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Tittel
Genesis of the Joma Stratiform Sulphide Deposit, Central Norwegian Caledonides

Forfatter	Dato	År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Olsen, Jørn	16.06	1978	Grong Gruber AS

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Røyrvik	Nord-Trøndelag		1924 1	Grong

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geologi		Jomaforekomsten

Råstoffgruppe	Råstofftype
Malm/metall	Cu, Zn, Py

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Del av doktor-arbeid, skrevet på engelsk
Forkomsten i en bergartsserie med grønnsteiner, fyllitter og kvartsitter i en svakt metamorfisert skyvedekke sekvens. 2 deformasjonsperioder.
Tholeiitic basaltsammensetning, dannet i en back-arc basin.
2 hovedtyper malm : Massive pylag med kalksteiner og massive cpy/po malm medbreksjer i klorittskifer.
Diskusjon av cpy/po-malmen sin genese i lys av den stratigrafiske posisjon

Kopi til:
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7894 Limingen.

FREMDRIFTSRAPPORT.

Inneholder hovedresultatene av mitt arbeid på Joma-malmen fra juni -76 til juni -78.

Trondheim, 16-6-1978.

Jørn Olsen.

Jørn Olsen.

FORORD.

Fremdriftsrapporten inneholder resultatene av arbeidet frem til juni 1978. Ingen detaljerte mineralogiske/petrografiske beskrivelser presenteres.

Selve rapporten er to-delt. Først presenteres det foreløpige manuskript til IAGOD-møtet, Salt Lake City, U.S.A., august 1978. Manuskriptet presenterer hovedkonklusjonene for Joma-malmens opprinnelse.
Dernest presenteres i Appendix I - VI resultatene av 72 fulle silikat-analyser, hvorav 59 er utført av undertegnede ved Geol.Inst., NTH, mens 13 er utført ved Kjemisk avd., Norg. Geol. Undersøkelse. Appendix VII inneholder et diagram i hvilket 4433 Cu/Zn - analyser er plottet. Disse analysene er utført ved Grong Gruver A/S.

Jostein Sandvik og Ivar Rømme introduserte undertegnede til den edle kunst å utføre fulle silikat-analyser. I.Rømme utførte analysene på FeO, samt noen Fe_2O_3.
Anne Irene Johannesen tracet figurer og vertikal-snittene i bilagsmappen.

Bilag: En mappe inneholdende 30 fargelagte geologiske vertikalsnitt fra Joma-malmen.
En mappe inneholdenede tracingene til disse vertikalsnittene.

GENESIS OF THE JOMA STRATIFORM SULPHIDE DEPOSIT, CENTRAL NORWEGIAN CALEDONIDES.

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ABSTRACT.

The Joma orebody is a massive, stratiform sulphide deposit interbedded in a rock series consisting of greenstones, phyllites and quartzites, belonging to a weakly metamorphosed nappe sequence in the central Scandinavian Caledonides. The area has undergone at least two episodes of penetrative deformation.

The ore body is situated within a sequence of basaltic greenstones of tholeiitic composition. Trace element contents of the greenstones suggest formation in a back-arc basin.

The deposit consist of two principal ore types: 1) a massive, pyritic layer with interbedded meta-limestone and lenses of chlorite schist, and 2) a massive chalcopyrite/pyrrhotite ore containing layers, lenses and rolled fragments of pyritic ore, chlorite schist and quartz.

The genesis of the chalcopyrite/pyrrhotite ore is discussed in the light of its stratigraphic position.

GEOLOGICAL SETTING.

The Joma stratiform sulphide deposit is situated in the north-eastern part of the Grong Area, a name given to a depressed segment of the Køli nappe sequence in the central Norwegian Caledonides. A recent review of previous work within the area, and a description of its geology and tectonics is given by Halls et al. (1977), see Fig. 1.

The Joma deposit is imbedded in the greenstones of the Røyrvik Group, which is an equivalent of the Remdalen Group in Swedish terminology (Kollung, 1978). This unit dominate the lithology of the Leipik Nappe of Zachrisson (1969), see Fig.1.

Halls et al. (1977) interpret the Gjersvik eruptive complex as representing a somewhat immature, ensimatic island arc. The

Limingen Group is a series of sediments derived from the rocks of this island arc during a period of uplift and erosion.

The stratigraphic position of the Røyrvik Group with respect to the Limingen Group is difficult to establish, since the contact between them is represented by the thrust zone at the base of the Gjersvik Nappe (Fig. 1). No fossil remains have yet been found within the Røyrvik Group to help in this discussion. Therefore, trace element contents of the greenstones will be given below in an attempt to indicate the relative positions of the Røyrvik and Limingen Groups. Furthermore, a short description of the Joma deposit will be given with reference to its genesis. Detailed petrological, structural or ore textural descriptions will not be presented here.

TECTONO-STRATIGRAPHIC POSITION OF THE RØYRVIK GROUP.

GENERAL

The succession of rocks has been subjected to at least two periods of deformation. The earliest recordable deformation (D_1) is represented by isoclinal folds (F_1) with a NW-SE-trending axial direction, and, on a larger scale, by thrusting and nappe development. The second deformation (D_2) was accompanied by open to tight assymetric folds (F_2) at nearly right angles to the F_1-axis. As seen from Fig.1, the thrust zones of D_1 are clearly deformed by D_2 (Halls et al., 1977; Kollung, 1978). Less important deformations may have occured subsequent to these, but are not yet fully documented. D_1 and D_2 are both accompanied by a penetrative schistosity. However, enough remnants of primary textures are found throughout the area to permit an interpretation of the geological evolution.

The Røyrvik Group consists of a quartz-conglomerate (the Portfjäll conglomerate) grading laterally into a series of quartzites (mapped as a sandstone facies near the Portfjäll conglomerate by S. Kollung), phyllites with lenses of bituminous schists, and greenstones/greenschists (Joma greenstone). The petrography of these rocks has been described by Strand (1956) and Nilsson (1964).

The Joma greenstones are pale-green calcareous basalts of Tholeiitic affinity (classification based on TiO_2 - Zr/P_2O_5-relations after Winchester and Floyd, 1976). Pillow lavas, and locally hyaloclastites, are present, indicating a submarine deposition. The Joma greenstones occur at three levels within the Røyrvik Group. So far no distinct differences have been found between these greenstones.

The Røyrvik Group thus represents a sequence of sub-marine volcanics and sediments laid down in relatively shallow water. The basin of deposition was probably limited to the east by the Portfjäll conglomerate. An equivalent of this conglomerate in Sweden, the Remdalen conglomerate, is found to form a slight angular unconformity with the rocks further to the east (Zachrisson, 1969).

To the west, the geological setting is complicated by the overthrusting of the Limingen Group over the Røyrvik Group. However, there is no evidence that the thrusting is of regional dimensions, as the contact between the two groups is not always strongly tectonized (Kollung, 1978). Moreover, there is no significant difference in metamorphic grade across the thrust zone, as is commonly associated with other thrust zones of proven regional importance in the central Caledonides (e.g. the Helgeland nappe to the west). Thus, the thrusting of the Gjersvik Nappe over the Leipik Nappe (Fig.1) could be of limited regional importance.

THIS STUDY.

Geochemical results published by Gale (1975), Vokes and Gale (1976), and Pearce and Gale (1977) indicate that the Joma greenstones were formed near a continental margin. Halls et al., 1977, found, as previously mentioned, that the Gjersvik eruptive complex to the west may be interpreted as the remnants of an island arc. Thus, one can find some indications for the possibilit that the relative positions of the Røyrvik Group has not been changed with respect to the Limingen Group.

To help in this tectonic interpretation, a series of 30 samples from the Joma greenstones have been analyzed for main and trace elements. Results are plotted in the discriminant diagram of Pearce and Cann (1973) shown in Fig. 2.

The Joma greenstones is seen to plot in both the field of Ocean Floor Basalts and in the field of Within Plate Basalts. Work by Hart et al. (1972), and Pearce and Cann (1973) suggest that there is little chemical difference between basalts from back-arc basins and those from the larger ocean basins. The distribution of the Joma greenstones from the field of OFB into the field of WPB in Fig.2, suggest that these rocks were formed near or at a continental margin, and that the basin of

– 362	VF	BANKES	
	ØF	SALVE	(MASSIV KIS)
– 375	ØF SYNK	—	
– 385	ST. ORT	—	
– 416	PR. 6	LASTING	
– 447	ØH /SLISS	LASTING /NOE BORING PÅ STROSS	
– 495	ØH	SALVE	

deposition was rather of back-arc type than of the larger ocean basin type.

The Røyrvik Group can therefore be interpreted as having been formed in a back-arc basin not to distal from a continental margin. The Gjersvik eruptive complex, to the west, would then represent the rocks of the associated island arc (Halls et al., 1977). The Limingen sediments, derived from this island arc, were deposited to the east, possibly towards a basin represented by the Røyrvik Group.

This would imply:

1) that the Limingen Group and the Røyrvik Group may have been deposited at roughly the same time, representing different facies deposited during the same tectonic event.
2) that the relative regional position of these groups were not changed by the overthrusting of the Gjersvik Nappe, indicating that this nappe is of limited regional importance.
3) that the Joma ore body was formed in a back-arc basin.

THE ORE BODY.

The Joma ore body is situated within the middle of the three volcanic horizons in the Røyrvik Group. Both regional studies and detailed mapping from the mine area have shown that the host rock stratigraphy of the Joma orebody is lying in an inverted position. The deformational history deduced from detailed mapping of the orebody is in accordance with the results obtained from regional studies (Kollung, 1978):

D_1 is represented by isoclinal folds (F_1, amplitudes of up to a few meters), which are seen to deform wall rocks as well as ore layers (Fig. 4). Mesoscale isoclinal folds (F_1) in the vicinity of the ore body probably represent parasite folds to larger isoclines with amplitudes of several hundred meters (Kollung, 1978). The main deformation of the ore body occurred during D_2, leading to open, assymetric crenulation folds (F_2) found at right angles to F_1.

The mapping of the orebody was thus carried out on cross-sections transverse to the F_2 fold-axis. One example of such a geological cross-section is presented in Fig.3. Turning the orebody back to its right-way up position, the immediate stratigraphy surrounding the ore body is found to be (Fig.3):

Top:	Basaltic greenstones/greenschists.
	Massive pyritic ore with interbedded layers and lenses of marble and chloritic schists.
	Massive chalcopyrite/pyrrhotite ore with bands, lenses and rolled fragments of pyritic ore, chloritic schists and quartz.
	Chloritic schist with bands and disseminations of chalcopyrite-pyrrhotite.
	Albitic rock veined by quartz and pyrite.
Bottom:	Basaltic greenstones/greenschists transected by abundant veins of pyrite associated with albite alteration.

THE GREENSTONES/GREENSCHISTS.

These rocks show a varied textural appearance, variations being due to primary features as well as to penetrative schistosity (S_1 as well as S_2).

Locally one find remnants of pillow lavas and hyaloclastites, while in most of the rocks immediately bordering the orebody, the schistosity has virtually destroyed all traces of primary structures. This nondescript, schistose fabric, combined with the uniform pale colour of the greenstones, makes it very difficult to differentiate between true lavas and possible pyroclastic and/or tuffogene equivalents. However, the character of the greenstone sequence can be demonstrated from geochemical studies as previously discussed.

ALBITIC ROCK VEINED BY QUARTZ AND PYRITE.

This is a peculiar rock unit which at first glance may show great resemblance to quartz-keratophyres. However, detailed investigations show that the rock probably represent a hydrethermal alteration product:

The rock is characteristicly white to pale grey in apparence, with bands and irregular veins of pyrite. The rock is partly fragmented in nature, the individual fragments often being zoned; alternate zones consist of: a) an aggregate of almost pure albite, and b) pyrite, mica (muscovite/phlogopite), sphene, albite and chlorite. Late stage veins between fragments consist essentially of pyrite and quartz.

This massive albitic rock grades into greenstones with veinlets of pyrite associated with, e.g., albitization.

The overall appearance of this rock unit indicate a complex history, the nature of which is yet not fully understood. Chemical composition (Table 1) indicate that the rock may have been basaltic. In field, the rock unit locally show a gradation from a massive appearance to a well banded rock with or without fragments. The albitic rock may therefore have originated from a mixed lithology of lava and pyroclasts. More work will have to be carried out to solve this problem.

However, the rock unit shows alteration phenomena closely resembling those one finds associated with hydrothermal systems. This, and the restriction of the rock type to one side of the ore body, strongly indicates that the rock represents the feeder zone for the solutions carrying the ore-forming components.

THE CHLORITE SCHIST.

Stratigraphically above the albitic rock a chloritic schist occurs, consisting of chlorites, albite, biotite, sphene, and with bands and disseminations of chalcopyrite and pyrrhotite. The chalcopyrite-pyrrhotite bands are on average less than one cm wide, and appear to be coccordant with the rock boundaries. Approaching the contact to the massive chalcopyrite-pyrrhotite ore the individual bands occasionally swell up to thicknesses of about 10 cm with interlayered bands of chlorite schist about the same size. The density of sulphide bands decreases away from the chalcopyrite-pyrrhotite ore, leaving the impression that there exist a gradational boundary between the chlorite schist and the chalcopyrite-pyrrhotite ore. A few veins of pyritic ore (about 5 - 10 cm wide) cut the chloritic schists at low angles to the chalcopyrite-pyrrhotite bands. Matrix minerals in these veins are essentially the same as described from the albitic rock above.

RELATION BETWEEN THE ALBITIC ROCK AND THE CHLORITE SCHIST.

To get an idea of the relationship between these rock units, their chemistries have been compared with the chemistry of the surrounding greenstones. Results are presented in Table 1.

The relative distribution of Mg show some interesting features. The albitic rock is depleted in this element with respect to the average of the greenstones, while the chloritic schist shows an enrichment. Referring to the zonation found in fragments of the albitic rock (involving Fe-Mg-bearing silicates) mentioned above, it seem justified to relate this effect to the hydrothermal events associated with the ore deposition. The chlorite schist may thus represent a Mg-rich syn-depositional layer of tuffaceous(?) mud.

The Fe-content shows an increase in both the albitic rock and in the chlorite schist, indicating that the element was introduced by the hydrothermal solutions. Part of this Fe is presently bound in sulphides.

The depletion of Ca in the 'feeder zone' was not immediately followed by deposition on the sea floor, resulting in the chloritic schist being relatively depleted in Ca. The Ca probably went into solution in the sea water, possibly later contributing to the layer of limestone within the pyritic ore body.

The structural and depositional relations between these rock units prior to hydrothermal alteration, is being investigated further.

THE PYRITIC ORE.

The massive pyritic layer, occurring stratigraphically above the chalcopyrite-pyrrhotite ore layer, is generally fine-grained. It consists of pyrite in a matrix of sphalerite, chalcopyrite, pyrrhotite, and accessory galena and cubanite. Magnetite is commonly consentrated in bands and lenses close to the boundary between the two ore layers. Other, minor, unidentified, sulphide phases occur.

Interbedded in the pyritic ore is a massive meta-limestone layer, mineralogically dominated by calcite. The layer is perfectly conformable to the other rock units. The marble is seen to be deformed by both F_1 and F_2, resulting in brecciation and boudinage effects, and, locally, in plastical deformation. Boundaries between marble and pyritic ore are gradational (although it is a rapid transition), the matrix in the sulphide ore on each side of the limestone being calcite. The evidence that the marble was in position prior to D_1, indicate a primary, sedimentary origin for this rock.

Lenses of chloritic schists, bands and lenses of magnetite and Fe-rich silicates, and locally sphalerite, are likewise found concordant to ore boundaries, and F_1-folds can be seen to deform these bands and lenses (Fig.4).

There is thus considerable evidence to indicate that all these features are pre-F_1, and therefore of probable syn-depositional origin.

THE CHALCOPYRITE-PYRRHOTITE ORE.

.The massive chalcopyrite-pyrrhotite ore is of the type that in the litterature has been designated 'durchbewegt' ore or 'breccia' ore. It consist primarily of chalcopyrite and pyrrhotite. Other minerals include magnetite (often associated with chloritic lenses), pyrite, cubanite, and mackinawite. Pyrite occurs in aggregates or single grains, normally rounded and cataclastic. Rounded fragments of pyritic ore, chlorite schist and quartz are abundant.
This ore type shows two striking features in Joma:

1) The ore occur in a stratigraphic position between the pyritic ore layer and tha chloritic schist. Its concordant appearence is not altered by deformation. Moreover, the mobility of the ore during deformation was limited.
2) Concordant with the boundary between the two ore layers, there occur, locally in the mine, thin bands of pyritic ore (up to a few centimeters thick) in the chalcopyrite-pyrrhotite ore. The bands concordantly follow the ore contacts over several meters leaving the impression of a gradational boundary. Locally, the bands are seen to be boudinaged, individual boudins showing lensoid and rolled shapes similar to those one find in totally 'durchbewegt' parts of the ore.

GENESIS OF THE CHALCOPYRITE-PYRRHOTITE ORE.

The chalcopyrite-pyrrhotite ore could probably have been formed by one of three principal processes:

1) A metamorphic process involving the breakdown of a former pyrite phase to pyrrhotite, followed by a mobilization of chalcopyrite and pyrrhotite into a massive ore body, e.g. McDonald (1967) and Vokes (1968, 1969).

2) A diffusion metasomatic process between a formerly pyritic (Cu-rich) ore layer and the chloritic schist to form a chalcopyrite-pyrrhotite ore. Advocates for the possibility of an exchange of Fe between sulphides and silicates during regional metamorphism, are, i.a., Bachinski (1976) and Juve (1977).

3) A primary exhalative-sedimentary process resulting in a layer of essentially the same chemical composition as the present ore layer.

Process 1.

This hypothesis for the origin of the massive chalcopyrite-pyrrhotite ore is found improbable, in the case of Joma, for several reasons:

a) Deformation of the ore body has produced fold hinges favourable for deposition of mobilized material on both sides of the ore body. The evident stratigraphical position of the chalcopyrite-pyrrhotite ore in Joma therefore argues against a purely metamorphic mobilization theory for the deposition.
b) The temperature of the metamorphic peak as indicated by the index minerals for the greenschist facies metamorphism, was below the temperature for which pyrite becomes unstable, i.a. Kullerud and Yoder (1959).
c) The stability of the pyrite during deformation is well documented in the ore textures.

Process 2.

This process could (theoretically) have occurred between a pyritic phase and chlorites in the sulphide matrix as a metamorphic reaction. However, in Joma there seem to be too little chlorite within the chalcopyrite-pyrrhotite ore to be able to account for the formation of all the pyrrhotite.

Another possibility would be an exchange of Fe between an original chalcopyrite-pyrite layer and the adjacent chlorite schist to produce the chalcopyrite-pyrrhotite ore. In this case, the process would include both a chemical and a mineralogical change within the ore layer (exchange of Fe and S to produce pyrrhotite from pyrite), and, according to the definition by Korzhinskii (1970), it should thus have been a metasomatic process.

Korzhinskii (1970) states that metasomatic processes can be ideally divided into a) infiltration metasomatism, and b) diffusion metasomatism. An infiltration metasomatic process will normally leave visible traces of various alteration phenomena within the rocks. The actual lack of such traces within the chloritic schist in Joma argues against the occurrence of infiltration metasomatic phenomena associated with metamorphic fluids. This leaves a diffusion metasomatic process to be considered.

The possible occurrence of this process is difficult to investigate, since no mineralogical indications are apparent. Pyrrhotite shows purely metamorphic microstructures, and the possible exchange of Fe and S thus must have occurred under prograde conditions, later recrystallization having destroyed eventual traces of metasomatism along grain boundaries.

Juve (1977) proposed that Mg-enrichment in chlorites at Stekenjokk could be the result of a process involving exchange of Fe and S between silicates and sulphides. In Joma, the distribution of Mg is better explained as a feature related to syn-depositional processes as discussed above.

It thus seems that the only approach to the problem is to study the distribution of Fe within the chloritic schist. If diffusion metasomatism has occurred, some systematic variation in composition of the chlorites is to be expected. According to Korzhinskii (1970) there is "extremely limited or even vanishing variation in the composition of minerals in infiltration metasomatic columns, whereas in diffusion metasomatic columns there is complete manifestation of such variations".

In Table 2 the results of 29 whole rock analyses are presented. The samples are dominated by chlorite. 6 samples are from areas barren in chalcopyrite-pyrrhotite ore, while 23 samples are from chlorite schist adjacent to chalcopyrite-pyrrhotite ore.

The Fe-content (given as Fe_2O_3) varies considerably within the chlorite schist. Thus, even if Table 2 seem to indicate a slight enrichment of Fe in areas adjacent to chalcopyrite-pyrrhotite (which one would not expect if the ore had originated by leaching of Fe from the chlorite schist), the material is too small to be conclusive.

The analyses of 14 samples across the chlorite schist from contact with 'feeder zone' to contact with chalcopyrite-pyrrhotite ore are presented in Fig. 5. Apparently, no systematic variation in Fe-content can be traced across the chlorite schist to indicate a diffusion metasomatic column. However, the material is too small and the variation in Fe-content is too high for any conclusions to be drawn.

It is felt, though, that if diffusion metasomatism had occurred, it should be manifested on all contacts between sulphides and chloritic schists, based on the fact that the whole ore deposit has been subject to the same metamorphic conditions. The absence of reaction effects along chloritic schists within the pyritic ore and along the contact between the 'feeder zone' and the chlorite schist, is taken as indication that the process is improbable in the case of Joma.

Process 3.

A primary sedimentary process for the formation of the chalcopyrite-pyrrhotite ore is favoured by the present author. This opinion is based on:

a) The perfectly conformable attitudes of the ore layers.
b) The presence of thin, concordant bands of pyritic ore in the chalcopyrite-pyrrhotite ore, leaving the impression of a transitional boundary.
c) The lack of evidence for a metamorphic or metasomatic origin for this ore layer.

This may indicate the presence of a primary FeS-phase that was, or has since become, pyrrhotite, in accordance with the results of Finlow-Bates et al. (1977) from Mount Isa.

CONCLUSIONS.

The Joma massive, stratiform sulphide deposit was probably formed in a back-arc basin. The adjacent island arc is represented by the rocks of the Gjersvik eruptive complex to the west (Halls et al., 1977), indicating that the following possibilities have to be considered:

1. The Røyrvik Group and the Limingen Group occur in their correct relative positions, and the Gjersvik Nappe may thus be of limited regional importance.
2. The Røyrvik and the Limingen Groups may be of roughly the same age.

The Joma deposit was probably formed by an exhalative-sedimentary process, following the nomenclature of Oftedahl (1958). The event included:

A. The formation of a feeder zone with associated alteration phenomena including depletion of Mg and Ca.
B. The deposition of a Fe/Mg- rich tuffaceous(?) mud immediately overlying the feeder zone in the original stratigraphy.
C. The deposition of Fe-sulphides showing a gradation from an early Cu-rich layer represented by the present chalcopyrite-pyrrhotite ore, into a more Zn-rich and Cu-poor pyritic top layer. The occurrence of limestone and schist layers within the ore, show that the deposition of sulphides was

not continuous.

The relative positions and bulk chemistries of these layers were maintained during deformation and metamorphism.

ACKNOWLEDGEMENTS.

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Sver. Geol. Unders., C644, 33 p.

TEXT TO FIGURES.

Fig. 1. From Halls et al., 1977. Map showing main structural and stratigraphic units that can be distinguished within Køli nappe sequence in the Grong-Stekenjokk district. (1) Thrust at base of Olden basement nappe; (2) thrust at base of Seve-Køli nappes; (3) thrust separating Seve and Køli sequences within Seve-Køli Nappe Complex; (4) thrust separating Gjersvik Nappe at top of Køli nappe sequence from high-grade metamorphic rocks of Helgeland Nappe Complex.
Location of main ore deposits: Sk, Skorovas; Gj, Gjersvik; Jo, Joma; St, Stekenjokk.

Fig. 2. Discrimination diagram using Ti, Zr, and Y after Pearce and Cann (1973). WPB- Within plate basalts; LKT-Low-potassium tholeiites; OFB- Ocean floor basalts; CAB-Calc alkali basalts.

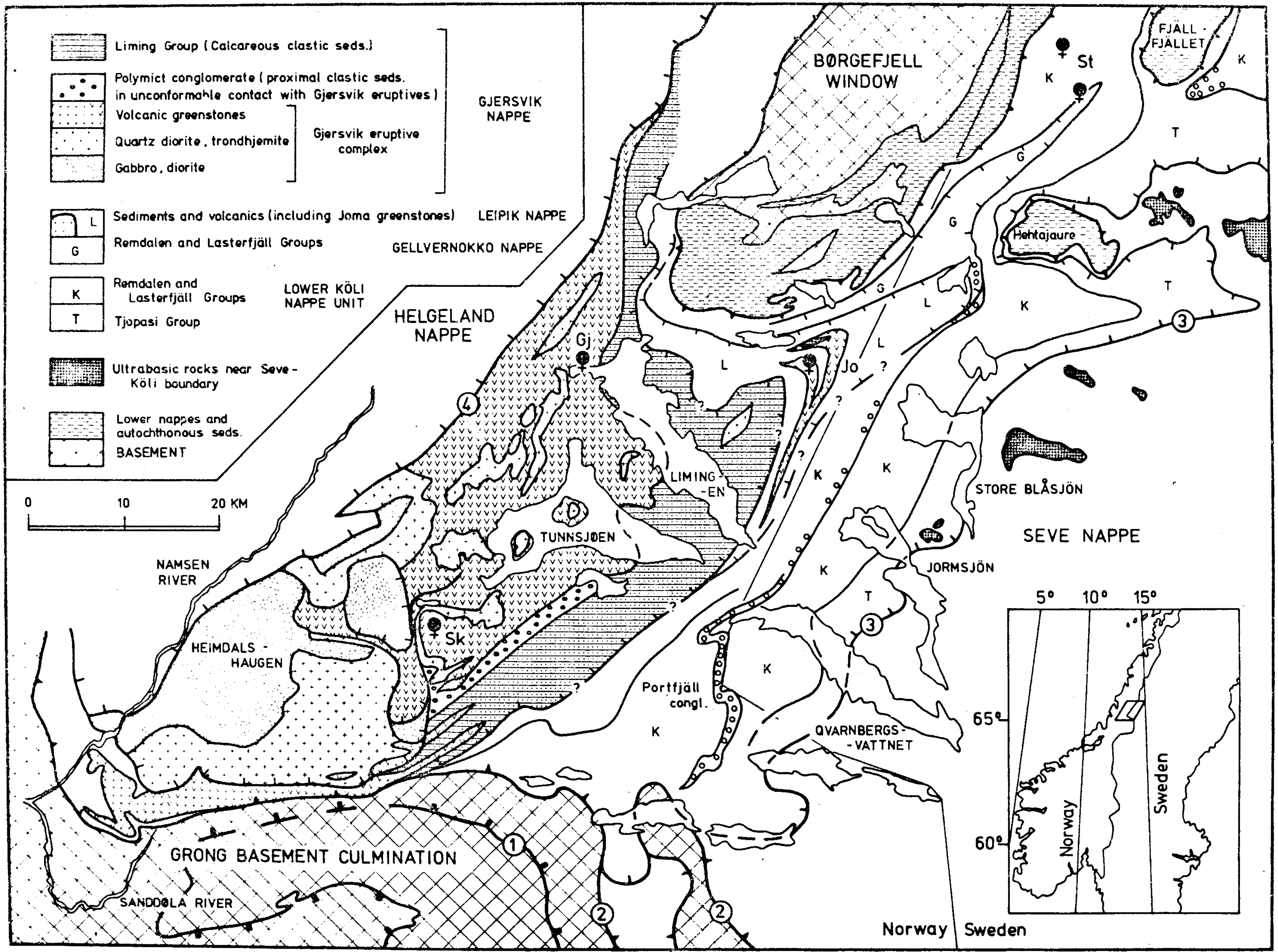
Fig. 3. Geological cross-section from the Joma massive sulphide deposit. At roughly right angles to the F_2- axis. For simplification, only main geological units are shown.

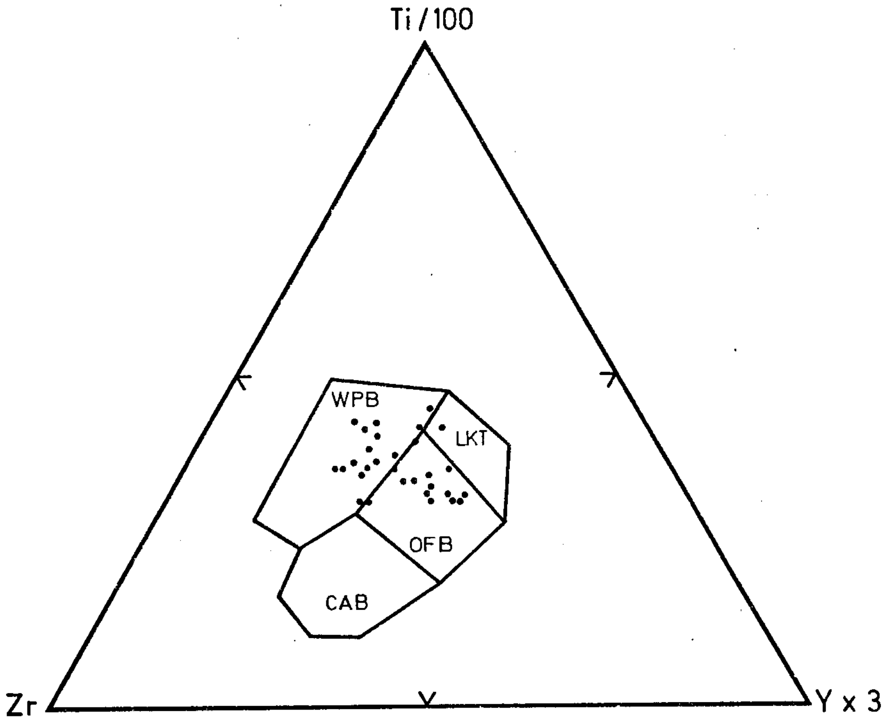
Fig. 4. Fold styles in Joma. a) Isoclinally (F_1) deformed lens of chloritic schist within the pyritic ore layer. b) Open crenulation fold (F_2) deforming greenstone and pyritic ore. (Fotos: A. Reinsbakken).

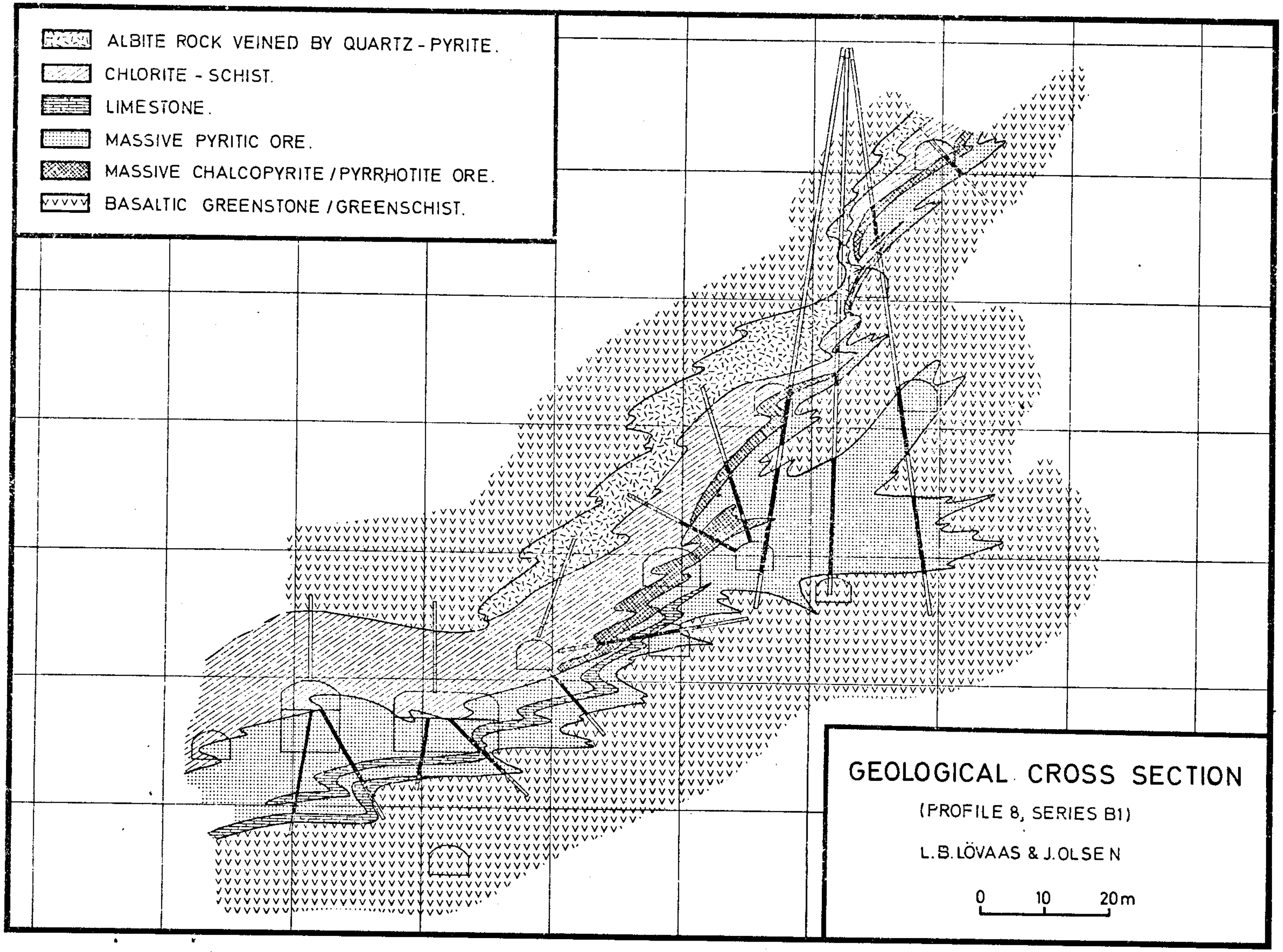
Fig. 5. Cross-section of the inverted stratigraphy showing distribution of Fe (given as Fe_2O_3) across the chloritic schist.

Table 1. Average chemical composition of the wall rocks.

Table 2. Distribution of Fe (given as Fe_2O_3) within the chloritic schist.


Liming Group (Calcareous clastic seds.)
Polymict conglomerate (proximal clastic seds. in unconformable contact with Gjersvik eruptives)
Volcanic greenstones
Quartz diorite, trondhjemite
Gabbro, diorite
Gjersvik eruptive complex
GJERSVIK NAPPE
Sediments and volcanics (including Joma greenstones)
LEIPIK NAPPE
Remdalen and Lasterfjäll Groups
GELLVERNOKKO NAPPE
Remdalen and Lasterfjäll Groups
Tjopasi Group
LOWER KÖLI NAPPE UNIT
Ultrabasic rocks near Seve-Köli boundary
Lower nappes and autochthonous seds.
BASEMENT
0
10
20 KM
HELGELAND NAPPE
BØRGEFJELL WINDOW
FJÄLL-FJÄLLET
St
Hehtajaure
Gj
Jo
LIMING-EN
TUNNSJØEN
STORE BLÅSJÖN
SEVE NAPPE
JORMSJÖN
NAMSEN RIVER
HEIMDALS-HAUGEN
Sk
Portfjäll congl.
QVARNBERGS-VATTNET
GRONG BASEMENT CULMINATION
SANDDØLA RIVER
Norway
Sweden
5°
10°
15°
65°
60°


Ti / 100
WPB
LKT
OFB
CAB
Zr
Y x 3



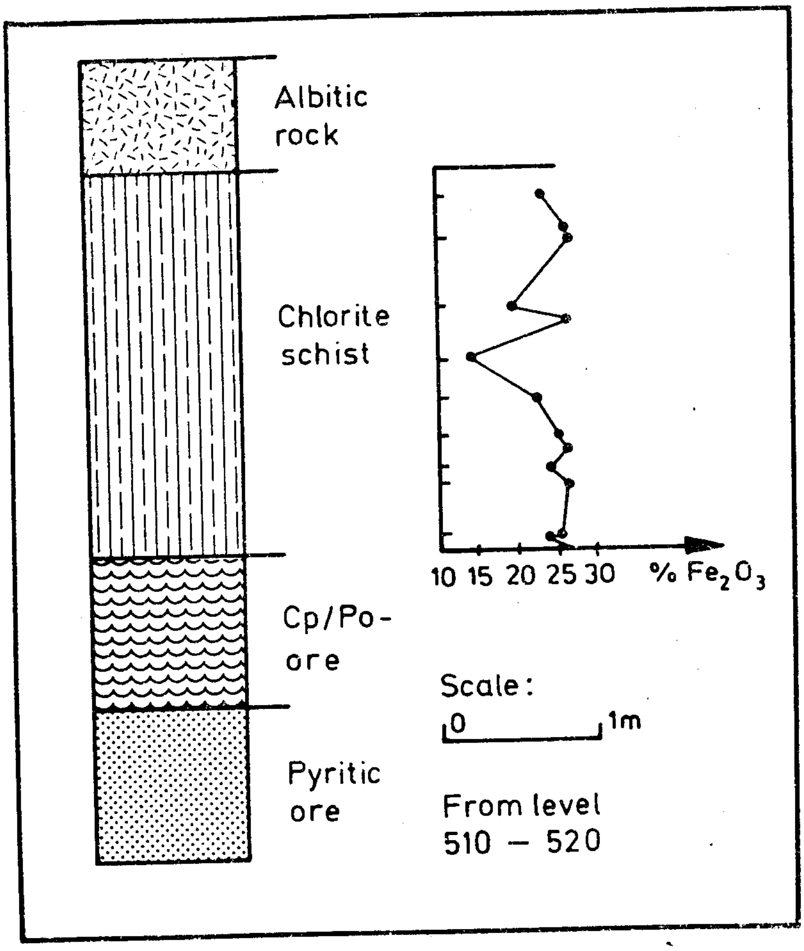
ALBITE ROCK VEINED BY QUARTZ - PYRITE.
CHLORITE - SCHIST.
LIMESTONE.
MASSIVE PYRITIC ORE.
MASSIVE CHALCOPYRITE / PYRRHOTITE ORE.
BASALTIC GREENSTONE / GREENSCHIST.
GEOLOGICAL CROSS SECTION
(PROFILE 8, SERIES B1)
L.B. LÖVAAS & J. OLSEN
0 10 20m

Rock unit	Greenstones		Albitic rock		Chlorite schist	
No.of samples	18		8		9	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
SiO_2	44.22	1.79	47.32	2.56	27.14	5.90
Al_2O_3	16.23	1.47	15.59	1.70	16.62	2.03
Fe_2O_3	9.63	1.09	15.70	3.25	29.83	6.24
TiO_2	1.18	0.22	1.84	0.30	1.70	0.61
MgO	7.58	1.51	2.75	1.28	12.41	1.78
CaO	11.79	2.11	1.77	0.22	2.54	1.68
Na_2O	3.03	0.61	6.25	0.99	1.45	1.13
K_2O	0.46	0.64	0.60	0.42	0.10	0.00
MnO	0.14	0.04	o.o7	0.02	0.20	0.03
P_2O_5	0.11	0.03	o.16	0.04	0.16	0.07
L.O.I.	6.07	1.89	8.19	1.89	10.27	1.45

TABLE 1.

	All analyses.	Chlorite schist from areas barren in cp-po.	Chlorite schist from areas adjacent to cp-po.
No. of samples	29	6	23
Mean Fe_2O_3	24.28	17.78	25.97
Std. dev.	7.22	3.22	7.04

TABLE 2.


Albitic rock
Chlorite schist
Cp/Po-ore
Pyritic ore
10 15 20 25 30
% Fe_2O_3
Scale:
0
1m
From level 510 — 520

APPENDIX I - VI.

Tabellarisk oppstilling av analyseresultater.

APPENDIX I.

Analyser på grønn-
steiner fra gruva.

Anal. v/J. Olsen,
Geol. Institutt.

TABLE 1 JOMA GRØNNSTEIN 1 - 32/76 JØRN OLSEN

	JO 1_76 *	JO 2_76 *	JO 3_76 *	JO 4_76 *	JO 5_76 *	JO 6_76 *	JO 7_76 *	JO 8_76 *
SIO2	42.10	46.24	40.57	43.36	38.63	45.00	45.50	47.58
AL2O3	16.10	15.90	19.90	15.30	18.80	17.10	16.30	15.40
FE2O3	8.70	9.97	13.84	9.46	9.15	9.30	8.90	9.85
TIO2	.89	1.13	1.42	1.19	1.10	1.02	.99	1.59
MGO	7.50	7.95	10.40	6.90	8.48	8.51	8.46	8.79
CAO	14.36	11.67	4.82	15.34	7.99	10.66	11.33	8.27
NA2O	3.16	3.25	3.19	2.72	2.84	3.34	3.39	3.89
K2O	.30	.20	.50	.10	2.37	.50	.40	.50
MNO	.12	.12	.12	.14	.23	.13	.12	.26
P2O5	.06	.08	.08	.10	.06	.06	.12	.16
L.O.I.	6.54	4.05	6.61	5.74	10.23	4.15	4.46	4.83
TOTAL	99.83	100.56	101.45	100.35	99.88	99.77	99.97	101.12

PPM

ZR	57	74	64	74	79	72	68	80
Y	23	25	21	26	22	25	14	24
SR	244	231	101	240	155	217	207	220
RB	6	7	10	0	17	0	0	0
ZN	87	110	98	79	398	103	101	179
CU	105	200	127	92	200	200	200	350
NI	170	187	121	132	161	170	186	114
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0

1 - 32/76

TABLE 1 JOMA GRØNNSTEIN [redacted] [redacted] JØRN OLSEN

	J0 9_76	* J010_76	* J011_76	* J012_76	* J013_76	* J014_76	* J015_76	* J016_76 *
SIO2	42.00	42.96	42.96	47.70	37.52	42.58	46.02	29.28
AL2O3	19.20	17.70	18.30	17.80	17.90	20.60	18.40	9.70
FE2O3	10.65	9.50	9.80	8.30	23.99	12.64	11.25	6.87
TIO2	1.11	1.05	1.14	1.08	2.26	1.14	1.65	.65
MGO	6.44	9.19	8.83	8.17	7.41	6.91	9.72	6.42
CAO	8.90	11.82	12.12	7.58	2.03	1.12	2.62	25.61
NA2O	4.14	2.57	2.52	2.70	3.23	3.30	5.01	1.84
K2O	.10	.10	.10	2.67	.70	3.29	.20	.30
MNO	.15	.13	.12	.13	.15	.13	.14	.15
P2O5	.11	.11	.08	.06	.21	.09	.09	.08
L.O.I.	7.78	4.96	5.40	3.82	7.25	8.22	5.58	19.75
TOTAL	100.58	100.09	101.37	100.01	102.65	100.02	100.68	100.65

PPM

ZR	65	69	75	61	143	65	65	58
Y	12	21	16	16	28	14	26	22
SR	143	205	206	143	53	49	60	268
RB	0	0	0	28	0	25	0	11
ZN	95	71	89	111	199	354	571	51
CU	92	83	103	300	700	400	450	115
NI	99	270	263	111	106	218	205	111
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0

1 - 32/76

TABLE 1. JOMA GRØNNSTEIN [redacted] JØRN OLSEN

	J017_76	* J018_76	* J019_76	* J020_76	* J021_76	* J022_76	* J023_76	* J024_76 *
SIO2	48.67	44.82	40.81	43.59	45.94	43.55	41.81	41.64
AL2O3	19.90	17.40	14.80	15.70	15.20	13.90	15.10	15.10
FE2O3	10.82	10.69	7.55	7.51	10.06	9.06	8.70	7.90
TIO2	1.16	1.32	.25	.95	1.33	1.28	.98	.94
MGO	7.19	8.18	6.45	6.84	5.69	6.44	10.57	9.06
CAO	1.40	11.74	15.10	12.48	12.02	13.93	13.75	14.95
NA2O	6.09	2.43	3.49	3.61	2.70	2.80	1.89	2.08
K2O	.20	.20	1.20	1.39	.10	.10	.70	1.09
MNO	.08	.13	.12	.12	.13	.13	.14	.13
P2O5	.06	.12	.08	.08	.14	.14	.11	.10
L.O.I.	5.14	3.67	10.02	8.15	8.31	9.79	7.11	8.51
TOTAL	100.71	100.70	99.87	100.42	101.62	101.12	100.86	101.50

PPM

ZR	58	75	53	62	79	85	86	83
Y	24	33	26	24	27	22	18	17
SR	52	226	163	175	256	330	221	246
RB	10	0	18	14	17	4	3	29
ZN	330	76	193	193	80	72	70	72
CU	12	42	200	200	90	70	125	45
NI	178	127	82	90	138	88	313	268
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0

TABLE 1. JOMA GRØNNSTEIN [redacted] 1 - 32/76 JØRN OLSEN

	J025_76 *	J026_76 *	J027_76 *	J028_76 *	J029_76 *	J030_76 *	J031_76 *	J032_76 *
SIO2	43.56	43.30	49.48	40.59	34.65	44.33	32.17	44.02
AL2O3	15.90	16.20	14.60	15.20	12.47	18.80	17.70	13.60
FE2O3	10.19	10.38	11.73	15.48	17.35	10.34	26.94	12.41
TIO2	1.57	1.56	1.36	1.50	1.82	1.80	1.59	1.04
MGO	4.82	5.05	9.61	11.38	18.38	10.12	9.76	8.14
CAO	13.39	12.94	4.34	4.01	7.23	3.22	1.49	9.98
NA2O	2.66	2.67	4.61	3.30	.16	3.25	2.22	4.05
K2O	.10	.10	.10	.60	.10	2.18	.10	.70
MNO	.19	.20	.11	.15	.16	.20	.14	.12
P2O5	.18	.14	.08	.13	.16	.15	.10	.12
L.O.I.	8.00	7.89	5.50	7.88	9.38	6.87	8.27	4.68
TOTAL	100.56	100.43	101.52	100.22	101.86	101.26	100.48	98.86
PPM								
ZR	63	92	97	117	146	139	89	67
Y	21	15	17	23	22	22	18	28
SR	221	275	68	67	95	63	61	116
RB	0	0	0	6	0	6	0	10
ZN	96	93	1905	2045	798	429	449	292
CU	115	130	550	150	40	77	3150	750
NI	136	134	124	137	105	129	85	115
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0

troverdige änalyser.

*** TABLE 2.. JØMA GRØNNSTEIN [redacted] JØRN OLSEN

ELEMENT	MINIMUM	MAXIMUM	MEAN	STD.DEV
SIO2	41.81	47.70	44.22	1.79
AL2O3	13.60	19.20	16.23	1.47
FE2O3	7.51	12.41	9.63	1.C9
TIO2	.89	1.59	1.18	.22
MGO	4.82	10.57	7.58	1.51
CAO	7.58	15.34	11.79	2.11
NA2O	1.89	4.14	3.03	.61
K2O	.10	2.67	.46	.64
MNO	.12	.26	.14	.C4
P2O5	.06	.18	.11	.C3
L.O.I.	3.67	9.79	6.07	1.89
ZR	57.	92.	72.	9.
Y	12.	33.	22.	6.
SR	116.	330.	215.	5C.
RB	0.	28.	5.	8.
ZN	70.	292.	111.	56.
CU	42.	750.	18C.	164.
NI	88.	313.	158.	65.
	0.	0.	0.	C.
	0.	0.	C.	C.
[redacted]	0.	0.	0.	C.
	0.	0.	0.	C.
	45.	84.	64.	11.

NT = 18.

Gjennomsnitt av 14 antall omvandlede grønnsteiner.

*** TABLE 3. JOMA GRØNNSTEIN U - OI/ML JØRN OLSEN

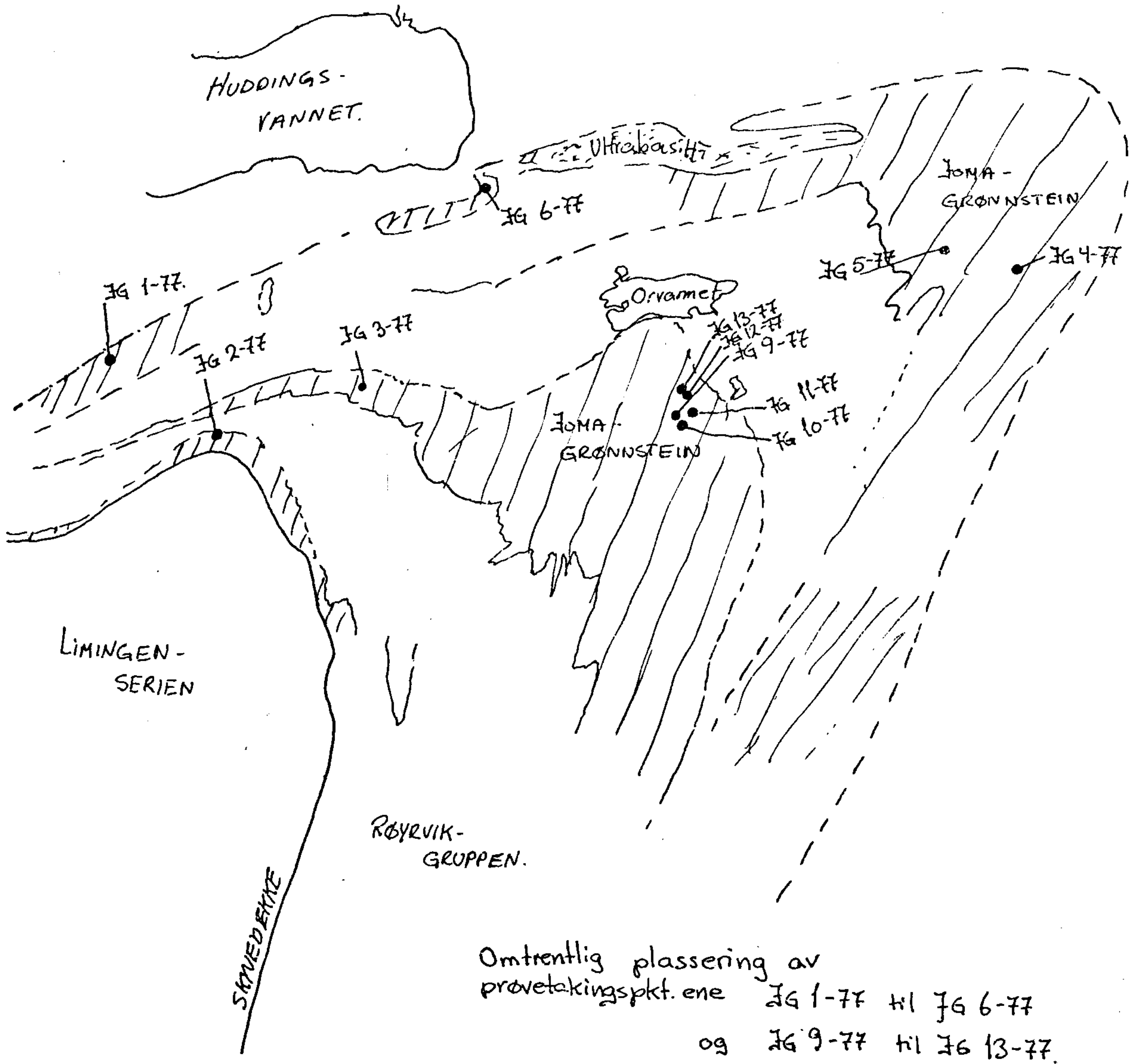
ELEMENT	MINIMUM	MAXIMUM	MEAN	STD.DEV
SIO2	29.28	49.48	40.50	5.82
AL2O3	9.70	20.60	16.70	3.16
FE2O3	6.87	26.94	13.27	5.98
TIO2	.25	2.26	1.33	.51
MGO	6.42	18.38	9.38	3.04
CAO	1.12	25.61	6.85	7.08
NA2O	.16	6.09	3.19	1.45
K2O	.10	3.29	.92	1.01
MNO	.08	.23	.14	.04
P2O5	.06	.21	.10	.04
L.O.I.	5.14	19.75	8.51	3.61
ZR	53.	146.	90.	34.
Y	14.	28.	22.	4.
SR	49.	268.	107.	73.
RB	0.	29.	9.	10.
ZN	51.	2045.	564.	632.
CU	12.	3150.	444.	807.
NI	82.	268.	145.	54.
	0.	0.	0.	0.
	0.	0.	0.	0.
[redacted]	0.	0.	0.	0.
	0.	0.	0.	0.
	53.	194.	78.	35.

NT = 14.

APPENDIX II.

Analyser av Joma-grønnstein utført ved Kjemisk avd., Norg.Geol.Unders.

Norg. Geol. Undersøkelse utførte 13 kjemiske analyser på grønnsteinsprøver fra Joma-grønnsteinene. Prøvetakingspunktene er vist i nedenstående skisse. Analyseresultatene presenteres i tabeller på de følgende sider.



Omtrentlig plassering av
prøvetakingspkt. ene JG 1-77 til JG 6-77
og JG 9-77 til JG 13-77.
JG. 7-77 er fra berghallene ved topp silo
JG 8-77 er fra nivå 510 i gruva.

Prøve JG 11-77 er fra massiv Albitt-fels i heng av malmen ved dagbruddet.

TABLE 4.

	JG1-77	JG2-77	JG3-77	JG4-77	JG5-77	JG6-77	JG7-77	JG8-77
SiO_2	49,61	46,25	45,95	48,40	48,10	45,90	46,80	41,15
Al_2O_3	13,80	18,32	15,43	16,26	17,25	15,86	14,33	16,89
Fe_2O_3	10,46	11,08	11,60	10,19	8,81	10,96	9,96	11,37
TiO_2	2,04	2,57	1,48	2,47	2,29	2,10	1,82	1,21
MgO	8,54	7,32	8,69	5,76	7,90	8,95	8,36	6,76
CaO	9,18	4,16	10,58	8,17	7,76	9,66	11,06	11,60
Na_2O	3,3	3,9	1,9	3,0	3,9	2,4	2,8	2,6
K_2O	0,54	1,44	0,04	1,01	1,00	0,56	0,16	<0,01
MnO	0,16	0,13	0,18	0,13	0,15	0,16	0,16	0,13
P_2O_5	0,27	0,76	0,15	0,48	0,49	0,35	0,31	0,14

Nb	12	26	<5	35	49	24	21	<5
Zr	160	369	92	200	178	176	146	72
Y	35	30	32	36	28	35	31	29
Sr	203	227	205	362	376	307	335	376
Rb	9	26	<5	16	16	8	<5	<5
Zn	86	99	86	83	66	85	80	69
Cu	<5	<5	<5	28	48	49	46	<5
Ni	116	79	91	102	54	151	144	82
Cr	258	111	281	209	166	344	367	336
V	255	209	250	285	269	260	218	233
Ba	90	166	<10	188	182	208	35	<10
Pb	<10	13	11	<10	<10	<10	11	13
Co	39	23	39	38	23	44	37	38

TABLE 4

	J6 9-77	J6 10-77	J6 11-77	J6 12-77	J6 13-77
SiO_2	47,80	44,76	42,50	47,95	45,11
Al_2O_3	14,91	17,92	20,10	16,40	15,86
Fe_2O_3	12,89	9,26	10,07	9,69	9,74
TiO_2	1,91	1,15	1,53	1,02	1,03
MgO	6,56	8,57	9,10	9,56	7,93
CaO	10,81	10,53	3,87	10,07	11,94
Na_2O	2,9	1,3	2,6	2,7	2,3
K_2O	0,05	1,51	1,68	0,11	0,50
MnO	0,18	0,12	0,17	0,14	0,13
P_2O_5	0,21	0,11	0,14	0,10	0,12
Nb	5	<5	<5	<5	<5
Zr	131	82	88	68	69
Y	40	26	33	27	27
Sr	195	274	72	100	185
Rb	<5	14	12	<5	6
Zn	106	62	424	84	76
Cu	5	70	99	26	38
Ni	85	137	81	120	81
Cr	210	308	411	298	282
V	317	183	337	169	179
Ba	<10	81	61	14	36
Pb	<10	<10	228	10	<10
Co	36	23	25	29	22

APPENDIX III.

Analyser av kloritt-
skifere fra gruva.

Anal.v/J.Olsen,
Geol.Institutt.

TABLE 5. JOMA/KLORITTSKIFERE.

	33/76	34/76	35/76	36/76	37/76	38/76	39/76
SiO_2	23.77	26.90	25.76	39.46	22.57	23.06	39,34
TiO_2	2.69	1.28	1.64	1.82	1.09	0.98	1.24
Al_2O_3	18.0	14.99	16.37	12.58	14.21	19.50	16.55
Fe_2O_3	6.22	10.38	12.96	4.66	12.76	2.48	1.09
FeO	20.39	19.05	12.70	20.22	18.04	25.98	12.76
MnO	0.16	0.21	0.14	0.19	0.26	0.23	0.18
MgO	13.63	12.56	4.86	7.30	13.11	15.63	8.05
CaO	2.34	1.15	7.66	2.45	6.39	0.88	10.14
Na_2O	0.36	3.26	2.94	0.00	0.55	0.00	1.87
K_2O	0.1	0.1	4.58	0.6	0.1	0.1	0.1
P_2O_5	0.23	0.06	0.15	0.06	0.12	0.13	0.04
L.O.I.	11.40	10.23	9.94	10.99	10.48	11.53	8.14
SUM	99.29	100.17	99.70	100.33	99.68	100.50	99.50
Zn	287	773	178	806	529	253	763
Cu	450	22	250	800	6000	550	2100
Ni	100	180	101	95	107	218	102
Co	139	71	63	38	318	149	244

TABLE 5. JOMA/KLORITTSKIFERE

	40/76	41.76	42/76	43/76	44/76	45/76	60/76
SiO_2	29.20	32.44	27.73	38.74	19.59	38.96	29.40
TiO_2	2.13	2.11	2.15	0.96	1.80	1.10	0.97
Al_2O_3	17.50	18.40	17.90	14.10	14.20	14.90	14.50
Fe_2O_3	9.00	4.35	7.43	1.95	21.32	4.16	10.49
FeO	17.02	18.18	18.69	12.42	17.36	13.54	21.74
MnO	0.19	0.18	0.20	0.16	0.17	0.16	0.10
MgO	10.83	10.89	12.08	11.36	9.71	13.28	7.99
CaO	2.26	2.10	1.90	9.22	1.95	3.91	1.99
Na_2O	1.98	2.34	1.37	2.95	0.67	2.52	0.25
K_2O	0.10	0.10	0.10	0.10	0.10	0.10	5.13
P_2O_5	0.17	0.20	0.22	0.08	0.25	0.08	0.12
L.O.I.	9.75	9.18	10.28	10.28	12.24	7.33	7.30
SUM	100.13	100.47	100.05	99.45	99.36	100.04	99.98
Zn	483	420	449	333	562	734	648
Cu	3700	1950	1950	1350	11050	900	3950
Ni	89	68	117	106	105	78	105
Co	206	148	177	43	482	61	166

Gjennomsnitt av 9 beste analyser.

*** TABLE 6. JOMA KLORITTSKIFER

ELEMENT	MINIMUM	MAXIMUM	MEAN	STD.DEV
SIO2	19.59	38.96	27.14	5.90
AL2O3	14.20	19.50	16.62	2.03
FE2O3	19.20	40.61	29.83	6.24
TIO2	.98	2.69	1.70	.61
MGO	9.71	15.63	12.41	1.78
CAO	.88	6.39	2.54	1.68
NA2O	.00	3.26	1.45	1.13
K2O	.10	.10	.10	.00
MNO	.16	.26	.20	.03
P2O5	.06	.25	.16	.07
L.O.I.	7.33	12.24	10.27	1.45
[illegible]	*******	0.	0.	0.

ANT = 9.

"FIN

APPENDIX IV.

Analyser av albitt-
fels fra gruva.

Anal. v/J.Olsen,
Geol. Institutt.

TABLE 7 JOMA/ALBITT-FELS.

	46/76	47/76	48/76	49/76	50/76	51/76	52/76
SiO_2	41.77	51.18	48.45	43.67	49.75	47.86	44.43
TiO_2	2.23	1.55	1.63	1.47	1.79	2.07	2.37
Al_2O_3	17.4	16.34	17.8	12.00	14.99	15.30	16.70
Fe_2O_3	4.78	5.29	5.56	18.83	11.42	13.32	12.79
FeO	8.30	5.71	6.02	2.76	3.21	3.00	2.92
MnO	0.17	0.09	0.11	0.08	0.07	0.07	0.08
MgO	10.82	4.38	4.89	2.57	1.78	1.74	3.11
CaO	2.21	1.63	1.78	1.35	1.84	1.80	2.13
Na_2O	3.63	6.96	6.44	4.21	6.82	6.58	5.44
K_2O	0.2	0.1	0.1	0.06	0.6	0.70	1.38
P_2O_5	0.15	0.14	0.17	0.11	0.11	0.15	0.22
L.O.I.	8.37	6.25	6.28	12.32	7.45	8.14	8.31
SUM	100.37	99.62	99.23	99.97	99.83	100.73	99.88
Zn	522	308	358	1707	333	414	202
Cu	400	200	250	3400	1950	2350	600
Ni	139	149	125	79	99	93	115
Co	87	71	74	77	89	96	77

TABLE 7. JOMA/ALBITT-FELS

	53/76	54/76
SiO_2	46.01	47.20
TiO_2	1.84	2.00
Al_2O_3	15.70	15.90
Fe_2O_3	14.44	12.63
FeO	1.84	2.57
MnO	0.04	0.05
MgO	1.43	2.08
CaO	1.88	1.74
Na_2O	7.30	6.23
K_2O	0.40	0.89
P_2O_5	0.18	0.18
L.O.I.	8.35	8.46
SUM	99.41	99.93
Zn	1407	377
Cu	550	500
Ni	61	71
Co	67	74

Gjennomsnitt av 8 beste analyser.

*** TABLE 8. JOMA ALBITITT

ELEMENT	MINIMUM	MAXIMUM	MEAN	STD.DEV
SIO2	43.67	51.18	47.32	2.56
AL2O3	12.00	17.80	15.59	1.70
FE2O3	11.00	21.90	15.70	3.25
TIO2	1.47	2.37	1.84	.30
MGO	1.43	4.89	2.75	1.28
CAO	1.35	2.13	1.77	.22
NA2O	4.21	7.30	6.25	.99
K2O	.10	1.38	.60	.42
MNO	.04	.11	.07	.02
P2O5	.11	.22	.16	.04
L.O.I.	6.25	12.32	8.19	1.89
[redacted]	*******	0.	0.	0.

ANT = 8.

"FIN

APPENDIX V.

Anal. av Røyrvik-
fylitt.

Anal. v/J.Olsen,
Geol.Institutt.

TABLE 9. JOMA/RØYRVIK-FYLLITT.

	57/76	58/76	59/76
SiO_2	71.06	55.63	53.17
TiO_2	0.44	1.01	0.50
Al_2O_3	8.20	12.40	8.66
Fe_2O_3	1.57	1.51	2.00
FeO	5.95	5.11	17.61
MnO	0.53	0.17	0.24
MgO	2.24	2.67	2.38
CaO	3.88	9.53	4.07
Na_2O	0.04	0.45	0.13
K_2O	1.79	3.47	1.88
P_2O_5	0.18	0.22	0.22
L.O.I.	3.90	7.10	8.92
SUM	99.78	99.27	99.78
Zn	113	77	121
Cu	90	115	300
Ni	73	104	147
Co	40	41	40

APPENDIX VI.

En analyse av blå-
kvarts fra gruva.

Anal. v/J.Olsen,
Geol.Institutt.

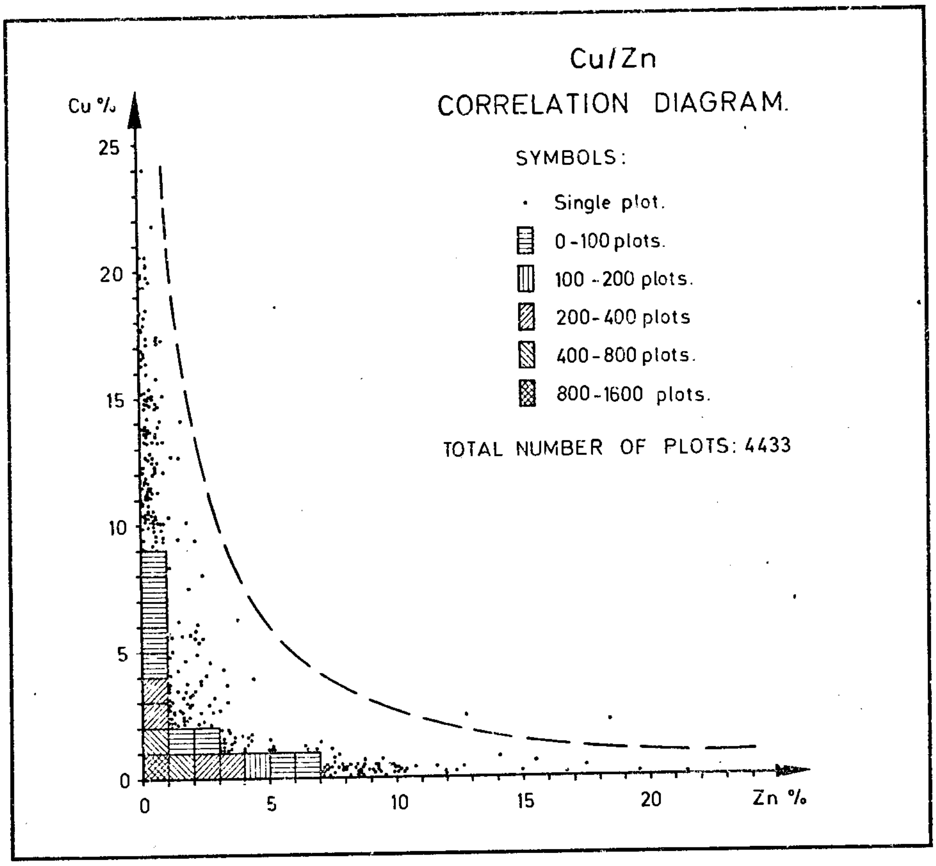
TABLE 10. JOMA/BLÅKVARTS

	55/76
SiO_2	73.55
TiO_2	0.02
Al_2O_3	0.74
Fe_2O_3	0.61
FeO	6.97
MnO	0.06
MgO	0.06
CaO	12.45
Na_2O	0.01
K_2O	0.1
P_2O_5	0.06
L.O.I.	4.61
SUM	99.24
Zn	8
Cu	110
Ni	23
Co	-

APPENDIX VII.

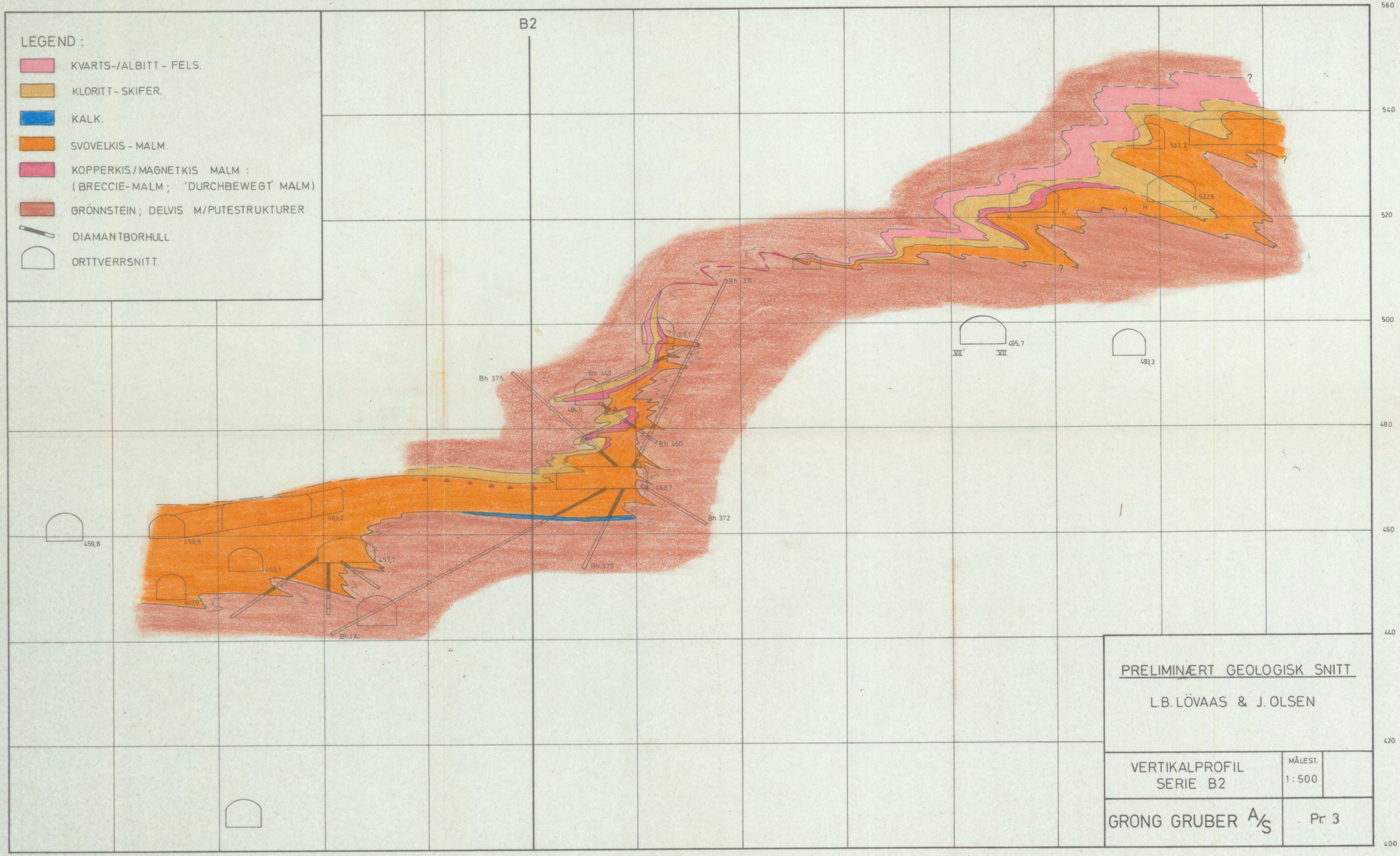
Plotting av Cu/Zn-analyser fra Joma-malmen.

Analysert v/Grong Gruver A/S.



Diagrammet viser den relative fordelingen av Cu og Zn i Joma-malmen. I diagrammet er ikke skilt mellom de to malmtyper.

Diagrammet baseres på 4433 analyser utført ved Grong Gruver A/S.



PRELIMINÆRT GEOLOGISK SNITT

L.B. LÖVAAS & J. OLSEN

VERTIKALPROFIL
SERIE B2

MÅLEST.
1 : 500

GRONG GRUBER A/S

Pr. 3


B2
LEGEND:
KVARTS-/ALBITT - FELS.
KLORITT SKIFER.
KALK.
SVOVELKIS - MALM.
KOPPERKIS/MAGNETKIS MALM :
(BRECCIE-MALM ; 'DURCHBEWEGT' MALM).
GRONNSTEIN ; DELVIS M/PUTESTRUKTURER.
DIAMANTBORHULL.
ORTTVERRSNITT.
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480
460
440
420
400
380
522,6
499,3
499,1
486,1
469,9
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Bh 438
Bh 401
Bh 400
Bh 399
Bh 402
Bh 604
Bh 650
Bh 441
Bh 440
Bh 398
Bh 397
Bh 603
Bh 602
Bh 395
Bh 396
Bh 651
PRELIMINÆRT GEOLOGISK SNITT
L.B. LÖVAAS & J. OLSEN
VERTIKALPROFIL
SERIE B2
MÅLEST.
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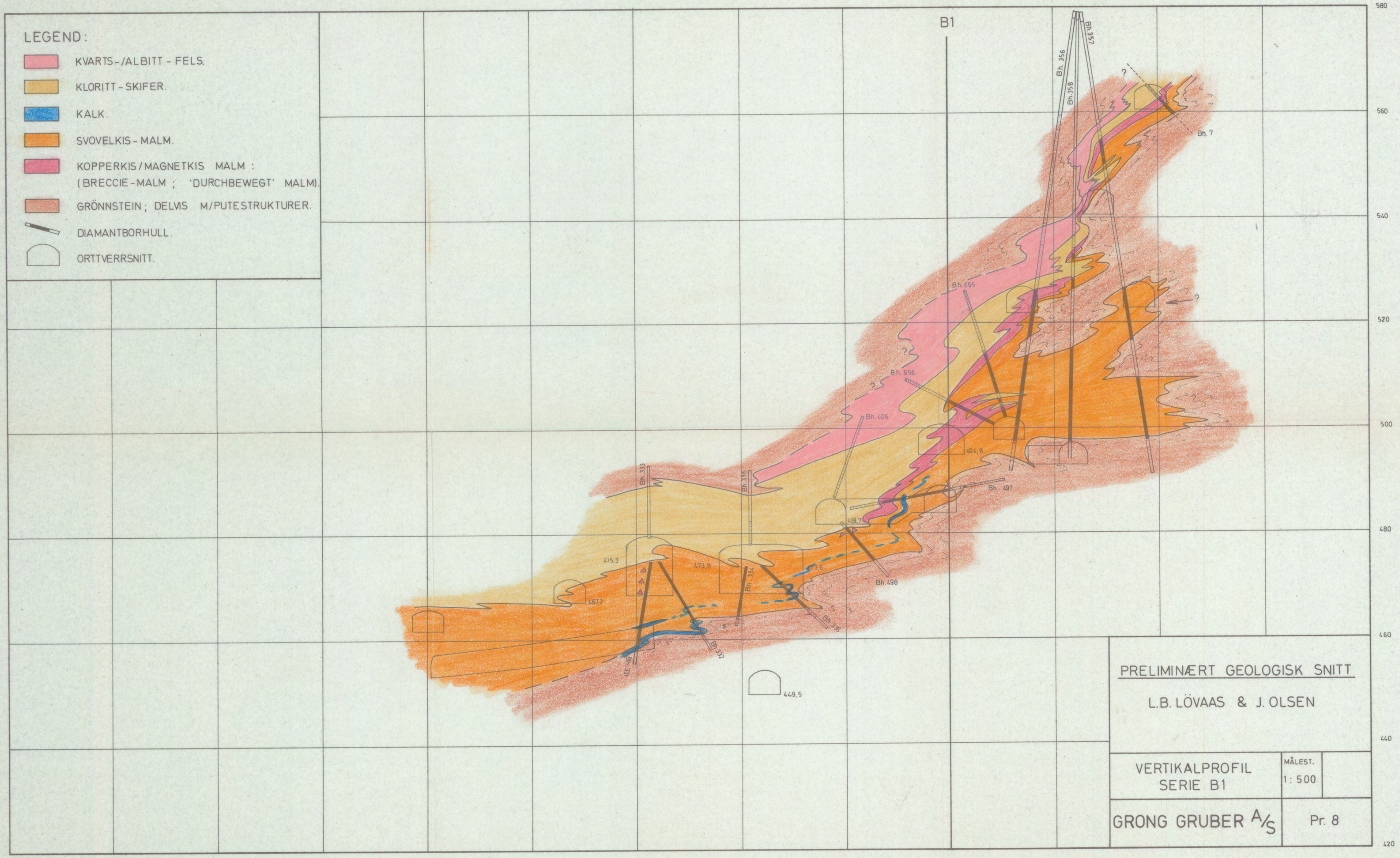
GRONG GRUBER A/S
Pr. 7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KVARTS-/ALBITT-FELS.
KLORITT-SKIFER.
KALK.
SVOVELKIS-MALM.
KOPPERKIS/MAGNETKIS MALM :
(BRECCIE-MALM ; 'DURCHBEWEGT' MALM).
GRÖNNSTEIN ; DELVIS M/PUTESTRUKTURER.
DIAMANTBORHULL.
ORTTVERRSNITT.
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Bh. 358
Bh. 7
Bh. 655
Bh. 656
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Bh. 334
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467,7
449,5
580
560
540
520
500
480
460
440
420
PRELIMINÆRT GEOLOGISK SNITT
L.B. LÖVAAS & J. OLSEN
VERTIKALPROFIL
SERIE B1
MÅLEST.
1:500
GRONG GRUBER A/S
Pr. 8