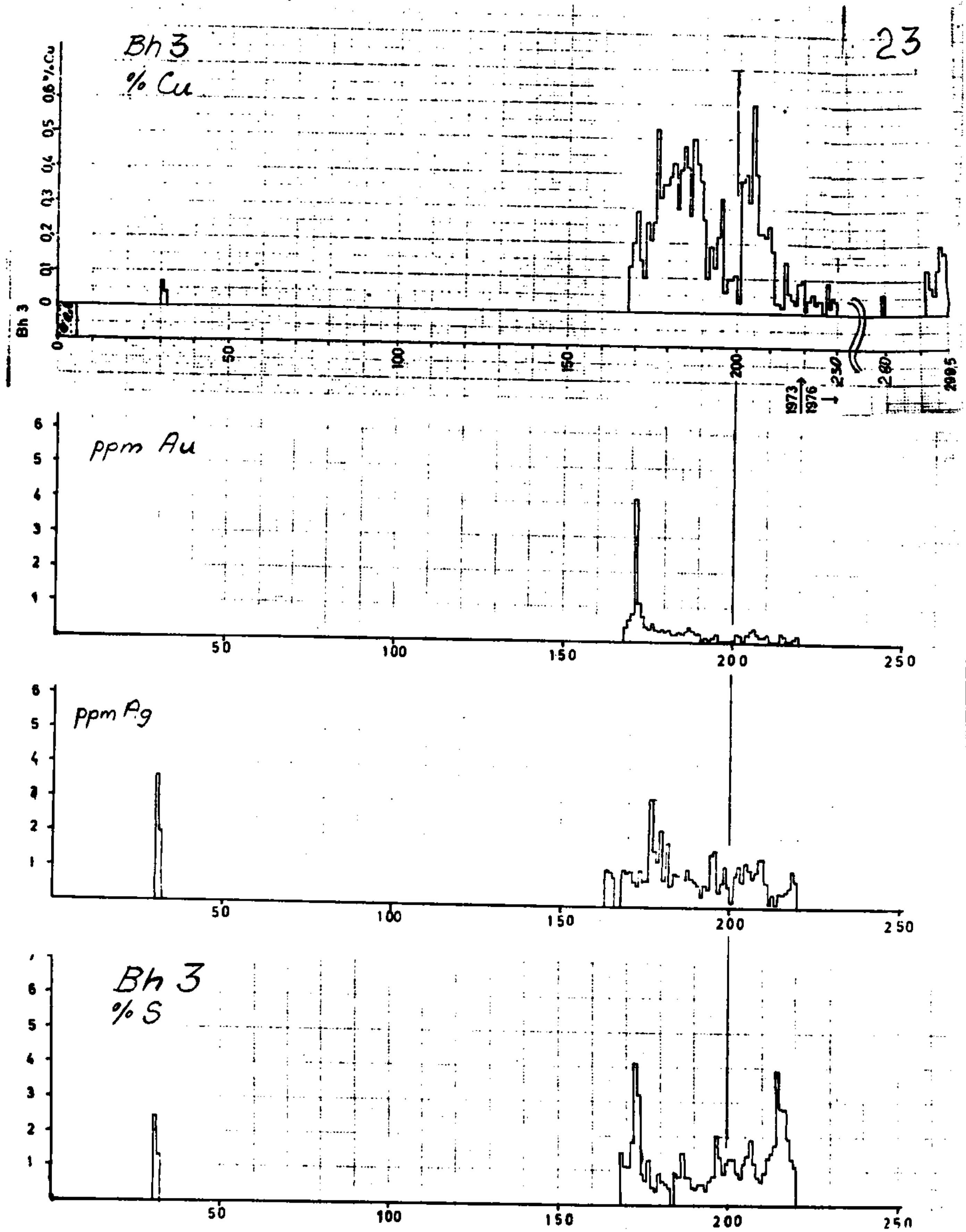

Bh.1
% Cu
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
10 20 30 40 50 60 bm.
ppm Ag
10
9
8
7
6
5
4
3
2
1
10 20 30 40 50 60 bm.
Bh. 1.
ppm Au.
10
9
8
7
6
5
4
3
2
1
10 20 30 40 50 60 bm.


%Cu Bh2
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 bm.


ppm Au.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 bm.


ppm Ag
7
6
5
4
3
2
1
50
100
150
200


%S
Bh2
7
6
5
4
3
2
1
50
100
150
200


Bh 3
% Cu
0.6 % Cu
0.5
0.4
0.3
0.2
0.1
0
Bh 3
0
50
100
150
200
250
280
298.5
1973
1976
ppm Au
6
5
4
3
2
1
50
100
150
200
250
ppm Ag
6
5
4
3
2
1
50
100
150
200
250
Bh 3
% S
6
5
4
3
2
1
50
100
150
200
250

CORE LOGS

Kjernerapport og boroversikt Raitevarre

1973:

Bh.	Dyp	Tidsrom	Skift	m/skift
1	98,7	4-10/8	7(langsk.)	≤ 13
2	155,05	13-29/8	19	8,2
3	220,15	1-21/9	32½	6,8
4	83,7	23-28/9	10½	8,0
Sum	557,60	4/8 - 28/9	69	8,1

1976:

5	231,3	27/7
6	196,0	
7	157,4	
8	223,5	
3	79,2	7/9
	887,4 m	27/7-7/9 = 43 dg - 6 fridg-8dg.flytt = 29 dg
		59 dg 58 sk.

): effekt 15,3 m/skift

Med andre ord - omtrent det dobbelte av effekten fra 1973 med nesten tilsvarende maskinen.

Bh 1 Start 4/8 ferdige 10/8. Dyp 99 m. 7 langskift. 13 m/skift.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
0 - 3,5		Overdekket		P.g.a. dypforvitring må det bores jordboring
				ned til 3,5 m. Spor Cpy i de grove kjernene som
				sannsynligvis er insituhublokk.
3,5 - 10	~ 90°			Lys dioritisk gneis med enkelte mørkere partier
				med amf., biotit og klorit. (Mulig også fuchsit
				ved 9,8 m) Oppspr. ca. 10 spr/m.
				Mineralisering: Spor Cpy nesten i hele kasser,
				men trolig ∠ 0,1 % Cu. Noe bedre 9,6 - 9,7 m
		0,11	9-10: Cu,Ag,Ni,Zn	med kloritt. Mørkt bløtt ertsminr ? ved 9,2 m.
				prøve.
10 - 20	~ 90°			Som foregående, men mindre Cpy.
				Prøve 10,8 m av mørkt ertsminr m/Cpy
				" 13,6 m av Py og Mk for kjem. analyse og slip.
20 - 30	~ 90°	0,03	22-30: Cu,Ag,Ni,Zn	Vesentlig kloritrik gneis.
		0,03	23-24: " " " "	Minr: Mye py og spor Cpy spesielt i forbindelse
				med kloriten. Analyse av 22-24 m. Noe MK.
		0,05 ÷	35-36: " " " "	
30 - 40	~ 80°	0,08 ÷	36-37: " " " "	Bergart: Gneis med tiltagende kloritinnhold
		0,12 +	37-38: " " " "	mot 40 m.
		0,13 +	38-39: " " " "	Minr: Spor Cpy 30-35 m. Mot 40 m sterkere spor
		0,25 +	39-40: " " " "	og tildels pen mineralisering med Spy og MK.
				Relativt lite Py. 38-39 ser ut til å være best.
				Prøve.
40-50		0,24	40-41: Cu,Ag,Ni,Zn	Bergart: Relativt mye klorit i gneisen.
		0,35	41-42: " " " "	Avtagende kloritinnh. mot 50 m.
		0,24	42-43: " " " "	Kvartsone 41.8 - 42 m.
		0,11	43-44: " " " "	Mineralisering: Stort sett pen impr. frem til 47,0 m
		0,03 +	44-45: " " " "	Prøve 41,4 og 46,1 av pen Cpy-minr. 44-45, 48-49
		0,31	45-46: " " " "	og 49-50 svakt impr.
		0,31	46-47: " " " "	
		0,13	47-48: " " " "	
		0,09 +	48-49: " " " "	
		0,09 +	49-50: " " " "	
50-60	~ 90°			Bergart: Grå gneis med jevn fordeling av klorit.
				Minr. : Svak impr. av Cpy. Beste impr. 50-52 m.
60-70				Bergart: Som foreg.
				Minr. : Litt MK og Py og kun svake spor av Cpy.
70-80				Bergart: Som foreg., men med klorit.
				Prøve fra 70,2 m med klorit, Py, MK og litt Cpy.
				Minr. : Litt py og MK med rike tydelige Cpy-spor.
80-90	80-90°			Bergart: Vanlig gneis 80-84,7 som foregående.
				84,7-90 granat-glimmergneis med kvartsøyne.
				Prøve 88,8 m.
				Minr. : Litt Cpy og MK i kvarts ved 82,6.
				Ellers meget svake kobberspor. Kan ikke se Cpy i
				granatgneisen. Forholdsvis lite pyrit.
90-98,7	80-90°			Bergart: Vesentlig granatgl.gneis m/kvartsøyne,
				men sonevis med den vanlige gneis og hydrothermal-
				kvartssonen.
				Minr.: Noe Py hele veien, men svært svake spor
				med Cpy og Mk.
				Hulldyp 99,0 m
				Kjernelengde 98,7 m

Bh. 2. Start 13/8 ferdig etter nattskift 29.8. Mask.havari 16/8-23/8) i 19 skift 8,2 m/skift.
(3 hele skift + mange små stopp 6 skift v/prakk)
Dyp 155,o5. (Vært oppe i 23 m/skift 12 m/skift effektivt)

Dyp	Lagdeling	Kjernetap	Analyse/prøve	Beskrivelse
0-5,0		overd.		Overd. ca. 2 m. 2 - 5 m dypforvitring.
5-10	~ 80°		6,7 : MK og Cpy i lys b.a. 9,05: Granat gl sk.	Bergart: Grov granatgl.sk. granater 1-2 cm. Soner med litt grafitt. Kis i soner med kvarts (?) og feltspat. Mineralisering: MK i soner med kvarts (?) og feltsp (prøve) MK også i granatgl.sk. Spor med Cpy. Litt grafit.
10-20	90°			Bergart: Som foregående 10-15,2. 15,2-20 etterhvert lysere bergart med spett av biotitt og diffuse granater. Mot 20 som en lys grå gneis. Mineralisering: MK 12,8 - 15,0 ~ 5 % kis. Mindre kis 15-20 m. 10-15 m litt (spor) grafit.
20-30	90°			Bergart: Vekslende granatførende gl.gneis. Lite granater fra 27 m. og soner med grønnstens-(klorit) materiale med kvarts og kalkspatsoner. På slutten enkelte blåkvartssoner. Minr.: Lite MK (spor)
30-40	80-90°		38,85 MK og sph ? 39,5 " " " ?	Bergart: Vekslende som foregående, men bare få granater. Fremdeles "blåkvarts" i klorit-sonene. Minr. : MK fra 3,7 - 40 i veksl. mengde ~ 10 % kis. Også sinkblende ? prøve. En del karbonat med kisen. Grafit 33,95 - 34,20.
40-50	80-90°		41,4 Granat m/korona	Bergart: Vesentlig grå til mørk grå gneis med med spredte granater og tildels kalkførende. Granatene har en lys reaksjonssone rundt seg. Minr.: Kun litt MK. Kan ikke se grafit.
50-60	80-90°		56,4 Veksl. Kv og kalksp. 54,8 Cp-ansaml.	Bergart: Som foreg., men mer skifrig og mindre granat. Flere kalkspatsoner på opptil 2-3 cm. Kalkspatsonene veksler med kvartssoner og gl. Betydelig med kalksp. i gneisen. Minr.: 54,6-56 veksl. grafit kalksp./kvarts med litt MK og spor Cpy, særlig med grafit. Prøve av største Cpy-ansamling.
60-70			66,3 Omv.granat	Bergart: Mørkere noe mer skifrig gneis. Kan ikke se granater, men hvite spetter som kan tenkes å være omv. granater. Joda, det stemmer det ! kan se granatrelikter i de hvite minr.ansamlingene. (Prøve) se prøve 41,4. Flere grafitrike soner. Tekt: Knusesoner 63,9-64,3, 65,4-65,5, 66,4-66,6, 68,o-68,1, 68,4-69,o, 69,6-70,o. Delvis breksiert fra 64-70 m. Minr.: Grafitsoner i hele kassen fra få cm opp til ca. 1 m (nesten sammenhengende 61,5-62,5). En del MK og noe Cpy i breksjesonene med kalkspat og euhedral kvarts. (Prøve) ∠ 5 % sulfider i kassen.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
70-80	~ 90°		76,95-77,03: Minr. m/høy glans i grafit 77-78: Cu,Ni,Ag,Zn	Bergart: Grafitskifer og kalksten("kalkgneis") 71,6-75,9. Kalkgneis også som soner i grafitskiferen. Tekt: En del knusesoner og breksiering, men ikke så mye som i foregående kasse. Minr.: Grafit-rik skifer 70-71,6, 71,9-72,2, 75,8-80, med litt kalk 78-78,5. Litt Cpy hele veien i grafitsk. på speil. Ubestemt minr. med høy glans i grafitsk. Prøve. Py på små (∠ 1 cm) ganger med Kv og kalksp. Tar ut 77-78 til analyse.
80-90	90°			Bergart: Grafitsk 80-83,1, 86,2-86,5 med noe kalk på samme måte som foreg. kasse. 83,1-86,5 vekslende kalkgn. og granatførende vanlig grå gneis. Granater m/korona. 86,5-90 vanlig grå gl.gn. med granater m/korona. Minr.: I grafitsk. Cpy på speil som foreg. I gneisen også pene Cpy-spor, men på sprekker med MK
90-100	70-90°			Bergart: Vesentlig grå gn. m/granater. Enkelte kvarts og kalkspatsoner. Minr.: Litt MK og litt Cpy (spor). Hurtig oksidering på MK ! Belegg etter bare 2-3 dg !
100-110	90°			Bergart: Som foreg. samt en del biotit og klorit. Minr.: Litt MK og spor Cpy spes. på sprekker i lysere partier (kvartsitrike).
110-120	70-90°			Bergart: Grå gn. m/omv. granater samt endel biotit og klorit. Kloritsone 112,7-114,7. Minr.: Litt Mk. Kan ikke se Cpy.
120-130			122,2: MK,Cpy 121,9: Cpy,Mk (Py)	Bergart: Grå gn. med flekker som trolig har vært granater + granater ! En del biotit. Tekt : Breksje 120,120,6. Kittet sammen med kalkspat. Minr.: Cpy-soner: 120-122,9 , 127,6-130. Siste sone har en del py m/Cpy.
		÷	120 -121 : Cu,Ni,Zn,Ag	
		0,2	121 -122 : " " " "	
		rel. lite	122 -122,9: " " " "	
		0	122,9-124 : " " " "	
		0	124 -125 : " " " "	
		0	125 -126,6: " " " "	
		0	126,6-127,6: " " " "	
		>0,3	127,6-128 : " " " "	
		÷	128 -129 : " " " "	
		÷	129 -130 : " " " "	
130-140	70-90°		130 - 131 : " " " "	Bergart: Grå gneis m/muskovit og biotit. Kan ikke se granat. Minr.: 130-140 m mer eller mindre impregnert med Cpy, Cpy-holdig py og MK. Alle 10 m må analyseres.
			131 - 132 : " " " "	
			132 - 133 : " " " "	
			133 - 134 : " " " "	
			134 - 135 : " " " "	
			135 - 136 : " " " "	
			136 - 137 : " " " "	
			137 - 138 : " " " "	
			138 - 139 : " " " "	
			139 - 140 : " " " "	
			140,0: Py og Cpy 137,5: Py, MK og Cpy	

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
	(140-140,5 45° !		146,6: Gn.m/"kvartsøyne",MK,Cpy 143,2: Gl.gn m/Py,Cpy	
140-150	$70-90^{\circ}$		+140,141: Cu,Ni,Zn,Ag +141-142: " " " " +142-143: " " " " +143-144: " " " " +144-145: " " " " +145-146: " " " " +146-147: " " " " +147-148: " " " " o 148-149: " " " " +149-150: " " " "	Bergart: Grå gneis. Kan ikke se granat, men "kvartsøyne" som kan minne om omvandlede granater (prøve). Spetter med klorit og soner med biotit og muskovit. Minr.: Mineralisert som i forrige kasse med Cpy-holdig Py, Py, Cpy og Mk. Hull - Dyp = Kjernelengde.
150-155,05			151,9: Lys gn.m/klorit MK,PY,Cpy 152,6: Gn spettet m.klorit eller amf. ? 155,05: Gl.gn.m/granat+Cpy +150-151: Cu,Ni,Ag,Zn +151-152: " " " " +152-153: " " " " o 153,154: " " " " o 154-155: " " " "	Bergart: 150-153,4 som før med spetter av klorit (eller amfibol ?) Prøve. Muligens noe granatrelikter nærmere 153,4 m. 153,4 - 155,05 en gl.gn. med rikelig med granater (prøve). Minr.: Svakere med Cpy enn i siste kasse. Svakere spor når granatene kommer inn, men pen Cpy-Mk-stripe ved 154,4. Dette hullet burde ha vært kjørt lenger, men ble avblåst p.g.a. dynamosvikt og pumpefestesvikt. Maskinen ble flyttet mens dette ble reparert for å utnytte tiden.

Bh. 3. Start 1/9, ferdig 21/9. Helg 7-10/9): 32 ½ skift. Hulldyp 220,15
): 6,8 m/skift

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
0-5,5				Overdekket og grov kjerneboring.
5,5-10				Bergart: Granatgn. 5,5-7,7 og 9-10 m/kvartsøyne som er omv. granat og med granat. Grafitisk:7,7-9 sterkt grafitholdig. Minr.: Intet.
10-20				Bergart: Granatgn. m. klorit og amf.: 10-16,7, 16,9-17,2, 17,25-17,35, 19,3-19,5. Feit grafitsk. 16,7-16,9, 17,2-17,25, 17,35-19,3, 19,5-20. Minr.: Intet. Spor av MK i grafit.
20-30	$70-85^{\circ}$ mest 70°		22,7-22,9: Grafitsk. og gn.m/ MK,Cpy,Sph.	Bergart: Grafitsk. med noen få striper gneis Veksl. grafitinnh. Minr.: Pene spor av MK, Sph, Spy spesielt i de lysere partier på sprekker og i tynne lag.
30-40	$67-70^{\circ}$		30-31: Cu,Zn,Ni,Ag 31-32: " " " " 38,6: Grafitsk. m/MK,Cpy,Sph.	Bergart: Grafitsk. veksl. type og mørke partier. Tekt.: Breksjesone (sammenkittet m/kvarts: 32-32,2) Minr.: Som foregående m/MK Cpy og litt Sph. spesielt i de lyseste partier.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
40-50	47°,60°,73°		42,05: Py,MK,Sph,Cpy	Bergart: Grafitsk. 40-44,2, 44,8-44,9, 45,05-46,2, 49,8-50. Grå gneis m/granat, omvandl. granat ("kvartsøyne") gl. klorit, amf. i 44,2-44,8, 44,9-45,05, 46,2-49,9. Minr.: Som 30-40 m, men noe mer py. Kalkspatfyllinger.
50-60	60°,67°		52,8: Grafitsk.-gneis 53,5: Grafitsk./m.Cpy	Bergart: Grafitsk. veksl. lys og mørk. Der den er lys ligner den gneisen med omv. granater + litt grafit (prøve). Tekt.: Breksje sammenkittet m/kvarts: 50-50,2, 53,7-54,3. Flere knusesoner. Minr.: En del pene spor med Cpy og MK. Prøve 53,5.
60-70	60°,68°,45°			Bergart: Grafitsk. lys type fra 64-70 m. Tekt.: Knusesone 66,7-67,o. Minr.: Litt Cpy (spor) og MK. Mindre enn foreg. kasse.
70-80	60,60,52,45°			Bergart: Veksl. grafitsk. og grå gn. med og uten grafit. Tekt.: Noen knusesoner. Minr.: Litt MK, py, Cpy, Sph (spor)
80 - 90	80°,63°,63°			Bergart: Grå gneis m/granat 80-82,7, 86,7-90 med et parti små graftisoner. Grafitsk og grå gneis i veksl. 82,7-86,7. Tekt.: Knusesoner (6 stk) 10-40 cm fra 83-89 m. Minr.: Kun svake Cpy-spor + MK og py.
90 -100	66°(?), 70°(?)			Bergart: Biotit-granatgneis. Minr.: Ikke spor.
100-110	?		102,7: Granat m.omv.sone	Bergart: Som foreg. Granatstørrelsen vekslende helt opp i 1 cm. Noen steder omv. sone rundt granatene. Prøve. Minr.: Ikke spor.
110-120	100°,90°, 100°		114,6: Grønt minr. Kalksp?	Bergart: Veksl. grafitsk., grafitholdig gn. og gn. m/granat ca. 50/50. Soner med grønt minr. Kalkspat? litt for hardt. Også granater i grafithorisonter. Tekt.: Breksje sammenkittet 1o7,4-108,10. Ellers flere knusesoner. Minr.: Spor Cpy og litt MK særlig i forb. med sprekker og breksjesoner.
120-130	80°,80°, 100°			Bergart: Veksl. grafitsk og granatgneis som foreg. dog mest gneis (≲ 2,5 m grafitsk) Tekt.: Breksje sammenkittet 120,7-121,4, knusesone: 122,5-122,8. Minr.: Kun spor Cpy + MK og Py litt.
130-140	100°,90°, 80°,100°			Bergart: Biotitgn. med litt granater i beg. som etter hvert blir borte. Litt grafitsk og gneis 132-134 og 135,5-135,8. Minr.: Spor Cpy i forb. med grafitsonene.
140-150	?		143,o: Klorit	Bergart: Granat-biotit gneis med kraftige kloritsoner 141,5-144,5, 146,3-147. Granatene er delvis omv. m/korona av kvarts(?) Minr.: Kun spor av MK og Cpy.
150-160	90°		156,7: Gneis m/kloritspetter	Bergart: Grå biotitgneis med kun få granater, men spekket med kloritspetter. Minr.: Kun spor Cpy.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
160-170	?		168-169: Cu,Zn,Ni,Ag 169-170: " " " "	Bergart: Grå gn. grovspettet m/klorit. Noe mindre klorit fra 166 m. Minr.: Litt Cpy og py fra 166 m. Sanns ≤ 0,10 % Cu. Cpy rose 166,8.
170-180	80°,70°, 80°,100°		172,5: Klorit-musk.-cericit-bergart m/Cpy, MK, Py. 173-174: Cu,Ni,Zn,Ag 175-176: " " " " 176-177: " " " "	Bergart: Lys gl.gneis (skifer) med mye muskovit (cericit) stedvis grønt + kloritsoner. Minr.: Cpy, Mk, Py flekkvis i bestemte soner. 5-10 cm. Disse utgjør lite totalt. Stedvis også betydelig med Py. Lite MK. Cpy finnes også utenom de anal. soner muligens på samme nivå, men svak mineralisering
180-190	70°,80°,100°		189,1: Kvartsit 180-181: Cu. 181-182 182-183 183-184 184-185 185-186 186-187 187-188 188-189 189-190	Bergart: Lys gn. m/klorit. amf.gl. m/granat. Kvartsitisk type på slutten. Minr.: Cpy i hele kassen 0,1-0,2 % Cu.
190-200	?		192,0: Amf.gn. 190-191: Cu 191-192 192-193 193-194 194-195 195-196 196-197 197-198	Bergart: Gneis med amf. og klorit. biotit og cericit. Minr.: Svak Cpy - Py - minr. 190-198 ~0,1 % Cu.
200-210			202,5: Cericit m/Cpy - 200-201: Cu o 201-202 + 202-203 + 203-204 + 204-205 o 205-206 o 206-207 o 207-208 o 208-209 o 209-210	Bergart: Amf. gneis m/klorit, kvarts, cericit. Minr.: Pen Cpy-impr. særlig 202-205 m, men hele kassen må anal.
210-220,15	100°(?)		214-215: Cu 215,3: Musk.-cericitgn.m/ py og spor (?) Cpy.	Bergart: Cericit (musk) - klorit - gneis m/amf. Minr.: Vesentlig py, men også litt Cpy. (0,1 %). Tar stikkprøveanalyse av en av de beste metre.

1976. Forlengelse av Bh. 3 fra 219,3 - 300 m.

Dyp	Sp/pr.m	Analyse	Beskrivelse
219,3-220	5		Ba. lys glimmerrik gneis.
220 - 230			Mineral. imp. svovelkis
230 - 240	5		Ba. 230.0-230,9 som foregående kasse. 230,9-240 vekslende dioritisk gneis med granat Mi. imp. svovelkis.
240-250	5		Som foreg. m.svake spor Cu på siste m.
250-260	5		" " vekslende med lys gneis.
260-270	5		Ba. 260-268,0 som foregående, 268,0-270 - Kloritrik gneis. Mi. imp. svovelkis.
270-280	5	279-280,0: Cu	Ba. 270-272,5 Kloritrik gneis. 272,5-280,0 vekslende kloritgneis (spetter) granatførende. Mi. imp. svovelkis, 272,6-272,9 gode spor Cu + svake spor i to siste m.
280-290	5		Ba. som foreg.(med granat og klorit spetter) Mi. 280-280,5 imp. svovelkis med god spor Cu. 208,5 -290 imp. svovelkis.
290-300	5	297,0-298,0: Cu	Ba. som foregående. Mi. imp. svovelkis 292,0-298,5 spor Cu beste m til analyse.

250°-70° SN Bh. 4 Start 23/9 ferdig 28/9 10 1/2 skift. Dyp 83,7 : 8,0 m/skift

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
0-10	100°,50°		7-8 : Cu 8-9 : " 9-10: " 8,7 Py i cericitisk gn.	0-3,0 overdekket Bergart: Gneis m/amf. noen granater. Kraftig cerisitisert (muskovit flak). Minr.: Mer og mindre Py-førende 5-10 % Py som stedvis er gullig og følgelig trolig fører noe Cu. Mest py fra 7,0-10 m.
10-20			10,8: Py i cericitisk gn. 10-11: Cu 11-12: 12-13: 13-14: 14-15:	Bergart: Gneis lys vekslende, men mest cericitrik med amf. og granater (+ klorit) Minr.: Py hele veien, men mest 10-15 m. Noen få grafitkorn.
20-30			20-21: Cu 21-22: " 29-30: "	Bergart: Som foregående. Minr.: Py som foreg. Hele kassen reanalyseres hvis Cu.
30-40			30-31: Cu 31-32: " 34-35: "	Bergart: Som før. Minr.: Py som før, mest 30-35. Gedigent Cu 30,90! Hele kassen reanalyseres hvis Cu.
40- 50			41-42: Cu 42-43: " 41,3 :	Bergart: Som før, men mindre py. Mye klorit. Minr.: Noe mindre Py enn tidligere. Kan se spor MK og Cpy. Anal. alt hvis Cu.
50-60	~ 100°		50-51 51-52 52,7 : MK i klorit	Bergart: Klorit -amf.-granat gneis. Lik tidligere gneis, men noe mindre cericit-muskovit. Minr.: Py som før. En del MK i klorit 52,3-53.
60-70	80 - 100		64,9 : Py - Cpy 60-61: Cu 61-62 62-63 63-64 64-65 65-66 66-67 67-68, 68-69, 69-70.	Bergart: Som før, noe mer sliret p.g.a. stedvis store granater. Minr.: Kvartssone 64-64,5. Pen Cpy minr. 64,5-65. Eller en god del gul py.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
70-80	?		70-71: Cu 71-72 72-73 73-74 74-75 75-76 76-77 70,6: Py-Cpy	<u>Bergart</u>: Grå gneis m/granat. <u>Klorit</u> amf. <u>Minr.</u>: Tildels <u>pen</u> Cpy-holdig py fra 70-77 m. Dog sterkt vekslende. Også en del flekker med MK. Analyse 70-77 m.
80-83,7	80-100°	∠0,05 Cu	80-81: Cu 81-82: " 83,0 : Granatgn. m/MK,py,Cpy	<u>Bergart</u>: Grå gneis sliret, som etter hvert blir sterkt granatførende. <u>Minr.</u>: Lite Py, men den ser ut til å inneholde Cpy. Litt Mk.

<u>Bh. 5.</u>

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
8-10	70-80°	8 m o.d.		<u>Ba:</u> Veksl. dior. gneis og amf.-klorit gneis. Kan ikke se granat. I den grove kjernen sees litt grafitskifer.
10-20	60-80°	8 spr.m	0 17-18 Cu 0,0 18-19 " 0,0 19-20 "	<u>Ba:</u> som foregående. <u>Minr.:</u> Meget fink. Cpy 18-20 m og litt MK. Ellers spor av py.
20-30		9 "	20-30 " (en pr. m)	<u>Ba:</u> Ves. dior. gn. Kvartsførende 28-28,6 en kloritisk sone. <u>Minr.</u>: Cpy i veksl. mengde, men ofte <u>meget</u> fink. Enkelte klyser i forts. m/kvartsroser og kloritsoner.
30-40		12 "	30-40 " "	<u>Ba:</u> Homogen dioritisk gneis. <u>Minr.</u>: Spor Cpy. Svakt fra 36-40, men hele kassen må analyseres. Noen striper med flusspat
40-50		5 "	40-41 "	<u>Ba:</u> Dior. gn. m/amf. og klorit. Litt granat fra ca. 46 m. <u>Minr.</u>: Meget lite Cpy 40-46 m. 3-4 ~/cm CaF_2 - kvarts. NB! Ikke CaF_2, men anhyd
50-60		4 "		<u>Ba:</u> Dioritisk gn.(m/amf) m/klorit og kvarts og granat. <u>Minr.</u>: Litt Py og meget svake spor MK og Cpy.
60-70		5 "		<u>Ba:</u> Dioritisk gn. m/amf, klorit, kvarts og spor granat. <u>Minr.</u>: Litt py + spor MK og Cpy. Typeprøve av Py-sone v/66,8 og Cpy-stripe ved 64,3 m.
70-80		3		<u>Ba:</u> Dioritisk gn. m/amf., klorit, granat og rel. mye kvarts. Enkelte 3-5cm kvartssoner. <u>Minr.</u>: Litt py og meget svake spor MK og Cpy.
80-90		3		<u>Ba:</u> Dioritisk gn. m/a mf., klorit, kvarts (ikke granat). <u>Minr.</u>: Jevnt m/Py.
90-100		6	o 91-92,3 Cu 0,10 0,1 92,3-94 " 0,15	<u>Ba:</u> Dioritisk (amf.) gneis mer vekslende enn foregående. En del kvarts og klorit. <u>Minr.</u>: Fra 92,3 Cpy (lite) og Py samt noen striper <u>CaF_2</u>. Nei anhydrit. Hele kassen må anal. hvis dette gir resultat.
100-110		5	102-103,5 Cu,Pb,Ag 103,5-105 " 105-106 " 106-107 " 107-108 " 108-109 " 109-110 "	<u>Ba:</u> Dior. gn. med en del kvarts, amf. og klorit. <u>Minr.</u>: Py i hele kassen. Fra 103,5-110 Cpy, py og spor blyglans.

Dyp	Lagdeling	spr./m	Analyse		Beskrivelse
110-120		7	110-120	Cu	<u>Ba:</u> Dior. gn. m. kvarts, muskovit, klorit og amf. (ikke granat) <u>Minr.</u>: Cpy, MK, Py. Bra med Cpy 111-118. Lite 118-120, men hele kassen må anal. Pene ansaml. Cpy i kvartssoner ofte med litt MK.
120-130		4	120-127	Cu	<u>Ba:</u> Dior. gn. forholdsvis homogen med enkelte kvartssoner. Granat fra ca. 125,7. Ellers klorit, amf. Noe Cr-glimmer litt <u>Minr.</u>: Litt Cpy 120-127. Ellers mest Py og
130-140		8	130-131	Cu	<u>Ba:</u> Dior. gn. m/kvartssoner på opptil 0,7 m Musk. sk. Ba er svakt granatførende med noe amf. og klorit. <u>Minr.</u>: Svært lite Cpy, men spor i hele kassen. Tar en stikkprøveanalyse 130-131. Mot 140 vesentlig Py. Litt MK og noen roser CaF_2 (nei anhydrit) i kvartssonene.
140-150		6	146-146,7 146,7-148 148-149 149-150	Pb,Ag,Cu " " " " " " " " "	<u>Ba:</u> Lys dioritisk gn. Mye glimmer (Glimmersk) <u>Minr.</u>: Py. Blyglans fra 146,7-150, men en tydelig sone PbS fra 146,7-148. Spor Cpy <u>Tekt</u>: En kan se at det har vært bevegelse i minr. Pb-sone med bl.a. kalkspatutfellinger
150-160			159-160	Cu	<u>Ba:</u> Dior. gn. med spetter av h.bl. som delvis er omv. til klorit. + kvarts. <u>Minr.</u>: Svake spor Pbs i <u>tekt. sone</u> 150-154,3. Dette må evt. analyseres hvis 148-150 slår til Ellers spor Cpy spes. mot 160 m. Stikkprøve 159-160. En del py. En god del CaF_2 (nei anhydrit) i tekt. sone spes. ved 151,5.
160-170		3	160-161	Cu	<u>Ba:</u> Som foregående. <u>Minr.</u>: Litt Cpy spes. 160-161 i et kloritrikt mørkt parti. Ellers for det meste py og spor MK. Stjerner Cpy i hele kassen. 10 cm CaF_2 ved 165,1.
170-180		3			<u>Ba:</u> Som foregående. <u>Minr.</u>: Ves. py, men enkelte korn Cpy. 10 cm pen Cpy- minr. ved 172,6-172,7.
180-190		3			<u>Ba:</u> Som foreg., men noe granat + fuchsit. <u>Minr.</u>: Ves. py og MK, men spor Cpy.
190-200		3	197-198 198-199 199-200	Cu	<u>Ba:</u> Som foreg. <u>Minr.</u>: Cpy 190-191,3 og 197-200 0,2 % Cu og litt spor i mellom samt en del py + litt MK.
200-210		4	200-201 209-210,6		<u>Ba:</u> Homogen dior. gn. En del klorit og litt granat. <u>Minr.</u>: I forb. med kloritrike soner noe Cpy i hele kassen + Py.
210-220		4			<u>Ba:</u> Litt granat i dior. gn. Amfibolit 210,6-212,3. <u>Minr.</u>: "Sonen" forts. med litt Cpy frem til amfiboliten ved 210,6. Ellers er det litt py og spor Cpy.
220-231,3		3			<u>Ba:</u> Dior. gn. m. litt granat. Amf. 221,5-222,8. <u>Minr.</u>: Litt py og spor Cpy men stort sett svært lite.

Bh. 6.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
0-10	0-5,9 O.d.	6	5,9-7 : Cu,Ag (Pb) 7 - 8 : " " 8 - 9 : " " 9 -10 : " "	Ba: Lys dioritisk gn. m/spetter av delvis omv. amf. (i klorit). Opptil 10 cm's "rustsoner" nær sprekker p.g.a. dypforvitring Minr.: Jevnt impr. med en meget fink. Cpy. Kan også se et blankt minr. AgS ? Nei !
10-20		6	10-20 : " " "Ikke" tatt med (15-20 svak) i første omg.	Ba: Som foreg. Noe fuchsit. Minr.: Som foreg. frem til ca. 15 m, men hele kassen bør anal. Ved 13,05 et mørkt minr. m/høy glans AgS ? Nei !
20-30		4	20-30 : Cu	Ba: Dioritisk spettet gn. homogen m/amf. omv. til klorit. Minr.: Jevnt impr. med Cpy og svært lite py.
30-40		7	30-40: Cu Ag	Ba: Som foreg. Minr.: Svakt med Cpy fra 30-35, men noe bedre 35-40. Ved 33,6, 34,7 og 38,9 svart mykt minr. MoS_2 ? AgS ? Nei ! Fahlerts ? Prøver.
40-50		8		Ba: Som foreg. Minr.: Svake spor Cpy og litt py. Pen stripe av det ukjente minr. ved 40,6 (prøve). Ikke analyse av denne kassen, men den bør anal. hvis 30-40 har interesse. Cu- innh.
50-60		7	59-60: Cu	Ba: Som foreg. Fuchsit ved 56,3 Minr.: Spor Cpy i hele kassen. Stikkprøve-analyse. Ellers litt pen py og spor MK.
60-70		7	60-61 : Cu	Ba: Som foreg., men noe lysere. Minr.: Spor Cpy i hele kassen. Stikkprøve-analyse. Ellers litt py og MK. Kvartssoner 61,7-62,4, 67,4-67,6.
70-80		7		Ba: Forskifret gn. med mye musk. og klorit, men også den typiske spettete dior.gn. Litt fuchsit Au ! Nei ! Minr.: Pyrit rel. mye (3-5 %). Svært lik foreg. kasse.
80-90		6		
90-100		4		Ba: Dior.gn. litt forskifret. Minr.: ~ 5 % Py.
100-110		6		Ba: Dior.gn. m/granat som ved ca. 105 m går over i en forskifret type m/Fuchsit. Minr.: En del py (3-5 %) i hele kassen. Litt Cpy fra 100-102. < 0,1 %
110-120		6		Ba: Dior.gn. m/kun spor av granat. Minr.: Spor Cpy spes. i beg. av kassen og en del py og MK 3-5 %.
120-130		5		Ba: Dior. gn. Minr.: Spor Cpy. Spor (dråper) av ZnS mørk type og 3-5 % MK og Py.
130-140		8		Ba: Dior.gn. Minr.: Py og Mk 3 - 5 %

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
140-150		8	142,7-144 : Cu 144 -150 : "	Ba: 140-143 tett dior. gn. m/små granater. Senere mer lys og forskifret. Minr.: Py i hele kassen. Fra 142,7 litt Cpy. Tar anal. ut denne kassen.
150-160				Ba: Dior.gn. m/granat fra 152 m. Minr.: Svært lite Cpy. Noe bedre 159-160. Py og MK ~ 1-3 %.
160-170		4		Ba: Dior. gn. m. granat til 164 m ellers den typiske dioriten. Minr.: Spor Cpy. ~ 1 % py. Tydelig mindre svovel nå.
170-180		4	170 - 171 : Cu 171 - 172 : "	Ba: Dior. gn. typisk med tildels store h. bl. (klorit) - lister. Litt granat. Minr.: Cpy (litt) i hele kassen. Mest til å beg. med. Prøve anal. de to første metre. Ellers py og MK.
180-190		4		Ba: Dior. gn. m/granat. Mye granat spes. fra 186 m. Minr.: Svake spor Cpy eller lite Py og MK.
190-196		6		Ba: Granatrik dioritisk gn. m/lister av gr. hornbl. (klorit) og kloritsoner. Minr.: Py og MK.

Bh. 7

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
3-10	0-3 o.d.	12		Ba: Lys utlutet dior. gn. spes. fra 3-6 m. Minr.: Kun spor Py.
10-20		15	10-20 : Cu	Ba: Lys dior. gn. Minr.: Fra ca. 11 m Cpy som i de første metre er omv. til malakit. Litt py og mobilisert grafit (?)
20-30		8	20-21,3: Cu 0,72 21,3-22: Cu o 0,05 22-23 : Cu o 0,01	Ba: Lys dior.gn. 20-21,3. 21,3-30 granatførende kloritrik gn. Minr.: Pent Cpy-minr. 20-21,3. Senere fritt for Cpy. Bare litt py og MK.
30-40		6	35-36 : Cu 36-37 : 37-38 : 38-39 : 39-40 :	Ba: Granatførende kloritisk gn. 30-35,0. 35-40 lys noe skifrig dior.gn. 35-36 en kloritrik sone med vel mye Py, MK og Cpy. Minr.: Cpy 35-40 (~ 0,1 %) ellers en del Py og MK.
40-50		8		Ba: Dior. gn. Minr.: Spor Cpy i hele kassen og litt Py. Må analyseres hvis 36-40 glimter til.
50-60		10	57-58 : Cu (evt. Ag) 58-59 : " 59-60 : "	Ba: Dior. gn. 57-59 et amf. og kloritrikt parti. Minr.: Svake spor Cpy. Noe bedre 57-60. Ved 57,2 svart blankt minr. Ellers noe Py og MK.
60-70		6		Ba: Lys dior. gn. Minr.: Cpy - MK ansaml. ved 67,05. Litt Cpy-impr. videre 0,3 m. Ellers er det bare spor Cpy i kassen. Lite Py og MK.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
70-80		4	74-80 : Cu	Ba: Dior. gn. med rek. mye klorit fra ca. 75 m. Minr.: Litt Cpy i hele kassen. Noe "mer" fra ca. 75 m. Lite Py og MK.
80-90		5	?	Ba: Dior. gn. Minr.: Cpy i hele kassen, men for lite. Bør analyseres hvis 74-80 glimter til. Litt MK og Py.
90-100		4	96-100 : Cu	Ba: Lys dior. gn. Minr.: Litt Cpy spes. fra 97-100. Meget finimpr. Lite MK og Py.
100-110		4	100-110 : Cu (Ag ?)	Ba: Lys dior. gn. m/noen fuchsitstriper. Minr.: Svakt impr. m/ Cpy i hele kassen, men vel svakt. Noe bedre de siste 4 m. Mener jeg ser det blanke minr. Lite py og MK.
110-120		6	110-117 : Cu	Ba: Dior. gn. m/ endel klorit. Litt fuchsit. Minr.: Forholdsvis mye Py, litt MK og Cpy. Svært lite Cpy de siste 3 m. (Bra 110-111 m)
120-130		5		Ba: Som foreg. Minr.: Mye (5 %) Py ikke Cpy.
130-140		5		Ba: Lys dior.gn. litt forskifret. Minr.: Py ~ 3 %. Kun meget svake spor Cpy.
140-150		4		Ba: Lys dior. gn. (typisk) prøve Minr.: Litt py og MK, ellers kun helt svake spor Cpy.
150-157,4		6		Ba: Lys noe forskifret dior. gn. m/litt fuchsit. Minr.: Litt py og MK.

Bh. 8

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
0-10	0-5 o.d.	10		Ba: Lys dior. gn. m/granat i veksl. m/ svartsk. svartsk ikke radioaktiv. Minr.: MK i svartsk. ikke Ni-utslag med dimetkylglyoksim på friske kjerner.
10-20		8		Ba: 10-12,4 svartsk og 12.4-20 grå dioritisk gn. m. små røde granater. Minr.: MK i svartsk.
20-30		7		Ba: Svartsk (40 %) i veksl. m/ grå granatførende dior. gn. Svartsk 29,3-30. Minr.: MK i svartsk.
30-40	∢ 80°	20		Ba: Svartsk 30-34,8. 34,8-40 granatførende gn. med opptil 0,5 cm granatporfyroblaster forskj. fra foregående der granatene var svært små. Granatene er også omvandlet (i kvarts). Ikke radioaktiv.
40-50		6		Ba: Dioritisk gn. med store tildels omvandlete granatporfyroblaster.
50-60		12		Ba: Gneis m/grove granatporfyroblaster 50-55. 55-60 veksl. gneis og svartskifer, mest svartskifer. Minr.: MK og Py i svartskifer.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
60-70	= 70°	20		Ba: Svartsk i veksl. m/granatgn. Fra 69,0 granatgn. Tekt.: Noe breksiert og oppknust. Minr.: MK og Cpy. Sinkbl. i knusesonen ved 60,8. Ett spor Cpy !
70-80		10		Ba: Gneis med kvartsøyne som vesentlig er omv. granat. Minr.: Noen soner med litt MK. Spor Cpy i MK - sonene.
80-90		6		Ba: Som foreg., men etterhvert en del hornblende som et omv. til klorit. Minr.: Disseminert Py ∠ 3 %.
90-100		5		Ba: Som foreg. Minr.: Py som foreg.
100-110		5		Som foreg. Et par små korn Cpy.
110-120		8	116-117 : Cu 117-118 : " 118-119 : " 119-120 : "	Ba: Dioritisk gn. med kloritspetter. Noe lysere fra 116 m. Minr.: Py i første del, men noe Cpy fra 116 m. Spor CaF_2 .
120-130		8	120-121 : " 121-122 : " videre til 128 hvis Cu i 120-122	Ba: Dior. gn. hvitspettet. Litt granat mot 130 m. Minr.: Litt Cpy fram til 128, men mest Py. Tar anal. av de første to m.
130-140		6	133-134 : Cu 134-135 : " 135-136 : "	Ba: Som foreg. men noe mer gl.-rik. Minr.: Noe py (3 %) og spor Cpy. Tar stikkprøveanal. av 3 m fra 133-136.
140-150		6	148-149 : " 149-150 : "	Ba: Klorit-spettet gneis Minr.: Noe py (3 %) og spor Cpy. Må ta stikk prøve anal. 148-150. 0,2 m CaF_2 ved 147 m.
150-160		6		Ba: Rel. mørk kloritrik gneis. Minr.: Litt py ∠ 3 % og svake spor Cpy. 150-153 anal. hvis 148-150 slår til CaF_2 159,5-159,8.
160-170		4		Ba: Grovspettet dior. klorit gn. 160 165 Mot 170 m mer gl. rik (granat). Minr.: Litt py.
170-180		6		Ba: Lys klorit gl. gneis. Minr.: Litt py og spor Cpy.
180-190		5		Ba: som foregående Minr.: Noe mer py enn foreg. og kun svake spor Cpy.
190-200		3		Ba: Spettet hornbl. (klorit) - gneis og noen få små granater. Minr.: Kun spor Py.
200-210		4		Ba: Som foregående Minr.: Litt Py og uhyre små Cpy spor.
210-220		4		Ba: Som foreg., men 219,1-220 kloritsone. Minr.: Litt Py og spor Cpy.
220-223,5		4		Ba: Kloritsone 220-220,2. Ellers vanlig type. Minr.: Litt py.

PRELIMINARY REPORT ON THE GOLD FROM RAITEVARRE.

Together 16 polished sections from the drillholes no. 5, 6, 7 and 8 are microscoped.

The gold that is observed is extremely finegrained. 28 goldgraines with size from 4 μm down to less than 1 μm are found. Most of the goldgraines are less than 2 μm. The very finegrained size of the graines makes it very hard to judge the silver content in the graines from the colour.

The gold seems especially to be found in a parageneses with dessemi-nated grains and grains of chalcopyrite and pyrrhotite grown together. In a few grains there are small amounts of mackinawite in chalco-pyrite. In this paragenesis is found goldgraines as inclusions in chalcopyrite and in pyrrhotite. Goldgraines are also observed on the crystal boundaries between chalcopyrite and pyrrhotite (fig. 1), pyrrhotite/non opaque-facies and chalcopyrite/mackinawite. Some gold-graines are also found as inclusions in none opaque facies, but al-ways in the vicinity of sulphidegraines.

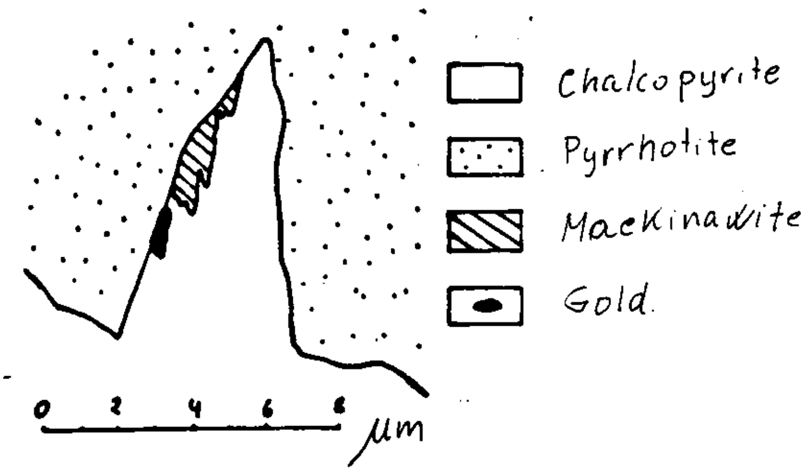


Fig. 1. Gold on the crystal boundary between chalcopyrite and pyrrhotite.

In a paragenesis of larger aggregates of chalcopyrite, pyrrhotite and pyrite gold is found as inclusions in pyrite and as very small graines in hair-line veinlets with chalcopyrite in pyrite. (Fig. 2).

Too few polished sections are studied to give any conclusions about the occurence of the gold. The neutron activating analysis indicates however also that the gold is very finegrained. For nearly all the samples from Raitevarre the difference between the two parallel analysis of each sample are less than the standard error of the mean for the analysis. (Samples from Bidjovagge where gold can be found in much larger grains, shows less regularity between the parallels).

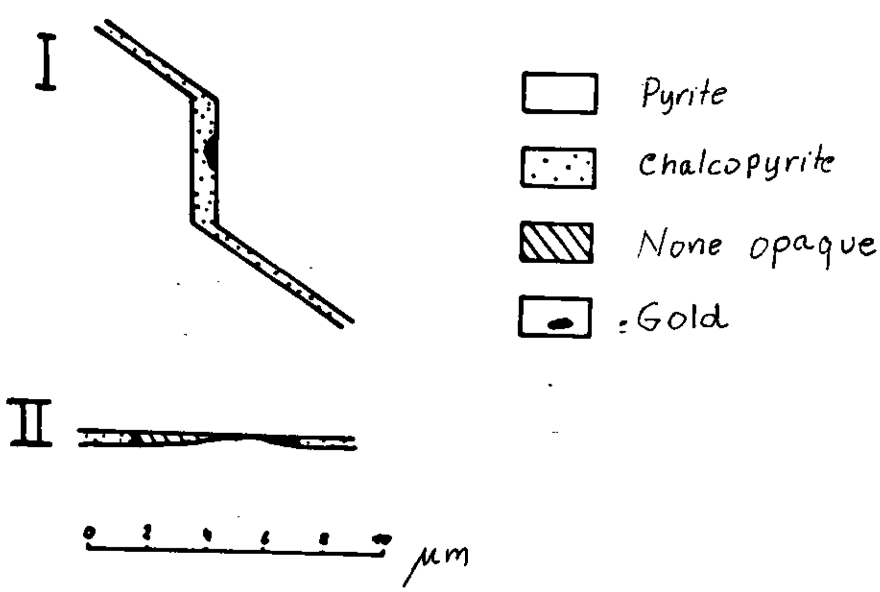


Fig. 2. Two examples on hair-line veinlets with chalcopyrite and gold in pyrite.

Unidentified minerals which might contain precious metals are observed as inclusions in pyrite and pyrrhotite. Those facies occurs in very small graines, but those will be tried to be identified with microprobe.

A plan for the follow up work of the gold in Raitevarre could be :

1. A further sampling of samples for polished sections. By comparing the microscopic results with the analytical results the relationship of the gold to the different oretypes can be mapped.

2. A mixed ore sample (~3/4 kg) is grind down to 90 % ÷ 74 μm, fractionated and each fraction is washed on superpanner to find eventually larger gold graines.

3. A concentrate of chalcopyrite and a concentrate of pyrite is grind down to 100 % ÷ 45 μm, is cyanated and the residue is analysed to registrate any submicroscopic gold.

In three of the sections, molybdenite is found in "not small" amounts. This mineral should possibly be followed up by new ore tests ?

Blindern, June 1980.

Ragnar Hagen (sign.)

Nr. 5. 5000. 5-74.

The Porcupine camp - A model for gold exploration in the Archean

By WILLIAM O. KARVINEN
Ontario Ministry of Natural Resources

The Porcupine camp has been a major producer of gold over the past 66 years during which time a total of about $2.0 billion worth of gold (calculated at $35.00/oz) has been mined from over two dozen different deposits. From maximum output in the early 1940s, production has steadily declined and today only four mines remain in operation. Although there has been a dramatic increase in the price of gold in recent years, most of the typical underground gold mines not only in Timmins but throughout the Canadian shield have been struggling financially because of their antiquated operations and because the mines, designed for vein-type ores, are labor intensive and difficult to mechanize. Because of increasing costs of conventional mining and the depletion of known ore reserves, it appears that production will continue to decline.

All past and present producing mines in Timmins were found and developed during the period 1909 to 1935. No significant new deposits have been found in the past 40 years and as a result it is the general impression of the mining industry that the camp has been well explored and is nearing exhaustion. It should be noted however, that all past geological investigations pertaining to the origin of the deposits were done using epigenetic models. No modern studies examining the total evolution of the rocks in the area and their relationships to the deposits have been done. In the light of past epigenetic models, the camp probably has little to offer for future exploration, but as will be shown in this paper, a syngenetic model for the origin of the deposits offers several important exploration parameters.

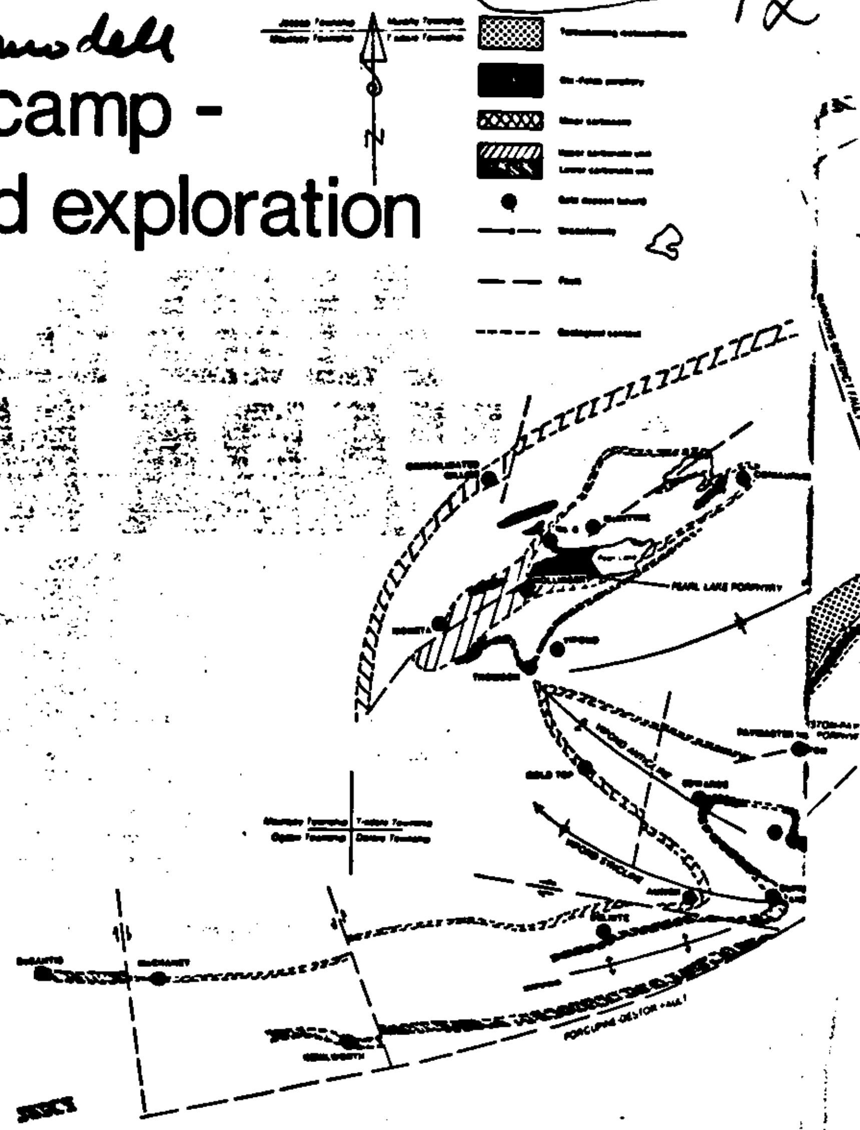


Figure 1. Distribution of carbonate-rich rocks, porphyries and gold deposits in the Timmins area

Better models needed

Because most modern geophysical and many geochemical techniques are incapable of detecting gold ore under overburden or at depth in rocks, it appears that the only way new deposits are going to be found, especially in overburden areas, is to develop and expand geological exploration parameters or guidelines. In order to do this better models depicting the origin and evolution of known deposits have to be developed. In Timmins, and elsewhere, the simple epigenetic models centred around felsic intrusions (*e.g.*, Pearl Lake Porphyry) or fault systems (*e.g.*, Porcupine-Destor Fault) have had serious problems in explaining several important features of the deposits as well as the origin of many of the deposits.

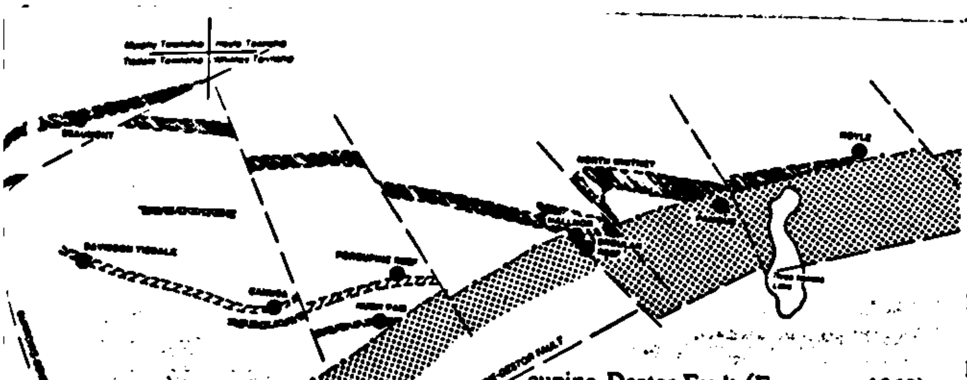
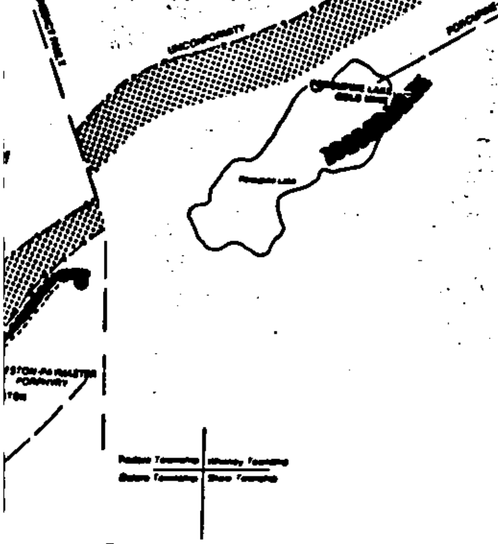
The only variation from the epigenetic theme was a model proposed by Pyke (1975) in which he suggested that the gold ores in Timmins are closely related to and possibly derived from altered flows of ultramafic rocks. In areas outside of Timmins, particularly at Larder Lake, Ridler (1976) and Tihor (*pers. comm.*, 1977) have subscribed to various forms of syngenetic models to explain the origin of gold deposits in that camp.

In the Timmins area, the key to gold mineralization must certainly lie in the origin of the carbonate-rich rocks which are an intimate feature of all the deposits. In past epigenetic models, these rocks have been interpreted as wall-rock alteration and although they have been described in various detail in many reports on the area, no areal maps exist which show where the carbonate-rich rocks are located and what their relationships are to the main rock types and structures in the area.

Study initiated

As a result, a study was initiated by the writer in 1976 to establish the spatial distribution of carbonate-rich rocks and their relation to gold deposits, and to determine if such rocks are indeed crosscutting as the epigenetic models imply or if they are concordant with respect to the enclosing country rocks. The main results of the investigation are listed below:

- Two major and one minor carbonate-rich units, consisting mainly of ankerite and/or magnesite, quartz, chlorite and sericite and varying in thickness from 20 m to over 200 m are present in the Timmins area (Fig.1).

• Both major units are distinct strata-bound units which can be followed along strike for over 15 km and are easily distinguished from one another. All exposed contacts are concordant with the enclosing rocks except in one locality south of the Dome mine.
• All quartz-feldspar porphyries in the area occur along or near one of the carbonate-rich units and are intimately associated with them.
• All deposits which ever produced gold in the area are located on or near the carbonate-rich rocks or the porphyries.

Based on these results and the following descriptions and illustrations of the geology of gold in Timmins, it will be demonstrated that gold was first enriched in these ancient rocks during felsic volcanism and exhalative activity which produced the carbonate-rich rocks and that during subsequent metamorphism and deformation associated with the Kenoran Orogeny, gold was further concentrated into a network of quartz-carbonate veins.

General geology

Timmins is located in the northwestern part of the Archean Abitibi Greenstone Belt. In the immediate area, metavolcanic rocks have been divided into two groups: the lower Deloro Group and the upper Tisdale Group (Fig.2). In the early days the distinction was made on lithological differences and the fact that the two groups are separated by an east-west trending structure known as the Porcupine-Destor Fault (Ferguson, 1968). Recently evidence from the distribution of ultramafic flows has been used by Pyke (1975) to confirm this age relationship. Each group represents a volcanic cycle, grading upward from a series of basal ultramafic and high-magnesium basalts to felsic metavolcanics. A major difference between the two groups is the fact that the upper portion of the Deloro Group contains abundant oxide, sulphide and carbonate facies iron formations whereas iron formation is lacking in the Tisdale Group. Although numerous showings and prospects have been reported from the Deloro Group iron formations, no major concentrations of gold have been found.

Metasedimentary rocks (mainly turbidites) of the Porcupine Group (Pyke, 1975) formerly known as "Keewatin sediments" conformably overlie the Tisdale Group metavolcanics. Locally, a younger turbidite sequence, long known as the Temiskaming, overlies with distinct angular unconformity the older metasediments and metavolcanics (Figs.2 and 3).

The most obvious structures in the area are the easterly-plunging Porcupine Syncline and the Porcupine-Destor Fault (Fig.3). The geometry of the rocks has been delineated through the use of major marker horizons such as the V8 and the V10B flows (Ferguson, 1968) and more recently through the use of ultramafic flows (Pyke, 1975). Although numerous papers (Hurst, 1936; Moore, 1953; Davies, 1977) have dealt superficially with the structures of the area no rigorous analysis which explains the structural evolution of the rocks is available. The most obvious penetrative planar and linear elements seen in the field can be related to the Porcupine Syncline and most of the ore zones and porphyry bodies near the nose of this fold have been re-shaped and now plunge in the direction of that fold. Other structures, such as the oval interference structure in the Hollinger-Coniaurum area as well as older lineations and foliations indicate a pre-Porcupine Syncline phase of isoclinal folding as well as a later phase of open cross-folding (*e.g.*, Vipond Anticline).

The major phases of folding are reflected by the variety of vein configurations ranging from those which are straight and undeformed to those which are tightly folded or completely broken by intensive deformation. The main types of vein sets that have been described (Jones, 1948) are: well-defined, continuous veins that pinch and swell such as the quartz-ankerite veins at the Aunor; sinuous folded veins; tabular veins; and en-echelon,

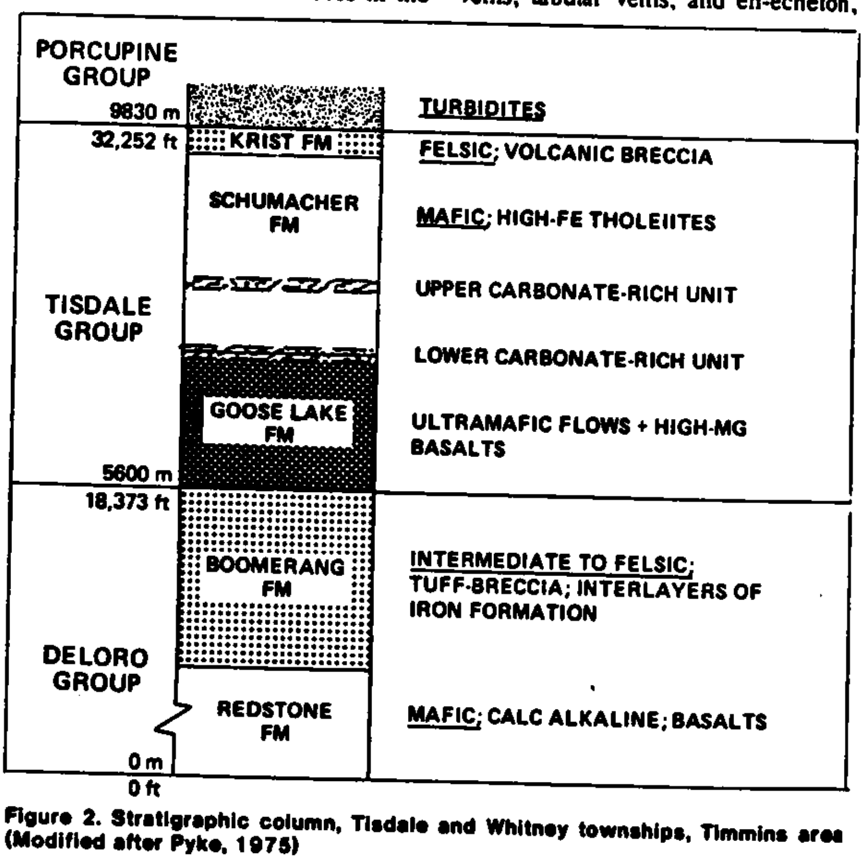


Figure 2. Stratigraphic column, Tisdale and Whitney townships, Timmins area (Modified after Pyke, 1975)

S-shaped veins. This variety of vein shapes suggests vein formation to have occurred periodically throughout the deformation period.

Gold occurs as the native metal or in sulphides, predominantly pyrite, in systems of veins which consist predominantly of quartz and ankerite and varying amounts of tourmaline. Auriferous pyrite-rich zones have been delineated in some mines (*e.g.*, Aunor, Schumacher). Other important accessory minerals are fuchsite, scheelite, arsenopyrite, albite, pyrrhotite, chalcopyrite, galena, sphalerite and gold-silver tellurides. The ratio of gold to silver in the ores is about 5 to 1.

Carbonate-rich rocks

The lower carbonate (Fig.1) is the thicker of the two major units (average 70 m) and consists predominantly of carbonatized ultramafic flows and tuffs and some layered massive carbonate of possible sedimentary origin. The Lower Unit is characterized by the predominance of magnesite (70 to 90 per cent) with lesser amounts of talc, sericite, chlorite, quartz, fuchsite (chrome muscovite) and pyrite. Relict textures, such as poly-suturing and spinifex can be found in completely carbonatized flows and in places bombs and pyroclastic fragments are present in the carbonatized ultramafic tuffs. Stratigraphically, the Lower Unit occurs near the upper part of the Goose Lake Formation (Fig.2). Deposits which occur on or near the Lower Unit are: DeSantis, Kenilworth (Naybob), Delnite, Aunor, Buffalo-Ankerite, Edwards, Dome, Hollinger (?), Schumacher (McIntyre), Beaumont, Hallnor, Broulan Reef, North Whitney, Porcupine Lake, Pamour and Hoyle.

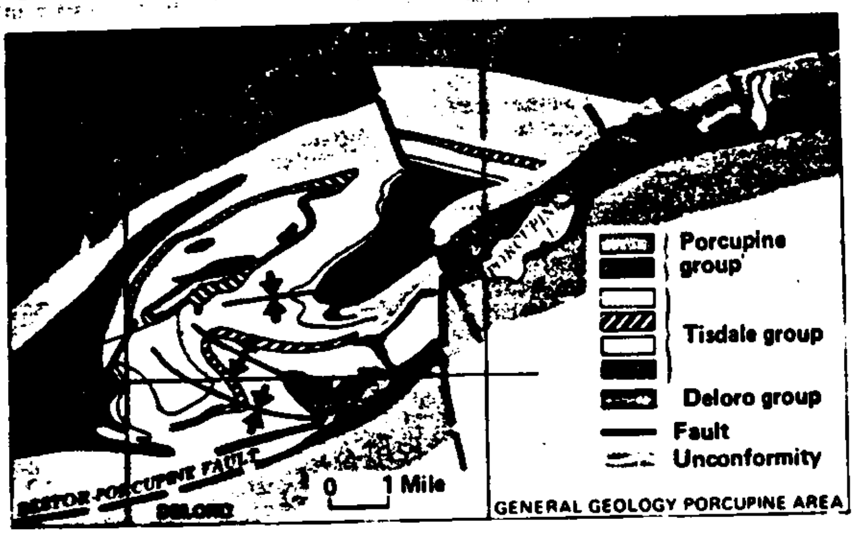


Figure 3. General geology of the Porcupine area

The upper carbonate-rich unit averages about 30 m in thickness and occurs about 670 m stratigraphically above the Lower Unit (Fig.2). In Tisdale Township, the Upper Unit closely follows the "99 flow" of the "Vipond Subgroup" (Ferguson, 1968), but towards the east in Whitney Township, the unit is found a few hundred metres below the "99 flow" thus suggesting some regional transgression. The Upper Unit is characterized by the abundance of ankerite (40 to 80 per cent) and the absence of chrome muscovite (fuchsite). In addition to ankerite, other minerals include chlorite, relict plagioclase, sericite, quartz and pyrite. Unlike the Lower Unit which is normally massive, and medium to coarse-grained, the Upper Unit is very fine-grained and is usually well-foliated. Discontinuous lenses of massive ankerite interlayered with silicate-rich lenses are a common feature. Relict textures and structures suggest that much of the Upper Unit represents either a carbonatized tuff or a mixture of sedimentary carbonate and tuff. Towards the west, in Ogden Township in the vicinity of the McEnaney deposit, the Upper Unit begins to change laterally into a graphitic phyllite. In northeastern Tisdale Township in the vicinity of the Davidson Tisdale property, parts of the Upper Unit are represented by carbonatized massive and pillowed basalts. Deposits which occur on or near the Upper Unit are: McEnanay, Gold Top, Paymaster (?), Dome, Moneta, Hollinger, Schumacher (McIntyre), Vipond (?), Thompson (?), Coniaurum, Consolidated Gillies, Davidson Tisdale, Canusa and Porcupine Reef.

Staining technique

Because iron-magnesium carbonates weather brown, they are easily recognized on surface and thus readily distinguished from the non-carbonatized mafic volcanic rocks which weather greenish-black to black. However, underground or in drill core, the carbonate-rich units, particularly the Upper Unit, are easily missed and at many of the mines in Timmins they have been mapped as dacites, andesites, bleached volcanics, etc. A simple staining technique can be used in the field to determine the presence of both ankerite and magnesite.

Irregular bodies of quartz-feldspar porphyry are an intimate association of the lower carbonate unit. Only the

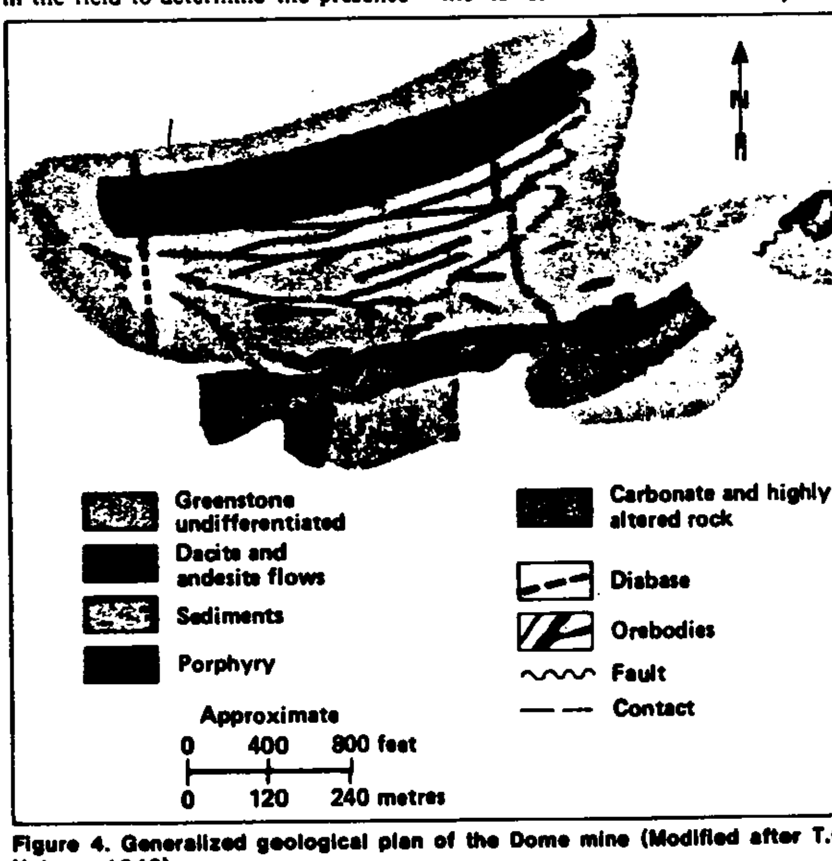


Figure 4. Generalized geological plan of the Dome mine (Modified after T.C. Holmes, 1948)

bigger bodies such as the Pearl Lake and Paymaster porphyries are shown in Fig. 1. In detail, however, numerous thin lenses of porphyry, ranging from a metre or two to several tens of metres thick are commonly found in the Lower Unit. In general, the porphyries consist of quartz, sodic plagioclase and sericite with small amounts of pyrite. Textures vary from massive to porphyritic and normally quartz-eyes are common in most varieties. Fragments, reminiscent of extrusive felsic volcanic material can be found locally, particularly in the smaller bodies. The porphyries contain varying amounts of ankerite and calcite, especially near the contacts, and at the Schumacher Mine (former McIntyre), a variety of alteration assemblages related to the Au-Mo-Cu mineralization have been identified (Luhta, 1974).

Three Groups

In general, the gold deposits of the Timmins area can be divided into three groups:

1. those associated with carbonate and large masses of porphyry;
2. those found in major fold structures of carbonate units containing minor porphyry;
3. those which occur along the local unconformity near the main carbonate units.

The two major areas represented by group 1 deposits are centred around the Pearl Lake and Preston-Paymaster porphyries. The Moneta, Hollinger, Schumacher (McIntyre) and Coniaurum deposits are located in and near the fringes of the easterly-plunging Pearl Lake Porphyry and also within thickened parts of the upper carbonate unit. The structural complexity in the area makes stratigraphic interpretations difficult, but it appears that older rocks of the lower Schumacher Formation (Fig.2) are exposed in the core of the anticlinal dome in the immediate area. One outcrop of fuchsite-bearing carbonate (green carbonate), identical to that of the Lower Unit outcrops near the old glory hole on the Hollinger property. It is conceivable that both at the Hollinger and at the deeper levels of the Schumacher (McIntyre), ore associated with the Lower Unit was also mined.

The major mines in the vicinity of the Preston-Paymaster Porphyry include the Dome, Paymaster and Preston. Carbonate rocks of the Lower Unit have been well documented at the Dome (Fig.4) and it is possible that the quartz-ankerite veins which stratigraphically occur within or near the "99 flow" at the Dome and Paymaster are equivalent to the Upper Unit.

Deposits of group 2 located at noses of folds or in flexures in the carbonate units and associated with small bodies of porphyry are represented by the DeSantis, Kenilworth (Naybob), Delnite, Aunor, Buffalo-Ankerite, Edwards and North Whitney mines. At many of these deposits, the carbonate unit has been well mapped (e.g. Aunor-Delnite), but in places the unit has been interpreted as dacite, andesite or bleached country rocks. The correlation between structure and location of vein systems is well illustrated at the Buffalo-Ankerite and Aunor where the ore zones plunge in the same direction as the Vipond Syncline.

The third group of deposits is represented by the Dome, Broulan Reef, Hugh Pam, Hallnor, Pamour and Hoyle Mines. Mineralization at these deposits is located, mainly in sediments, at a local angular unconformity between the older sequence of mafic metavolcanics and metasediments (Keewatin) and the younger succession of conglomerates and turbidites (Temiskaming). The striking feature about these deposits is that each is located where a carbonate unit is cut by the unconformity (Fig.1). This is well illustrated by the geology in the vicinity of the Hallnor and West Pamour properties (Figs.5 and 6). In this area, both the metavolcanics and carbonate units as well as the angular unconformity are overturned and dip at different angles to the north. The lines of intersection between the moderately dipping carbonate units and the steeply dipping unconformity plunge northeast and coincide remarkably well with the plunge of gold-bearing vein systems in the sediments. This explains why the

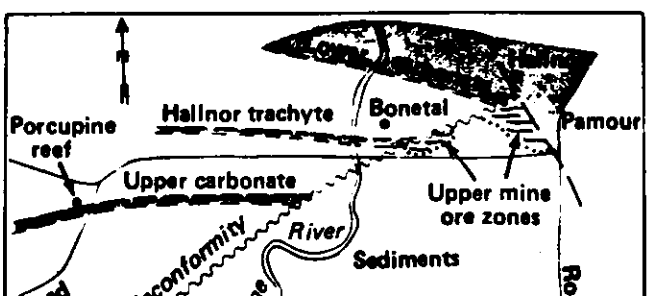


Figure 5. Surface geology in the vicinity of the Hallnor mine

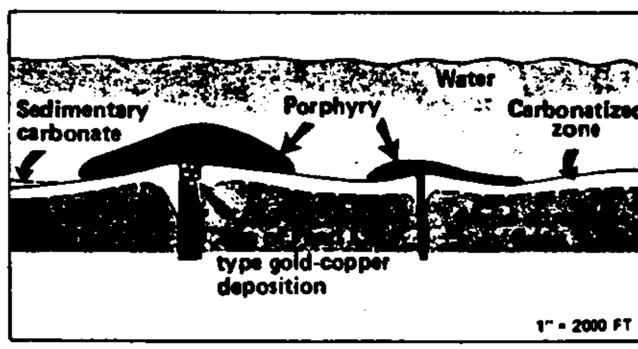


Figure 7. Formation of felsic domes and ocean floor carbonatization through volcanic and exhalative activity

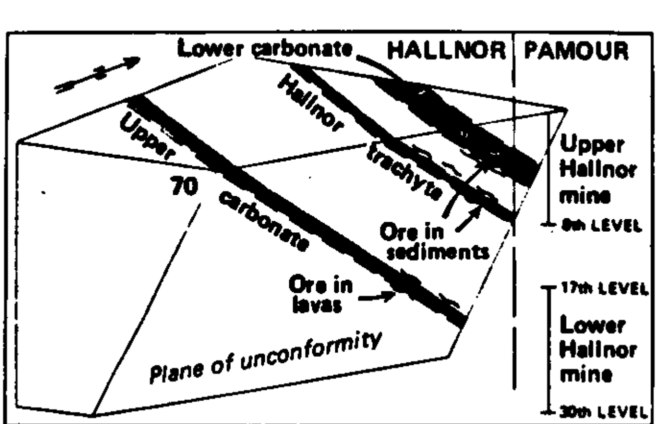


Figure 6. Block diagram showing projection of auriferous units onto plane of unconformity, Hallnor mine

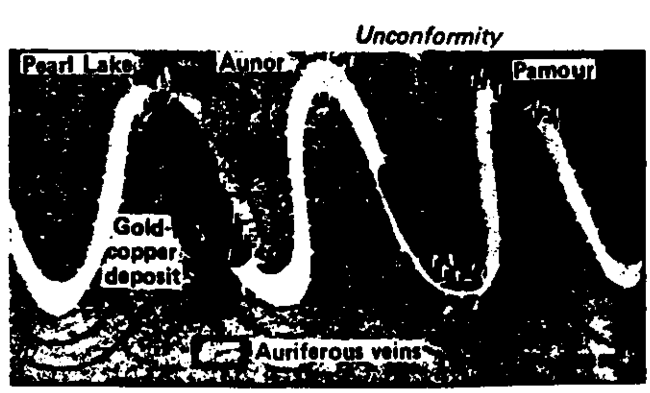


Figure 8. Regional metamorphism and deformation, resulting in concentration of gold into quartz-carbonate veins at structurally favorable sites

ore zones in the upper part of the Hallnor plunge into the nearby Pamour property and why ore was intersected in the lower part of the mine where the upper unit was encountered (Fig.6). Other examples of this type of control are evident at the Pamour.

It is interesting to note, that apart from the lenses of porphyry beneath the unconformity at the Dome, no porphyries of any description are found in or near the other deposits of group 3. The only exception, perhaps, is the carbonatized felsic rock, known as the "Hallnor trachyte" at the Hallnor (Fig.5) which has been mapped intermittently by the writer in parts of Whitney Township.

The model

A model depicting the genesis of the gold deposit in the Timmins area must take into consideration the following facts:

- Although quartz vein systems are common in all the metavolcanic-metasedimentary rocks of the area, gold-bearing veins occur only within, and mostly, near the carbonate-rich units or major porphyry bodies as illustrated in Fig. 1.
- The carbonate-rich rocks form distinct, stratabound units. The only exception of crosscutting carbonate rocks is found on the west contact of the Preston-Paymaster Porphyry south of Dome. The writer believes that the Preston-Paymaster Porphyry is partly intrusive and located in a volcanic vent and that the crosscutting carbonate is associated with the vent area.
- All quartz-feldspar porphyries in the area occur within a narrow stratigraphic interval which in most places is coincident with the lower carbonate unit. An exception may be the Preston-Paymaster Porphyry, parts of which may be associated with the Upper Unit.
- All rocks, including the carbonate units and porphyries, have been penetratively deformed by at least three phases of deformation.
- The variety of deformed gold-bearing vein systems indicates a close chronological association with regional deformation and metamorphism.
- Fragments of green carbonate are found in the Krist Formation of the upper Tisdale Group (Fig.2) and in the conglomerates of the younger (Temiskaming) sediments.
- Metals enriched in the deposits and host rocks include those which normally show affinities to mafic-ultramafic rocks (*e.g.*, Ni, Cr) and those which are normally enriched in felsic rocks such as B, W, Mo, Te, Pb, and Sb. Other metals also present are Cu, Zn, Ag and Mo.
- Breccia containing a matrix of auriferous sulphides in altered mafic volcanics is common in the No. 6 shaft area of the Schumacher (McIntyre) Mine. The alteration and breccia are widespread, crosscutting and irregular and may represent vent areas in rocks stratigraphically beneath the Pearl Lake Porphyry.

Karvinen

Formation of deposits

Based on these facts and the numerous detailed accounts of individual deposits (Ferguson, 1968), the following sequence of events which led to the formation of the deposits is envisaged. Extrusion and high level intrusion of felsic rocks and extensive exhalative-fumarolic activity resulted in the carbonatization of a variety of rock types on the ocean floor along the rock-water interface, particularly in the vicinity of major vents such as the Pearl Lake and Paymaster-Preston areas (Fig.7). In addition in places away from vents, some sedimentary carbonate was deposited. It was at this time, that gold and a number of other elements were first enriched in these rocks. Also the low-grade, disseminated Mo-Au-Cu deposit in the Pearl Lake Porphyry was formed during this stage.

Subsequent regional greenschist metamorphism and deformation of the volcanic pile resulted in the remobilization of gold and other trace elements, previously enriched in the carbonate units, into dilatant fractures where they were deposited as veins during the various phases of deformation (Fig.8). Fold noses, porphyry contacts and the plane of the local unconformity were particularly favorable sites for the formation of gold-bearing veins.

The foregoing syngenetic model has several implications regarding exploration for new deposits as well as the possibility of developing low-grade, high-tonnage deposits. Stratigraphic units of intensely carbonatized rock have greatest potential for gold mineralization, particularly in major vent areas which may be represented by masses of quartz-feldspar porphyry or altered breccia zones in underlying rocks. Recognition of carbonate-rich rocks, particularly in drill core, is best done by staining. For ankerite, the stain can be done using potassium ferricyanide in dilute (2 per cent) hydrochloric acid. For magnesite, use titan yellow in dilute (5 per cent) sodium hydroxide solution (It should be noted that although "metamorphic carbonate" (calcite) is present in all the volcanics in the area, none is found in the carbonate units).

Within and near such units, intensely folded or deformed sections or areas of associated quartz-feldspar porphyry are most favorable for high-grade, vein-type mineralization.

Sulphide-bearing zones in less deformed parts have potential for low-grade, high-tonnage type deposits.

At present there is no method for evaluating the potential of the favorable carbonate-rich strata covered by overburden except by intense drilling. Even this method is limited. Lithogeochemical studies being conducted by the Ontario Geological Survey and McMaster University may result in the delineation of simple geochemical parameters which will assist in such an evaluation. **CMJ**

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Geochemical and geophysical techniques for gold exploration

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Resource Geophysics and Geochemistry Div,
Geological Survey of Canada

Practically all the geochemical methods of prospecting are applicable in the search for auriferous deposits. The methods employed depend essentially upon the terrain, the degree of weathering of the deposits, availability of soils, drainage sediments, vegetation, and so on. The gold pan (heavy mineral prospecting) is a time-honored method of locating concentrations of gold in both placers and primary deposits. Details respecting geochemical prospecting for auriferous deposits are given in Boyle (1979).

The favorable rocks for the occurrence of auriferous deposits are listed in Table 1. Categories 1 and 2 harbor most gold-quartz deposits and Category 3 contains major gold reserves, particularly in the Witwatersrand, South Africa. Attention is drawn to Category 5 as possible large tonnage low grade deposits.

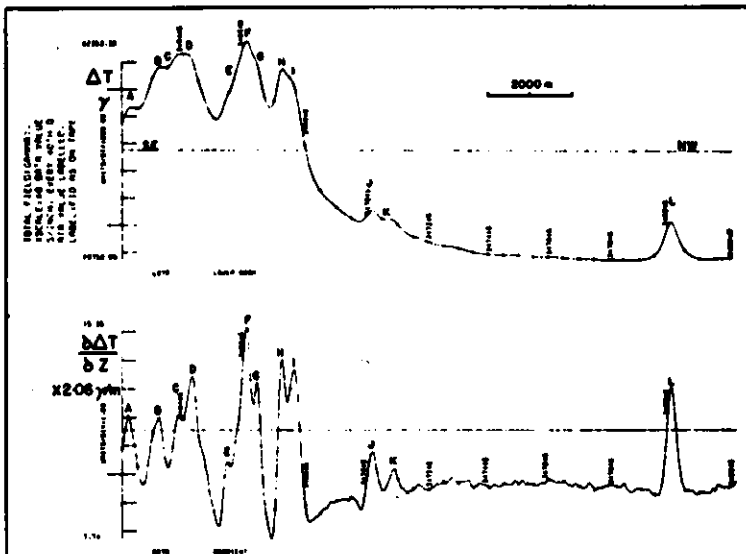
Table 1. Favorable rocks for the occurrence of gold deposits

1. **Volcanic (basalts, andesites, dacites, rhyolites)**
   Equivalent tuffs and breccias
   Greenstone, greenschist and propylitic belts
2. **Sedimentary**
   Greywacke-slate belts
   Iron formations
   Carbonaceous-graphitic-sulphidic slates and schists
   Carbonate-skarn assemblages
3. **Sedimentary**
   Pyritic or hematitic quartz-pebble conglomerates
   Pyritic quartzites
4. **Sedimentary**
   Modern and fossil placers
5. **Igneous**
   Quartz-feldspar porphyry
   Syenite
   Granite

Favorable structures for the deposition of gold are noted in Table 2 which is essentially self explanatory. The chemically favorable rocks for replacement deposits are listed in Table 3.

Table 2. Favorable structures for the occurrence of gold deposits

1. Carbonated shear and schist zones in greenstone belts.
2. Faults, fractures, sheeted and brecciated zones in propylitic belts.
3. Faults, fractures, bedding plane discontinuities and shears, drag folds, crushed zones and openings on anticlines (saddle reefs) in greywacke-slate assemblages and other sedimentary rocks.
4. Fracture zones, shear zones, brecciated (stockwork) zones in igneous rocks.



TOTAL FIELD AND VERTICAL GRADIENT PROFILES
KASMERE LAKE, MANITOBA

Gold is a good indicator of auriferous deposits; other specific indicator (pathfinder) elements for gold are Ag, As, Sb, and Te.

Table 3. Chemically favorable rocks for the occurrence of gold deposits

1. Carbonate rocks, calcareous shales and schists.
2. Porous sandstone, arkose and conglomerate.
3. Tuffs, iron formations.
4. Ultrabasic, basic and intermediate igneous rocks.

Table 4 lists other indicators for use in all types of geochemical surveys. The indicator to be chosen depends on the type of deposit, its elemental constitution and weathered characteristics, and on the nature of the primary and secondary halos associated with the deposit.

Table 4. Indicator (pathfinder) elements and compounds of gold deposits in approximate order of effectiveness

1. Au, Ag, As, Sb, Te
2. SiO_2, CO_2, B,F,S
3. K, Na, Rb
4. Cu, Zn, Pb, Hg, W
5. U, Mo, Pt metals
6. Au, Ag, Bi, Te, W, B, As, Sb, Sn, Zr, P, Pt metals (indicators of placer deposits)

Notes respecting both these surveys are of a reconnaissance (regional) and detailed nature. Notes respecting both types are given in Tables 5 and 6.

Table 5. Regional lithochemical surveys for gold deposits

1. Analyses of unselected rocks and/or mineral separates on a regional scale.
2. Analyses of specific rock types and/or mineral separates on a regional scale (e.g. porphyry dykes; batholiths and small stocks of porphyry, syenite and granite; specific beds or formations such as quartz-pebble conglomerates, iron formations, etc).
3. Analyses of materials of all observed "leakage halos" on a regional or areal scale, including shear zones, fault breccia, fracture fillings, quartz veins, alteration zones, jasperoid, etc.

Table 6. Detailed lithochemical surveys for gold deposits

1. Analyses of materials of all "leakage halos" as in (3) in Table 5.
2. Analyses of rocks on profiles across shear zones, stockworks, etc utilizing gold and its indicator elements in Table 4.
3. Analyses of rocks on profiles across shear zones, stockworks, etc utilizing major elemental ratios, e.g. K/Na, SiO_2/CO_2, etc.

Attention is called to the analyses of the materials of "leakage halos" on both a regional and detailed scale. Methods involving major elemental ratios, e.g. K/Na

Table 7. Pedochemical surveys for gold deposits

1. Near surface pedochemical surveys utilizing samples of soil, till, etc and/or mineral separates (heavy minerals) from these materials.
2. Deep overburden surveys utilizing near bedrock unconsolidated materials and/or mineral separates (heavy minerals) from these materials.

and SiO_2/CO_2, should receive more attention in detailed exploration for ore shoots.

Pedochemical surveys

The types of pedochemical surveys applicable in the search for auriferous deposits are listed in Table 7. Near surface surveys based on humus sampling (A horizon) have proved effective in many parts of Canada. Deep overburden surveys utilizing near bedrock unconsolidated materials are recommended where the soils, till, gravel and other surficial materials are thick (over 5 m). Heavy miner-surveys of near surface and basal soil, till, and other glacial materials have not been extensively employed but should prove useful in most terrains.

Hydrochemical surveys

These include those based on water, drainage sediments, precipitates, and heavy minerals from drainage sediments (Table 8).

Table 8. Hydrochemical surveys for gold deposits

1. Water (underground, spring, surface, snow).
2. Drainage sediments (stream, river, lake).
3. Heavy minerals from drainage sediments (panning).
4. Precipitates on stream sediments (limonite coatings, wad crusts, etc).
5. Precipitates at spring orifices (limonite, wad, silica-alumina gels, etc).

Water surveys are not particularly effective for outlining auriferous belts using gold as indicator; other pathfinders such as Zn, Cu, and As may be effective in some areas. Drainage sediments and panned heavy mineral separates from these sediments have proven effective in outlining auriferous belts in many parts of the world.

Biogeochemical surveys

These surveys are listed in Table 9. There are no specific indicator plants or animals of auriferous deposits, although many plants accumulate gold. Analyses of these plants provide a method of outlining favorable auriferous zones. Many fossil residues particularly thucholite and anthraxolite may be auriferous (e.g. Witwatersrand, South Africa). Analyses of these residues may be an indicator of quartz-pebble conglomerates and other types of gold deposits. Analyses of the humic horizons of soils has proven effective in outlining auriferous zones in many parts of the world.

Table 9. Biogeochemical surveys for gold deposits

1. Geobotanical.
2. Analyses of plants and animals
3. Analyses of fossil residues (coal bitumen, thucholite, anthraxolite, etc).
4. Analyses of humic horizons of soil and till profiles.
5. Analyses of bogs.
6. Analyses of termite and ant hills, gopher and groundhog mounds, etc.

Atmochemical surveys

Some auriferous deposits contain small quantities of thorium and uranium which yield helium and radon as disintegration products. Such deposits may be indicated by their higher than normal emanative helium and radon content.

Radiometric surveys

Certain types of auriferous deposits contain thorium and uranium at the minor and trace element level. Examples are the Witwatersrand quartz-pebble conglomerates and various Proterozoic and younger vein-type deposits (e.g. Tennant Creek, Northern Territory, Australia). Most vein and lode gold deposits are also marked by alteration zones in which potassium (including the radioactive ^{40}K isotope) is considerably enriched. Certain placers are enriched in radioactive minerals such as monazite and zircon.

These features provide a method, utilizing gamma-ray spectrometers and other radiometric apparatus, for detecting and outlining many types of gold deposits. Little work of this nature has been done in Canada; during the 1980 field season the Geological Survey will commence detailed radiometric studies of various auriferous areas to evaluate the methods.

Geophysical prospecting for gold

Geophysical techniques have not hitherto been much utilized directly in prospecting for gold, mainly because gold is usually present in such small amounts in its deposits that the element does not alter the physical properties of its host rock to any measurable degree. However, it is to be expected that the induced polarization technique would respond where disseminated gold was present in sufficient concentration although it would not be expected that such cases would be very frequent. Where gold occurs in association with sulphides the exploration target is much easier to locate by geophysical techniques.

Thus, the application of geophysics in gold prospecting has been mainly confined to indirect methods that delineate geological structures with which gold may be associated.

With the recent development of the Geological Survey of Canada's aeromagnetic gradiometer as a tool for detailed geological programs it is readily apparent that such surveys will be of considerable value in elucidating some of the complicated geological structures that are a feature of many gold camps. Perhaps it is appropriate here to illustrate some of the advantages of the aeromagnetic gradiometer technique in comparison to the single sensor instrument. The aeromagnetic gradiometer consists simply of two magnetometers separated a short distance apart so that the difference in readings of the two instruments can be measured.

Since 1975, more than 40,000 line miles of gradiometer data have been obtained as a result of about 20 surveys in a variety of Precambrian terrains to demonstrate the effectiveness of the gradiometer technique. These have resulted in the publication to date of 45 vertical gradient maps contoured at an interval of 0.025 gammas per metre in addition to six Open Files of the surveys. Thus, there is now a sufficient body of experimental evidence to demonstrate the improved capability of the gradiometer technique over single sensor surveys. These advantages are summarized as follows:

1) superior resolution of anomalies produced by closely-spaced geological formations;

2) anomalies produced by near-surface features are emphasized with respect to those resulting from more deeply-buried rock formations;

3) direct delineation of vertical contacts by the zero gradient contour value i.e. vertical contact mapper;

4) regional gradient of the earth's magnetic field and diurnal variation are automatically removed.

We expect that interest in the vertical gradiometer will continue to grow and that it will be utilized to survey problem areas of the Canadian Precambrian Shield where the geology is complex and/or is covered by drift, and where the superior definition of the gradiometer (with its higher cost) is warranted.

As an experiment to ascertain the value of the aeromagnetic gradiometer technique to gold exploration programs, the Geological Survey of Canada will refly the Val D'Or sheet (NTS 32 C/4) in 1980 using the GSC Queenair survey aircraft. The survey is being carried out at the request of the Association of Prospectors of Quebec and will cover the important Cadillac Break with which a number of important gold deposits are associated. If the results of the experimental gradiometer survey appear to be useful for gold exploration, then hopefully an enlarged program could be carried out if the appropriate funding is made available.

Mineralleting med hjelp av vegetasjonen

drives av sovjetiske geokjemikere. Nylig fant de en gullåre ved analyse av bjørkesevje. Gullinnholdet i sevjen øker sterkt når treet vokser over rike årer. (Ny Teknik, p.7, nr 25, 19. juni 1980).

Consider geochemistry when seeking gold

Respectively, C. F. Gleeson and Associates, Ltd., Ottawa; and Geological Survey of Canada, Ottawa.

49 Ib278

Initially it was not man that sought gold but nature that brought it to him in the form of alluvial grains and nuggets glittering on a stream bed. Since early Egyptian times (4000 B.C.) prospecting for gold has been dependent on visual recognition. Today with the aid of geochemistry man's capability to detect gold has been greatly extended, making it possible to find deposits that have no physical surface expression.

Gold is a member of Group IB of the Periodic Table which includes copper, silver and gold. In its chemical reactions gold (Au) resembles silver (Ag) in some respects, but its chemical character is markedly more noble. The principal oxidation states of gold are Au (I) (aurous) and Au (III) (auric). These states are unknown as aquo-ions in solutions, the element being present mainly in complexes of the type $[Au(CN)_2]^-$, $[AuCl_2]^-$, $[Au(OH)_4]^-$, $[AuCl_4]^-$ and $[AuS]^-$.

The abundance of gold in the upper lithosphere is about 5 parts per billion (ppb) and the gold/silver ratio is about 0.1. The average gold content of igneous-type rocks in parts per billion is — ultrabasic (4), gabbro-basalt (7), diorite-andesite (5) and granite-rhyolite (3); in sedimentary rocks the average is — sandstone and conglomerate (30), normal shale (4), and limestone (3). Certain graphitic shales, sulphide schists, phosphorites and some types of sandstones and conglomerates may contain up to 2,100 ppb gold or more.

The average gold content of soils is 5 ppb and the average for natural fresh waters is 0.03 ppb; for sea water the average is 0.012 ppb. Most plants and animals contain less than 1,000 ppb in the ash.

The principal types of gold deposits are quartz-pebble conglomerates (Witwatersrand type), gold quartz veins and stockworks (Yellowknife type), disseminated deposits (Carlin type), and modern placers. In all these deposits the principal gold mineral is native gold; other auriferous minerals in gold deposits include various tellurides and aurostibite. The tenor of most gold deposits ranges from 1-35 ppm gold (1 oz./ton = 34.38 ppm).*

As with so many other elements, applications of geochemical exploration techniques in the search for gold have increased due in a large part to advancements in analytical techniques. The two most common analytical methods employed for gold in commercial laboratories in Canada involve determination of the metal by a combined fire assay and neutron activation method or combined fire assay and atomic absorption spectrophotometric method. Detection limits using 10 grams of sample are in the order of 1 ppb for the former method and 5 ppb for the latter. For plant analysis, Minski et al (1977) have described a sensitive and precise method using a nondestructive neutron activation technique which requires 250 m[illegible]m. and has a detection limit of 0.1-1 ppb depending on the sodium content of the sample.

Reconnaissance surveys: The most effective reconnaissance method in prospecting for gold, especially in areas with well developed drainage systems, is panning followed by chemical analysis for gold in the heavy mineral separates.

The authors (Boyle and Gleeson, 1972) analyzed some 400 heavy mineral concentrates for gold from stream sediments over a 1,900 square mile area centred on Keno Hill, Yukon. All of the known gold deposits were indicated by the dispersion trains of gold in the heavy mineral concentrates; in addition several anomalous areas not known to contain gold were defined (Figure 1). It is interesting to note that examination of the concentrates under a binocular microscope prior to chemical analysis indicated that gold was present only in samples taken from placer gold workings. Much of the gold detected by the chemical analyses is bound in other minerals, especially in secondary iron hydroxides such as limonite and goethite.

Surveys by the Geological Survey of Canada in which gold particles were counted in heavy mineral concentrates from tills and eskers in the Kirkland Lake area are effective in defining auriferous glacial trains (Lee, 1963, 1965). Chemical analysis of heavy mineral concentrates from eskers is one of the few surface reconnaissance geochemical techniques that can be used in areas covered by glacio-lacustrine sediments. Analyses of heavy mineral concentrates from till samples at depth have also proven to be a viable semi-reconnaissance exploration technique in heavily overburdened areas (Gleeson and Hornbrook, 1975).

In Northern Ontario auriferous alteration halos in Precambrian felsic plutonic rocks have been defined by chemical analyses for gold. W. J. Wolfe (1976) states that limited systematic sampling of granitic intrusions at 30-50 randomly distributed sites may be sufficient to estimate the gold exploration potential of stock-sized bodies. Analyses of rock samples for gold were primarily responsible for defining fine-grained disseminated gold deposits in the Carlin-Cortez area in Nevada (U.S. Geol. Surv., 1968). From these examples it follows that where sufficient outcrop is present rock geochemistry utilizing gold as the indicator can be an effective tool for selecting target areas and defining deposits.

Detailed surveys: The presence of gold in living plants and the enrichment of gold in the humus layer

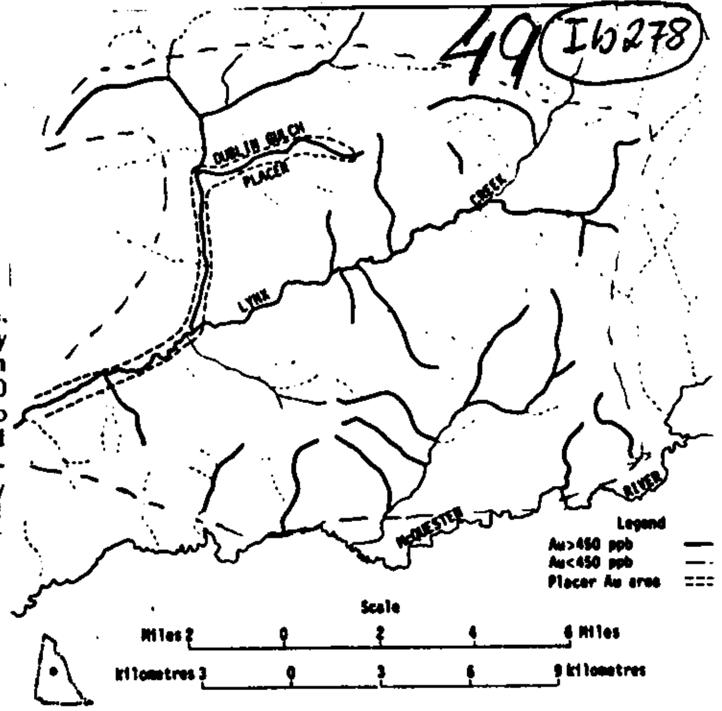


FIGURE 1 · Gold in heavy mineral concentrates, Dublin Gulch area, Yu. (after Boyle and Gleeson, 1972 — see references).

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Northern Miner March 8 1979

*) Fair 31,103 g (ppm) = 1 Troy ounce. Her er ref. til short ton.

of the soil were demonstrated some 42 years ago (Goldschmidt, 1937), and more recently by Curtin *et al* (1968), who have shown that gold in humus-rich forest soil is effective in delineating gold deposits covered by colluvium and glacial drift in the Empire district, Colorado. Similarly, soil surveys carried out by one of the authors (CFG) in the Kirkland Lake, Noranda, and Val d'Or areas have shown that the best anomaly definition in areas covered by permeable till is that obtained from gold in humus. In areas where well-developed podsols occur there is much less enrichment of gold in the "B" horizon over known gold occurrences, whereas there are marked gold anomalies in the highly decomposed humus from the same sites (Figure 2). Follow up drilling on humus anomalies was 80% successful in finding auriferous zones buried beneath 3-120 ft. of permeable glacial cover. The anomalies in the humus appear directly over the subcrop of the auriferous zones, and their dispersion patterns appear little affected by slope or glacial transport. Gold in humus from some 3,000 samples taken from gold properties in the Abitibi area of Quebec ranged from less than 5 ppb to 8,300 ppb with an average (median value) of about 12 ppb. Significant anomalous values were generally greater than 100 ppb gold.

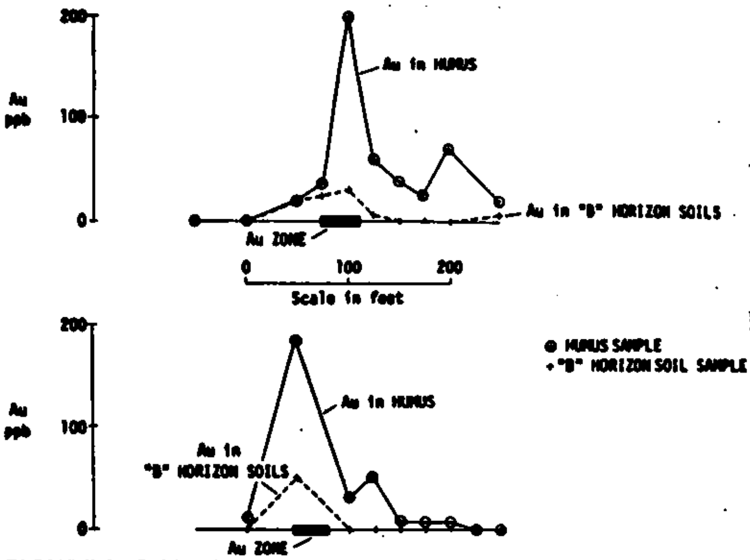


FIGURE 2: Gold in humus and "B" horizon soils over certain gold-bearing zones in the Abitibi region of Quebec.

In an oxidizing environment the uptake of gold by plants and its subsequent concentration in humus has been attributed principally to cyanides (Lakin *et al*, 1974) produced by the hydrolysis of cyanogenic glycocides. Over 1,000 species of plants are known to produce free cyanide naturally. Lakin and his co-authors (1974) concluded that:

"... ample hydrogen cyanide is formed in the soil by hydrolysis of cyanogenic plants, animals and fungi to result in solution of gold in an oxygenated environment. The gold cyanide thus formed is absorbed by plants but they do not use it as a nutrient. It is therefore found accumulating as a reject in the woody parts of a plant. The decomposition of plant debris results in the reduction of the gold in the plant material and gold accumulation in the humus horizon of the soil."

In areas covered by impermeable glacial deposits such as glacio-lacustrine silts and clays surface sampling of soils and humus gives negative results for gold. In these environments systematic till sampling at depth has proven effective in delimitating gold zones covered by 3-160 ft. of glacio-lacustrine material. The best anomaly definition has been obtained from gold analyses on the heavy mineral fraction of the till. In such a situation one is defining gold dispersed as particles in a non-oxidizing environment.

A/S Sydvaranger.
Prospekteringsavdeling.
Nordraaks vei 2. 1324 **Lysaker, Norge.**
Tlf: 538976 - 120518

INTERN RAPPORT.

DATO: 24/2-1981	**RAPPORT NR:** 1149	**KARTBLAD** 2033 III, IV.	**Antall sider** 50 **—"— bilag**

SAKSBEARBEIDER Bernt Røsholt

RAPPORT VEDRØRENDE:

Target area Raitevarre.

RESYMÉ:

The prospecting work done at Raitevarre is summarized from 1962 to 1980. Together 1445 m of core drilling is carried out in 8 holes.

Low grade copper-gold mineralizations are found in considerable amounts. Sections of more than 20 m of thickness with 0,44 % Cu are reported.

This type of mineralization extends to the south and it is pointed on the possibilities to find favorable structures where gold or gold/copper could be deposited after remobilization.

It is believed that the extensive low grade alluvial gold deposits must have some major sources in this area.

Reduced geochemical and geophysical maps, core log, gold report from Raitevarre by Hagen, gold prospecting model etc. are enclosed.

FORDELING

OSLO:

- [ ] Prosp. ktr.
- [ ] Bernt Røsholt
- [ ] Henriksen
- [x] Bugge

KIRKENES:

ANDRE:

- [ ] Union Minerals
- [ ] " " Olmore
- [ ] Bergmester

KOMMENTAR:

Contents

Page

Target area Raitevarre

Introduction

The Raitevarre area is situated 69° 17' North, 25° East and lies about 40 km's SW of the village Karasjok in Finmark about 300 m above sea level. The area is mapped in detail by Røsholt. See Fig. 2.

The Karasjok area is regionally mapped by H. Wennervirta (1968). Most of the rocks in the area belong to the Karasjok group which is Svekofenno-karelian (2000 m y). The rocks are metamorphic sediments and vulcanites in the amphibolite facies. To the west and to the east the prefennokarelian basal complex (2800 m y) occurs with granodioritic and quartzdioritic gneisses with migmatites to the west and granulites (Svekofennokarelian metamorphics) to the east. H. Skålvoll (1971).
The attached map Fig. 1 shows the southern part of the Karasjok area. Several types of prospecting activities are carried out in the area with the greatest activity in the period from 1967 to 1969.

Summary of prospecting work

Geophysics

Regional aerial magnetometry and electromagnetics was measured by NGU in 1962 over a large part of Finnmark. The rather flat topography is very good for aircraft measurements.

At Raitevarre some recognizing electromagnetic slingram and magnetic profiles were done 1968. Later the same year there was done a helicopter survey by Terratest AB that covered 45 km^2 of the area. It was done magnetic and electromagnetic measurement in 582 profilekm's. In the center of the geochemical anomalous area see under "geochemistry", the profile distance was 50 m and outside the distance was 100 m. The profiles were flown in NE-SW direction at right angle to the general strike of the rocks.

P.15
Fig. 3 shows the electromagnetic In Phase Component over the area. It is measured in ppm of the primary field. A clear NW-SE-strike is seen on the electromagnetic anomalies due to the black schists. There are also electro-magnetic anomalies to the NE that are believed to be caused by black schist and pyrrhotite in the amphibole gneisses. Several outcrops of this type of mineralization is found. The Out of Phase Component and the magnetic anomaly map also indicates the NW-SE-strike of the rocks.
Under "enclosures" in the back of this report copies of EM and magnetic measurements are enclosed.

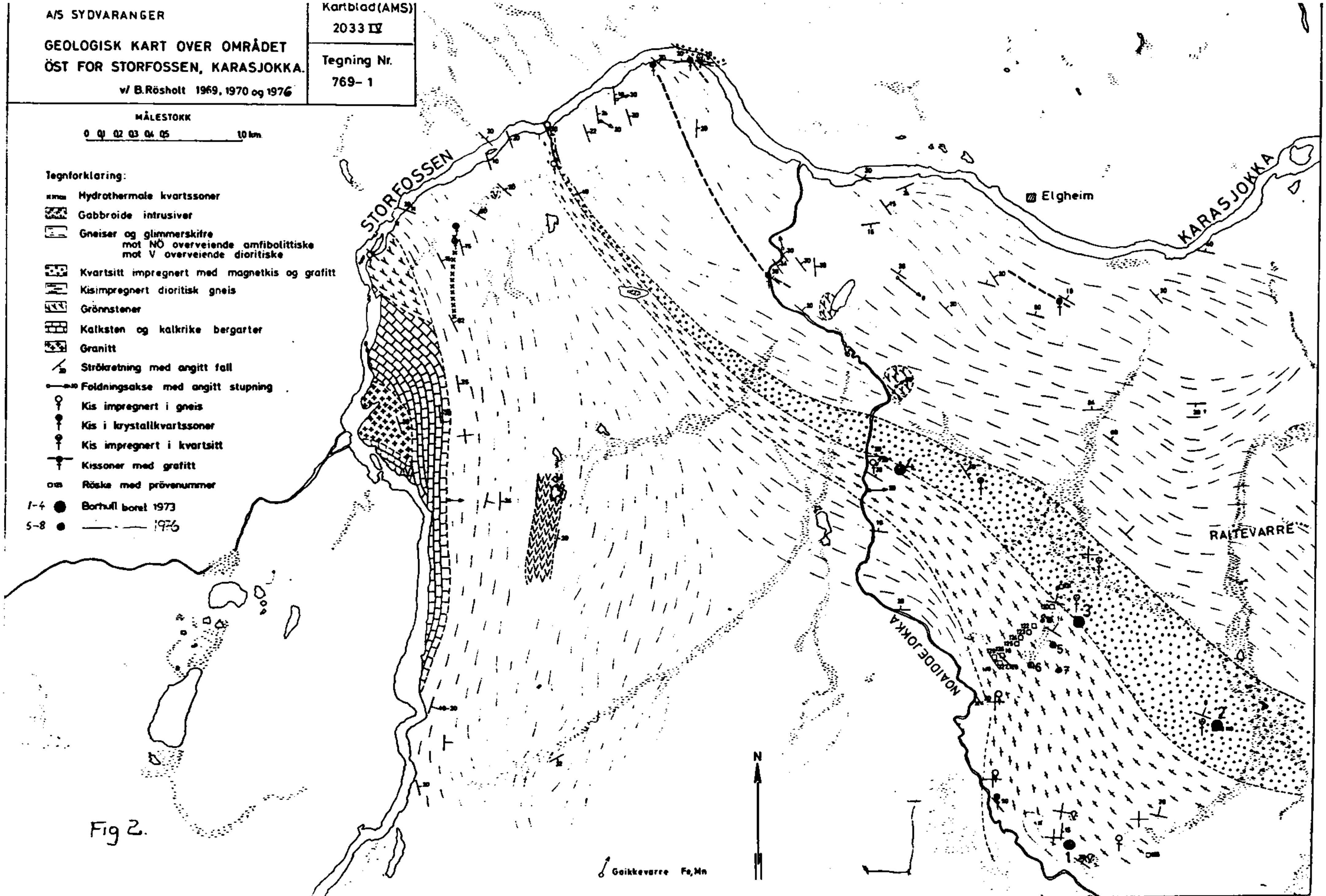

A/S SYDVARANGER
GEOLOGISK KART OVER OMRÅDET
ÖST FOR STORFOSSEN, KARASJOKKA.
v/ B.Rösholt 1969, 1970 og 1976
Kartblad (AMS)
2033 IV
Tegning Nr.
769- 1
MÅLESTOKK
0 0,1 0,2 0,3 0,4 0,5 1,0 km
Tegnforklaring:
Hydrothermale kvartssoner
Gabbroide intrusiver
Gneiser og glimmerskifre
mot NÖ overveiende amfibolittiske
mot V overveiende dioritiske
Kvartsitt impregnert med magnetkis og grafitt
Kisimpregnert dioritisk gneis
Grönnstener
Kalksten og kalkrike bergarter
Granitt
Strökretning med angitt fall
Foldningsakse med angitt stupning
Kis impregnert i gneis
Kis i krystallkvartssoner
Kis impregnert i kvartsitt
Kissoner med grafitt
Röske med prövenummer
1-4 Borhull boret 1973
5-8 1976
STORFOSSEN
KARASJOKKA
Elgheim
RAITEVARRE
NOAIDDEJOKKA
Geikkevarre Fe, Mn
N

Fig 2.

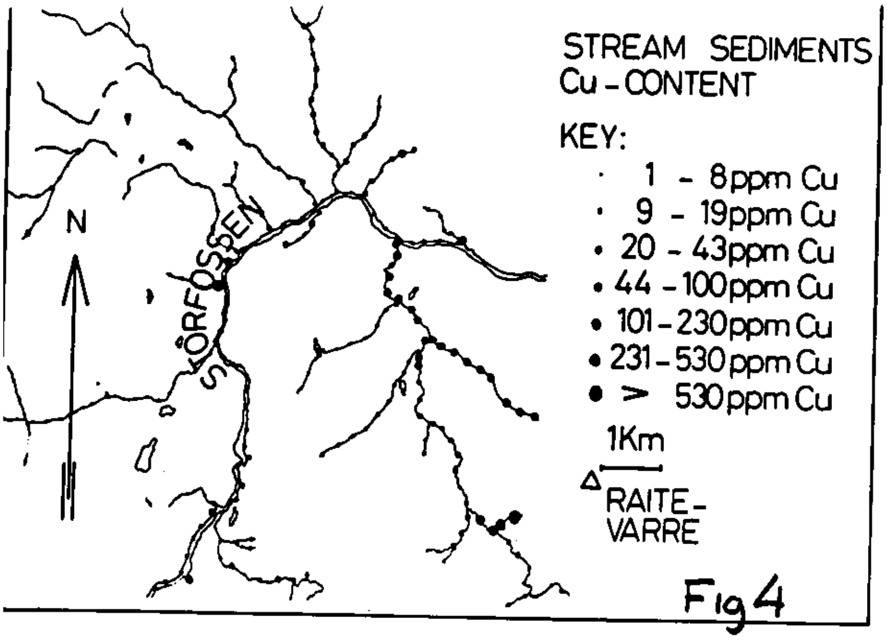

STREAM SEDIMENTS
Cu - CONTENT
KEY:
1 - 8ppm Cu
9 - 19ppm Cu
20 - 43ppm Cu
44 - 100ppm Cu
101 - 230ppm Cu
231 - 530 ppm Cu
> 530ppm Cu
1Km
RAITE-
VARRE
N
SÖRFOSSEN

Fig 4

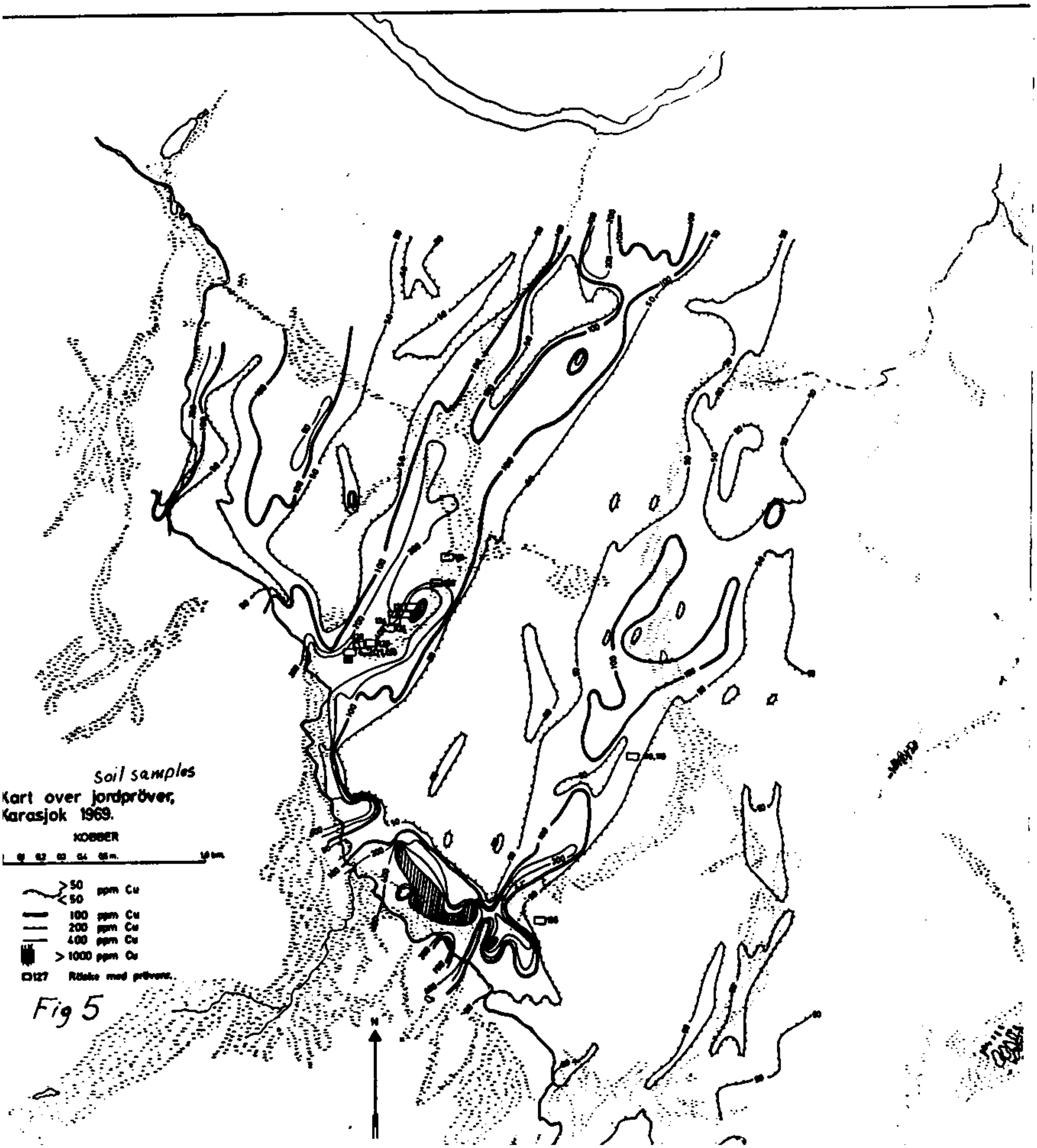

Soil samples
Kart over jordpröver,
Karasjok 1969.
KOBBER
>50 ppm Cu
<50
100 ppm Cu
200 ppm Cu
400 ppm Cu
>1000 ppm Cu
N

Fig 5

Geochemistry

Stream sediments

In 1967 the NGU did stream sediment sampling for Sydvaranger. An area of 330 km^2 was covered with 838 samples. The samples were taken each 250 m. This geochemical investigation resulted in different anomalies. One of the anomalies was very clear with high values in copper, zinc and silver. The highest copper and zinc contents were above 600 ppm and the highest silver content was 0,9 ppm. Fig. 4 shows the copper contents in the stream sediments in the Storfossen - Raitevarre area.

Soil sampling

In the field soil samples are taken over an area of 10 km^2 in a grid of 250 x 50 m with E-W-going profiles. The distance between the profiles is 250 m and distance between each sample in the profiles is 50 m.

The samples were taken at depths from 0,5 to 1,0 m.

Fig.'s No. 5, 6, 7 and 8 shows the distribution of Cu, Ag, Zn and Ni. The copper and silver anomalies give a fairly similar pattern while the zinc and nickel distribution is more or less random with mostly background metal contents.

On Fig. 5 the copper anomalies show two areas with copper contents more than 1000 ppm. The largest anomaly has a copper content above 1000 ppm over an area of approximately 5 ha. In this area the copper bearing dioritic gneiss is cropping out. There are three distinct ridges with a NNW strike. This strike is parallell to the ice movement direction. It is not believed, however, that the ice movement has caused the shape of the anomalies. The area just NNW of the highest copper anomaly-area is definite low in copper, so it is not likely to belive that the NNW anomaly ridges are caused by the ice movement. This statement is confirmed by the silver anomalies, which have no elongations parallell to the ice movement, Fig. 6.
The areas with very high copper content are belived to be caused by at least to factors.

1. Above the copper bearing dioritic gneiss there is a black schist rich in pyrrhotite. Both the black schist and gneiss is nearly flatlying with a gentle slope to the NW and have therefore a rather large area of exposure. The weathering of the pyrrhotite results in a strong chemical action on the copper bearing gneiss with deep weathering of the rock and leaching of the copper.

2. The copper anomalies are concentrated in the lower parts of the terrain. Analyses of water that comes out the morraine in the lower parts of the

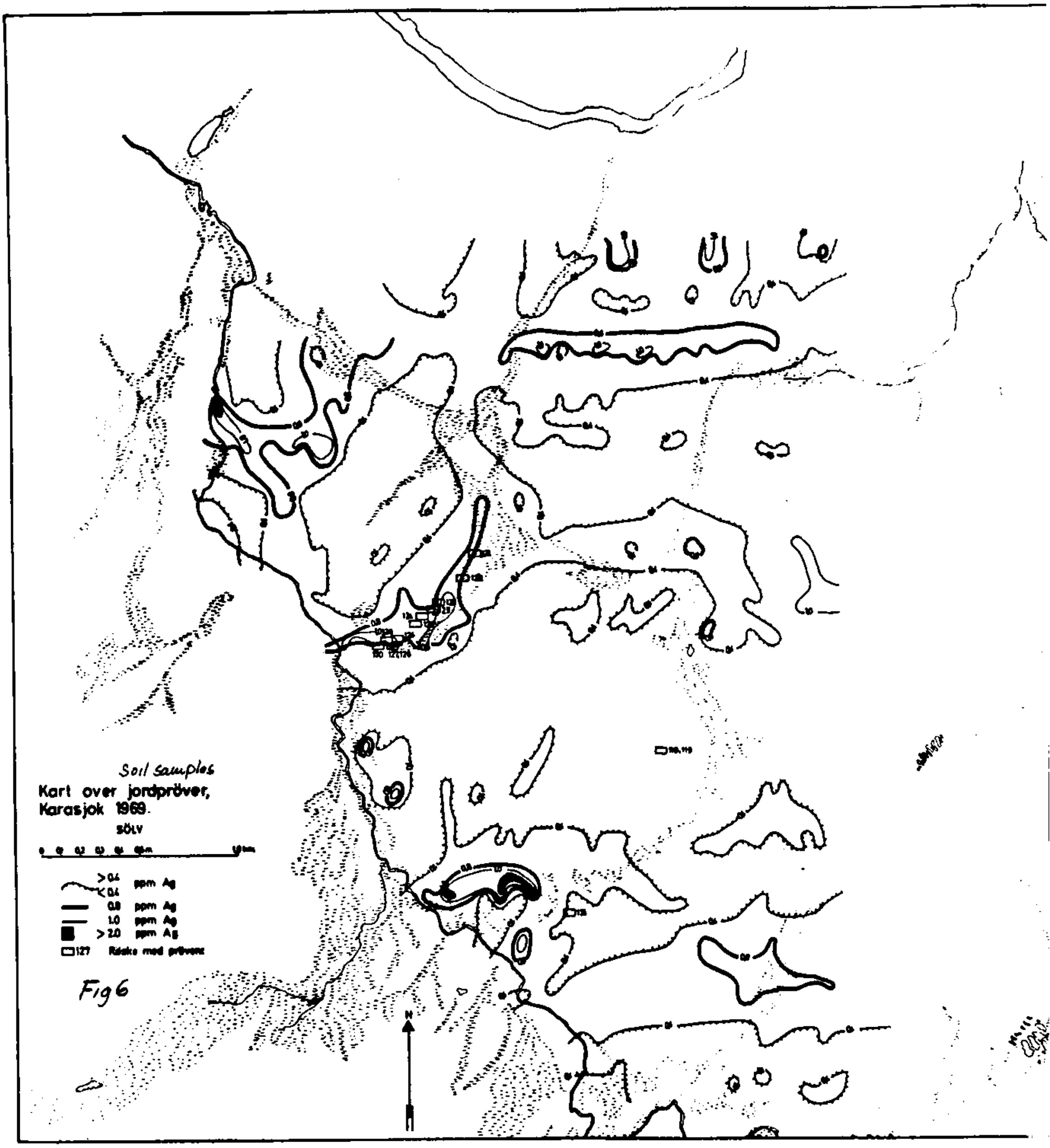

Soil samples
Kart over jordpröver,
Karasjok 1969.
SÖLV
>0.4 ppm Ag
<0.4
0.8 ppm Ag
1.0 ppm Ag
>2.0 ppm Ag
127 Rösko med prövenr.
N

Fig 6

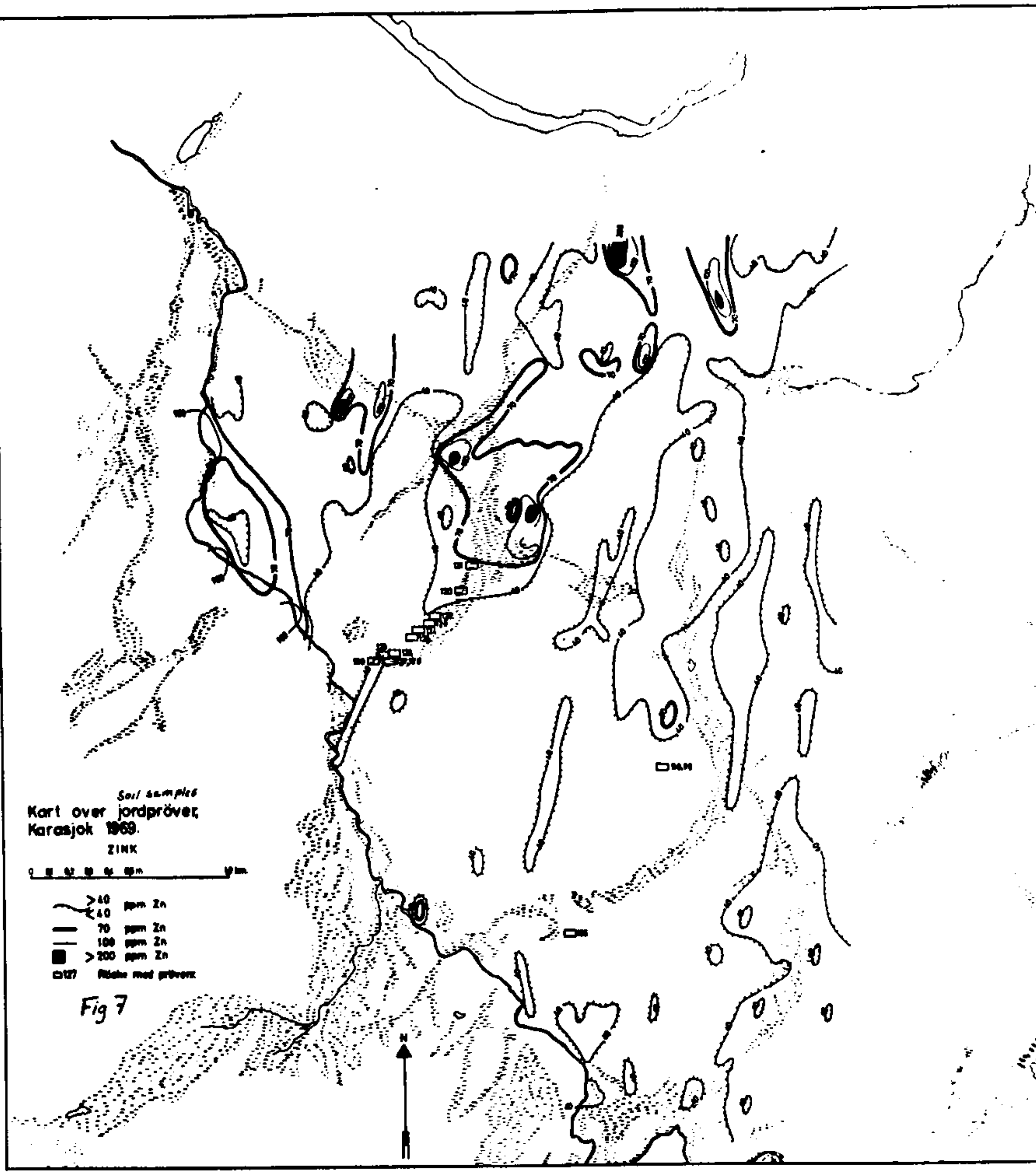
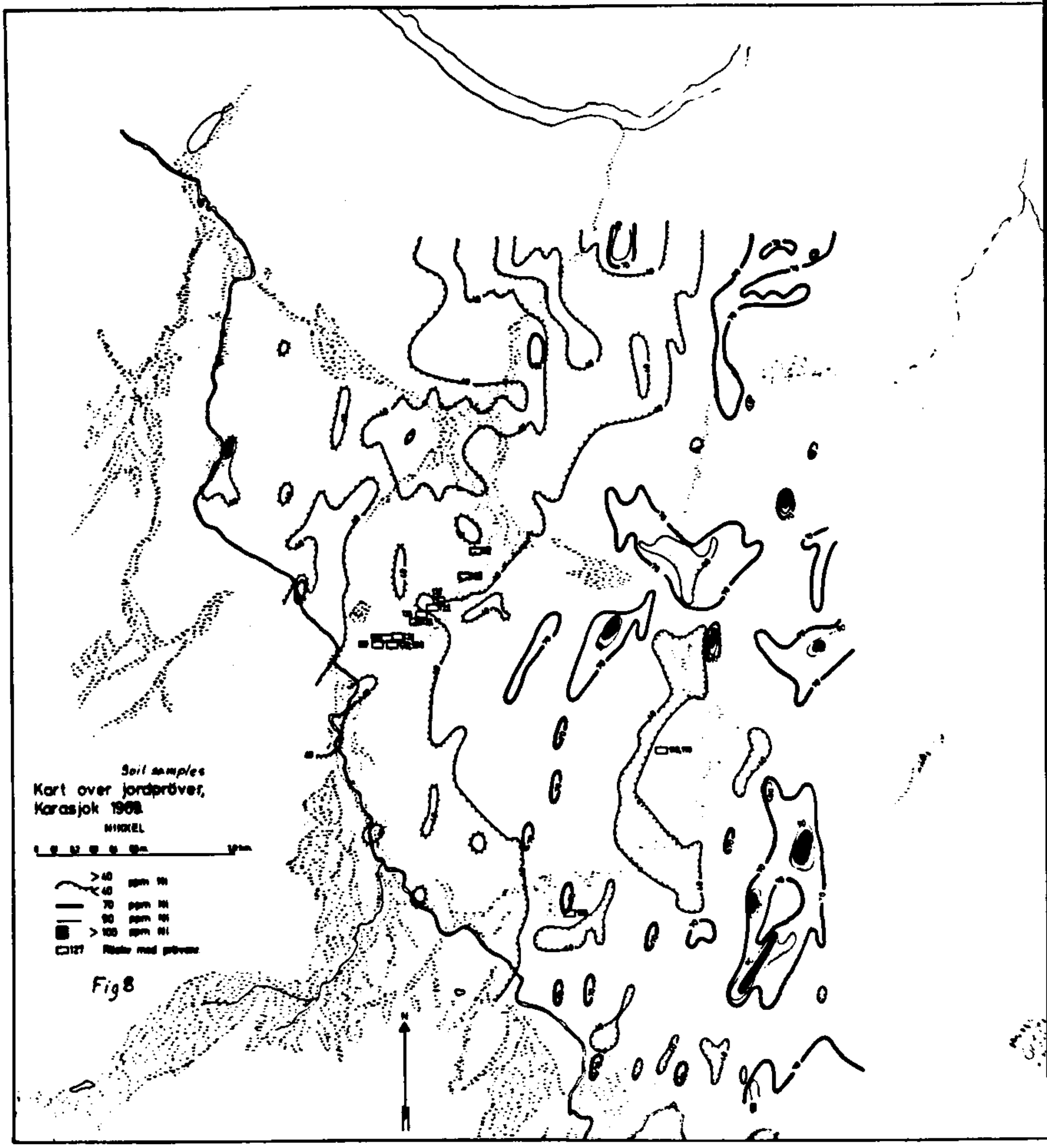

Soil samples
Kart over jordpröver,
Karasjok 1969.
ZINK
>40 ppm Zn
<40
70 ppm Zn
100 ppm Zn
>200 ppm Zn

Fig 7


Soil samples
Kart over jordpröver,
Karasjok 1968
NIKKEL
Fig 8

terrain have a high copper content. The copper content in the water decreses rapidly (see below) and the copper is belived mainly to be deposited here.

In the copper anomaly area W of Raitevarre ground water is coming out. Copper analyses of the water gave 0,040 ppm in "the well", 0,025 ppm 200 m down stream and less than 0,010 ppm 600 m from "the well".

"The well" gave more than enough water to supply the drilling of one machine throughout a dry summer. We can then assume that it produces at least 5000 liters per hour 200 days a year.

With these figures approximately 1 kg of copper will be deposited pro anno from this well. If this process has been going on since the end of the last ice age, 10000 kg's of copper has been deposited. This amount of copper is of the same order what is belived to be in the anomaly area W of Raitevarre.

Copper poisoned areas

Two major copper poisoned areas can be pointed out. These areas are coinsiding with the copper anomaly areas. Early in the work of this area we became aware of the peculiar vegetation of the poisoned areas. The grass has a reddish colour throughout the whole summer. Lots of Viscaria Alpina or the "copper flower" is found in the areas and the normal ground cover vegetation is mostly replaced by Juncus trifidus, Festrica avine and Deschamps flexuoa. In the center of the areas patches of several square meters are completely free of vegetation. These patches are heavily poisoned and copper contents up to 3% is found here. Bølviken (NGU) who earlier had worked with poisoned areas in southern part of Norway was informed of this poisoning. Together with Låg he visited the area and they have described the poisoning (1974).

Fig. 9 is a air photo that shows the copper poisoning in a hill. The copper bearing gneiss is cropping out nearly on top of a hill and tongues of poisoned areas are seen from the outcrops and down the hill. This pattern is rather unique and the prospector should of course be aware of such features. NW of this unique pattern is the large poisoned area W of Raitevarre. On the black and white air photos this large poisoned area looks very much like ordinary peat bogs.

Remote sensing

Infrared air photos.

Fjellanger-Widerøe A/S has taken infrared photos from air over the area for NGU. The poisoned areas are really showing up very good on these photos. They are nearly equal to the results from the soil samples, and anomalies with copper contents above 1000 ppm are seen very well. The areas rich in copper are getting grey blue on the infrared film while the ordinary healthy vegetation appears with a red colour.

Satellite images

Satellite images over the area from the LANDSAT-1 are studied by Lyon, Bølviken et al (1976). LANDSAT-1 images are taken from an altitude of 900 km's and each image coveres an area of 185 km in square. The camera in the LANDSAT-1 is a multispectral camera with four channels (No. 4-7) which registrates energy from waves with wavelengths from 0,5 to 1,1 microns. LANDSAT-1 resolution is limited to one pixel (0,4 hectars).

Over the actual areas a satellite image was enlarged. Close examination of this revealed a ninepixel linear bright area in channel 5 that seemed to coincide with the soil sample copper anomaly W of Raitevarre shown in the center of Fig. 5. The size of this anomaly is approximately 600 m long and 80 m wide. Two smaller anomalies just SE of this anomaly with sizes 120 m long end 12 m wide and 35 m long and 7 m wide were also studied. These two smaller anomalies could not be detected on the satellite image due to the LANDSAT resolution capability. The largest copper anomaly to the SE near Noaiddejokka (Fig. 5) was not studied due to lack of time and transport facilities.
The satellite image is computerised and this has given a model with different letters, Fig. 10. Each letter represents one pixel and the poisoned area is believed to be represented by C's. The anomaly W of Raitevarre is believed to be the N-S-groupings of C's called "camp corridor anomaly" on Fig. 10. Fig. 10 covers 800 hectars or 2000 pixels around the copper poisoned area or "camp corridor anomaly".

Core drilling

Diamond core drilling was carried out at Raitevarre with 558 m 1973 and 1445 m 887 m 1976. As shown on map fig. 2 holes No. 1-4 were drilled in 1973 and in 1976 holes No. 5-8. In addition hole No. 3 was elongated with 80 m in 1976. The results from the drilling is summarized in the following tabel:

Drillhole No. 4 is the only hole which is not vertical. It is drilled with 70° inclination in direction 250^g and it has only a copper content of 0,016%. A number of 10 samples gave an average content of 0,17 ppm Au and 0,66 ppm Ag and a number of 12 samples gave an average content of 2,26% S.

In drillhole No. 5 from 146,7 - 148,0 small amounts of galena is found in a tectonic zone. The lead content was 0,72% with traces of copper and silver.

Fig. No. 11 shows drillholes No. 1, 2, 3 with the results from 1973. This figure gives an impression of the size and position of the copper bearing gneiss.

In the back of this report the anlytical results are presented graphically for copper from all drillholes, for gold, silver and sulphur from holes No. 1, 2 and 3. The core-logs are also enclosed.

Latest prospecting activity

No active prospecting is carried out by Sydvaranger since 1976 in the Raitevarre area. NGU however, has done helicopter measurements and core drilling south of Raitevarre in 1980. This work was carried out because the premining consessions owned by the norwegian government over the iron-manganese-deposits south of Raitevarre expires in April 1981.
Sydvaranger's premining consessions over Raitevarre will also expire at the same time. All results from NGU's latest activity will be free during spring 1981. This will enable us to do a much better interpretation of the geology and important structures in the vicinity of Raitevarre.

Geology

Most of the inner parts of Finnmark country is covered with glacial till from 1 to 4 m and often more,as in the bottom of the valleys,where the thickness of the overburden can go up to 20 m.
At Raitevarre the average thickness of the glacial till is 4,8 m from the 8 drillsites. The actual thickness of the glacial till is less than 4,8 m since a deep weathering from 0,2 - 1,2 m is found in the copper minera lized gneiss. The reason for this can be both chemical weathering and frost action. Stratigrafically above the copper bearing gneiss there is a black schist rich in pyrrhotite (see Fig. 2). This pyrrhotite is believed to be decomposed into sulphuric acid and limonite. Together with the frost action the sulfuric acid has acted on the underlying gneiss and this has resulted in the deep weathering. The weathered gneiss is partly very rusty even if similar unweathered gneiss is practically free of iron compounds. It is therefore reasonable to believe that the rusty colour of the weathered gneiss is limonite from the decomposed pyrrhotite.

Fig. 2 shows a geological map of the Raitevarre area. The map is based on observations from a few outcrops especially along the river Noaiddejokka, trenches, geophysics and drilling.
In the lower parts of the metasedimentary sequence, we have the copper bearing gneiss. This gneiss is mostly dioritic in composition with amphiboles altered into chlorite. Red garnets are also common in varying amounts. They are often partly altered into quartz and chlorite. In the upper parts of the gneiss there are also bands with limestone. Sections rather rich in fuchsite is found in or near to the copper bearing gneiss. Other sections with anhydrite are also found. (7-F-Davies 1980).

The contact to the mineralization seems to be rather sharp on the hanging wall, but is gradually fading out against the footwall. Chlorite is found near and in the mineralized area.

Above the gneiss there is a black schist. The contact is gradually changing from the black schist to the gneiss with alternating bands of black schist, limestone and gneiss. In the black schist sequence there are calcareous schists, micaschists, garnet-micaschists and chlorite-schists. The black schist itself has a great variation in the graphite content. In the areas with highest graphite content there are also much pyrrhotite and some pyrite. Sphalerite is also found in the black schist. Above the black schist there is a more massive amphibole gneiss. There are also bands of dioritic gneiss in this amphibole gneiss, but the amphiboles are dominating.

Copper and gold minera lizations

It should be stated that the Raitevarre minera lization today is a subeconomic deposit. Still it should be noted that sections of more than 20 m has copper contents of 0,44%. For comparison the Boliden mine Aitik in N-Sweeden is mined on 0,4% Cu with a cut off grade at 0,22% Cu. The copper-Gold-silver-sulphurcontent in the drillcores can be seen in the table under the chapter drilling, and as enclosures.

Chalcopyrite is the main copper mineral, and it is disseminated. Veinlets of chalcopyrite are also found. Chalcocite and native copper is also registered. Pyrite and a little pyrrhotite is also found in the minera lized zones, but the areas rich in copper seem to be associated only with small amounts of pyrite. In the areas with much pyrite, there is little or no copper.

Sphalerite is found as traces in the black schists.

In the copper mineral ized areas there is also found galena. The galena is not associated with the copper. Some places the galena occurs in partly brecciated zones, but it is also found in undisturbed zones.
Gold and silver is found in nearly all samples analyzed. The gold content varies from zero up to 8 ppm, while the mean gold content generally is the same in ppm as the copper content in percent.
It should be noted that a little gold also is found in copperfree zones like in drillhole No. 4. Here it is rather much pyrite (2,26% S mean content in 12 samples).

Small gold grains in a number of 28 are found in 16 polished sections from drillholes 5, 6, 7 and 8. See report by Ragnar Hagen, enclosed. Hagen reports that the gold is bound to a parageneses of dessiminated grains of pyrrhotite and chalcopyrite grown together.
This is a very important registration and will be followed up in the ore dressing tests (see next chapter) to obtain as much gold as possible.
Ore dressing test carried out on the drillcores from drillhole No. 3 the gold was enriched 24 times in the copper concentrate while the copper was enriched 40 times.
Small amounts of molybdenite is also reported by Hagen.
The silver content is relatively low compared with gold. In drillhole No. 2, 3 and 4 it is only 1 ppm Ag and in drillhole No. 1 approximately 3 ppm.

Ore dressing tests

Flotation tests are done on core samples from drillhole No. 2 and 3. The conclusions from these tests are that the chalcopyrite is very finegrained and often mixed with pyrite. It is therefore difficult to make a good copper concentrate. The best copper concentrate was obtained from the samples from drillhole No. 3 with a copper content of 10,7 % Cu. This is a concentration ratio of 40. The gold content in the copper concentrate was 6,39 ppm and the silver content 22 ppm. Compared to copper a little more than 50% of the gold and silver was concentrated in the copper concentrate.

More flotation tests are now carried out at the Technical University of Trondheim on the samples from drillhole No. 5, 6, 7 and 8. The fact that gold is found in parageneses of pyrrhotite and chalcopyrite grown together is taken into account in these tests.

Recomandations for further prospecting work

Primarily the most important factors of the prospecting work carried out should be summarized:

1. The low grade copper-gold bearing gneiss is found along the strike of the rocks from Raitevarre to Bæivasgiedde (fig. 1). This is a distance of at least 20 km. Some places the copper content is up to 0,44% over 20 m of thickness.

2. Together with the copperminera lizations it is gold with mean contents in ppm of the same order as copper in percent. Gold is also found in pyritic zones. Alluvial gold deposits along the river of Karasjokka and Bavtajokka have been worked on, in several periods since the 17th century, and alluvial gold is found all over the area.

3. The chromium mica fuchsite is found several places in the area. This can indicate that the existing sedimentary rocks partly are derived from an environment of ultramafic rocks.

4. NGU has done geophysical measurements by helicopter 1980 over a rather large area between Raitevarre and Bæivasgiedde. The results from these measurements and from some core drillings will be given free this spring.

5. Wennervirta (1968) has mapped the Karasjok area. He also has made a tectonic map (fig. 12, transparent overlay to fig. 1).

6. It should be stated that the area is well covered by glacial till exept along the major rivers and on the highest tops.

7. The Biedjovagge copper-gold mine 90 km's W of Raitevarre is situated in the same Precambrian formation. Here it is important gold concentrations in the ore. Gold is also found in "encouraging" concentrations outside the ore, but not as alluvial gold like it is found in the Raitevarre area. Fuchsiterich sediments are reported from Biedjovagge, but they are not yet studied.
   From the Kittilä area, however, which is some 190 km's S of Raitevarre it is described an area with chromian marble (Pekkala and Puustinen 1978). The chromian marble is sulphide impregnated. Some places the sulphide content is as high as 30% and the rock is then called a sulphide schist.

In a few random samples from this sulphide bearing schist the gold content is as high as 0,5 ppm.
Gold is found in quartz-ankerite veins in Finnish Lapland.

Bearing in mind the information summarized above and that the mineralogy and geology at Raitevarre is very similar to the Timmins area in Ontario Canada (Karvinen 1978*), Davies 1980, Morrison 1980, the following suggestions for a follow up work on the prospecting work can be set up:

*The Karvinen paper is so important that it is enclosed to this report.

1. Detailed structural mapping of the area to find favorable units of structure where possible remobilisation and enrichment of the gold has taken place. Fig. 13 is a compilation of the distribution of different elongation directions of all geophysical, geochemical and geological disiplines that are worked out in the Raitevarre area. In NGU-report No. 1561-02 1980,B. Rindstad describes the use and benefits of an EDB-program of digitalisation -statistics, plots and grids of lineaments red by Landsat 1, 2 and 3.
Together with the information that will be free from NGU's work in the area, the structural analyses over Raitevarre (fig. 13), the digitalisation of the lineaments registrated by the Landsatelites and the work done by Wennervirta (fig. 12) there should be a good base for the follow up work on the structural problems.

2. Detailed geological mapping should be carried out. We should especially do follow up work on the volcanic rocks. Morrison (1980) states that association between volcanic necks and major gold fields has been observed elsewhere on the Abitibi greenstone Belt of north-eastern Ontario and north-western Quebec.
The erosion and redeposition of soft sediments and fresh lavas, submarine fumarolic activity, and the remobilization of quartz and gold by heat from volcanic necks are believed to have been significant in this area.
Volcanic rocks, even agglomerates, are described from the area (Wennervirta 1968). Solid rock geochemistry and analyses of several elements should guide us to find important volcanic centers or volcanic necks. Important host minerals like tourmaline and ankerite should also be looked for.

3. Prospecting techniques of geochemistry and geophysics should be considered after the geological and structural work. Boyle and Hood (1980) and Northern Miner (1979). (Enclosures).

Conclusional remarks and costs

The Raitevarre area has several similarities to other gold associated areas in the vicinity (Biedjovagge and Kittilä) and also to major gold producing districts like Timmins Ontario. No gold deposits have been found in the Raitevarre area so far exept for the lowgrade gold content in Raitevarre and 2 ppm Au in a quartz vein from Storfossen. In Finnish Lapland however narrow gold-ankerite veins are found.

Alluvial gold is found all over the inner Finnmark. The total amount of gold must therefore be of considerable magnitude. If the gold bearing rocks are not totally eroded it is believed that there must still exist some major sources to the alluvial gold. These sources are considered to be remobilised and accumulated gold from ore types like Raitevarre.

We should also prospect for mineable copper ore of Raitevarre type. The possibilities to find gold deposits of the type described above seems, however, to be at least as good as for finding economic ore of the Raite type.

Sydvaranger's premining consessions for the Raitevarre area is rather soon expiering (April 1981). The coming seasons we therefore should raise our efforts to carry throug a prospecting program which ends up with a satisfactional answer if there are any minable copper-gold deposits in the area or not.

Costs

In the field season of 1981 only geological and structural mapping will be done. Additional costs will be field transportation and analytical costs. The 1981 costs are therefore believed to be covered under the 1981 budget.

Stabekk february 24 1981

Bernt Røsholt

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HELICOPTER MEASUREMENTS

Em in phase

EM out of phase

Magnetic vertical gradient

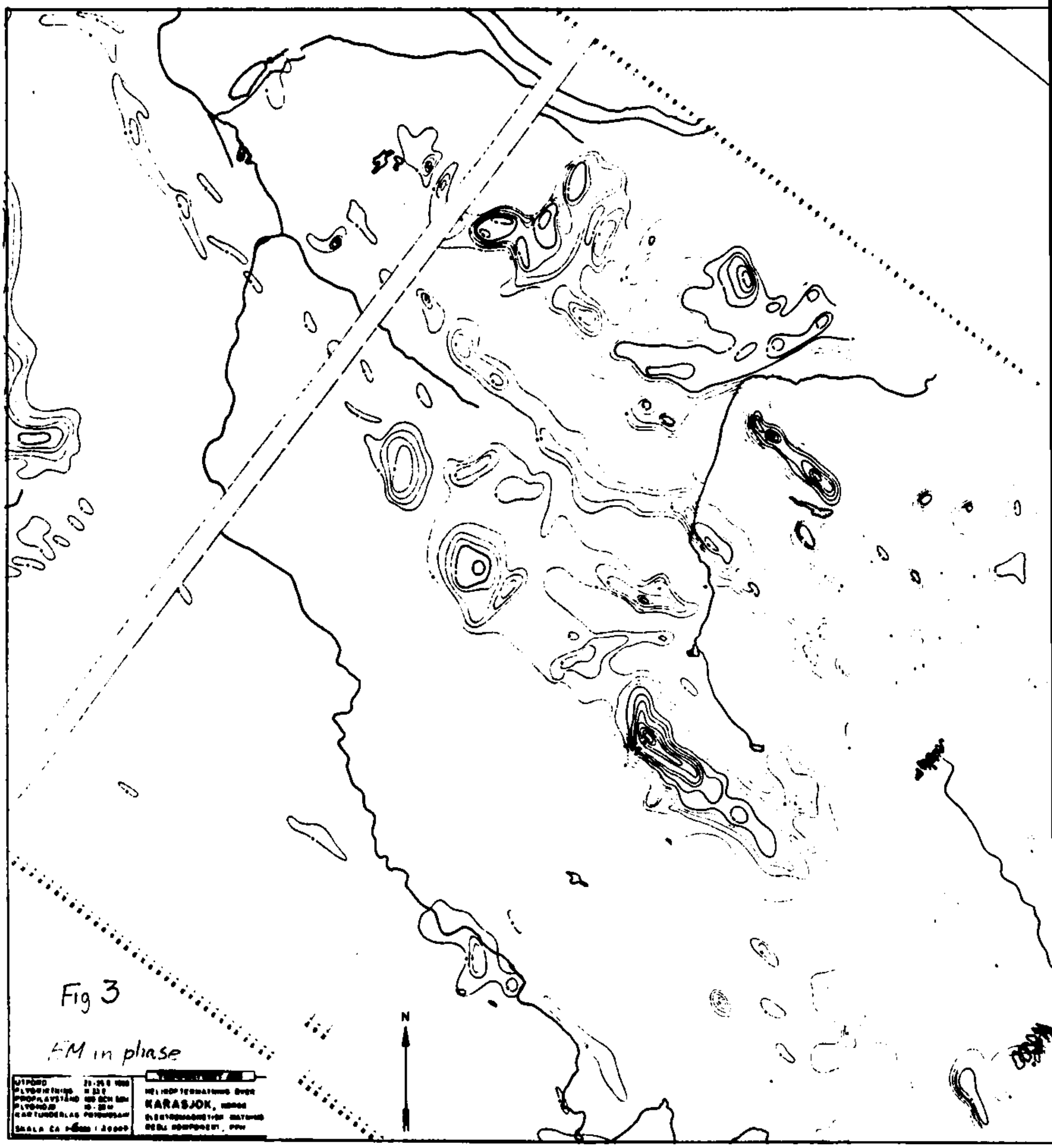
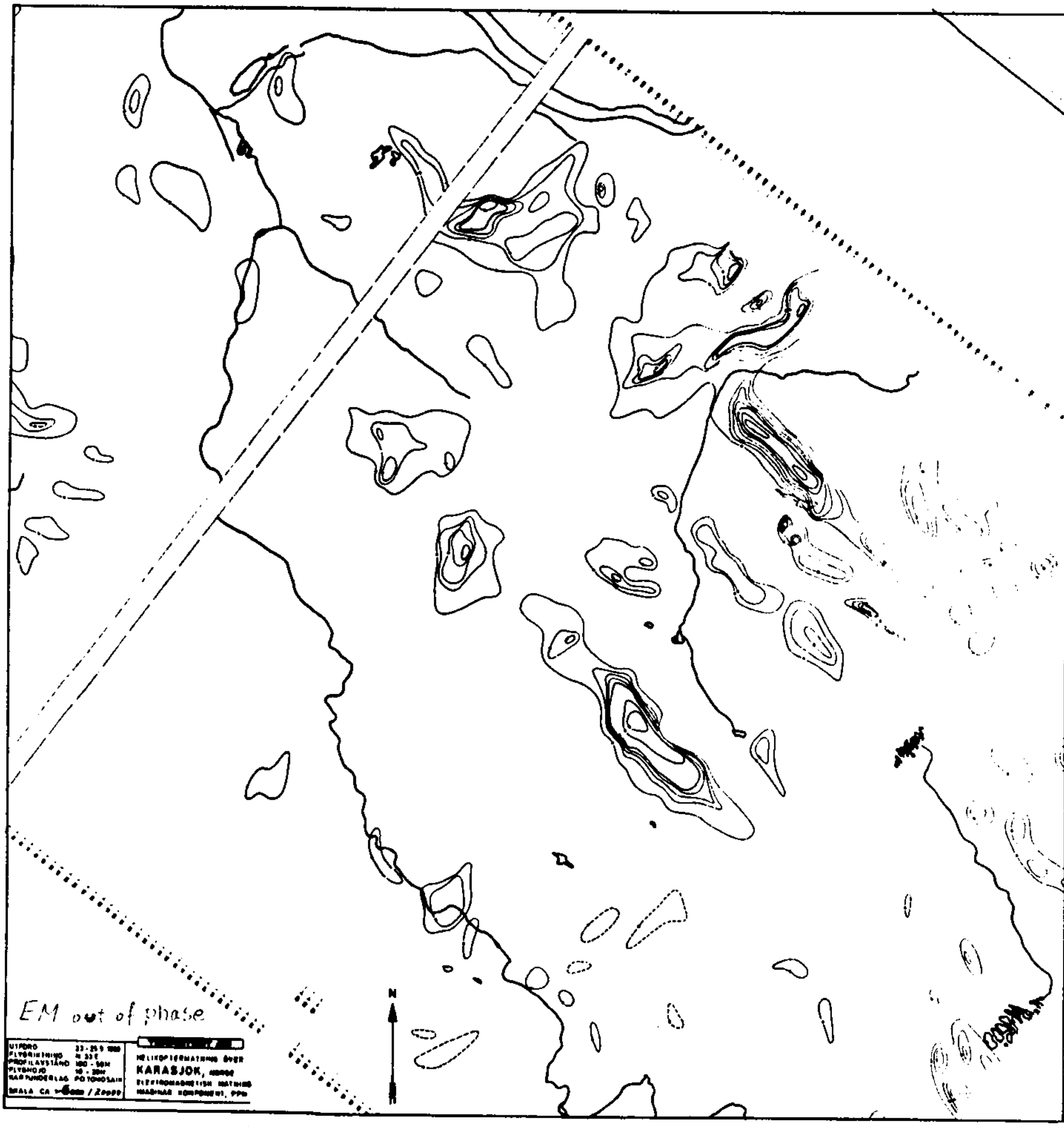
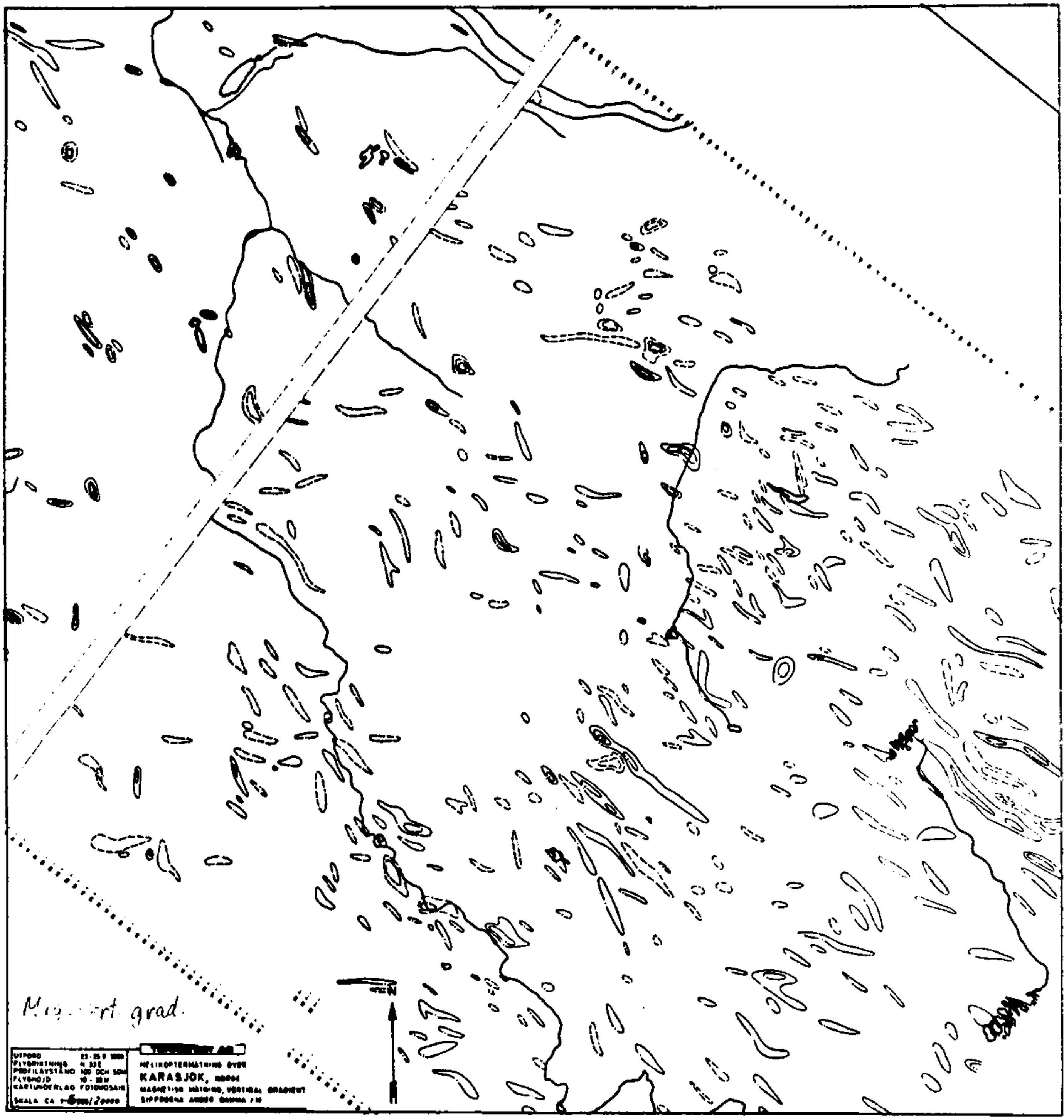


Fig 3

EM in phase

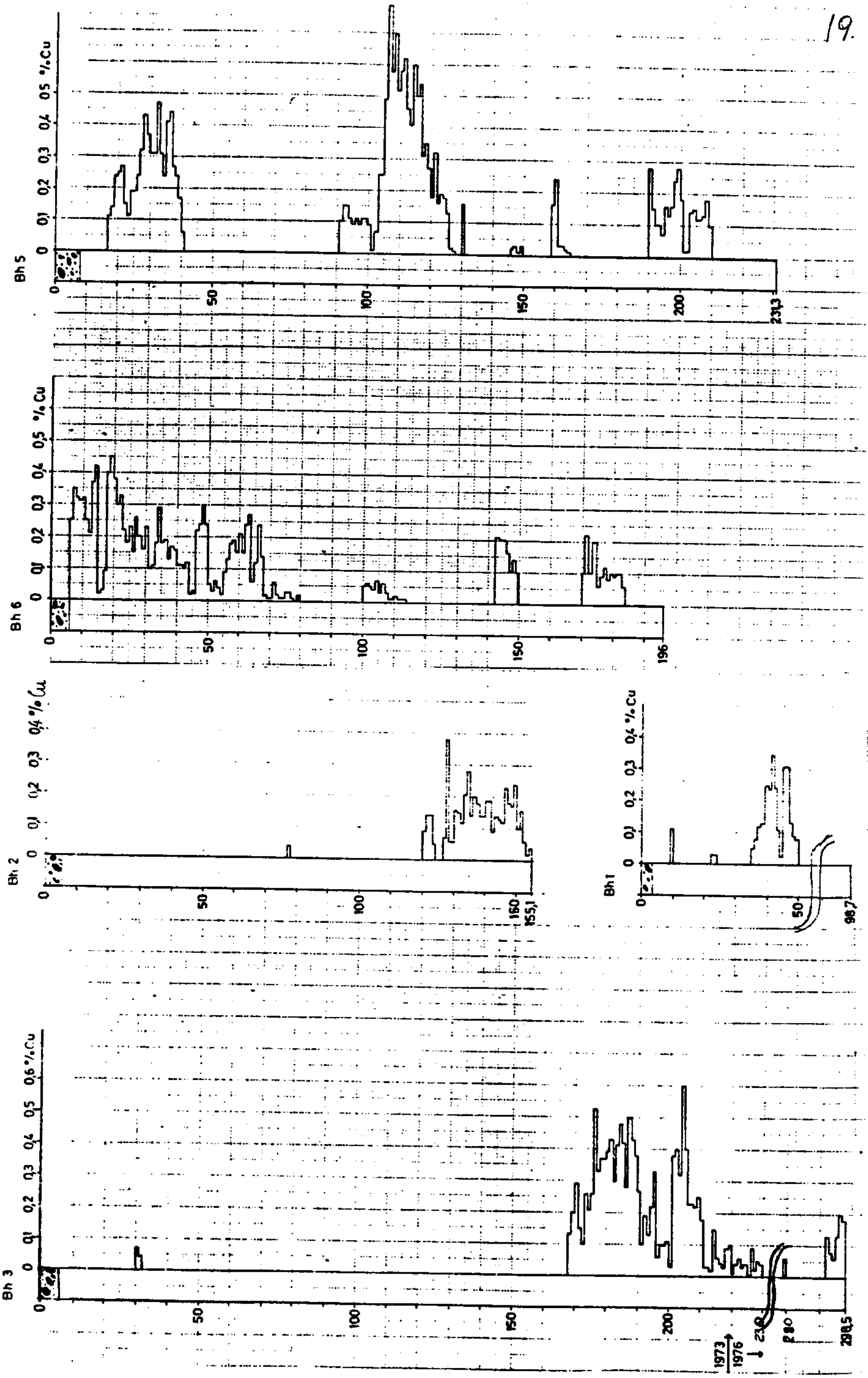

EM out of phase
UTFØRD
FLYRETNING
PROFILAVSTAND
FLYHØJD
KARASJOK,
N

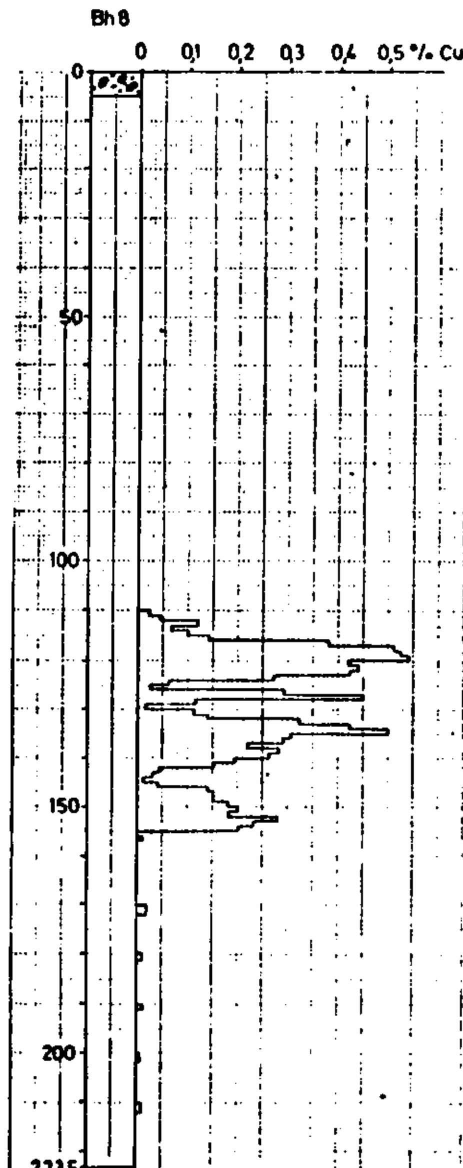


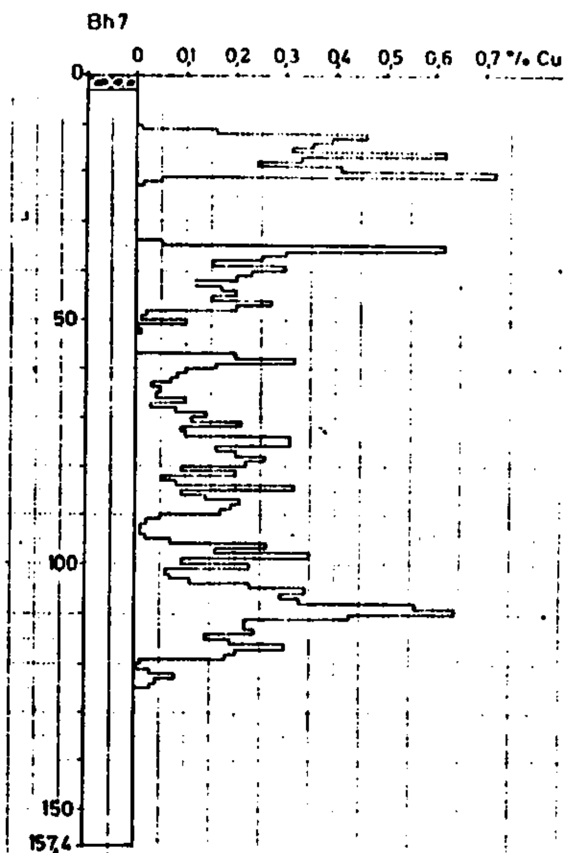
grad.
UTFÖRD
FLYGRIKTNING
PROFILAVSTÅND
FLYGHÖJD
KARTUNDERLAG FOTOMOSAIK
SKALA CA
HELIKOPTERMÄTNING ÖVER
KARASJOK,
MAGNETISK MÄTNING, VERTIKAL GRADIENT
N

ANALYTICAL RESULTS FROM DRILLHOLES

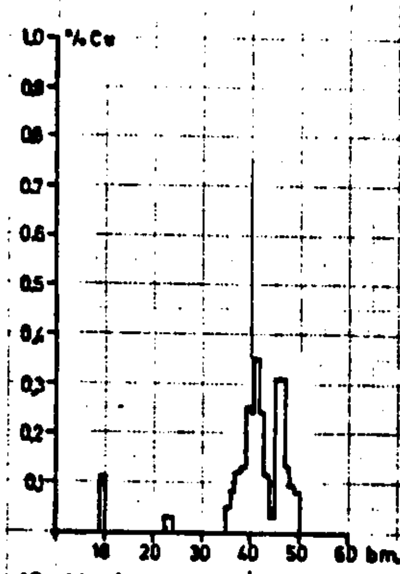
No. 1 - 8 Cu, Au, Ag, S

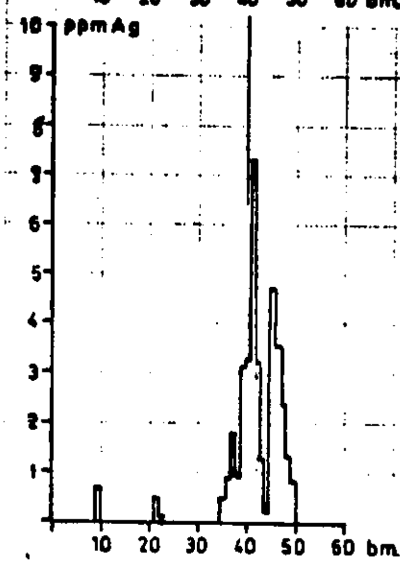

Bh 5
% Cu
231,3
Bh 6
196
Bh 2
155,1
Bh 1
98,7
Bh 3
298,5
1973
1976


Bh 8
0
0,1
0,2
0,3
0,4
0,5 % Cu
0
50
100
150
200
221,5

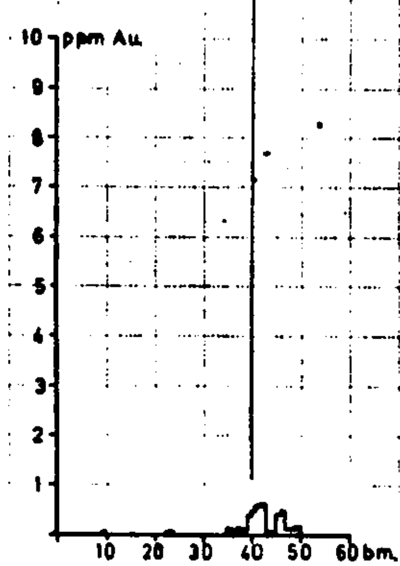

Bh 7
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7 % Cu
0
50
100
150
157,4

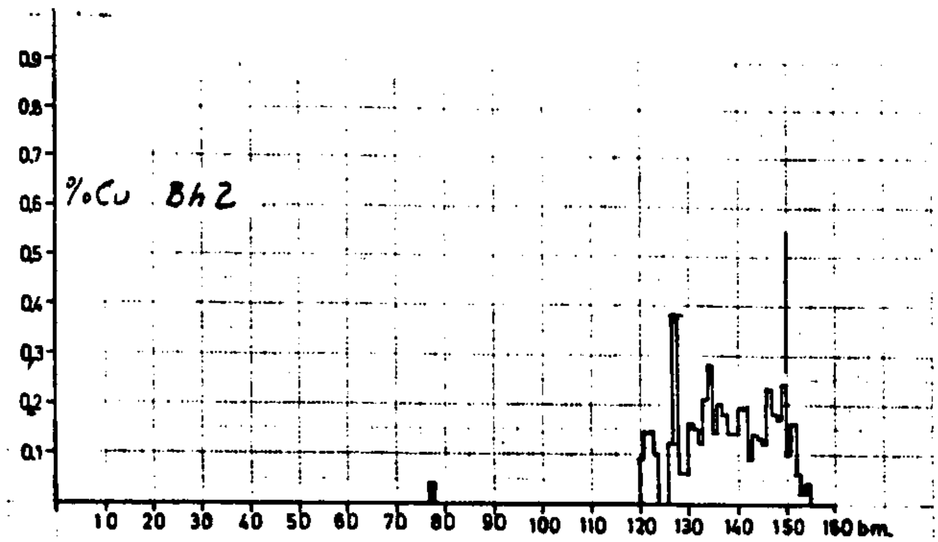
Bh. 1

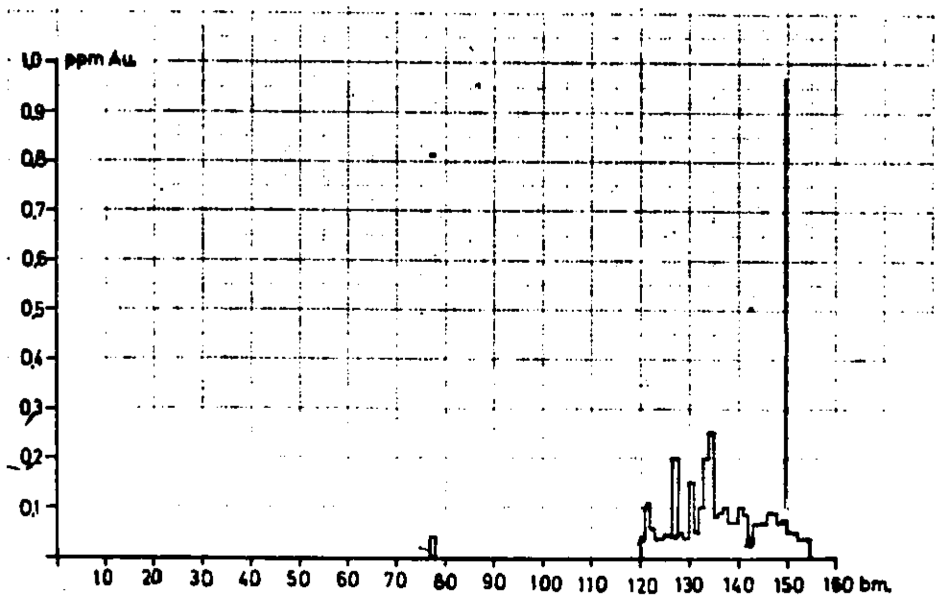

% Cu
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10 20 30 40 50 60 bm.

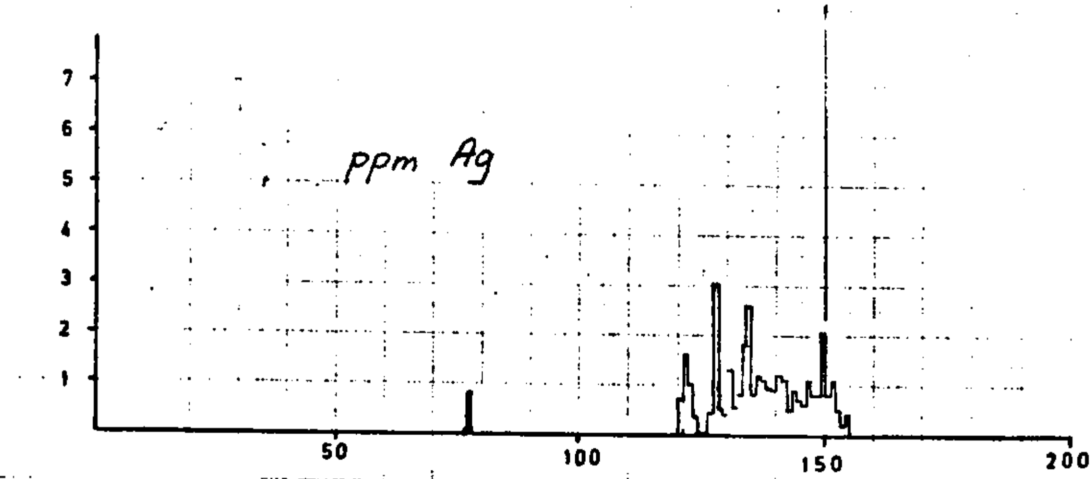

ppm Ag
10
9
8
7
6
5
4
3
2
1
10 20 30 40 50 60 bm.

Bh. 1


ppm Au
10
9
8
7
6
5
4
3
2
1
10 20 30 40 50 60 bm.


%Cu Bh2
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 bm.


ppm Au.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 bm.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5
4
3
2
1
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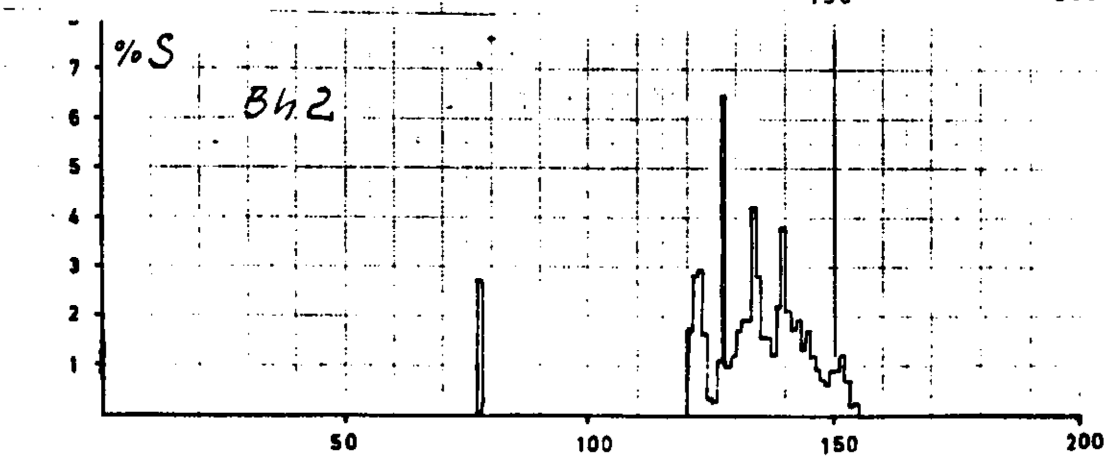
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Bh2
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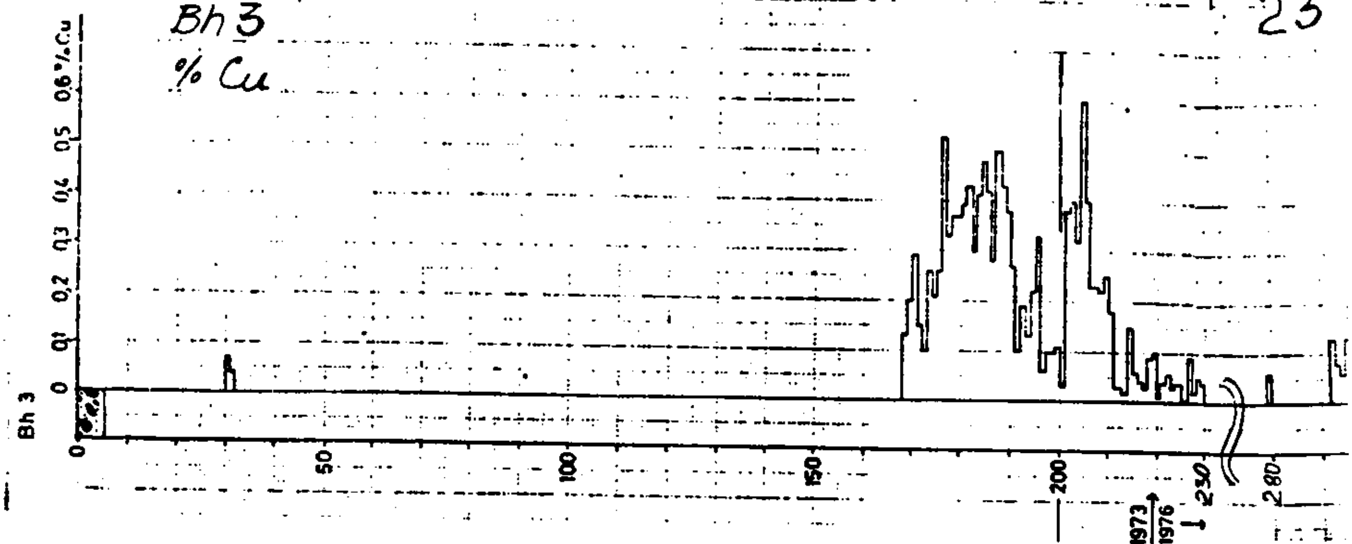
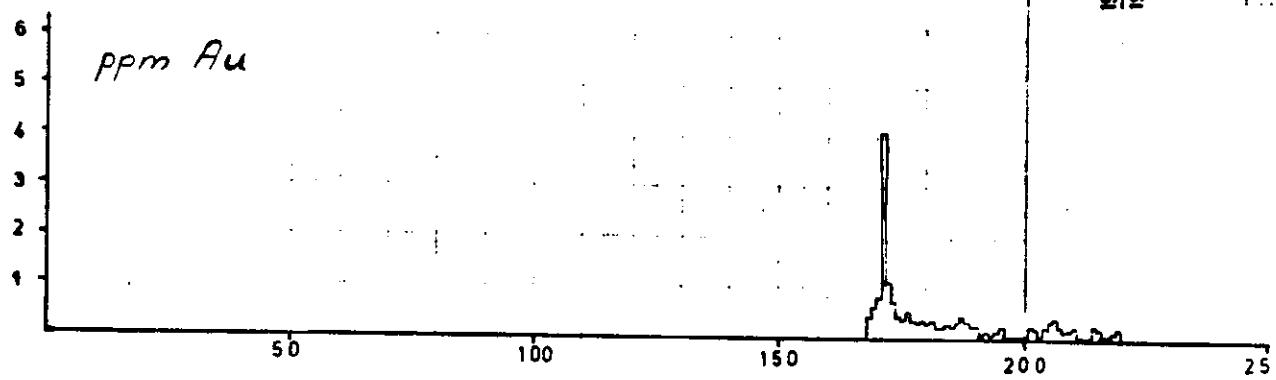

Bh 3
% Cu
0.6 % Cu
0.5
0.4
0.3
0.2
0.1
0
Bh 3
0
50
100
150
200
250
280
1973
1976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200
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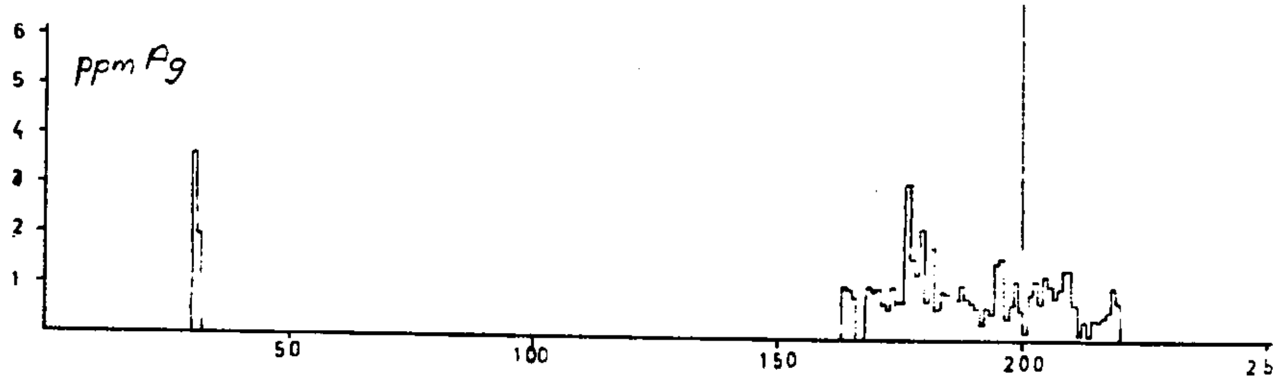
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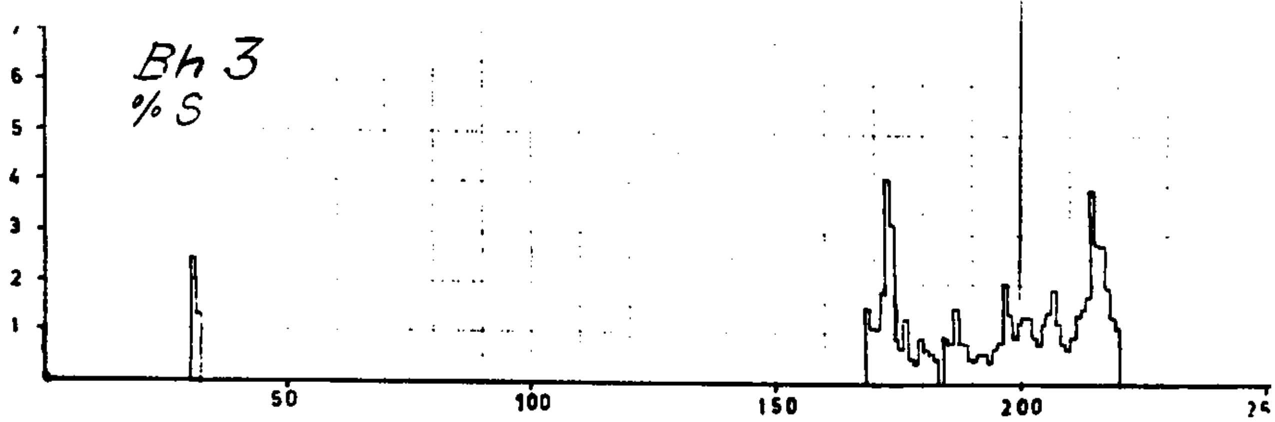

Bh 3
% S
6
5
4
3
2
1
50
100
150
200
250

CORE LOGS

Kjernerapport og boroversikt Raitevarre

1973:

Bh.	Dyp	Tidsrom	Skift	m/skift
1	98,7	4-10/8	7(langsk.)	≤ 13
2	155,05	13-29/8	19	8,2
3	220,15	1-21/9	32½	6,8
4	83,7	23-28/9	10½	8,0
Sum	557,60	4/8 - 28/9	69	8,1

1976:

5	231,3	27/7
6	196,0	
7	157,4	
8	223,5	
3	79,2	7/9

887,4 m 27/7-7/9 = 43 dg - 6 fridg-8dg.flytt = 29 dg
59 dg 58 sk.

): effekt 15,3 m/skift

Med andre ord - omtrent det dobbelte av effekten fra 1973 med nesten tilsvarende maskinen.

Bh 1 Start 4/8 ferdige 10/8. Dyp 99 m. 7 langskift. 13 m/skift.

Dyp	Legdeling	Kjernetap	Analyse	Beskrivelse
0 - 3,5		Overdekket		P.g.a. dypforvitring må det bores jordboring ned til 3,5 m. Spor Cpy i de grove kjernene som sannsynligvis er insithublokk.
3,5 - 10	~ 90°	0,11	9-10: Cu,Ag,Ni,Zn	Lys dioritisk gneis med enkelte mørkere partier med amf., biotit og klorit. (Mulig også fuchsit ved 9,8 m) Oppspr. ca. 10 spr/m. Mineralisering: Spor Cpy nesten i hele kasser, men trolig ∠ 0,1 % Cu. Noe bedre 9,6 - 9,7 m med kloritt. Mørkt bløtt ertsminr ? ved 9,2 m. prøve.
10 - 20	~ 90°			Som foregående, men mindre Cpy. Prøve 10,8 m av mørkt ertsminr m/Cpy " 13,6 m av Py og Mk for kjem. analyse og slip
20 - 30	~ 90°	0,03 0,03	22-30: Cu,Ag,Ni,Zn 23-24: " " " "	Vesentlig kloritrik gneis. Minr: Mye py og spor Cpy spesielt i forbindelse med kloriten. Analyse av 22-24 m. Noe MK.
30 - 40	~ 80°	0,05 ÷ 0,08 ÷ 0,12 ÷ 0,13 + 0,25 +	35-36: " " " " 36-37: " " " " 37-38: " " " " 38-39: " " " " 39-40: " " " "	Bergart: Gneis med tiltagende kloritinnhold mot 40 m. Minr: Spor Cpy 30-35 m. Mot 40 m sterkere spor og tildels pen mineralisering med Spy og MK. Relativt lite Py. 38-39 ser ut til å være best. Prøve.
40-50		0,24 0,35 0,24 0,11 0,03 ÷ 0,31 0,31 0,13 0,09 ÷ 0,09 ÷	40-41: Cu,Ag,Ni,Zn 41-42: " " " " 42-43: " " " " 43-44: " " " " 44-45: " " " " 45-46: " " " " 46-47: " " " " 47-48: " " " " 48-49: " " " " 49-50: " " " "	Bergart: Relativt mye klorit i gneisen. Avtagende kloritinnh. mot 50 m. Kvartsone 41.8 - 42 m. Mineralisering: Stort sett pen impr. frem til 47,0 Prøve 41,4 og 46,1 av pen Cpy-minr. 44-45, 48-49 og 49-50 svakt impr.
50-60	~ 90°			Bergart: Grå gneis med jevn fordeling av klorit. Minr. : Svak impr. av Cpy. Beste impr. 50-52 m.
60-70				Bergart: Som foreg. Minr. : Litt MK og Py og kun svake spor av Cpy.
70-80				Bergart: Som foreg., men med klorit. Prøve fra 70,2 m med klorit, Py, MK og litt Cpy. Minr. : Litt py og MK med rike tydelige Cpy-spo
80-90	80-90°			Bergart: Vanlig gneis 80-84,7 som foregående. 84,7-90 granat-glimmergneis med kvartsøyne. Prøve 88,8 m. Minr. : Litt Cpy og MK i kvarts ved 82,6. Ellers meget svake kobberspor. Kan ikke se Cpy i granatgneisen. Forholdsvis lite pyrit.
90-98,7	80-90°			Bergart: Vesentlig granatgl.gneis m/kvartsøyne, men sonevis med den vanlige gneis og hydrothermal-kvartssonen. Minr.: Noe Py hele veien, men svært svake spor med Cpy og Mk. Hulldyp 99,0 m Kjernelengde 98,7 m

Bh. 2. Start 13/8 ferdig etter nattskift 29.8. Mask.havari 16/8-23/8) i 19 skift 8,2 m/skift.
(3 hele skift + mange små stopp 6 skift v/prakk)
Dyp 155,05. (Vært oppe i 23 m/skift 12 m/skift effektivt)

Dyp	Lagdeling	Kjernetap	Analyse/prøve	Beskrivelse
0-5,0		overd.		Overd. ca. 2 m. 2 - 5 m dypforvitring.
5-10	~ 80°		6,7 : MK og Cpy i lys b.a. 9,05: Granat gl sk.	Bergart: Grov granatgl.sk. granater 1-2 cm. Soner med litt grafitt. Kis i soner med kvarts (?) og feltspat. Mineralisering: MK i soner med kvarts (?) og feltsp (prøve) MK også i granatgl.sk. Spor med Cpy. Litt grafit.
10-20	90°			Bergart: Som foregående 10-15,2. 15,2-20 etterhver lysere bergart med spett av biotitt og diffuse granater. Mot 20 som en lys grå gneis. Mineralisering: MK 12,8 - 15,0 ~ 5 % kis. Mindre kis 15-20 m. 10-15 m litt (spor) grafit.
20-30	90°			Bergart: Vekslende granatførende gl.gneis. Lite granater fra 27 m. og soner med grønnstens-(klorit) materiale med kvarts og kalkspatsoner. På slutten enkelte blåkvartssoner. Minr.: Lite MK (spor)
30-40	80-90°		38,85 MK og sph ? 39,5 " " " ?	Bergart: Vekslende som foregående, men bare få granater. Fremdeles "blåkvarts" i klorit-sonene. Minr. : MK fra 3,7 - 40 i veksl. mengde ~ 10 % kis. Også sinkblende ? prøve. En del karbonat med kisen. Grafit 33,95 - 34,20.
40-50	80-90°		41,4 Granat m/korona	Bergart: Vesentlig grå til mørk grå gneis med med spredte granater og tildels kalkførende. Granatene har en lys reaksjonssone rundt seg. Minr.: Kun litt MK. Kan ikke se grafit.
50-60	80-90°		56,4 Veksl. Kv og kalksp. 54,8 Cp-ansaml.	Bergart: Som foreg., men mer skifrig og mindre granat. Flere kalkspatsoner på opptil 2-3 cm. Kalkspatsonene veksler med kvartssoner og gl. Betydelig med kalksp. i gneisen. Minr.: 54,6-56 veksl. grafit kalksp./kvarts med litt MK og spor Cpy, særlig med grafit. Prøve av største Cpy-ansamling.
60-70			66,3 Omv.granat	Bergart: Mørkere noe mer skifrig gneis. Kan ikke se granater, men hvite spetter som kan tenkes å være omv. granater. Joda, det stemmer det ! kan se granatrelikter i de hvite minr.ansamlingene. (Prøve) se prøve 41,4. Flere grafitrike soner. Tekt: Knusesoner 63,9-64,3, 65,4-65,5, 66,4-66,6, 68,0-68,1, 68,4-69,0, 69,6-70,0. Delvis breksiert fra 64-70 m. Minr.: Grafitsoner i hele kassen fra få cm opp til ca. 1 m (nesten sammenhengende 61,5-62,5) En del MK og noe Cpy i breksjesonene med kalkspat og euhedral kvarts. (Prøve) ∠ 5 % sulfider i kassen.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
70-80	~ 90°		76,95-77,03: Minr. m/høy glans i grafit 77-78: Cu,Ni,Ag,Zn	<u>Bergart</u>: Grafitskifer og kalksten("kalkgneis") 71,6-75,9. Kalkgneis også som soner i grafitskiferen. <u>Tekt:</u> En del knusesoner og breksiering, men ikke så mye som i foregående kasse. <u>Minr.</u>: Grafit-rik skifer 70-71,6, 71,9-72,2, 75,8-80, med litt kalk 78-78,5. Litt Cpy hele veien i grafitsk. på speil. Ubestemt minr. me høy glans i grafitsk. Prøve. Py på små (∠ 1 cm) ganger med Kv og kalksp. Tar ut 77-78 til analyse.
80-90	90°			<u>Bergart</u>: Grafitsk 80-83,1, 86,2-86,5 med noe kalk på samme måte som foreg. kasse. 83,1-86,5 vekslende kalkgn. og granatførende vanlig grå gneis. Granater m/korona. 86,5-90 vanlig grå gl.gn. med granater m/korona. <u>Minr.</u>: I grafitsk. Cpy på speil som foreg. I gneisen også pene Cpy-spor, men på sprekker med
90-100	70-90°			<u>Bergart</u>: Vesentlig grå gn. m/granater. Enkelte kvarts og kalkspatsoner. <u>Minr.</u>: Litt MK og litt Cpy (spor). Hurtig oksidering på MK ! Belegg etter bare 2-3 dg !
100-110	90°			<u>Bergart</u>: Som foreg. samt en del biotit og klori <u>Minr.</u>: Litt MK og spor Cpy spes. på sprekker i lysere partier (kvartsitrike).
110-120	70-90°			<u>Bergart</u>: Grå gn. m/omv. granater samt endel biotit og klorit. Kloritsone 112,7-114,7. <u>Minr.</u>: Litt Mk. Kan ikke se Cpy.
120-130			122,2: MK,Cpy 121,9: Cpy,Mk (Py)	<u>Bergart</u>: Grå gn. med flekker som trolig har vært granater + granater ! En del biotit. <u>Tekt</u> : Breksje 120,120,6. Kittet sammen med kalkspat. <u>Minr.</u>: Cpy-soner: 120-122,9 , 127,6-130. Siste sone har en del py m/Cpy.
		÷	120 -121 : Cu,Ni,Zn,Ag	
		0,2	121 -122 : " " " "	
		rel. lite	122 -122,9: " " " "	
		0	122,9-124 : " " " "	
		0	124 -125 : " " " "	
		0	125 -126,6: " " " "	
		0	126,6-127,6: " " " "	
		>0,3	127,6-128 : " " " "	
		÷	128 -129 : " " " "	
		÷	129 -130 : " " " "	
130-140	70-90°		130 - 131 : " " " "	<u>Bergart</u>: Grå gneis m/muskovit og biotit. Kan ikke se granat. <u>Minr.</u>: 130-140 m mer eller mindre impregnert med Cpy, Cpy-holdig py og MK. Alle 10 m må analyseres.
			131 - 132 : " " " "	
			132 - 133 : " " " "	
			133 - 134 : " " " "	
			134 - 135 : " " " "	
			135 - 136 : " " " "	
			136 - 137 : " " " "	
			137 - 138 : " " " "	
			138 - 139 : " " " "	
			139 - 140 : " " " "	
			140,o: Py og Cpy	
			137,5: Py, MK og Cpy	

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
	(140-140,5 45° !		146,6: Gn.m/"kvartsøyne",MK,Cpy 143,2: Gl.gn m/Py,Cpy	
140-150	70-90°		+140,141: Cu,Ni,Zn,Ag +141-142: " " " " +142-143: " " " " +143-144: " " " " +144-145: " " " " +145-146: " " " " +146-147: " " " " +147-148: " " " " o 148-149: " " " " +149-150: " " " "	Bergart: Grå gneis. Kan ikke se granat, men "kvartsøyne" som kan minne om omvandlede granater (prøve). Spetter med klorit og soner med biotit og muskovit. Minr.: Mineralisert som i forrige kasse med Cpy-holdig Py, Po, Cpy og Mk. Hull - Dyp = Kjernelengde.
150-155,05			151,9: Lys gn.m/klorit MK,PY,Cpy 152,6: Gn spettet m.klorit eller amf. ? 155,05: Gl.gn.m/granat+Cpy +150-151: Cu,Ni,Ag,Zn +151-152: " " " " +152-153: " " " " o 153,154: " " " " o 154-155: " " " "	Bergart: 150-153,4 som før med spetter av klorit (eller amfibol ?) Prøve. Muligens noe granatrelikter nærmere 153,4 153,4 - 155,05 en gl.gn. med rikelig med granater (prøve). Minr.: Svakere med Cpy enn i siste kasse. Svakere spor når granatene kommer inn, men pen Cpy-Mk-stripe ved 154,4. Dette hullet burde ha vært kjørt lenger, men ble avblåst p.g.a. dynamosvikt og pumpefestesvikt. Maskinen ble flyttet mens dette ble reparert for å utnytte tiden.

Bh. 3. Start 1/9, ferdig 21/9. Helg 7-10/9): 32 ½ skift. Hulldyp 220,15
): 6,8 m/skift

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
0-5,5				Overdekket og grov kjerneboring.
5,5-10				Bergart: Granatgn. 5,5-7,7 og 9-10 m/kvartsøyne som er omv. granat og med granat. Grafitisk: 7,7-9 sterkt grafitholdig. Minr.: Intet.
10-20				Bergart: Granatgn. m. klorit og amf.: 10-16,7, 16,9-17,2, 17,25-17,35, 19,3-19,5 Feit grafitsk. 16,7-16,9, 17,2-17,25, 17,35-19,3, 19,5-20. Minr.: Intet. Spor av MK i grafit.
20-30	70-85° mest 70°		22,7-22,9: Grafitsk. og gn.m/ MK,Cpy,Sph.	Bergart: Grafitsk. med noen få striper gn Veksl. grafitinnh. Minr.: Pene spor av MK, Sph, Spy spesiel i de lysere partier på sprekker og i tynn lag.
30-40	67-70°		30-31: Cu,Zn,Ni,Ag 31-32: " " " " 38,6: Grafitsk. m/MK,Cpy,Sph.	Bergart: Grafitsk. veksl. type og mørke partier. Tekt.: Breksjesone (sammenkittet m/kvart 32-32,2) Minr.: Som foregående m/MK Cpy og litt S spesielt i de lyseste partier.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
40-50	47°,60°,73°		42,05: Py,MK,Sph,Cpy	Bergart: Grafitsk. 40-44,2, 44,8-44,9, 45,05-46,2, 49,8-50. Grå gneis m/granat, omvandl. granat ("kvartsøyne") gl. klorit, amf. i 44,2-44,8, 44,9-45,05, 46,2-49,9. Minr.: Som 30-40 m, men noe mer py. Kalkspatfyllinger.
50-60	60°,67°		52,8: Grafitsk.-gneis 53,5: Grafitsk./m.Cpy	Bergart: Grafitsk. veksl. lys og mørk. Der den er lys ligner den gneisen med omv. granater + litt grafit (prøve). Tekt.: Breksje sammenkittet m/kvarts: 50-50,2, 53,7-54,3. Flere knusesoner. Minr.: En del pene spor med Cpy og MK. Prøve 53,5.
60-70	60°,68°,45°			Bergart: Grafitsk. lys type fra 64-70 m. Tekt.: Knusesone 66,7-67,o. Minr.: Litt Cpy (spor) og MK. Mindre enn foreg. kasse.
70-80	60,60,52,45°			Bergart: Veksl. grafitsk. og grå gn. med og uten grafit. Tekt.: Noen knusesoner. Minr.: Litt MK, py, Cpy, Sph (spor)
80 - 90	80°,63°,63°			Bergart: Grå gneis m/granat 80-82,7, 86,7-90 med et parti små graftisoner. Grafitsk og gr gneis i veksl. 82,7-86,7. Tekt.: Knusesoner (6 stk) 10-40 cm fra 83-89 m. Minr.: Kun svake Cpy-spor + MK og py.
90 -100	66°(?), 70°(?)			Bergart: Biotit-granatgneis. Minr.: Ikke spor.
100-110	?		102,7: Granat m.omv.sone	Bergart: Som foreg. Granatstørrelsen veksler helt opp i 1 cm. Noen steder omv. sone rundt granatene. Prøve. Minr.: Ikke spor.
110-120	100°,90°, 100°		114,6: Grønt minr. Kalksp?	Bergart: Veksl. grafitsk., grafitholdig gn. gn. m/granat ca. 50/50. Soner med grønt minr. Kalkspat? litt for hardt. Også granater i grafithorisonter. Tekt.: Breksje sammenkittet 1o7,4-108,10. Ellers flere knusesoner. Minr.: Spor Cpy og litt MK særlig i forb med sprekker og breksjesoner.
120-130	80°,80°, 100°			Bergart: Veksl. grafitsk og granatgneis som foreg. dog mest gneis (≤ 2,5 m grafitsk) Tekt.: Breksje sammenkittet 120,7-121,4, knusesone: 122,5-122,8. Minr.: Kun spor Cpy + MK og Py litt.
130-140	100°,90°, 80°,100°			Bergart: Biotitgn. med litt granater i beg. som etter hvert blir borte. Litt grafitsk og gneis 132-134 og 135,5-135,8 Minr.: Spor Cpy i forb. med grafitsonene.
140-150	?		143,o: Klorit	Bergart: Granat-biotit gneis med kraftige kloritsoner 141,5-144,5, 146,3-147. Granatene er delvis omv. m/korona av kvarts(Minr.: Kun spor av MK og Cpy.
150-160	90°		156,7: Gneis m/kloritspetter	Bergart: Grå biotitgneis med kun få granater, men spekket med kloritspetter. Minr.: Kun spor Cpy.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
160-170	?		168-169: Cu,Zn,Ni,Ag 169-170: " " " "	Bergart: Grå gn. grovspettet m/klorit. Noe mindre klorit fra 166 m. Minr.: Litt Cpy og py fra 166 m. Sanns ~ 0,10 % Cu. Cpy rose 166,8.
170-180	80°,70°, 80°,100°		172,5: Klorit-musk.-cericit-bergart m/Cpy, MK, Py. 173-174: Cu,Ni,Zn,Ag 175-176: " " " " 176-177: " " " "	Bergart: Lys gl.gneis (skifer) med mye muskovit (cericit) stedvis grønt + kloritson Minr.: Cpy, Mk, Py flekkvis i bestemte soner. 5-10 cm. Disse utgjør lite totalt. Stedvis også betydelig med Py. Lite MK. Cpy finnes også utenom de anal. soner muligens på samme nivå, men svak mineraliser
180-190	70°,80°,100°		189,1: Kvartsit 180-181: Cu. 181-182 182-183 183-184 184-185 185-186 186-187 187-188 188-189 189-190	Bergart: Lys gn. m/klorit. amf.gl. m/granat. Kvartsitisk type på slutten. Minr.: Cpy i hele kassen 0,1-0,2 % Cu.
190-200	?		192,0: Amf.gn. 190-191: Cu 191-192 192-193 193-194 194-195 195-196 196-197 197-198	Bergart: Gneis med amf. og klorit. biotit og cericit. Minr.: Svak Cpy - Py - minr. 190-198 ~0,1 % Cu.
200-210			202,5: Cericit m/Cpy - 200-201: Cu o 201-202 + 202-203 + 203-204 + 204-205 o 205-206 o 206-207 o 207-208 o 208-209 o 209-210	Bergart: Amf. gneis m/klorit, kvarts, cerici Minr.: Pen Cpy-impr. særlig 202-205 m, men hele kassen må anal.
210-220,15	100°(?)		214-215: Cu 215,3: Musk.-cericitgn.m/ py og spor (?) Cpy.	Bergart: Cericit (musk) - klorit - gneis m/amf. Minr.: Vesentlig py, men også litt Cpy. (0,1 %). Tar stikkprøveanalyse av en av de beste metre.

1976. Forlengelse av Bh. 3 fra 219,3 - 300 m.

Dyp	Sp/pr.m	Analyse	Beskrivelse
219,3-220	5		Ba. lys glimmerrik gneis.
220 - 230			Mineral. imp. svovelkis
230 - 240	5		Ba. 230.0-230,9 som foregående kasse. 230,9-240 vekslende dioritisk gneis med granat Mi. imp. svovelkis.
240-250	5		Som foreg. m.svake spor Cu på siste m.
250-260	5		" " vekslende med lys gneis.
260-270	5		Ba. 260-268,0 som foregående, 268,0-270 - Kloritrik gneis. Mi. imp. svovelkis.
270-280	5	279-280,0: Cu	Ba. 270-272,5 Kloritrik gneis. 272,5-280,0 vekslende kloritgneis (spetter) granatførend Mi. imp. svovelkis, 272,6-272,9 gode spor Cu + svake spor i to siste m.
280-290	5		Ba. som foreg.(med granat og klorit spetter) Mi. 280-280,5 imp. svovelkis med god spor Cu 208,5 -290 imp. svovelkis.
290-300	5	297,0-298,0: Cu	Ba. som foregående. Mi. imp. svovelkis 292,0-298,5 spor Cu beste m til analyse.

250°-70° SN   Bh. 4   Start 23/9 ferdig 28/9   10 1/2 skift. Dyp 83,7   : 8,0 m/skift

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
0-10	100°,50°		7-8 : Cu 8-9 : " 9-10: " 8,7 Py i cericitisk gn.	0-3,0 overdekket Bergart: Gneis m/amf. noen granater. Kraftig cerisitisert (muskovit flak). Minr.: Mer og mindre Py-førende 5-10 % Py som stedvis er gullig og følgelig trolig fører noe Cu. Mest py fra 7,0-10 m.
10-20			10,8: Py i cericitisk gn. 10-11: Cu 11-12: 12-13: 13-14: 14-15:	Bergart: Gneis lys vekslende, men mest cericitrik med amf. og granater (+ klorit) Minr.: Py hele veien, men mest 10-15 m. Noen få grafitkorn.
20-30			20-21: Cu 21-22: " 29-30: "	Bergart: Som foregående. Minr.: Py som foreg. Hele kassen reanalyseres hvis Cu.
30-40			30-31: Cu 31-32: " 34-35: "	Bergart: Som før. Minr.: Py som før, mest 30-35. Gedigent Cu 30,90! Hele kassen reanalyseres hvis Cu.
40- 50			41-42: Cu 42-43: " 41,3 :	Bergart: Som før, men mindre py. Mye klorit. Minr.: Noe mindre Py enn tidligere. Kan se spor MK og Cpy. Anal. alt hvis Cu.
50-60	~ 100°		50-51 51-52 52,7 : MK i klorit	Bergart: Klorit -amf.-granat gneis. Lik tidligere gneis, men noe mindre cericit-muskovit. Minr.: Py som før. En del MK i klorit 52,3-53.
60-70	80 - 100		64,9 : Py - Cpy 60-61: Cu 61-62 62-63 63-64 64-65 65-66 66-67 67-68, 68-69, 69-70.	Bergart: Som før, noe mer sliret p.g.a. stedvis store granater. Minr.: Kvartssone 64-64,5. Pen Cpy minr. 64,5-65. Eller en god del gul py.

Dyp	Lagdeling	Kjernetap	Analyse	Beskrivelse
70-80	?		70-71: Cu 71-72 72-73 73-74 74-75 75-76 76-77 70,6: Py-Cpy	<u>Bergart</u>: Grå gneis m/granat. <u>Klorit</u> amf. <u>Minr.</u>: Tildels <u>pen</u> Cpy-holdig py fra 70-77 m. Dog sterkt vekslende. Også en del flekker med MK. Analyse 70-77 m.
80-83,7	80-100°	∠0,05 Cu	80-81: Cu 81-82: " 83,0 : Granatgn. m/MK,py,Cpy	<u>Bergart</u>: Grå gneis sliret, som etter hvert blir sterkt granatførende. <u>Minr.</u>: Lite Py, men den ser ut til å inneholde Cpy. Litt Mk.

<u>Bh. 5.</u>

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
8-10	70-80°	8 m o.d.		<u>Ba:</u> Veksl. dior. gneis og amf.-klorit gneis. Kan ikke se granat. I den grove kjernen sees litt grafitskifer.
10-20	60-80°	8 spr.m	0 17-18 Cu 0,0 18-19 " 0,0 19-20 "	<u>Ba:</u> som foregående. <u>Minr.:</u> Meget fink. Cpy 18-20 m og litt MK. Ellers spor av py.
20-30		9 "	20-30 " (en pr. m)	<u>Ba:</u> Ves. dior. gn. Kvartsførende 28-28, en kloritisk sone. <u>Minr.:</u> Cpy i veksl. mengde, men ofte <u>meget</u> fink. Enkelte klyser i forts. m/kvartsroser og kloritsoner.
30-40		12 "	30-40 " "	<u>Ba:</u> Homogen dioritisk gneis. <u>Minr.:</u> Spor Cpy. Svakt fra 36-40, men hele kassen må analyseres. Noen striper med fluss
40-50		5 "	40-41 "	<u>Ba:</u> Dior. gn. m/amf. og klorit. Litt granat fra ca. 46 m. <u>Minr.:</u> Meget lite Cpy 40-46 m. 3-4 ~/cm CaF_2 - kvarts. NB! Ikke CaF_2, men an
50-60		4 "		<u>Ba:</u> Dioritisk gn.(m/amf) m/klorit og kvarts og granat. <u>Minr.:</u> Litt Py og meget svake spor MK og Cp
60-70		5 "		<u>Ba:</u> Dioritisk gn. m/amf, klorit,kvarts og spor granat. <u>Minr.:</u> Litt py + spor MK og Cpy. Typeprøve Py-sone v/66,8 og Cpy-stripe ved 64,3 m.
70-80		3		<u>Ba:</u> Dioritisk gn. m/amf., klorit, granat og rel. mye kvarts. Enkelte 3-5cm kvartssone <u>Minr.:</u> Litt py og meget svake spor MK og Cpy
80-90		3		<u>Ba:</u> Dioritisk gn. m/a mf., klorit, kvarts (ikke granat). <u>Minr.:</u> Jevnt m/Py.
90-100		6	o 91-92,3 Cu 0,10 0,1 92,3-94 " 0,15	<u>Ba:</u> Dioritisk (amf.) gneis mer vekslende enn foregående. En del kvarts og klorit. <u>Minr.:</u> Fra 92,3 Cpy (lite) og Py samt noen striper <u>CaF_2</u> . Nei anhydrit. Hele kassen må anal. hvis dette gir resultat
100-110		5	102-103,5 Cu,Pb,Ag 103,5-105 " 105-106 " 106-107 " 107-108 " 108-109 " 109-110 "	<u>Ba:</u> Dior. gn. med en del kvarts, amf. og klorit. <u>Minr.:</u> Py i hele kassen. Fra 103,5-110 Cpy, py og spor blyglans.

Dyp	Lagdeling	spr./m	Analyse		Beskrivelse
110-120		7	110-120	Cu	Ba: Dior. gn. m. kvarts, muskovit, klorit og amf. (ikke granat) Minr.: Cpy, MK, Py. Bra med Cpy 111-118. Lite 118-120, men hele kassen må anal. Pene ansaml. Cpy i kvartssoner ofte med litt MK.
120-130		4	120-127	Cu	Ba: Dior. gn. forholdsvis homogen med enkelte kvartssoner. Granat fra ca. 125,7. Ellers klorit, amf. Noe Cr-glimmer litt Minr.: Litt Cpy 120-127. Ellers mest Py og
130-140		8	130-131	Cu	Ba: Dior. gn. m/kvartssoner på opptil 0,7 Musk. sk. Ba er svakt granatførende med noe amf. og klorit. Minr.: Svært lite Cpy, men spor i hele kasse: Tar en stikkprøveanalyse 130-131. Mot 140 vesentlig Py. Litt MK og noen roser CaF_2 (ne anhydr.) i kvartssonene.
140-150		6	146-146,7 146,7-148 148-149 149-150	Pb,Ag,Cu " " " " " " " " "	Ba: Lys dioritisk gn. Mye glimmer (Glimmersk) Minr.: Py. Blyglans fra 146,7-150, men en tydelig sone PbS fra 146,7-148. Spor Cpy Tekt: En kan se at det har vært bevegelse i minr. Pb-sone med bl.a. kalkspatutfelling
150-160			159-160	Cu	Ba: Dior. gn. med spetter av h.bl. som delvis er omv. til klorit. + kvarts. Minr.: Svake spor Pbs i tekt. sone 150-154, Dette må evt. analyseres hvis 148-150 slår t Ellers spor Cpy spes. mot 160 m. Stikkprøve 159-160. En del py. En god del CaF_2 (Nei anhydrit!) i tekt. so spes. ved 151,5.
160-170		3	160-161	Cu	Ba: Som foregående. Minr.: Litt Cpy spes. 160-161 i et kloritri mørkt parti. Ellers for det meste py og spo MK. Stjerner Cpy i hele kassen. 10 cm CaF_2 ved 165,1.
170-180		3			Ba: Som foregående. Minr.: Ves. py, men enkelte korn Cpy. 10 cm pen Cpy- minr. ved 172,6-172,7.
180-190		3			Ba: Som foreg., men noe granat + fuchsit. Minr.: Ves. py og MK, men spor Cpy.
190-200		3	197-198 198-199 199-200	Cu	Ba: Som foreg. Minr.: Cpy 190-191,3 og 197-200 0,2 % Cu og litt spor i mellom samt en del py + litt MK.
200-210		4	200-201 209-210,6		Ba: Homogen dior. gn. En del klorit og litt granat. Minr.: I forb. med kloritrike soner noe Cpy i hele kassen + Py.
210-220		4			Ba: Litt granat i dior. gn. Amfibolit 210,6-212,3. Minr.: "Sonen" forts. med litt Cpy frem ti: amfiboliten ved 210,6. Ellers er det litt py og spor Cpy.
220-231,3		3			Ba: Dior. gn. m. litt granat. Amf. 221,5-222,8. Minr.: Litt py og spor Cpy men stort sett svært lite.

Bh. 6.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
0-10	0-5,9 O.d.	6	5,9-7 : Cu,Ag (Pb) 7 - 8 : " " 8 - 9 : " " 9 -10 : " "	Ba: Lys dioritisk gn. m/spetter av delvis omv. amf. (i klorit). Opptil 10 cm's "rustsoner" nær sprekker p.g.a. dypforvitri Minr.: Jevnt impr. med en meget fink. Cpy. Kan også se et blankt minr. AgS ? Nei!
10-20		6	10-20 : " " "Ikke" tatt med (15-20 svak) i første omg.	Ba: Som foreg. Noe fuchsit. Minr.: Som foreg. frem til ca. 15 m, men hel kassen bør anal. Ved 13,05 et mørkt minr. m/høy glans AgS ? Nei!
20-30		4	20-30 : Cu	Ba: Dioritisk spettet gn. homogen m/amf. omv. til klorit. Minr.: Jevnt impr. med Cpy og svært lite py.
30-40		7	30-40: Cu Ag	Ba: Som foreg. Minr.: Svakt med Cpy fra 30-35, men noe bedre 35-40. Ved 33,6, 34,7 og 38,9 svart mykt minr. MoS_2 ? AgS ? Nei! Fahlerts ? Prøver.
40-50		8		Ba: Som foreg. Minr.: Svake spor Cpy og litt py. Pen stripe av det ukjente minr. ved 40,6 (prøve). Ikke analyse av denne kassen, men den bør anal. hvis 30-40 har interesse. Cu- innh.
50-60		7	59-60: Cu	Ba: Som foreg. Fuchsit ved 56,3 Minr.: Spor Cpy i hele kassen. Stikkprøve-analyse. Ellers litt pen py og spor MK.
60-70		7	60-61 : Cu	Ba: Som foreg., men noe lysere. Minr.: Spor Cpy i hele kassen. Stikkprøve-analyse. Ellers litt py og MK. Kvartssoner 61,7-62,4, 67,4-67,6.
70-80		7		Ba: Forskifret gn. med mye musk. og klori men også den typiske spettete dior.gn. Litt fuchsit Au ! Nei! Minr.: Pyrit rel. mye (3-5 %). Svært lik foreg. kasse.
80-90		6		
90-100		4		Ba: Dior.gn. litt forskifret. Minr.: ~ 5 % Py.
100-110		6		Ba: Dior.gn. m/granat som ved ca. 105 m går over i en forskifret type m/Fuchsit. Minr.: En del py (3-5 %) i hele kassen. Litt Cpy fra 100-102. $<$ 0,1 %
110-120		6		Ba: Dior.gn. m/kun spor av granat. Minr.: Spor Cpy spes. i beg. av kassen og en del py og MK 3-5 %.
120-130		5		Ba: Dior. gn. Minr.: Spor Cpy. Spor (dråper) av ZnS mørk type og 3-5 % MK og Py.
130-140		8		Ba: Dior.gn. Minr.: Py og Mk 3 - 5 %

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
140-150		8	142,7-144 : Cu 144 -150 : "	Ba: 140-143 tett dior. gn. m/små granater Senere mer lys og forskifret. Minr.: Py i hele kassen. Fra 142,7 litt Cpy Tar anal. ut denne kassen.
150-160				Ba: Dior.gn. m/granat fra 152 m. Minr.: Svært lite Cpy. Noe bedre 159-160. Py og MK ~ 1-3 %.
160-170		4		Ba: Dior. gn. m. granat til 164 m ellers den typiske dioriten. Minr.: Spor Cpy. ~ 1 % py. Tydelig mindre svovel nå.
170-180		4	170 - 171 : Cu 171 - 172 : "	Ba: Dior. gn. typisk med tildels store h. bl. (klorit) - lister. Litt granat. Minr.: Cpy (litt) i hele kassen. Mest til å beg. med. Prøve anal. de to første metre. Ellers py og MK.
180-190		4		Ba: Dior. gn. m/granat. Mye granat spes. fra 186 m. Minr.: Svake spor Cpy eller lite Py og MK.
190-196		6		Ba: Granatrik dioritisk gn. m/lister av gr. hornbl. (klorit) og kloritsoner. Minr.: Py og MK.

Bh. 7

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
3-10	0-3 o.d.	12		Ba: Lys utlutet dior. gn. spes. fra 3-6 m Minr.: Kun spor Py.
10-20		15	10-20 : Cu	Ba: Lys dior. gn. Minr.: Fra ca. 11 m Cpy som i de første metre er omv. til malakit. Litt py og mobilisert grafit (?)
20-30		8	20-21,3: Cu 0,72 21,3-22: Cu o 0,05 22-23 : Cu o 0,01	Ba: Lys dior.gn. 20-21,3. 21,3-30 granatførende kloritrik gn. Minr.: Pent Cpy-minr. 20-21,3. Senere fritt for Cpy. Bare litt py og MK.
30-40		6	35-36 : Cu 36-37 : 37-38 : 38-39 : 39-40 :	Ba: Granatførende kloritisk gn. 30-35,0. 35-40 lys noe skifrig dior.gn. 35-36 en kloritrik sone med vel mye Py, MK og Cpy. Minr.: Cpy 35-40 (~ 0,1 %) ellers en del Py og MK.
40-50		8		Ba: Dior. gn. Minr.: Spor Cpy i hele kassen og litt Py. Må analyseres hvis 36-40 glimter til.
50-60		10	57-58 : Cu (evt. Ag) 58-59 : " 59-60 : "	Ba: Dior. gn. 57-59 et amf. og kloritrik parti. Minr.: Svake spor Cpy. Noe bedre 57-60. Ved 57,2 svart blankt minr. Ellers noe py og MK.
60-70		6		Ba: Lys dior. gn. Minr.: Cpy - MK ansaml. ved 67,05. Litt Cpy-impr. videre 0,3 m. Ellers er det bare spor Cpy i kassen. Lite Py og MK.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
70-80		4	74-80 : Cu	Ba: Dior. gn. med rek. mye klorit fra ca. 75 m. Minr.: Litt Cpy i hele kassen. Noe "mer" fra ca. 75 m. Lite Py og MK.
80-90		5	?	Ba: Dior. gn. Minr.: Cpy i hele kassen, men for lite. Bør analyseres hvis 74-80 glimter til. Litt MK og Py.
90-100		4	96-100 : Cu	Ba: Lys dior. gn. Minr.: Litt Cpy spes. fra 97-100. Meget finimpr. Lite MK og Py.
100-110		4	100-110 : Cu (Ag ?)	Ba: Lys dior. gn. m/noen fuchsitstriper. Minr.: Svakt impr. m/ Cpy i hele kassen, men vel svakt. Noe bedre de siste 4 m. Mener jeg ser det blanke minr. Lite py og MK.
110-120		6	110-117 : Cu	Ba: Dior. gn. m/ endel klorit. Litt fuchsit. Minr.: Forholdsvis mye Py, litt MK og Cpy. Svært lite Cpy de siste 3 m. (Bra 110-111 m)
120-130		5		Ba: Som foreg. Minr.: Mye (5 %) Py ikke Cpy.
130-140		5		Ba: Lys dior.gn. litt forskifret. Minr.: Py ~ 3 %. Kun meget svake spor Cp
140-150		4		Ba: Lys dior. gn. (typisk) prøve Minr.: Litt py og MK, ellers kun helt svake spor Cpy.
150-157,4		6		Ba: Lys noe forskifret dior. gn. m/lit. fuchsit. Minr.: Litt py og MK.

Bh. 8.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
0-10	0-5 o.d.	10		Ba: Lys dior. gn. m/granat i veksl. m/ svartsk. svartsk ikke radioaktiv. Minr.: MK i svartsk. ikke Ni-utslag med dimetkylglyoksim på friske kjerner.
10-20		8		Ba: 10-12,4 svartsk og 12.4-20 grå dioritisk gn. m. små røde granater. Minr.: MK i svartsk.
20-30		7		Ba: Svartsk (40 %) i veksl. m/ grå granatførende dior. gn. Svartsk 29,3-30. Minr.: MK i svartsk.
30-40	∢ 80°	20		Ba: Svartsk 30-34,8. 34,8-40 granatførende gn. med opptil 0,5 cm granatporfyroblaster forskj. fra foregående der granatene var svært små. Granatene er også omvandlet (i kvarts). Ikke radioaktiv.
40-50		6		Ba: Dioritisk gn. med store tildels omvandlete granatporfyroblaster.
50-60		12		Ba: Gneis m/grove granatporfyroblaster 50-55. 55-60 veksl. gneis og svartskifer, mest svartskifer. Minr.: MK og Py i svartskifer.

Dyp	Lagdeling	spr./m	Analyse	Beskrivelse
60-70	∡ 70°	20		Ba: Svartsk i veksl. m/granatgn. Fra 69,0 granatgn. Tekt.: Noe breksiert og oppknust. Minr.: MK og Cpy. Sinkbl. i knusesonen ved 60,8. Ett spor Cpy !
70-80		10		Ba: Gneis med kvartsøyne som vesentlig er omv. granat. Minr.: Noen soner med litt MK. Spor Cpy i MK - sonene.
80-90		6		Ba: Som foreg., men etterhvert en del hornblende som et omv. til klorit. Minr.: Disseminert Py ∠ 3 %.
90-100		5		Ba: Som foreg. Minr.: Py som foreg.
100-110		5		Som foreg. Et par små korn Cpy.
110-120		8	116-117 : Cu 117-118 : " 118-119 : " 119-120 : "	Ba: Dioritisk gn. med kloritspetter. Noe lysere fra 116 m. Minr.: Py i første del, men noe Cpy fra 116 m. Spor CaF_2 .
120-130		8	120-121 : " 121-122 : " videre til 128 hvis Cu i 120-122	Ba: Dior. gn. hvitspettet. Litt granat mot 130 m. Minr.: Litt Cpy fram til 128, men mest Py Tar anal. av de første to m.
130-140		6	133-134 : Cu 134-135 : " 135-136 : "	Ba: Som foreg. men noe mer gl.-rik. Minr.: Noe py (3 %) og spor Cpy. Tar stikkprøveanal. av 3 m fra 133-136.
140-150		6	148-149 : " 149-150 : "	Ba: Klorit-spettet gneis Minr.: Noe py (3 %) og spor Cpy. Må ta sti prøve anal. 148-150. 0,2 m CaF_2 ved 147 m.
150-160		6		Ba: Rel. mørk kloritrik gneis. Minr.: Litt py ∠ 3 % og svake spor Cpy. 150-153 anal. hvis 148-150 slår til CaF_2 159,5-159,8.
160-170		4		Ba: Grovspettet dior. klorit gn. 160 l Mot 170 m mer gl. rik (granat). Minr.: Litt py.
170-180		6		Ba: Lys klorit gl. gneis. Minr.: Litt py og spor Cpy.
180-190		5		Ba: som foregående Minr.: Noe mer py enn foreg. og kun svake spor Cpy.
190-200		3		Ba: Spettet hornbl. (klorit) - gneis og noen få små granater. Minr.: Kun spor Py.
200-210		4		Ba: Som foregående Minr.: Litt Py og uhyre små Cpy spor.
210-220		4		Ba: Som foreg., men 219,1-220 kloritsone. Minr.: Litt Py og spor Cpy.
220-223,5		4		Ba: Kloritsone 220-220,2. Ellers vanlig type. Minr.: Litt py.

PRELIMINARY REPORT ON THE GOLD FROM RAITEVARRE.

Together 16 polished sections from the drillholes no. 5, 6, 7 and 8 are microscoped.

The gold that is observed is extremely finegrained. 28 goldgraines with size from 4 μm down to less than 1 μm are found. Most of the goldgraines are less than 2 μm. The very finegrained size of the graines makes it very hard to judge the silver content in the graines from the colour.

The gold seems especially to be found in a parageneses with dessemi-nated grains and grains of chalcopyrite and pyrrhotite grown together. In a few grains there are small amounts of mackinawite in chalco-pyrite. In this paragenesis is found goldgraines as inclusions in chalcopyrite and in pyrrhotite. Goldgraines are also observed on the crystal boundaries between chalcopyrite and pyrrhotite (fig. 1), pyrrhotite/non opaque-facies and chalcopyrite/mackinawite. Some gold-graines are also found as inclusions in none opaque facies, but al-ways in the vicinity of sulphidegraines.

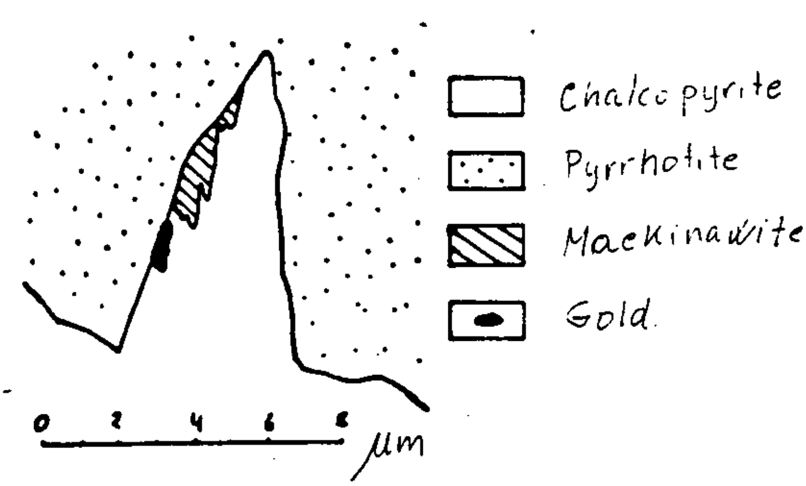


Fig. 1. Gold on the crystal boundary between chalcopyrite and pyrrhotite.

In a paragenesis of larger aggregates of chalcopyrite, pyrrhotite and pyrite gold is found as inclusions in pyrite and as very small graines in hair-line veinlets with chalcopyrite in pyrite. (Fig. 2).

Too few polished sections are studied to give any conclusions about the occurence of the gold. The neutron activating analysis indicates however also that the gold is very finegrained. For nearly all the samples from Raitevarre the difference between the two parallel analysis of each sample are less than the standard error of the mean for the analysis. (Samples from Bidjovagge where gold can be found in much larger grains, shows less regularity between the parallels).

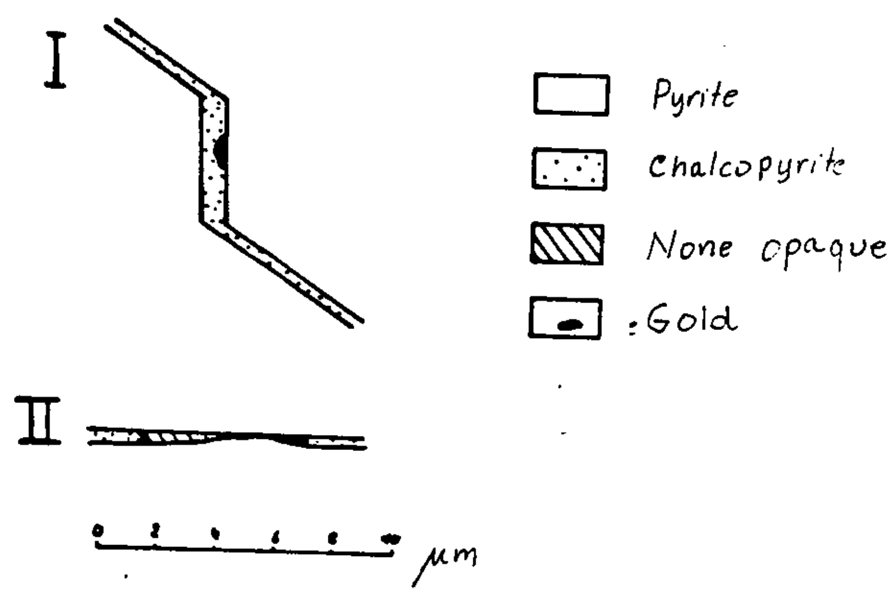


Fig. 2. Two examples on hair-line veinlets with chalcopyrite and gold in pyrite.

Unidentified minerals which might contain precious metals are observe as inclusions in pyrite and pyrrhotite. Those facies occurs in very small graines, but those will be tried to be identified with micropro

A plan for the follow up work of the gold in Raitevarre could be :

1. A further sampling of samples for polished sections. By comparing the microscopic results with the analytical results the relationship of the gold to the different oretypes can be mapped.

2. A mixed ore sample (~ 3/4 kg) is grind down to 90 % ÷ 74 μm, fractionated and each fraction is washed on superpanner to find eventually larger gold graines.

3. A concentrate of chalcopyrite and a concentrate of pyrite is grind down to 100 % ÷ 45 μm, is cyanated and the residue is analysed to registrate any submicroscopic gold.

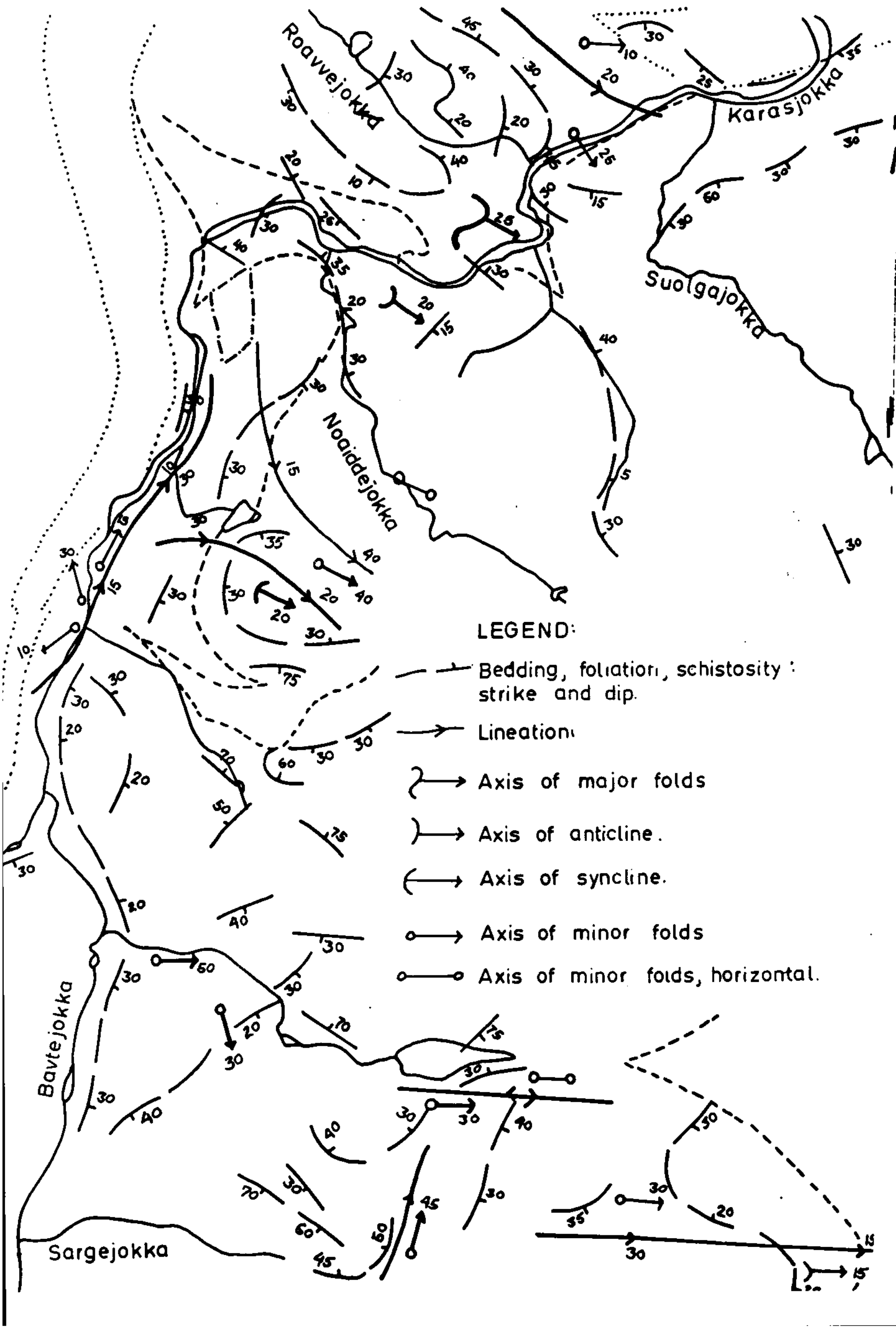
In three of the sections, molybdenite is found in "not small" amount This mineral should possibly be followed up by new ore tests ?

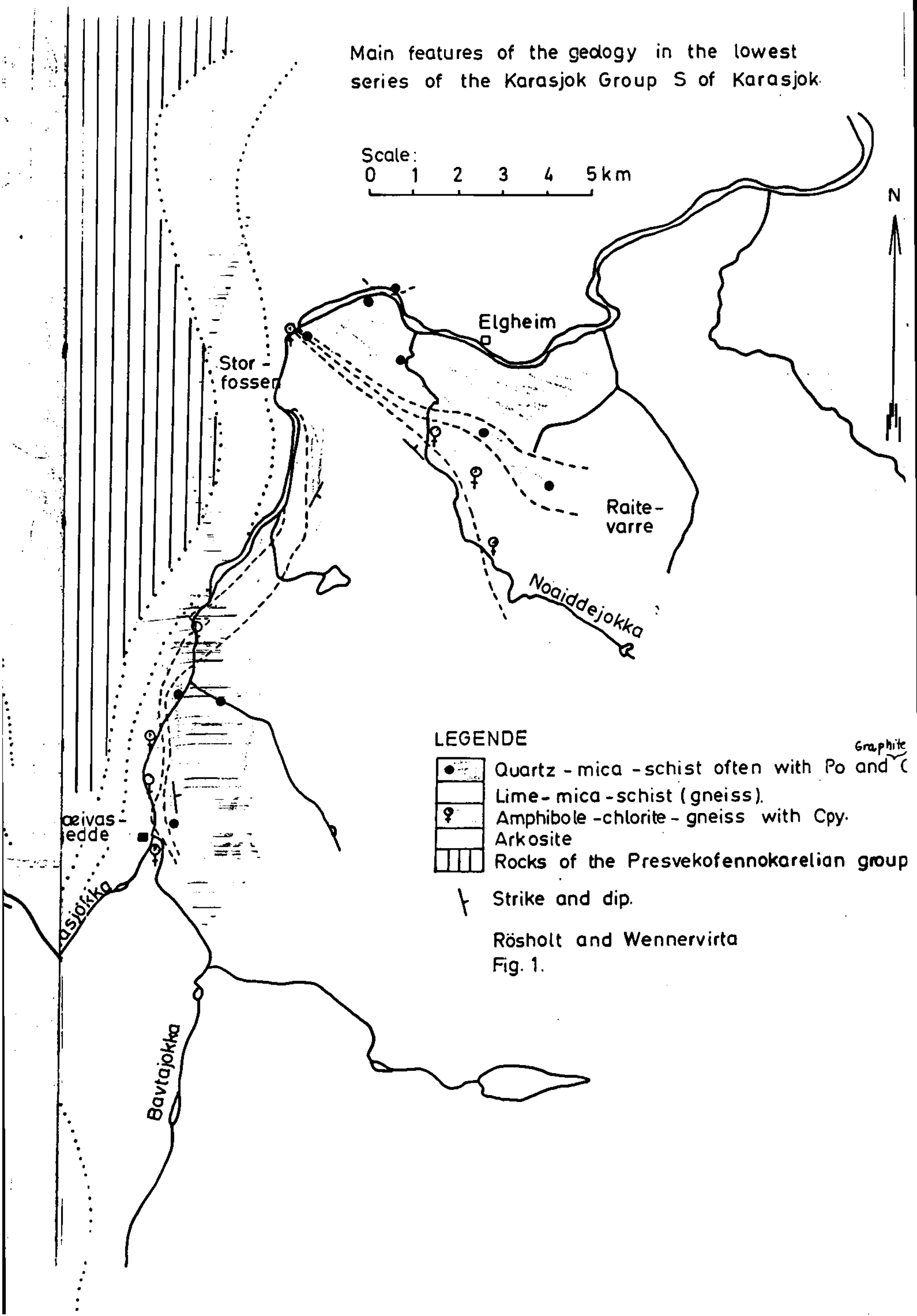
Blindern, June 1980.

Ragnar Hagen (sign.)

Tectonic map of the southern region of Karasjok.
After H. Wennerwirta 1968.
Scale 1:100 000

Fig 12.





Main features of the geology in the lowest series of the Karasjok Group S of Karasjok.

Rösholt and Wennervirta
Fig. 1.

The Porcupine camp - A model for gold exploration in the Archean

By WILLIAM O. KARVINEN
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The Porcupine camp has been a major producer of gold over the past 66 years during which time a total of about $2.0 billion worth of gold (calculated at $35.00/oz) has been mined from over two dozen different deposits. From maximum output in the early 1940s, production has steadily declined and today only four mines remain in operation. Although there has been a dramatic increase in the price of gold in recent years, most of the typical underground gold mines not only in Timmins but throughout the Canadian shield have been struggling financially because of their antiquated operations and because the mines, designed for vein-type ores, are labor intensive and difficult to mechanize. Because of increasing costs of conventional mining and the depletion of known ore reserves, it appears that production will continue to decline.

All past and present producing mines in Timmins were found and developed during the period 1909 to 1935. No significant new deposits have been found in the past 40 years and as a result it is the general impression of the mining industry that the camp has been well explored and is nearing exhaustion. It should be noted however, that all past geological investigations pertaining to the origin of the deposits were done using epigenetic models. No modern studies examining the total evolution of the rocks in the area and their relationships to the deposits have been done. In the light of past epigenetic models, the camp probably has little to offer for future exploration, but as will be shown in this paper, a syngenetic model for the origin of the deposits offers several important exploration parameters.

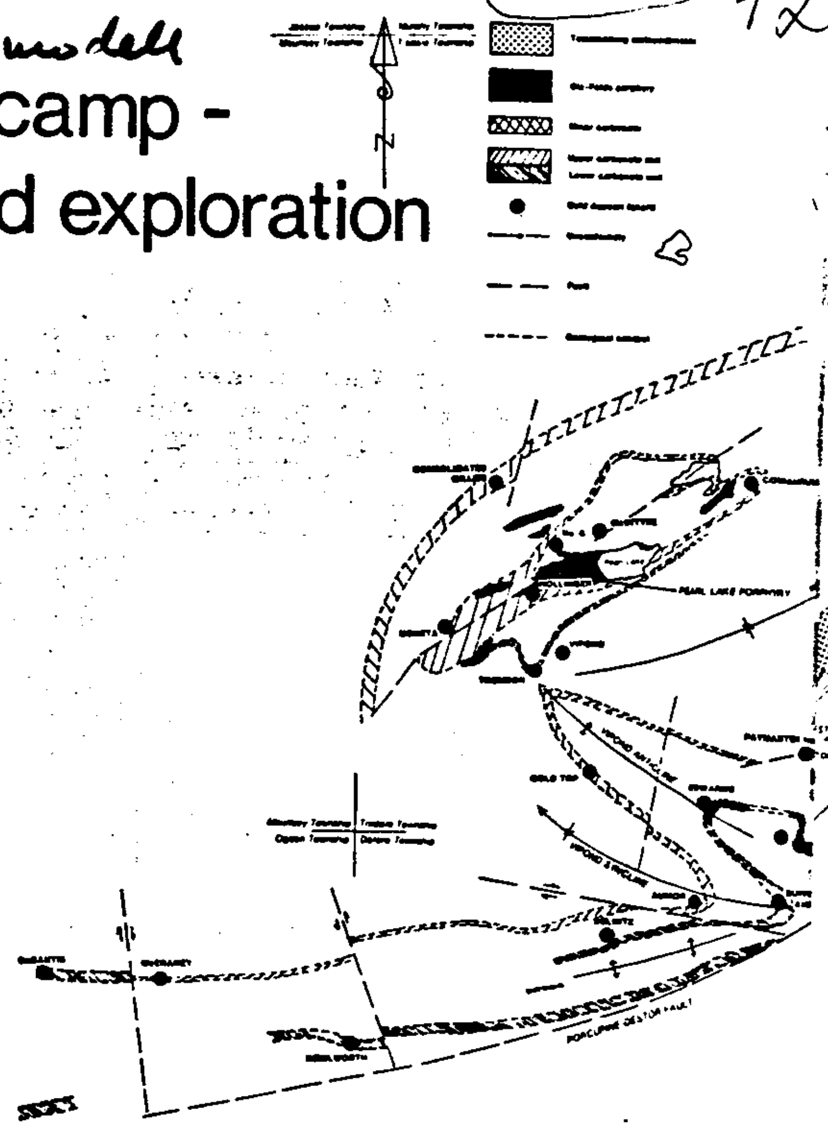


Figure 1. Distribution of carbonate-rich rocks, porphyries and gold deposits in the Timmins area

Better models needed

Because most modern geophysical and many geochemical techniques are incapable of detecting gold ore under overburden or at depth in rocks, it appears that the only way new deposits are going to be found, especially in overburden areas, is to develop and expand geological exploration parameters or guidelines. In order to do this better models depicting the origin and evolution of known deposits have to be developed. In Timmins, and elsewhere, the simple epigenetic models centred around felsic intrusions (*e.g.*, Pearl Lake Porphyry) or fault systems (*e.g.*, Porcupine-Destor Fault) have had serious problems in explaining several important features of the deposits as well as the origin of many of the deposits.

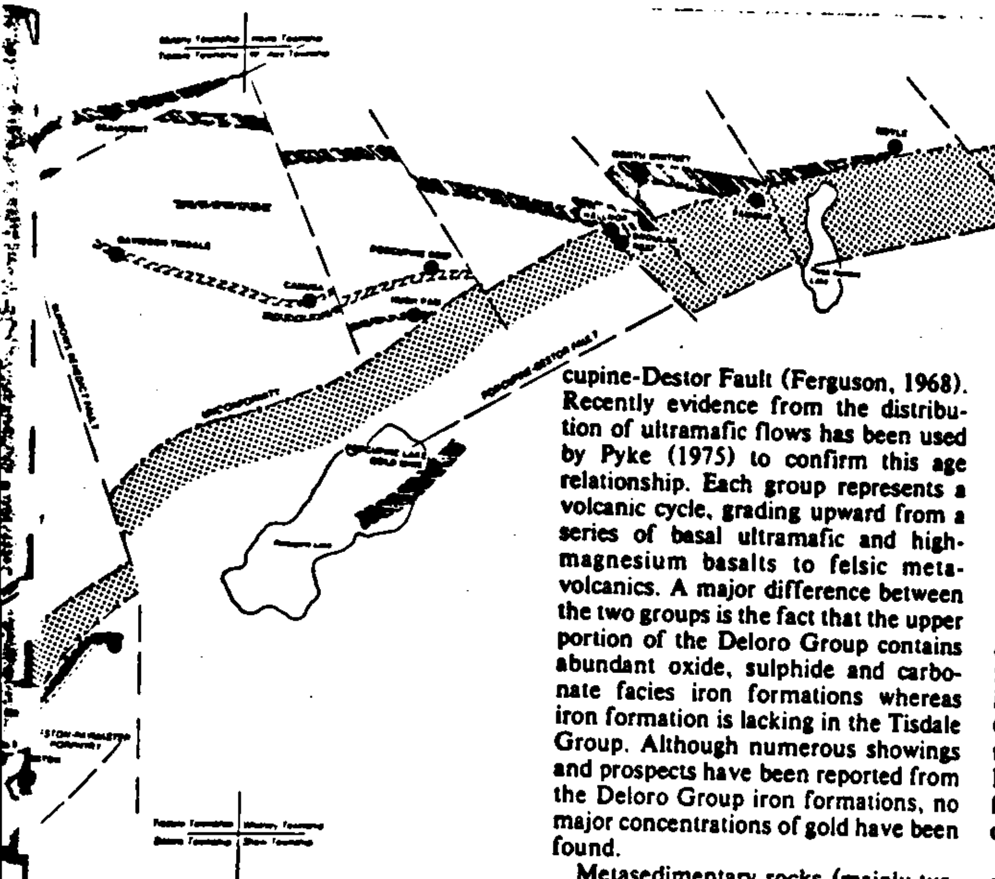
The only variation from the epigenetic theme was a model proposed by Pyke (1975) in which he suggested that the gold ores in Timmins are closely related to and possibly derived from altered flows of ultramafic rocks. In areas outside of Timmins, particularly at Larder Lake, Ridler (1976) and Tihor (*pers. comm.*, 1977) have subscribed to various forms of syngenetic models to explain the origin of gold deposits in that camp.

In the Timmins area, the key to gold mineralization must certainly lie in the origin of the carbonate-rich rocks which are an intimate feature of all the deposits. In past epigenetic models, these rocks have been interpreted as wall-rock alteration and although they have been described in various detail in many reports on the area, no areal maps exist which show where the carbonate-rich rocks are located and what their relationships are to the main rock types and structures in the area.

Study initiated

As a result, a study was initiated by the writer in 1976 to establish the spatial distribution of carbonate-rich rocks and their relation to gold deposits, and to determine if such rocks are indeed crosscutting as the epigenetic models imply or if they are concordant with respect to the enclosing country rocks. The main results of the investigation are listed below:

- Two major and one minor carbonate-rich units, consisting mainly of ankerite and/or magnesite, quartz, chlorite and sericite and varying in thickness from 20 m to over 200 m are present in the Timmins area (Fig. 1).



• Both major units are distinct strata-bound units which can be followed along strike for over 15 km and are easily distinguished from one another. All exposed contacts are concordant with the enclosing rocks except in one locality south of the Dome mine.

• All quartz-feldspar porphyries in the area occur along or near one of the carbonate-rich units and are intimately associated with them.

• All deposits which ever produced gold in the area are located on or near the carbonate-rich rocks or the porphyries.

Based on these results and the following descriptions and illustrations of the geology of gold in Timmins, it will be demonstrated that gold was first enriched in these ancient rocks during felsic volcanism and exhalative activity which produced the carbonate-rich rocks and that during subsequent metamorphism and deformation associated with the Kenoran Orogeny, gold was further concentrated into a network of quartz-carbonate veins.

General geology

Timmins is located in the northwestern part of the Archean Abitibi Greenstone Belt. In the immediate area, metavolcanic rocks have been divided into two groups: the lower Deloro Group and the upper Tisdale Group (Fig.2). In the early days the distinction was made on lithological differences and the fact that the two groups are separated by an east-west trending structure known as the Porcupine-Destor Fault (Ferguson, 1968). Recently evidence from the distribution of ultramafic flows has been used by Pyke (1975) to confirm this age relationship. Each group represents a volcanic cycle, grading upward from a series of basal ultramafic and high-magnesium basalts to felsic metavolcanics. A major difference between the two groups is the fact that the upper portion of the Deloro Group contains abundant oxide, sulphide and carbonate facies iron formations whereas iron formation is lacking in the Tisdale Group. Although numerous showings and prospects have been reported from the Deloro Group iron formations, no major concentrations of gold have been found.

Metasedimentary rocks (mainly turbidites) of the Porcupine Group (Pyke, 1975) formerly known as "Keewatin sediments" conformably overlie the Tisdale Group metavolcanics. Locally, a younger turbidite sequence, long known as the Temiskaming, overlies with distinct angular unconformity the older metasediments and metavolcanics (Figs.2 and 3).

The most obvious structures in the area are the easterly-plunging Porcupine Syncline and the Porcupine-Destor Fault (Fig.3). The geometry of the rocks has been delineated through the use of major marker horizons such as the V8 and the V10B flows (Ferguson, 1968) and more recently through the use of ultramafic flows (Pyke, 1975). Although numerous papers (Hurst, 1936; Moore, 1953; Davies, 1977) have dealt superficially with the structures of the area no rigorous analysis which explains the structural evolution of the rocks is available. The most obvious penetrative planar and linear elements seen in the field can be related to the Porcupine Syncline and most of the ore zones and porphyry bodies near the nose of this fold have been re-shaped and now plunge in the direction of that fold. Other structures, such as the oval interference structure in the Hollinger-Coniaurum area as well as older lineations and foliations indicate a pre-Porcupine Syncline phase of isoclinal folding as well as a later phase of open cross-folding (*e.g.*, Vipond Anticline).

The major phases of folding are reflected by the variety of vein configurations ranging from those which are straight and undeformed to those which are tightly folded or completely broken by intensive deformation. The main types of vein sets that have been described (Jones, 1948) are: well-defined, continuous veins that pinch and swell such as the quartz-ankerite veins at the Aunor; sinuous folded veins; tabular veins; and en-echelon,

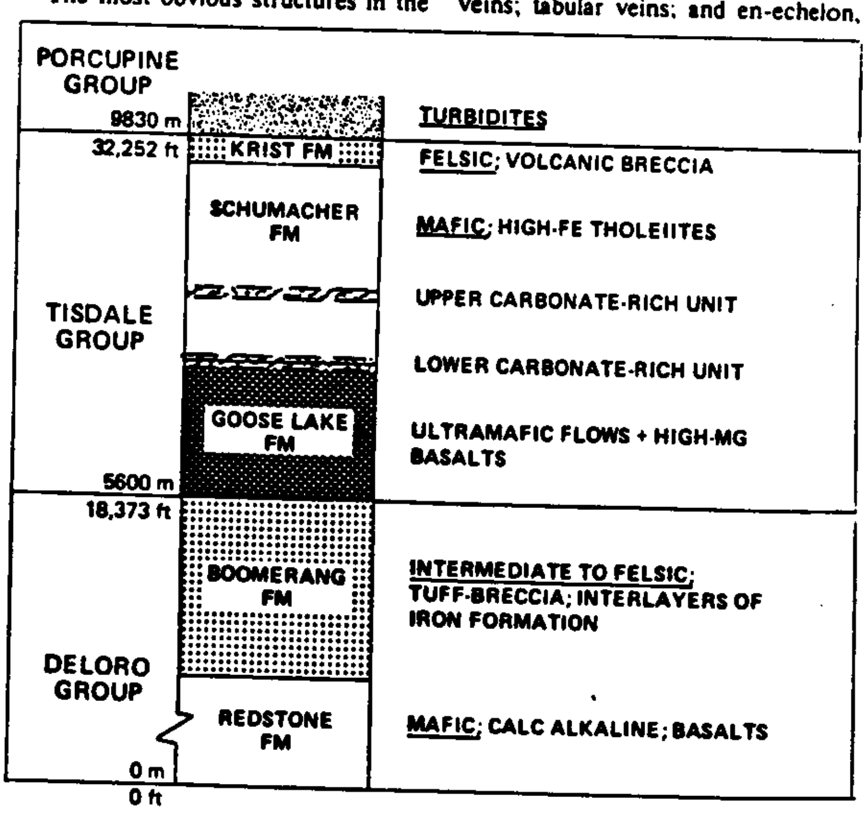


Figure 2. Stratigraphic column, Tisdale and Whitney townships, Timmins area (Modified after Pyke, 1975)

S-shaped veins. This variety of vein shapes suggests vein formation to have occurred periodically throughout the deformation period.

Gold occurs as the native metal or in sulphides, predominantly pyrite, in systems of veins which consist predominantly of quartz and ankerite and varying amounts of tourmaline. Auriferous pyrite-rich zones have been delineated in some mines (*e.g.*, Aunor, Schumacher). Other important accessory minerals are fuchsite, scheelite, arsenopyrite, albite, pyrrhotite, chalcopyrite, galena, sphalerite and gold-silver tellurides. The ratio of gold to silver in the ores is about 5 to 1.

Carbonate-rich rocks

The lower carbonate (Fig.1) is the thicker of the two major units (average 70 m) and consists predominantly of carbonatized ultramafic flows and tuffs and some layered massive carbonate of possible sedimentary origin. The Lower Unit is characterized by the predominance of magnesite (70 to 90 per cent) with lesser amounts of talc, sericite, chlorite, quartz, fuchsite (chrome muscovite) and pyrite. Relict textures, such as poly-suturing and spinifex can be found in completely carbonatized flows and in places bombs and pyroclastic fragments are present in the carbonatized ultramafic tuffs. Stratigraphically, the Lower Unit occurs near the upper part of the Goose Lake Formation (Fig.2). Deposits which occur on or near the Lower Unit are: DeSantis, Kenilworth (Naybob), Delnite, Aunor, Buffalo-Ankerite, Edwards, Dome, Hollinger (?), Schumacher (McIntyre), Beaumont, Hallnor, Broulan Reef, North Whitney, Porcupine Lake, Pamour and Hoyle.

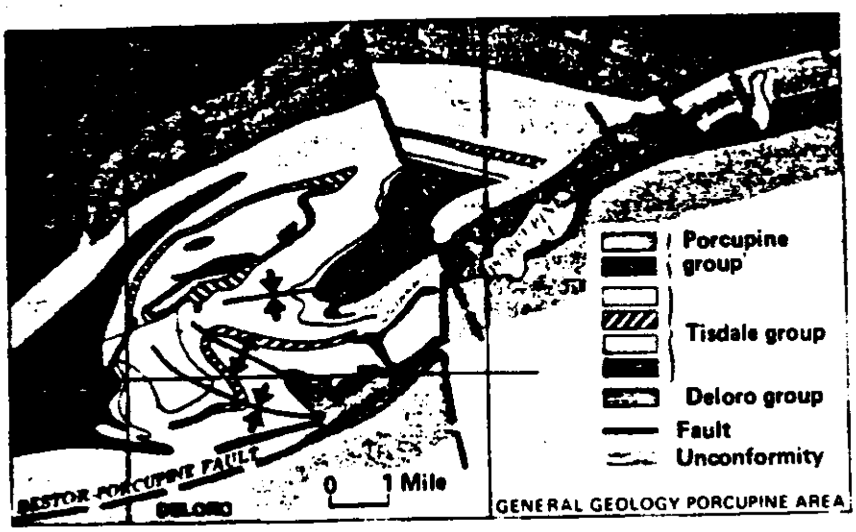


Figure 3. General geology of the Porcupine area

The upper carbonate-rich unit averages about 30 m in thickness and occurs about 670 m stratigraphically above the Lower Unit (Fig.2). In Tisdale Township, the Upper Unit closely follows the "99 flow" of the "Vipond Subgroup" (Ferguson, 1968), but towards the east in Whitney Township, the unit is found a few hundred metres below the "99 flow" thus suggesting some regional transgression. The Upper Unit is characterized by the abundance of ankerite (40 to 80 per cent) and the absence of chrome muscovite (fuchsite). In addition to ankerite, other minerals include chlorite, relict plagioclase, sericite, quartz and pyrite. Unlike the Lower Unit which is normally massive, and medium to coarse-grained, the Upper Unit is very fine-grained and is usually well-foliated. Discontinuous lenses of massive ankerite interlayered with silicate-rich lenses are a common feature. Relict textures and structures suggest that much of the Upper Unit represents either a carbonatized tuff or a mixture of sedimentary carbonate and tuff. Towards the west, in Ogden Township in the vicinity of the McEnaney deposit, the Upper Unit begins to change laterally into a graphitic phyllite. In northeastern Tisdale Township in the vicinity of the Davidson Tisdale property, parts of the Upper Unit are represented by carbonatized massive and pillowed basalts. Deposits which occur on or near the Upper Unit are: McEnanay, Gold Top, Paymaster (?), Dome, Moneta, Hollinger, Schumacher (McIntyre), Vipond (?), Thompson (?), Coniaurum, Consolidated Gillies, Davidson Tisdale, Canusa and Porcupine Reef.

Staining technique

Because iron-magnesium carbonates weather brown, they are easily recognized on surface and thus readily distinguished from the non-carbonatized mafic volcanic rocks which weather greenish-black to black. However, underground or in drill core, the carbonate-rich units, particularly the Upper Unit, are easily missed and at many of the mines in Timmins they have been mapped as dacites, andesites, bleached volcanics, etc. A simple staining technique can be used in the field to determine the presence of both ankerite and magnesite.

Irregular bodies of quartz-feldspar porphyry are an intimate association of the lower carbonate unit. Only the

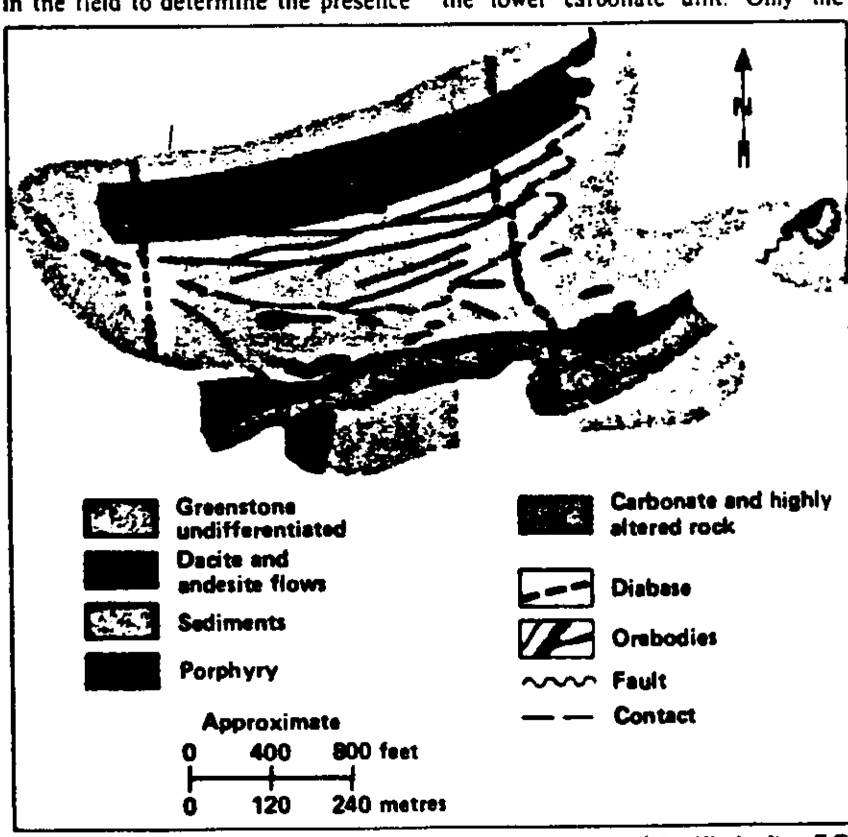


Figure 4. Generalized geological plan of the Dome mine (Modified after T.C. Holmes, 1948)

bigger bodies such as the Pearl Lake and Paymaster porphyries are shown in Fig. 1. In detail, however, numerous thin lenses of porphyry, ranging from a metre or two to several tens of metres thick are commonly found in the Lower Unit. In general, the porphyries consist of quartz, sodic plagioclase and sericite with small amounts of pyrite. Textures vary from massive to porphyritic and normally quartz-eyes are common in most varieties. Fragments, reminiscent of extrusive felsic volcanic material can be found locally, particularly in the smaller bodies. The porphyries contain varying amounts of ankerite and calcite, especially near the contacts, and at the Schumacher Mine (former McIntyre), a variety of alteration assemblages related to the Au-Mo-Cu mineralization have been identified (Luhta, 1974).

Three Groups

In general, the gold deposits of the Timmins area can be divided into three groups:

1. those associated with carbonate and large masses of porphyry;
2. those found in major fold structures of carbonate units containing minor porphyry;
3. those which occur along the local unconformity near the main carbonate units.

The two major areas represented by group 1 deposits are centred around the Pearl Lake and Preston-Paymaster porphyries. The Moneta, Hollinger, Schumacher (McIntyre) and Coniaurum deposits are located in and near the fringes of the easterly-plunging Pearl Lake Porphyry and also within thickened parts of the upper carbonate unit. The structural complexity in the area makes stratigraphic interpretations difficult, but it appears that older rocks of the lower Schumacher Formation (Fig.2) are exposed in the core of the anticlinal dome in the immediate area. One outcrop of fuchsite-bearing carbonate (green carbonate), identical to that of the Lower Unit outcrops near the old glory hole on the Hollinger property. It is conceivable that both at the Hollinger and at the deeper levels of the Schumacher (McIntyre), ore associated with the Lower Unit was also mined.

The major mines in the vicinity of the Preston-Paymaster Porphyry include the Dome, Paymaster and Preston. Carbonate rocks of the Lower Unit have been well documented at the Dome (Fig.4) and it is possible that the quartz-ankerite veins which stratigraphically occur within or near the "99 flow" at the Dome and Paymaster are equivalent to the Upper Unit.

Deposits of group 2 located at noses of folds or in flexures in the carbonate units and associated with small bodies of porphyry are represented by the DeSantis, Kenilworth (Naybob), Delnite, Aunor, Buffalo-Ankerite, Edwards and North Whitney mines. At many of these deposits, the carbonate unit has been well mapped (e.g. Aunor-Delnite), but in places the unit has been interpreted as dacite, andesite or bleached country rocks. The correlation between structure and location of vein systems is well illustrated at the Buffalo-Ankerite and Aunor where the ore zones plunge in the same direction as the Vipond Syncline.

The third group of deposits is represented by the Dome, Broulan Reef, Hugh Pam, Hallnor, Pamour and Hoyle Mines. Mineralization at these deposits is located, mainly in sediments, at a local angular unconformity between the older sequence of mafic metavolcanics and metasediments (Keewatin) and the younger succession of conglomerates and turbidites (Temiskaming). The striking feature about these deposits is that each is located where a carbonate unit is cut by the unconformity (Fig.1). This is well illustrated by the geology in the vicinity of the Hallnor and West Pamour properties (Figs.5 and 6). In this area, both the metavolcanics and carbonate units as well as the angular unconformity are overturned and dip at different angles to the north. The lines of intersection between the moderately dipping carbonate units and the steeply dipping unconformity plunge northeast and coincide remarkably well with the plunge of gold-bearing vein systems in the sediments. This explains why the

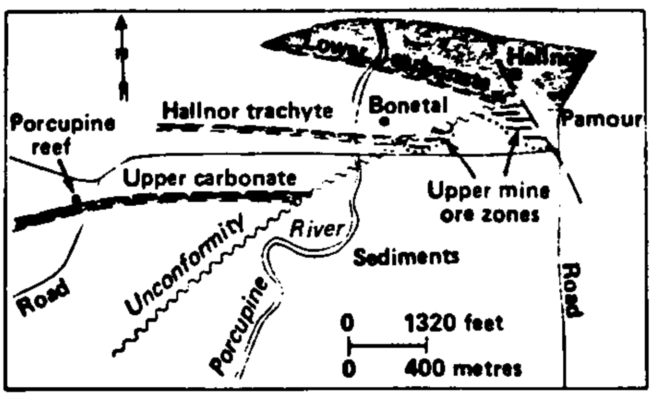


Figure 5. Surface geology in the vicinity of the Hallnor mine

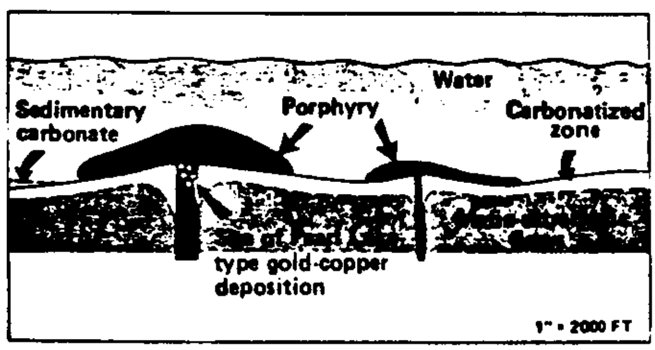


Figure 7. Formation of felsic domes and ocean floor carbonatization through volcanic and exhalative activity

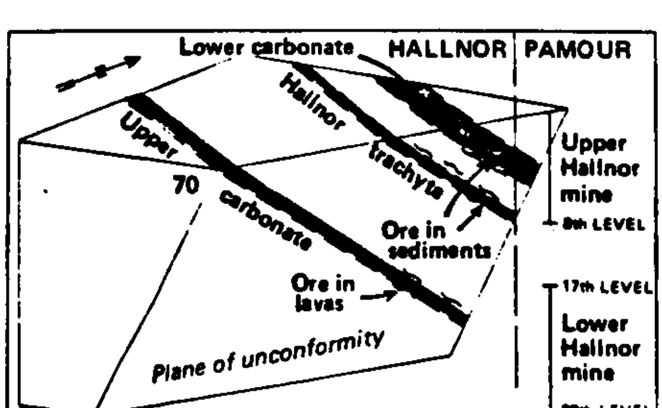


Figure 6. Block diagram showing projection of auriferous units onto plane of unconformity, Hallnor mine

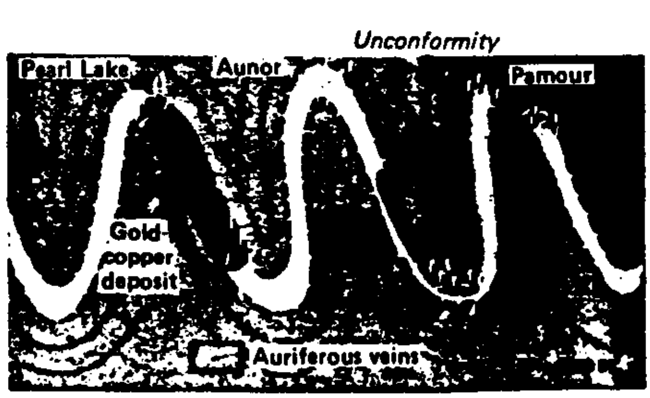


Figure 8. Regional metamorphism and deformation, resulting in concentration of gold into quartz-carbonate veins at structurally favorable sites

ore zones in the upper part of the Hallnor plunge into the nearby Pamour property and why ore was intersected in the lower part of the mine where the upper unit was encountered (Fig.6). Other examples of this type of control are evident at the Pamour.

It is interesting to note, that apart from the lenses of porphyry beneath the unconformity at the Dome, no porphyries of any description are found in or near the other deposits of group 3. The only exception, perhaps, is the carbonatized felsic rock, known as the "Hallnor trachyte" at the Hallnor (Fig.5) which has been mapped intermittently by the writer in parts of Whitney Township.

The model

A model depicting the genesis of the gold deposit in the Timmins area must take into consideration the following facts:

- Although quartz vein systems are common in all the metavolcanic-metasedimentary rocks of the area, gold-bearing veins occur only within, and mostly, near the carbonate-rich units or major porphyry bodies as illustrated in Fig. 1.
- The carbonate-rich rocks form distinct, stratabound units. The only exception of crosscutting carbonate rocks is found on the west contact of the Preston-Paymaster Porphyry south of Dome. The writer believes that the Preston-Paymaster Porphyry is partly intrusive and located in a volcanic vent and that the crosscutting carbonate is associated with the vent area.
- All quartz-feldspar porphyries in the area occur within a narrow stratigraphic interval which in most places is coincident with the lower carbonate unit. An exception may be the Preston-Paymaster Porphyry, parts of which may be associated with the Upper Unit.
- All rocks, including the carbonate units and porphyries, have been penetratively deformed by at least three phases of deformation.
- The variety of deformed gold-bearing vein systems indicates a close chronological association with regional deformation and metamorphism.
- Fragments of green carbonate are found in the Krist Formation of the upper Tisdale Group (Fig.2) and in the conglomerates of the younger (Temiskaming) sediments.
- Metals enriched in the deposits and host rocks include those which normally show affinities to mafic-ultramafic rocks (*e.g.*, Ni, Cr) and those which are normally enriched in felsic rocks such as B, W, Mo, Te, Pb, and Sb. Other metals also present are Cu, Zn, Ag and Mo.
- Breccia containing a matrix of auriferous sulphides in altered mafic volcanics is common in the No. 6 shaft area of the Schumacher (McIntyre) Mine. The alteration and breccia are widespread, crosscutting and irregular and may represent vent areas in rocks stratigraphically beneath the Pearl Lake Porphyry.

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Formation of deposits

Based on these facts and the numerous detailed accounts of individual deposits (Ferguson, 1968), the following sequence of events which led to the formation of the deposits is envisaged. Extrusion and high level intrusion of felsic rocks and extensive exhalative-fumarolic activity resulted in the carbonatization of a variety of rock types on the ocean floor along the rock-water interface, particularly in the vicinity of major vents such as the Pearl Lake and Paymaster-Preston areas (Fig.7). In addition in places away from vents, some sedimentary carbonate was deposited. It was at this time, that gold and a number of other elements were first enriched in these rocks. Also the low-grade, disseminated Mo-Au-Cu deposit in the Pearl Lake Porphyry was formed during this stage.

Subsequent regional greenschist metamorphism and deformation of the volcanic pile resulted in the remobilization of gold and other trace elements, previously enriched in the carbonate units, into dilatant fractures where they were deposited as veins during the various phases of deformation (Fig.8). Fold noses, porphyry contacts and the plane of the local unconformity were particularly favorable sites for the formation of gold-bearing veins.

The foregoing syngenetic model has several implications regarding exploration for new deposits as well as the possibility of developing low-grade, high-tonnage deposits. Stratigraphic units of intensely carbonatized rock have greatest potential for gold mineralization, particularly in major vent areas which may be represented by masses of quartz-feldspar porphyry or altered breccia zones in underlying rocks. Recognition of carbonate-rich rocks, particularly in drill core, is best done by staining. For ankerite, the stain can be done using potassium ferricyanide in dilute (2 per cent) hydrochloric acid. For magnesite, use titan yellow in dilute (5 per cent) sodium hydroxide solution (It should be noted that although "metamorphic carbonate" (calcite) is present in all the volcanics in the area, none is found in the carbonate units).

Within and near such units, intensely folded or deformed sections or areas of associated quartz-feldspar porphyry are most favorable for high-grade, vein-type mineralization.

Sulphide-bearing zones in less deformed parts have potential for low-grade, high-tonnage type deposits.

At present there is no method for evaluating the potential of the favorable carbonate-rich strata covered by overburden except by intense drilling. Even this method is limited. Lithogeochemical studies being conducted by the Ontario Geological Survey and McMaster University may result in the delineation of simple geochemical parameters which will assist in such an evaluation. **CMJ**

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Geochemical and geophysical techniques for gold exploration

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Practically all the geochemical methods of prospecting are applicable in the search for auriferous deposits. The methods employed depend essentially upon the terrain, the degree of weathering of the deposits, availability of soils, drainage sediments, vegetation, and so on. The gold pan (heavy mineral prospecting) is a time-honored method of locating concentrations of gold in both placers and primary deposits. Details respecting geochemical prospecting for auriferous deposits are given in Boyle (1979).

The favorable rocks for the

Table 1. Favorable rocks for the occurrence of gold deposits

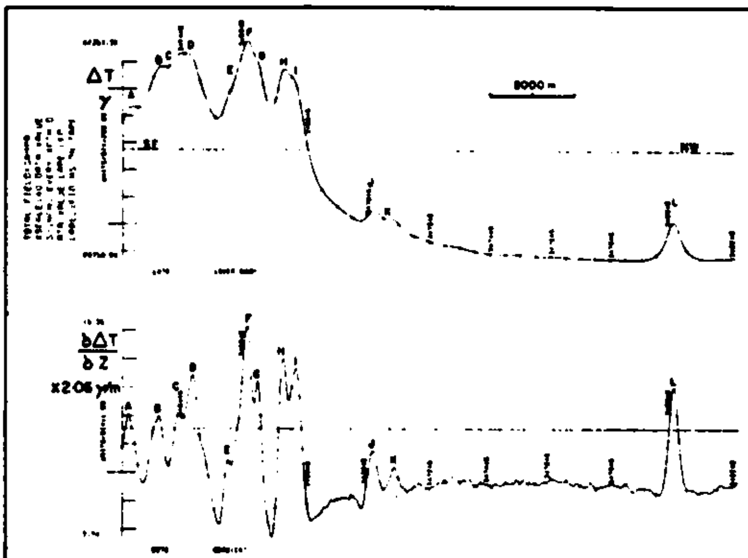
1. Volcanic (basalts, andesites, dacites, rhyolites)
   Equivalent tuffs and breccias
   Greenstone, greenschist and propylitic belts
2. Sedimentary
   Greywacke-slate belts
   Iron formations
   Carbonaceous-graphitic-sulphidic slates and schists
   Carbonate-skarn assemblages
3. Sedimentary
   Pyritic or hematitic quartz-pebble conglomerates
   Pyritic quartzites
4. Sedimentary
   Modern and fossil placers
5. Igneous
   Quartz-feldspar porphyry
   Syenite
   Granite

occurrence of auriferous deposits are listed in Table 1. Categories 1 and 2 harbor most gold-quartz deposits and Category 3 contains major gold reserves, particularly in the Witwatersrand, South Africa. Attention is drawn to Category 5 as possible large tonnage low grade deposits.

Favorable structures for the deposition of gold are noted in Table 2 which is essentially self explanatory. The chemically favorable rocks for replacement deposits are listed in Table 3.

Table 2. Favorable structures for the occurrence of gold deposits

1. Carbonated shear and schist zones in greenstone belts.
2. Faults, fractures, sheeted and brecciated zones in propylitic belts.
3. Faults, fractures, bedding plane discontinuities and shears, drag folds, crushed zones and openings on anticlines (saddle reefs) in greywacke-slate assemblages and other sedimentary rocks.
4. Fracture zones, shear zones, brecciated (stockwork) zones in igneous rocks.



TOTAL FIELD AND VERTICAL GRADIENT PROFILES
KASMERE LAKE, MANITOBA

Gold is a good indicator of auriferous deposits; other specific indicator (pathfinder) elements for gold are Ag, As, Sb, and Te.

Table 3. Chemically favorable rocks for the occurrence of gold deposits

1. Carbonate rocks, calcareous shales and schists.
2. Porous sandstone, arkose and conglomerate.
3. Tuffs, iron formations.
4. Ultrabasic, basic and intermediate igneous rocks.

Table 4 lists other indicators for use in all types of geochemical surveys. The indicator to be chosen depends on the type of deposit, its elemental constitution and weathered characteristics, and on the nature of the primary and secondary halos associated with the deposit.

Table 4. Indicator (pathfinder) elements and compounds of gold deposits in approximate order of effectiveness

1. Au, Ag, As, Sb, Te
2. SiO_2, CO_2, B,F,S
3. K, Na, Rb
4. Cu, Zn, Pb, Hg, W
5. U, Mo, Pt metals
6. Au, Ag, Bi, Te, W, B, As, Sb, Sn, Zr, P, Pt metals (indicators of placer deposits)

nature. Notes respecting both

These surveys are of a reconnaissance (regional) and detailed types are given in Tables 5 and 6 .

Table 5. Regional lithochemical surveys for gold deposits

1. Analyses of unselected rocks and/or mineral separates on a regional scale.
2. Analyses of specific rock types and/or mineral separates on a regional scale (e.g. porphyry dykes; batholiths and small stocks of porphyry, syenite and granite; specific beds or formations such as quartz-pebble conglomerates, iron formations, etc).
3. Analyses of materials of all observed "leakage halos" on a regional or areal scale, including shear zones, fault breccia, fracture fillings, quartz veins, alteration zones, jasperoid, etc.

Table 6. Detailed lithochemical surveys for gold deposits

1. Analyses of materials of all "leakage halos" as in (3) in Table 5.
2. Analyses of rocks on profiles across shear zones, stockworks, etc utilizing gold and its indicator elements in Table 4.
3. Analyses of rocks on profiles across shear zones, stockworks, etc utilizing major elemental ratios, e.g. K/Na, SiO_2/CO_2, etc.

Attention is called to the analyses of the materials of "leakage halos" on both a regional and detailed scale. Methods involving major elemental ratios, e.g. K/Na

Table 7. Pedochemical surveys for gold deposits

1. Near surface pedochemical surveys utilizing samples of soil, till, etc and/or mineral separates (heavy minerals) from these materials.
2. Deep overburden surveys utilizing near bedrock unconsolidated materials and/or mineral separates (heavy minerals) from these materials.

and SiO_2/CO_2, should receive more attention in detailed exploration for ore shoots.

Pedochemical surveys

The types of pedochemical surveys applicable in the search for auriferous deposits are listed in Table 7. Near surface surveys based on humus sampling (A horizon) have proved effective in many parts of Canada. Deep overburden surveys utilizing near bedrock unconsolidated materials are recommended where the soils, till, gravel and other surficial materials are thick (over 5 m). Heavy miner-surveys of near surface and basal soil, till, and other glacial materials have not been extensively employed but should prove useful in most terrains.

Hydrochemical surveys

These include those based on water, drainage sediments, precipitates, and heavy minerals from drainage sediments (Table 8).

Table 8. Hydrochemical surveys for gold deposits

1. Water (underground, spring, surface, snow).
2. Drainage sediments (stream, river, lake).
3. Heavy minerals from drainage sediments (panning).
4. Precipitates on stream sediments (limonite coatings, wad crusts, etc).
5. Precipitates at spring orifices (limonite, wad, silica-alumina gels, etc).

Water surveys are not particularly effective for outlining auriferous belts using gold as indicator; other pathfinders such as Zn, Cu, and As may be effective in some areas. Drainage sediments and panned heavy mineral separates from these sediments have proven effective in outlining auriferous belts in many parts of the world.

Biogeochemical surveys

These surveys are listed in Table 9. There are no specific indicators for plants or animals of auriferous deposits, although many plants accumulate gold. Analyses of these plants provide a method of outlining favorable auriferous zones. Many fossil residues particularly thucholite and anthraxolite may be auriferous (e.g. Witwatersrand, South Africa). Analyses of these residues may be an indicator of quartz-pebble conglomerates and other types of gold deposits. Analyses of the humic horizons of soils has proven effective in outlining auriferous zones in many parts of the world.

Table 9. Biogeochemical surveys for gold deposits *)

1. Geobotanical.
2. Analyses of plants and animals
3. Analyses of fossil residues (coal bitumen, thucholite, anthraxolite, etc).
4. Analyses of humic horizons of soil and till profiles.
5. Analyses of bogs.
6. Analyses of termite and ant hills, gopher and groundhog mounds, etc.

Atmochemical surveys

Some auriferous deposits contain small quantities of thorium and uranium which yield helium and radon as disintegration products. Such deposits may be indicated by their higher than normal emanative helium and radon content.

Radiometric surveys

Certain types of auriferous deposits contain thorium and uranium at the minor and trace element level. Examples are the Witwatersrand quartz-pebble conglomerates and various Proterozoic and younger vein-type deposits (e.g. Tennant Creek, Northern Territory, Australia). Most vein and lode gold deposits are also marked by alteration zones in which potassium (including the radioactive ^{40}K isotope) is considerably enriched. Certain placers are enriched in radioactive minerals such as monazite and zircon.

These features provide a method, utilizing gamma-ray spectrometers and other radiometric apparatus, for detecting and outlining many types of gold deposits. Little work of this nature has been done in Canada; during the 1980 field season the Geological Survey will commence detailed radiometric studies of various auriferous areas to evaluate the methods.

Geophysical prospecting for gold

Geophysical techniques have not hitherto been much utilized directly in prospecting for gold, mainly because gold is usually present in such small amounts in its deposits that the element does not alter the physical properties of its host rock to any measurable degree. However, it is to be expected that the induced polarization technique would respond where disseminated gold was present in sufficient concentration although it would not be expected that such cases would be very frequent. Where gold occurs in association with sulphides the exploration target is much easier to locate by geophysical techniques.

Thus, the application of geophysics in gold prospecting has been mainly confined to indirect methods that delineate geological structures with which gold may be associated.

With the recent development of the Geological Survey of Canada's aeromagnetic gradiometer as a tool for detailed geological programs it is readily apparent that such surveys will be of considerable value in elucidating some of the complicated geological structures that are a feature of many gold camps. Perhaps it is appropriate here to illustrate some of the advantages of the aeromagnetic gradiometer technique in comparison to the single sensor instrument. The aeromagnetic gradiometer consists simply of two magnetometers separated a short distance apart so that the difference in readings of the two instruments can be measured.

Since 1975, more than 40,000 line miles of gradiometer data have been obtained as a result of about 20 surveys in a variety of Precambrian terrains to demonstrate the effectiveness of the gradiometer technique. These have resulted in the publication to date of 45 vertical gradient maps contoured at an interval of 0.025 gammas per metre in addition to six Open Files of the surveys. Thus, there is now a sufficient body of experimental evidence to demonstrate the improved capability of the gradiometer technique over single sensor surveys. These advantages are summarized as follows:

1) superior resolution of anomalies produced by closely-spaced geological formations;

2) anomalies produced by near-surface features are emphasized with respect to those resulting from more deeply-buried rock formations;

3) direct delineation of vertical contacts by the zero gradient contour value i.e. vertical contact mapper;

4) regional gradient of the earth's magnetic field and diurnal variation are automatically removed.

We expect that interest in the vertical gradiometer will continue to grow and that it will be utilized to survey problem areas of the Canadian Precambrian Shield where the geology is complex and/or is covered by drift, and where the superior definition of the gradiometer (with its higher cost) is warranted.

As an experiment to ascertain the value of the aeromagnetic gradiometer technique to gold exploration programs, the Geological Survey of Canada will refly the Val D'Or sheet (NTS 32 C/4) 1980 using the GSC Queen[...] survey aircraft. The survey is [...] ing carried out at the request [...] the Association of Prospectors [...] Quebec and will cover the imp[...] tant Cadillac Break with which [...] number of important gold [...] posits are associated. If the resu[...] of the experimental gradiome[...] survey appear to be useful [...] gold exploration, then hopefu[...] an enlarged program could [...] carried out if the appropria[...] funding is made available.

Mineralleting med hjelp av vegetasjonen

drives av sovjetiske geokjemikere. Nylig fant de en gullåre ved analyse av bjørkesevje. Gullinnholdet i sevjen øker sterkt når treet vokser over rike årer. (Ny Teknik, p.7, nr 25, 19. juni 1980).

TU nr 40 2/10-88

Consider geochemistry when seeking gold

... Associates, Ltd., Ottawa, and Geological Survey of Canada, Ottawa

Initially it was not man that sought gold but nature that brought it to him in the form of alluvial grains and nuggets glittering on a stream bed. Since early Egyptian times (4000 B.C.) prospecting for gold has been dependent on visual recognition. Today with the aid of geochemistry man's capability to detect gold has been greatly extended, making it possible to find deposits that have no physical surface expression.

Gold is a member of Group IB of the Periodic Table which includes copper, silver and gold. In its chemical reactions gold (Au) resembles silver (Ag) in some respects, but its chemical character is markedly more noble. The principal oxidation states of gold are Au (I) (aurous) and Au (III) (auric). These states are unknown as aquo-ions in solutions, the element being present mainly in complexes of the type $[Au(CN)_2]^-$, $[AuCl_2]^-$, $[Au(OH)_4]^-$, $[AuCl_4]^-$ and $[AuS]^-$.

The abundance of gold in the upper lithosphere is about 5 parts per billion (ppb) and the gold/silver ratio is about 0.1. The average gold content of igneous-type rocks in parts per billion is – ultrabasic (4), gabbro-basalt (7), diorite-andesite (5) and granite-rhyolite (3); in sedimentary rocks the average is – sandstone and conglomerate (30), normal shale (4), and limestone (3). Certain graphitic shales, sulphide schists, phosphorites and some types of sandstones and conglomerates may contain up to 2,100 ppb gold or more.

The average gold content of soils is 5 ppb and the average for natural fresh waters is 0.03 ppb; for sea water the average is 0.012 ppb. Most plants and animals contain less than 1,000 ppb in the ash.

The principal types of gold deposits are quartz-pebble conglomerates (Witwatersrand type), gold quartz veins and stockworks (Yellowknife type), disseminated deposits (Carlin type), and modern placers. In all these deposits the principal gold mineral is native gold; other auriferous minerals in gold deposits include various tellurides and aurostibite. The tenor of most gold deposits ranges from 1-35 ppm gold (1 oz./ton = 34.38 ppm).*

As with so many other elements, applications of geochemical exploration techniques in the search for gold have increased due in a large part to advancements in analytical techniques. The two most common analytical methods employed for gold in commercial laboratories in Canada involve determination of the metal by a combined fire assay and neutron activation method or combined fire assay and atomic absorption spectrophotometric method. Detection limits using 10 grams of sample are in the order of 1 ppb for the former method and 5 ppb for the latter. For plant analysis, Minski *et al* (1977) have described a sensitive and precise method using a nondestructive neutron activation technique which requires 250 mg of sample and has a detection limit of 0.1-1 ppb depending on the sodium content of the sample.

Reconnaissance surveys: **The most effective reconnaissance method in prospecting for gold, especially in areas with well developed drainage systems, is panning followed by chemical analysis for gold in the heavy mineral separates.**

The authors (Boyle and Gleeson, 1972) analyzed some 400 heavy mineral concentrates for gold from stream sediments over a 1,900 square mile area centred on Keno Hill, Yukon. All of the known gold deposits were indicated by the dispersion trains of gold in the heavy mineral concentrates; in addition several anomalous areas not known to contain gold were defined (Figure 1). It is interesting to note that examination of the concentrates under a binocular microscope prior to chemical analysis indicated that gold was present only in samples taken from placer gold workings. Much of the gold detected by the chemical analyses is bound in other minerals, especially in secondary iron hydroxides such as limonite and goethite.

Surveys by the Geological Survey of Canada in which gold particles were counted in heavy mineral concentrates from tills and eskers in the Kirkland Lake area are effective in defining auriferous glacial trains (Lee, 1963, 1965). Chemical analysis of heavy mineral concentrates from eskers is one of the few surface reconnaissance geochemical techniques that can be used in areas covered by glacio-lacustrine sediments. Analyses of heavy mineral concentrates from till samples at depth have also proven to be a viable semi-reconnaissance exploration technique in heavily overburdened areas (Gleeson and Hornbrook, 1975).

In Northern Ontario auriferous alteration halos in Precambrian felsic plutonic rocks have been defined by chemical analyses for gold. W. J. Wolfe (1976) states that limited systematic sampling of granitic intrusions at 30-50 randomly distributed sites may be sufficient to estimate the gold exploration potential of stock-sized bodies. Analyses of rock samples for gold were primarily responsible for defining fine-grained disseminated gold deposits in the Carlin-Cortez area in Nevada (U.S. Geol. Surv., 1968). From these examples it follows that where sufficient outcrop is present rock geochemistry utilizing gold as the indicator can be an effective tool for selecting target areas and defining deposits.

Detailed surveys: The presence of gold in living plants and the enrichment of gold in the humus layer

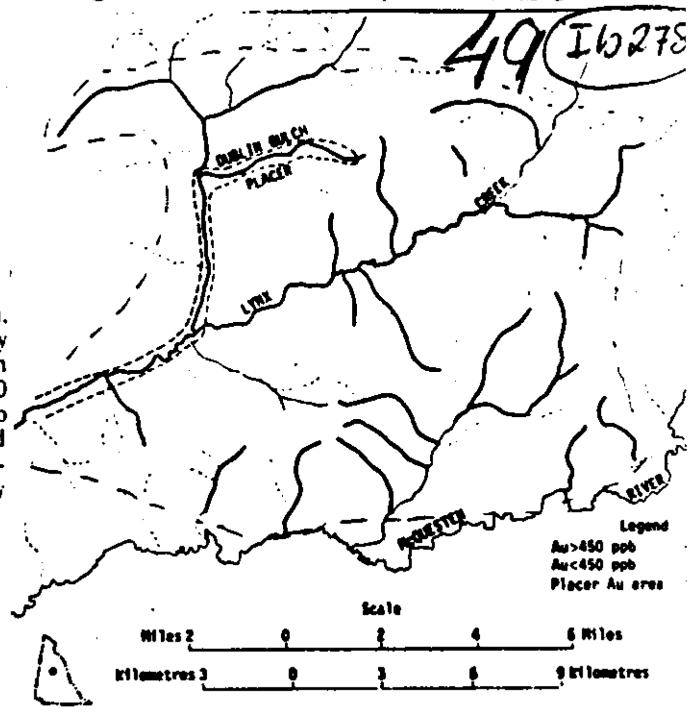


FIGURE 1: Gold in heavy mineral concentrates, Dublin Gulch area, (after Boyle and Gleeson, 1972 – see references).

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*: Fail 31.103 g (ppm) = 1 Troy ounce
However not fit short ton.

of the soil were demonstrated some 42 years ago (Goldschmidt, 1937), and more recently by Curtin *et al* (1968), who have shown that gold in humus-rich forest soil is effective in delineating gold deposits covered by colluvium and glacial drift in the Empire district, Colorado. Similarly, soil surveys carried out by one of the authors (CFG) in the Kirkland Lake, Noranda, and Val d'Or areas have shown that the best anomaly definition in areas covered by permeable till is that obtained from gold in humus. In areas where well-developed podsols occur there is much less enrichment of gold in the "B" horizon over known gold occurrences, whereas there are marked gold anomalies in the highly decomposed humus from the same sites (Figure 2). Follow up drilling on humus anomalies was 80% successful in finding auriferous zones buried beneath 3-120 ft. of permeable glacial cover. The anomalies in the humus appear directly over the subcrop of the auriferous zones, and their dispersion patterns appear little affected by slope or glacial transport. Gold in humus from some 3,000 samples taken from gold properties in the Abitibi area of Quebec ranged from less than 5 ppb to 8,300 ppb with an average (median value) of about 12 ppb. Significant anomalous values were generally greater than 100 ppb gold.

In an oxidizing environment the uptake of gold by plants and its subsequent concentration in humus has been attributed principally to cyanides (Lakin *et al*, 1974) produced by the hydrolysis of cyanogenic glycocides. Over 1,000 species of plants are known to produce free cyanide naturally. Lakin and his co-authors (1974) concluded that:

"... ample hydrogen cyanide is formed in the soil by hydrolysis of cyanogenic plants, animals and fungi to result in solution of gold in an oxygenated environment. The gold cyanide thus formed is absorbed by plants but they do not use it as a nutrient. It is therefore found accumulating as a reject in the woody parts of a plant. The decomposition of plant debris results in the reduction of the gold in the plant material and gold accumulation in the humus horizon of the soil."

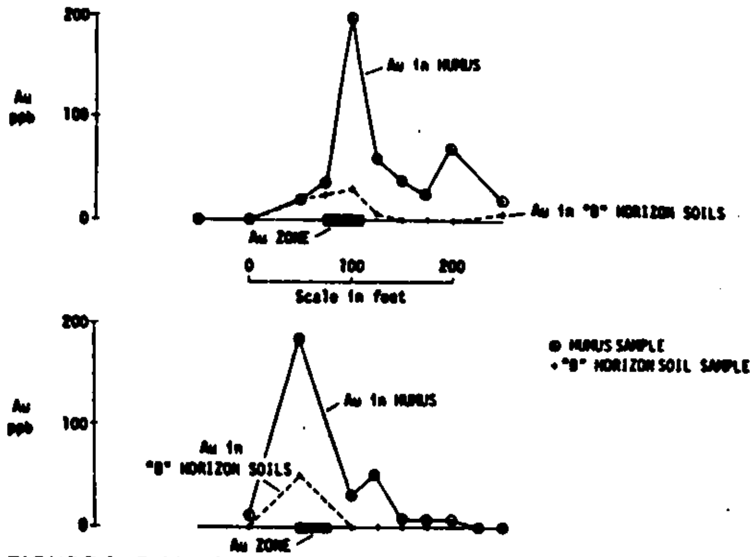
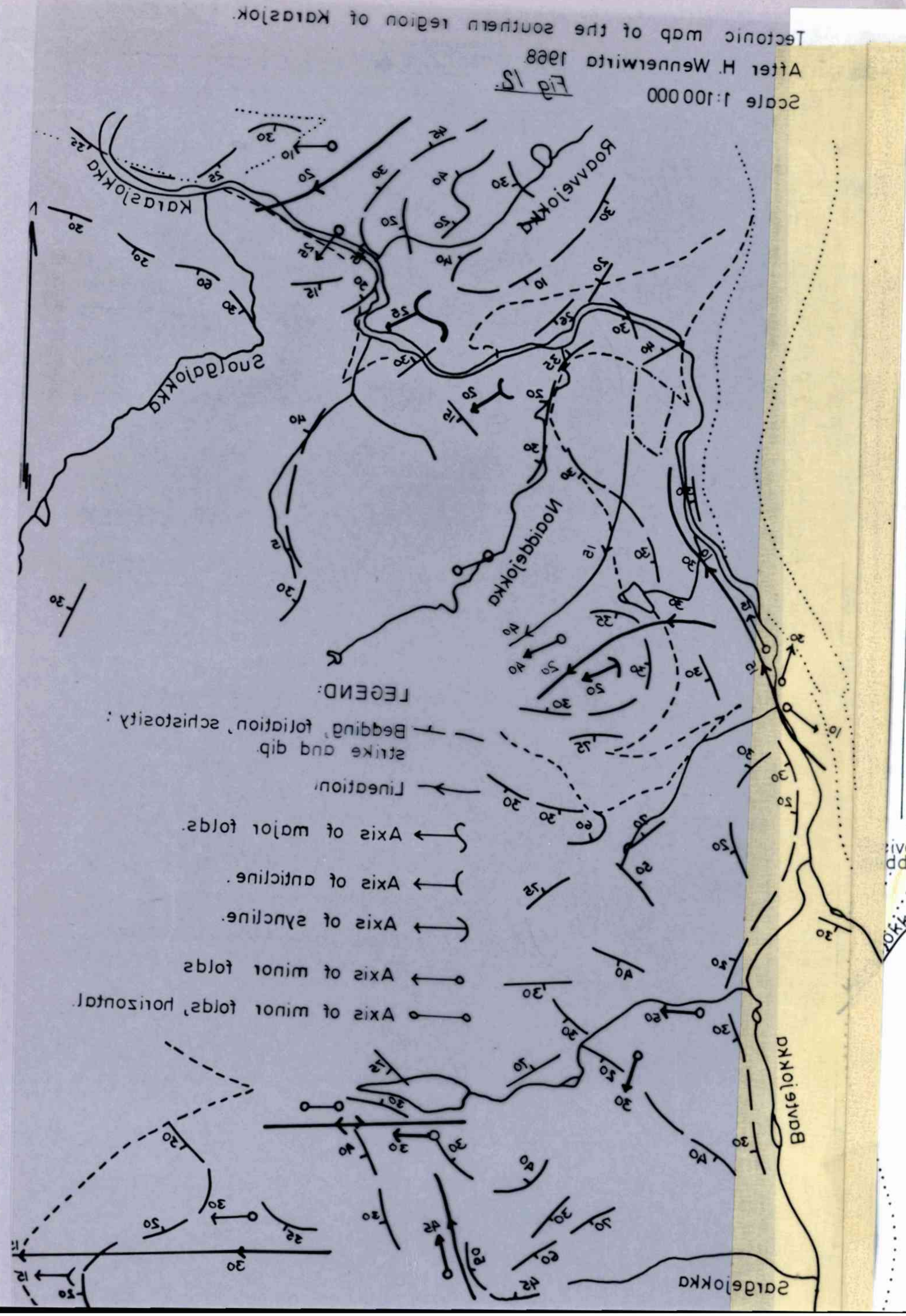
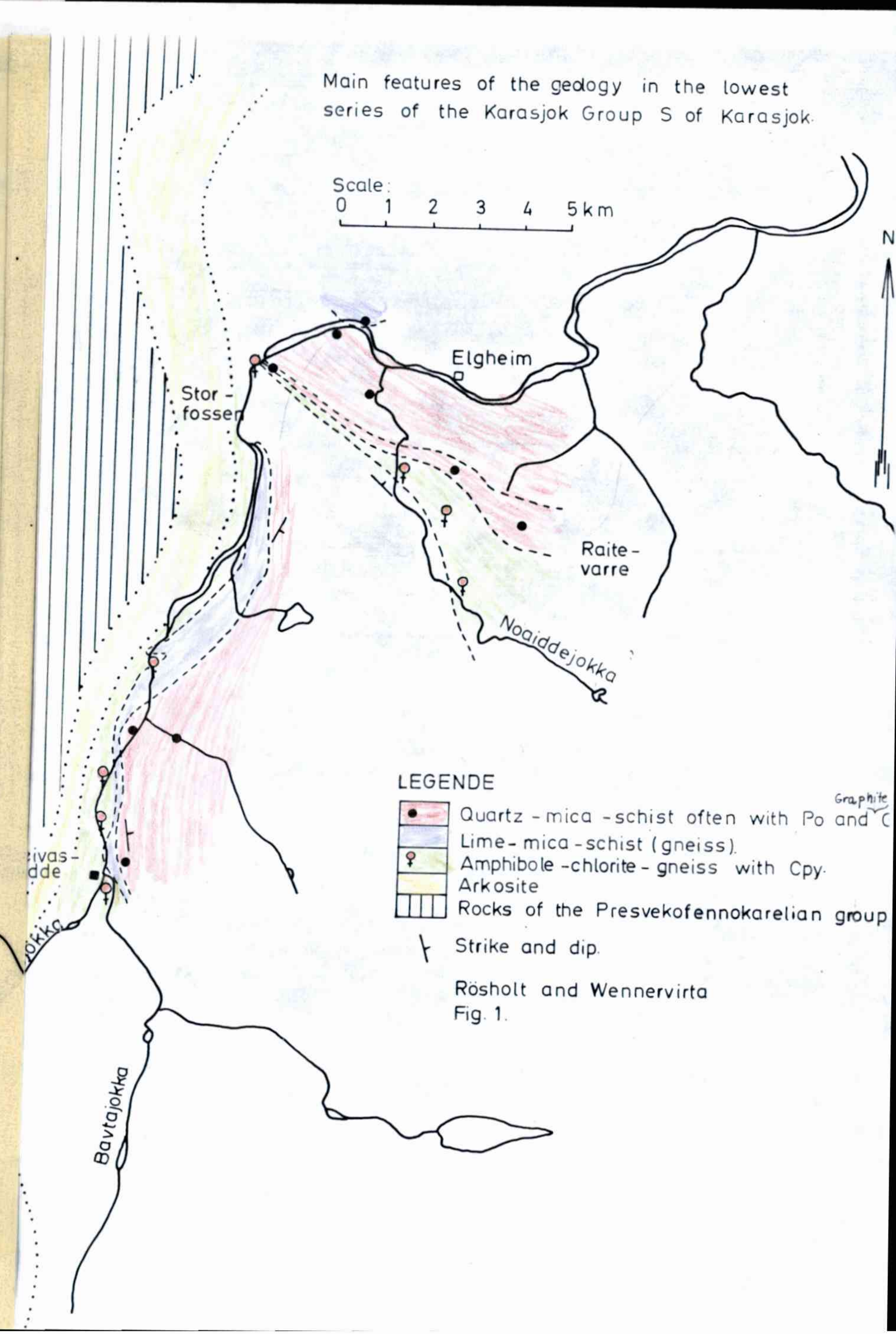


FIGURE 2 · Gold in humus and "B" horizon soils over certain gold-bearing zones in the Abitibi region of Quebec.

In areas covered by impermeable glacial deposits such as glacio-lacustrine silts and clays surface sampling of soils and humus gives negative results for gold. In these environments systematic till sampling at depth has proven effective in delimitating gold zones covered by 3-160 ft. of glacio-lacustrine material. The best anomaly definition has been obtained from gold analyses on the heavy mineral fraction of the till. In such a situation one is defining gold dispersed as particles in a non-oxidizing environment.


Tectonic map of the southern region of Karasjok.
After H. Wennerwirta 1968.
Fig 12.
Scale 1:100 000
Karasjokka
Roavvejokka
Suolgajokka
Noaiddejokka
Bavtejokka
Sargejokka
LEGEND:
Bedding, foliation, schistosity: strike and dip.
Lineation.
Axis of major folds.
Axis of anticline.
Axis of syncline.
Axis of minor folds
Axis of minor folds, horizontal.


Main features of the geology in the lowest series of the Karasjok Group S of Karasjok.
Scale: 0 1 2 3 4 5 km
N
Elgheim
Stor-fossen
Raite-varre
Noaiddejokka
Bavtajokka
LEGENDE
Quartz - mica - schist often with Po and Graphite
Lime - mica - schist (gneiss).
Amphibole - chlorite - gneiss with Cpy.
Arkosite
Rocks of the Presvekofennokarelian group
Strike and dip.
Rösholt and Wennervirta
Fig. 1.