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Roktdal project report

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ROKTDAL PROJECT REPORT

BP-NORGE MINERALS LTD. 1981

LIST OF CONTENT

1) SUMMARY

The project was generated to assess the potential of Cu-Pb-Zn-Ag-CaF_2 mineralization occurring in metasediments exposed in Pre-cambrian basement windows of the Tømmerås antiform and Grong-Olden culmination.

At June 14th 1981 field work started in the Roktdal J.V. project with BP Norge A/S Minerals as operator.

The extension of the area under investigation is shown in the location map.

Norsk Hydro had performed exploration at the Roktdal and Gressamoen showings from 1976 onwards, consisting of mapping, ground geophysics and diamond drilling, suggesting that the Pb-CaF_2 mineralization in metasediments is of synsedimentary origin and that other parts of metasediments in a comparable tectonostratigraphic position could have potential as hosts for a low grade, high tonnage disseminated base metal mineralization.

1981 work consisted of regional reconnaissance traverse mapping, stream sediment sampling and extensive rock chip geochemistry throughout the windows, and has defined 6 anomalous areas which warrant investigation and ground follow up. These anomalous areas are equally distributed between the Roktdal area and the Grong Olden culmination, and relate to metasedimentary sequences of quartzites, marbles, hornblende-micaschists, and amphibolites within a host rock consisting essentially of leptite.

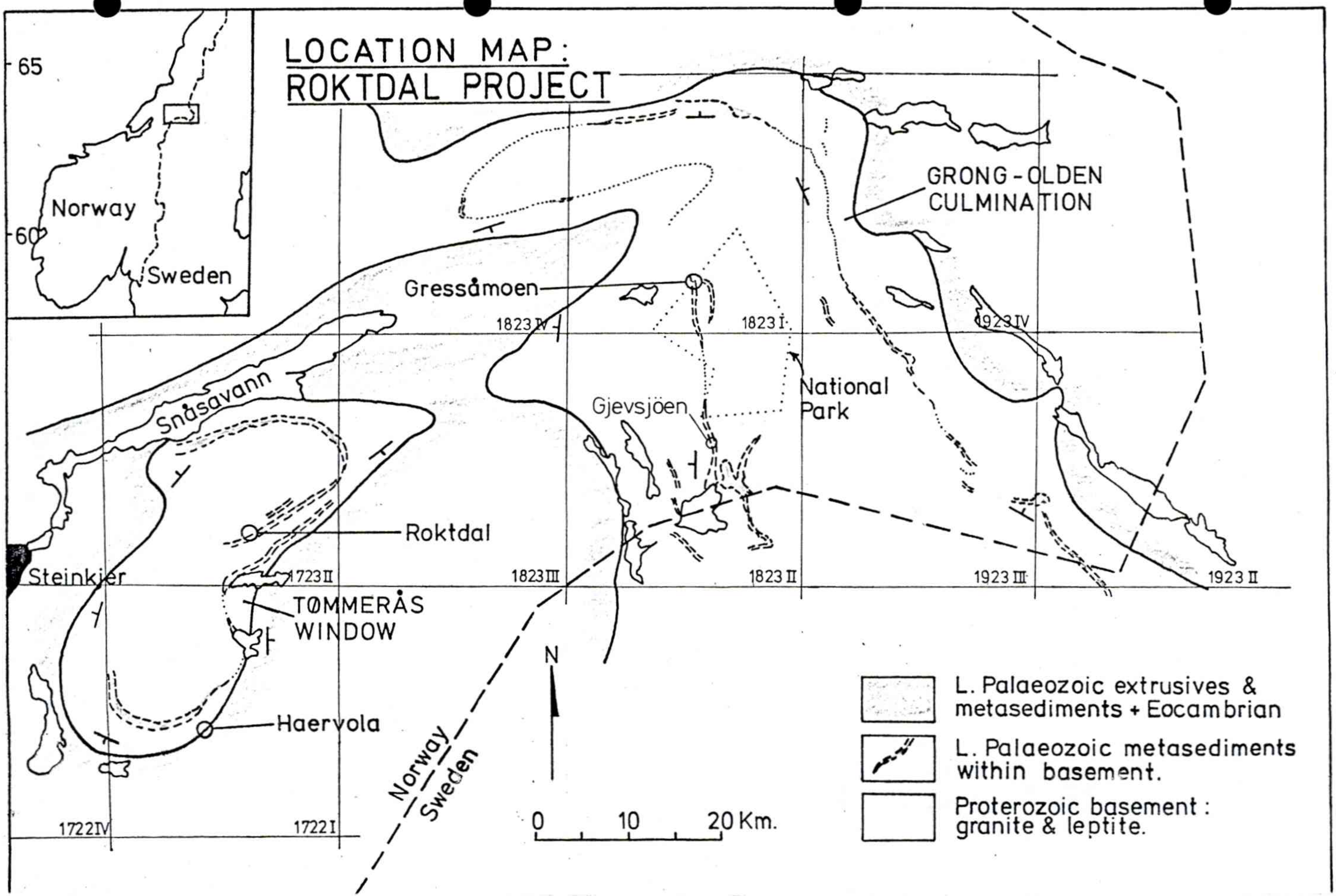
The largest and most distinct anomaly was found at Gjevsjøen (see location map) where metasedimentary sequences composed of variable proportions of quartzites, marbles and mica-schists were mapped. These sequences are the strike continuation of the galena-mineralized metasediments of Gressamoen.

Follow up of the anomalous areas in 1981 has already resulted in a new area of Pb-Zn mineralisation being located at Haervola, in the south-east quadrant of the Tømmerås window.

Haervola will be one of the areas checked in detail by local mapping, re-sampling and deep overburdensampling in 1982.

The Roktdal showing itself, discovered early this century, consisting of stratiform Pb-Zn-Ag-CaF_2 mineralisation associated with amphibolites and marbles is also to be re-investigated. The work around the main Roktdal show will consist of more detailed lithological and structural mapping, rock chip sampling, blasting and reconnaissance IP to determine whether areas of higher galena content do give a response.

By the end of 1982 field season a decision on the feasibility of this project will be made.


LOCATION MAP:
ROKTDAL PROJECT
65
60
Norway
Sweden
GRONG - OLDEN
CULMINATION
Gressåmoen
1823 IV
1823 I
1923 IV
National
Park
Snåsavann
Gjevsjöen
Roktdal
Steinkjer
1723 II
1823 III
1823 II
1923 III
1923 II
TØMMERÅS
WINDOW
N
Haervola
Norway
Sweden
0
10
20 Km.
1722 IV
1722 I
L. Palaeozoic extrusives &
metasediments + Eocambrian
L. Palaeozoic metasediments
within basement.
Proterozoic basement :
granite & leptite.

2. CONCLUSIONS AND RECOMMENDATIONS

From the results of the 1981 field season the following conclusions can be drawn:

i) The galena mineralization in the Gressåmoen quartzite is of synsedimentary origin.

ii) The origin of the base-metal mineralization at Roktdal is obscured by hydrothermal recrystallization, but the appearance of banded carbonate/fluorite make a mobilization of the metal-sulphides from a primary mineralized metasedimentary sequence likely.

iii) The above mentioned metasedimentary sequences are regarded as imbricate slices of lower Palaeozoic age, rather than being autöchtonous parts of the basement.

iv) The stream-sediment geochemical methodology applied was found to be successful in detecting and confirming known mineralization at Roktdal and Gressåmoen.

v) The anomalies found by routine measurements of fluoride in water correlate to an excellent degree with increased fluoride content in the rocks of the catchment area. i.e. Meldalen structure and Gressåmoen prospect

Based on the results from the 1981 reconnaissance programme the following work programme for 1982 is recommended:

I) Re-appraisal of the Roktdal showing itself with special emphasis on the spatial and temporal relationship between metasediments and large scale NE-SW trending breccia-zones extending over the entire Tømmeras antiform
The work around the main Roktdal show should consist of detailed lithological and structural mapping, rock chip sampling, blasting and reconnaissance ground geophysics (i.e. IP) to determine whether this type of mineralization does give a response.

II) Application for permission from the national park administration to investigate the nature of the Gressåmoen mineralization in detail, following the same concept as mentioned above.

III) Follow up of geochemical anomalies delineated in 1981 with following priorities (refer to chapter 5.1.3)

a) Anomaly E Gjevsjøen
b) Anomaly A Snåsavatnet
c) Anomaly B Roktheia
d) Anomaly F Andorsjøen.

The follow up work should consist of: resampling of anomalous stream systems, deep overburden sampling in the catchment areas, detailed lithological structural mapping in combination with rock chip sampling and reconnaissance ground geophysics such as VLF, Magnetometer and IP.

When encouraging results are achieved towards the end of 1982 field season a short hole DDH programme will be proposed and a contingency release will be sought.

Some areas with potential mineralization are envisaged to be poorly exposed or covered by swamps. These areas may be flown with an airborne EM-system in late 1982 or 1983.

To cover the costs of this follow up work and reinvestigation of the Roktdal prospect an expenditure of 419.000 Nkr. is proposed.

3. INTRODUCTION

3.1. OBJECTIVES OF REPORT

The exploration target is stratiform Pb-Zn-Ag mineralization in metasedimentary sequences with economical significant fluorite content. The economic target size is calculated to be 5 mill. tons of 10-12% lead/zinc combined. However the average silver content of the ore is regarded critical to the development of any mineralization. The average grade of the ore is reported between 135 - 602 g/t silver. Galena samples taken this year from Roktdal and Gressamoen were analyzed to contain 760 ppm and 960 ppm Ag. respectively.
As the known base metal mineralization is connected with metasedimentary sequences consisting of marbles, quartzites and greenschists the objective of the project was to assess the potential of these metasediments in the Tømmerås and Grong-Olden basement windows (Location map Fig.1
The synsedimentary nature of the mineralization at Roktdal is obscured by hydrothermal redistribution, whereas at Gressåmoen evidence of hydrothermal activity is lacking.

The metasediments have been correlated with the Jämtland-supergroup of lower Palaeozoic age. (Gee et al). It is possible that the mineralization represents a broadly lateral equivalent of the Laisvall and Vassbo type deposits in Sweden.

The following exploration concept was followed:

i) Reconnaissance geological mapping at a scale of 1:25.000 and 1:50.000 to delineate metasedimentary sequences within the basement windows.

ii) Lithogeochemical sampling of Metasediments and Leptite/Granite host rock to detect finely disseminated base metal-mineralization. WHY ?? Motivation.

iii) Reconnaissance stream sediment and water sampling concentrating mainly on areas containg metasediments in order to detect the presence of mineralized lithologies.

3.2. SUMMARY OF PREVIOUS WORK

The Roktdal Pb-Zn mineralization was discovered in 1907 and over the following years limited test mining was undertaken to test the economic potential of the mineralization, which was described as being of hydrothermal origin.

In 1976 Norsk Hydro undertook their initial geological reconnaissance and VLF measurements. It was recommended that the VLF-Anomalies found in the vicinity of the mineralization should be followed up, while a primary sedimentary origin of the banded carbonate, fluorite rock with disseminated galena was postulated.

In 1977 the Roktdal showing was mapped at a scale of 1:2.000, additional ground geophysics (VLF + Magnetometer) were employed and 6 diamond drill holes (totalling 301 m) were placed to test geophysical anomalies.

In addition, a regional geochemical programme was carried out in the area around extending up to 5 km from the Roktdal prospect consisting of 90 stream sediment and 360 water samples. In the following year the metasedimentary sequences south of Gressåmoen were mapped at a reconnaissance level which led to a geochemical sampling programme over parts of the metasediments in the Grong-Olden culmination in which 74 water samples, 92 stream sediments and 30 soil samples were taken.

3.2.1. RESULTS

In the Roktdal mineralization two types of ore were distinguished:

1) High grade, massive galena-sphalerite-chalcopyrite ore with quartz as gangue. The ore is described to occur in lenses and veins and is remobilized if not purely of hydrothermal origin.

2) Medium to fine grained limestone with disseminated galena, sphalerite and minor chalcopyrite and pyrite. The sulfides form stringers parallel to the banding of the limestone. A grey - colourless fluorite occurs as impregnation and 1 - 4 cm thick bands parallel to the foliation of the limestone. The rocks show apparent sedimentary banding being strongly deformed. It was concluded that these Carbonates represent a component of the so-called Bjørntjern schist and a primary sedimentary origin of the metal-sulfides was postulated, leading to a reconnaissance geochemical programme.

Over a 2,4 km long base line ground geophysics (VFL and magnetics) was carried out along profiles spaced 50 m. apart with station intervals varying between 12,5 m and 6 m apart. This resulted in the definition of narrow, elongated zones of FRAZER-FILTER anomalies showing no significant correlation between conductive zones and outcropping mineralization.

The strongest VLF Anomaly south of the occurrences and perpendicular to the main structure was explained by conductive overburden and underlying graphite schists.

The magnetic low anomalies coincide with the exposure of an amphibolitic rock having a varying apparent width of between 5 and 200 m. The stream sediment reconnaissance resulted in the definition of weak base-metal anomalies in the vicinity of the mineralized structure.

Approximately 3 km SW of the Roktdal prospect, 6 sample points taken within one stream system showed a multi-element anomaly which was explained by the presence of graphitic schists.

In 1978 a geological reconnaissance was undertaken in the Grong-Olden culmination in order to assess the regional setting of the Galena-mineralized quartzite found near Gresså-moen. The metasedimentary sequences consisting of phyllites, quartzites and marbles were found to continue southward into Sweden and a correlation with the lower Palaezoic Jämtland supergroup was suggested. Also, the geochemical reconnaissance in the Grong-Olden culmination defined low order stream sediment anomalies in streams draining metasediments north of the Gressåmoen occurence.

3.3. DESCRIPTION OF RECONNAISSANCE TECHNIQUES WORK – STATISTICS.

The following reconnaissance techniques were applied in order to delineate metasedimentary horizons favourable for massive and disseminated base-metal mineralization:

3.3.1 GEOLOGICAL MAPPING AT 1:25.000 SCALE

Already known metasediments were mapped and rock chip samples were taken.

Areas with no apparent metasediments were mapped along profiles 1 - 2 km. apart. Due to thick overburden, scree and vegetation at lower altitudes best outcrops were found along stream and road sections.

Geological, lithological and structural data were compiled in maps.

During 10 man months (Field geologists) an area of 413 km^2 was mapped and a total of 293 rock chip samples were collected.

3.3.2 GEOCHEMICAL SAMPLING.

The areas containing metasedimentary sequences were subsequently covered by stream sediment and water sampling. In order to test the validity of the exploration concept and to gain experience in the terrain the central part of the Tømmerås antiform was sampled as a whole.

Streams within an area totalling 351 km^2 were sampled during 19 man/months (Field assistants) resulting in 530 stream sediment and 738 water samples.

The average sample density is calculated to approx. 1,5 samples/ km^2, but due to irregular drainage pattern and highly varying stream-sediment development, the sample density is not constant, but varies between 5 - 1 sample/km^2. For further details concerning sampling and analytical procedures refer to chapter 4.

3. LAND STATUS CLAIMS

In the area under investigation i.e. precambrian basement in the Tømmeras antiform and Grong-Olden Culmination the following claims are staked:

OWNER	MUTINGSNO. NAME AREA m^2	DATE OF REGIST-RATION	MAP SHEET	ELEMENTS CLAIMED
Norsk Hydro	43/1980-TB Gressåmoen 1 250.000	18.11.80	1823 I Andorsjøen	Cu, Pb, Zn, Ag
Norsk Hydro	44/1980-TB Gressåmoen 2 250.000	18.11.80	1823 I Andorsjøen	Cu, Pb, Zn, Ag
Norsk Hydro	45/1980-TB Gressåmoen 3 250.000	18.11.80	1823 I Andorsjøen	Cu, Pb, Zn, Ag
Norsk Hydro	46/1980-TB Gressåmoen 4 250.000	18.11.80	1823 I Andorsjøen	Cu, Pb, Zn, Ag
Norsk Hydro	47/1980-TB Gressåmoen 5 250.000	18.11.80	1823 I Andorsjøen	Cu, Pb, Zn, Ag
Norsk Hydro	48/1980-TB Gressåmoen 6 250.000	18.11.80	1823 I Andorsjøen	Cu, Pb, Zn, Ag
Norsk Hydro	NM49/1980-TB 250.000		1823 II Gjevsjøen	Pb, Zu, Cu
Norsk Hydro	NM50/1980-TB 250.000		1823 II Gjevsjøen	Pb, Zu, Cu
Norsk Hydro	53/1976-TB Roktheia 1 300.000	06.12.76	1723 II Snåsavat-net	Pb, Zn, Cu
Norsk Hydro	54/1976-TB Roktheia 2 300.000	04.05.76	1723 II Snåsavat-net	Pb, Zn, Cu
Norsk Hydro	51/1980-TB Leirsjøen 1 250.000	18.11.80	1823 IV Grong	Pb, Zn, Cu, Ag
Norsk Hydro	52/1980-TB Leirsjøen 2 250.000	18.11.80	1823 IV Grong	Pb, Zn, Cu, Ag

OWNER	MUTINGSNO. NAME AREA m^2	DATE OF REGIST-RATION	MAP SHEET	ELEMENTS CLAIMED
Norsk Hydro	53/1980-TB Leirsjøen 3 250.000	18.11.80	1823 IV Grong	Pb, Zn, Cu, Ag
Norsk Hydro	54/1980-TB Leirsjøen 4 250.000	18.11.80	1823 IV Grong	Pb, Zn, Cu, Ag
Norsk Hydro	55/1980-TB Leirsjøen 5 250.000	18.11.80	1823 IV Grong	Pb, Zn, Cu, Ag
Norsk Hydro	56/1980-TB Leirsjøen 6 250.000	18.11.80	1823 IV Grong	Pb, Zn, Cu
BP Minerals Norge A/S	NM162/1981-TB Høysjøen 1 250.000	23.11.81	1722 I Vuku	Pb, Zn, Cu
BP Minerals Norge A/S	NM164/1981-TB Høysjøen 2 250.000	23.11.81	1722 I Vuku	Pb, Zn, Cu
BP Minerals Norge A/S	NM164/1981-TB Høysjøen 3 250.000	23.11.81	1722 I Vuku	Pb, Zn, Cu

No claims of competitors in the project area are recorded at the Bergmester in Trondheim.

A final decision on the feasibility of the Roktdal project must be made before the 6.12.1983, as after the new mining law claims can be held over a period of up to 7 years, followed by an application for an "utmal" which demands a feasibility study of the prospect.

4. REGIONAL GEOLOGY

4.1. SYNOPSIS OF PUBLISHED DATA

4.1.1 MAPS

Except at impractically small scales, there do not exist any maps of the Tømmerås area within N.G.U. archives. The earliest "modern" treatments of the area are those by Wolff (3) and Peacey (4) who published maps of the eastern margins of, and the whole of Tømmerås respectively (1:200.000 and 1:140.000), together with comprehensive accounts of the structure and stratigraphy of these areas. The southern Tømmerås area is also included in the 1:250.000 Trondheim sheet (16). In the Grong-Olden area, the pre-1960 maps of S. Foslie (12, 13, 15, 15) published by N.G.U. (1:100.000) cover all areas investigated by BP Minerals-Norge A.S. The quality of these maps, and the reliability of contacts is generally adequate, although the interpretation and nomenclature of the lithologies mapped are often debatable. It is considered that the quality of mapping executed by BP Minerals-Norge is, in many localities, a significant improvement on the published material.

4.1.2 LITERATURE

Existing interpretations of the geology of the Tømmerås and Grong-Olden windows (1, 2, 5, 6, 7, 8, 10) are heavily biased toward nappe tectonics, correlation and variations of metamorphic grade related to orogenesis, without references towards mineralization that are of any significance. Following the earlier conclusions of Asklund (1), Oftedahl (2) and Gee (7,8), Peacey has summarized the main tectono-stratigraphic divisions in the Tømmerås-Grong-Olden tracts:

a) A lowest-visible unit consisting mainly of coarse-graine granite and leptite, the Olden Nappe (2), forming the cores of antiformal windows and containing thin remnants of a lower Palaeozoic sedimentary sequence which are correlated with the Jämtland Supergroup (7, 8).

b) Further Precambrian and Lower Palaeozoic sediments and basic volcanics, having a primary unconformable contact with the window lithologies (Lekdalsvann & Snåsa Groups), occurring to the north and south of the Tømmerås window and in the complimentary synform on its north-western flank.

c) The highest division of Palaeozoic sediments and acid to basic volcanics, lying allochthonously within the complimentary synform on the eastern flank of the Tømmerås window.

Representatives of divisions b) and c) separate the outcrops of the Tømmerås and Grong-Olden windows in a structural basin. To the north and east of the Grong-Olden window lie a series of sub-nappes composed of lithologies that are broadly correlated with the nappes of the Snåsa-Trondheim district, forming part of the great Seve-Køli Nappe.

Other publications (9, 11) purely concern dating of granitic lithologies within the Grong-Olden culmination. Results indicate a Svecofennian age of approximately 1700 Ma., with a Caledonian overprint at 400-500 Ma.

4.2 RECONNAISSANCE MAPPING - TOMMERÅS ANTIFORM

The non-genetic term 'leptite', originally coined by 19th century Swedish geologists to describe the fine-grained rocks of granitic to syenitic composition occurring within the basal sequences of the Scandinavian "mountain-chain", has been in use up to present time to describe one of the most common lithologies of the Tømmerås and Grong-Olden windows. Although it is now possible to conclude the most likely genesis of this lithology with confidence and, via abundant geochemical data, a classification is also possible, the term has been retained in this section of the report for purposes of convenience. The true position of this lithology and its variants in the igneous spectrum will be discussed in section 4.

It should be noted that estimates of lithological thicknesses stated in the following section are, in such highly deformed areas, those resulting from tectonic modification of primary thicknesses and are not 'true' thicknesses as such.

4 .2.1 LITHOLOGIES

4 .2.1.1 LEPTITES (Plates 1 & 2)

The "ordinary" leptites of the Tømmerås area are a massive to slabby, fine to medium-grained, buff to pink-coloured and relatively homogeneous lithology. They are composed essentially of alkali felspar and quartz with accessory phyllosilicates (chlorite ± muscovite ± biotite), and commonly contain evenly dispersed coarse (to 2 mm), grains of felspar which may either be metamorphic porphyroblasts or the representatives, albeit modified, of primary phenocrysts. Significant contents of opaque minerals are lacking in the ordinary leptites, locally however fine disseminations of specularite, magnetite, pyrolusite and pyrite have been recorded.

Such leptites occur as the matrix for the other lithologies within the Tømmerås windows, outcropping over an area of at least 300 km^2, and having a minimum tectono-stratigraphic thickness of several kilometres. They become increasingly foliated in the vicinity of contacts with metabasic bodies and metasediments, and are crudely gradational into other types of leptite via an increase in micas (towards micaceous leptites) and coarse felspar grains (towards augen leptite).

Current consensus of opinion favours an acid extrusive origin for these leptites (Peacey 1964, Gee 1974, Andreasson and Lagerblad 1980) although Reymer (1979) considers them to be granite mylonites derived from the Precambrian basement. That these leptites occur in such large volumes over such a large area, and their homogeneity over such areas, however, is contrary to the normal mode of occurrence of acid extrusives of any age or environment. Similarly, that the leptites have at least locally suffered a certain degree of cataclastic deformation is undisputed, however a uniform degree of such deformation to the point of producing mylonites over such large areas is contradicted by Peacey's petrographic investigations. The ordinary leptites are therefore considered to be the representatives of fine- to medium-grained acid intrusives. Such an origin is confirmed in the western part of the Grong-Olden window, where the leptites are practically identical to those of Tømmerås, at a locality where typical ordinary leptites have been observed to vein coarse-grained Grong-Olden granite (1823I, U99000M 37200).

4.2.1.2 MICACEOUS LEPTITES (Plates 3 & 4)

The micaceous leptites are a predominantly grey-coloured, fine to medium-grained lithology, with or without coarse grains of felspar which frequently demonstrate the effects of cataclasis, such as extension, dislocation and milling.

The fine banding which is commonly observed in this lithology can be mainly attributed to tectonic flattening and extension, rather than to any primary fabric. Orthogonal jointing may be developed in the micaceous leptites to such a degree that the rock readily divides into cm-size cubes with little more than hand pressure. Perfect pervasive monoplanar schistosity is not however commonly developed, but rather a tendency to form thin flagstones.

These leptites occur both as minor local variations of the ordinary leptites and also as discreet horizons within the latter in thicknesses of up to several metres. Such horizons commonly occur in the vicinity of contacts with the metasediments and with the allochthonous Palaeozoic schist sequence on the eastern flank of the Tømmerås window.

It is considered that a sedimentary genesis for the micaceous leptites via erosion of supposedly leptite extrusives, as proscribed by Peacey is by no means certain. Mineralogies and textures typical of the micaceous leptites could be produced by tectonism, possibly accompanied by metamorphic differentiation, of the augen leptites. (see below).

The only opaque minerals recorded within these leptites in the field consisted of local fine to medium-grained disseminations of pyrite or hematite.

4.2.1.3 AUGEN LEPTITES (Plates 5 & 6)

The augen leptites consist of abundant coarse (to 1 cm) porphyroblasts or modified phenocrysts of K and low-Ca felspar in a light to dark grey-brown matrix of quartz and felspar together with abundant chlorite, biotite and muscovite. Similar to the micaceous leptites, only local fine disseminations of pyrite and hematite have been observed.

The augen leptites occur predominantly as discreet horizons of 0,3 to several hundred m. thickness within ordinary leptite, notably in northern, south-central and eastern tracts of Tømmerås. Contacts with the ordinary leptites are generally sharp. At a locality in central southern Tømmerås, a knife-sharp contact between a thin bifurcating lens of augen leptite and ordinary leptite was recorded. The form of this lens and the apparent local absence of shearzones suggests that the textures of the augen leptites are, at least partly, of primary igneous origin, representing that of felspar-porphyritic minor intrusive sheets. It has been suggested that such augen textures may have been produced by dynamic metamorphism, since such textures have been commonly observed to occur in the vicinity of zones of calaclasis. Naturally the occurrence of augen and "durchbewegung"-type textures can be demonstrated to be purely the effect of tectonic processes within numerous of the more highly deformed areas (usually of amphibolite facies and above) of the Caledonide orogen and its basement. In the Tømmerås area, however, it can be argued that the presence of anistropies such as intrusive porphyrite bodies within otherwise homogeneous volumes of leptite would naturally present foci for the release of strain via shearing during deformation.

4.2.1.4. METABASICS (Plates 7 & 8)

Lensoid bodies of metabasic composition, normally to several tens of metres in thickness occur irregularly distributed throughout the Tømmerås area. Textures within these bodies vary from that of metagabbroic to meta-amphibolitic, being principally composed of hornblende, plag. felspar and chlorite with accessory magnetite, biotite, pyrite, and locally pyrrhotite, chalcopyrite. A schistose chloritic envelope is not uncommonly developed following dynamic metamorphism in their contact zones due to the competence difference between the metabasics and their hosts. On a broad scale the metabasic bodies lie comfomably within the leptites, however on a local scale it has been observed that the contacts frequently transect the foliation of the latter, and there seems little doubt that these bodies are of intrusive origin.

Their age and relationship to mineralization at Roktdal is uncertain. Since the Precambrian lithologies of Tømmerås were apparently not metamorphosed before the Caledonian orogeny, it is possible that they are of lower Palaeozoic age, possibly being deep-seated representatives of the massive volumes of basic lava which were extruded over the Grong-Trondheim region at this time. In other areas of the Caledonides it has been shown that such bodies both exploit pre-existing weaknesses during their emplacement and act as loci themselves for subsequent planes of displacement during deformation. At Roktdal therefore, where the mineralization appears to be strongly controlled by fracture tectonics and where it can be observed in drillcore that the mineralization, at least in part, transects the metabasic-leptite contacts, it is possible that the former acted as mechanical aid to fracturing and mineralization. Otherwise, the metabasic bodies are not considered to be genetically related to the mineralization at Roktdal.

4.2.1.5. HAERVOLA GRANITE (Plates 9 & 10)

The Haervola granite is a large (15 x 1,5 km) lensoid body composed of quartz, predominantly K-felspar, muscovite and accessory biotite, chlorite, occurring along the south-eastern margin of the Tømmerås window, having a western contact with leptites and an eastern contact with allochthonous lower Palaeozoic schists. Contacts to the north with the granite gneisses are diffuse, as are parts of its contact to the south-west with granite-gneisses and leptites. The granite is relatively homogeneous coarse-grained with only rare local development of an aplitic facies and an apparently complete lack of any pegmatitic facies.

Several topographically significant late-stage lineaments transect the body, along parts of which the granite has been brecciated by multi-stage quartz vein injection containing Pb-Cu mineralization (p.). The contact zones of this breccia are sharp, there being little or no visible hydrothermal alteration of the granite. Apart from rare disseminations of galena in the immediate vicinity of this breccia, magnetite and specularite are the only opaques recorded in the Haervola granite.

The granite has been interpreted by Wolff (1960) as being of Precambrian age on the grounds that a supposedly Caledonian mylonite zone occurring along its contacts must indicate an age greater than that of the Paleozoic schists. The use of this evidence is considered unsatisfactory, since a late-Caledonian mylonite zone could equally well permit a lower Palaeozoic age for the granite. The similarity in geochemistry between the ordinary leptites and the Haervola granite (P.) is considered to be more positive evidence in favour of a Precambrian age.

4.2.1.6 GRANITE-GNEISS (Plate 11)

The granite-gneiss is a coarsely foliated (cm-scale) lithology consisting essentially of K-felspar with finer intercalations of quartz, felspar and muscovite, chlorite and biotite. The lithology outcrops in a belt along the south-western, southern and south-eastern margins of the Tømmerås window, but is interrupted in the south-east by the Haervola granite, into which it is gradational. Such field relations, together with the observed mineralogical and geochemical similarities suggest that the granite-gneiss is a tectonic facies of the Haervola granite. Similar to the latter, no significant disseminations of opaque minerals have been observed in the granite-gneiss.

4.2.1.7 METASEDIMENTS (Plates 12 - 15)

Broadly conformable horizons of undisputed sedimentary provenance occur at two tectono-stratigraphic positions within the leptites of the Tømmerås window, a) an upper position, along the eastern and southern peripheral zones (Lustadvatnet - W. Haervola - W. Høysjøen - Grunnvola, b) a lower position, occurring centrally and discontinuously (Snåsavatnet - Roktdal Lauvatnet). The metasedimentary sequences, varying from <1 to ~ 250 m thickness, consist of varying proportions of quartzite, marble, muscovite and chloritic schist or phyllite, and graphite/biotite schist. The effects of varying degrees of dynamic metamorphism such as metamorphic grade and folding/dislocation are commonly displayed, while the contacts of the sequences with their hosts are almost invariably demonstrably tectonised.

In the Tømmerås area, the quartzites are generally fine to microgranular lithologies, usually grey in colour and commonly banded. Locally, finely disseminated pyrite is present. The marbles are most commonly grey equi-granular lithologies which are also locally pyritiferous. The pelitic metaseds are variable in texture according to metamorphic grade and chemical composition, ranging from well-cleaved phyllites to schists containing variable proportions of muscovite and chlorite with or without garnet. The graphitic and biotite schists are commonly closely associated, being homogeneous, well-cleaved black, but commonly rusty-weathering lithologies due to their high pyrite-marcasite contents. No significant base-metal mineralization has been recorded within demonstrably non-remobilized metasedimentary sequences in the Tømmerås area.

Over the majority of the Tømmerås area, the full metasedimentary sequence is either poorly developed or poorly preserved, being represented most commonly by crenulated muscovite-dominated schists containing abundant fine conformable quartz-vein boudins, while quartzite, marble and graphite schist occur only locally in dm-scale thickness. In the central areas around Roktdal however, the full sequence occurs commonly e.g. at Storroksaetra, 1,5 km. to the southeast of the Roktdal prospect, where the following inverted sequence occurs: leptite/quartzite/graphite schists/impure marble/ grey phyllite ± graphite/leptite.

4.2.2 STRUCTURES

The overall structure of the Tømmerås area, as defined by what is presumably the primary schistosity/foliation (S_1) is that of an elongate dome oriented N.E.-S.W., with average dips of 20-25^{o} to the N.W. and S.E., and 10-20^{o} to the N.E. and S.W. The homogeneity of the ordinary leptites does not permit the recognition either of major f_1 structures or their style within the Tømmerås window. The finely banded micaceous leptites and metasediments however commonly contain minor folds of tight isoclinal style which are presumed to be a reflection of the style of any major structures. The occurrence of two tectono-stratigraphic positions of metasedimentary sequences, although probably also due in part to imbrication, suggests the presence of such large scale fold structures.

From observation of the variation in orientations of S_1 on a local scale, it can be concluded that a late secondary (f_2) fold system of open style is superimposed on the major f_1 structures of Tømmerås. The axial planes of this basin-depression-type pattern appear to be sub-vertical and oriented almost orthogonally N.E.-S.W. and N.W.-S.E. Such late folding of the primary isoclinal (Caledonian) folds can be attributed to processes of mass equilibration within the basement following emplacement of the Caledonian allochthon. In addition it is evident that deviations from a model antiformal geometry must be expected in the vicinity of the larger metabasic bodies, due to competence contrast and the associated discrepancy of rotation rates during f_1 deformation.

The latest structures in the Tømmerås area, which are in all probability geometrically related to the above fold phase, are steeply-dipping fracture zones of numerous orders which pervade the area, but which do not in general appear to have incurred significant displacements. Such fractures, to which the mineralizations at Roktdal and Haervola appear to be related, frequently have strong topographic,air-photo and Landsat expressions (Chapter 7).

4.2.3 HYDROTHERMAL ALTERATION, VEINING AND MINERALIZATION.

4.2.3.1 ALTERED LEPTITE AND GRANITE-GNEISS (Plates 16 - 19)

The most important and predominant type of alteration of the ordinary leptites, and in one case of granitic gneiss, is that producing a striking pink to orange-coloured, commonly porous and/or vuggy lithology, with no apparent increase in grain size. Such alteration, which consists of K-felspathization and removal of SiO_2, Na_2O, has been observed at several localities in the Tømmerås area.

In drillcore from Roktdal, and also to a more limited extent in the ordinary leptites at surface (e.g. on the path up from Hatlingvatnet) such alteration is established initially along fine steeply-dipping fractures, extending to $\sim$ 1 cm into the leptite wallrock. In more extreme cases in Roktdal drillcore, alteration is practically complete over at least several decimetres, forming alteration zones several metres in extent. Such alteration has been recorded by previous surface workers in the Roktdal locality, however, the full extent of such zones could easily have been missed due to their restricted occurrence and also because subaerial weathering of the K-felspar rich zones produces a white to grey-pinkish coloured surface practically identical to that of ordinary leptite.

Notable examples of this type of alteration were recorded at four other localities in the Tømmerås area. North of Lustadvatnet (1723 II, 33W, U57850, MO 3200), in a sequence of fine-banded, augen and micaceous leptites, there occurs a zone approximately 30 m in strike length and extending at least 4 m across strike in which the latter lithologies are transected by fine sub-vertical veinlets with K-felspathization and hematization. At this locality it is noteworthy that a thin (25 cm) weakly pyritiferous horizon within the leptites has been analyzed to contain 2800 ppm Zn.

South of the Ogndal valley, central Tømmerås (1722 I, 32V, P40900, R97000) there occurs an intense zone of alteration, exposed in a roadcut to extend at least 25 m across strike. Exposure at this locality is otherwise very poor such that deep-overburden sampling would be necessary to ascertain the strike extension of this zone. At this locality, which is the most extensive recorded in Tømmerås, the ordinary leptite has been completely transformed to a reddish-orange porous lithology containing abundant vugs and veins of smoky quartz and/or pyrolusite.

North of Høysjøen (1722 I 32V, P43900, R85650) similar alteration occurs up to approximately 60 cm either side of two subvertical fracture zones which are spaced several hundred metres apart.

North of Kjesbuvatnet (1722I, 32V, P36350, R81300), granitic gneiss is also similarly pervasively altered, but in zones up to several dm. in extent which are predominantly subparallel to the primary foliation.

The genesis of these alteration zones is obviously linked with tectonic/hydrothermal events which occurred late in the history of the Tømmerås area since they invariably occur associated with steeply-dipping fractures. The geometry and mineralogy of such alteration suggests that the fluids responsible were low-temperature hydrothermal, possibly having a magmatic component, rather than cold fluids resulting from concentration and redistribution of formation and connate waters.

Other types of altered leptite of restricted occurrence in the Tømmerås area are those of specularite-rich leptite and pyrite + fluorite-bearing leptites. The former have been observed at one locality south of Ogndalen, but are not considered to be worthy of further attention. The latter have been observed in the Roktdal prospect locality, being conspicuous by their reddish colour in fresh section, and high Pb, Zn, Cu content (Cu 179 ppm, Pb 3973 ppm, Zn 3251 ppm, F 5610 ppm).

4.2.3.2 BRECCIATED LEPTITE (Plates 20 & 21)

Leptite breccias, consisting of angular altered fragments of leptite within a vuggy matrix of euhedral chalcedonic and platy quartz, with or without grey to purple fluorite, occur at numerous localities in the Tømmerås area associated with vertical or sub-vertical fractures. The platy quartz (confirmed by two independent X.R.D. analyses) is obviously a pseudomorph after a primary vein-breccia mineral. X.R.D. analysis shows the presence of traces of calcite within both fresh and weathered hand-picked samples of the platy quartz, suggesting the original mineral was calcite. Such an uncommon form of calcite is apparently a characteristic component of veining in the Ag ore veins at Kongsberg, S. Norway and of base-metal bearing veins in Freiberg, Harz Mts, S.E. Germany.

The occurrence of substantial amounts of fluorite in the leptite breccias is restricted to the Roktdal area, notably along the major E.N.E.-W.S.W-trending fracture which transects the N-S-trending series of mineralized exposures at Roktdal. Two generations of fluorite are distinguishable in this locality. a) early homogeneous fluorite now present as rounded equidimensional fragments within granular vein quartz, and b) later banded fluorite, which together with vuggy and chalcedonic quartz forms the last encrustation on cavity walls. Fine disseminations of pyrite and hematite occur locally in these breccias, but no base-metal mineralization has been recorded. The thickness of the breccias is generally only of dm-scale, however, in the above locality west of the Roktdal prospect, the brecciated zone attains a thickness of several metres. Contact relations of the breccias with their wallrocks are generally diffuse over cm. to dm.-scale.

The fractures with which such breccias appear to be predominantly associated are those trending N.E.-S.W. That the breccias are directly associated with such late-stage fractures, and that evidence of displacement (though not dilation) subsequent to breccia formation is lacking suggests that they are post-Caledonian in age. The temporal and structural relationship of this brecciation to the types of alteration described in 3.2.3.1 are unknown, the only two factors which the two phenomena have in common being an association with late, steep fractures and a tendency to contain secondary Mn-phases.

4.2.3.3 HAERVOLA BRECCIATION. (Plates 22 - 23)

Associated with a series of major fracture zones trending N.E.-S.W. which transect and form part of the contact of the Haervola granite, there occurs a significant zone of multi-stage vuggy quartz veining and brecciation. The greatest dilation exposed is to the south-east of Høysjøen beside the Vollen-Sagdalen track (1722 I, 32 V, P 44500, R 83900) where there occurs a zone of brecciated granite 5 - 6 m in width. Discontinous exposures of Pb-Cu mineralization have been recorded along this zone over a length of approximately 750 m. Extension of mineralization further north along this zone is considered unlikely as dilation appears to decrease rapidly in this direction. However, in a south to south-westerly direction, extension is probable, but masked by marshy overburden.

The mineralization consists of coarse (to cm-size) isolated grains of galena and chalcopyrite within grey rosette-formed vein quartz. The walls of vug cavities, which may reach several dms. in dimension, are lined with euhedral quartz to several cms. in length which are locally of the smoky, in fact truly black variety. The colouration of this quartz is apparently due to high levels of thorium. The granitic wallrock and fragments have suffered little or no alteration apart from silicification.

A thorough investigation of the hydrothermal 'stratigraphy' of the Haervola vein-breccia and its extension would entail removal of the small boulder scree which covers a high proportion of the brecciated zone, and deep-overburden sampling. Three claims have been recently registered by BP Minerals Norge to cover the Haervola mineralization.

4.2.3.4 MINERALIZATION AT ROKTDAL (Plates 24 - 30)

Zn-Pb-Cu mineralization of massive and vein types occurs in a series of natural and man-made exposures on Roktheia, north central Tømmerås and are claimed by Norsk Hydro (1723 II, 33 W: U 54650 MO 6900 to U 54650 M 04900).

At the surface, both types of mineralization occur in close spatial association with highly deformed horizons of banded carbonate-fluorite to the order of 1 m. in thickness. In drillcore however, irregular patches and fine veinlets containing galena and sphalerite have also been observed to occur within a north-south trending lensoid body of amphibolite which outcrops in the immediate vicinity of the prospect and which is broadly conformable with the Roktdal mineralization in plan. In section, however, this body clearly transects the major host of mineralization at a shallow angle. The mineralization essentially consists of galena and sphalerite, with variable, locally high contents of chalcopyrite, and pyrite, pyrrhotite. Massive mineralization is fine to medium-grained, while remobilized mineralization is fine to coarse-grained.

At surface, the tight isoclinal folding and often extreme degree of dislocation of fluorite bands within the medium to coarse equigranular carbonates is evidence in favour of a pre-deformation origin of banding. That this banding is often delicately fine, and is not related to vug-in-filling in turn suggests a sedimentary origin for the banded carbonate-fluorite lithology of Roktdal. However, the somewhat anomalous strike at this lithology within the larger structure of Tømmerås, together with a lack of inclusion of other metasedimentary components such as metapelites or quartzites, does suggest that these rocks do not constitute a 'normal' metasedimentary horizon. It is feasible that they have been tectonically squeezed in a semi-'plastic' state from a convenient source horizon. In this respect, the nearest metasedimentary horizons are now 1,5 km. distant, however, they may have been derived from a source above the present erosion surface, which can be estimated to have been the only of the order of several hundred metres distant.

Nei

The majority of mineralization observed in drillcore is that of remobilization type, which is also common at surface, consisting of predominantly coarse-grained galena sphalerite and chalcopyrite in a quartz-low Ab plagioclase (XRF)-carbonate-fluorite-biotite-muscovite gangue. It is noteworthy that the fluorite of relatively high specific gravity, in both remobilized and massive mineralization is practically non-fluorescent, suggesting the presence of rare-earths, which is confirmed by XRF analysis.

As described previously, the leptites in the vicinity of the Roktdal showings, and in drillcore are commonly altered to a distinctive reddish-coloured lithology in fresh section by K-felspathization/hematization. Locally the leptites have also been observed to contain fine intercalations or veinlets containing carbonate-fluorite.

As discussed previously, the mineralization at Roktdal is interpreted to have strong structural controls. From a consideration of existing relationships, the following sequence of events for mineralization at Roktdal can be proposed: 1) Intrusion of amphibolite into the leptites, possibly up to Palaeozoic time, 2) emplacement of the Caledonian allochthon, with imbrication and folding of the metasedimentary sequences within the leptites, and possible tectonic injection of the banded carbonate-fluorite lithology, together with base-metal mineralization along a favourable plane (influenced by the presence of the amphibolite and the competence contrast near its margins) 3) In late-Caledonian time and immediately post-dating the orogeny, the establishment and development of vertical fracture-tectonics, following a pattern influenced by the form of the Tømmerås basement dome on a large scale, but also locally influenced by the presence of anistropies such as metabasic bodies. Hydrothermal activity along fractures and remobilization of base-metals to form the veintype mineralization within the carbonate-fluorite and amphibolitic hosts at Roktdal and further alteration of the leptites and amphibolite.

4.3 RECONNAISSANCE MAPPING - GRONG-OLDEN CULMINATION.

Due to the considerable area of outcrop of the Grong-Olden window, reconnaissance in the area was confined specifically to those areas where metasediments of Bjørntjern schist type were known, or could be expected to occur. Four such areas can be defined; a) Gresså-moen-Lurudalen (Andorsjøen sheet 1823I), b) N. Gjevsjøen (Gjevsjøen sheet 1823 II), c) S. Sanddøla (Andorsjøen sheet 1823 I and Nordli Sheet 1923 IV) and W. Berglia (Blåfjellhatten sheet 1923 IV).

It should be noted that the general characteristics and variations of lithologies in the Tømmerås area, described in the previous sub-chapter, commonly apply to the lithologies occurring in the Grong-Olden area. The reader is therefore frequently referred to the previous section for background information.

4.3.1 LITHOLOGIES

4.3.1.1 LEPTITE (Plates 1 & 2)

Together with variably folded granites, the ordinary leptites form the matrix for the majority of other lithologies in the Grong-Olden window, as in the Tømmerås window. The variations in mineralogy and textures observed in the leptites are practically identical to those observed in the Tømmerås area. Within western Grong-Olden, in the Gressåmoen - Lurudalen area, the leptites are predominantly non-porphyritic, whereas to the north and the east, toward S. Sanddøla and Berglia they become strongly porphyritic. At some localities, notably west of Andorsjøen there is a tendency towards convergence between these sub-types and towards augen-leptite.

The nature of contacts between leptite and granite is variable, being generally diffuse over several metres. In N. Lurudalen, the contact zone is 1 - 2 km in width, while zones having typical ordinary leptite textures and diffuse contacts commonly occur within the granite. Veins of leptite within granite have also been observed, which is strong evidence for an igneous intrusive origin for the leptites. (see section for discussion on leptite genesis). To the south of Gressåmoen, towards Gjevsjøen, the contact zone between leptite and granite is occupied by a thin sequence of metasediments which includes the Pb-mineralization south of Gressåmoen farm.

4.3.1.2 MICACEOUS LEPTITE (Plates 3 & 4)

The micaceous leptites have only been observed to occur in significant development west of Andorsjøen where they are intercalated in a complex manner with ordinary and augen leptites. This locality is in the vicinity of contact with metavolcanic schists of the Lower Palaeozoic, in an obviously tectonised zone, and it is therefore considered that the micaceous leptites are the products of dynamic metamorphism of other leptites.

4.3.1.3 AUGEN LEPTITE (Plates 5 & 6)

Typical coarse-grained augen leptites similar to those of the Tømmerås area are developed at several localities in Grong-Olden. A discrete horizon trending parallel to, and only up to several hundred metres from, the contact with the Palaeozoic metavolcanic schists occurs extending discontinously northward from Statsklumpen (W. Andorsjøen) to north of the river Luru. In the Gressåmoen-Gjevsjøen leptite/granite contact zone, there occurs a discontinuous horizon of augen leptite, although none is recorded in the vicinity of the Gressåmoen prospect itself.

4.3.1.4 METABASICS (Plates 7 & 8)

Folded lensoid bodies and dykes of gabbroic to amphibolitic composition to 6 x 0,5 x 0,1 km, commonly containing weak pyritic impregnation, occur irregularly distributed throughout the areas mapped in Grong-Olden. As in Tømmerås, the overwhelming majority of these bodies are at least partly chloritized in their contact zones, and are demonstrably intrusive in origin. In the Berglia area however, (Blåfjellhatten sheet) there occurs a horizon of chlorite-amphibolite schist within leptites and associated with a thick sequence of metasediments that could represent metavolcanic material.

4.3.1.5 GRANITES (Plates 31 & 32)

The granites of Grong-Olden are coarse-grained and commonly foliated. Compared with those of the Tømmerås area, they appear to contain a lower content of K-felspar, being grey rather than pink-red in colour. The Grong-Olden granites are generally also more variable over shorter distances (i.e. tens of metres scale) with respect to texture and mineralogy compared with the Tømmerås granites and granite-gneisses. They are also commonly containing such heterogeneties as irregular pockets of pyritic impregnation (S. Gresssåmoen), xenoliths or slivers of quartzite locally thick veining of milky quartz and minor occurrences of felspathization and sericitization.

4.3.1.6 METASEDIMENTS (Plates 12 - 15)

In western Grong-Olden, horizons of Bjørntjern-schist-type metasediments, consisting of variable proportions of quartzite, muscovite-chlorite schists and marbles occur at two main tectono-stratigraphic levels: a) located along the granite-leptite contact zone in the Gressåmoen-Gjevsjøen tract and b) within granite in the upper Lurudalen - Nordre Gauptjørnaksla area. Both zones are discontinuous and intensely folded.

a) At the former horizon, the quartzites vary from being white, commonly containing weak pyritic impregnation, to predominantly grey-banded, and can reach tens of metres in thickness. At the Gressåmoen prospect such a quartzite is sporadically impregnated with fine-grained galena and chalcopyrite. The quartzites may be under or overlain by impure marbles to several hundred metres in thickness. Muscovite-dominated schist ± garnet and fine quartz boudins may also under- or overlie the quartzites. Such complex and variable relationships are due primarily to processes of extreme deformation.

The northward continuation of this metasedimentary unit into Lurudalen is not well exposed. It is apparent however that the unit swings north-westward and is thinned out tectonically along the line of the river Luru.

Where the unit 'emerges' on the eastern side of the Luru to the south-east of Kornmoen, the marbles are absent, while the quartzites remain either grey-banded or white-pyritic. The irregular and non-conformable occurrence of quartzite outcrops in this area and also in the marsh area to the west of the Gressåmoen prospect testifies toward a locally complex fold pattern.

b) In the upper Lurudalen - Nordre Gauptjørnaksla horizon, quartzite, quartz-muscovite schist and rarely marble occur within the granite, with tectonized contacts. The northward continuation of this unit is not known. However, the unit is severely deflected westward along the Luru such that a structural connection with the Gressåmoen metasediments cannot be ruled out.

In S. Sanddøla (Andorsjøen & Nordli sheets) discontinuous outcrops of quartzite and muscovite-dominated schist occur to several hundred metres in thickness within leptites. No significant mineralization has been recorded in this area.

In the Berglia area(Blåfjellhatten sheet),there occurs a thick and varied metasedimentary sequence consisting of quartzite, marble, muscovite- and graphite-schists. The quartzites vary from white to grey-banded, to a thickness of approximately 100 m. within porphyritic leptites. Weak pyritic impregnation is limited to white quartzite. A horizon of impure, relatively homogeneous marble to 150 m. thickness occurs both structurally below and laterally equivalent to the quartzite. No mineralization has been observed in this lithology. At an approximately equivalent stratigraphic position to the marbles to the south-east there occurs a relatively thick sequence of graphite-pyrite schist to a maximum thickness of ∼ 50 m. The latter lithologies are overlain by a horizon of quartz-muscovite schist which is typical of that from other areas in the Tømmerås and Grong-Olden windows, both in mineralogy and texture, and by an almost complete paucity of sulphides.

On the west shore of Lenglingen, a previously unreported occurrence of banded quartzites has been recorded, lying within leptites which themselves appear to be flanked by Palaeozoic metavolcanics. At least locally, these quartzites are strongly brecciated.

4.3.2 STRUCTURES

As in the Tømmerås area, the predominant deformational style in Grong-Olden is that of tight isoclinal folding, most commonly observed in the metasedimentary sequences. The axial planes of such folding dip at angles of 10 - 60^{o} away from the antiformal axis of Grong-Olden, which runs N.N. westward from E. Gjevsjøen to the S. Sanddøla area, where it swings abruptly W.S. westward towards Grong.

There does not appear to be any evidence for major post-schistosity folding in the Grong-Olden area. The major N.E.-S.W.-trending synform S.W. of Grisbakkfjella (Andorsjoen sheet, 1823I) is considered to be an expression of the geometry of the basement culmination rather than being a true post-schistosity fold.

Two types of fracturing can be distinguished: a) parallel to foliation, initiated during nappe emplacement, though probably reactivated during later events, and b) vertical to sub-vertical fractures, the majority of which have insignificant displacement. In upper Lurudalen, however it is apparent that the metasediments have been displaced and terminated along such a fracture. Similarly in the Berglia area such fractures, trending N.W.-S.W., control in part the outcrops of the local sequence of metasediments.

4.3.3 HYDROTHERMAL ALTERATION, VEINING AND MINERALIZATION

4.3.3.1. GRESSÅMOEN MINERALIZATION (Plate 31)

Approximately 1,4 km south-east of Gressåmoen farm (Andorsjöen sheet 1823 I, 33 W, VO4550, M 31300), galena-chalcopyrite mineralization occurs as sporadic impregnations within grey quartzite, and is claimed by Norsk Hydro. Mineralization occurs over a thickness of approximately 4 - 5 metres, with an apparent strike length of the order of 10 metres. Exposure of in-situ mineralization is however limited by heavy boulder scree cover. No visible hydrothermal alteration halo can be detected at this prospect, and it is probable that the mineralization is of syngenetic origin, albeit modified by post-depositional processes, e.g. the occurrence of coarse grains of galena along the margins of quartz-vein boudins. Isolated examples of minor galena mineralization were also recorded at 150 m and ~ 1,5 km. south of the Gressåmoen prospect, within grey-banded and white quartzite respectively. No fluorite has been recorded at Gressåmoen, although an analysis from the prospect itself yields 0,57 % F, while that from the mineralized quartzite 1,5 km to the south yields 2,91 % F (1823 I, 33 W, V04550, M 30020).

No mineralization was recorded in the sequence of metasediments lying within granite to the east of the Gresså-moen metasediments. Locally however, on Nordre Gauptjørn-aksla, the quartzite component contains 1,05 % F.

4.3.3.2 GJEVSJØEN MINERALIZATION

Galena - sphalerite - pyrite and pyrrhotite - pyrite mineralization occurs over ~ 500 x 10 m, approximately 9 km to the north of Gjevsjøen farm (1823 II, 33 W, V 0570, M 1900) in a quartz-vein breccia, which is claimed by Norsk Hydro. Veining, consisting of vuggy white and smoky quartz, occurs predominantly in the quartz-muscovite-schist component of the metasediments, although at the southernmost observed locality ∼ 4 km west of Gjevsjøen farm (1823 II, 33 W, V 0230, M 1025) veining within marble also occurs. No significant fluorite has been recorded either in hand specimen or in rock analysis from the Gjevsjøen area, F^- in stream waters has however been analysed to exceed the threshold limit locally.

4.3.3 BRECCIATION AT BERGLIA (Plate 21)

In the Berglia area (1923 III, 33 W, V 27025, M 23680 and 1923 II, 33 W, V 49300, M 1300), leptite and quartzite respectively are veined, hematized and severely brecciated by clear drusy quartz veining. No base-metal mineralization has been recorded at these localities.

4.3.4 FLOAT MINERALIZATION

Approximately 10 km to the s.east of the latter area, during an inconclusive attempt (due to thick overburden) to ascertain whether or not the metasediments of the Berglia area could be traced eastwards into the nappes of Palaeozoic lithologies, rich coarse-grained but irregular sphalerite-pyrrhotite mineralization was recorded in a large angular float block. The mineralization occurs in association with garnet-pyroxene skarn assemblage within quartzite and marble, which has evidently been intruded by medium- to coarse-grained diorite/granodiorite.

5. GEOCHEMISTRY.

5.1. STREAM SEDIMENT GEOCHEMISTRY.

5.1.1 SAMPLING PROCEDURE.

The sampling procedure followed the methods introduced and successfully applied by the N.G.U. (pers comm.)

The samples were taken preferentially from first and second order streams and sieved in the field into two size fractions of + and - 80 mesh. The fraction + 200 mesh was rejected. Both fractions were split in the field and care was taken that each sample bag containted atleast 10 gr. fine fraction and 100 gr. coarse fraction. Three percent of the samples were duplicated in the field, to assess the site to site variation of the sample points. The pH of the water was determined using a transparent test tube and indicator fluid. Water samples were taken upstream from the sediment sieving, resulting in approx. 200 ml. of clear water.

The sample points were marked in the field with flourescent flagging tape and aluminium tags on which the sample numbers were imprinted.

The following parameters were recorded in the field, using computer coding forms. (see example)

EXPLANATION OF CODING FOR STREAM SEDIMENT SAMPLES.

Card 1

Cols. 2 - 5	Project Number 0001
Cols. 6 - 7	Team identification Number
Cols. 8 - 11	Sample Number
Cols. 12	Duplicate Sample: 1
Cols. 13 - 14	Norway NN
Cols. 15 - 18	Map sheet
Cols. 22 - 27	Easting UTM coordinates
Cols. 28 - 33	Northing UTM coordinates
Cols. 34	Reliability

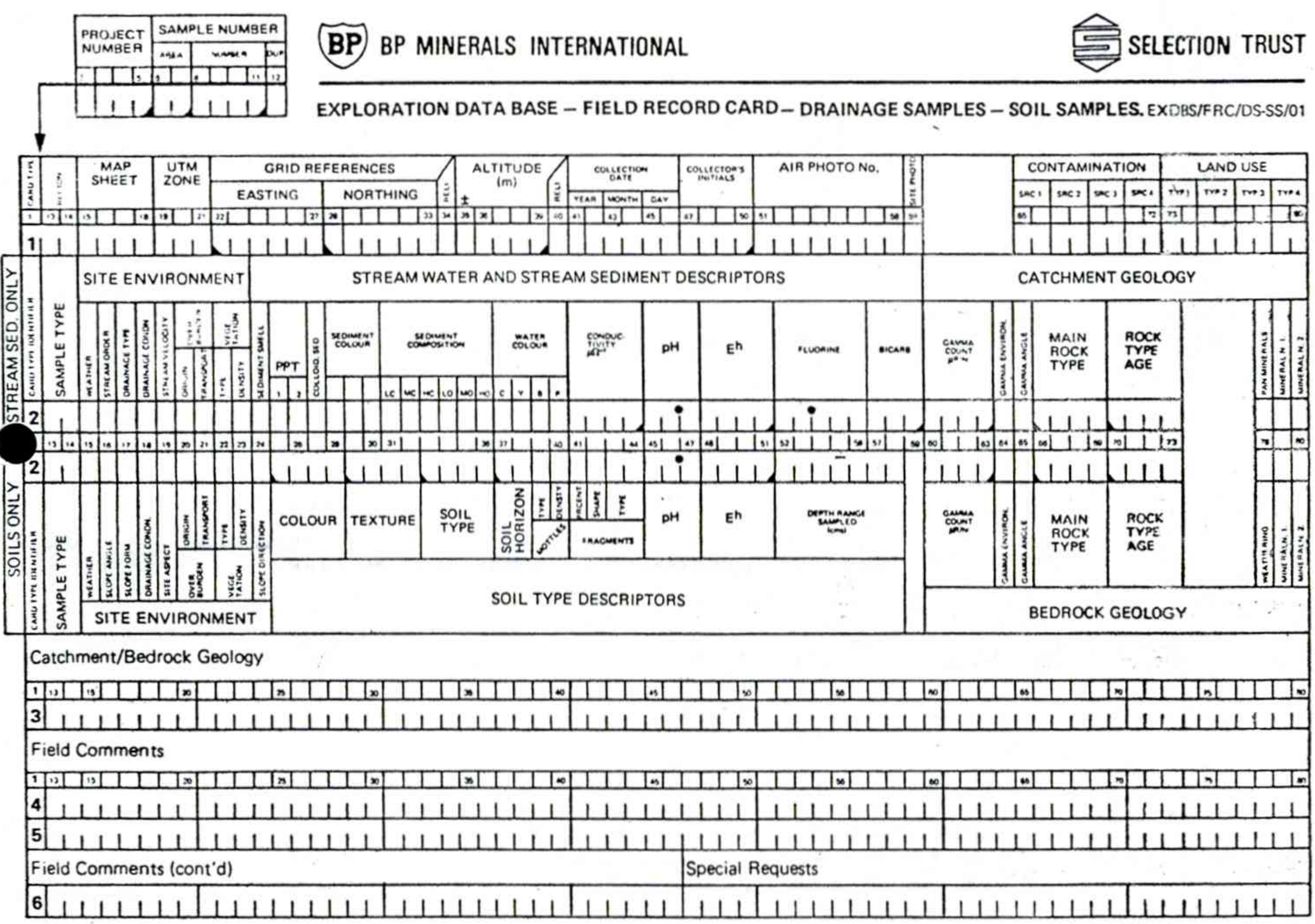
Cols. 41 - 46	Collection date
Cols. 47 - 50	Area identification. TO 1 = Tømmeras GO 1 = Grong-Olden culmination
Cols. 51 - 58	Air Photo Number
Cols. 59	Photo taken at sample point = 1
Cols. 65 - 72	Up to four different sources of contamination such as urbanization, roads, railways, garbage etc.
Cols. 73 - 80	Land use, i.e. Tundra, grassland, bogs, forest etc.

Card 2

Cols. 13 + 14	Sample type identification 10 = stream sediment only 11 = stream water only 12 = stream sediment + water sample 20 = spring sediment only 21 = spring water only 22 = spring sediment + water sample 31 = lake water only 32 = lake sediment near shore 33 = lake sediment and lake water
Col. 15	Weather, precipitation
Col. 16	Stream order
Col. 17	Stream size
Col. 18	Water flow
Col. 19	Stream velocity
Col. 20 + 21	Overburden origin + transport i.e. residual soils, Till, Moraine, Talus etc.
Col. 41 - 44	Conductivity: Not determined.
Col. 45 - 47	ph
Col. 48 - 51	Eh Not determined
Col. 52 - 56	Fluorine concentration in ppb.
Col. 57 - 59	Bicarbonate concentration Not determined
Col. 60 - 78	Catchment geology

Col. 78 - 80 Mineralized rocks
code up to two types of Mineralization.
Card 3, 4, 5, 6 Further remarks and special requests.

As care was taken to collect a composite sample from along as well as across the streams, the samples are considered to be adequately representative of the stream sediments. The water suspended material in the bottom of the sieve was allowed to settle for a while, and colloids were decanted carefully to avoid interference on results by hydromorphic anomalies.



PROJECT NUMBER | SAMPLE NUMBER

BP MINERALS INTERNATIONAL

SELECTION TRUST

EXPLORATION DATA BASE – FIELD RECORD CARD – DRAINAGE SAMPLES – SOIL SAMPLES. EXDBS/FRC/DS-SS/01

MAP SHEET | UTM ZONE | GRID REFERENCES: EASTING, NORTHING | ALTITUDE (m) | COLLECTION DATE: YEAR, MONTH, DAY | COLLECTOR'S INITIALS | AIR PHOTO No. | CONTAMINATION | LAND USE

STREAM SED. ONLY: SAMPLE TYPE | SITE ENVIRONMENT | STREAM WATER AND STREAM SEDIMENT DESCRIPTORS: PPT, SEDIMENT COLOUR, SEDIMENT COMPOSITION, WATER COLOUR, CONDUCTIVITY, pH, Eh, FLUORINE, BICARB | CATCHMENT GEOLOGY: GAMMA COUNT, MAIN ROCK TYPE, ROCK TYPE AGE

SOILS ONLY: SAMPLE TYPE | SITE ENVIRONMENT | SOIL TYPE DESCRIPTORS: COLOUR, TEXTURE, SOIL TYPE, SOIL HORIZON, MOTTLES, FRAGMENTS, pH, Eh, DEPTH RANGE SAMPLED | BEDROCK GEOLOGY: GAMMA COUNT, MAIN ROCK TYPE, ROCK TYPE AGE

Catchment/Bedrock Geology

Field Comments

Field Comments (cont'd) | Special Requests

5.1.2 ANALYTICAL TECHNIQUES

5.1.2.1 STREAM SEDIMENT SAMPLES

The samples were stored and dried at 60° C in "waterproof" bags.

As an orientation study the first 19 samples were analysed in two different laboratories and both grain size fractions were used in order to detect any grain size dependence of the base-metal content.

Although the amount of samples analysed does not allow statistical treatment the following remarks can be made with an acceptable degree of confidence:

i) In general the + 80 mesh fraction contains 20 % higher Pb + Zn values. This could be due to overall higher Mn and Fe concentrations. Fe is generally 40 % higher in the coarse grained fraction.

ii) There is no obvious grain size denpendency of base-metal values as such and the background + threshold values are slightly shifted but reflect equal trends.

It was therefore decided to analyse the - 80 mesh size fraction, as it could be expected to trace anomalies as well as with the + 80 mesh fraction. The use of - 80 mesh size fraction also has further advantages such as:

- easier handling and drying
- better homogeneity of the sample material
- less shipping weight
- faster and more complete acid attack.

As the two laboratories applied different digestions and analytical methodes the procedures are compared and general conclusions are made.

Acme Analytical Laboratories, Vancouver, Canada	Griffith Laboratories, Liverpool, England
ICP Geochemical analysis simultaneous A 0,5 gram of sample is digested with 3 ml of 3:1:3 Nitric acid to Hydrochloric acid to water at 90°C, for 1 hour. The sample is diluted with water to 10,0 ml.	Atomic absorption. A 0,5 gram sample is digested with 3:1 nitric/per chloric acids. Extraction with 25 % hydrochloric acid.

From the results it can be seen that the acid attack prior to the ICP analysis is stronger resulting in higher Fe, Mn values and subsequently in slightly increased base metal values. Nevertheless the contrast between anomalous and background values remains constant.

Although the ICP analysis provides more elements analysed, the AAS method was preferred as the overall costs were lower and the turnaround time much faster. The ICP-leach is partial only for: Ca, P, Mg, Al, Ti, La, W and Ba .Cu, Pb, Zn are regarded to be the best path-finder elements for base metal exploration, so that ICP-analysis would not yield much more essential information.
A total of 28 sub-samples were selected randomly, split and analysed under different sample numbers.

The results are given in Table 1. The overall reproducibility for the subsamples as well as for the analytical results for standard 1 is satisfactory. Table 2. The results reported for international standards such as CCU-1, Kc-1, MP-1 and HV-1 lie within ± 10 % from the assay results.

SUB-SAMPLES STREAM SEDIMENTS
ANALYTICAL RESULTS
TABLE 1

Sa. Nos.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm
190008	15	6	22	60	0,56	< 1	< 1
120980	4	< 5	11	64	0,52	5	3
190009	5	< 5	11	50	0,13	< 1	< 1
190940	2	< 5	6	60	0,20	2	2
190010	4	< 5	11	22	0,10	< 1	< 1
120901	4	< 5	11	64	0,52	1	5
190011	3	< 5	10	12	0,02	1	1
1209100	1	22	7	22	0,04	< 1	< 1
190012	6	6	31	150	0,98	2	1
1209115	5	6	15	110	0,82	3	< 1
190013	8	< 5	15	62	0,21	1	< 1
1209137	6	6	10	88	0,23	< 1	< 1
190014	15	6	24	112	0,60	3	1
120459	2	6	18	124	0,61	7	6
190015	24	8	27	37	0,13	< 1	< 1
120482	2	< 5	4	34	0,15	2	< 1
190016	7	12	45	155	0,69	3	10
120617	3	6	20	176	0,80	11	18
190017	7	8	34	190	0,95	4	7
120653	6	8	24	192	0,95	12	9
190018	5	6	23	98	0,61	2	6
120725	2	< 5	20	155	0,72	7	12
190019	3	6	15	63	0,34	1	< 1
120740	3	< 5	9	66	0,32	< 1	5
190020	3	12	21	82	0,44	2	5
120758	5	< 5	12	125	0,47	2	7
190066	8	70	28	224	1,01	8	8
121106	6	59	30	245	1,08	12	8
190067	8	17	34	658	0,97	2	9
121118	9	11	33	549	1,00	8	9
190068	5	11	10	65	0,28	43	3
1204159	6	10	9	72	0,24	10	1

TABLE 1 - Cont.

II.

Sa. Nos.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm
190069	15	19	55	535	1,71	9	22
1204170	21	11	77	730	2,21	64	16
190070	6	24	33	187	0,59	8	7
1204181	7	25	33	261	0,71	11	7
190071	18	12	56	467	1,63	2	15
1204200	17	15	62	536	1,50	8	15
190072	10	13	23	144	0,79	3	7
1204213	9	12	29	207	1,01	4	8
190073	7	11	16	104	0,56	9	6
330402	8	13	14	103	0,58	9	5
190074	6	9	18	170	0,79	12	8
120669	6	7	17	170	0,72	12	7
190075	6	10	20	73	0,36	2	5
120693	7	18	27	75	0,31	2	2
190076	10	15	8	46	0,20	2	3
1204143	6	5	7	48	0,21	< 1	< 1
190078	6	13	8	79	0,45	< 1	2
1204154	6	8	12	94	0,50	2	< 1
190079	6	11	24	590	0,80	7	6
1209158	7	15	27	197	0,78	2	8
190080	9	11	24	264	0,82	8	6
1209167	7	10	23	260	0,89	8	7
190081	6	5	10	78	0,36	2	2
1209177	6	10	10	71	0,35	1	3

TABLE 1 Cont. ANALYTICAL RESULTS
SUBSAMPLES VEGETATION AND SOIL SAMPLES

Sa. Nos.	Cu ppm	Pb ppm	Zn ppm	Mn %	Fe %		
190024 VH 1)	230	165	580	2,29	0,53		
400325 VH	202	39	610	1,26	0,18		
190030 VH	210	40	660	1,54	0,18		
400334 VH	179	33	510	1,46	0,13		
190031 VH	208	47	590	1,79	0,15		
400346 VH	224	46	670	2,15	0,21		
190032 VH	222	43	610	2,87	0,15		
400354 VH	256	56	625	3,75	0,22		
190033 VH	191	37	450	3,87	0,20		
400365 VH	241	44	540	2,93	0,20		
190034 VH	195	34	570	2,42	0,17		
400378 VH	171	51	460	1,79	0,27		
190035 VH	207	43	550	1,53	0,51		
400386 VH	233	41	660	2,05	0,34		
190037 VH	234	47	720	5,20	0,19		
4003113 VH	220	44	645	4,65	0,49		
190042 VB 2)	112	37	5000	4,10	0,77		
400360 VB	121	40	4900	3,86	0,17		
190043 VB	102	46	5000	8,00	0,43		
400374 VB	100	33	5100	8,00	0,17		
190044 VB	126	44	4000	3,67	1,33		
400386 VB	135	32	3810	3,80	0,17		
190052 VC 3)	167	19	2030	1,95	0,18		
400369 VC	160	11	1630	2,00	0,11		
190053 VC	208	28	2430	0,43	0,18		
400380 VC	141	7	1470	0,33	0,10		
190054 VC	135	29	1750	2,61	0,17		
400395 VC	119	23	1290	2,15	0,23		
190057 AH 4)	31	166	130	95	1,22		
40[illegible]24 AH	23	115	155	92	0,[illegible]		

TABLE 1 Cont.

Sa. Nos.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe ppm	Co ppm	Ni ppm
190063 AH	57	121	153	410	1,56		
4003109 AH	56	139	168	370	1,16		
190064 AH	101	103	141	200	5,00		
4003120 AH	70	73	103	165	3,60		
190065 AH	146	115	138	430	2,68		
4003130 AH	109	87	114	364	3,50		
190082 BM 5)	28	17	31	142	2,23		
400302 BM	32	19	37	102	2,27		
190083 BM	55	21	42	260	2,95		
400305 BM	79	19	51	336	3,19		
190084 BM	15	15	18	174	0,94		
400313 BM	16	17	27	304	1,16		

1) VH = Vegetation sample, Heather

2) VB = " " , Birch

3) VC = " " , Conifer

4) AH = Hummus sample, top of soil profile

5) BM = Soil sample, B-horizon of soil profile

TABLE 2 STANDARD 1 ANALYTICAL RESULTS.

Sa. No.		ppm Cu	ppm Pb	Zn ppm	Ni ppm	Co ppm	Fe %	Mn ppm
190004		20	84	88	12	6	0,78	88
190005		73+)	82	78	10	5	0,80	92
190007		135+)	80	74	12	8	0,83	76
190078		10	80	60	14	6	0,79	103
190021		10	106	63	10	2	0,81	105
190022		15	74	61	10	2	0,76	100
190023		39	76	79	10	2	0,82	103
190027		18	114	171	11	2	0,70	70
190028		20	96	122	11	2	0,67	82

+) Due to contamination

5.1.2.2 FLUORINE ANALYSIS OF NATURAL WATERS.

Before taking the water samples in the field the polyethylene bottles were carefully washed and rinsed.

Approximately 200 ml of sample was taken, 50 ml of which was used for analysis. To avoid absorption and loss of fluoride ions, care was taken such that water samples were not handled with glass-labware.

Fluoride standards ranging from 40 - 1000 ppb were prepared and a calibration procedure for the instrumentation developed.

The following instruments were used:

i) portable pH/ionanalyser 407 A Orion
ii) single fluoride electrode
iii) standard reference electrode

A constant volume of 5 ml. Tisab III (Total ionic strength adjustment buffer) was added to each sample in order to assure constant pH and release fluorite ions bound in iron and aluminium complexes. The solution was stirred thoroughly for 3 min, using a magnetic stirrer, the electrodes inserted and the value recorded after equilibrium was reached.

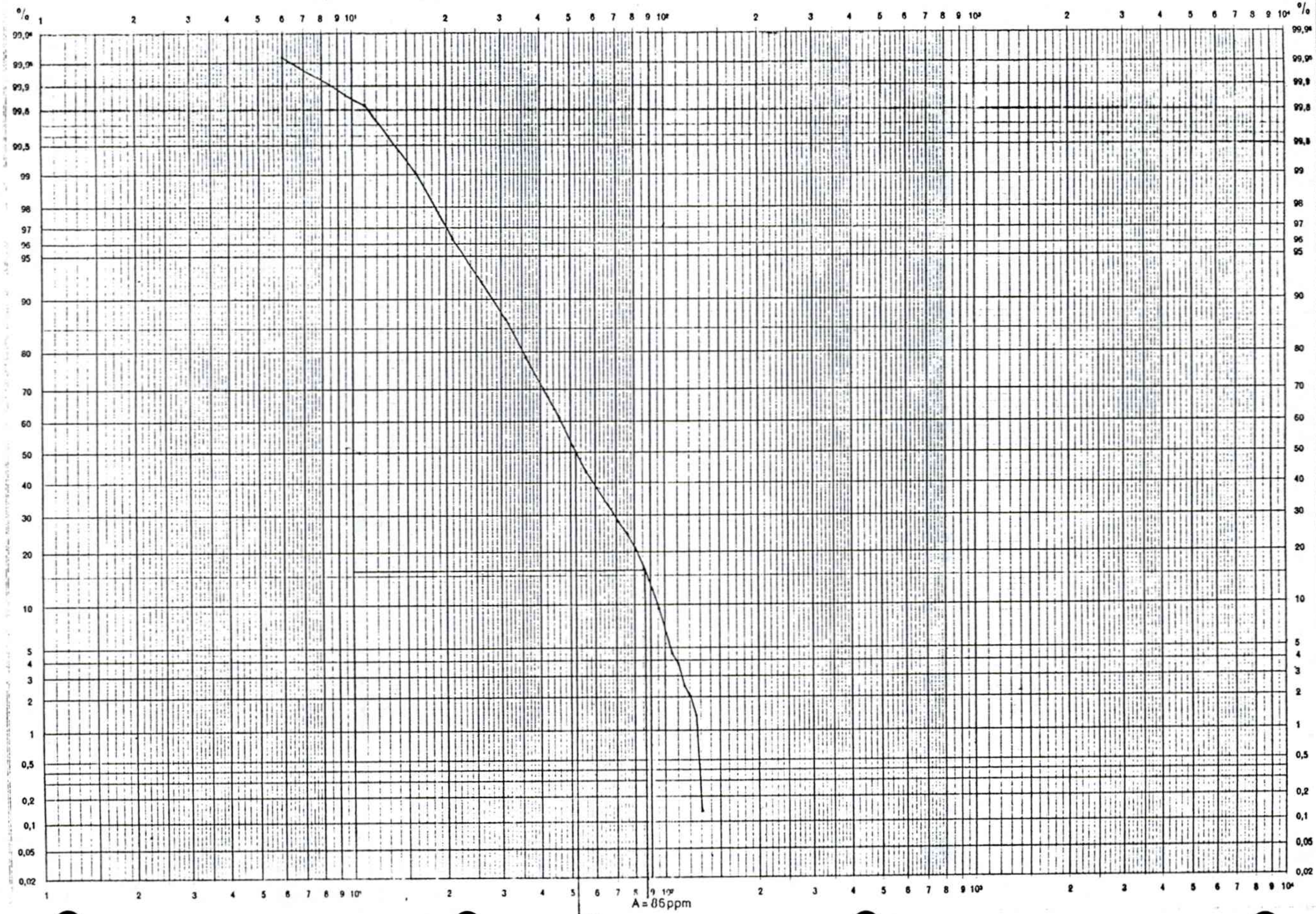
Standard readings were taken every ten measurements, and the electrode slope checked before and after a series of analyses.

The temperature of the solution was kept between 20^o and 22^o Celsius. A number of samples were analysed directly upon receipt in the field office and then 2, 4 and 6 days later in order to estimate the effect of storage on the fluorine concentration. It was found, that the differences are within the precision level of the instrument, so it is apparent that short term storage has no critical effect.

The results were treated in a statistically similar way to the stream sediment analysis, the threshold being calculated to be 115 ppb F - at the 97,5% level in the cumulative frequency plot. (Fig. 1, Table 3).

FIGURE 1

F - plot: waters



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Wahrscheinlichkeitsnetz

Abszissenachse logarithmisch, Ordinatenachse nach dem Gaußsc... Integral geteilt

FLUORINE IN STREAM WATERS - ANOMALIES

Background = 52 ppb, Threshold = 115 ppb (≥ $\bar{X}$ + 3 SD),
Multiples of background.

SAMPLE NO.	ANOMALY	SAMPLE NO.	ANOMALY
11.04.47	2,7	12.06.77	2,2
12.04.137	2,1	82	2,9
165	2,2	84	3,0
166	3,3	85	3,1
167	2,6	89	2,5
168	2,9	12.07.29	2,3
169	2,2	21.09.01	4,9
172	2,2	11.09.04	12,0
173	2,2	27	6,3
174	2,3	43	2,5
175	2,2	46	3,3
177	2,2	58	2,4
178	2,4	12.09.59	4,7
179	2,2	11.09.61	2,4
181	2,2	62	3,1
182	2,3	63	3,3
208	2,4	64	3,0
209	2,3	12.09.93	3,0
210	2,9	103	2,4
211	3,0	105	4,4
212	3,0	106	3,6
218	2,7	107	2,7
219	2,7	108	3,2
220	2,7	133	2,9
221	2,5	134	2,6
11.06.11	2,9	139	2,9
12.06.42	2,4	149	5,1
50	2,5		
51	2,4		

5.1.3 DISCUSSION OF RESULTS - ANOMALIES

5.1.3.1 THRESHOLD SELECTION

The analytical results from the stream sediment reconnaissance programme are listed in Appendix A.

The frequency distribution was calculated for the elements analysed using the following class- intervals:

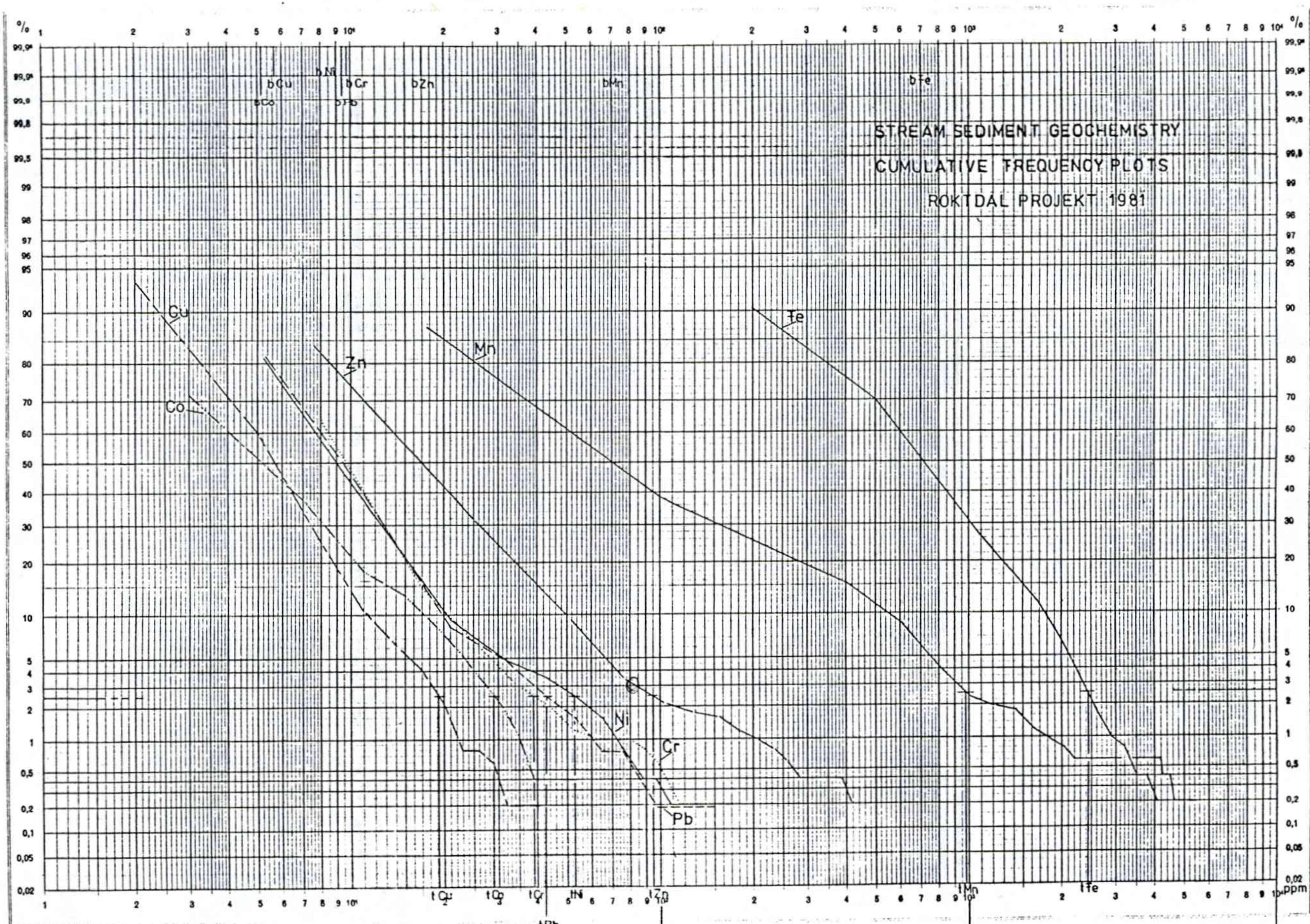
Cu = 3 ppm
Pb = 10 ppm
Zn = 25 ppm
Mn = 200 ppm
Fe = 0,2 %
Ni = 10 ppm
Co = 3 ppm
Cr = 8 ppm

Figure 2 shows the cumulative frequency distribution plots for all elements.

The cumulative frequency plot for Fe shows only very weak inflection points, so that the distribution can be regarded as lognormal and the anomaly threshold was defined as $\bar{X}$ + 3 SD at 2,4 % Fe.

The Mn-plot shows weak inflections at 8 % and 97,5 %
This is probably due to an overlap of the anomalous population over the background population.

As the Mn-concentration in stream sediment samples is not only dependent on the Mn content of the eroded rock but highly dependent on complex physico-chemical parameters such as ph and Eh leading frequently to precipitation of Manganese-hydroxides no threshold was calculated for the background population.



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Abszissenachse logarithmisch, Ordinatenachse nach dem Gaußschen Integral geteilt

The Zn-plot shows a distinct inflection point at 96,5 % so that an anomalous population is evident ranging from about 80 ppm - 420 ppm Zn.

The frequency distribution curves for the elements Co, Cr and Ni, choosen for analysis to detect base metal anomalies bound to graphitic schists and meta-basics, reflect a complex mixture of populations. It is noteworthy that especially Ni shows a strong skewness at the 95 % level and is therefore regarded as most indicative for the lithologies mentioned above.

The following lower thresholds are applied to define the probable occurence of black-shales and/or meta-basics in the drainage system:

Co 15 ppm Cr 35 ppm Ni 30 ppm

The copper distribution appears to be lognormal and the anomaly threshold is set 97,5 % = 19 ppm.

The Pb-plot reflects the most complex distribution of concentrations which is due to the fact that a number of samples were taken from streams clearly cutting Galena-mineralized rocks.

The strongest inflection occurs at 92 % (21 ppm Pb) and a second change in slope at 98,2 % (52 ppm Pb).

Setting thresholds at 84 % ($\bar{X}$ + 2 SD) and 97,5% ($\bar{X}$ + 3 SD) should be adequate to spot also weak anomalies probably caused by mineralization.

In Table 3 the statistical parameters are listed and Table 4 gives a listing of anomalous samples and their order calculated as multiples of back-ground.

TABLE 3

STREAM SEDIMENT GEOCHEMISTRY

STATISTICS

	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cr ppm
$\bar{X}$ arithmetic	6.1	10.8	26.4	259.8	0.82	7.2	9.1	11.6
S.D. arithmetic	4.6	12.4	36.0	431.2	0.62	7.8	14.7	11.7
RANGE	<1 - 41	<5 - 147	7 - 420	14 - 5500	0.06 - 4.2	<1 - 54	<1 - 180	<1 - 120
BACKGROUND	6	9	17	70	0,71	5,2	9,5	9,8
$\bar{X}$ + 3 SD	19	43	95	975	2.4	29	53	39
$\bar{X}$ + 2 SD	9	17	40	400	1.4	12	17	17

TABLE 4

ANOMALOUS SAMPLES: STREAM SEDIMENTS TØMMERÅS AND GRONG-OLDEN AREAS

(Greater than ($\bar{X}$ + 3SD); multiples of background)

SAMP. NO.	Cu	Pb	Zn	Mn	Fe	Co	Ni	Cr
ppm Background	6	9	17	70	0,71%	5	10	10
10.04.19	5							
10.06.01					3			
10.07.03				23				
12.04.58					3	6		
74				66	5	10		
75					3	6		
97						6		
105				16				
110				16				
122	5							
162				59				
163	3		7		4			4
166	3						6	10
169								10
170	4							
171							6	12
172								6
175	7							5
176	4							
177				25				
178		5						
216	3							
221	4							
12.06.03							6	
04							8	
05					4	6	8	
07	4				3	6	8	
08					3	7	6	
09							5	
10					3	7	7	
11	5				4	7	6	
12						6		
29		6	5					
31	5				6	10		
72		8						
85		16	13					

TABLE 4 (Contd.)

ANOMALOUS SAMPLES: STREAM SEDIMENTS TØMMERÅS AND GRONG-OLDEN AREAS
(Greater than ($\bar{X}$ + 3SD); multiples of background)

SAMP. NO.	Cu	Pb	Zn	Mn	Fe	Co	Ni	Cr
12.06.86		6						
95			10					
96		5	15					
97		6	14					
98		5	11					
99		9	24	28				
100		11	10					
12.07.06				16				
07				16				
09		5	6	18	4	9		
13						6		
14						6		
15				22				
21				15	5			
22					4	6		
12.07.41						8	19	
12.09.61				79		6		
91					6			
106							11	
144					4			
174							8	
12.11.06		6						
11								5
15								4
16		5						
21								5
33.07.01							6	

5.1.3.2 ANOMALY: A
LOCATION: East slope of Raudbeinklumpan 1723 II SNÅSAVATNET

SA. NOS.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm
120709	16	42	108	1240	2,62	45	24
120629	5	54	92	780	1,33	17	8

GEOLOGY OF CATCHMENT AREA: Leptite, Biotite schist, Quartzites, Marbles, Amphibolites, Mica-schists.

Remarks: poor sediment development.

Ranking and Recommendation:

As this base metal anomaly correlates with anomalous concentrations of the remaining elements analysed, it is possible that either coprecipitation with Fe and Mn or lithologies rich in ferromagnesians are responsible for the base metal content. The follow up should be limited to resampling of the stream system and lithogeochemical sampling/mapping of the rocks in the catchment area.

5.1.3.3 ANOMALY: B

LOCATION: SE-slope of Roktheia 1723 II SNÅSAVATNET

SA. NOS	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm
Standard 1 average of analyses	20	86	82	95	0,80	4	12
RS 10.04.17	2	52	6	80	0,29	2	4

GEOLOGY OF CATCHMENT AREA: Altered leptite with disseminated galena, sphalerite, chalcopyrite and fluorite. Metasediments.

Field comments: None

Ranking and Recommendation:

The catchment area covers 8 km^2 in which there occur 3 more anomalies of greater than ($\bar{X}$ + 2 SD).

Detailed stream sediment/bank sampling and geological mapping/ rock chip sampling is recommended.
To be included in Roktdal re-appraisal.

5.1.3.4 ANOMALY: C

LOCATION: MELDALEN STRUCTURE, WEST OF ROKTHEIA
1723 II SNÅSAVATNET

SA. NOS.

SA. NOS.	
110946	Fluorine anomalies X + 3SD
120993	
110943	
1209103	
1209107	
1209108	
1209105	
1209106	
1209134	
110964	
1209139	
110961	
110962	
110963	

GEOLOGY OF CATHCMENT AREA: Leptite, partly brecciated, with anomalous Fluorite concentrations. See chapter 5.2.3.1.

Ranking and Recommendations:

The high Fluor-levels in the water samples are certainly due to the Fluorite mineralization in the brecciated leptites. As this mineralization is clearly late stage hydrothermal and no base metal anomalies were found, no further work is recommended.

.1.3.5 ANOMALY: D

LOCATION: 1823 III Snåsa, Valley of Roktdal from Roktsjøen to Hevdesåsen.

SA. NOS.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm
120631	27	14	84	624	4,24	54	6
120611	29	14	54	766	2,60	37	53

GEOLOGY OF CATCHMENT AREA:

Lower palaeozoic cover rocks, mainly graphitic schists and phyllites.

RANKING AND RECOMMENDATION:

The area extends over 8 km^2 and some other 11 weaker Cu, Zn anomalies lie within that tract.

In good accordance with the overall 2 - 3 times higher Cu-Zn content of the rock samples from the palaeozoic cover rocks from Haervola, the stream sediments show slightly increased Cu- Zn- Fe- Co- and Ni-values. Therefore these anomalies are regarded as reflections of the higher background metal-content of the graphitic-phyllitic schists and warrant no further investigation recommended.

5.1.2.6 ANOMALY: E

LOCATION: 1823 II GJEVSJØEN, Western boundary of Gressåmoen National park from Gaasejaervu in the north of Saeterfjellet.

SA. NOS.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe%	Ni ppm	Co ppm
120685	12	147	228	702	1,20	6	10
120686	14	50	74	106	0,67	3	6
120695	10	30	174	502	1,27	8	8
120696	12	48	260	862	1,46	13	12
120697	9	55	233	758	1,34	15	9
120698	7	47	194	420	1,20	12	8
120699	10	85	400	2050	2,16	15	17
12069100	9	95	165	316	1,21	10	7

GEOLOGY OF CATCHMENT AREA:

A 300-700 m wide sequence of metasediments, mainly carbonates, quartzites and mica schists bordered by leptite in the west and granitic gneisses towards east. The sequences stretches continuosly over 10 km and ends in the south in a tight fold trending NE - SW, resulting in a duplication of the thickness.

Rock chip samples taken from Quartzites and mica schists show slightly increased base metal contents.

The metasedimentary sequence is strongly tectonized and brecciated towards its margins with the leptites. One of these structures inhibits a quartz-vein with remobilized Pyrite-chalcopyrite mineralization. This occurence is claimed by N.H.

RANKING AND RECOMMENDATION

Neither the field comments nor the analytical results (relatively low Fe and Mn values) suggest this anomaly to be false. It is considered to be directly due to base-metal enrichment in quartzites and marbles which belong to the same horizon as the Gressåmoen disseminated galena - mineralized quartzite lithology. The geochemical anomalies are more frequent where a fold closure in the metasediemnts occurs. The base metal anomalies in the north correlate with high fluorine content of stream water samples.

The following follow up work is recommended:

i) detalied stream sediment sampling over the entire area and extension southward ~ 15 km^2.

ii) detailed geological mapping and intensive lithogeochemical sampling.

iii) deep overburden sampling in areas with poor exposure.

iv) test survey with ground geophysics such as VLF and magnetometer.

5.1.3.7 ANOMALY: F

LOCALITY: 1823 I Andorsjøen

Between Gresåmoen Farm in the north and Gresåklumpen in the south.

SA. NOS.	Cu ppm	Pb ppm	Zn ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cr ppm
1204215	20	33	60	541	1.64	12	13	17
1204221	21	13	91	298	1.69	11	14	30
1204166	20	12	76	650	1,80	16	66	106
1204169	17	16	57	454	1,49	15	46	96
1204170	21	11	77	730	2,21	22	64	120
1204171	11	9	38	259	0,89	7	25	54
1204172	12	10	45	300	0,84	9	24	50
1204175	41	35	27	179	0,52	6	1	5
1204176	21	8	68	307	1,86	15	20	22
1204177	12	34	46	1768	1,20	12	13	24
1204178	8	49	58	487	0,88	7	3	8
121106	6	59	30	245	1,08	8	12	20
121111	10	8	57	406	1,60	15	26	46
121115	12	19	42	610	1,22	9	18	42
121116	17	45	61	1550	2,10	20	31	30
121121	9	13	25	169	0,85	29	22	49

GEOLOGY OF CATCHMENT AREA:

Two strips of metasediments, consisting of quartzites, marbles, phyllites and metabasic rocks, striking North-South occur within leptites and coarse grained granite-gneiss.

The drainage pattern reflects the outcropping metasediments, due to the relative ease of their erosion.

Ranking and Recommendation:

Two samples taken from Stugubekken, which crosscuts the Galena-mineralized quartzite are clearly anomalous in lead-concentrations and six stream-sediment samples show lead values $> \bar{X} + 2$ SD.

Therefore the sampling techniques applied are considered to be adequate in detecting low grade, disseminated base metal mineralization. The stream west of Stugubekken draining metasediments, shows a similar cluster of ead anomalies and fluorine concentrations, whereas towards the south and east of the catchment area high copper and highly anomalous Co, Ni and Cr concentrations occur.

These Co, Ni and Cr-anomalies are likely due to the meta-basics which occur commonly within the granite and leptites locally and are therefore regarded of no economic significance.

As the entire stream system occurs within the National park, recommendations for follow-up work are dependent on permission from the authorities regarding the nature of future detailed investigations.

The following follow-up scheme is suggested:

i) Removal of scree from the Gressåmoen-showing by trenching blasting to assess the slope and extension of the mineralized quartzite.

ii) Detailed geological mapping in conjunction with litho-geochemical sampling.

iii) Detailed soil/stream geochemistry from Stugubekken catchment westward

iv) Ground geophysics test surveys, VLF, Magnetometer and possibly IP to prove the response of disseminated galena-mineralization.

5.1.3.8 ANOMALY: G

LOCATION: 1823 IV Grong North-West slope of Kolåsfjellet

SA. No.	Cu	Pb	Zn	Mn	Fe%	Ni	Co	Cr. ppm
1204162	15	21	51	4100	2,11	30	15	33
1204163	20	12	119	810	2,70	51	20	42

GEOLOGY OF CATCHMENT AREA:

Granitic gneiss and foliated granitic-gneiss

Ranking and Recommendation:

The high Fe-Mn concentrations and increased Ni, Co, Cr values suggest that this base metal anomaly is due to coprecipitation with Fe, Mn and overall higher Cu and Zn content of the lithologies in the catchment area.

No further investigation recommended.

5.2. ROCK CHIP GEOCHEMISTRY

5.2.1 SAMPLING PROCEDURES

Samples consisting of fresh rock chips, devoid of weathering surfaces or organic material, collected over areas considered to be representative of individual exposures, were taken of all lithological types. Hand specimens for selected thin- and polished sections were taken simultaneously (section 4). A total of 260 samples, consisting of 85 metasediments, 108 leptites, 67 intrusives and 10 Palaeozoic schists from Haervola were taken at sampling densities considered sufficient to demonstrate both regional and local variations in lithogeochemistry. Sample weight was of the order of 1 kg.

5.2.2 ANALYTICAL TECHNIQUES

Samples were jaw-crushed to - 5 mm and split using facilities provided by N.G.U. at Trondheim. To avoid errors due to cross-contamination at the crushing stage, samples that obviously contained high contents of base-metals had been previously marked in the field. Such samples were the last to be crushed in any one batch. A split of each sample was despatched to M.E.S.A. for analysis, and an equivalent split retained.

At M.E.S.A, samples were Tema-ground, and pressed-powder pellets formed, which were analyzed on a Phillips PW 1400 x-ray fluorescene machine. All elements except those of group 50 were analyzed using a 3 KW rhodium anode x-ray tube, the latter being analyzed using a chrome anode tube. Concentrations of the following oxide and trace elements were thus determined: SiO_2, Al_2O_3, TiO_2, Fe_2O_3, MgO, CaO, Na_2O, K_2O, MnO, P_2O_5, As, Ba, Bi, Ce, Co, Cr, Cu, Mo, Nb, Ni, Pb, Rb, Sr, S, Th, U, V, W, Zn, Zr. FeO was determined by standard dichromate titration following digestion in HF + H_2SO_4. F^- was determined using a specific ion electrode after fusion.

5.2.3 PRELIMINARY DISCUSSION OF RESULTS - ANOMALIES (See Figs. 3,4, Tables 5,6)

5.2.3.1 LEPTITES

The analyses of the ordinary leptites reveal the remarkable geochemical homogeniety of this lithology over wide areas, which parallels their monotonous character in the field. The analyses of micaceous and augen leptites are more variable, but are mutually comparable. The micaceous (17 samples) and augen leptites (20 samples) are distinguished from the ordinary leptites (52 samples) by the following parameters, where the factors quoted are those of contents in the micaceous and augen leptites relative to those of the ordinary leptites: SiO_2 ($<$ 67% in micaceous augen l.), AL_2O_3 ($>$ 14% in micaceous & augen l.), TiO_2 (2 x), Fe_2O_3 (2 x), MgO (10 x), CaO (7 x), Ba (100 x), Sr (10 x). The majority of these parametres obviously reflect the greater content of phyllosilicates in the micaceous and augen leptites.

Within the ordinary leptite group only, two anomalous samples can be recognized at present, these having slightly higher values of Nb than is usual. (81.04.49 & 70). Three samples of micaceous leptite contain anomalous contents of base-metals a) 81.01.25 - 146 ppm Cu, 124 ppm Zn (~ 3,5 km north of Bjørnfjellet, N. Tømmerås), b) 81.02.12 - 40 ppm Pb (~ 2 km south of Bjørnhifjellet), c) 81.10.19 - 2757 ppm Zn (1 km. north of Lustadvatnet, E. Tømmerås). Several samples of leptite are anomalous regarding fluorine content: 81.05.02 (5 x background), 81.05.13 (4 x Bkg), 81.05.48 (13 x Bkg) and 81.05.56 (9 x Bkg), all being from the western slopes of Roktheia. Sample 81.05.71 (4 x Bkg) is from southern Tømmerås.

The altered and brecciated leptites do not in general differ significantly in geochemistry from the ordinary leptites apart from expected variations in for example, SiO_2, K_2O, Na_2O, CaO. The brecciated leptites from sub-vertical fracture zones on the western slopes of Roktheia are all anomalous in fluorine (to 147 x background). A sample of altered leptite (81.05.01) from Roktdal is however significantly anomalous in base-metals, having Cu 179 ppm, Pb 3973 ppm, Zn 3251 ppm, As 245 ppm and F at 33 x background.

5.2.3.2 METABASICS

No anomalous samples of amphibolite or gabbro can be distinguished. The variations in geochemistry of the metabasics, having relatively high Ti and Zr contents, are consistent with those of basic eruptives proposed to be of ocean-floor rather than island- arc origin.

5.2.3.3. HAERVOLA GRANITE AND GRANITE-GNEISSES

The similarity in geochemistry between those lithologies supports the field evidence for a mutual convergence. The granite-gneisses being a tectonic facies of the Haervola granite. Samples of granite-gneiss having anomalous fluorine contents are 81.02.16 (N. Tømmerås, 6 x background) and 81.05.09 (West Ogndalen, central Tømmerås, 12 x background). No base-metal anomalies have been detected.

5.2.3.4. METASEDIMENTS

Several significant base-metal anomalies have been determined in samples of metasediments, the most notable of which are those from the Gjevsjøen-Gressåmoen tract in E. Grong-Olden (Gjevsjøen sheet 1823 II and Andorsjøen sheet 1823 I).

Two samples of quartzite, 81.02.30, (6,5 km N. Gjevsjøen farm) and 81.02.38 (1 km S.E. Gjevsjøen farm) contain 2,7xBkg. Zn + 3,8X Bkg. Pb and 3,2 x Bkg. Pb respectively. A sample of muscovite-schist, 81.03.02 (1 km N.W. Gjevsjøen farm) contains 2,7x BkgZn. No anomalous fluorine has been detected in these samples.

Approximately 15 km to the north of Gjevsjøen, along equivalent metasedimentary horizons in the Gressåmoen area, the following anomalies have been detected in quartzites:

a) the Gressåmoen prospect itself, 81.10.45 (985 x Bkg.,Pb, 5,3 x Bkg. Cu, 34 x Bkg. F)
b) ~ 1,5 km south of the prospect, 81.10.50 (72 x Bkg.Pb, 171 x Bkg. F)
c) ~ 1 km south of the prospect, 81.10.49 (9,5 x Bkg.F)
d) in the east Gressåmoen metased. horizon, ~ 3,5 km. S.E. of the prospect, 81.10.47 (6,7 x Bkg. Pb, 6 x Bkg. F)
e) in the above horizon, ~ 4 km. S.E. of the prospect, 81.11.04 (62 x Bkg.F)

Marble ~ 1,5 km east of the Roktdal prospect, 81.01.03, contains 5,5 x Bkg. Zn.

During sampling of the metasedimentary schists of Tømmerås, several samples of metasedimentary schists from the (?) Eocambrian Leksdalsvann Group flanking southern Tømmerås were also collected, partly for comparison with the Bjørntjern schists and partly during detailed sampling around the Haervola prospect. Apart from that (81.03.02, N.W. Gjevsjøen) and a muscovite schist from Kølasfjellet, N.E. Grong-Olden (81.02.34, 2,4 x Bkg. Zn, 3,2 x Bkg. Cu), reported above, no anomalous samples of metasedimentary schist could be detected in Tømmerås or Grong-Olden. All of the Leksdalsvann Group schists are however 'anomalous' (2,4 - 2,6 Bkg. Zn, to 3,1 x Bkg Cu). These samples are probably not in fact truly anomalous, but merely the reflection of a higher Zn background in the (?) Eocambrian schists, which is supported by the consistently high Zn values over a sampled strike length of ~ 22 km. It should be borne in mind however that the lithologies of the Leksdalsvann Group may have provided a source for hydrothermally redistributed Zn. The similarities in age and depositional environment between the calc-sandstones, siltstones and arkoses of the Leksdalsvann Group and the Vendian arkoses (sparagmites) which host the Pb-Zn deposits of Laisvall-Vassbo type should also be noted.

Fig. 3

Cu, Pb, Zn in Rock-chip samples - Metasediments

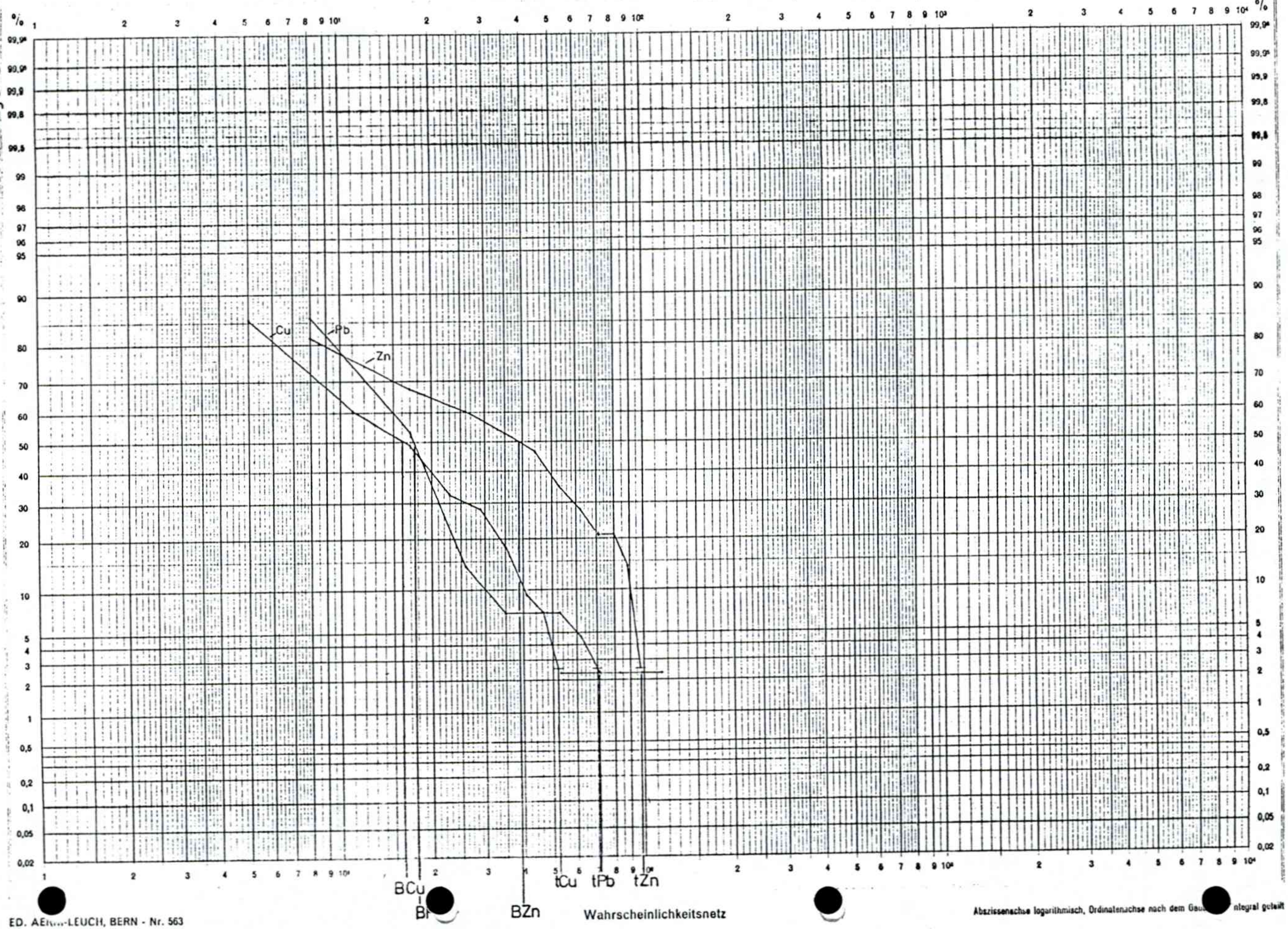


Fig. 4

F - in ROCK-CHIP SAMPLES

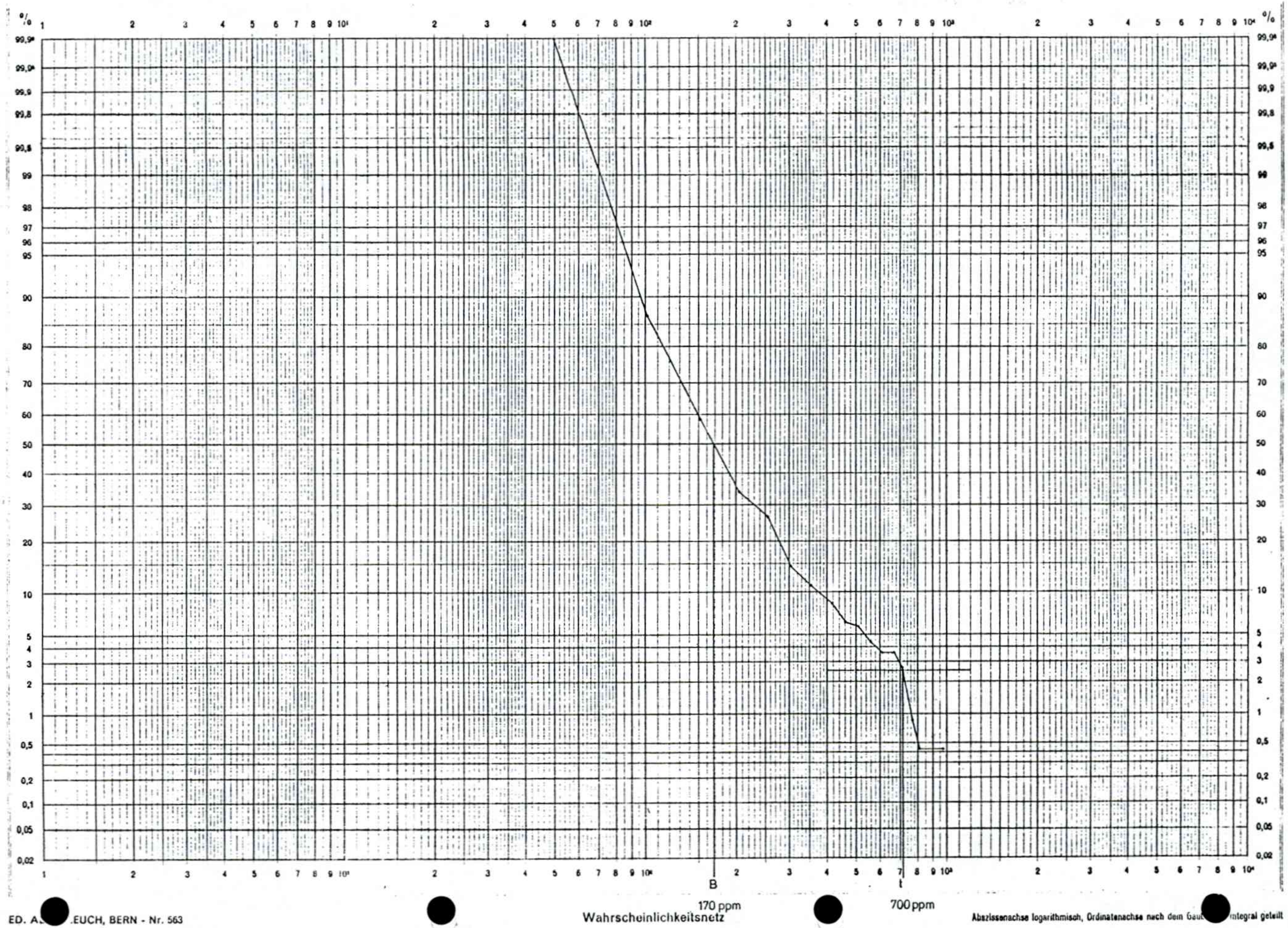


Table 5

LITHOGEOCHEMICAL ANOMALIES IN METASEDIMENTS

Zn, Cu, Pb: ($\bar{X}$ + 2 SD), x Bkg.

F: ($\bar{X}$ + 3 SD), Multiples of background

M: marble, Q: quartzite, MSB: Bjørntjern schist metaseds,

MSE:Metasedimentary schists of supposed Eocambrian age flanking S. Tømmerås.

	SAMPLE NO.	LITHOLOGY	Zn	Cu	Pb	F	
Bkg			38	16	18	170	ppm
Th.			95	50	60	700	ppm
	81.01.03	M	5,5	-	-	-	
	81.02.30	Q	2,7	-	3,8	-	
	34	MSB	2,4	3,2	-	-	
	38	Q	-	-	3,2	-	
	81.03.02	MSB	2,7	-	-	-	
	81.05.05	MSE	2,4	-	-	-	
	10	"	2,6	-	-	-	
	18	"	2,5	-	-	-	
	63	"	2,5	3,1	-	-	
	64	"	2,5	-	-	-	
	81.10.45	Q		5,3	985	33,7	
	47	"	-	-	6,7	6,1	
	49	"	-	-	-	9,5	
	50	"	-	-	72,0	171	
	81.11.04	"	-	-	-	61,5	

TABLE 6

FLUORINE IN ROCKS - ANOMALIES

Background = 170 ppm, Threshold = 700 ppm (Greater than ($\bar{X}$ + 3SD))

SAMPLE NO.	ANOMALY Multiples of background
81.02.16	5,9
81.05.01	33,0
02	4,7
09	12,3
13	4,3
32	4,3
33	4,3
34	117,7
35	147,0
36	69,4
37	77,7
48	13,2
56	9,4
71	4,2
81.09.32	4,1
81.10.45	33,7
47	6,1
49	9,5
50	171,2
81.11.04	61,5

5.3. BIOGEOCHEMISTRY

5.3.1 METHODOLOGY

Biogeochemical sampling at orientation-study level was carried out in the Roktdal area and to a greater extent in the south-east Haervola area. The aim of the surveys was to test a) the sensitivity of the method regarding known rich mineralization (Roktdal) and b) the feasibility of the method in sensing a mineralized fracture zone in poorly exposed terrain, where the results of other methods such as lithogeochemistry or geophysics could be predicted to be inconclusive or ambiguous (Haervola).

Vegetation and soil samples were ashed at 450°C, with digestion in 3:1 nitric/perchloric acid and extraction with 25 % hydrochloric acid. Such preparation and atomic absorption analysis for Cu, Pb, Zn, Fe, Mn, with results on an ash basis, were carried out by D.C. Griffith & Co. Ltd., Merseyside, England.

5.3.2. ORIENTATION STUDY ROKTDAL

A total of 9 sample points were selected downslope of Gruve 1 and Gruve 2 at Roktdal. The distance to the dumps was approximately 30 m so that close connections between the percolating waters draining the dumps and the different soil horizons was ensured.

The albeit limited sampling of the soil profile and heather vegetation was used to assess which horizon(s) best reflected the mineralization in terms of background and contrast.

The sample Nos. are: 5001/1A-9A
5001/1B-9B
5001/1C-9C
5001/1D-9D
Samples 1 - 4 = Gruve 1
Samples 5 - 9 = Gruve 2

The Ah-samples were taken from the top 5 - 10 cm thick layer of black, decomposed organic matter.

The B-samples orginate from a 5 - 15 cm thick layer of grey white leached clay rich material which is barely penetrateable by roots.

The C-samples represent the underlying more or less decomposed bedrock enriched in Fe-Mn sesquioxides leading occassionally to the development of cm thick ortstein.

In general the soils are very poorly developed and badly drained so that easy solifluction must be expected.

The coarse fragments in the C-Horizon were subangular to subrounded in shape suggesting a mixture of glacial debris and frost weathered in-situ material.

Bedrock was reached on the steeper slopes and hills at shallow depths often at ~ 20 - 30 cm, whereas in local depressions, m-thick organic material, mostly mosses are accumulated.

RESULTS:

In the following figures 5 - 11 the metal concentrations are plotted in logarithmic scale against the sample types. Different sample-numbers are represented by different ornaments. With the exception of samples 1 and 6 the copper concentration decreases almost constantly towards depth with a slight increase in the weathered bedrock. Sample 6 with the remarkable anomaly in the Ah-horixon was taken directly downslope the ore dump of Gruve 2. The concentration range from $<$ 2 ppm to 510 ppm Cu.

The lead is most enriched in the Ah-horizon and even the leached 'B' samples show concentrations up to 190 ppm supporting that lead is a relatively immobile element in this type of environment. The Ah-horizon concentrates lead up to 10.600 ppm, a factor between 100 and 200 compared with the decomposed bedrock.

Zinc shows a similar concentration pattern as copper with enrichment in the vegetation samples and constant decrease towards the 'B'-horizon.

The concentration factor in the vegetation ranges between 50 - 100 compared with the grey white leached B-layer of the soil profile.

The results for iron closely parallel those of lead with highest concentrations in the Ah-layer, but also show enrichment in the C-horizon to between 0,4 and 3,4 % Fe. This can be explained by the presence of precipitated Fe-Mn sesquioxides.

Since the grey-white leached reduced B-horizon cannot be expected to contain considerable amount of Fe^{3+} the concentrations of between 40 and 400 ppm Fe must be due to Fe^{2+}.

Manganese shows the widest range in concentrations from 24.300 - 16 ppm.

The heather-vegetation samples concentrate Manganese by the factor 30 - 300 compared with the C-horizon. It is noteworthy that sample 6, most close to the mineralization, is generally depleted in Manganese and strongly enriched in base-metals. The possible explanations are, that either the perculating waters themselves are depleted in Manganese, or that high base metal concentrations interfere with the assimilations and concentration of Manganese in heather plants. This effect will be further discussed regarding biogeochemical samples from Haervola.

The plots for Co and Ni show a parallel pattern to Pb and Fe with general enrichment in the Ah-horizon.

The overall range of concentrations through the profiles is small, indicating that the amount of these elements present, as well as their geochemical mobility, are generally low.

Figure 5

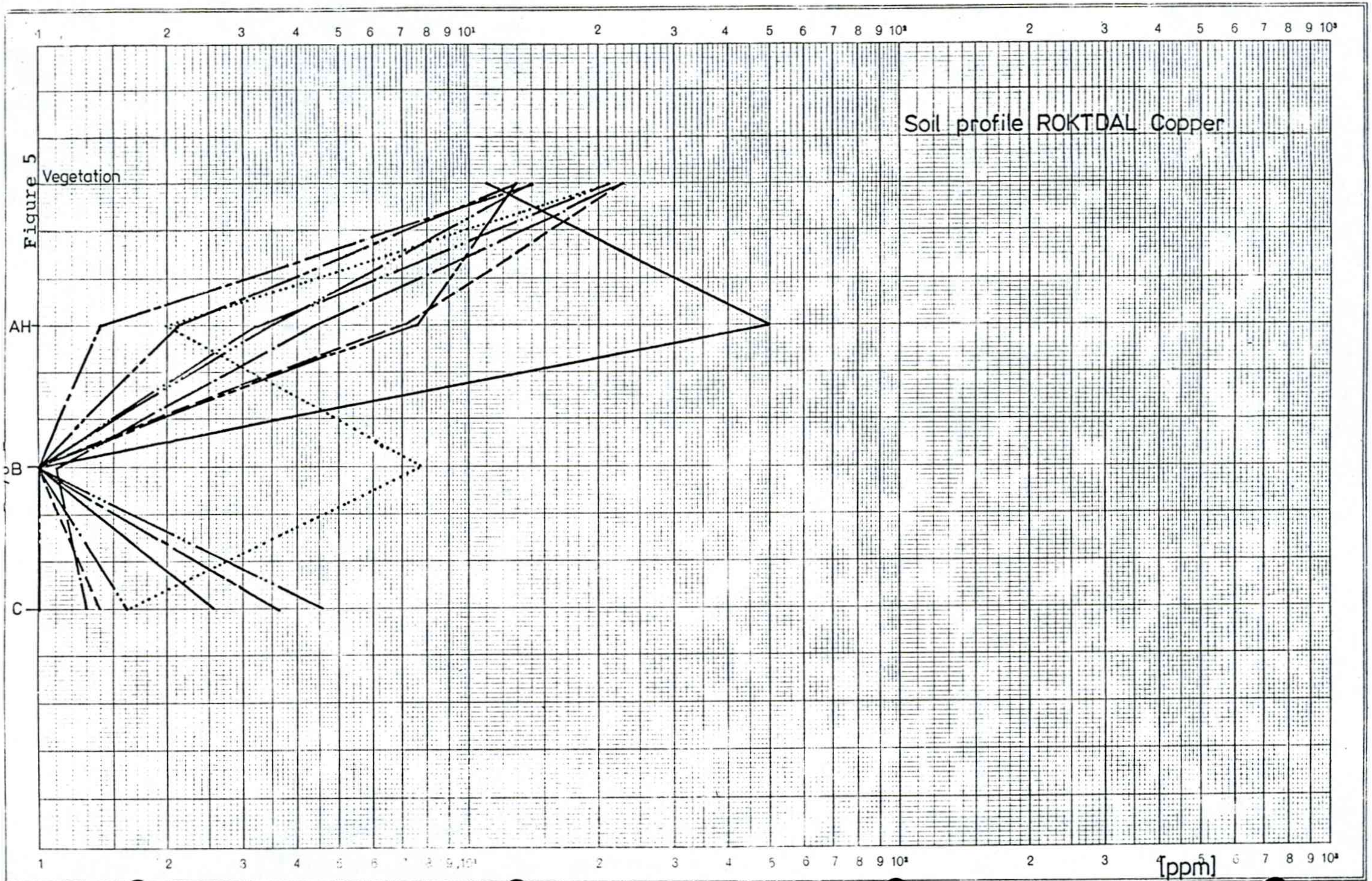
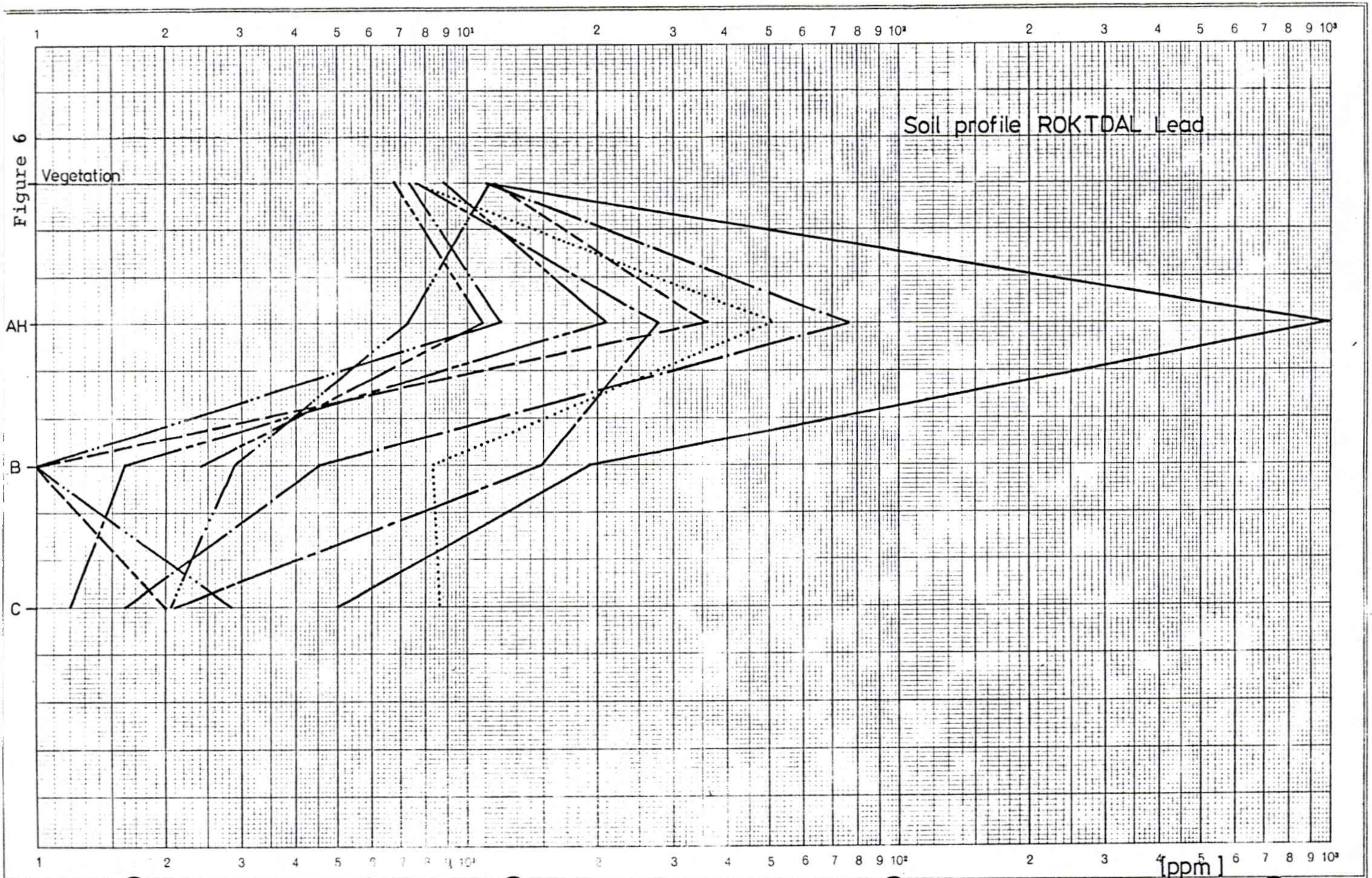

Soil profile ROKTDAL Copper
Vegetation
AH
B
C
1 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
[ppm]

Figure 6


Soil profile ROKTDAL Lead
Vegetation
AH
B
C
1 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
[ppm]
Logar. 1 - 1000 Einheit Unité
Nr. 534

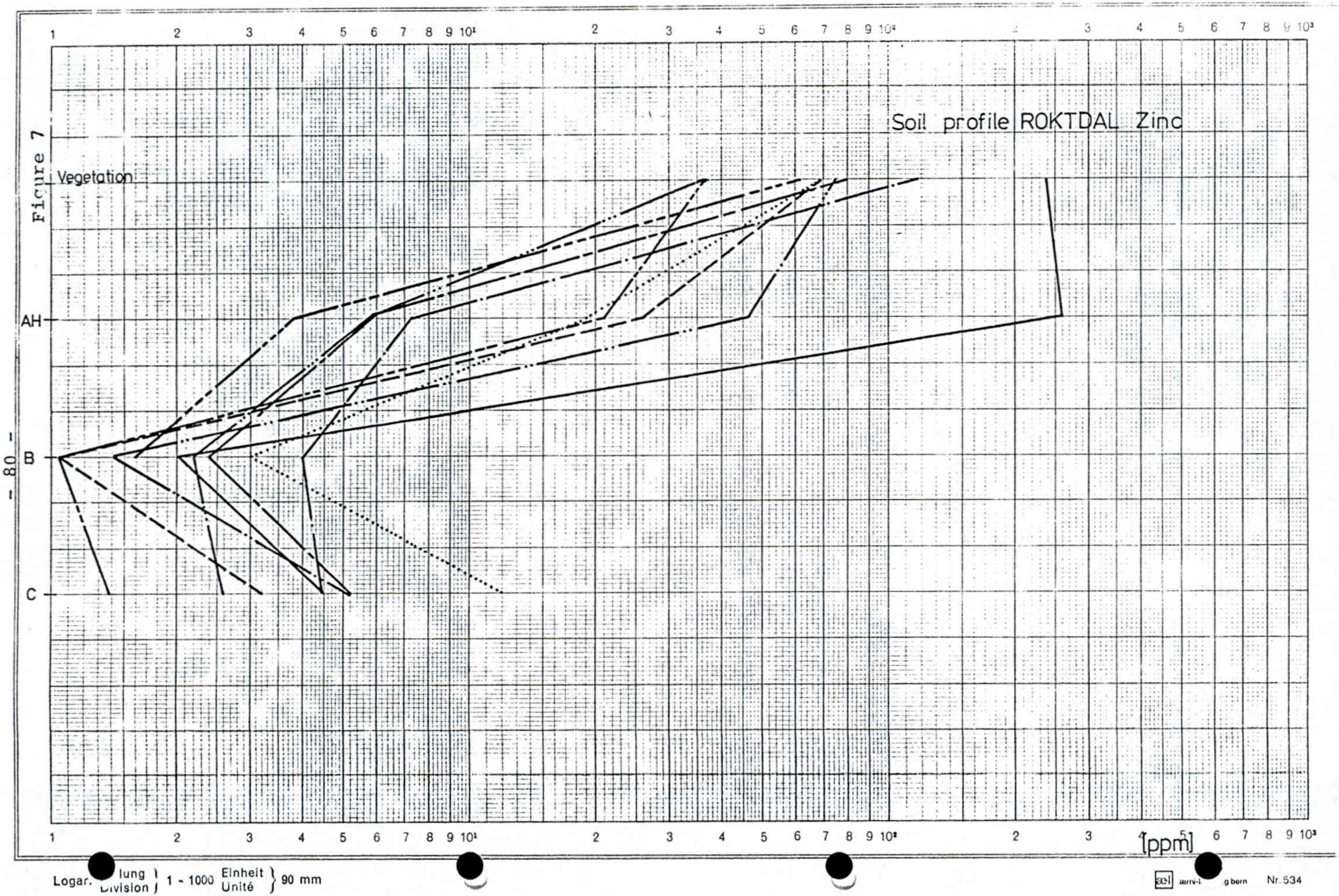
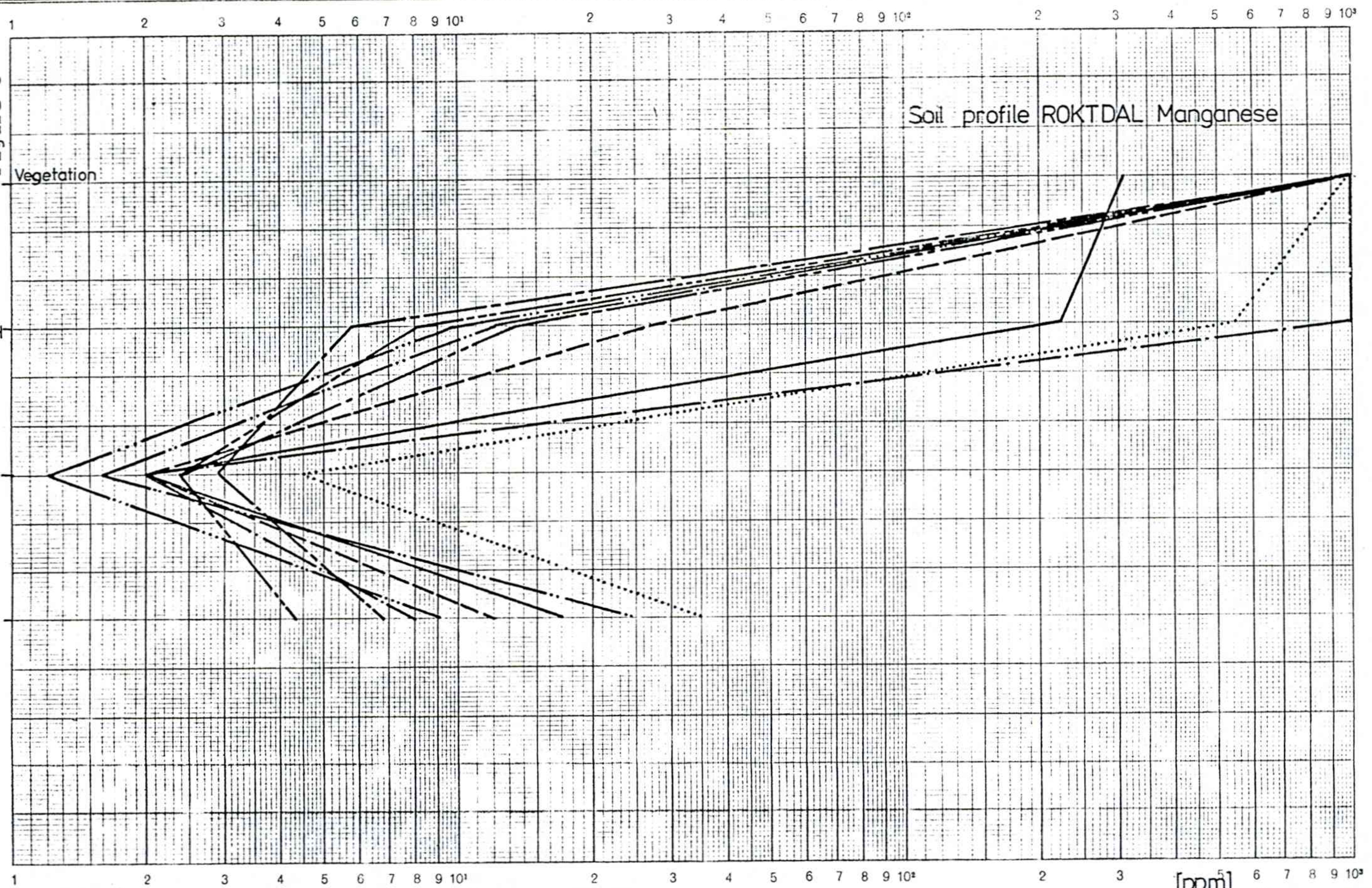

Soil profile ROKTDAL Zinc
Vegetation
AH
B
C
1 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
[ppm]
Logar. Teilung Division } 1 - 1000 Einheit Unité } 90 mm
Nr. 534

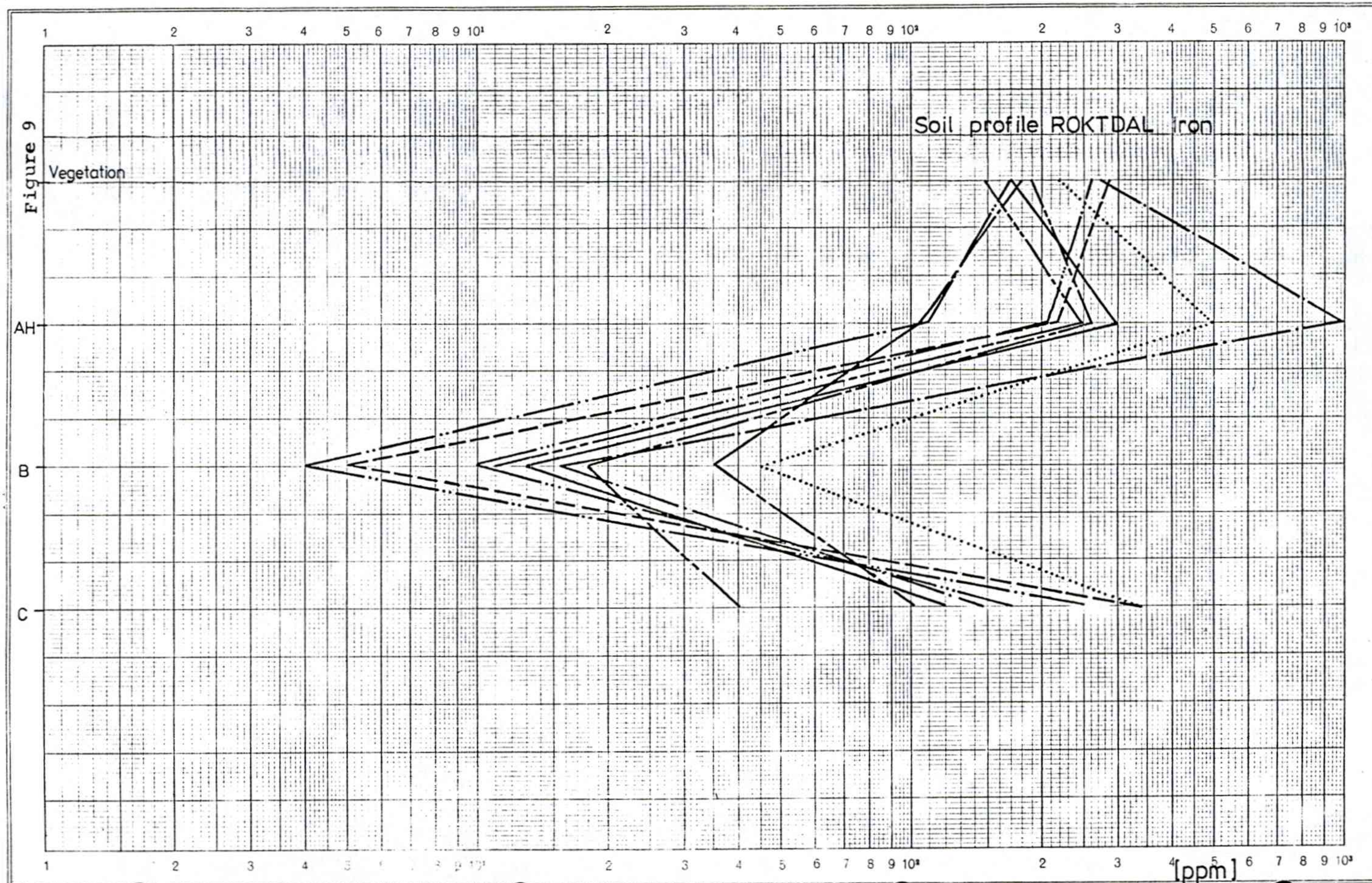
Figure 7

Figure 8



81

Figure 9



Soil profile ROKTDAL Iron
Vegetation
AH
B
C
1 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
[ppm]

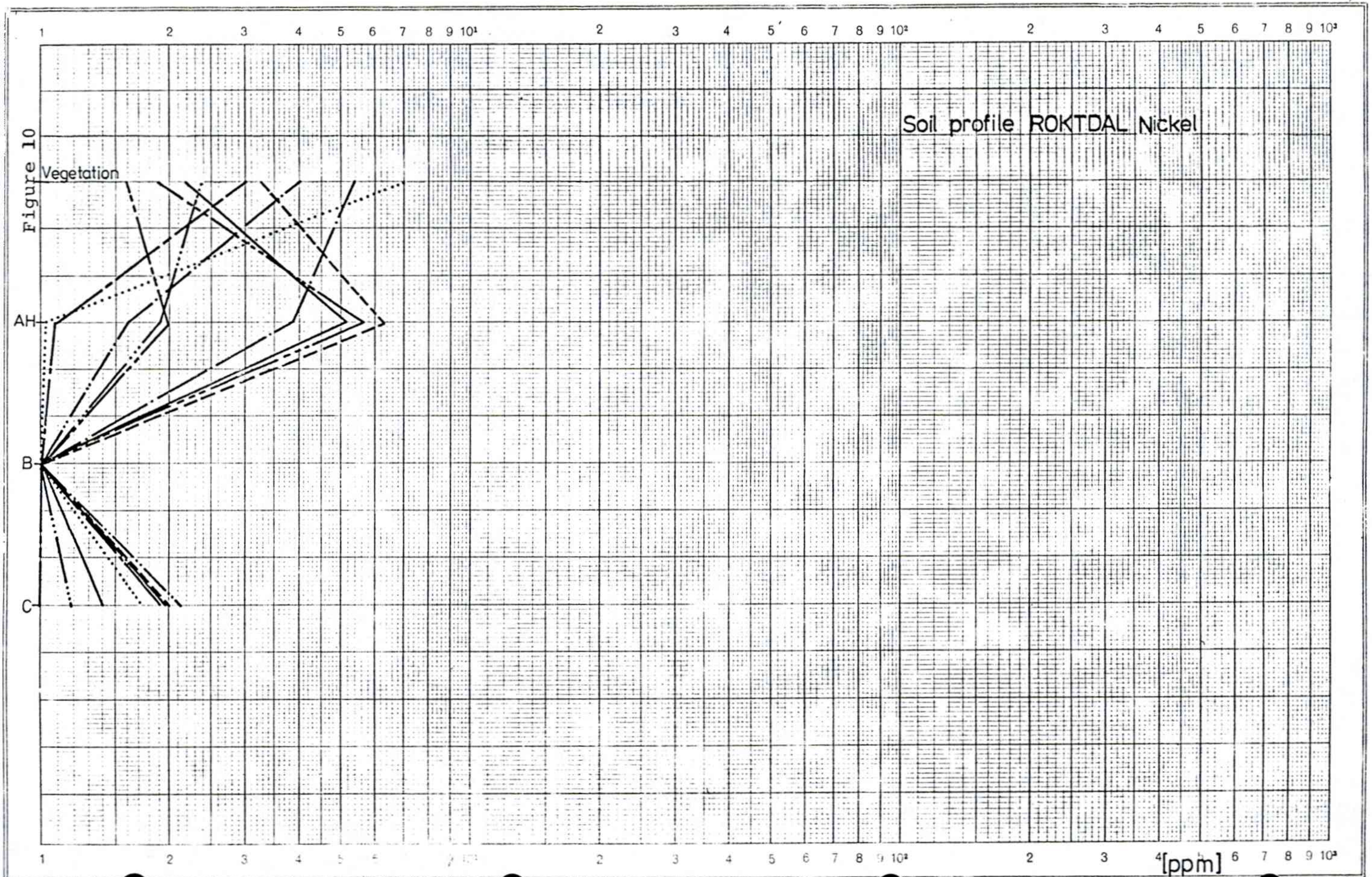

Soil profile ROKTDAL Nickel
Vegetation
AH
B
C
1 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
[ppm]

Figure 10

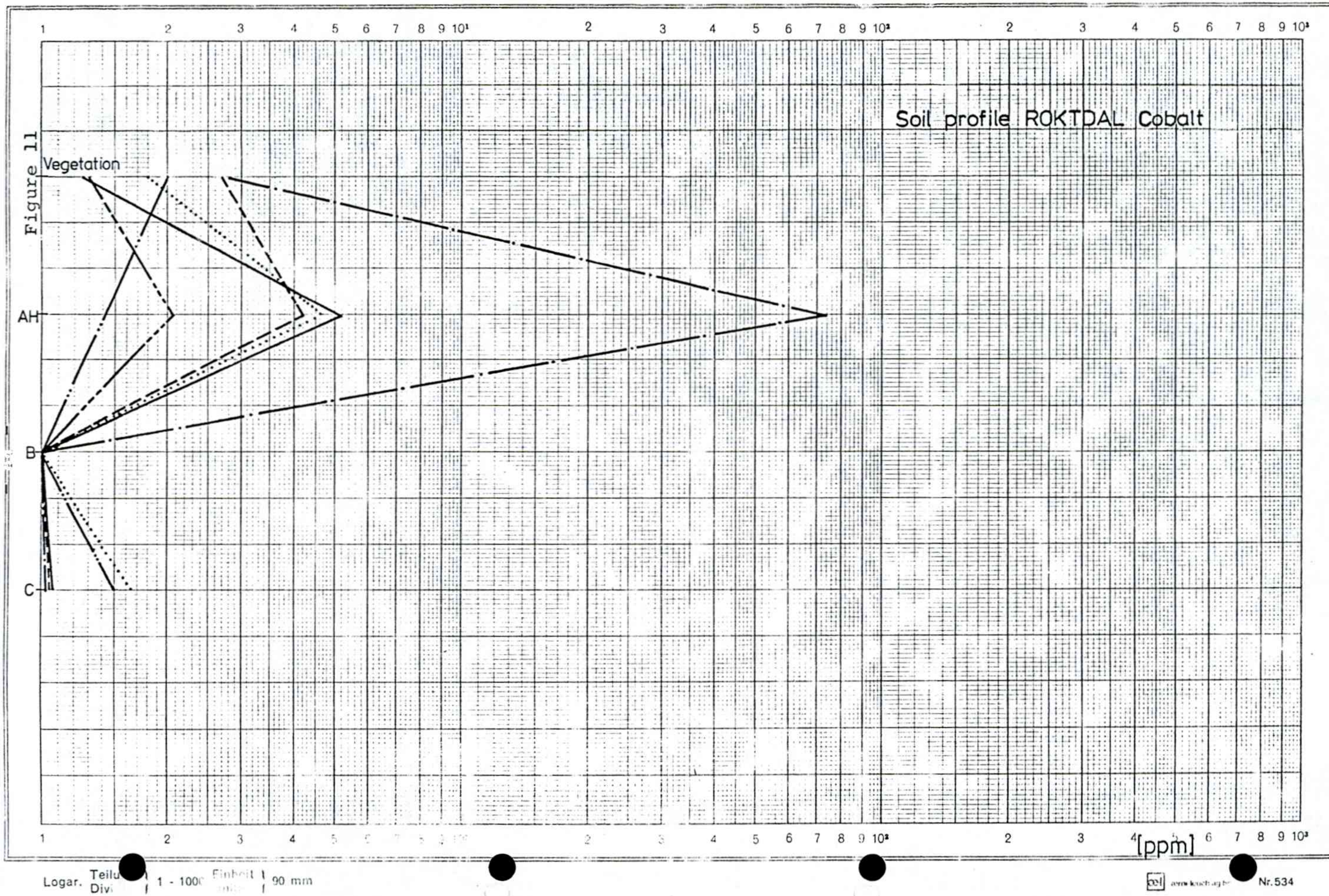


Figure 11
Soil profile ROKTDAL Cobalt
Vegetation
AH
B
C
1 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
[ppm]
Logar.
1 - 1000
90 mm
Nr. 534

5.3.3 HAERVOLA PROSPECT

Over the Haervola prospect, samples of birch, heather, spruce conifer and Ah, Bm soil horizons were taken simultaneously where possible, at intervals of $\sim$50 m, along 8 traverses spaced 75 to 375 m apart and oriented across the strike of the structure, WNW - ESE. To ensure sample homogeneity, vegetation samples were collected from growths of similar age and at a constant height above the ground. A total of 308 vegetation samples were collected from 132 sample points, each being approximately 2 l. in volume. Due to extreme lateral variations in soil profile development over distances of only a few metres, only 73 Ah and 22 Bm samples could be collected with confidence regarding sample homogeneity.

Background and threshold values for the different types of vegetation were calculated separately for sample points over Haervola granite and Palaeozoic-schist bedrock, as it was expected that greater levels of base-metal concentration in the latter would lead to two distinct populations in the sample set. The results of the statistical analysis, having been determined graphically (figs. 12-16)are given in tables 7,8 . Where no threshold could be determined at the upper 2,5 % level, the upper 5% level was taken as threshold. It is immediately apparent that the background and thresholds for vegetation over Haervola granite and Palaeozoic-schist differ insignificantly. Backgrounds and thresholds for Ah soils were also determined graphically (fig 17). The correlation between anomalies of Cu, Pb, Zn and those of Mn, Fe is low, suggesting that the majority of base-metal anomalies are not of hydromorphic origin.

A synopsis of the results is shown in figures 18-23 for the Ah soils, and for the greatest anomalies at each sample point in any vegetation type. From this overview, the following deductions can be made:

a) Zn anomalies in soils or vegetation do not relate to the Haervola fracture system, or to any other apparent controls.

This is to be expected since a sphaleritic component has not been identified in the mineralization at Haervola.

b) Cu anomalies in vegetation do not coincide with known structures, nor with topography/drainage, forming a linear group trending NE-SW across the prospect, with the greatest anomaly (9 x Bkg) over the prospect itself. This group may reflect the presence of a fracture which was not recorded in the field. Copper anomalies in Ah soils do not detect this trend, but cluster around the main fracture system, apart from one anomaly in the extreme s.east of the survey area.

c) Pb anomalies in both vegetation and soils cluster around the main fracture system, the greatest anomalies (to 55 x Bkg) being those in Ah soils from the immediate vicinity of known mineralization.

Considering the essential characteristics of Haervola mineralization, i.e. fracture-controlled and Pb-Cu-dominated, it can be concluded that Ah soils rather than vegetation best define the mineralized system in terms of both contrast and precision. Of the different types of vegetation, it is apparent that birch is the best samping medium, both in contrast and precision.

TABLE 7
BACKGROUND AND THRESHOLD VALUES FOR BASE-METAL CONTENTS OF VEGETATION AND Ah SOIL SAMPLES, HAERVOLA.

Bedrock, G: granite, PS: Palaeozoic schist
B: birch, H: heather, C: spruce
Bg: background, Th: threshold. (upper 2,5% of data)
+): Th of upper 5 % of data, - : no anomalous values apparent

Vegetation:

Element	Sample	G: Bg/Th (ppm)	PS: Bg/Th (ppm)
Cu	B	85/130	54/165
	H	210/255+)	215/305
	C	120/170	129/177+)
Pb	B	29/55	27/49
	H	51/-	51/92
	C	26/88	22/61 +)
Zn	B	3000/5650	2520/4900
	H	560/940	620/980
	C	1500/3075	1460/2150+)
Fe%	B	0,14/0,34	0,14/0,31
	H	0,19/0,52	0,20/0,49
	C	0,12/0,38	0,13/0,22+)
Mn%	B	2,4/8,7	2,0/5,4
	H	2,4/5,0	2,6/-
	C	1,9/5,2	1,7/3,6 +)

Ah soils:

Element	Background (ppm)	Threshold (upper 2,5%) (ppm)
Cu	42	220
Pb	80	260
Zn	100	640
Fe%	2.1	9,0
Mn	220	1500

TABLE 8

ANOMALOUS SAMPLES, VEGETATION AND Ah SOILS, HAERVOLA (Greater than ($\bar{X}$ + 3SD), multiples of background.

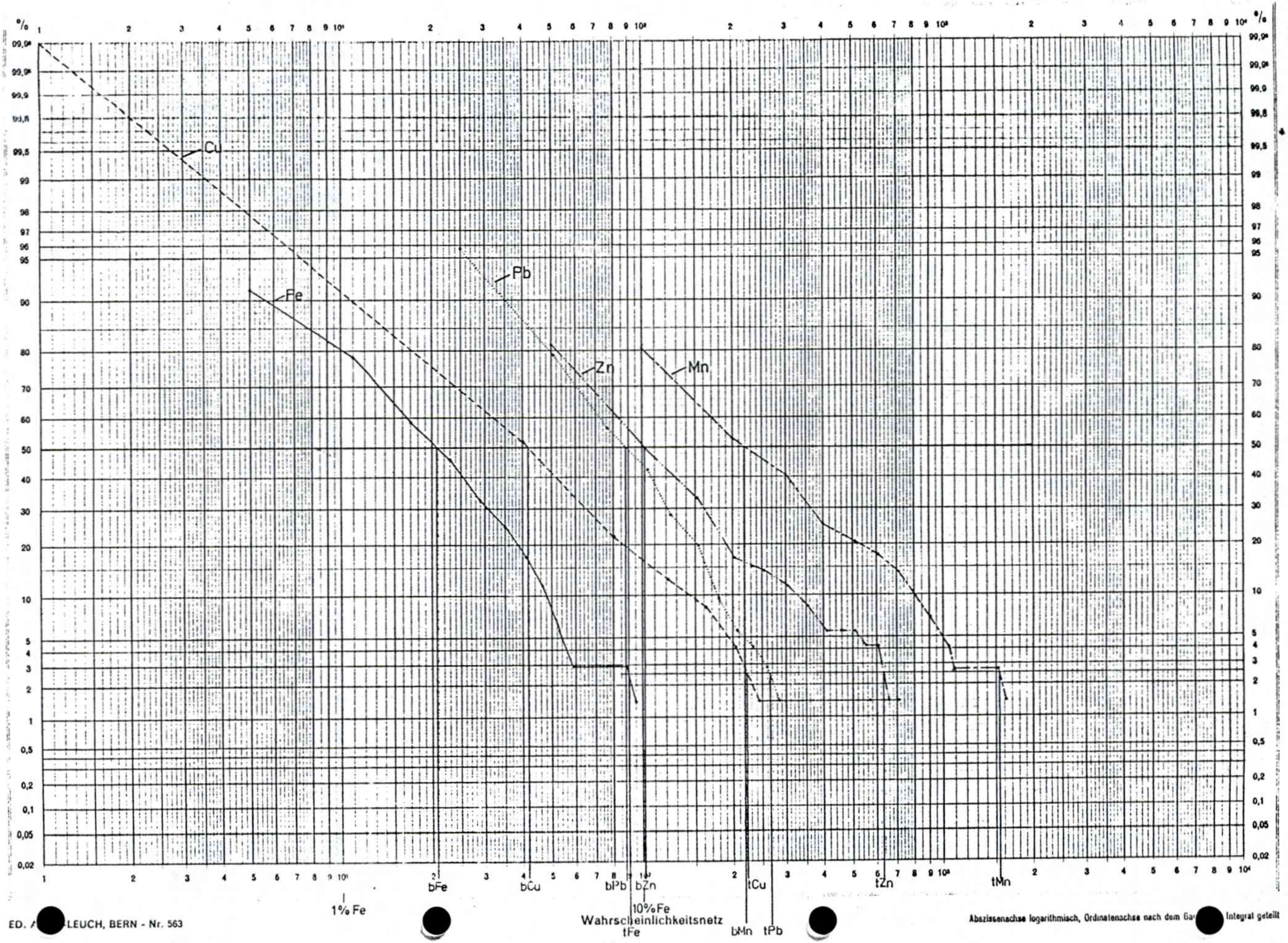
SAMP. NO	Cu	Pb	Zn	Mn	Fe
Ah 40.03.16	5,7				4,6
" 17			7,4		
VB 22	4,8	3,5			3,4
VH 22		4,5			2,4
VB 23			2,4		
" 24			2,1		
" 26				4,2	
" 28		2,2			
VC 29					1,8
Ah 30		21,3			
" 33	14,1		16,4	10,0	
VB 35					4,6
" 36					8,8
VC 37	1,5				
Ah 37			18,4		
VC 39			2,1		
VB 44		2,3			
VC 44	8,9	4,0			7,5
VB 47			2,1		2,2
VH 55	1,5				
VH 57		2,8	1,9		
VB 60			1,9		
VB 62			2,0		
VH 64	1,4				
VH 66				2,2	
Ah 66					6,8
VC 68			2,0		
VH 74				2,0	
Ah 74				198,0	
VH 75					2,8
VB 78		1,9			
" 79		1,6	2,4		2,4
VC 79				2,6	
Ah 79	276,0	55,0			
VB 80		1,6			
Ah 80	177,4	19,4	24,5		

TABLE 8 (Contd.)

ANOMALOUS SAMPLES, VEGETATION AND Ah SOILS

HAERVOLA (Greater than ($\bar{X}$ + 3SD), multiples of background.

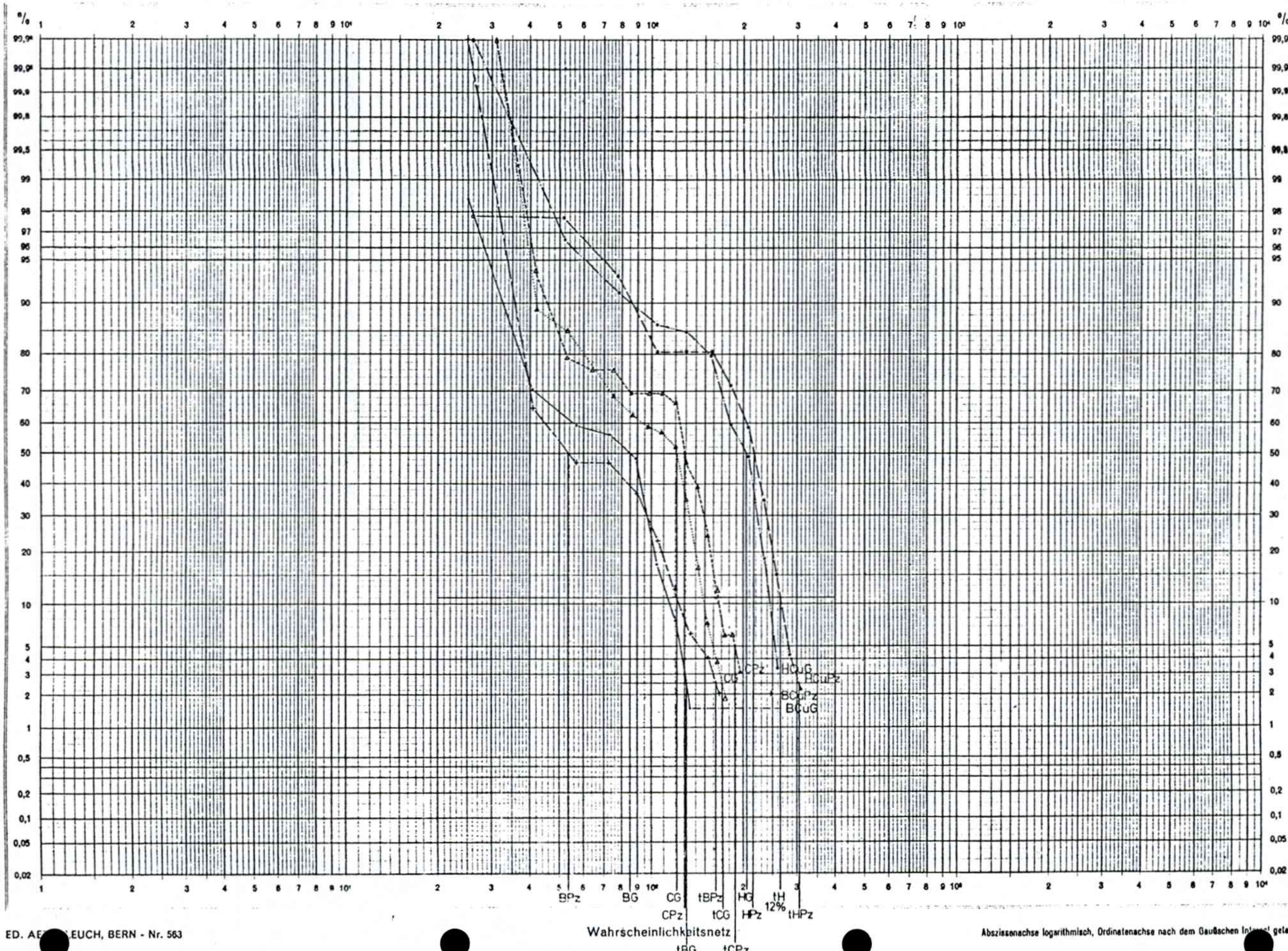
SAMP. NO.		Cu	Pb	Zn	Mn	Fe
VB	40.03.82			2,2		
"	85	3,2				
"	86	1,6				
"	88			1,9		
"	89				4,1	
Ah	94		3,7			
VB	98			2,0		
VH	99			2,1		
VC	99				3,4	
Ah	99			12,5		
VH	112			1,6		
"	119			1,7		
"	120				5,8	
"	121				2,8	
VB	121			2,0		
VH	122					5,9
VB	122					2,2
Ah	122					4,3
VB	126		2,0			2,5
"	127				3,6	
Ah	128					13,1
"	129		3,3			
VM	130					8,0
"	131					3,1



Cu
Fe
Pb
Zn
Mn
bFe
bCu
bPb
bZn
tCu
tZn
tMn
1% Fe
10% Fe
Wahrscheinlichkeitsnetz
tFe
bMn
tPb
ED. A[illegible]LEUCH, BERN - Nr. 563
Abszissenachse logarithmisch, Ordinatenachse nach dem Ga[illegible] Integral geteilt

Figure 17

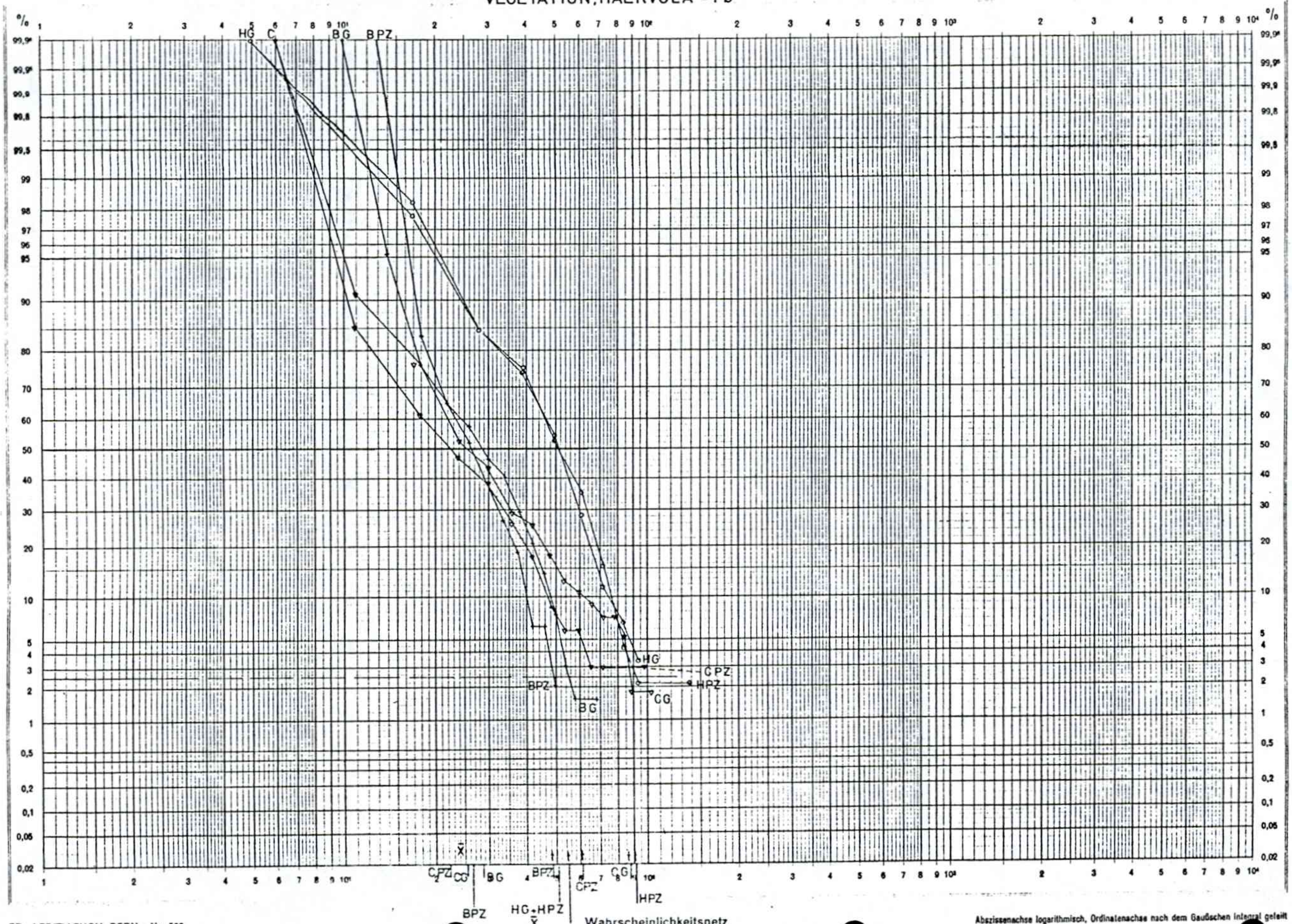
VEGETATION, HAERVOLA — Cu



ED. AE… LEUCH, BERN - Nr. 563

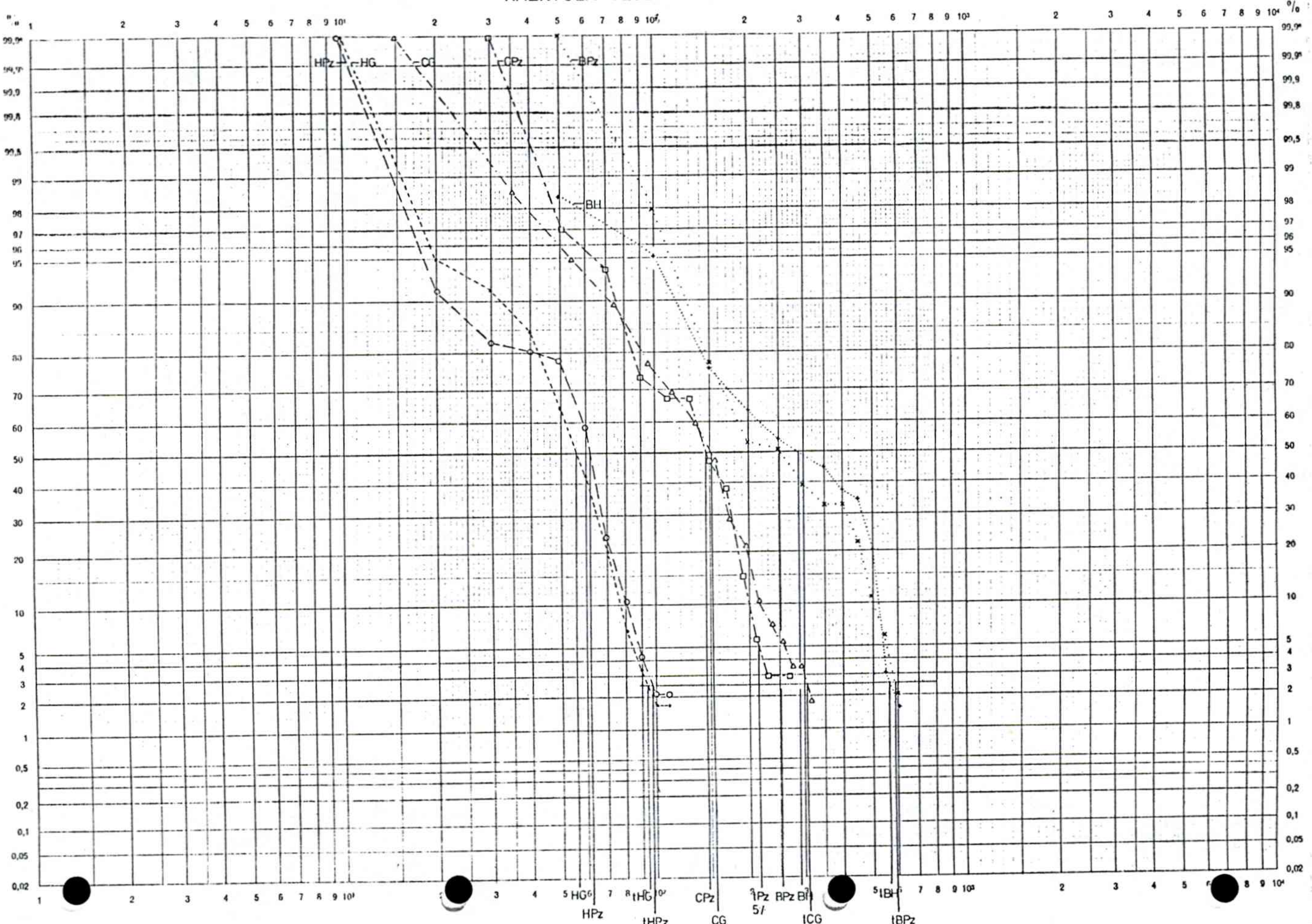
Abszissenachse logarithmisch, Ordinatenachse nach dem Gaußschen Integral geteilt

VEGETATION, HAERVOLA - Pb

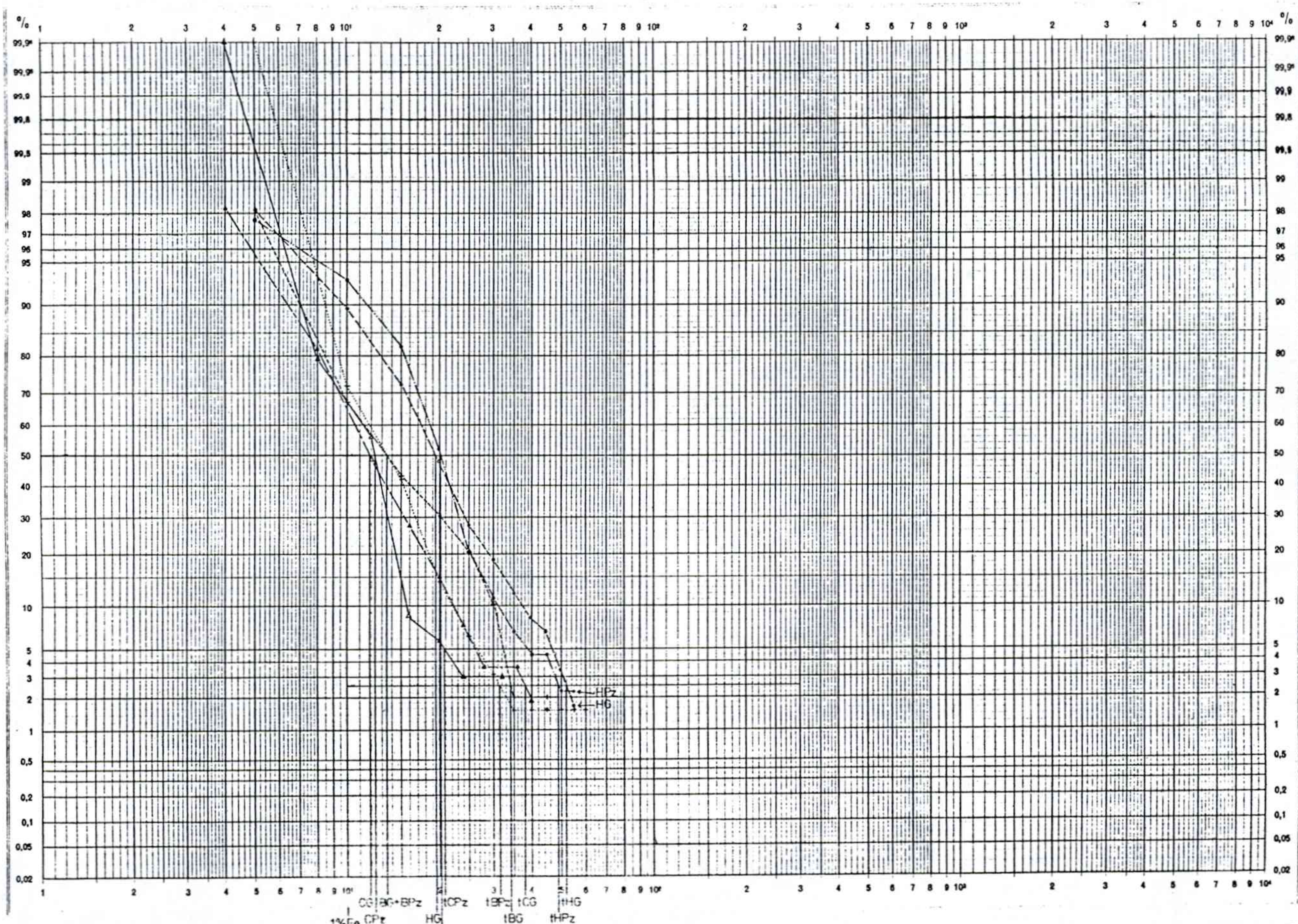


Abszissenachse logarithmisch, Ordinatenachse nach dem Gaußschen Integral geteilt

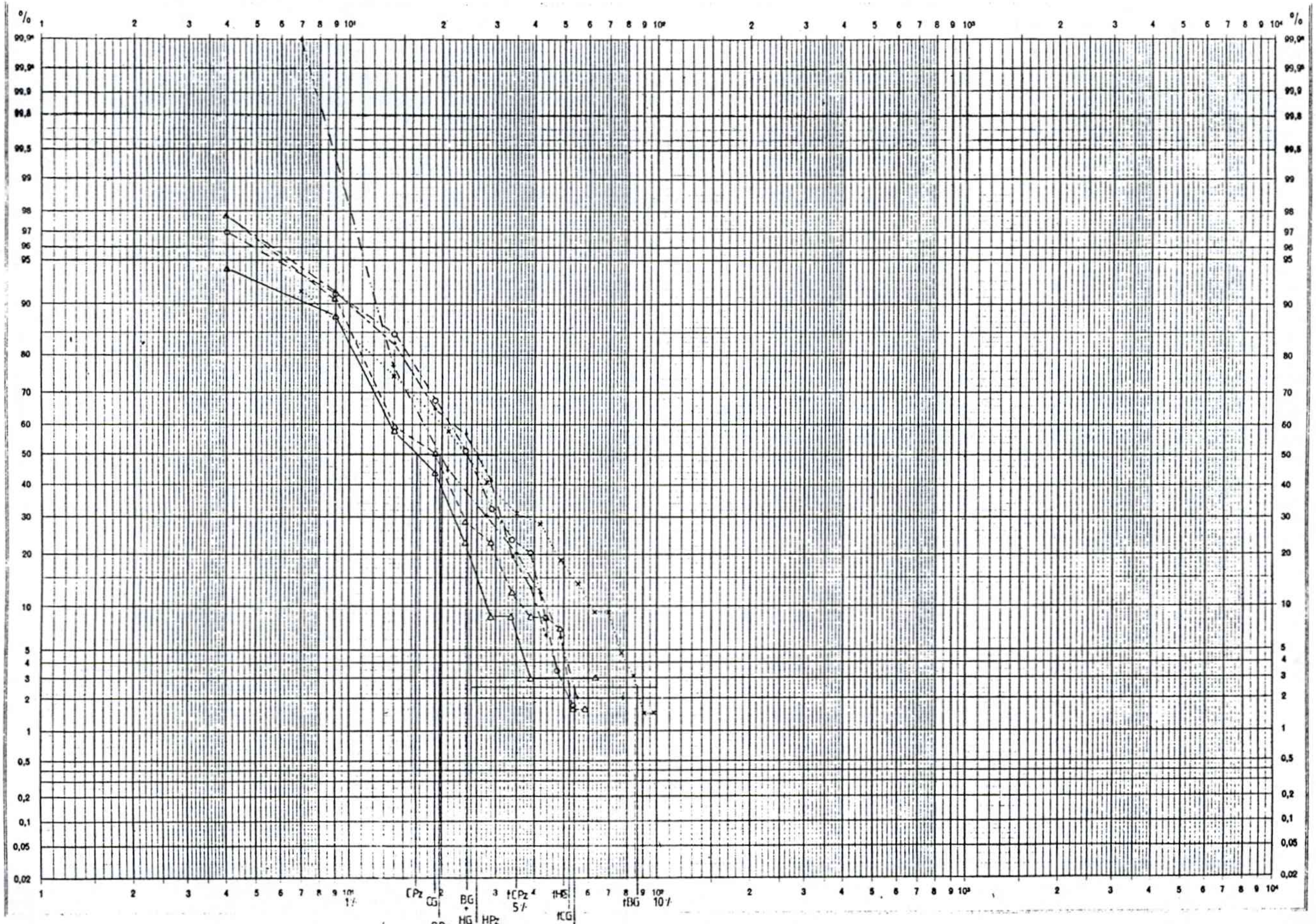
HAERVOLA VEGETATION — Zn



VEGETATION, HAERVOLA — Fe



VEGETATION , HAERVOLA—Mn



ED. [...]NI-LEUCH, BERN - Nr. 563

Wahrscheinlichkeitsnetz

Abszissenachse logarithmisch, Ordinatenachse nach dem Gaußsch[...]egral geteilt

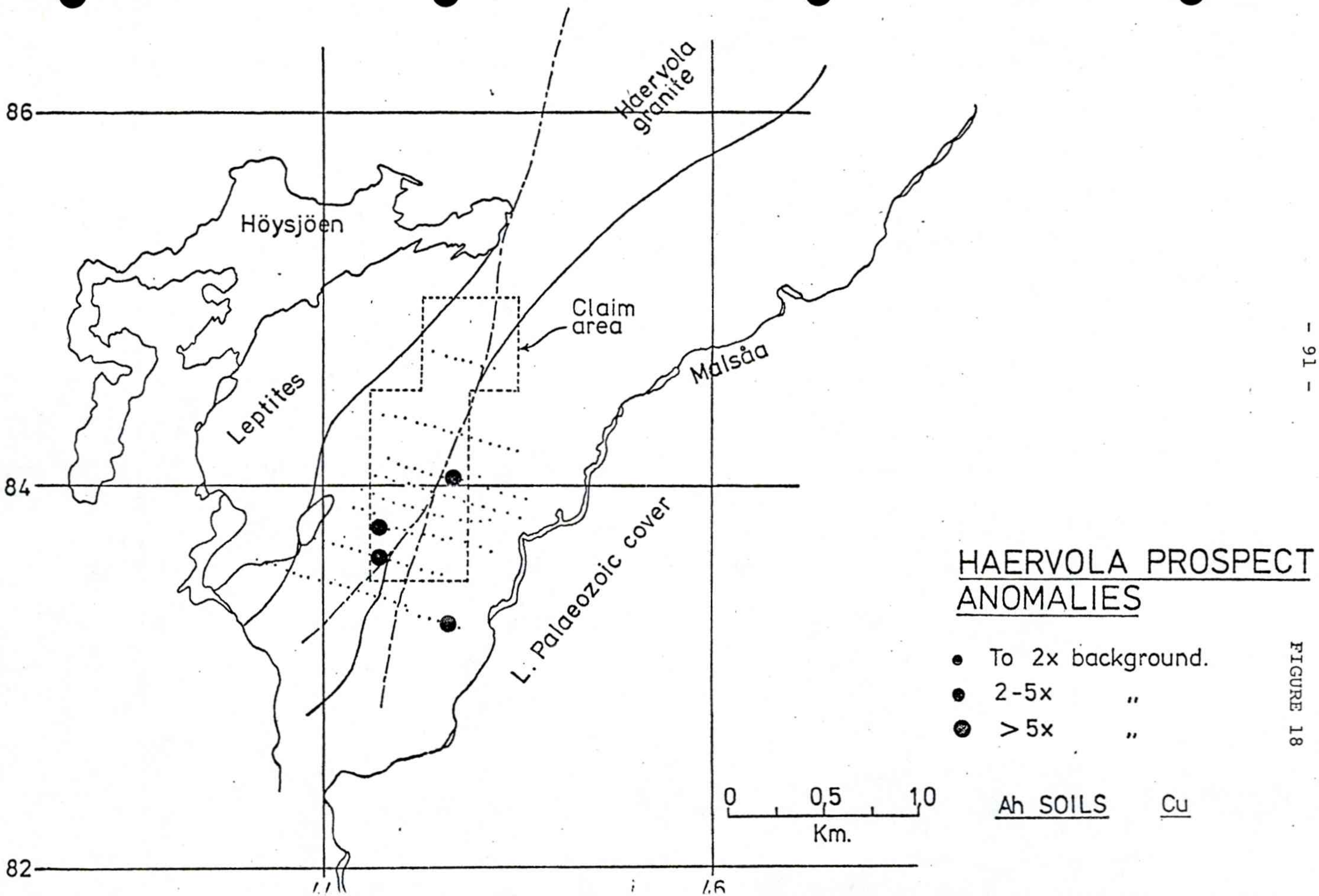

86
84
82
Haervola granite
Höysjöen
Claim area
Malsåa
Leptites
L. Palaeozoic cover
HAERVOLA PROSPECT ANOMALIES
To 2x background.
2-5x "
> 5x "
0 0,5 1,0
Km.
Ah SOILS Cu

FIGURE 18

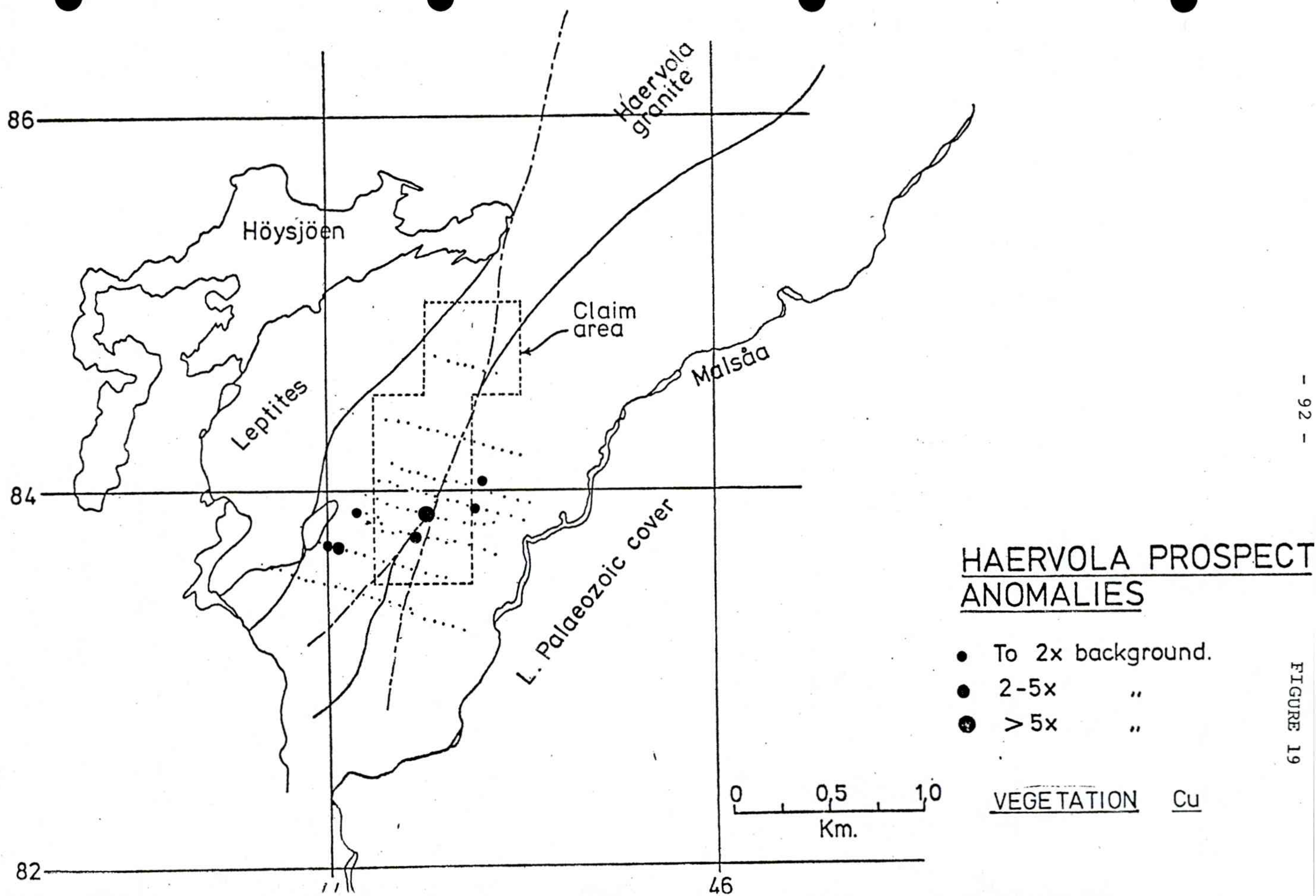
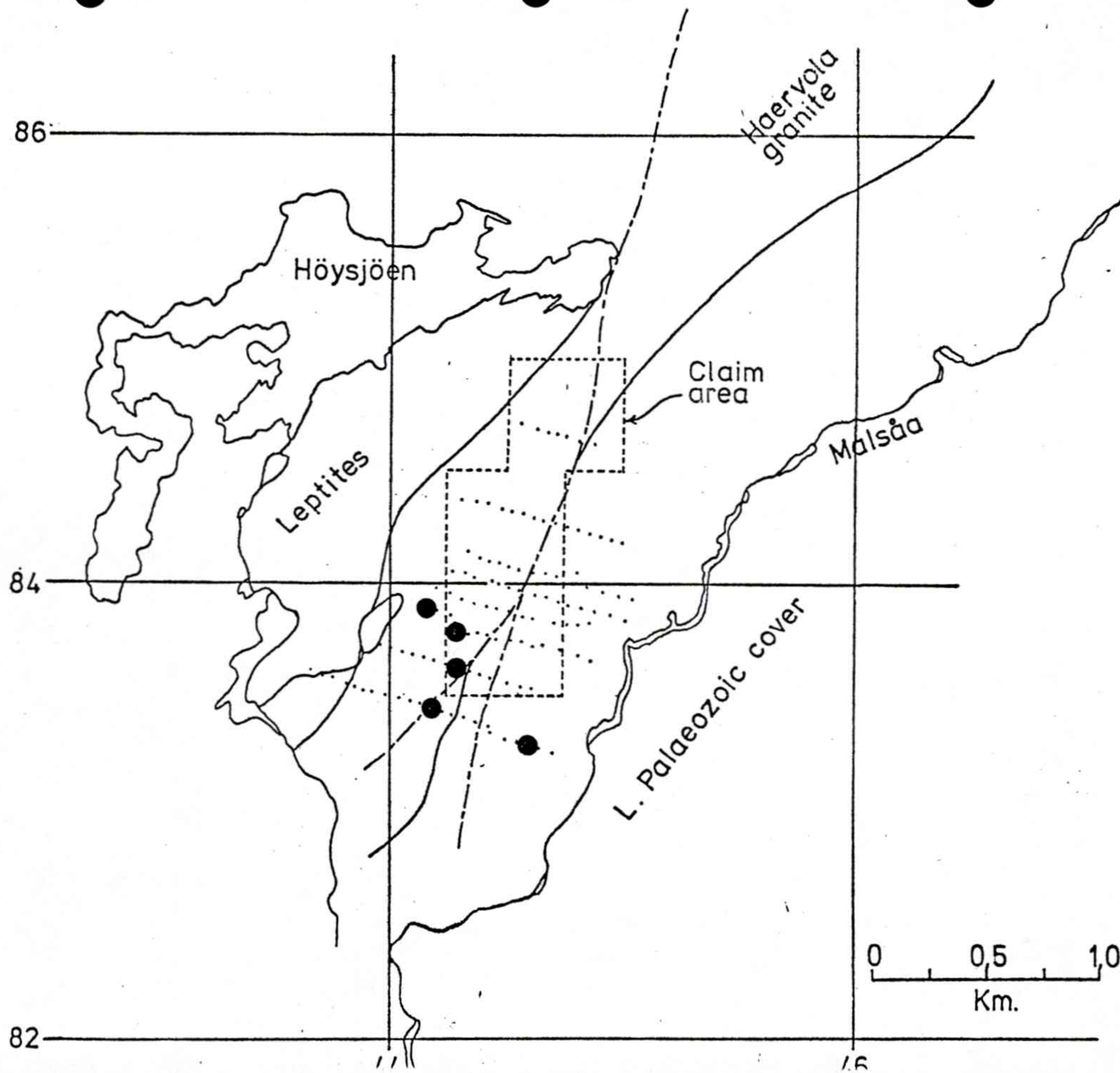

86
84
82
46
Haervola granite
Höysjöen
Claim area
Leptites
Malsåa
L. Palaeozoic cover
HAERVOLA PROSPECT ANOMALIES
To 2x background.
2-5x "
>5x "
0 0,5 1,0
Km.
VEGETATION Cu

FIGURE 19

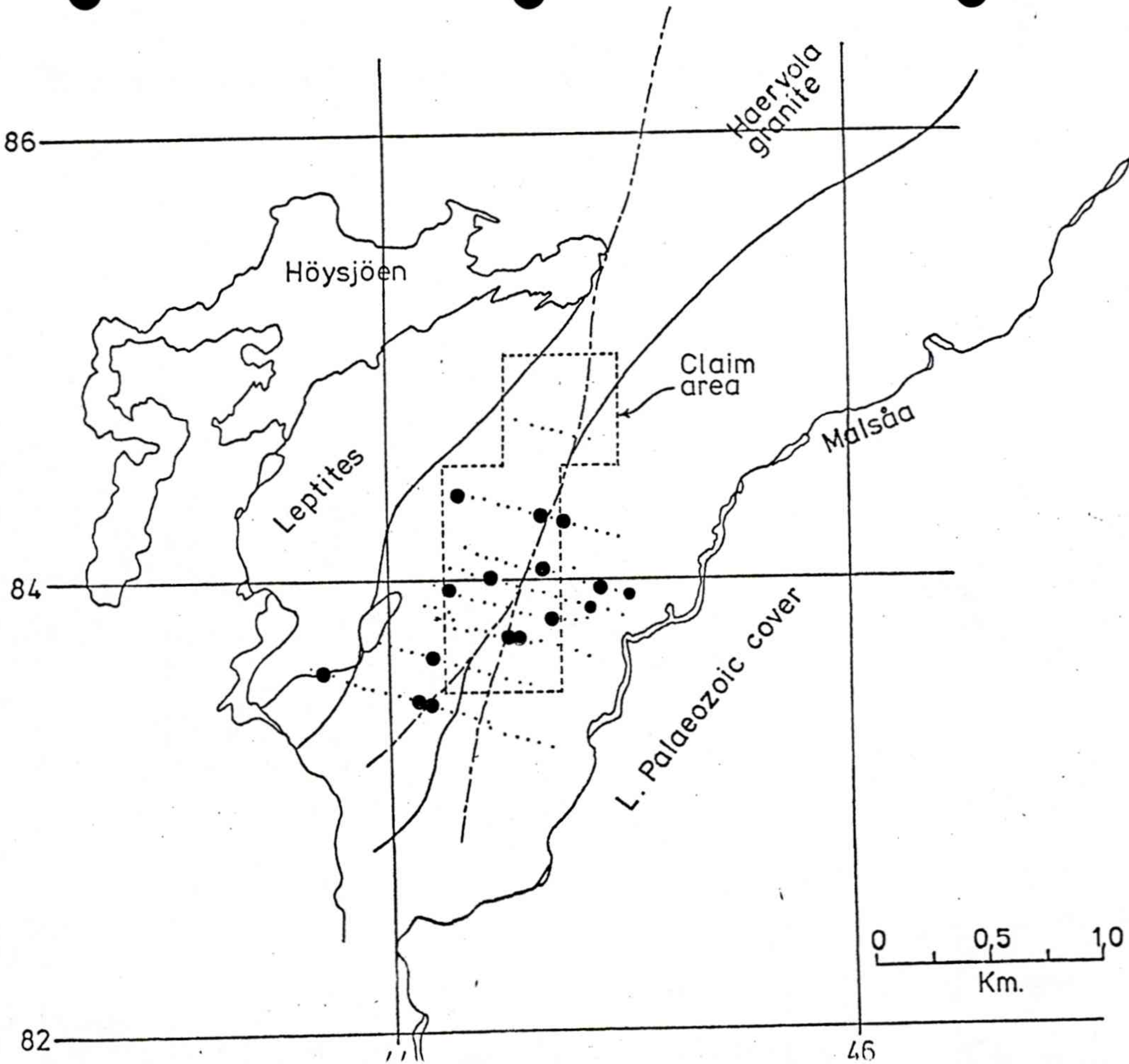


HAERVOLA PROSPECT ANOMALIES

- ● To 2x background.
- ● 2-5x "
- ● >5x "

Ah SOILS Zn

FIGURE 20

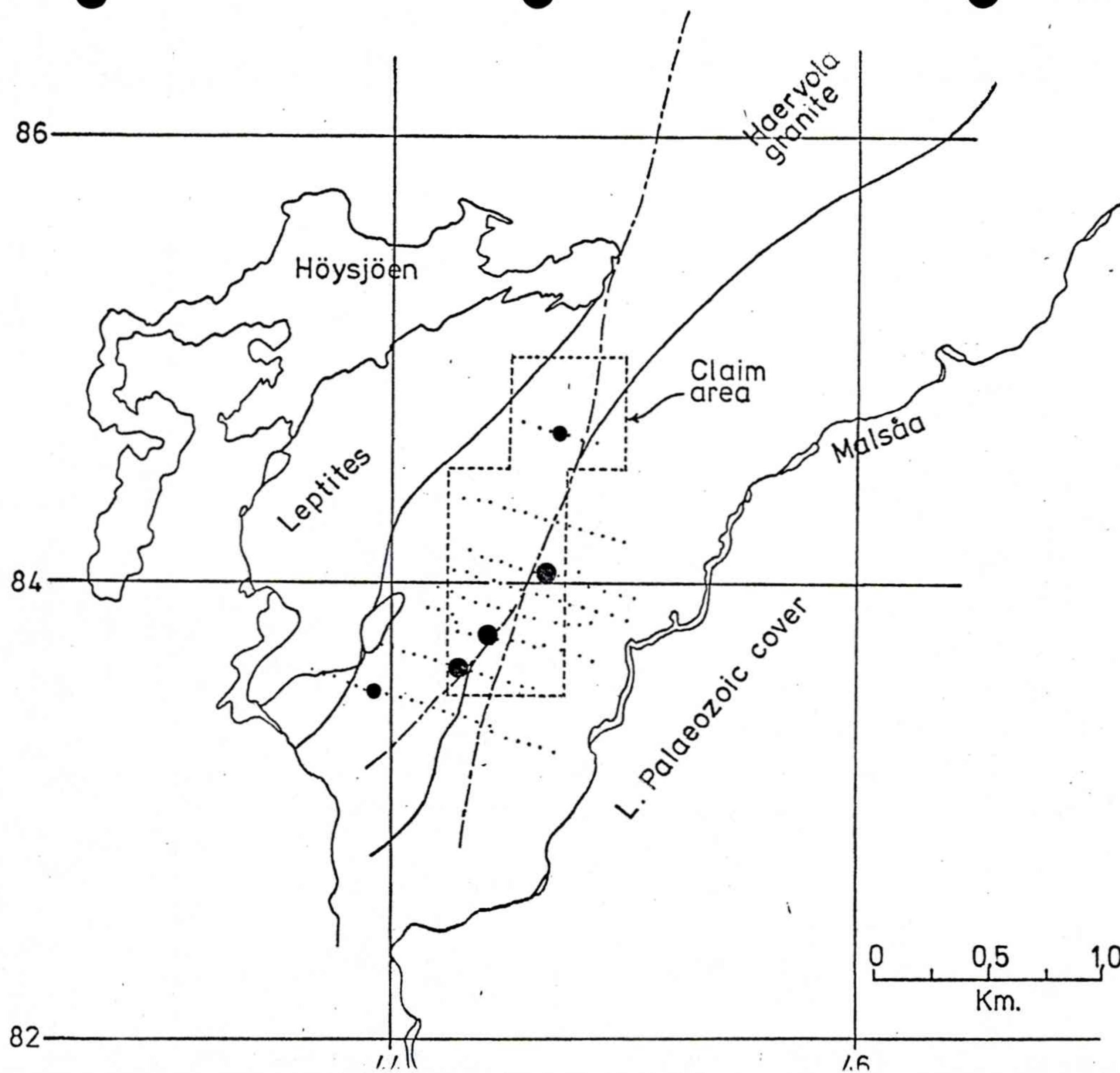


HAERVOLA PROSPECT ANOMALIES

- To 2x background.
- 2-5x "
- > 5x "

VEGETATION Zn

FIGURE 21

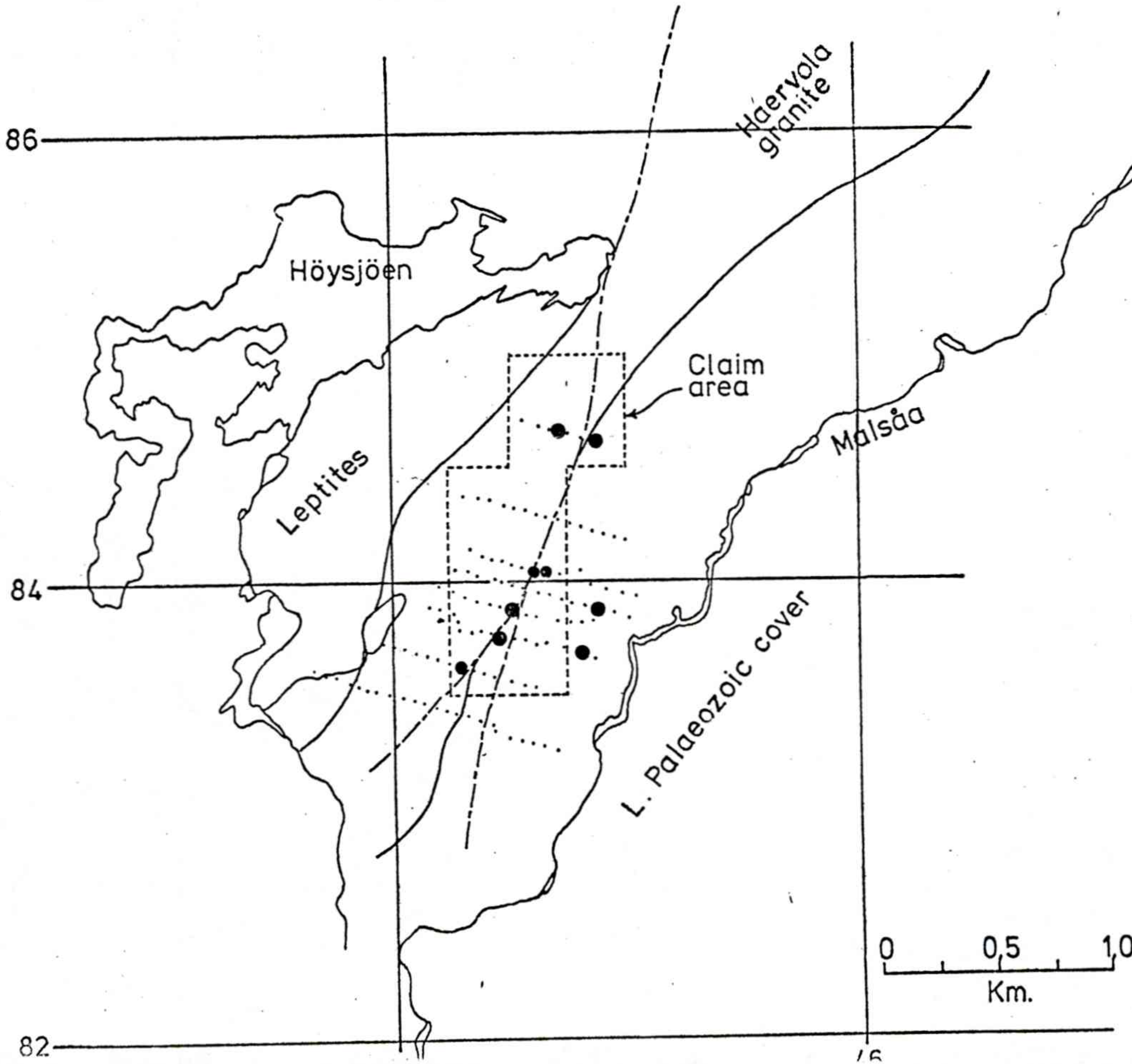


HAERVOLA PROSPECT ANOMALIES

- To 2x background.
- 2-5x "
- > 5x "

Ah SOILS Pb

FIGURE 22



HAERVOLA PROSPECT ANOMALIES

- To 2x background.
- 2-5x "
- > 5x "

VEGETATION Pb

FIGURE 23

6. LANDSAT STUDY

As part of a more comprehensive ERTS-study covering Nord Trøndelag and Nordland the Landsat image covering the Tømmerås window was enhanced.

See Plate 34, 35 and 36. The top left corner is occupied by Snåsavatnet.

Originally it was planned to extend the Landsat study to cover the Grong-Olden culmination. However, the computer tape was found to be incomplete such that coverage of Grong-Olden was lacking. Completion of the Landsat study is planned to take place over the winter. Image processing was carried out using an IBM computer in Oslo and a variety of colour composites and ratios were tested. The following combinations were found to give the best results for geological mapping:

Code	MSS	Colour	Remarks
1351	7 5 4	Red Green Blue	Colour composite, water black, vegetation red good resolution of major structures. Plate: 34
1591	7/5 6 4	Red Green Blue	Excellent resolution of structures. Plate: 35
1272	6/7 5/6 4/5	Red Green Blue	Water in white, possible to map additional structures to 1351 + 1591 especially under cover of vegetation southern shore of Snåsavatnet.

Fig. 24 shows the interpretation of lineaments and structures of the Tømmerås window. In Fig. 24 all lineaments recognizable from the colour composite, code 1351 are drawn and Fig.25 gives the amount of additional information obtained from Code 1591 and 1272. The latter ratios commonly show fold structures and faint extensions of mayor lineaments mapped from the colour composite.

The orientation of the most well developed lineaments is N.E.-S.W., parallel the main axis of the Tømmerås anticline.

Parallel to this strongly developed lineaments have formed with an average separation distance of approximately 5,0 km. The Roktdal showing occurs precisely within an area where one of these mayor structures crosscut at a high angle by 2 minor faults.

These small faults belong to a less distinct lineament pattern, trending N.E.-S.W. and crosscutting the main N.W.-S.E. trend almost orthogonally, suggesting a large scale blockfaulting of the competent leptite.

The majority of the N.W.-S.E. trending lineaments are expressed in the field by steeply dipping zones of brecciation as described in chapter 4.3.2.

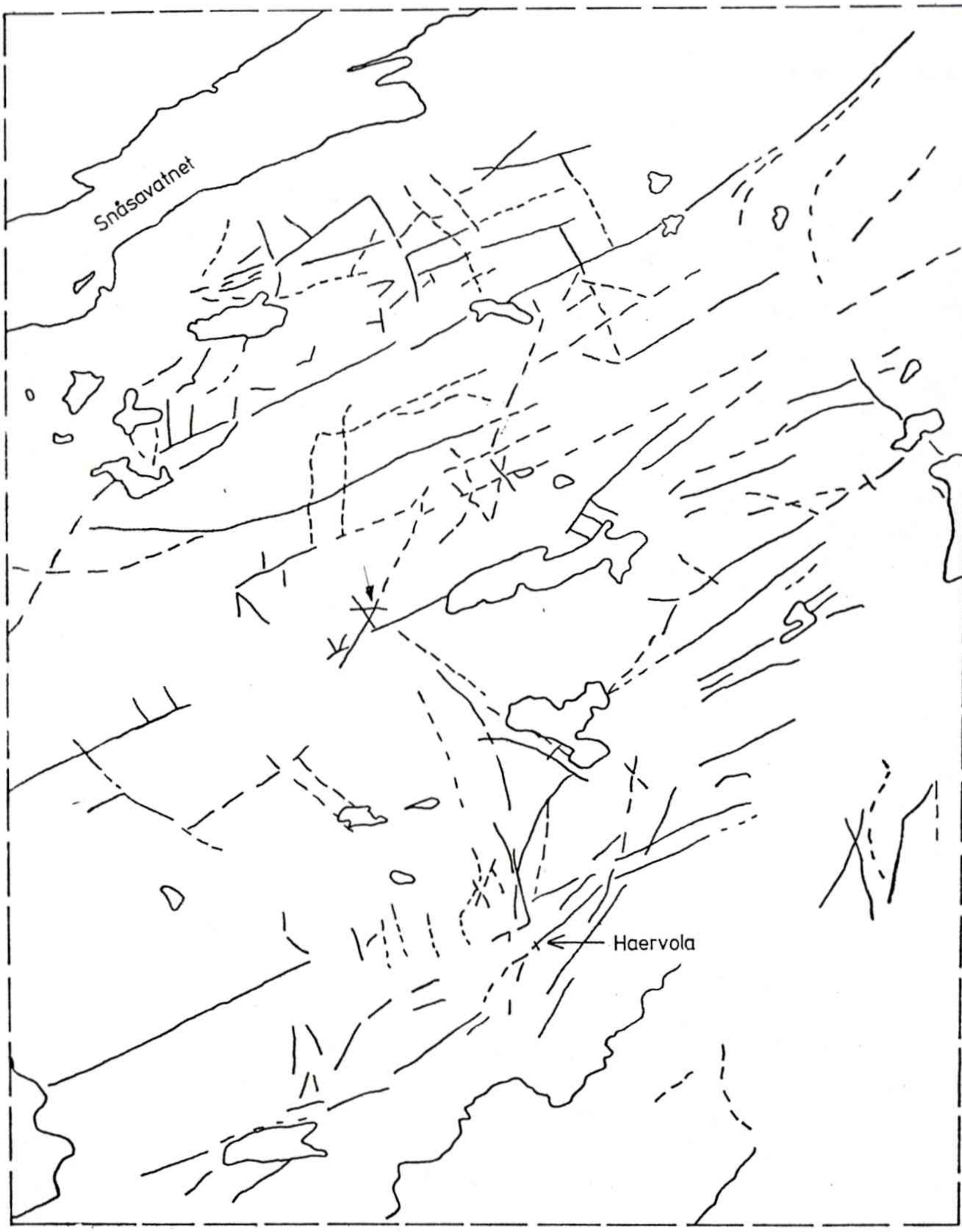
These narrow zones of brecciating could be traced continously in the field over several kilometres and represent planes of displacement that have been reactivated several times.

It is conceivable, that any hydrothermal solutions leading, for example, to vein type mineralization at Roktdal would rise preferentially along these zones of weakness.

The Haervola vein-type mineralization is situated amid a complex pattern of lineaments mainly trending N.W.-S.W. and being crosscut by arcuate faults forming the western boundary of the Haervola granite. Apart from structural interpretations no further attempt to distinguish lithologies was undertaken.

The mapped metasedimentary sequences were found to be too limited in outcrop area such that only very detailed and cost intensive analysis of the data would promise further information.

From the geological reconnaissance in the Grong-Olden culmination it is evident that the vegetation cover is considerably more developed over the metasediments, particularly where marbles are included in the sequence. These areas should be carefully expected in order to map lithologies from Landsat data with more confidence.



0 2,5 5,0 7,0 KM

Fig. 24

Landsat structures from Colour composite

Mss 7 RED

Mss 5 GREEN

Mss 4 BLUE

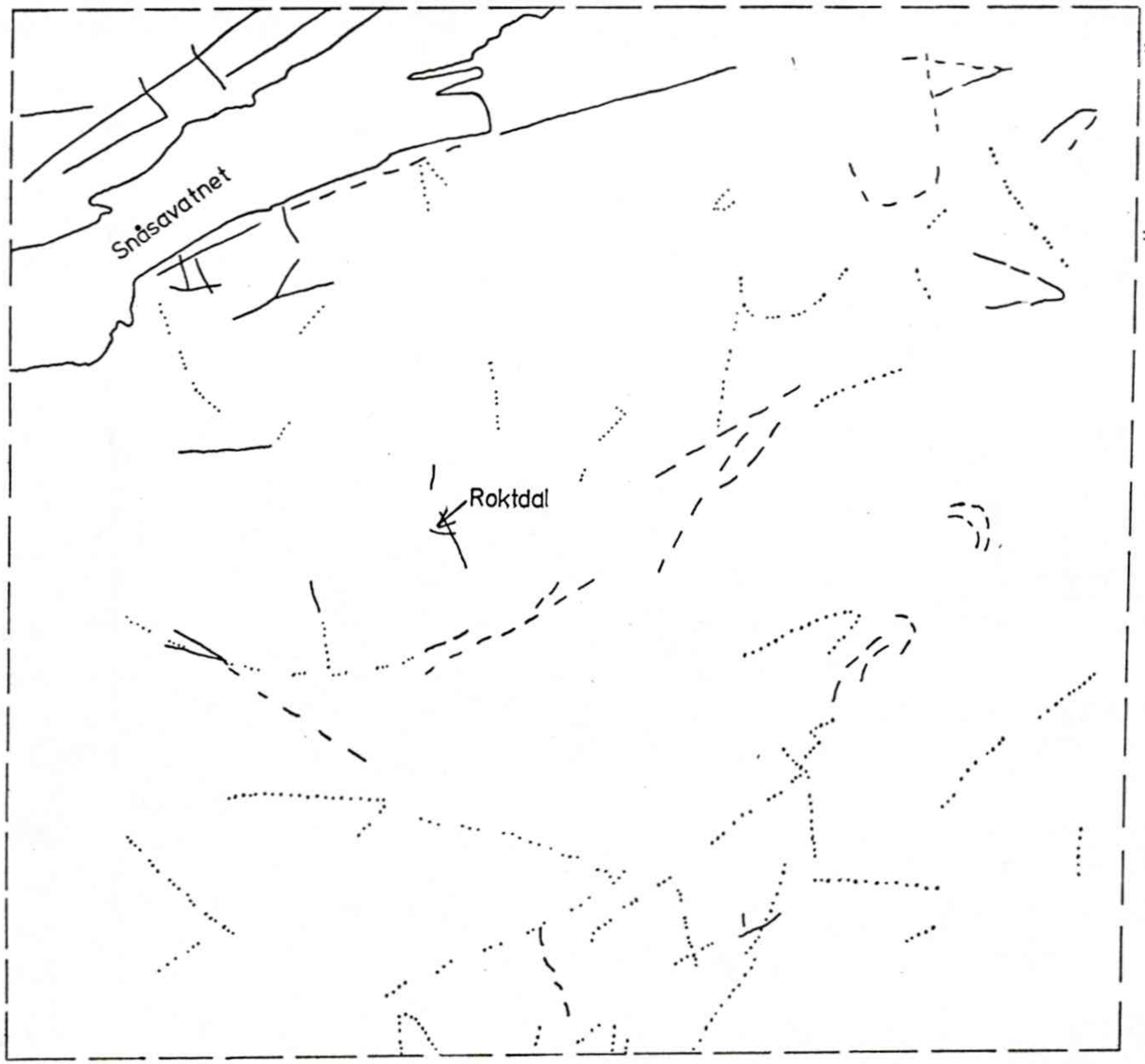


Fig. 25

=== Landsat structures from Ratios

Mss 6/7 RED
Mss 5/6 GREEN
Mss 4/5 BLUE

:::::: Landsat structures from Ratios

Mss 7/5 RED
Mss 6 GREEN
Mss 4 BLUE

8. BUDGET

The following table gives best estimates of the total expenditure until 31.12.1981.

The exact figure will be available by end of January 1982.

The proposed budget of 1.265.000 is estimated to be underspent by Nkr. 100.000.

This amount will be spent on a radiocommunication system to be used in the Roktdal project in 1982.

REVISED BUDGET ROKTDAL JOINT VENTURE 1981

	Proposed Budget	Revised Budget	Overrun	Underrun	Note
Salaries	310.000	250.000		+ 60.000	1
Vehicles	51.000	29.000		+ 22.000	2
Equipment	18.000	17.800		+ 200	3
Capital expenditure	-	260.000	- 260.000		3
Wages	288.000	270.000		+ 18.000	4
Fuel, maintenance	26.000	16.000		+ 10.000	5
Field camp.	13.000	23.000	- 10.000		6
Travel	46.700	22.000		+ 24.700	7
Geochemical analysis	147.500	90.000		+ 57.500	8
Geophysical surveys	15.000	3.000		+ 12.000	9
Landsat studies	20.000	15.000		+ 5.000	10
Trenching /blasting	7.000	-		+ 7.000	

	Proposed Budget	Revised Budget	Overrun	Underrun	Note
Consumables	64.100	100.000	- 35.900		11
Maps Photographs	6.000	23.000	- 17.000		12
Technical Research	5.000	5.000	-	-	13
Technical consultants	75.600	10.000		+ 65.600	14
Technical Liason	15.000	21.000	- 6.000		15
Airborne Logistical support	52.000	2.000		+ 50.000	
Contingency 9% 104.500					
Total	1.265.000	1.156.800	328.900	660.900	

REVISED BUDGET 1981
ROKTDAL I.V.

Explanations:

Note 1. 2 x 5 man month field geologist
60% of 10 man month project manager

Note 2. Nkr. 29.000 payment for mileage and car rental. The costs for the two purchased Toyota Hi-Lux are listed under capital-expenditure.

Note 3. +) The Toyota Hi-Lux were purchased at Nkr. 158.400.
Equipment - 1 Fluorine analyser + altimeter/compasses 17.800 Nkr.
+) Purchase of one deep overburden system for Nkr. 100.000.

+) Capital expenditure.

Note 4. Nkr. 15.000 wages draughtsman.
Nkr. 250.000 wages field assistants.

Note 5. Fuel, Maintentance Nkr. 15.100.

Note 6. Rent for field camp/huts, telephone

Note 7. Travel/Mob. Demob. BP-Norge staff + field assistants.

Note 8. Fees for geochemical analysis of stream sediments, soil, rock chip samples.

Note 9. Lease of Scintillometer

Note 10. Part of Nord Trøndelag study.

Note 11. Field equipment, copies, draughting material etc.

Note 12. Base maps, geol. maps, blow up's etc.

Note 13. Thin/polished sections

Note 14. C. Halls consultancy

Note 15. Technical Liason
M.J. Davies/Dr. Tom Elder

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10) Aukes, P.G., Reymer, A.P.S., de Ruiter, G.W.M., Stel, H. and Zwart, M.J., 1979: The geology of the Lierne District, northeast of the Grong culmination, Central Norway: N.G.U. 354, 115-29.

11) Klingspor, I and Trøeng, B., 1980: Rb-Sr and K-Ar determinations of the Proterozoic Olden granite, Central Caledonides, Jämtland, Sweden: G.F.F. 102, 515-22.

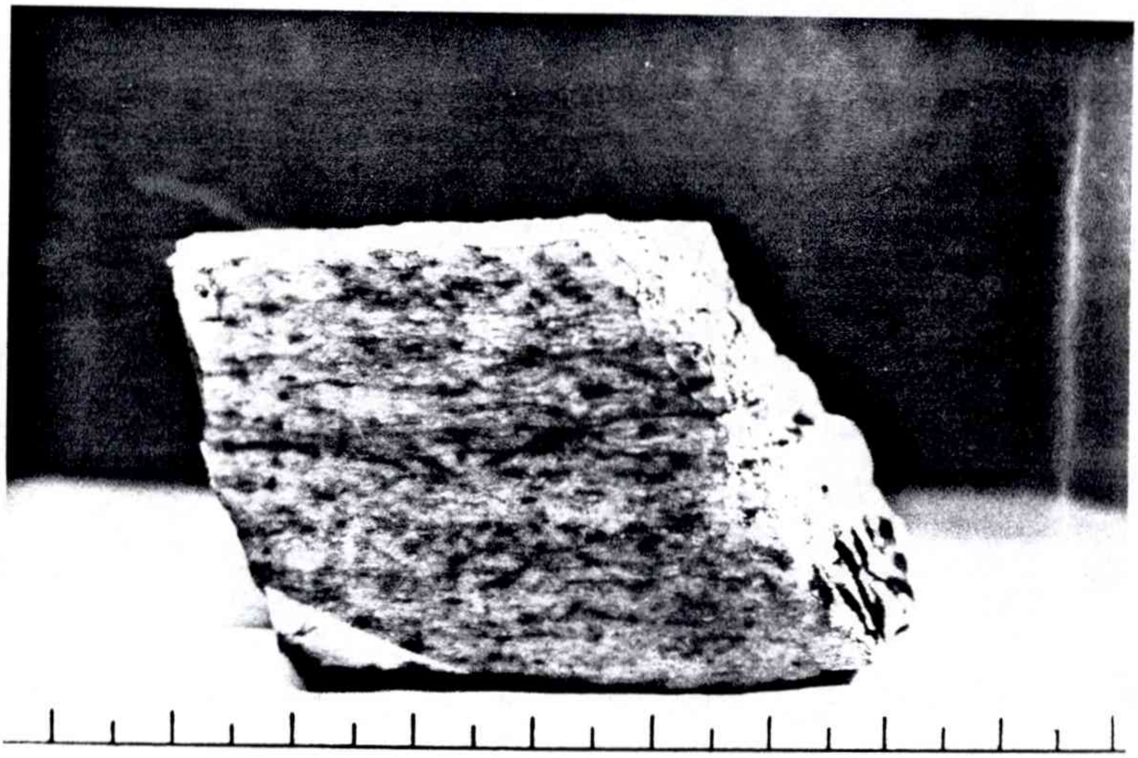
12) Foslie, S., 1959, Berggrunns geologiske kart, 1:100.000: Jaevsjo

13) Foslie, S., 1960, Berggrunns geologiske kart, 1:100.000: Nordli

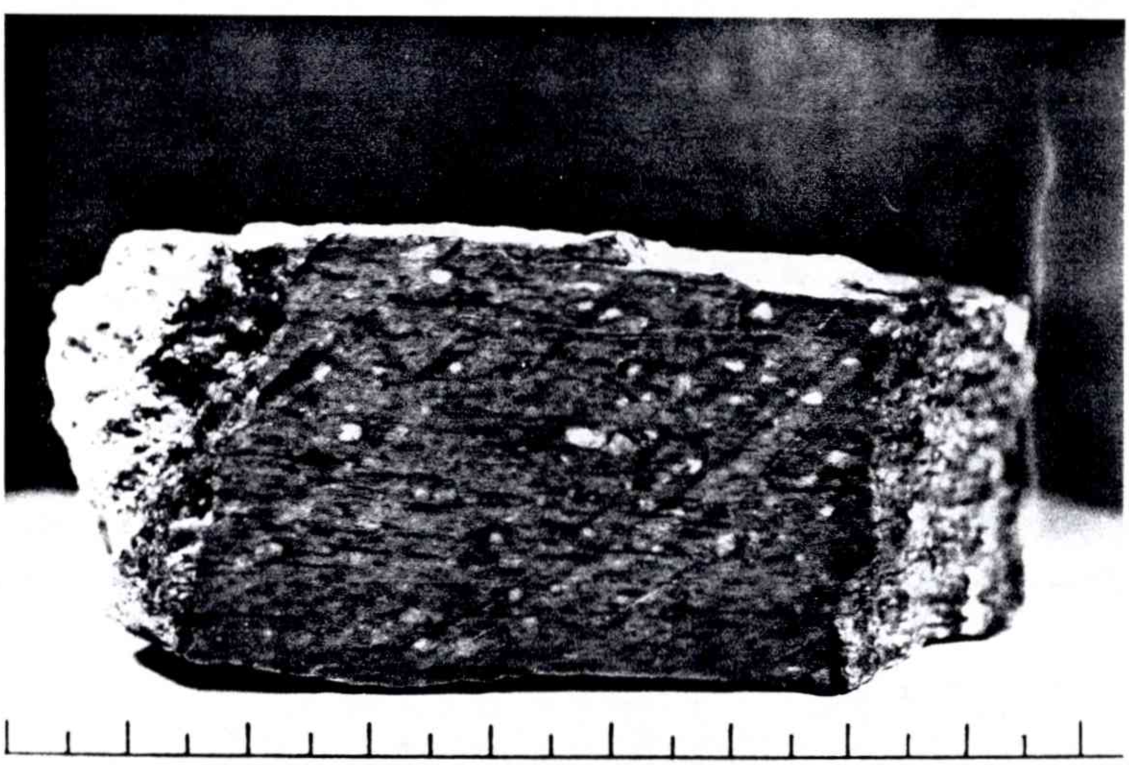
14) Foslie, S., 1958, Berggrunns geologiske kart, 1:100.000: Sandøla

15) Foslie, S., 1960, Berggrunns geologiske kart, 1:100.000: Sørli

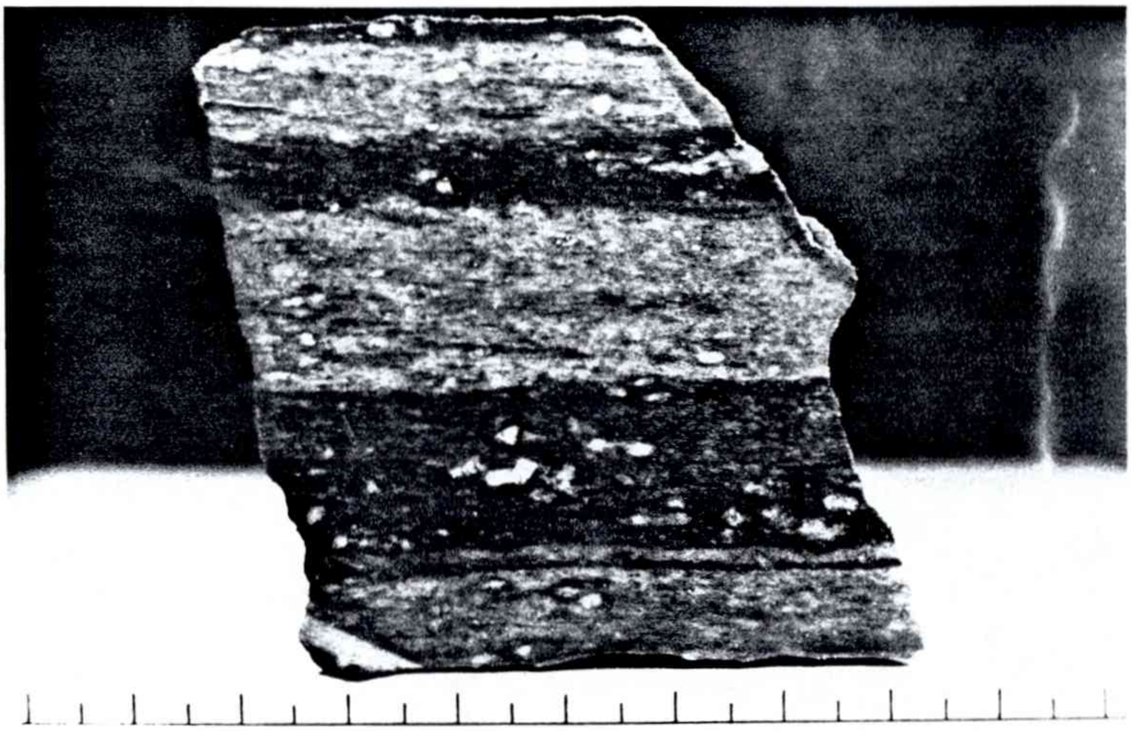
16) Wolff, F. Chr., 1976, Berggrunns geologiske kart, 1:250.000: Trondheim.



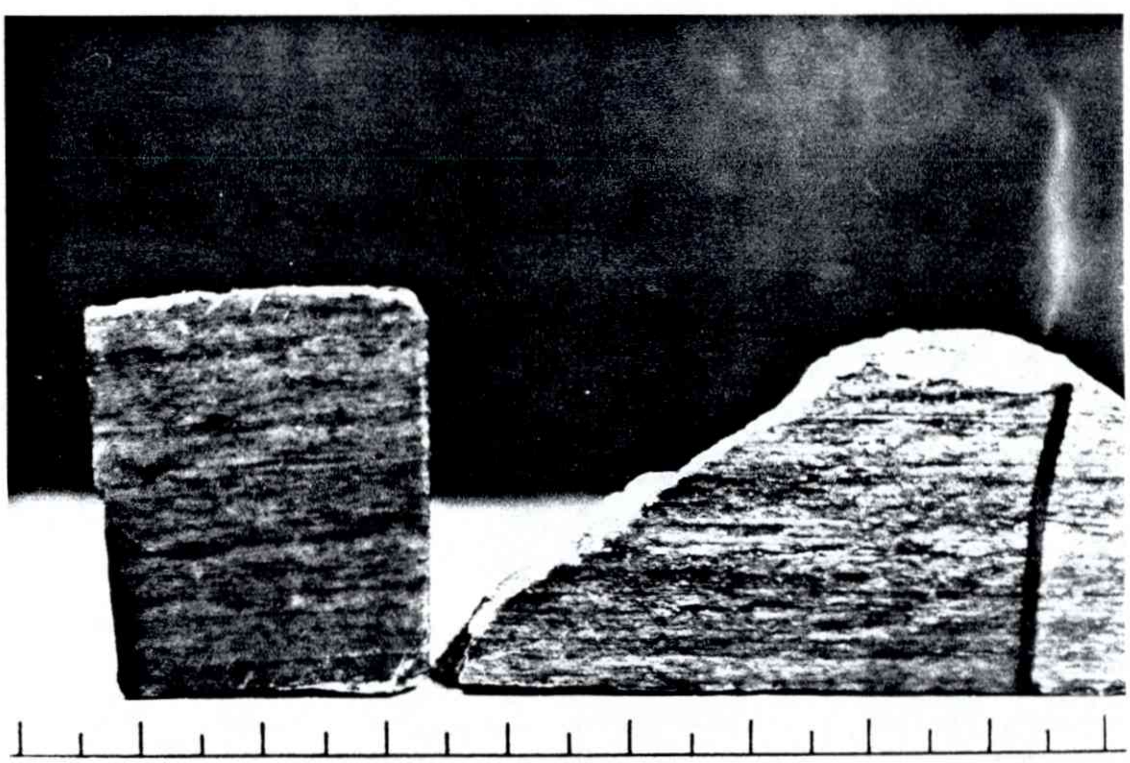
Pl. 1: Fine-grained leptite, north Lustadvatnet, e. Tømmerås (81.10.17)



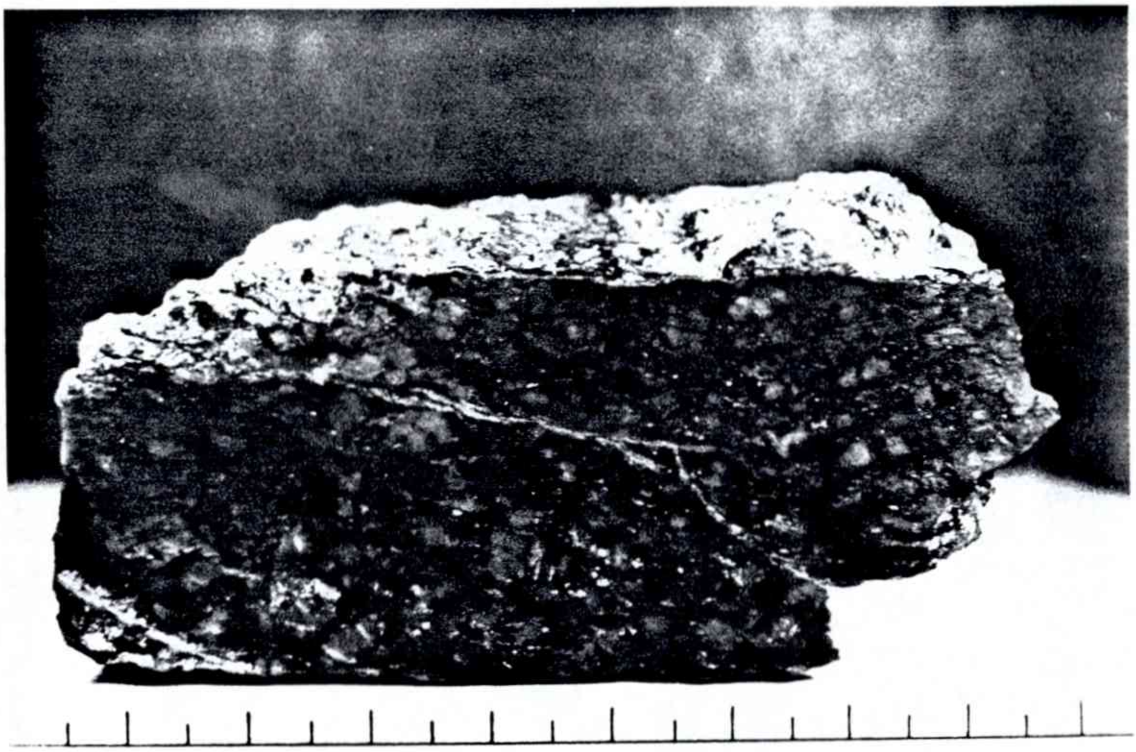
Pl. 2: Medium-grained leptite with coarse felspar, south Ogndalen, s. Tømmerås (81.10.14)



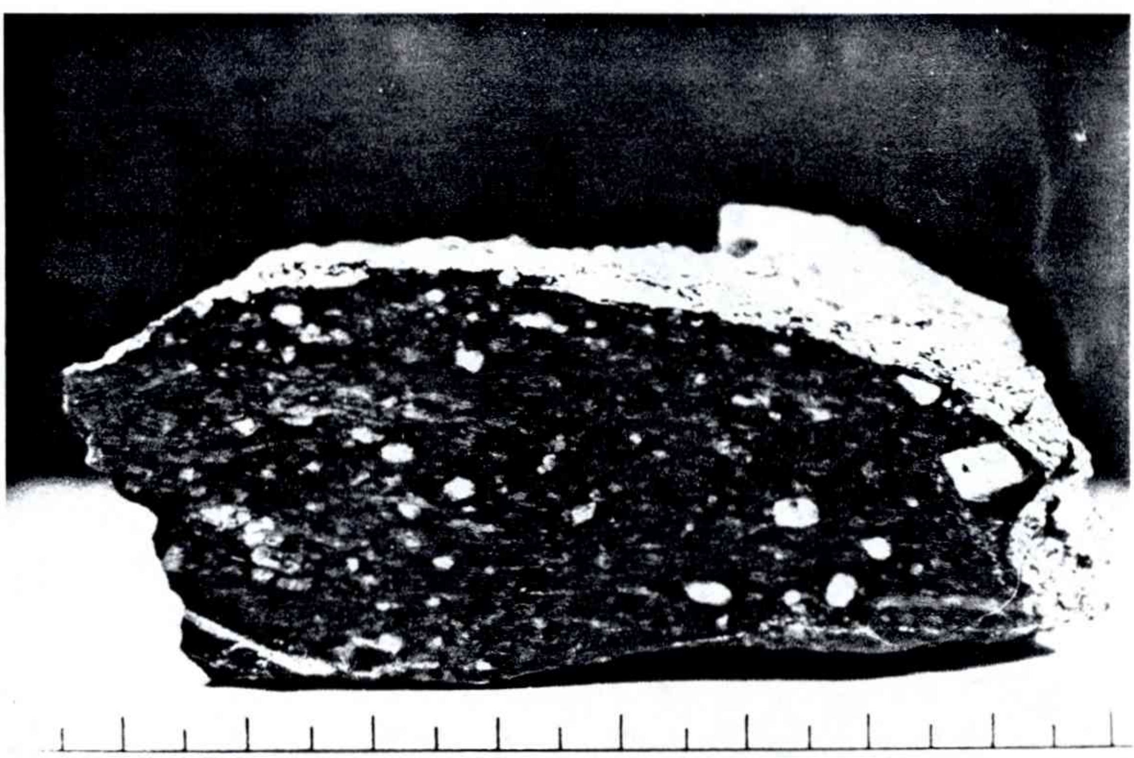
Pl. 3: Banded micaceous leptite, n. Tømmerås (80.01.21)



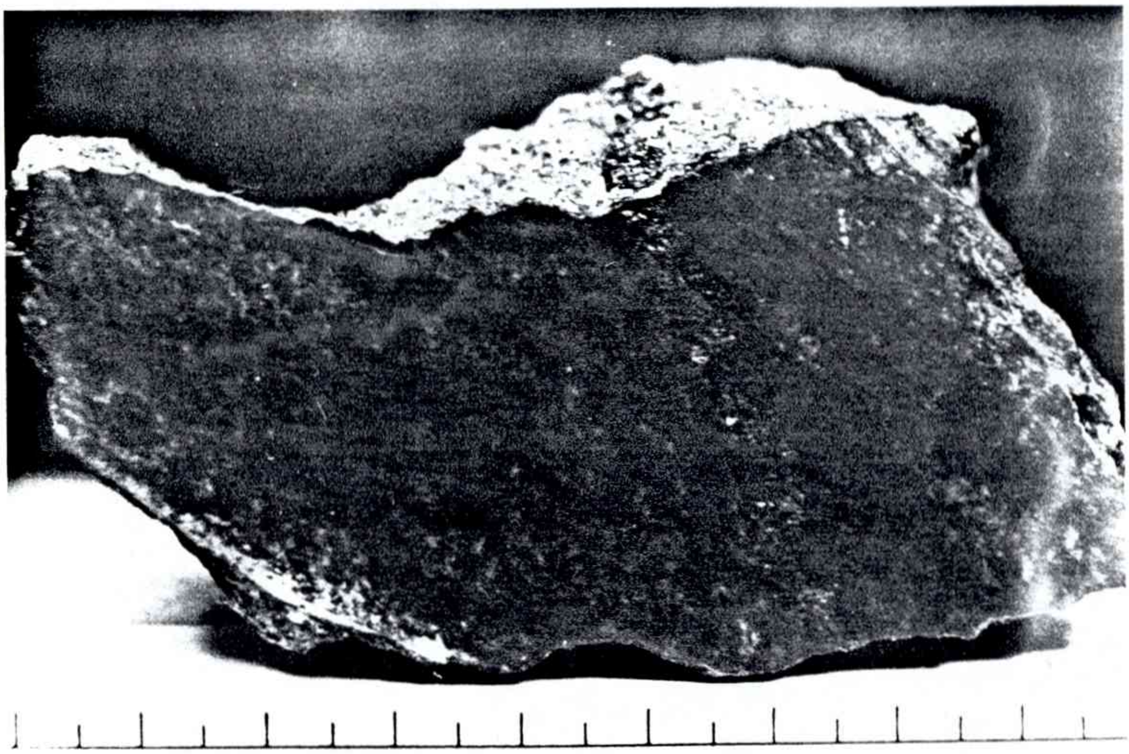
Pl. 4: Fine-banded micaceous leptite with 2757 ppm Zn, north Lustadvatnet, e. Tømmerås (81.10.19)



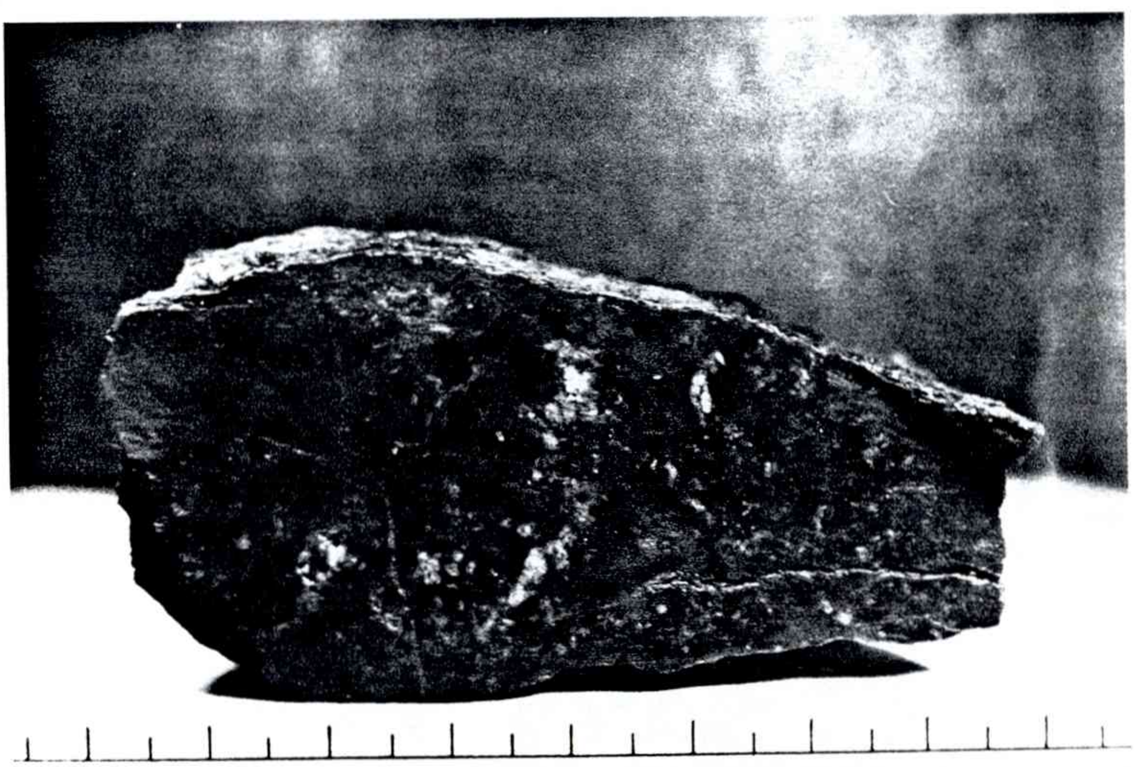
Pl. 5: Augen leptite, n. Tømmerås (80.01.25)



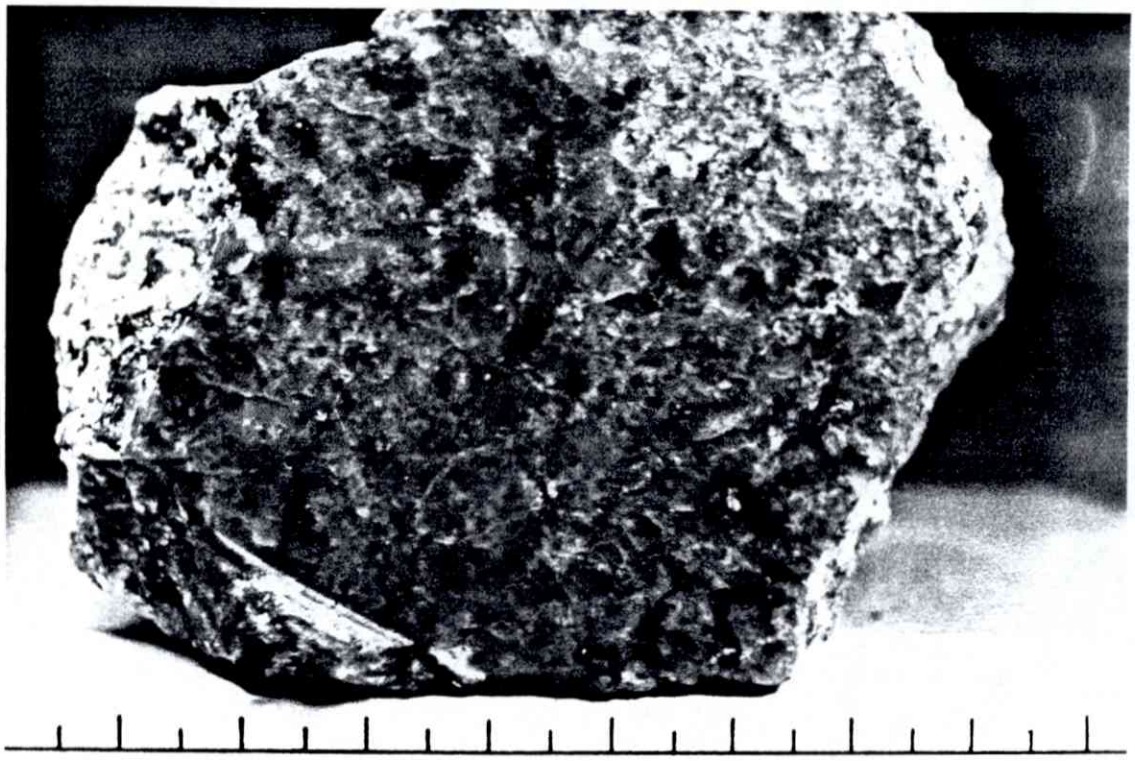
Pl. 6: Augen leptite, more deformed, n. Tømmerås (80.01.17)



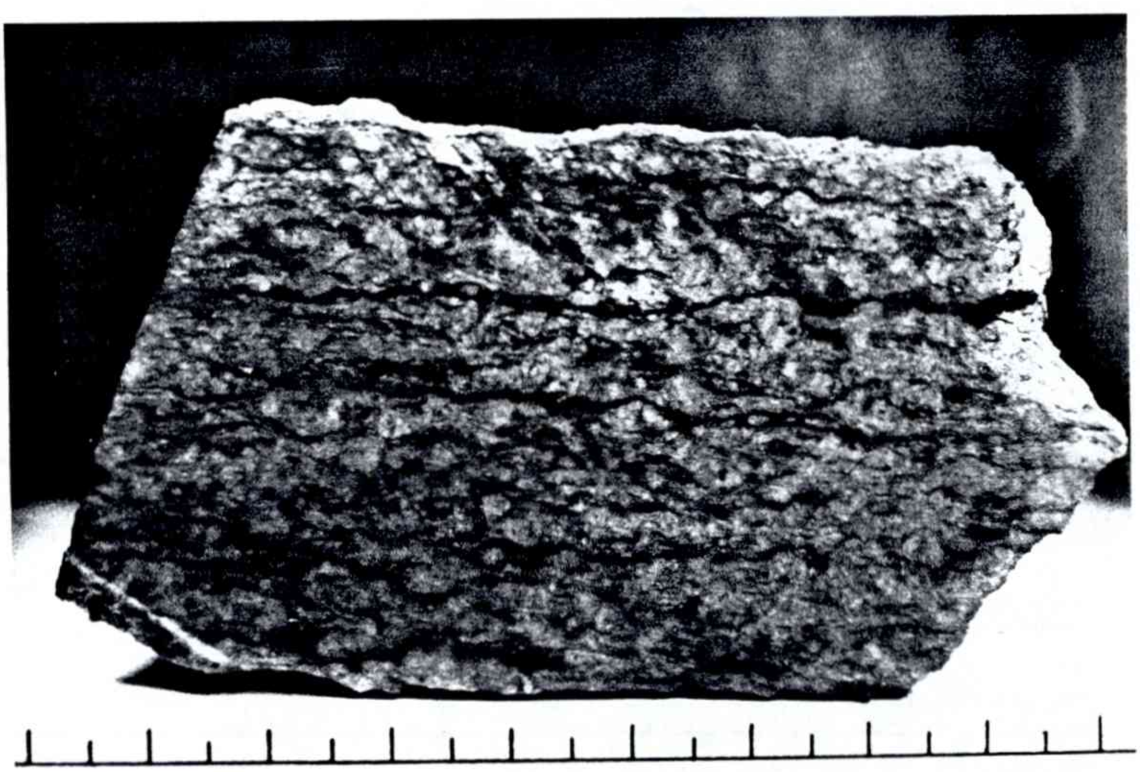
Pl. 7: Metagabbro/amphibolite, n. Tømmerås (80.01.27)



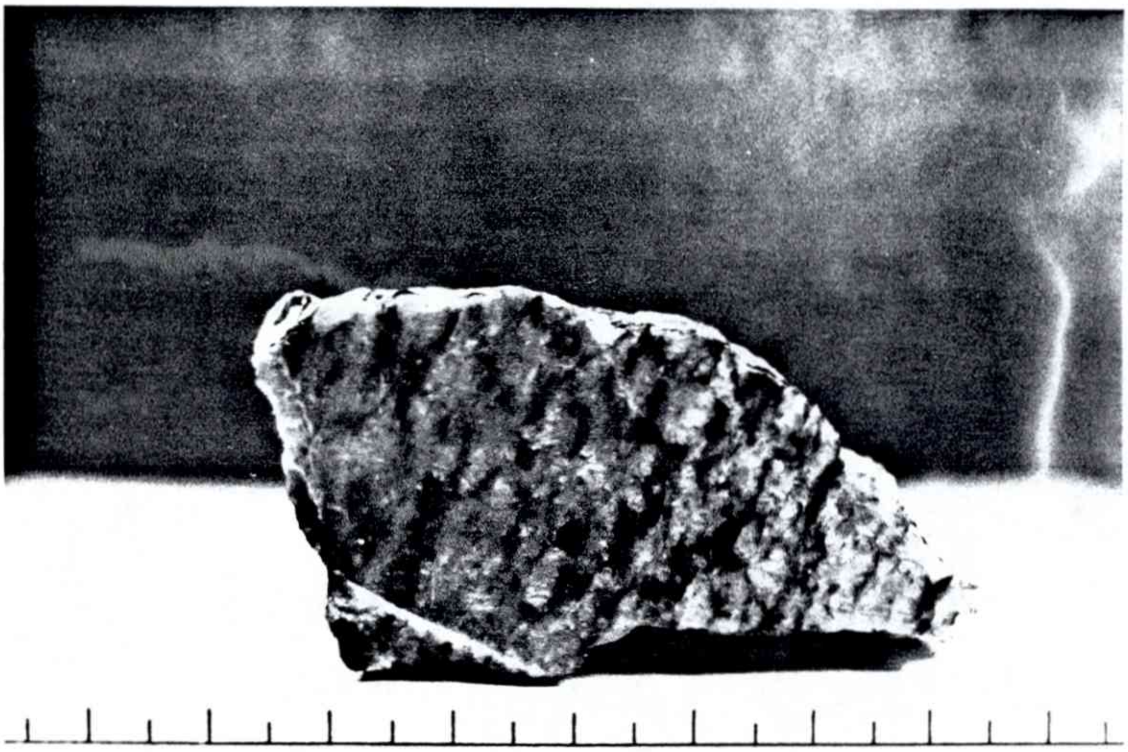
Pl. 8: Chlorite-amphibole schist in contact zone of metabasic body, n. Tømmerås (80.01.14)



Pl. 9: Haervola granite, s.e. Tømmerås (80.10.35)



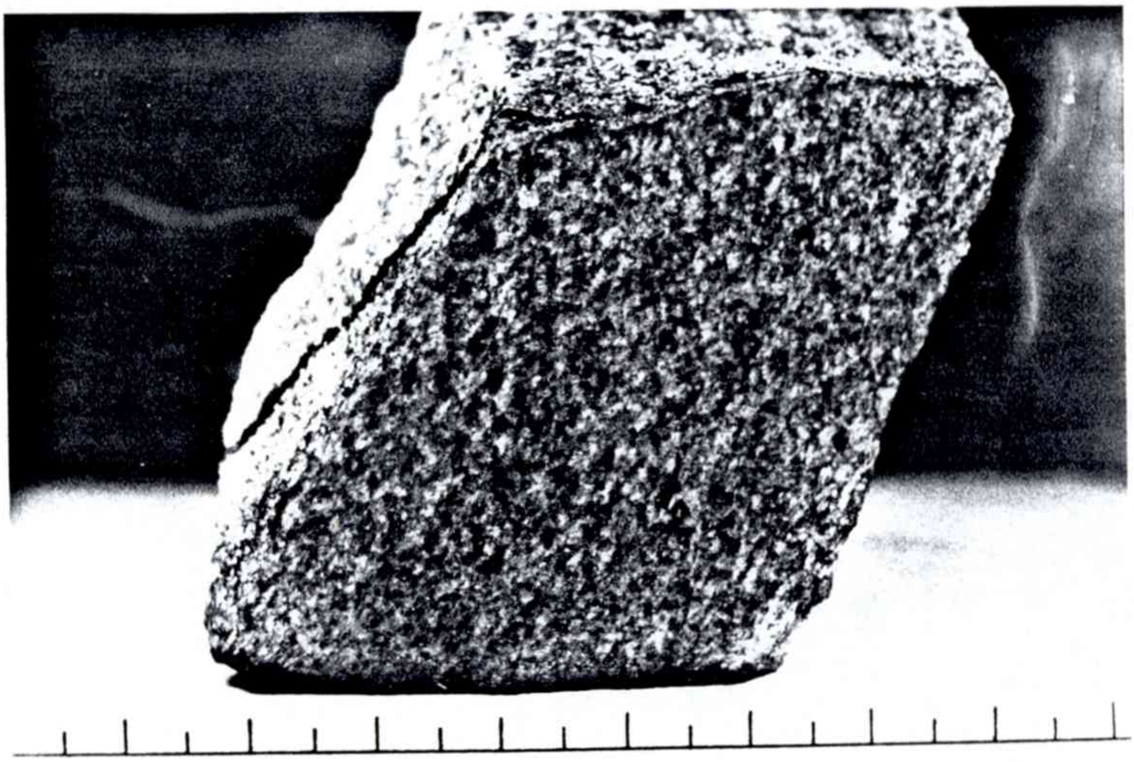
Pl. 10: Gneissose Haervola granite, s.e. Tømmerås (81.10.25)



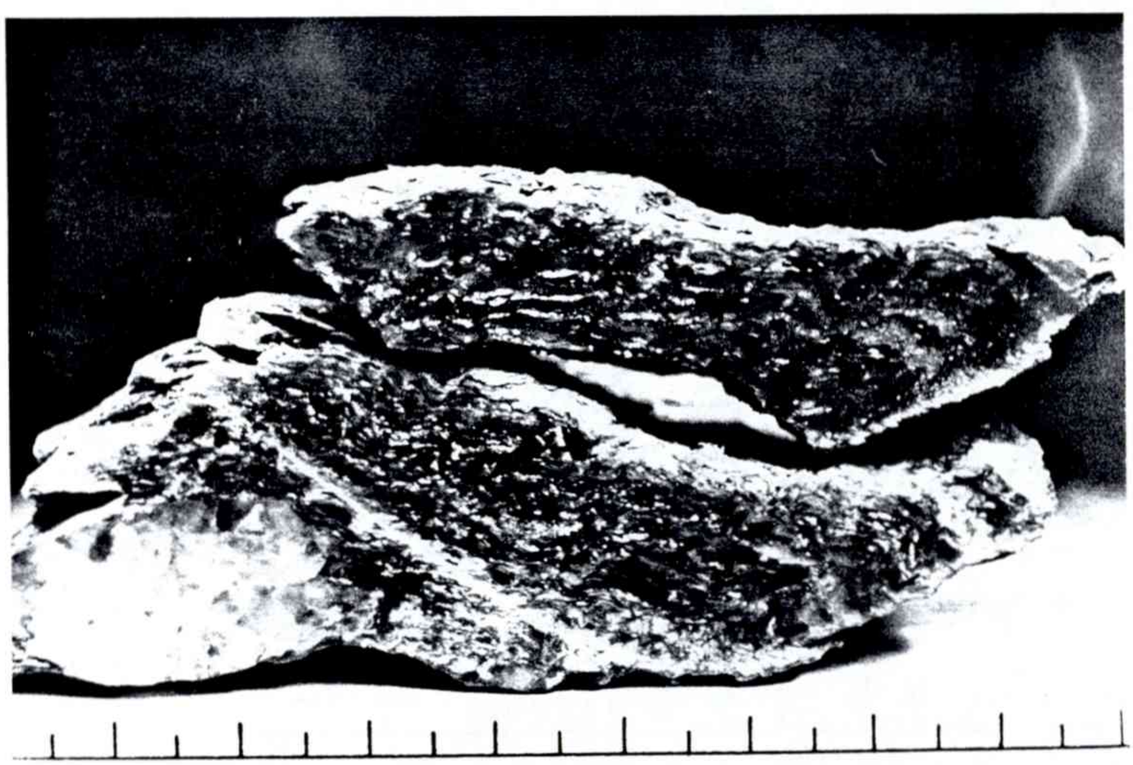
Pl. 11: Granite gneiss, Ogndalen, e. Tømmerås (81.10.02)

Pl. 12: White, pyritic quartzite, Berglia, e. Grong-Olden (81.10.57)

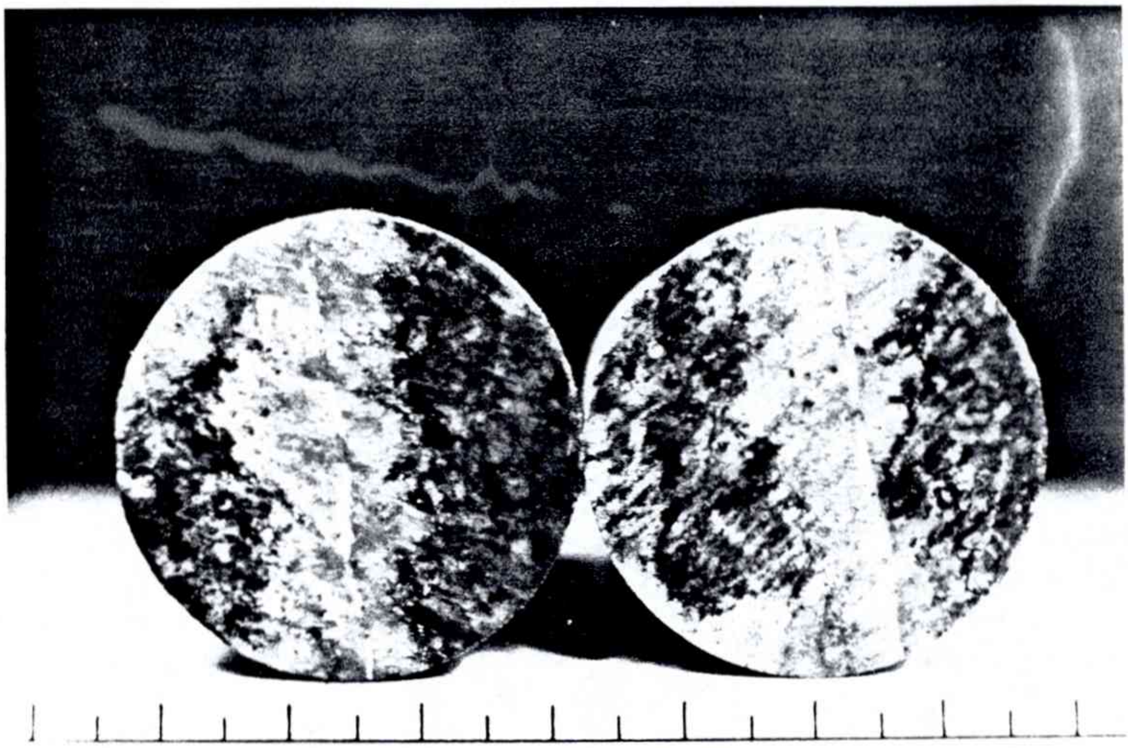
Pl. 13: Fine-banded grey quartzite + carbonate, Berglia, e. Grong-Olden (81.10.64)



Pl. 14: Impure marble, Gressåmoen, w. Grong-Olden (80.01.31)

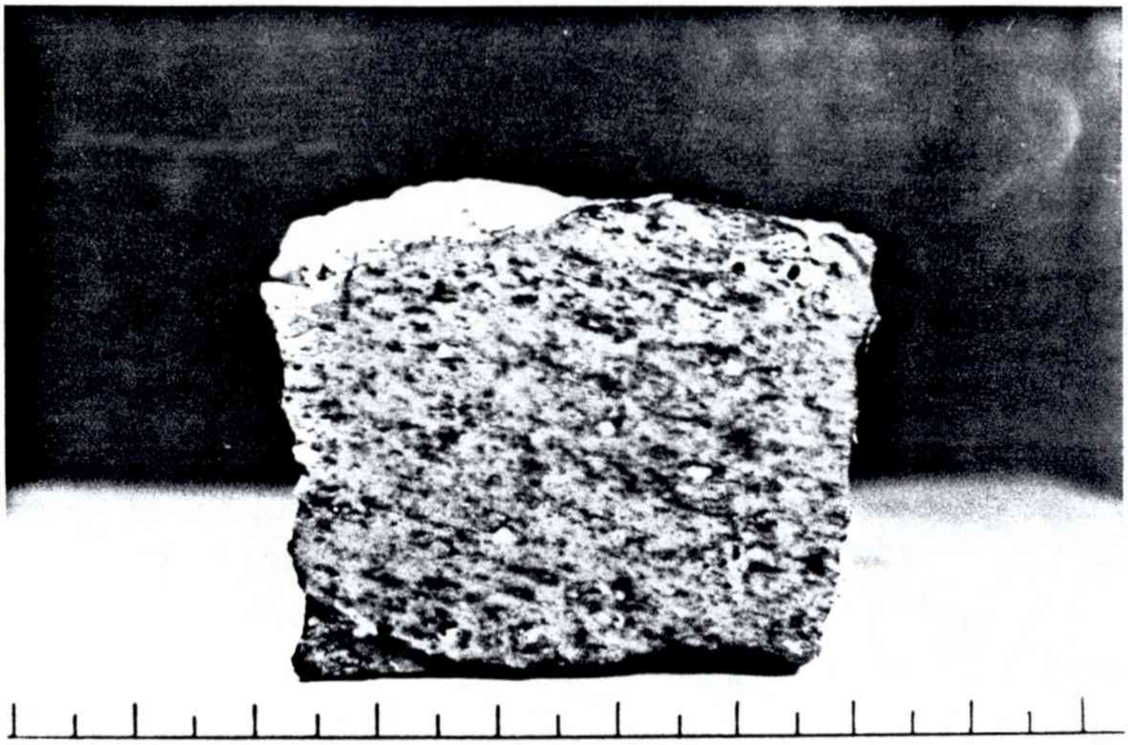


Pl. 15: Muscovite-garnet schist with quartz-vein boudins, n. Tømmerås (80.01.12)

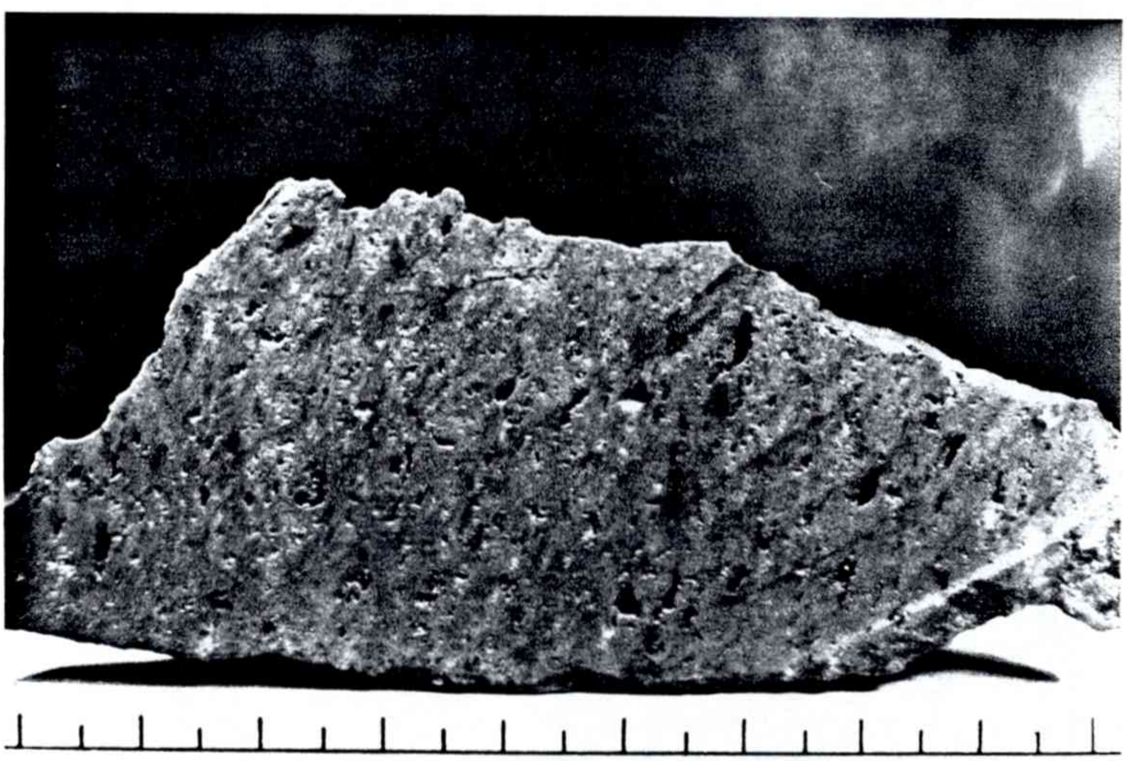


Pl. 16: Alteration of leptite along sub-vertical fractures, DDH 5, 34,3 m., Roktdal prospect (84.01.02)

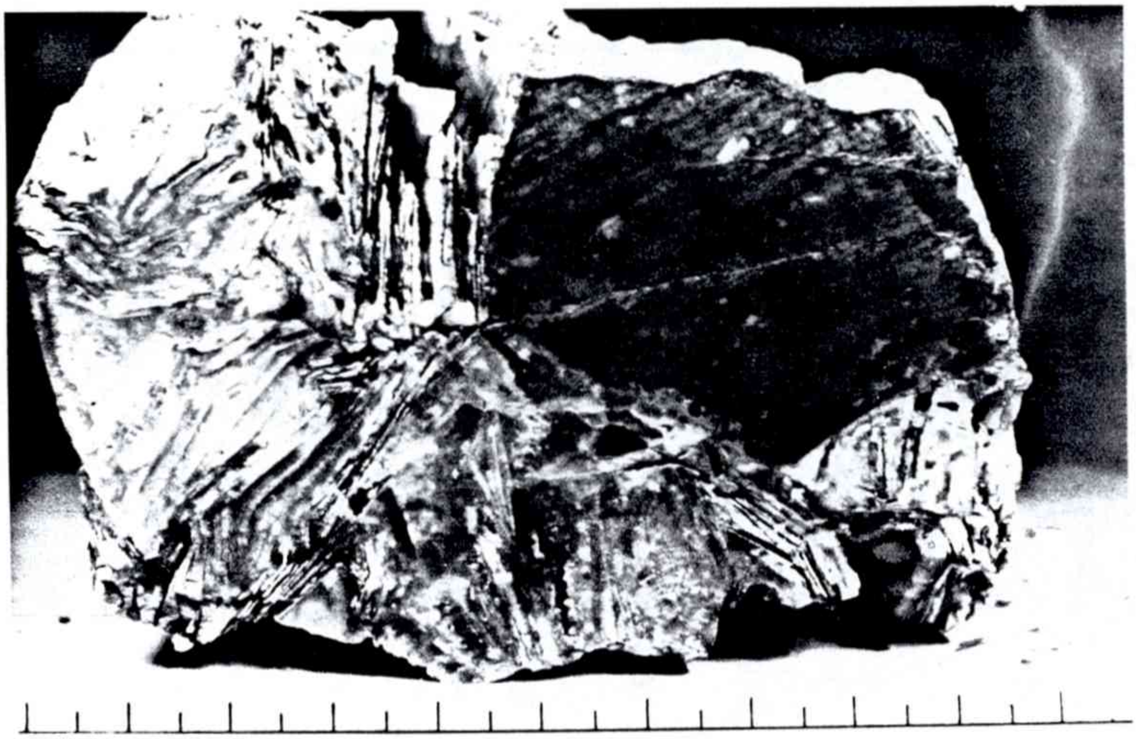
Pl. 17: Pervasively altered leptite with quartz-fluorite-amphibole veins, DDH 4, 51,9 m., Roktdal prospect. (84.01.09)



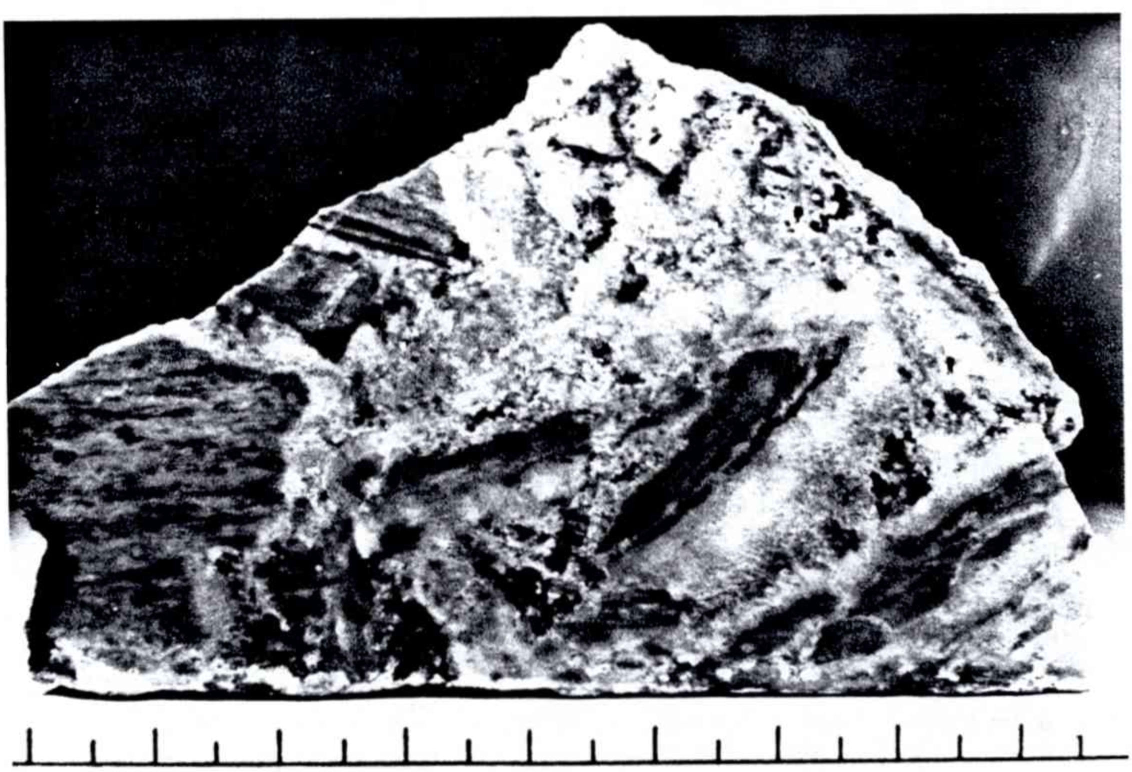
Pl. 18: Pervasively altered leptite, s. Ogndalen, s. central Tømmerås (81.10.12)



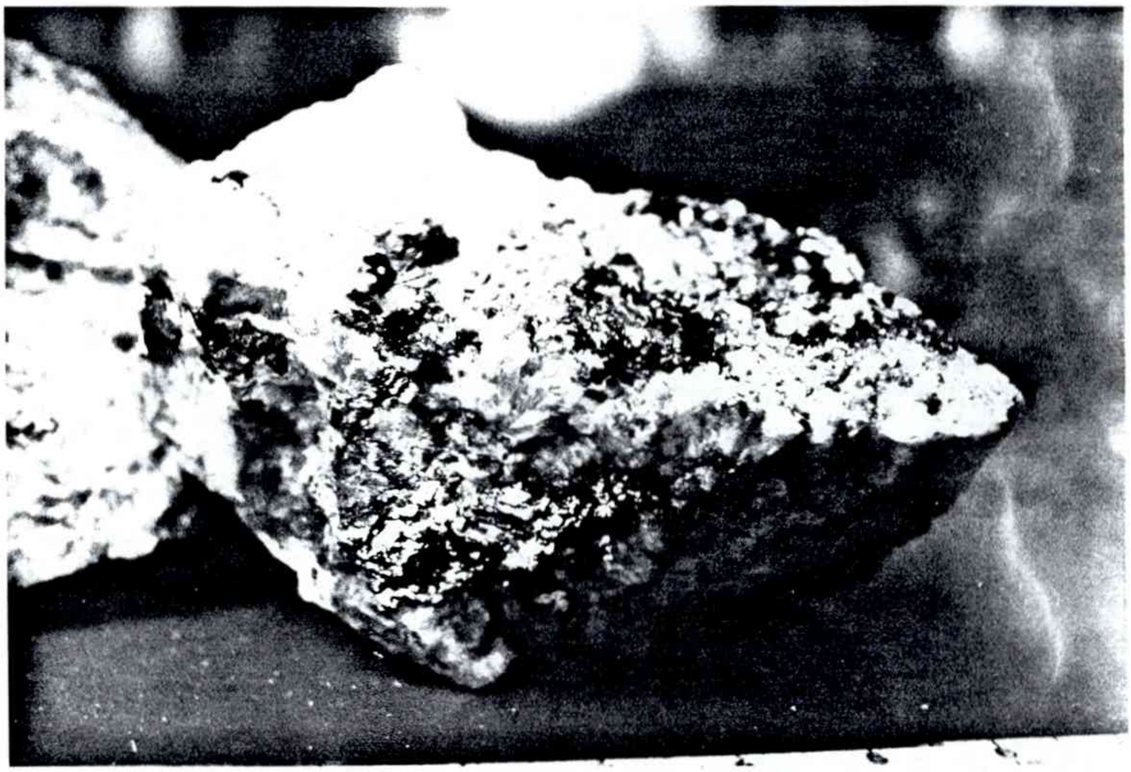
Pl. 19: Pervasively altered granitic gneiss, N. Kjesbuvatnet, s. Tømmerås (81.10.40)



Pl. 20: Leptite breccia, Meldalen fracture, west of Roktdal prospect (80.01.08)

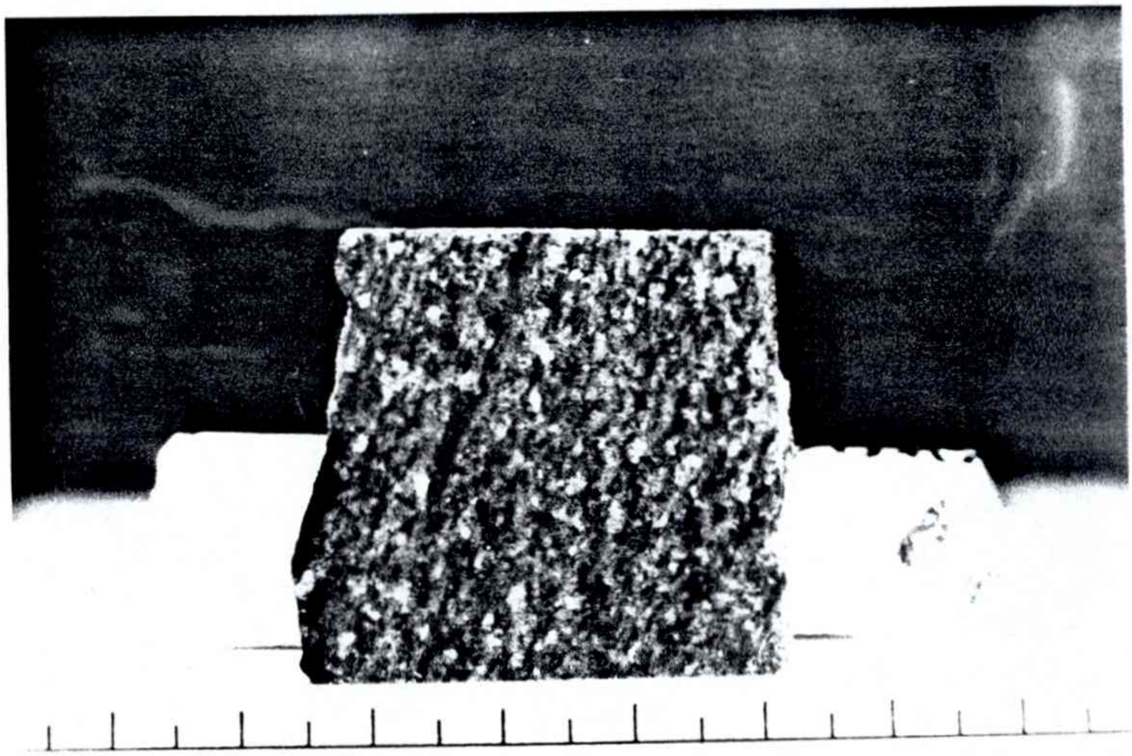


Pl. 21: Leptite breccia, Berglia, E. Grong-Olden (81.11.12)

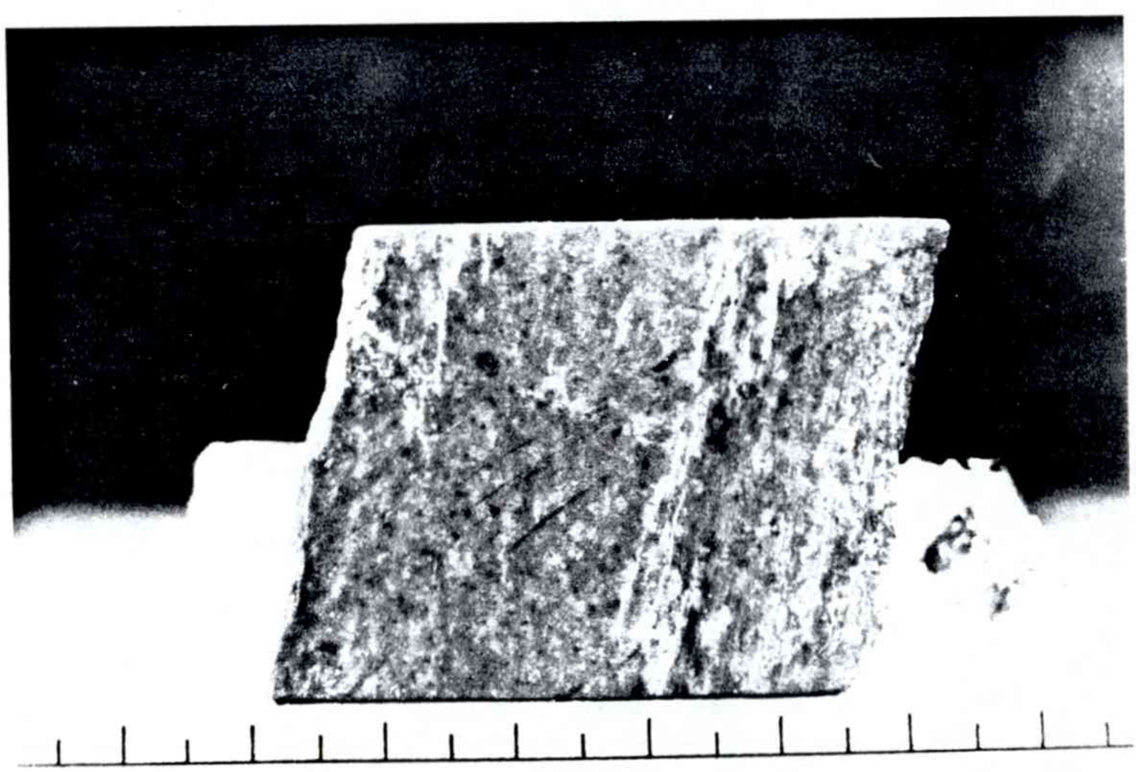


Pl. 22: Coarse-grained galena-chalcopyrite mineralization, Haervola, S.E. Tømmerås.

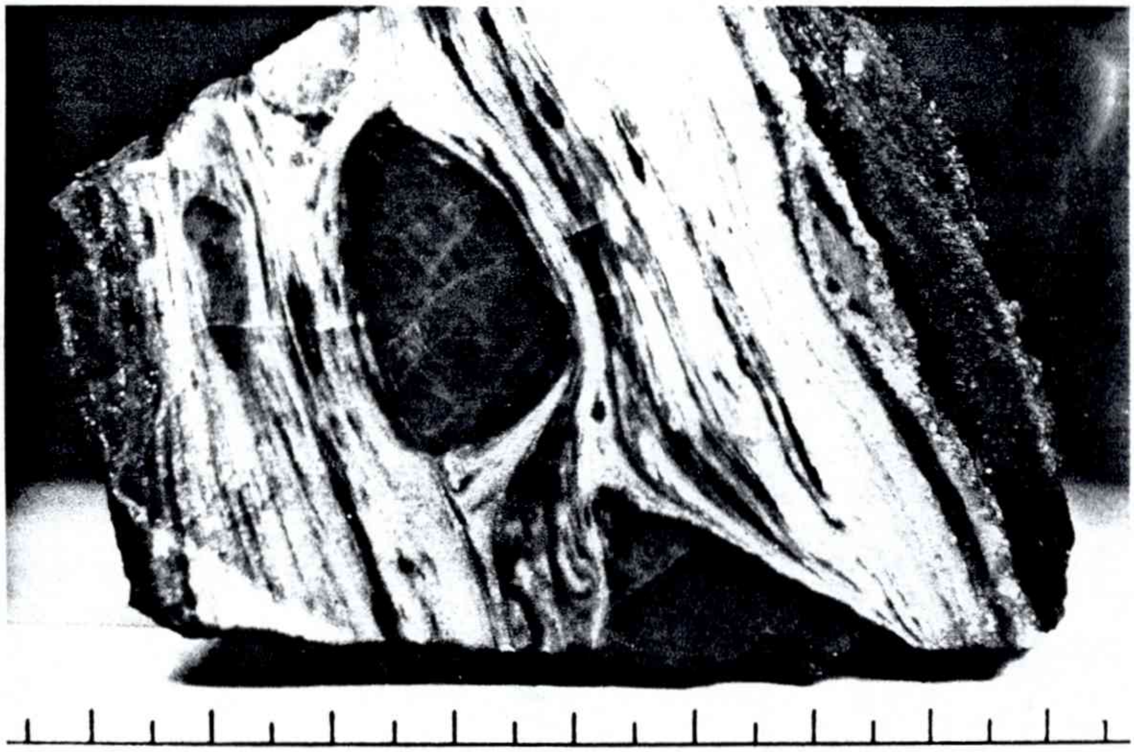
Pl. 23: Galena-chalcopyrite mineralization in rosette-formed vein quartz, Haervola.



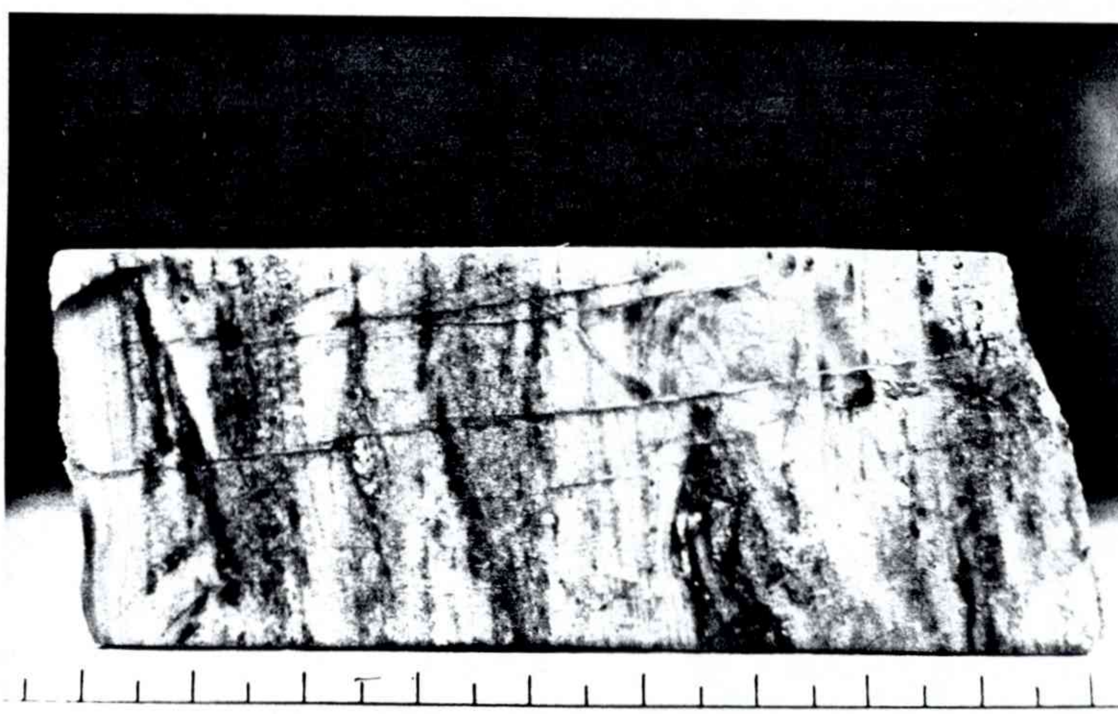
Pl. 24: 'Unaltered' leptite, DDH 6, 71,6 m., Roktdal prospect (84.01.14)



Pl. 25: Pervasively altered leptite, DDH 5, 38.6 m, Roktdal prospect (84.01.12)

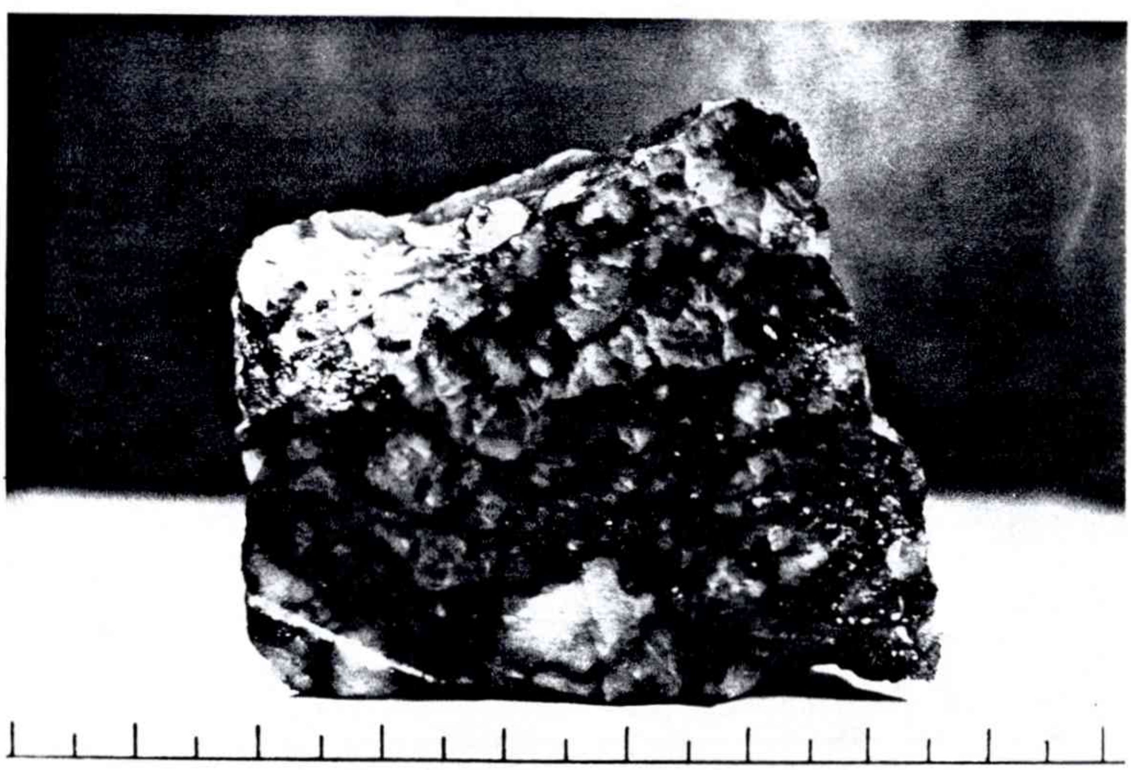


Pl. 26: Fluorite boudins in carbonates, Roktdal

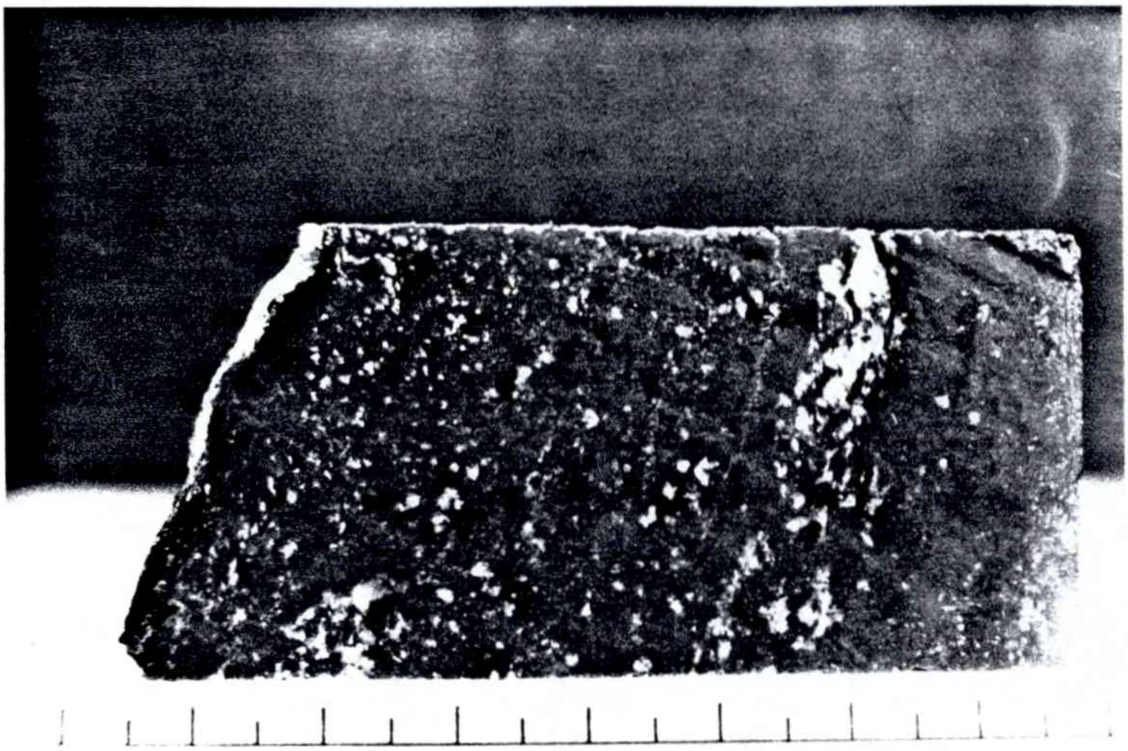


Pl. 27: Isoclinally folded fluorite-carbonate, DDH 3,
10,0 m., Roktdal prospect (84.01.06)

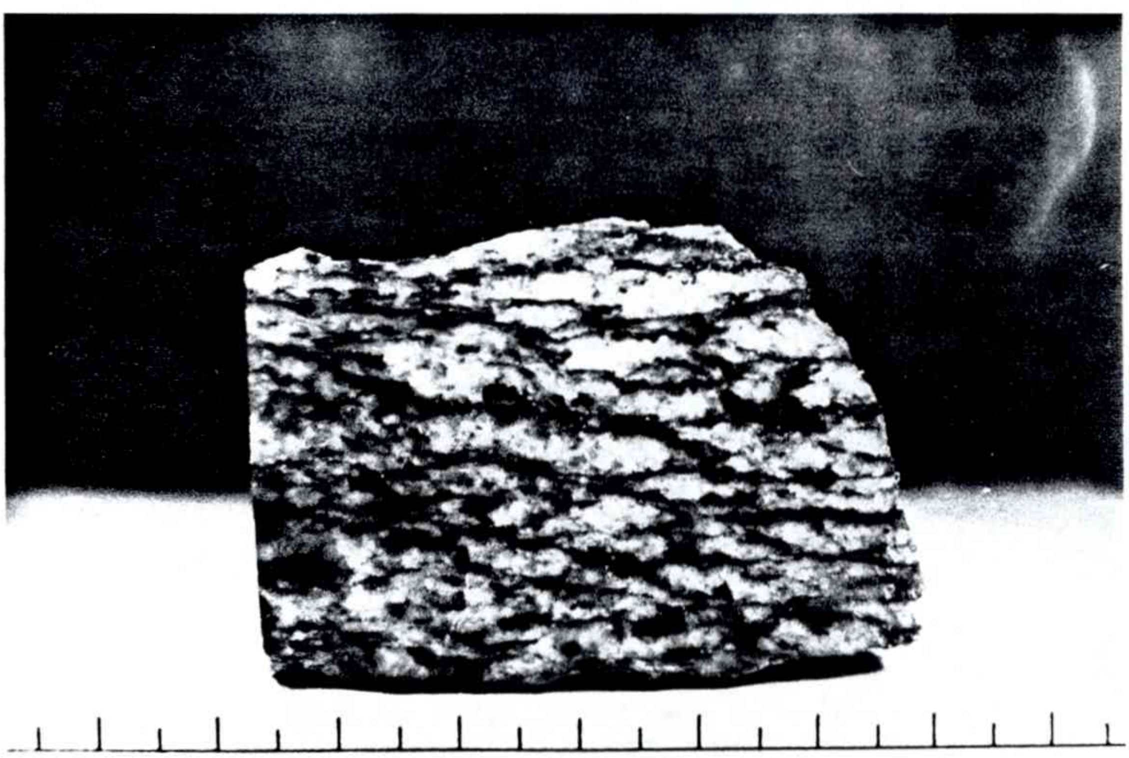
Pl. 28: Massive sphalerite-galena mineralization, Roktdal prospect.



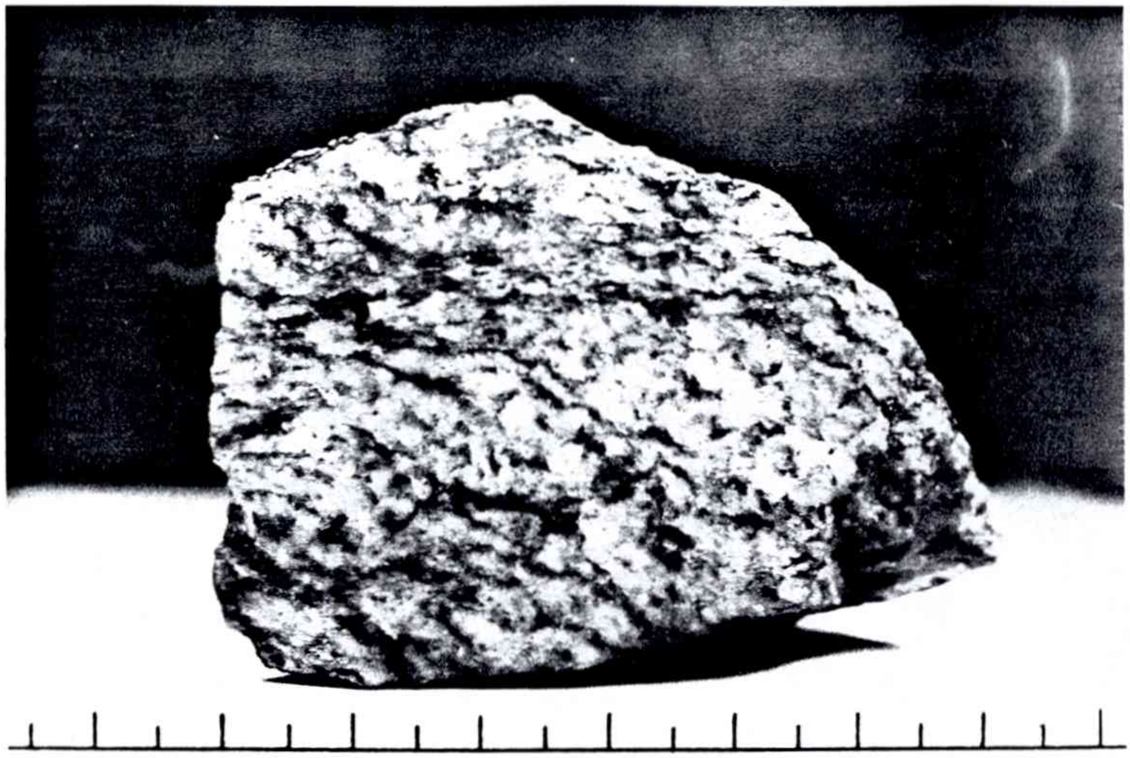
Pl. 29: Remobilized sphalerite-galena mineralization, Roktdal prospect.



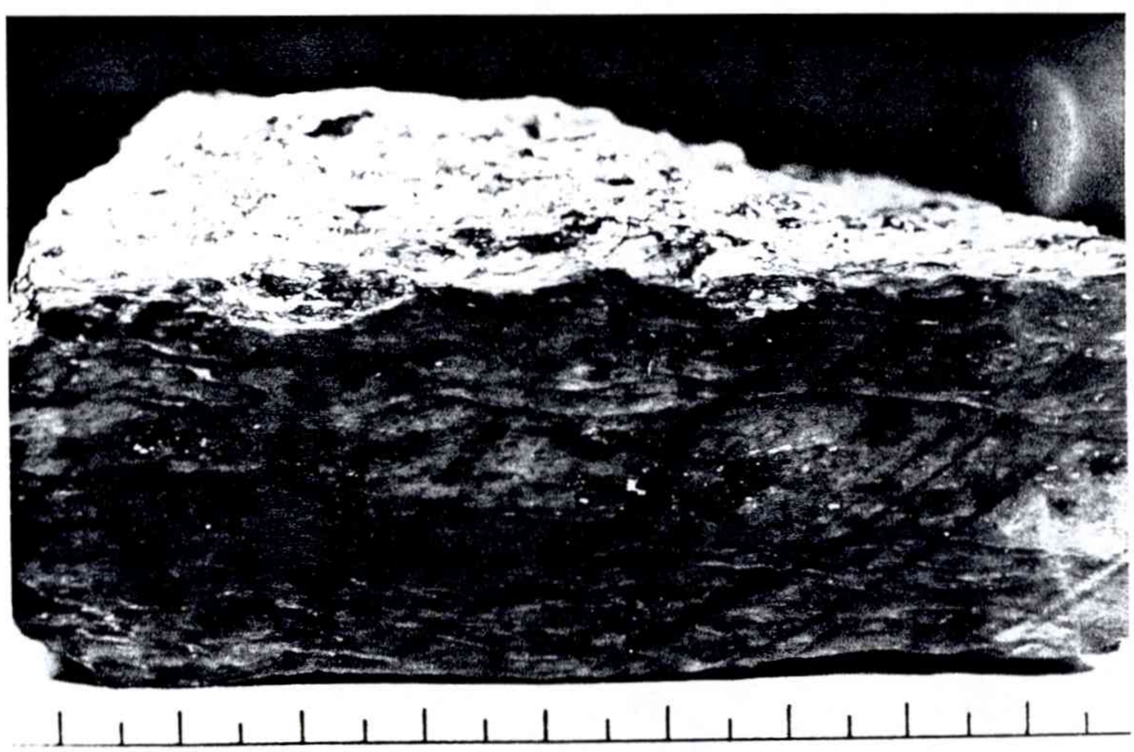
Pl. 30: Coarse-grained amphibolite with minor disseminations of galena and pyrite, DDH 4, 24,7 m., Roktdal prospect (84.01.08)



Pl. 31: Foliated granite, northern Lurudalen, W. Grong-Olden (80.10.52)



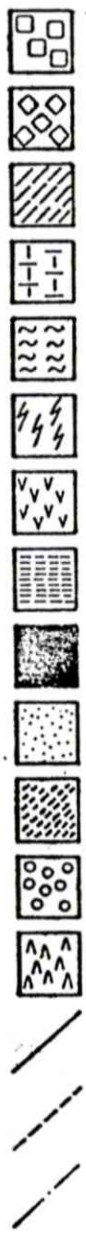
Pl. 32: Granite/leptite transition lithology, northern Lurudalen, W. Grong-Olden (80.10.53)



Pl. 33: Galena mineralization in grey quartzite, Gressåmoen prospect, W. Grong-Olden (80.01.35)

ROKTDAL PROJECT 1981
RECONNAISSANCE GEOLOGICAL MAPPING

LEGEND:



- LEPTITE
- AUGEN - LEPTITE
- MICACEOUS LEPTITE
- GRANITE
- GRANITIC - GNEISS
- BRECCIA
- METAGABBRO/AMPHIBOLITE
- PHYLLITE/GRAPHITIC SCHIST
- MARBLE
- QUARTZITE
- MICA - SCHIST
- PALAEOZOIC COVER ROCKS
- PALAEOZOIC GREENSTONES
- LITHOLOGICAL BOUNDARY
- BOUNDARY INFERRED
- FAULT / FRACTURE