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Tittel

Åsoren (Aasoren) copper prospect. Norway
Report on 1975 Investigations

Forfatter	Dato	Bedrift
H A Rosenqvist	17.05 1976	Outokumpu OY Otta Malm A/S

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Sel	Oppland	Østlandske	17184	Lillehammer

Fagområde	Dokument type	Forekomster
Geologi geofysikk boring malmberegning oppredning	Rapport	Åsoren (Aasoren) Myrumfeltet, Gravåi skjerp, Svartkampenfeltet, Heidal løsblokkområde
Råstofftype	**Emneord**	
Malm/metall	Cu S Ni Co Ag Au	

Sammendrag

Omfatter Åsoren, Myrum, Svartkampen, Heidal.
Resultatet av geologiske, geofysiske (VLF-EM, Mag) og diamantboringsarbeider (15 hull - 2900m), var grovt estimert en malm som viser in situ tonnasje på: 900 000 t med gj.snittlig 1,2% Cu og 6,7% S (Zn vanligvis >0,1%).
Andre elementer gir maksimalverdier på 915g/t Co, 268g/t Ni, 13 g/t Ag, >0,2 g/t Au.

Malmen opptrer tilsynelatende som linjaler i minst 3 horisonter innenfor Åsoren-sonen. Dimensjoner ca 2-3m brede, mindre enn 100m høye og omlag 300m lange og er orientert i foliasjonsplanet parallellt en lineasjon på N 40 grader.

Geologi, geofysikk, diamantboring, malmberegning og oppredning.Geologiske kart og profilverk med borhull. Tilsammen 28 figurer.

Appendix A: The rockmechanical Caracteristics in the Åsoren Area, Jorma Mustala 15.01.1975.
Appendix B: Preliminary study on consentrability of the Åsoren ore, M. Sari, K. Salminen, 1975

Outokumpu Oy

THE AASOREN COPPER-PROSPECT, NORWAY

Report on 1975 investigations

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1. INTRODUCTION

The Aasoren Cu-prospect at Otta, Norway, has been re-examined and further investigated since February 1975. The work was executed by an Otta Malm A/S - Outokumpu Oy joint venture.

This report deals with the results of geological and geophysical work as well as the diamond drilling carried out in the area. A rough estimate of probable in situ ore reserves shows a tonnage of 0.9 Mt with an average grade of 1.2 % Cu and 6.7 % S.

2. PREVIOUS WORK

Electromagnetic work in 1970 succeeded by diamond drilling in 1971 (Otta Malm A/S) revealed the northern continuation of known sulphide mineralization at Aasoren. General reconnaissance work, further drilling and electrical CP-measurements were carried out during 1973.

The results of 1970-73 investigations have been reported by Th. Holmsen (Otta Malm A/S) in yearly progress reports (1970, 1971, 1973). A summarizing report (Outokumpu internal) on the prospect was prepared by Rosenquist in 1974.

3. PRESENT WORK

Based on an assessment of the results of previous work in the area, it was decided to continue the investigations with main attention paid to the Aasoren deposit. During the 1975 period (February 75 - March 76) the following work was carried out:

3.1. Aasoren grid

(1) Surveying of an 0.75 km^2 area (Fig. 1) whereby also old drillholes were tied to the produced grid.

(2) Geological investigations of the Aasoren area, including the old workings as well as drill core material.

(3) An electromagnetic (VLF) and magnetic survey of the grid also including the running of a gravimetric test profile.

(4) A diamond drill program of 15 holes totalling some 2900 m in the sulphide mineralized zone of Aasoren.

(5) Metallurgical and rock mechanical tests of Aasoren drill core material.

3.2. The surroundings

(1) Geological reconnaissance and/or prospecting work, including the Myrum area, the Heidal area and the Svartkampen old workings.

(2) An electromagnetic (VLF) and magnetic survey of the Myrum grid area (Fig. 1).

4. GEOLOGY

4.1. General

The Cu-mineralization at Aasoren is associated with mafic to intermediate volcanic rocks, generally called greenstones. The greenstones belong to the upper part of an eugeosynclinal sequence, which in tectonic respect belongs to the so called Otta Nappe tectonic unit (Strand 1972). The sediments and volcanics of the nappe are believed to be of Cambro-Ordovician age. At Otta these rocks form a synclinal structure, along the SW limb of which the known sulphide mineralization has been concentrated.

4.2. The Aasoren grid

Apart from a general reconnaissance of the Otta area, geological observations were made from the outcrops of the grid area, in the old workings and from the drill cores. The main purposes of this work were to establish the type and extent of sulphide mineralization and if possible to find out the factors controlling the emplacement of sulphide enrichments.

4.2.1. Lithology

Except for the western marginal portion, consisting of greenschists, the Aasoren grid area is completely built up of greenstones. The greenschists are strongly schistose chlorite-mica rocks interpreted as pelitic and/or tuffitic sediments (Strand 1951, 1972). Magnetic anomalies here are caused by disseminated magnetite.

The Aasoren greenstones are mainly medium to fine-grained epidote-amphibolites, the typical mineral composition being amphibole (of the tremolite-actinolite series), plagioclase (albite), epidote and chlorite.

In more or less accessoric amounts occur carbonate, quartz, opaques, garnet, sphene and apatite. The majority of the greenstones can be interpreted as basaltic lavas of spilitic affinity. Occassionally occurring pillow structures indicate submarine extrusions.

Normal greenstones often grade into coarser massive types, possibly representing the inner parts of lava beds and/or perhaps separate intrusions as suggested by fine-grained contact zones.

Within the dark green basaltic greenstone occur elongated lenselike portions of more leuçocratic rocks. These are comparatively rich in albite, often forming porphyroblasts, the other constituents being epidote, chlorite, actilonite-tremolite and carbonate.

Pyroclastic intercalations within the greenstones also occur, usually of limited extension both in thickness and strike length. These pyroclastics may often be interpreted as volcanic breccias were fragments of fine-grained greenstone (mafic lava) occur in a coarser clastic-like matrix of similar or more leucocratic composition.

Rather persistently occurring on the footwall side of the Aasoren mineralized zone is a strongly tectonized horizon, which also may represent a pyroclastic sediment. In this characteristically small scale folded rock thin (< 0.5 cm) bands of actilonite-epidote-chlorite-albite alternate with leucocratic bands of albite-carbonate-chlorite-quartz. This frequently pyrite disseminated schist was used as a marker horizon ("stopper") during the drill program.

4.2.2. Ore mineralization

Minor amounts of iron sulphides, mainly pyrrhotite and to a lesser extent chalcopyrite and pyrite occur frequently in the Aasoren greenstones. Numerous prospect pits all over the grid area also reflect this fact. The pits appear to have been testing minor portions of enrichment revealed by oxidized (rusty) outcrops. As shown by geophysical ground surveys, most of the enriched sulphide mineralization is found within an approximately 100 m wide zone, the minimum strike length of which is 600 m. This is the minerlized zone where diamond drilling has been concentrated.

Irregular dissemination, lumps and veins of pyrrhotite plus subordinate chalcopyrite generally occur, often in a rather epigenetic manner, within the greenstones. There seems to be some tendency of minor scale enrichment within leucocratic epidote-albite-carbonate-quartz portions, possibly representing late mobilizates of the greenstones.

Sulphide enrichment at a larger scale, however, appears to be structurally controlled. Bodies of enrichment are ruler shaped, roughly occurring in a minimum of 3 horizons within the Aasoren zone (cf. enclosed drill sections). The dimensions of the "ore" rulers are divergent, rather theoretical averages being 2-3 m wide, less than 100 m high and some 300 m in length. The orientation of the "ore"bodies roughly parallells the foliation (N-S/70°) and lineation (40° N) of the area.

The sulphide enrichments (Figs. 4 - 9) occur brecciating their host rock, forming compact to semicompatc elongated "ore" lenses, usually associated with sulphide dissemination of varying intensity. The host greenstone is generally characterized by chloritization occassionally accompanied by the formation of pink garnets. Such chlorite schists also occur almost totally avoid of ore minerals, thus possibly indicating the influence of ore forming fluids.

The paragenesis of the sulphide mineralization at Aasoren is in order of abundance: pyrrhotite - chalcopyrite - pyrite - sphalerite - cubanite - mackinavite - cobalt pentlandite - molybdenite. Among oxide minerals magnetite and ilmenite occur frequently within the sulphide mineralized zone. Magnetite is found as elongated irregular lumps (occassionally of up to 3 m thickness) often in close association with sulphide enrichments.

The only base metal content of any economic significance appears to be that of copper. The rather erratic Cu-grade of the enriched bodies averages some 1.2 %. The Zn-content is of occassional type, the grade generally being below 0.1 %. Maximum results on assays for other metals show:

Co	915 g/t (ppm)
Ni	268 "
Ag	13 "
Au	<0.2 "

The average S-grade for the "ore"bodies is in the order of 6 %.

4.2.3. Structural setting

As shown by the enclosed map, the main observed structural elements in the Aasoren area are foliation and the linear features fold axis and lineation. The foliation, generally parallell with bedding if observeable, has a N-S/70° E orientation. The predominant plunge of the linear structures is steep to moderate SE for small-scale folding (often of drag fold type) and an average of 40° NNE for the lineation. Of importance are also small-scale folds with a moderate NE:ly plunge, observed in a few localities.

Because enrichment of sulphide mineralization is thought to be closely associated with the structural evolution of the area, the following hypothetic interpretation of observed elements if forwarded:

The regional setting of the Aasoren area is the SW limb of the Otta synclinal structure F_1. The axis of this folding has a NW-SE orientation as shown by Strand (1951) and later Barkey (1969) (Fig. 2). Sulphide mineralization, occurring in minor quantities at several levels of the folded pile of volcanics, were mobilized and possibly enriched in favourable localities such as the A-lineation of the F_1-folding.

Later an E-W or NW-SE oriented compressional force caused cross-folding with moderately towards NNE-plunging fold axis (F_2). This phase in structural evolution also bended the W-limb of the Otta syncline (F_1) into a steep N-S oriented position at Aasoren. Then the majority of folds observed in the Aasoren area, i.e. those with a steep-moderate SE:ly axial plunge, would represent F_1 (drag-) folds. Also as a consequence of the crossfolding (F_2), the F_1 - A lineation got a moderately northerly plunging orientation and might to some extent coincide with linear elements of the F_2-folding, such as F_2-B lineation. This event, i.e. the crossfolding, possibly leads to further mobilization and enrichment of the sulphide mineralization at Aasoren.

4.3. The surroundings

Geological reconnaissance work in the surrounding of Aasoren included:

(1) The Myrum area
(2) The Svartkampen Cu-showings
(3) The Heidal area

4.3.1. Myrum

This area, situated immediately SE of the Aasoren area (Fig. 1), was selected for a closer check because of lithological association with the Aasoren area as well as known sulphide showings and electromagnetic conductors.

The Myrum rocks are generally schistose EP-KLO-AB rocks, like the Aasoren area representing the W-limb of the Otta syncline. The general strike and dip of the area is SE/45° NE, i.e. semiparallell to the valley slope. Sudden and frequent variations are due to the F_2 crossfolding (cf. p. 6). Structural observations are shown on the enclosed map.

Sulphide mineralization FEK-SK plus subordinate CUK occur in scattered localities but appear to be of modest dimensions. Sulphides are found in narrow shear zones often associated with graphite. The almost compact FEK-SK±CUK mineralization at Gravåi prospect pit (K = 30.250/ L = 10.970) is a mobilized sulphide enrichment (Fig. 10) possibly controlled by a NNE-plunging linear structure.

4.3.2. Svartkampen

Four prospect pits of average size 60 m^3 occur at Svartkampen approximately 5 km SW of Otta. A brief examination of the workings revealed CUK-SK dominated ore mineralization closely associated with major quartz lenses within a mica-chlorite schist. The ore mineralization (chalcopyrite - pyrite - galena plus iron oxides, magnetite - hematite - limonite) occurs in viens and stringers of only a few cm:s in width. The quartz lenses, with associated ore veins generally restricted to the contact zones, occur within some 200 m of strike length. The scattered ore veins appear too small to be of economic interest.

4.3.3. Heidal

Boulders of massive sulphide mineralization, found by private persons and delivered to Otta Malm A/S, initiated a minor follow-up attempt in the Heidal area.

The locality of the findings is in the Sjoa river canyon (Map 1718 II - 5.13.5/68.46.5) some 15 km WSW of Otta. Microscopic examinations showed a compact pyrite mineralization with interstitially occurring chalcopyrite plus stripes of sphalerite and magnetite. Laboratory tests revealed maximum base metal contents in the order of 1 % Cu and 3 % Zn.

Boulder tracing was carried out in the assumed up-ice direction (SW) of the U-shaped river valley as well as along river banks of the Sjoa river canyon. Boulders of the target type were never found and the tracing was given up some 8 km from the starting point at Morsebakken.

5. GEOPHYSICS

Geophysical ground surveys, preceded by grid surveying, were carried out in the Aasoren and nearby Myrum areas (Fig. 1). The work, including electromagnetic (VLF) and magnetic measurements, interpretation and report writing, was done on contract basis by Suomen Malmi Oy. For technical details reference is made to the earlier distributed reports (SMOY/Pekka Mikkola 16.06.75 and 12.12.75). Only some summarizing comments are given here.

5.1. Aasoren grid

The survey outlined the Aasoren mineralized zone well but did not produce further anomalies indicative of previously unknown sulphide enrichment. The combination VLF-EM/MAG proved to be an effective tool in locating ore mineralization of similar type in the surroundings.

5.2. Myrum grid

The Myrum survey produced a somewhat confusing anomaly pattern, probably due to the effects of prevailing fold pattern and section of bedrock exposed. Several electromagnetic conductors were picked up, but none of them clearly indicate sulphide enrichment of the Aasoren type. However, some of the anomalies (e.g. 6, 16 and 13) are of interest and regarded as potential drill targets.

6. DIAMOND DRILLING

Diamond drilling of the mineralized zone at Aasoren was carried out in two phases:

I 5 holes - 1288 m (March-April 75)

II 10 " - 1608 " (December 75 - March 76)

Phase I was planned as a supplement to earlier drilling (1900 m), being restricted to the northern half of the zone, whereas Phase II mainly concentrated on the previously not drilled southern half. The actual drilling was performed by the local contractor Geobor A/S.

The cross-sectional distribution of holes and assayed material of the 1975 drill program are shown in the table below.

Section	Holes	Total meters	Assayed meters	Number of samples	Average sample
K≈10.245	1 (BH 30)	130.00 m	7.20 m	7	1.03 m
" 290	2 (25, 26)	270.00 "	17.25 "	15	1.18 "
" 345	2 (27, 28)	251.70 "	6.65 "	7	0.95 "
" 400	3 (29, 33, 34)	555.30 "	11.15 "	10	1.12 "
" 500	2 (24, 31)	329.80 "	11.95 "	14	0.85 "
" 600	1 (23)	251.00 "	12.50 "	9	1.39 "
" 650	1 (22)	270.00 "	10.30 "	7	1.47 "
" 700	2 (20, 21)	517.35 "	34.05 "	34	1.00 "
" 800	1 (32)	320.70 "	7.40 "	7	1.06 "
Total	15	2895.95 m	118.95 m	110	1.08 m

The treatment of drill core material can be summarized as follows:

(1) Photographing - colour slides

(2) Geological logging

(3) Sampling and splitting

/...

(4) Laboratory investigation including

- density determinations (phase I only)
- chemical assays: Cu, Zn, Fe and S, plus occassionally Co, Ni, Ag and Au
- microscopical examination of prepared polished and thin sections.

(5) Plotting of results on cross sections.

In addition to this routine treatment

(6) rock mechanical investigations were performed using specially collected type samples plus photo material, and

(7) metallurgical tests were carried out on a bulk sample (12 kg - 1.3 % Cu).

Results of the Aasoren drill program are shown on the enclosed drill sections and appendix reports by Jorma Mustala (rock mechanics) and Matti Saari (metallurgy).

7. ESTIMATE OF ORE RESERVES

Calculations of "ore in situ" reserves at Aasoren are based on DDH intersection data only. True widths of intersected sulphide enrichment and corresponding assay data have been roughly interpolated between holes as well as cross sections. Based on laboratory tests, a generalized value of 3.3 g/cm^3 has been used as the density of sulphide enrichment. Isolated sulphide enriched portions of less than 0.5 m width or less than 0.4 % Cu are not included in the estimate of reserves.

The build-up of the estimated tonnage and Cu-content of Aasoren is shown by tables A-D and enclosed drill sections plus sketch maps of longitudinal sections.

Calculated ore reserves

Table A: A-horizon

Section	Drillhole	True width	Tons	% Cu	% S
K=10.500	6	0.50 m	8.000 t	0.48	9.30
" 500	6	1.30	22.400	0.68	3.37
" 600	4	1.60	24.700	3.39	4.83
" 665	10	3.30	35.000	3.75	9.45
" 700	20	0.50	4.800	0.61	10.8
" 700	13	9.50	91.300	0.94	4.10
" 800	18	2.20	27.400	0.70	5.2
" 825	32	0.70	5.200	0.58	1.90
		Total	218.800 t	1.58	5.39

Table B: B-horizon

Section	Drillhole	True width	Tons	% Cu	% S
K=10.600	3	2.40 m	20.500 t	1.12	14.5
" 623	9	2.80	21.700	2.80	25.5
" 650	8	6.20	48.600	1.15	7.9
" 650	10	1.90	17.600	0.48	1.10
" 700	15	2.60	22.000	0.44	4.20
" 700	15	1.60	16.900	0.68	5.70
" 700	20	0.60	5.700	4.70	8.30
" 700	21	0.70	7.800	0.51	7.7
" 700	21	1.70	18.800	0.83	8.48
		Total	179.600 t	1.20	9.52

Table C: C-horizon

Section	Drillhole	True width	Tons	% Cu	% S
K=10.290	25	10.0 m	35.600 t	0.57	4.30
" 290	25	0.60	2.100	0.70	3.10
" 345	28	2.5	26.700	1.86	8.59
" 408	29	2.0	22.400	5.72	18.56
" 408	29	1.25	14.000	0.46	4.80
" 500	24	3.00	42.000	0.42	7.78
" 600	4	3.20	53.900	0.93	5.80
" 600	23	0.65	9.200	1.13	5.75
" 600	3	1.90	19.700	0.81	6.30
" 600	3	0.60	6.200	8.40	31.70
		Total	231.800 t	1.52	8.13
K=10.700	20	2.40	28.300	2.44	13.9
" 800	7	1.20	24.600	1.0	2.4
" 800	18	1.20	15.600	0.94	6.5
" 835	32	3.00	34.700	0.84	15.8
		Total	103.200 t	1.33	10.68

Table D: Aasoren total

Body (horizon)	Tons	% Cu	% S
A	218.800	1.58	5.39
B	179.600	1.20	9.52
C_{syd}	231.800	1.52	8.13
C_{nord}	103.200	1.33	10.68
	733.400	1.43	8.01
Appr. 20 % dilution	870.000 t	1.20 % Cu	6.75 % S

As shown by the maps, the above estimated reserves occur within 600 m of strike length and down to a depth of 200 (A, B) - 250 (C) m. The sulphide enriched bodies of the A and C horizons are still open down the plunge and it is not absolutely unlikely that also extensions of the B-horizon "ore" would be found down the plunge. Now, assuming a continuation of magnitudes indicated by the deepest DDH intersections, the hypothetical increase of potential ore reserves would be in the order of 2000 t / vertical m. Thus, roughly calculated, an extension of the sulphide enrichment down to say 500 m would increase the total reserves of Aasoren to approximately 1.5 Mt.

8. CONCLUDING REMARKS

The 1975 period of the Otta Malm - Outokumpu joint venture has considerably increased the knowledge of the Aasoren Cu-prospect, to which the main efforts were restricted. Unfortunately though, findings of immediate positive consequences have not been achieved. Geological examination and systematic drilling (sampling) of the sulphide enriched zone strengthened the conception of a highly heterogenous ore mineralization. The heterogenity is valid for size, form and location as well as the erratic base metal (Cu ± Zn) content of sulphide enrichment.

The estimated ore reserves of Aasoren are clearly smaller than those estimated before the present investigations. When this fact, though not completely, is due to increased data (DDH intersections) then the trend is negative. The Cu-mineralization is, however, still open down the plunge, but the possibilities of a substantial increase of the tonnage within reasonable limits of depth seem unlikely.

As indicated above, the 1975 program only included superficial reconnaissance of the Aasoren surroundings. The Myrum area revealed several EM-anomalies some of which are potential drill targets. The Otta greenstone areas including the Aasortjern EM-anomalies also warrant further exploration efforts.

Helsinki, May 17, 1976

Harry Rosenquist

H. Rosenquist

ENCLOSURES

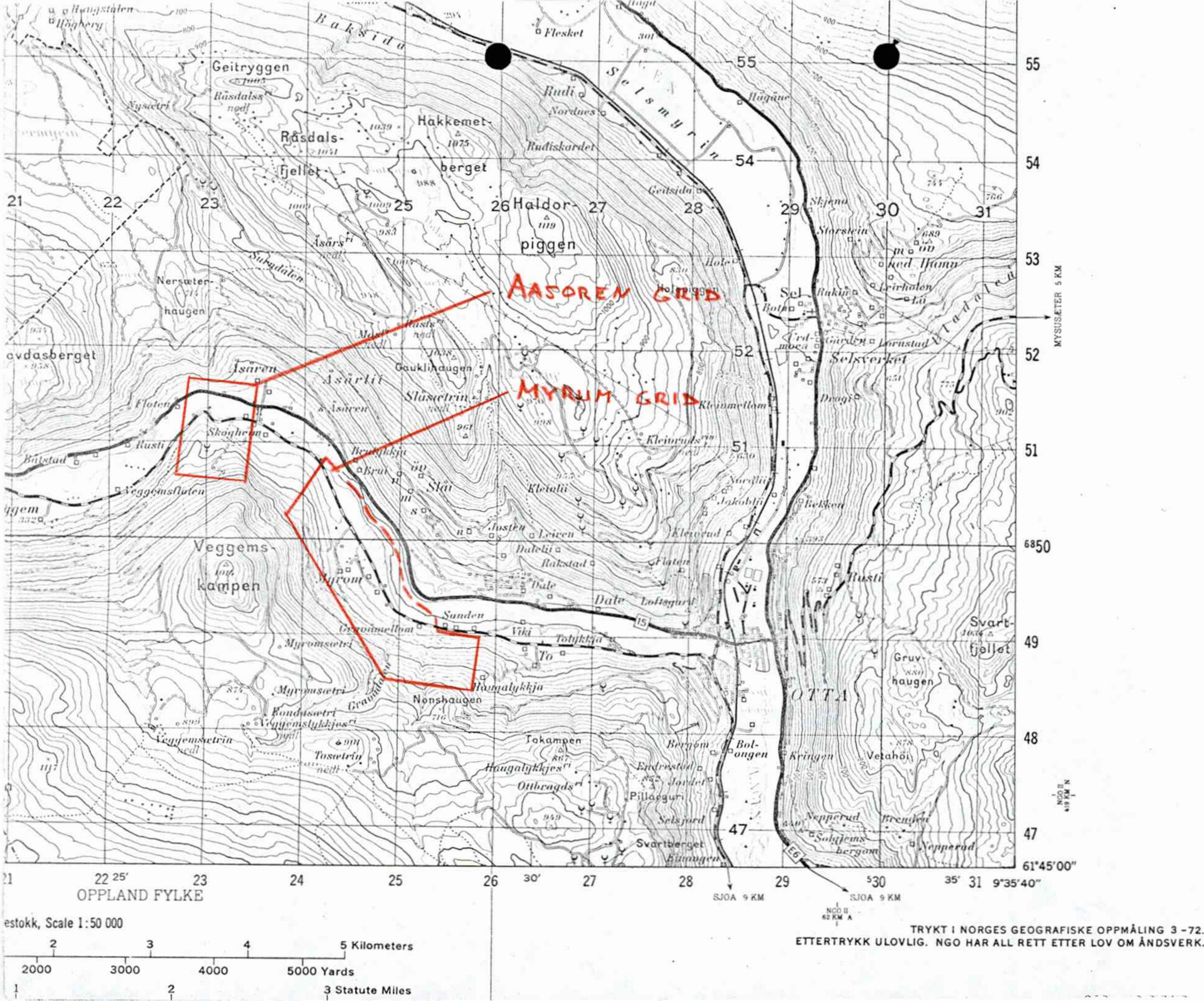


Fig. 1

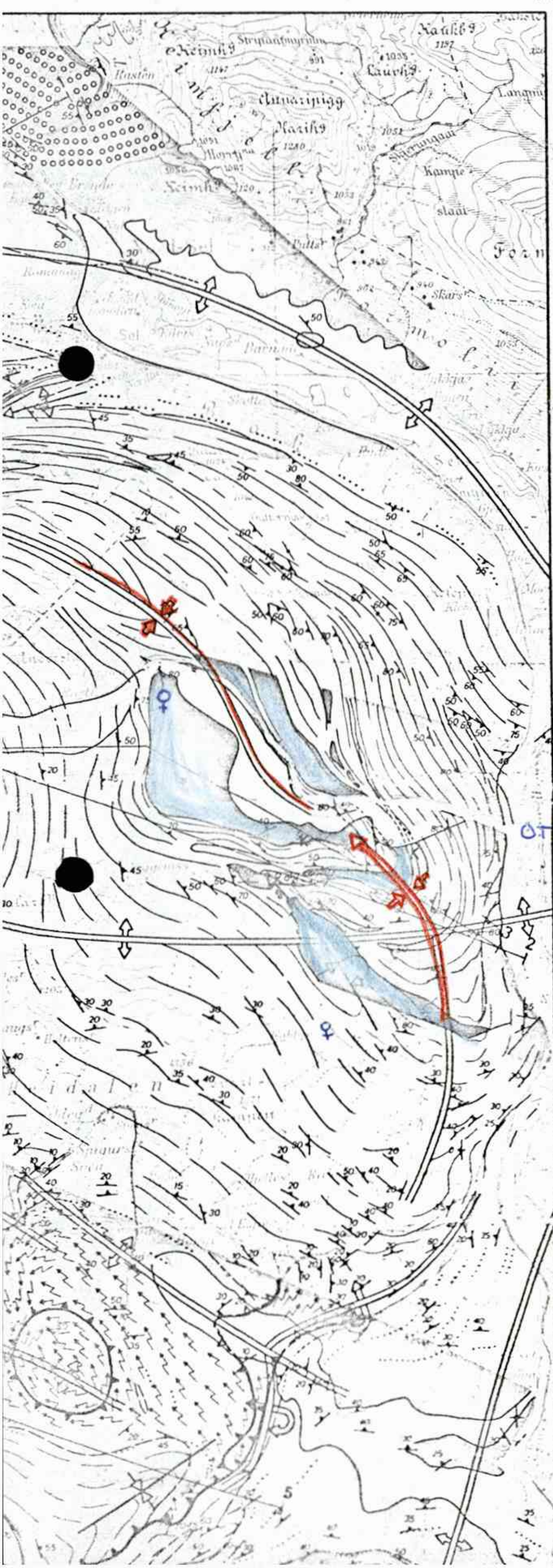
ORIENTATION MAP

1:50,000

Fig. 2.

STRUKTURKART
STRUCTURAL MAP

1°10'



Kartlagt for

NVE - STATSKRAFTVERKENE

i 1969 av NGU, Geofysisk avdeling
NGU oppdrag nr. 895
Prosjektleder: Henri Barkey

Målestokk 1: 100.000

0 2 4 6 8 10

Ekvidistanse 30 m

TEGNFORKLARING
Legend

OVERDEKKET (MORENE, ELVEAVSETNINGER OSV.)
Covered (moraine, river deposits etc.)

SEDIMENTKOMPLEKS (DELVIS OVERSKJØVET)
Sedimentary complex (partly overthrusted)

GARBENSKIFER (SELSKIFER)
«Garbenschiefer» (Sel micaschist)

LINSER AV KALKSTEIN I GARBENSKIFER
Lenses of limestone in «garbenschiefer»

SERPENTINKONGLOMERAT
Serpentine conglomerate

KLEBERSTEIN
Soapstone

ULTRABASITT, DELVIS SERPENTINISERT
Ultrabasic rock, partly serpentinized

TALKSKIFER
Talc-rich schists

GRØNNSTEIN
Greenstone

GRØNNSKIFER
Greenschists

HOVEDSAKELIG FYLLITT MED SVARTSKIFER
Mainly phyllite with intercalated black shales

HOVEDSAKELIG GRANATGLIMMERSKIFER MED SVARTSKIFER
Mainly garnet mica schist with intercalated black shales

OBSERVERTE SONER MED GRØNNSTEIN/GRØNNSKIFER
Observed zones with greenstone/greenschists

OBSERVERTE SONER MED AMFIBOLITT/KALKSKIFER
Observed zones with amphibolite/lime-rich bands

OBSERVERTE SONER MED SVARTSKIFER/KVARTSITT
Observed zones with black shales/quartzite

KVARTSRIK FYLLITT
Quartz-rich phyllite

HOVEDSAKELIG KVARTSITT
Mainly quartzite

ARKOSITT MED FYLLITTISKE BERGARTER
Arkosite with phyllitic rocks

KONGLOMERAT, HOVEDSAKELIG MED GNEISGRANITTISKE BOLLER
Conglomerate, mainly gneissgranitic pebbles

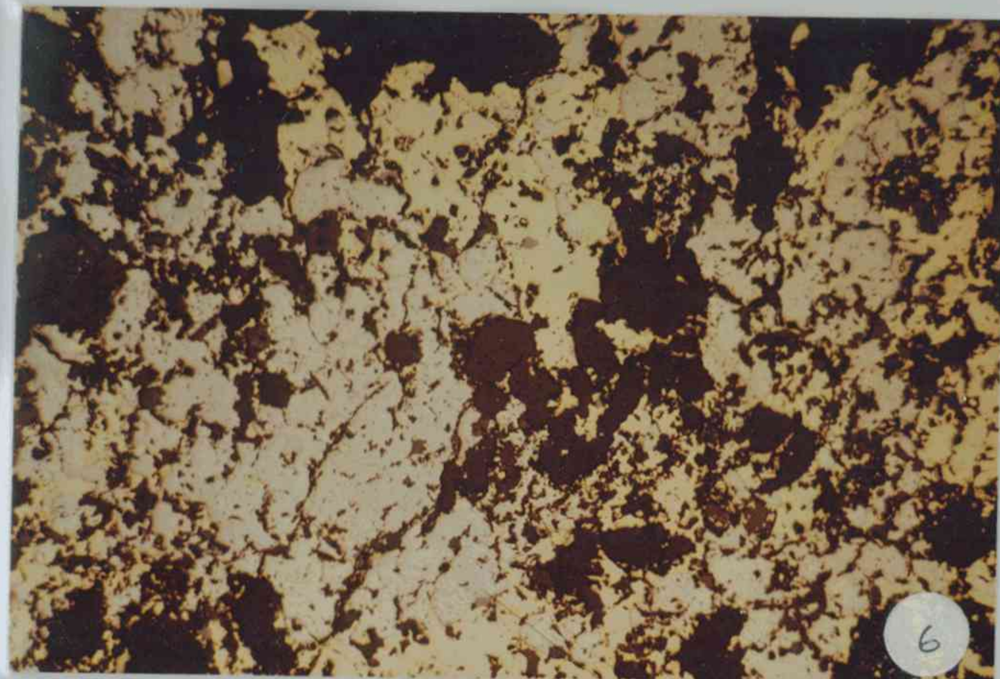
MYLONITTISKE OG TYNNSKIFRIGE BERGARTER, OVERVEIENDE SEDIMENTER
Mylonitic and schistose rocks, mainly sediments

JOTUNKOMPLEKS (SKYVEDEKKE)
Jotun complex (thrust masses)


3


7 8 9 10 11 12
5


4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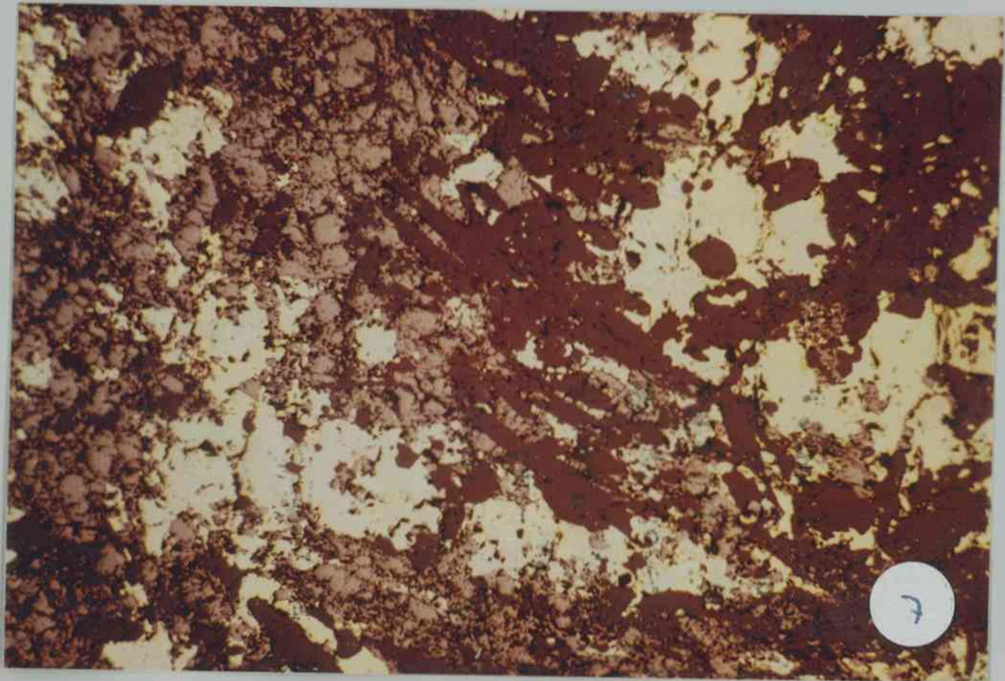

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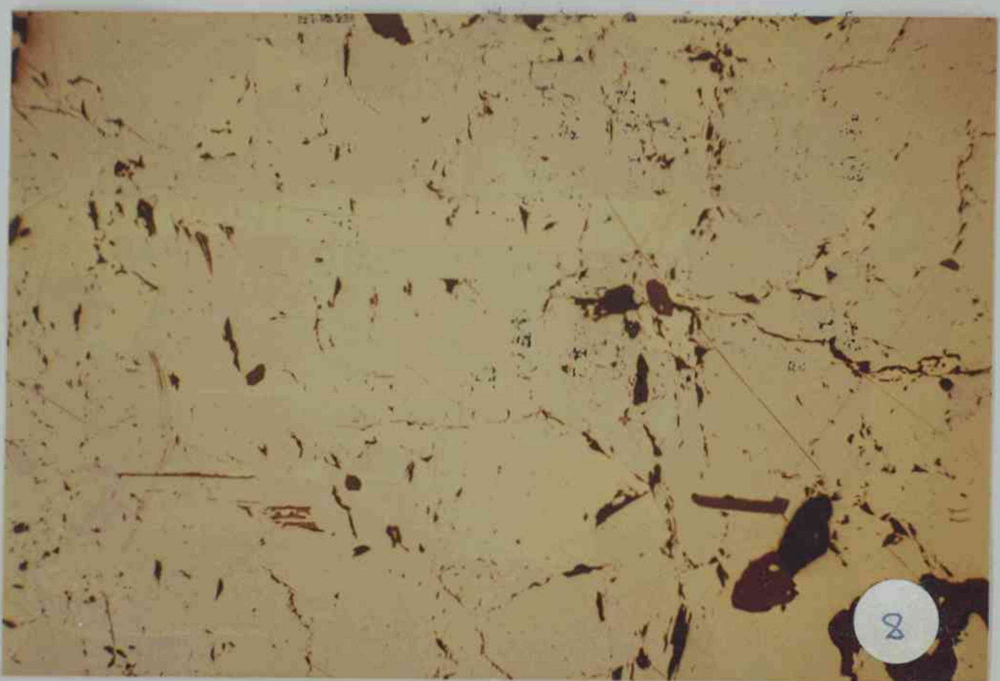
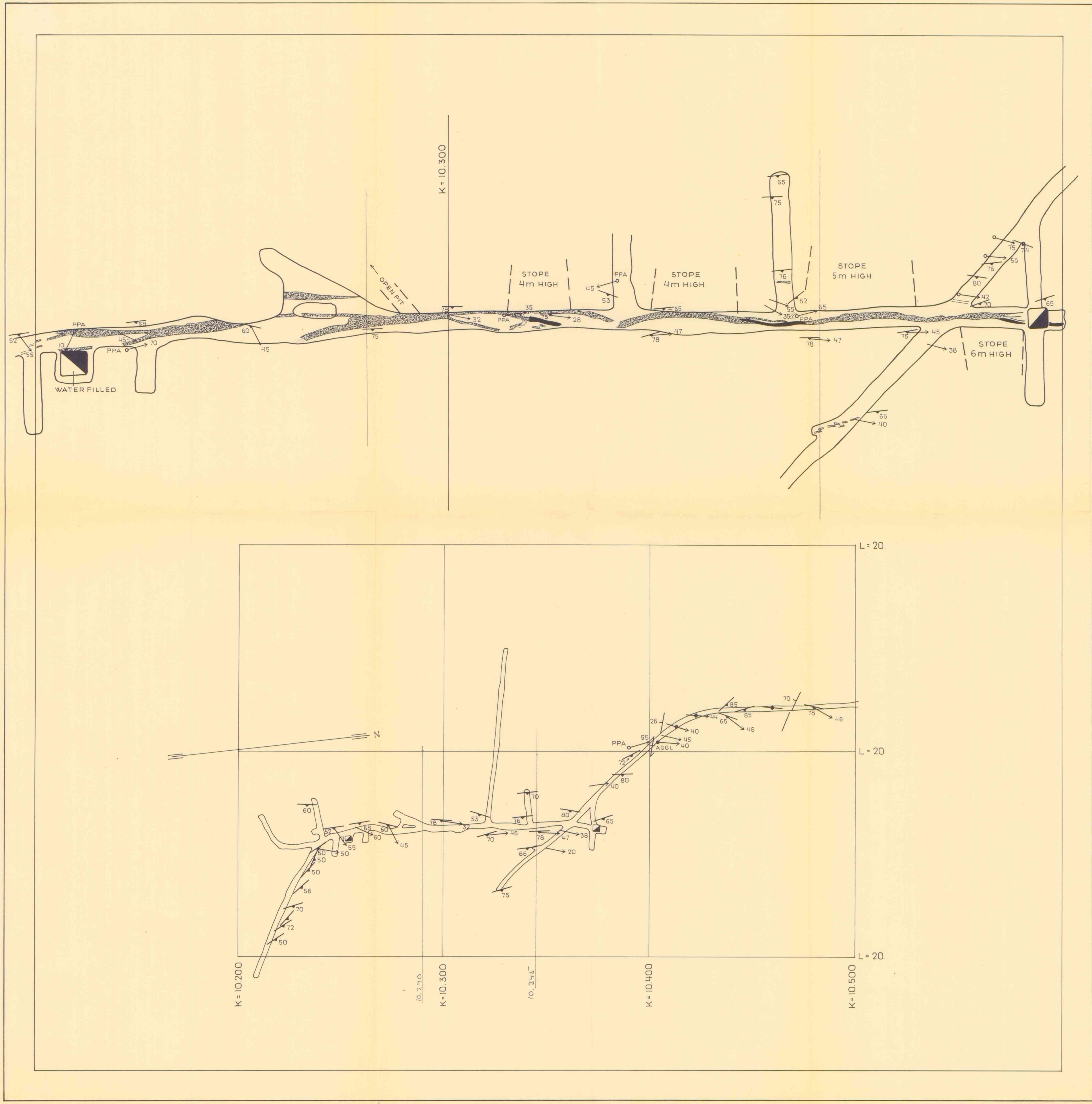


8

10

Otta elven
RIKS 15
OTTA
ÅSÅRBRUA
TYL
(305.5)
PPA 350/25
84 LEVEL ADIT
50 LEVEL ADIT
OPEN PIT
Gruvtjern
(389)
55 (TYL ?)
AGL
K = 10.800
K = 10.600
K = 10.400
K = 10.200
K = 10.000
L = 20.00
L = 20.200
L = 20.400
L = 20.600
L = 20.800
GREENSTONE
i.e. MAFIC-INTERMEDIATE VOLCANICS, BOTH LAVAS AND PYROCLASTICS
GREENSCHIST
PROSPECT PIT
JOINTING
SCHISTOSITY / FOLIATION
LINEATION
AXES OF MINOR FOLD
AXES OF MAJOR FOLD
RIGHT HAND STRUCTURE
OUTOKUMPU Oy
EXPLORATION DIVISION
1:2000
HR/LK 1976
AASOREN GRID
OTTA, NORWAY
GEOL OBSERVATIONS
Fig 11



ORE MINERALIZATION
SCHISTOSITY
LINEATION
MINOR FOLD AXIS
SHAFT

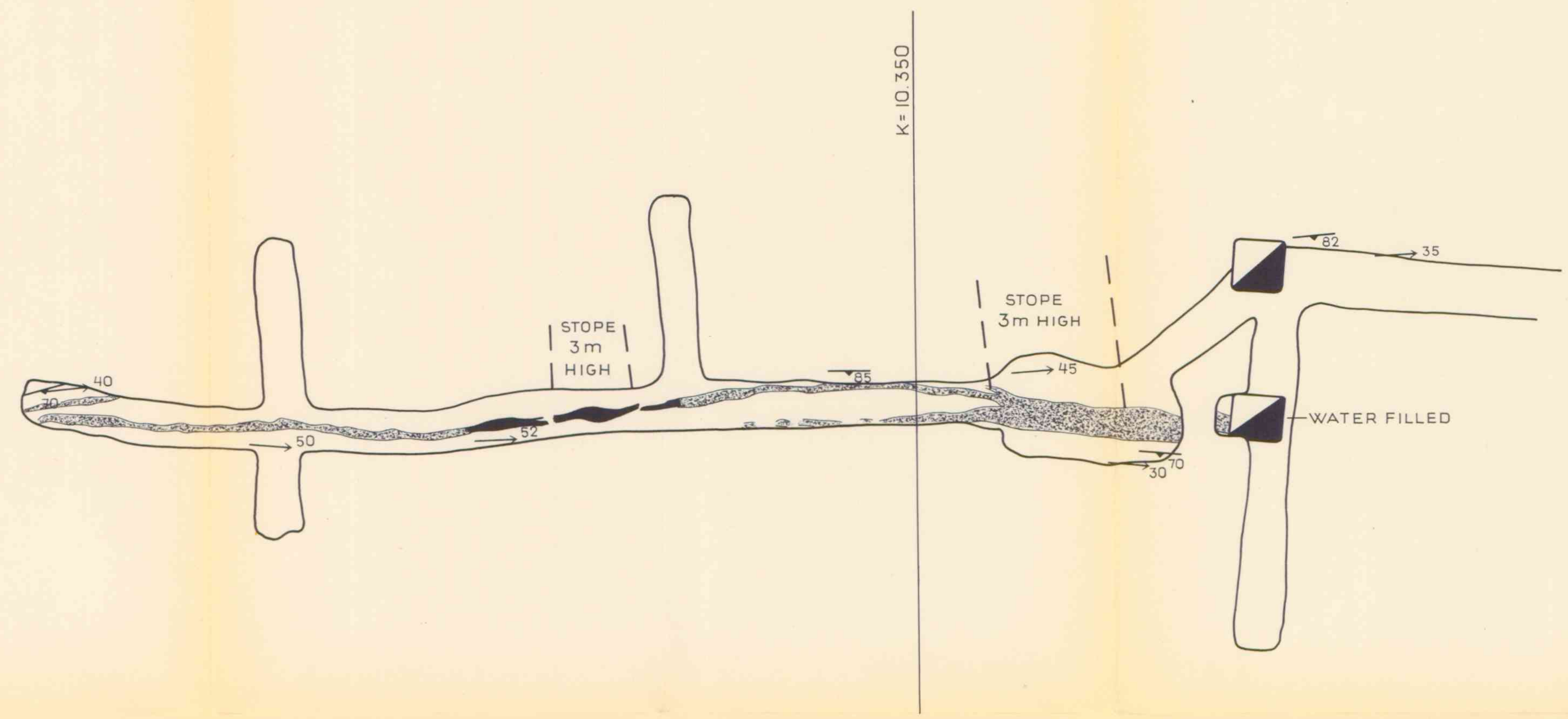
OUTOKUMPU Oy
Malminetsintä

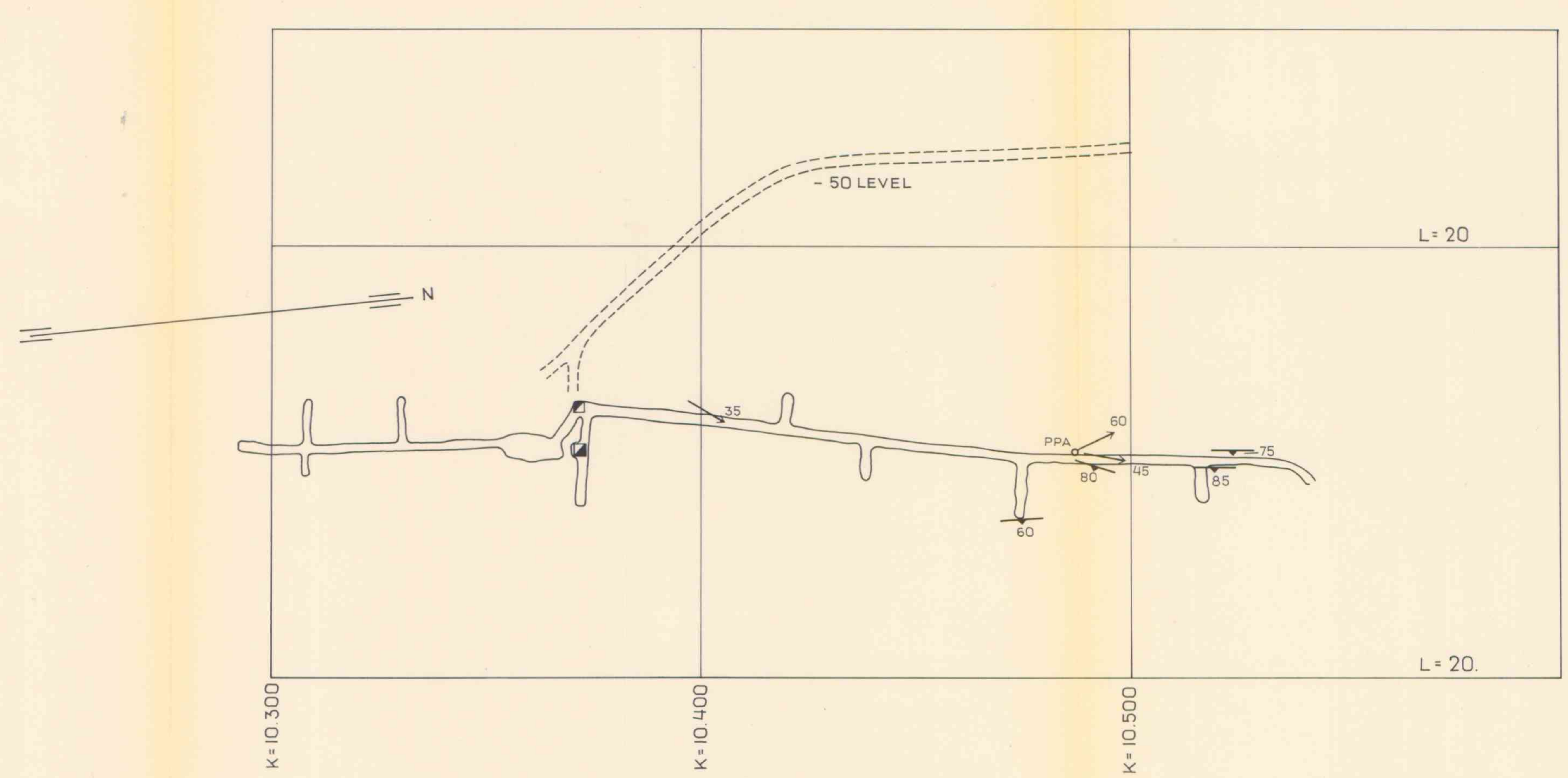
1:250 / 1:1000
HR/MLK -75

NORJA
AASOREN, OTTA

The old mine
-50 level

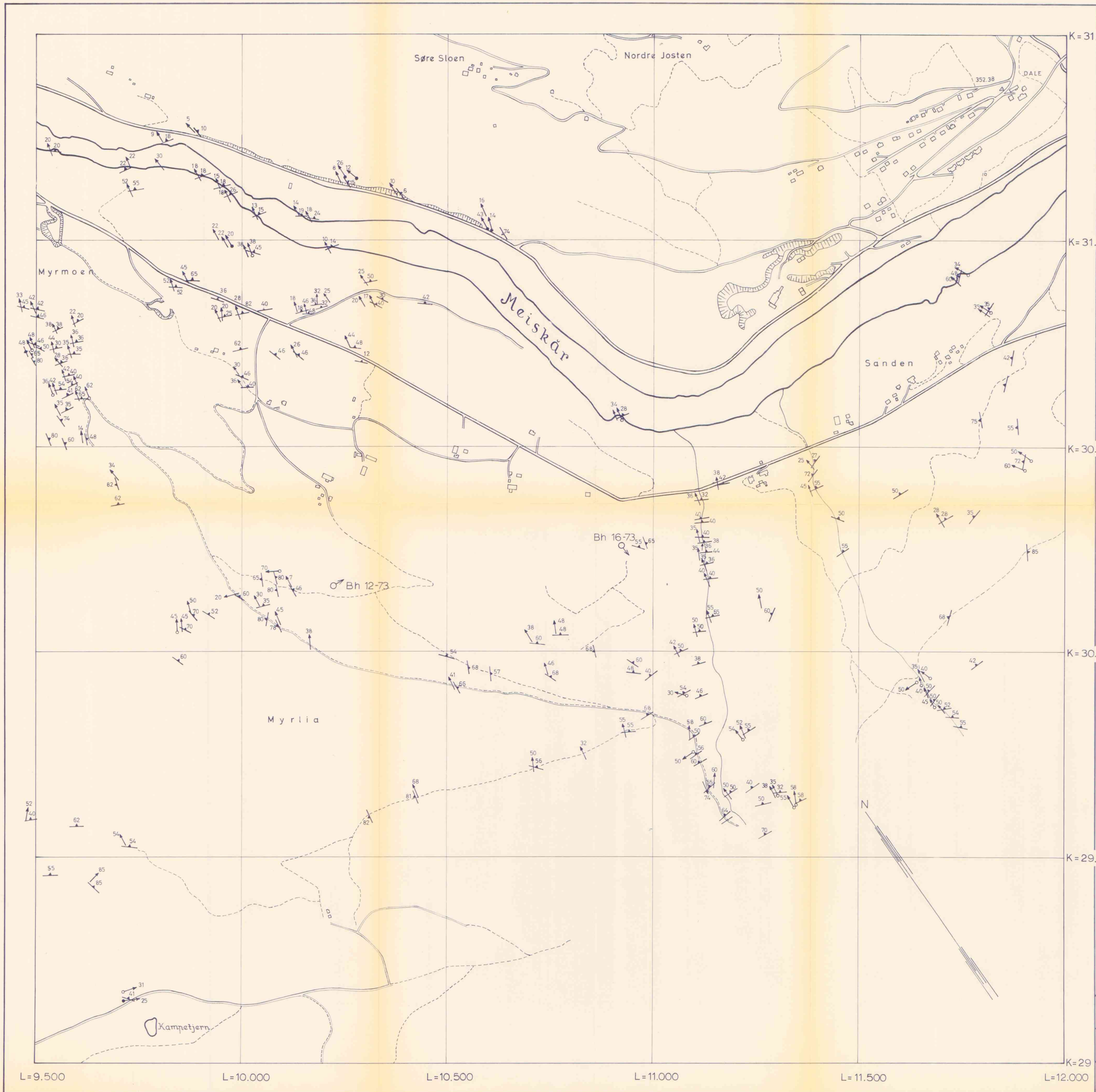
Fig 12.





ORE MINERALIZATION
70 SCHISTOSITY
45 LINEATION
40 MINOR FOLD AXIS
SHAFT

OUTOKUMPU Oy Malminetsintä	1:250 / 1:1000 HR/MLK -75
NORJA AASOREN, OTTA	
The old mine -84 level	Fig 13



JOINTING

SCHISTOSITY / FOLIATION

LINEATION

AXES OF MINOR FOLD

AXES OF MAJOR FOLD

RIGHT HAND STRUCTURE

OUTOKUMPU Oy
EXPLORATION DIVISION

1:5000

HR/LK-1976

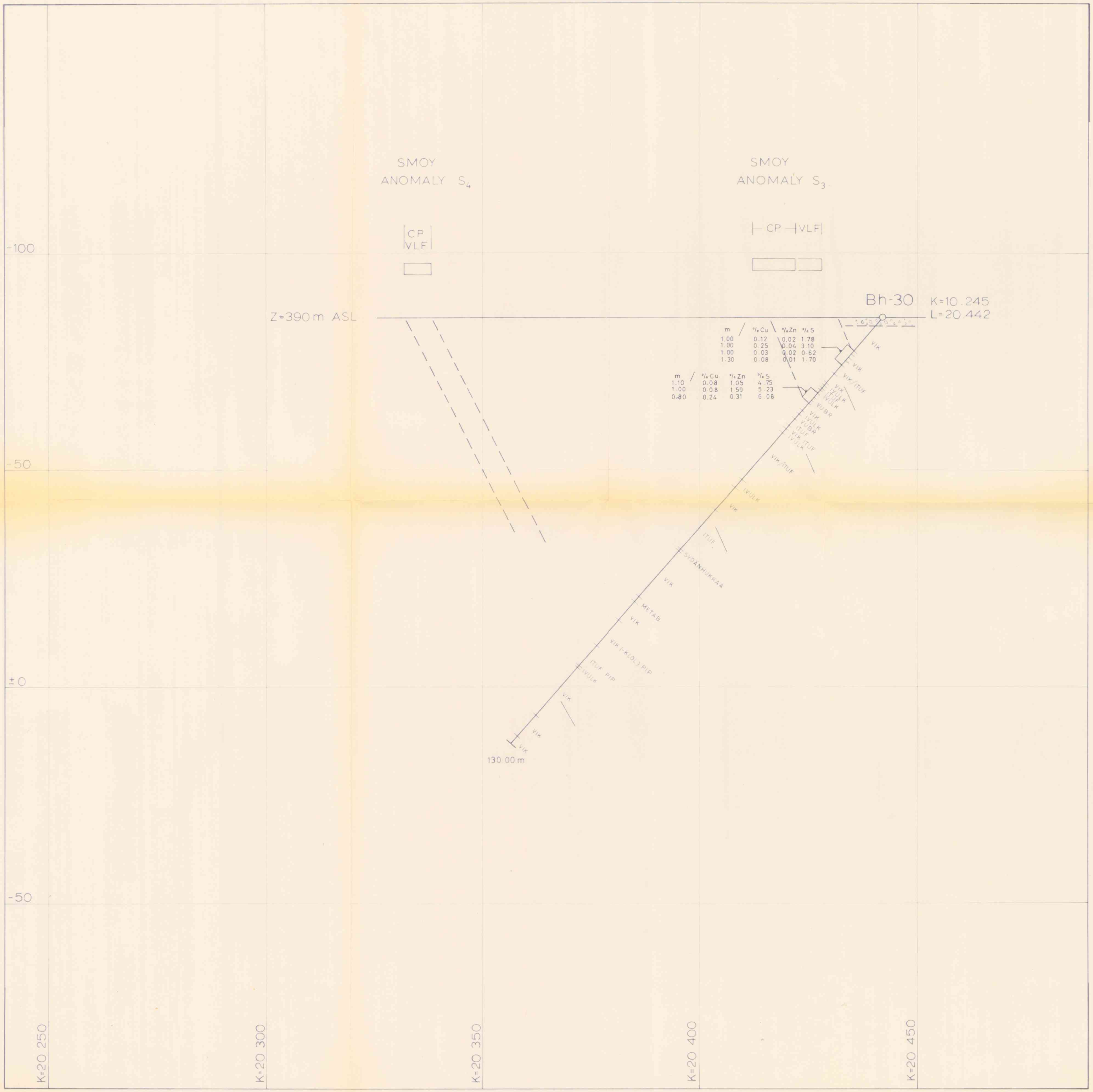
MYRUM GRID
OTTA, NORWAY

GEOL. OBSERVATIONS

Fig 14

AASOREN GRID 1:2000
ORIENTATION MAP

Fig 15



0-taso = -305 m

REIKÄ	K	L	Z	Suunta	Kaltev.
Bh-30	10.245	20.442	-390 m		

311

OUTOKUMPU Oy
Malminetsintä

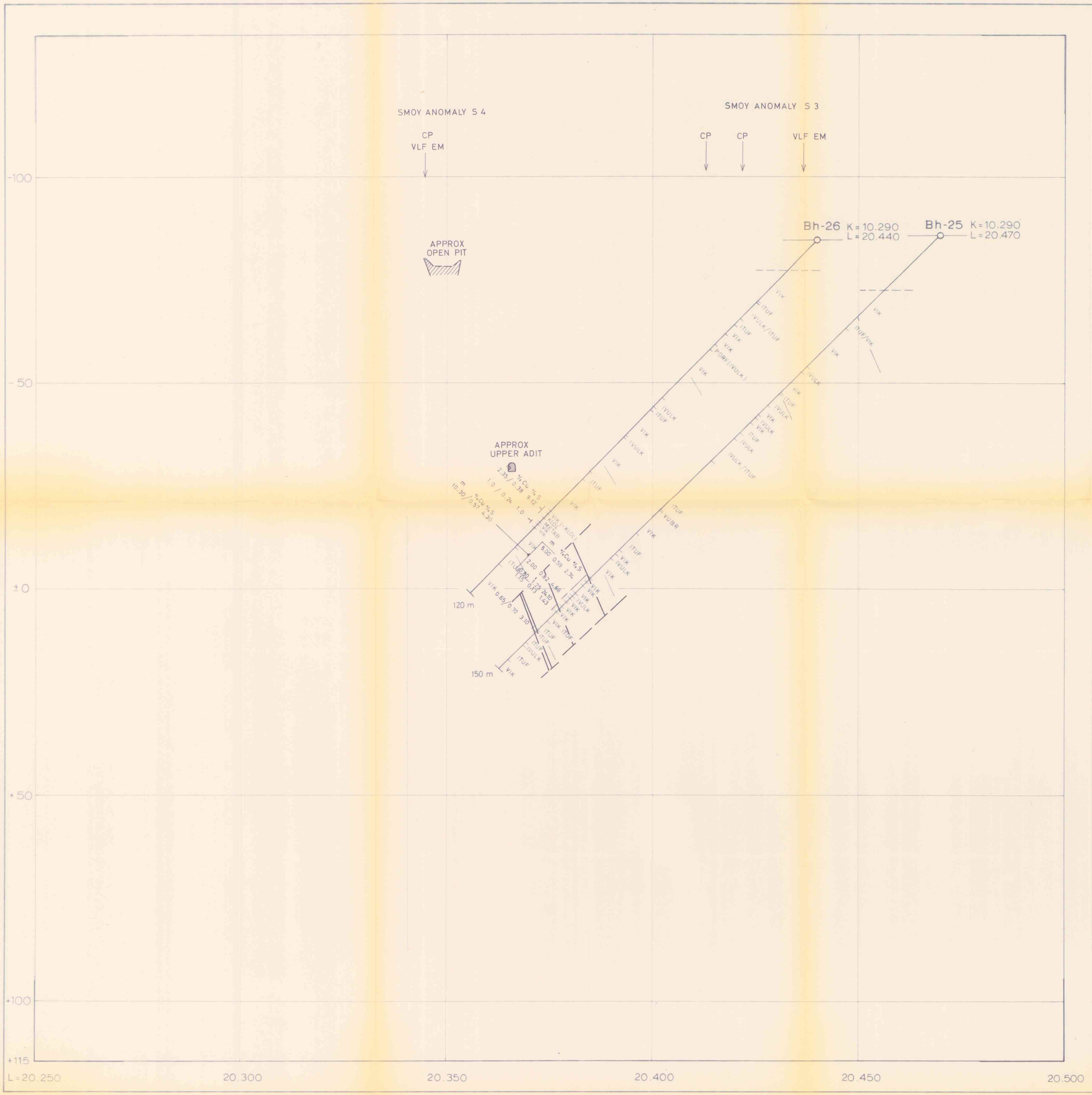
1:500

HR / LK 1976

NORJA
AASOREN

310

KAIRAUSPROF. K=10.245
Bh-30



±0-taso = 305 m

Reika	K	L	Z	Suunta	Kaltev.
Bh-25	10.290	20.470	~390 m	~284 mN	45°
Bh-26	10.290	20.440	~390 m	~284 mN	45°

311	
314	

OUTOKUMPU Oy
Malminetsintä

1:500

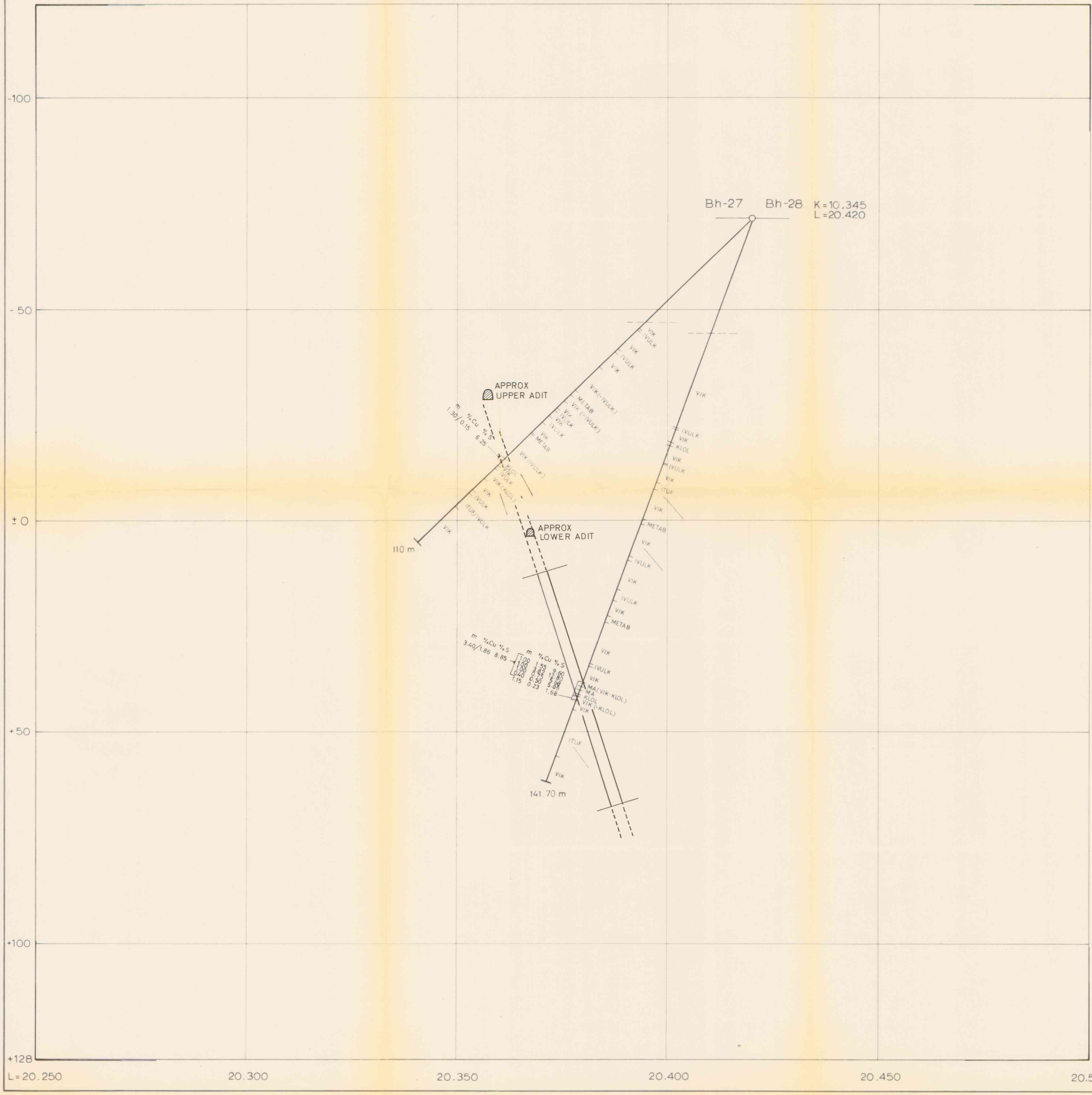
HR/LK-1976

NORJA
AASOREN

L = 20.250
– 20.500

310

Kairausprofiili K10.290
Bh-26,-25

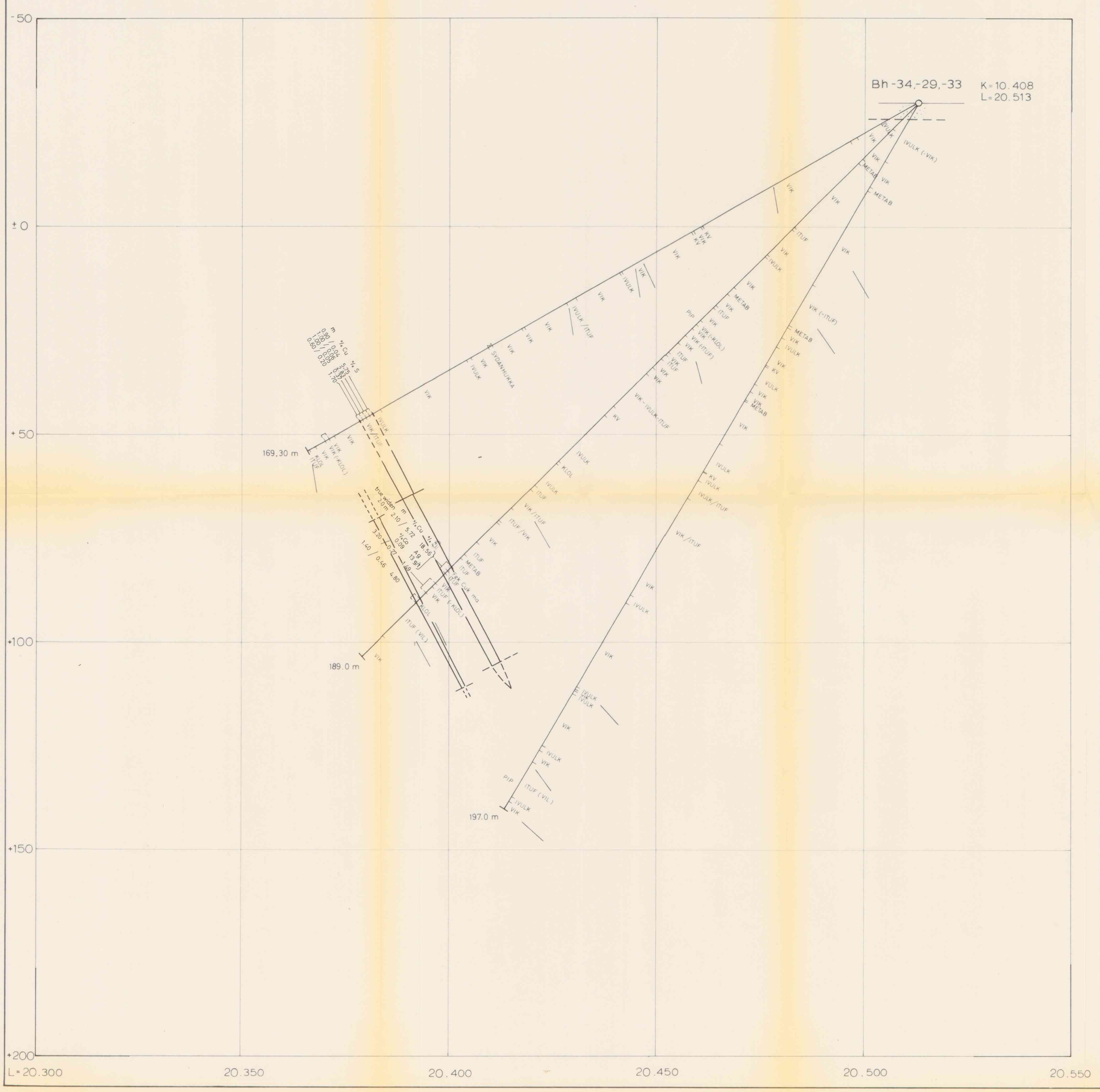


±0-taso = 305 m

Reika	K	L	Z	Suunta	Kaltev.
Bh-27	10.345	20.420	377m	~284mN	44°
Bh-28	10.345	20.420	377m	~284mN	70°

311	
314	

OUTOKUMPU Oy Malminetsintä	1:500 HR/LK-1976	
NORJA AASOREN	L = 20.250 – 20.500	310
Kairausprofiili K10.345 Bh-27, -28		



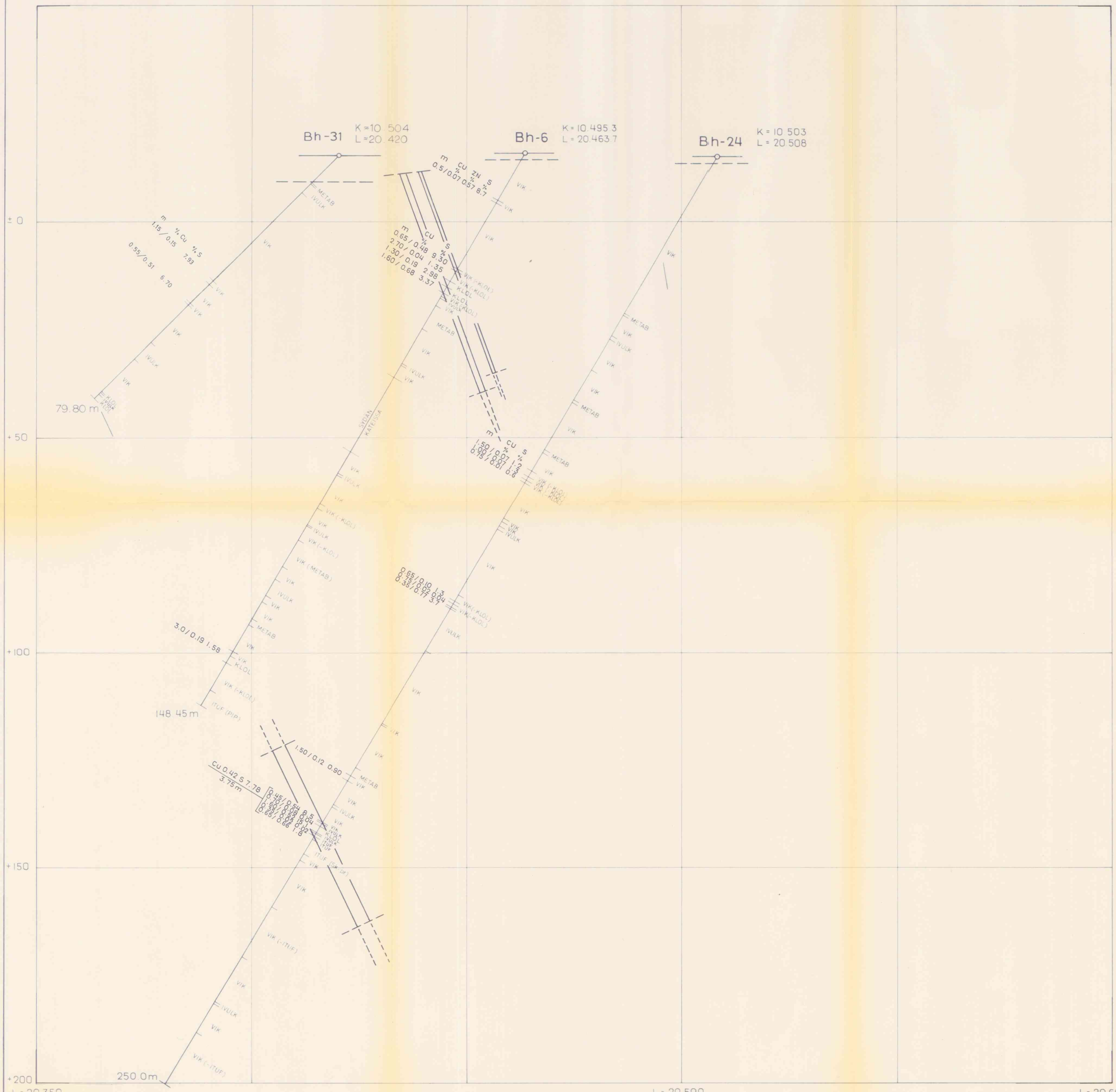
± 0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev.
Bh-29	10.408	20.513	-335 m		45°
Bh-33	10.408	20.513	-335 m		60°
Bh-34	10.408	20.513	-335 m		30°

311

314

OUTOKUMPU Oy Malminetsintä	1:500 HR/LK-1976	
NORJA AASOREN	L = 20.300 – 20.550	310
Kairausprofiili **K10.408** Bh-29,-33,-34		



±0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev.
Bh-6	10.495	20.463	+320.82	294.70g	60°
Bh-24	10.503	20.508	n.320.0	n.288°	60°
Bh-31	10.504	20.420	n.320.0	n.288°	45°

311	
314	

OUTOKUMPU Oy
Malminetsintä

1:500

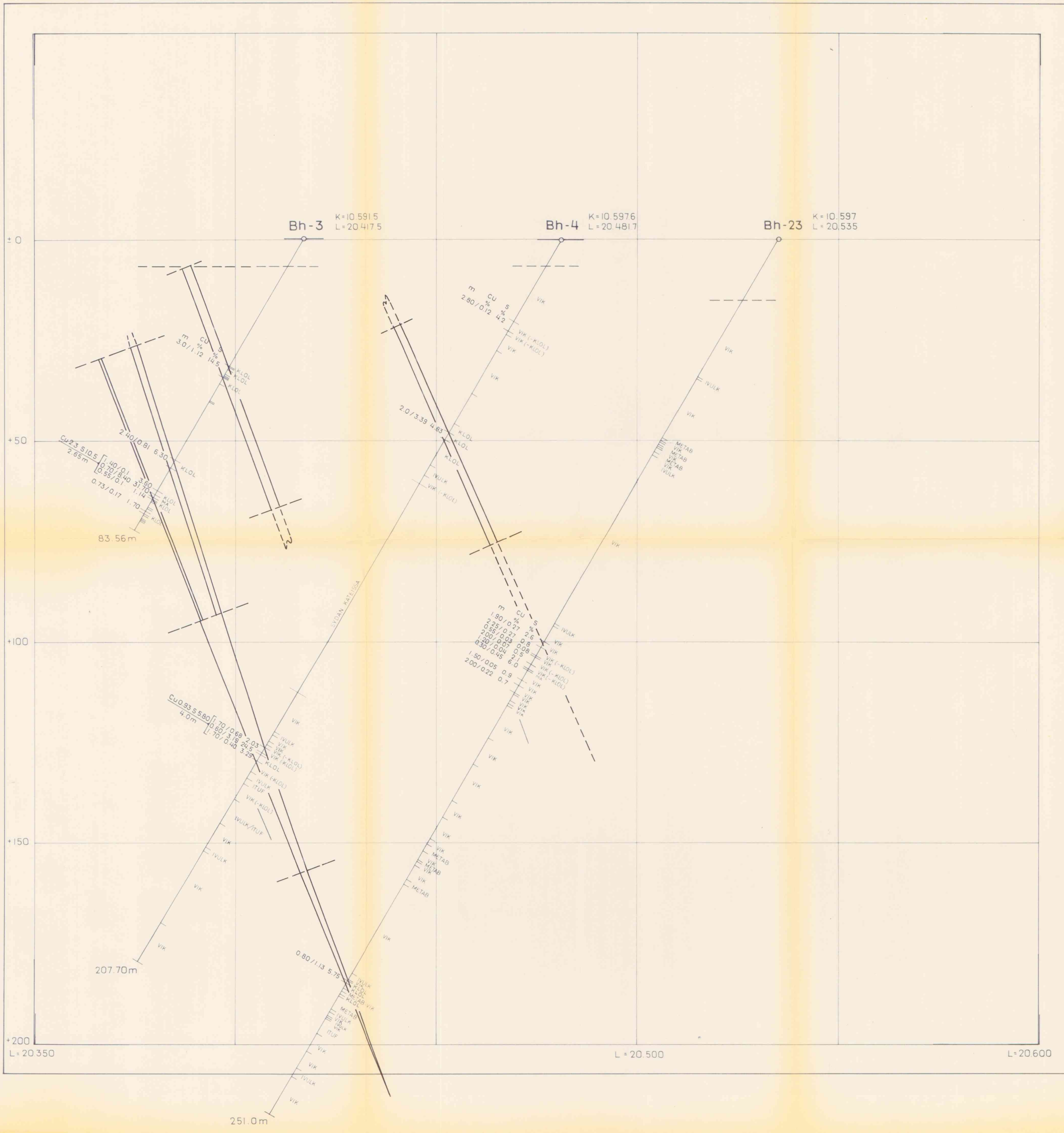
HR/MLK-75

NORJA
AASOREN

L=20.350
– 20.600

310

Kairausprofiili K=10.500
Bh-31,-6,-24



± 0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev.
Bh-3	10.591	20.417	+305.16	292.56^{g}	60°
Bh-4	10.597	20.481	+304.97	310.40^{g}	60°
Bh-23	10.597	20.535			60°

311

314

OUTOKUMPU Oy
Malminetsintä

1 : 500

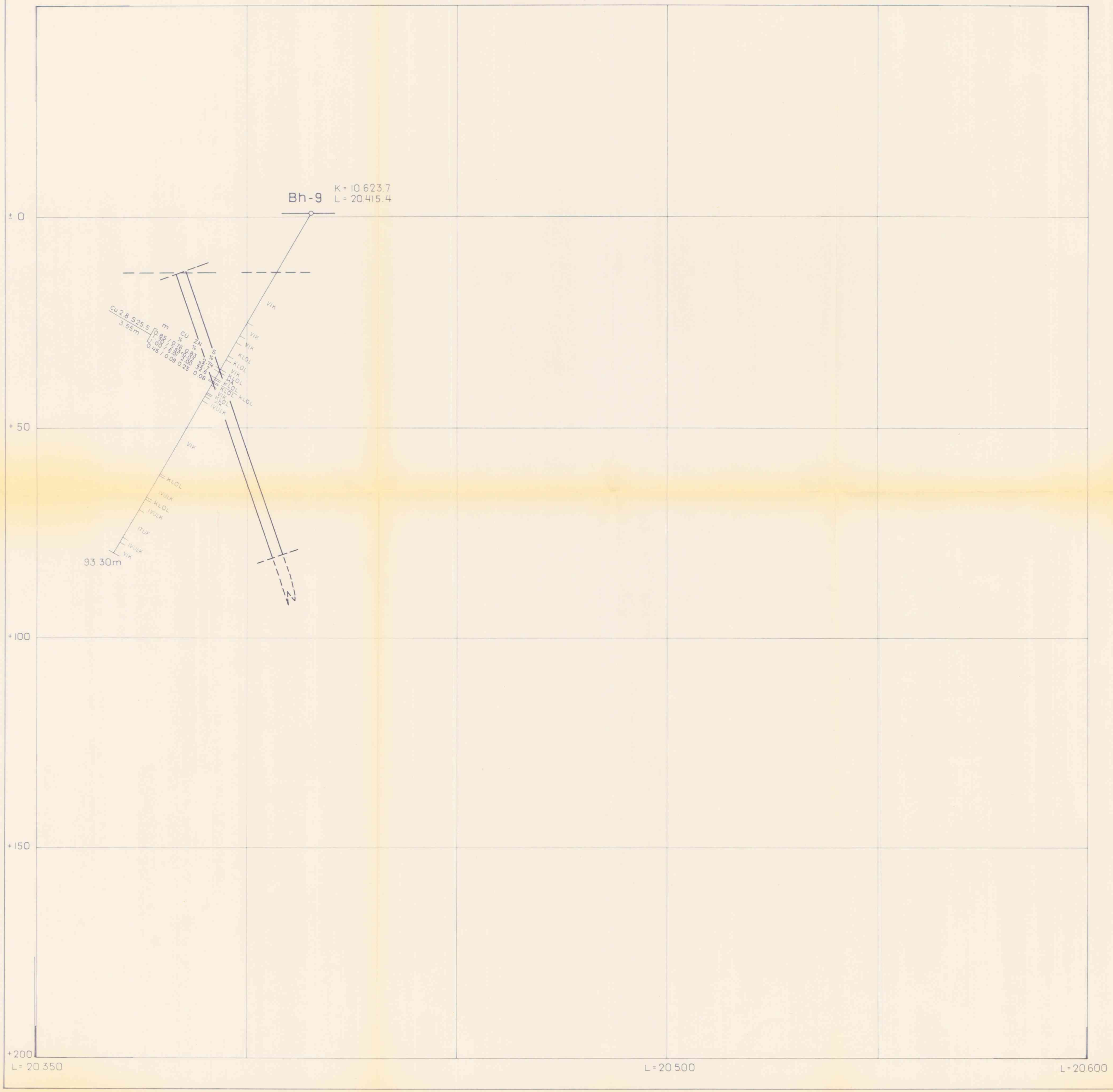
HR/MLK-75

NORJA
AASOREN

L = 20.350
- 20.600

310

Kairausprofiili K = 10.600
Bh-3, -4, -23



± 0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev.
Bh-9	10.623	20.415	+305.93	298.89^{g}	

311

314

OUTOKUMPU Oy
Malminetsintä

1 : 500

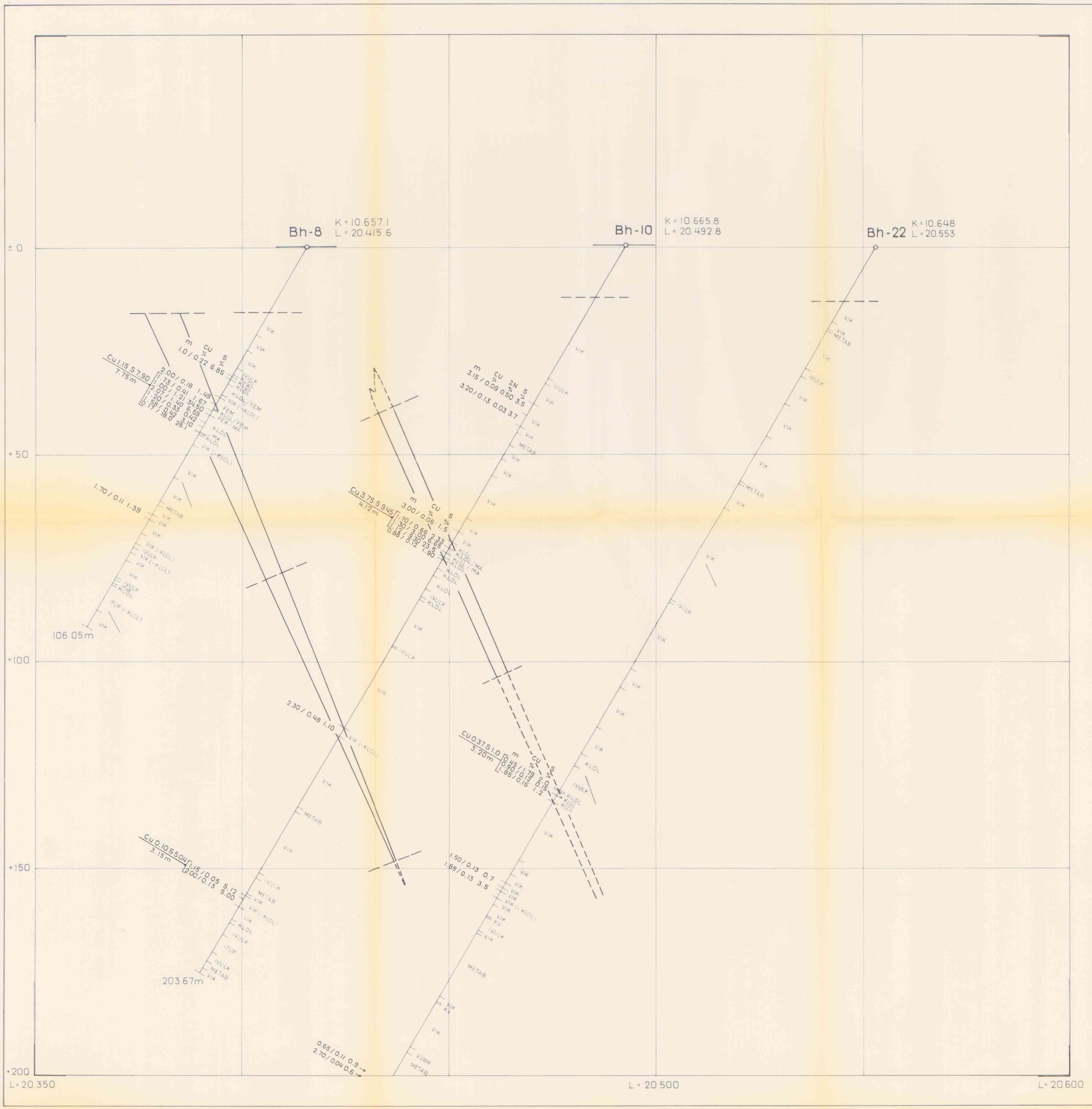
HR/MLK -75

NORJA
AASOREN

L = 20.350
- 20.600

310

Kairausprofiili K = 10.623
Bh-9



± 0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev
Bh-8	10.657	20.415	+305.18	306.78^{9}	
Bh-10	10.665	20.492	+305.56	301.03^{9}	
Bh-22	10.648	20.553			

311

314

OUTOKUMPU Oy
Malminetsintä

1 : 500

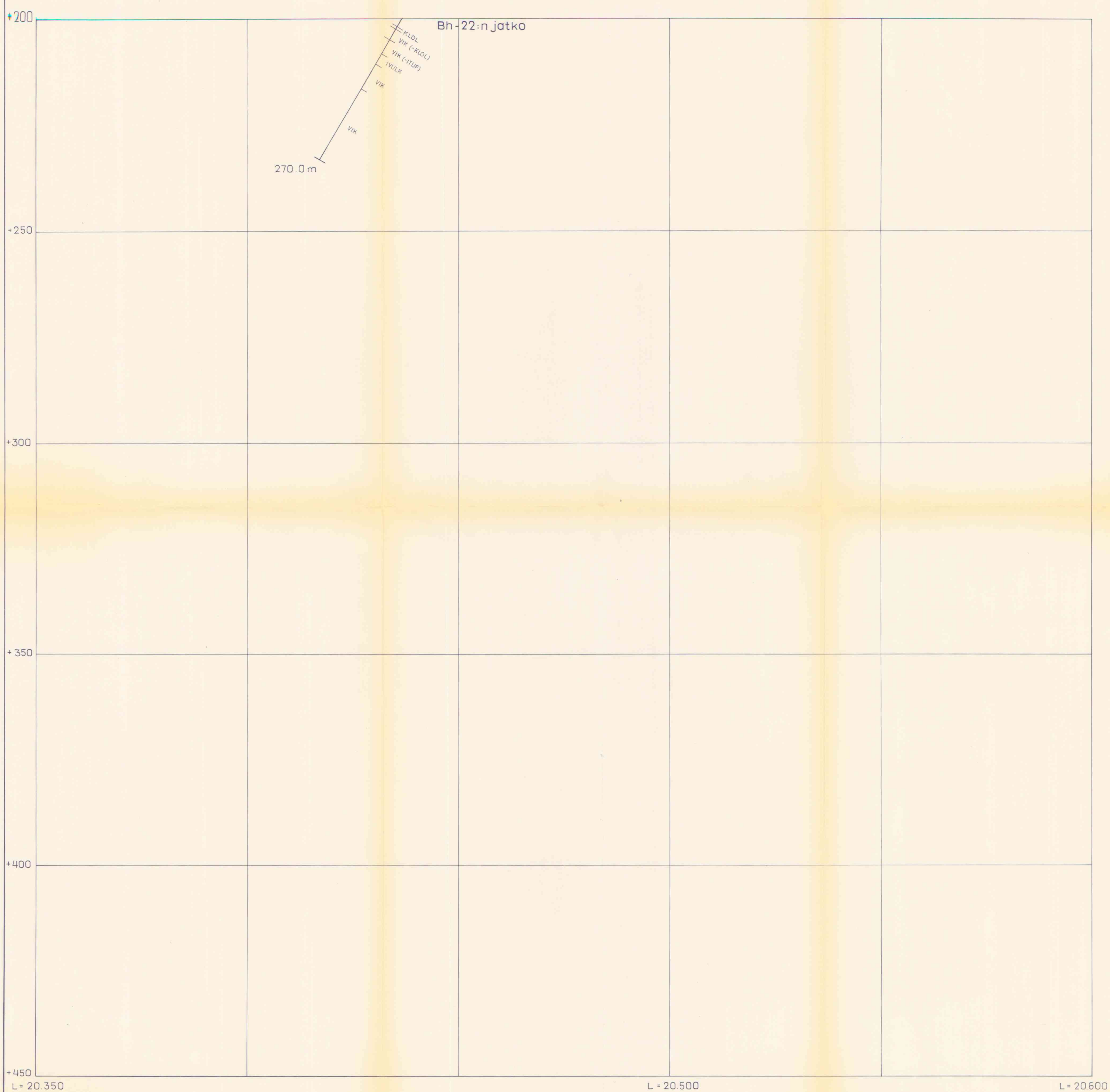
HR/MLK-75

NORJA
AASOREN

L = 20.350 – 20.600

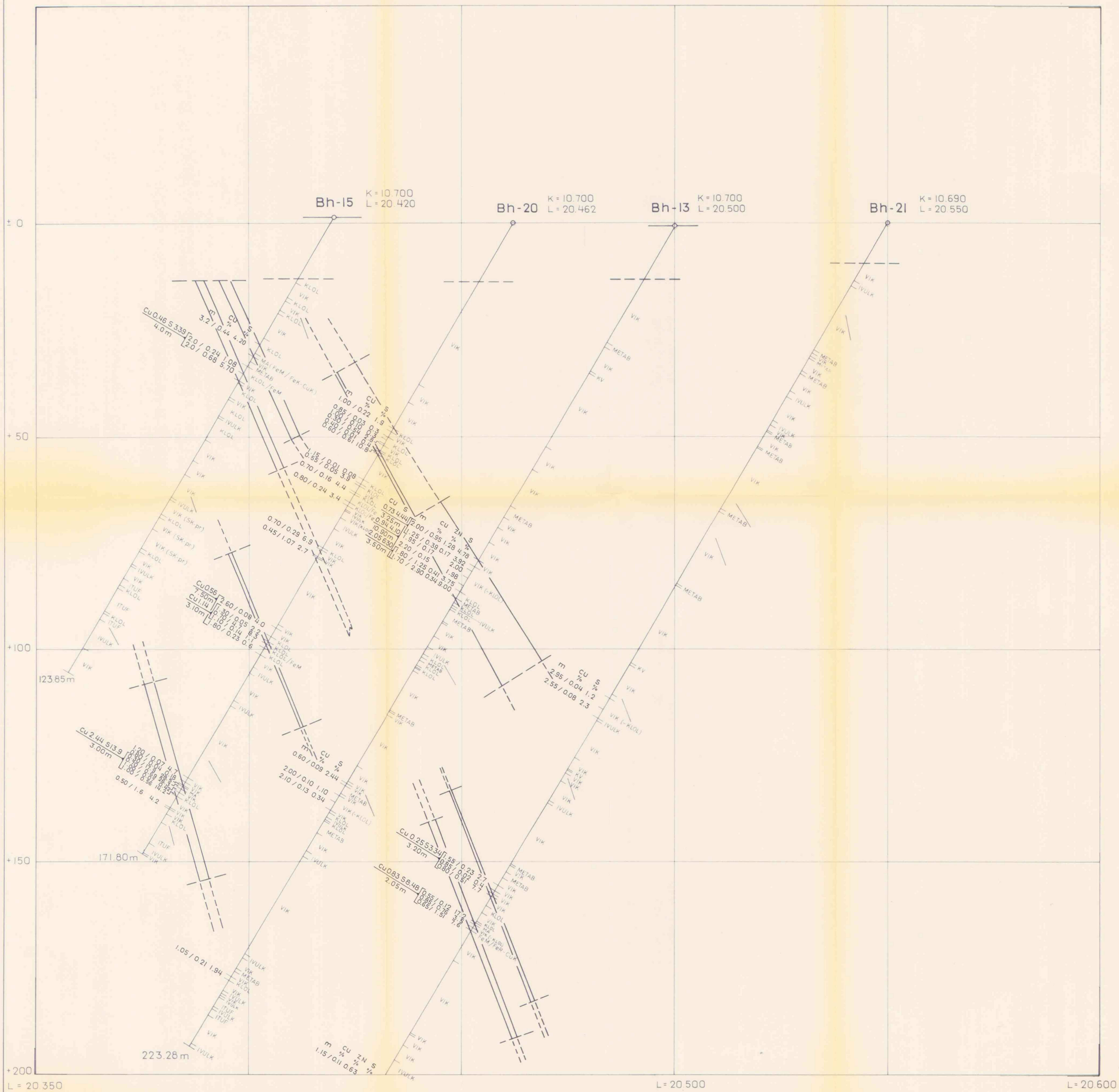
310

Kairausprofiili **K = 10.650**
Bh-8, -10, -22



Reikä	K	L	Z	Suunta	Kaltev.
Bh-22	10.648	20.553			

OUTOKUMPU Oy Malminetsintä	1:500 HR/MLK -75	
NORJA AASOREN	L = 20.350 – 20.600	310
Kairausprofiili K = 10.650 Bh-22:n jatko		



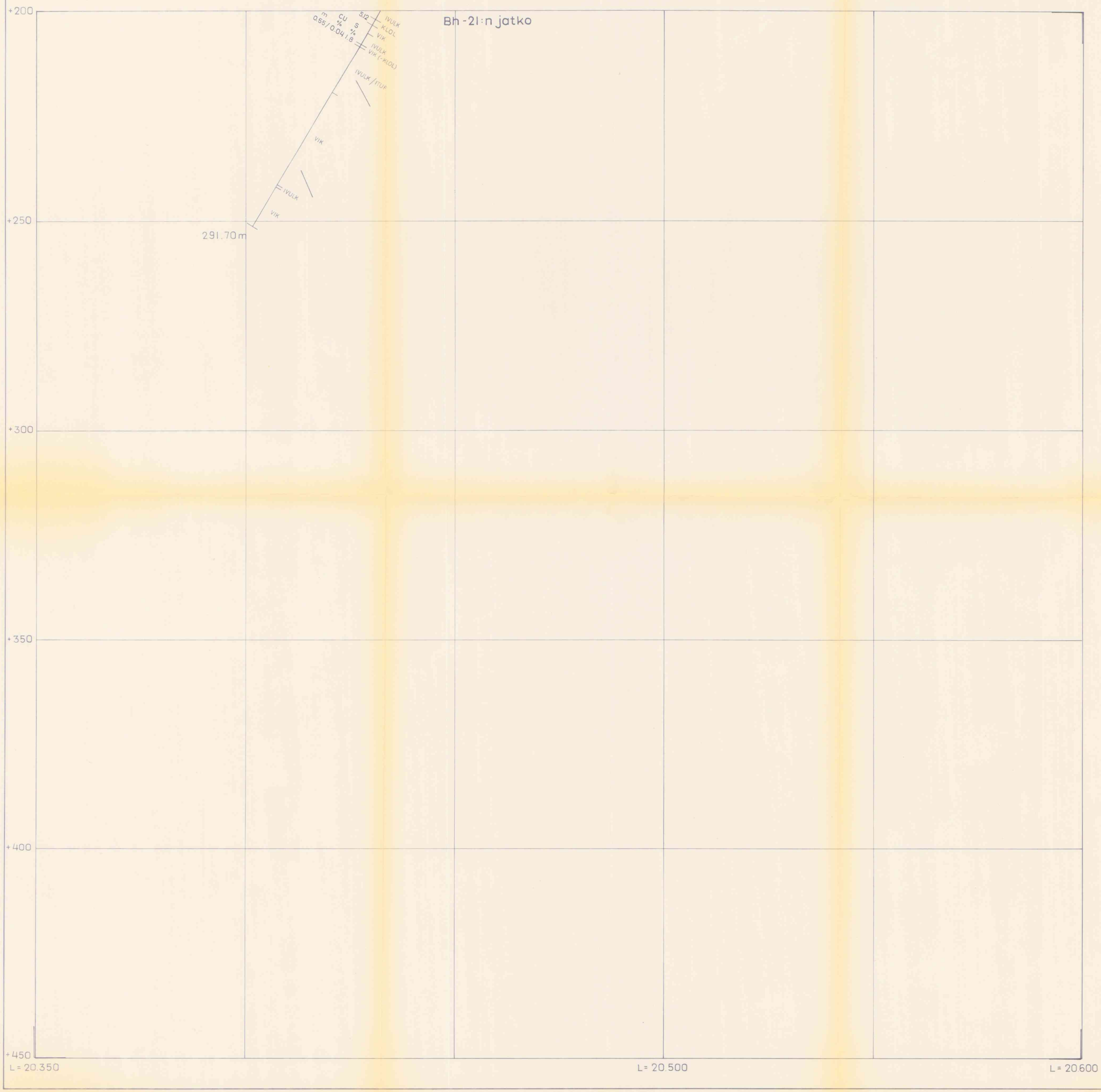
±0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev.
Bh-13	10.700	20.500	+304.32	311.62 g	
Bh-15	10.700	20.420	+306.51	296.01 g	
Bh-20	10.700	20.462			
Bh-21	10.690	20.550			

311

314

OUTOKUMPU Oy Malminetsintä	1:500 HR/MLK -75	
NORJA AASOREN	L = 20.350 – 20.600	310
Kairausprofiili K = 10.700 Bh-13, -15, -20, -21		



Reikä	K	L	Z	Suunta	Kaltev.
Bh-21	10.690	20.550			

311

OUTOKUMPU Oy
Malminetsintä

1:500

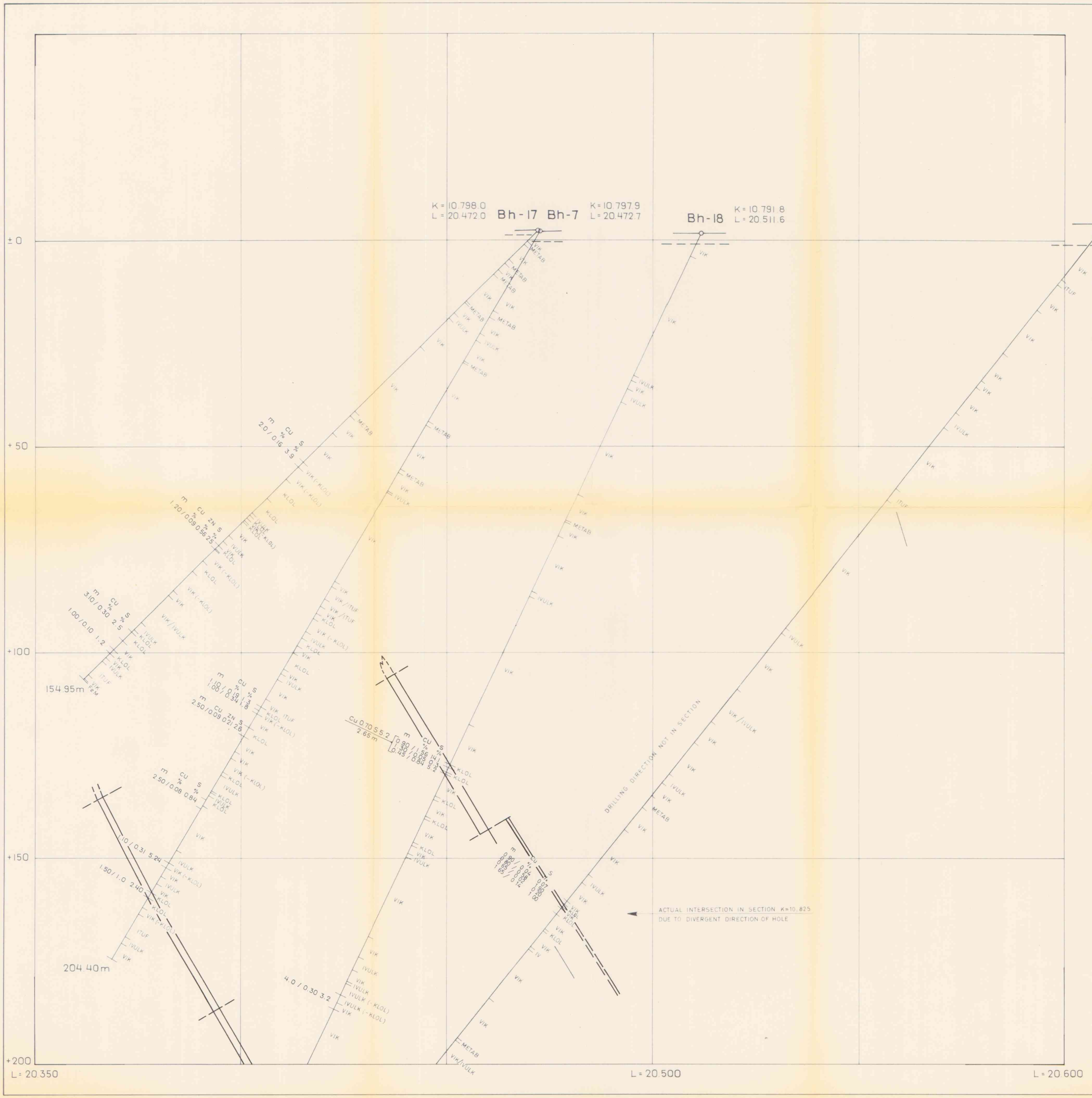
HR/MLK-75

NORJA
AASOREN

L=20.350
– 20.600

310

Kairausprofiili K=10.700
Bh-21:n jatko

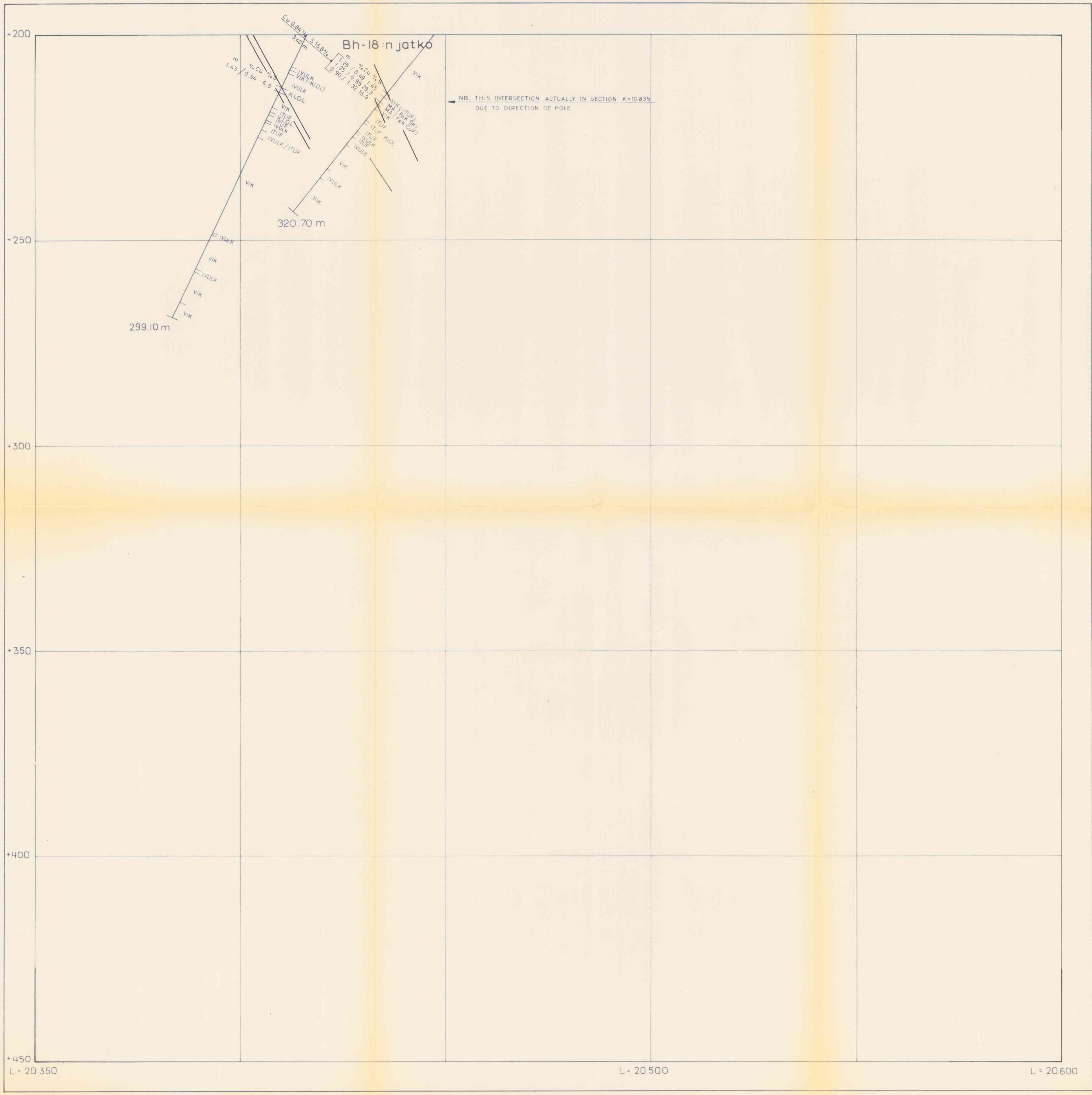


± 0-taso = 305 m

Reikä	K	L	Z	Suunta	Kaltev.
Bh-7	10.797	20.472	+307.32	311.54^g	~ 60°
Bh-17	10.798	20.472	+307.48	307.08^g	~ 45°
Bh-18	10.791	20.511	+306.72	305.43^g	~ 60°
Bh-32	10.792	20.610	-309.0		~ 52°

311	
314	

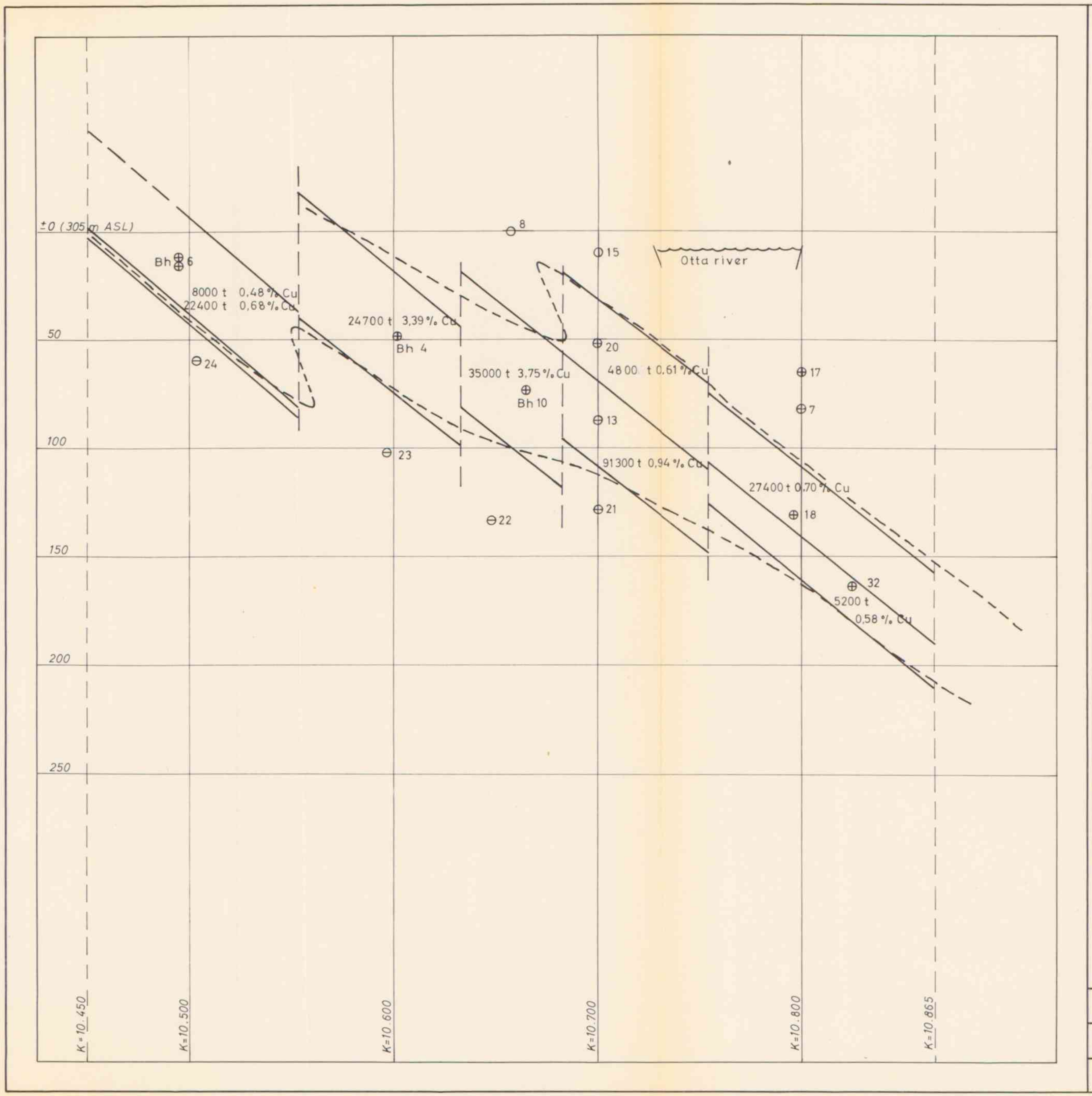
OUTOKUMPU Oy Malminetsintä	1 : 500 HR/MLK-75	
NORJA AASOREN	L = 20.350 – 20.600	310
Kairausprofiili K=10.800 Bh-7, -17, -18, -32		



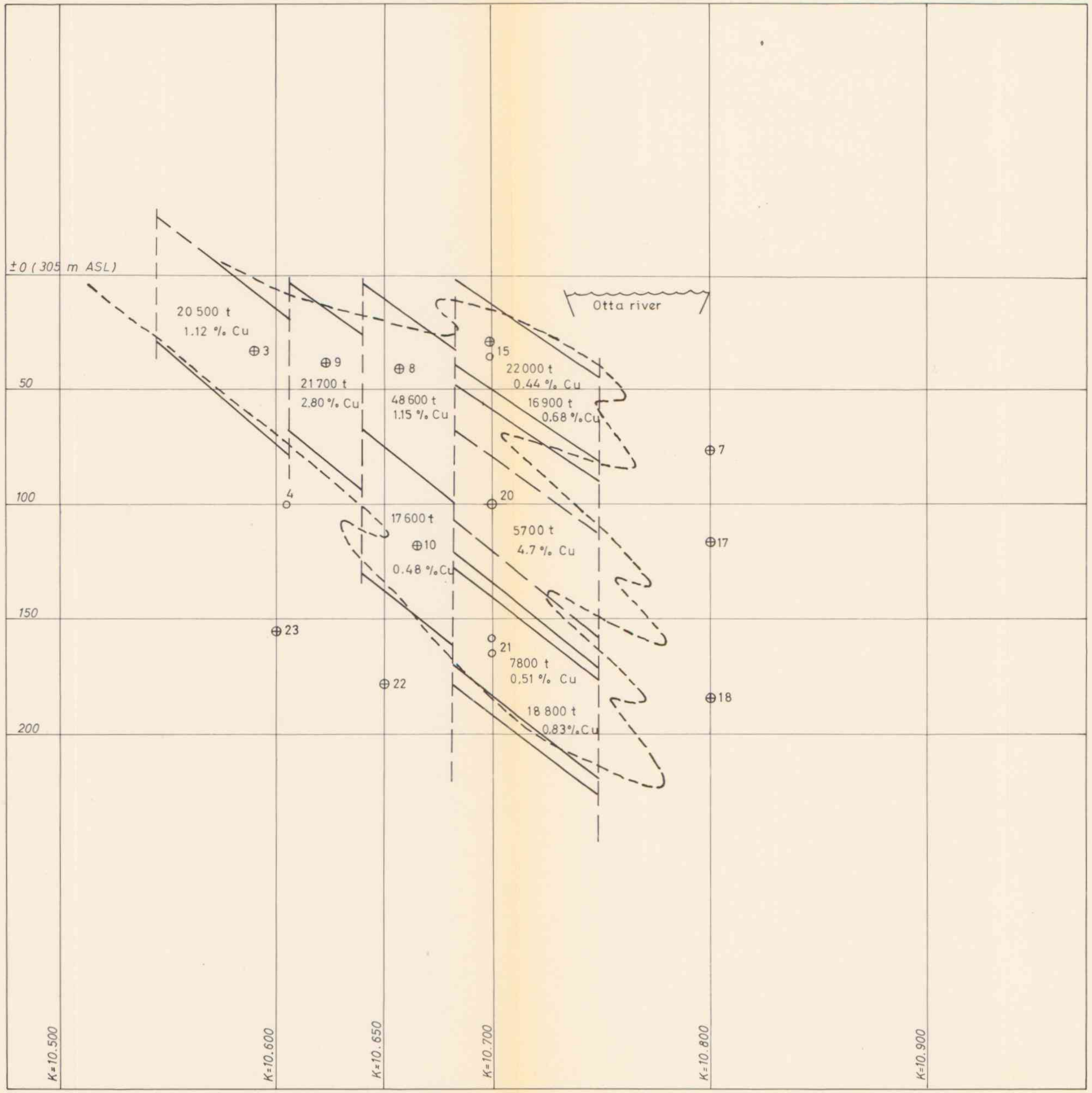
Reikä	K	L	Z	Suunta	Kaltev.
Bh-18	10.791	20.511	+306.72	305.43^{g}	
Bh-32	10.792	20.610	~309.0	300°mN ≈304°	

311	
314	

OUTOKUMPU Oy Malminetsintä	1 : 500	
	HR/MLK -75	
NORJA AASOREN	L = 20 350 – 20 600	310
Kairausprofiili **K=10.800** **Bh-18:n ja -32:n jatkot**		



OUTOKUMPU Oy Malminetsintä	1 2000	
	HR/LK	1976
NORJA AASOREN		
A-HORIZON Long sect. along dip	Fig 26	



B-HORIZON

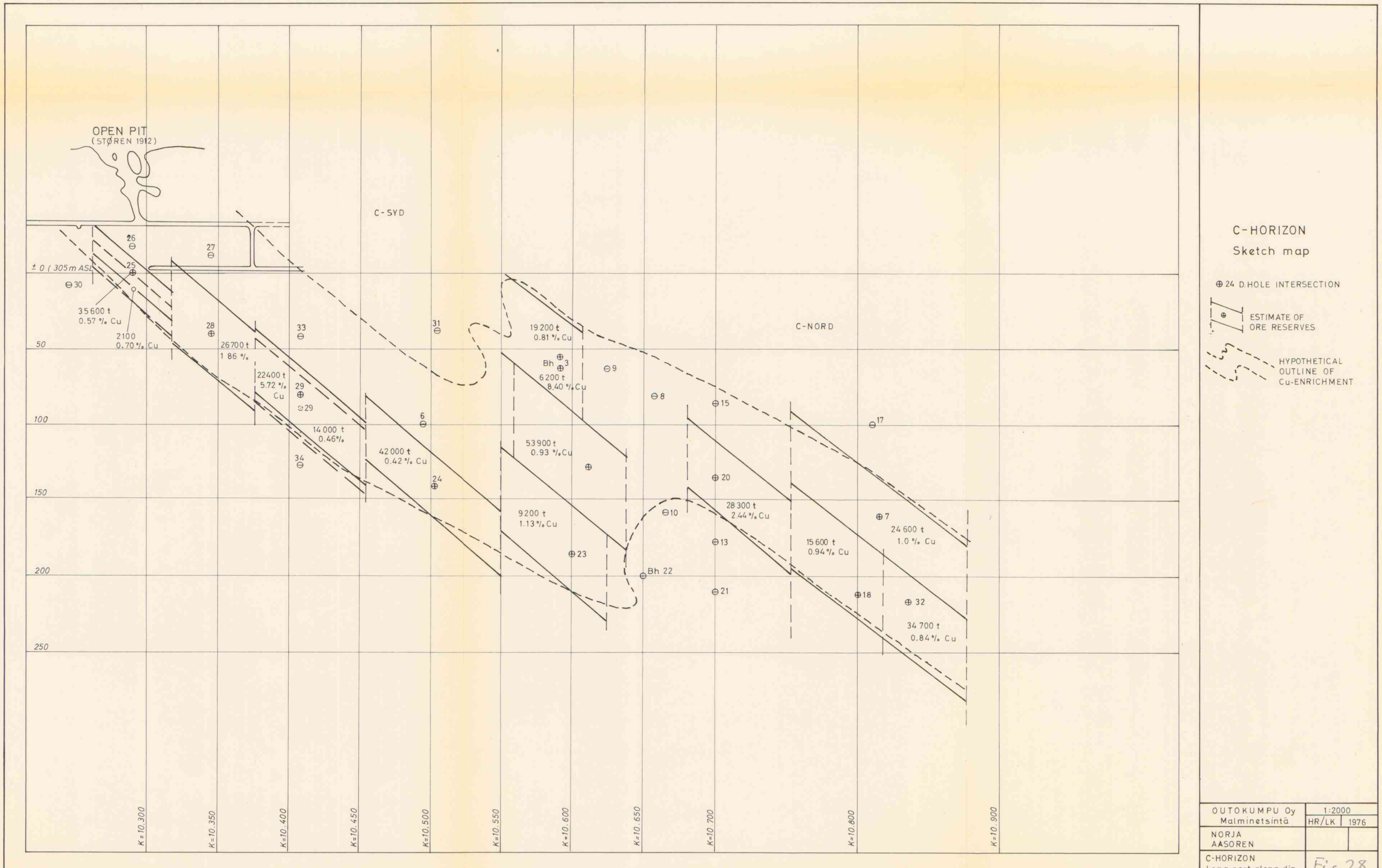
Sketch map

⊕20 D.HOLE INTERSECTION

ESTIMATE OF ORE RESERVES

HYPOTHETICAL OUTLINE OF Cu-ENRICHMENT

OUTOKUMPU Oy Malminetsintä	1:2000 HR/LK 1976
NORJA AASOREN	
B-HORIZON Long sect. along dip.	Fig 27.



OPEN PIT
(STØREN 1912)
C-SYD
C-NORD
± 0 (305m ASL)
50
100
150
200
250
26
25
27
30
35 600 t
0.57 % Cu
2100
0.70 % Cu
28
26700 t
1.86 %
33
22400 t
5.72 %
Cu
29
29
14 000 t
0.46 %
34
31
6
42 000 t
0.42 % Cu
24
19 200 t
0.81 % Cu
Bh 3
6 200 t
8.40 % Cu
9
53 900 t
0.93 % Cu
9 200 t
1.13 % Cu
23
8
15
20
10
Bh 22
28 300 t
2.44 % Cu
13
21
17
7
24 600 t
1.0 % Cu
15 600 t
0.94 % Cu
18
32
34 700 t
0.84 % Cu
K=10.300
K=10.350
K=10.400
K=10.450
K=10.500
K=10.550
K=10.600
K=10.650
K=10.700
K=10.800
K=10.900
C-HORIZON
Sketch map
24 D.HOLE INTERSECTION
ESTIMATE OF ORE RESERVES
HYPOTHETICAL OUTLINE OF Cu-ENRICHMENT
OUTOKUMPU Oy
Malminetsintä
1:2000
HR/LK
1976
NORJA
AASOREN
C-HORIZON
Long sect. along dip
Fig 28

Outokumpu Oy
Helsinki

APPENDIX A

The Rockmechanical Characteristics in the Aasoren Area

1. General

A mere visual observation already yielded the impression that the rock grades are quite fine-grained and solid, but not necessarily very rigid in crystal and matrix structure. This impression was confirmed in subsequent closer investigations. It should, however, be emphasized that the below presented opinions and thoughts are based on a relatively limited material of core samples, and the subscriber does not know how representative it is of the entire area.

2. Degree of rock fracturing and fissuring

The study was based on approx. 2 500 m of core sample, the cores being quite monotonous to examine, in a positive sense. The fissure frequency is low; in the entire material studied it averages 6-7 fissures/meter with quite a low range of variations (± 3-4 %), and consequently high fissure concentrations in these rocks are improbable.

Fissured rock was encountered only sparsely close to the surface (depth of 0-50 m), and further below a depth of 50 m as mere casual, scattered occurrences.

The degree of rock fracturing and fissuring must altogether be considered exceptionally low and it will not cause any significant problem in view of possible stoping activities.

3. Strength measurements of the rocks

The strength measurements of the rocks were conducted in the summer of 1975 with equipment belonging to the Mining Department of the Technical University of Helsinki. In the analysis of results, attention is turned to the low compressive strength and elasticity module values of particularly the chlorite but also the green schist. Under certain loading conditions, these rock types might behave somewhat plastically or in a reminiscent way. These rock types should be avoided in determining the location of supporting structures in the mine (pillars, etc.), or if this cannot be done, the rock characteristics should be considered in the dimensioning of supporting structures.

The greenstone shows a slightly higher rigidity than the above-mentioned rock types, and it represents the average in our rocks.

The mean elasticity module value obtained for the rocks in the Aasoren area was 39,4 GPa. Corresponding values from measurements in our rocks have been e.g. in Vihanti 81,5 GPa, in Vuonos 70,7 GPa, however in the Vuonos' serpentine 24,7 GPa. Said values should only be regarded as indicative at the most on which no conclusions as such can be drawn.

4. Analysis of results and conclusions

A basic characteristic of the rocks in the Aasoren area is their relatively high stability, as long as the load upon them with regard to the structural strength of the rock types remains below the critical limit. If this critical limit is surpassed, the rock disintegrates rapidly and probably also thoroughly. Applied to actual mining activities this means that said rock types begin to break and loosen only at the breaking point, contrary to what is generally the case at the mines of Outokumpu Oy, where the appearance of loose blocks is ordinarily due to rock fracturing or fissuring and not as much due to structural weakness.

In a rock environment such as the one in the Aasoren area, the possible stoping activities should be basically careful, still choosing "cut and fill" as stoping method would be exaggerated protection.

I give special mention to this, because Scandinavians seem to be keen on that particular method for long, narrow orebodies.
I believe that the Aasoren rocks are rigid enough for sublevel-stoping, provided the stoping units are kept small. The stoping units should not "in greediness" be enlarged, even when everything seems to be going great. In this type of rock, it is possible that events take a turn for the worse rapidly and without prior warning; and I believe this to be the case. In determining the final stope size and proportions between stope length and pillar strength, it would be well to know the local tension field in the rock also. It would perhaps be worthwhile to consult a local expert on those rock types for the tension measurements or at least in the interpretation of measurement results.

The purpose of rockmechanical investigations is to assist the mine planner by compiling such data which can help him in the general layout of the possible mine and above all in the choice of stoping method. If, in the case that a mine will spring up in the Aasoren area, the above presented results and the conclusions drawn on their basis can prove helpful in the exploitation of said ore, then the goal of this present study has been reached.

Olari, January 15, 1976
Jorma Mustala

<u>Enclosure</u>:

Result of rigidity measurements

O U T O K U M P U Oy
Exploration Department

ENCLOSURE

J Mustala/PAL 16.01.1976 1 (1)

ROCKMECHANICAL CHARACTERISTICS IN THE AASOREN AREA

Hole	Depth	Rock type x)	(O) [°]	l (mm)	d (mm)	F_m (kN)	Compressive strength σ_{pm} (MPa)	Tensile strength σ_{vm} (MPa)	Elasticity module $E_{t(40)}$ (GPa)	Poisson ratio
15-73	45.40-.60	klol	45	95	31.4	32.1	41.4	-	29.9	0.49
20-75	52.10-.30	vik	-	84	31.3	237	308	-	49.4	0.10
20-75	74.50-.70	klol	45	95	31.4	37.3	48.5	-	49.1	0.32
10-73	76.15-.40	vik	-	95	31.4	165	213	-	41.3	0.08
10-73	88.30-.50	klol	45	80	31.4	26.6	34.3	-	18.4	-
10-73	88.30-.50	klol	45	34.4	31.4	15.7	-	4.63	-	-
10-73	137.80-138.00	vik	65	93	31.5	77.2	99.0	-	42.8	0.15
10-73	137.80-138.00	vik	65	27.2	31.5	19.8	-	7.36	-	-
23-75	140.30-.50	vik	35	95	31.6	133	170	-	46.7	0.22
23-75	140.30-.50	vik	35	32.3	31.6	19.6	-	6.11	-	-
22-75	149.20-.40	vik	60	93	31.5	77.2	99.0	-	30.7	0.46
22-75	149.20-.40	vik	60	32.9	31.5	16.4	-	5.04	-	-
20-75	164.30-.50	vil	50	95	31.4	21.5	27.8	-	20	0.50
20-75	164.30-.50	vil	50	32.1	31.4	13.7	-	4.33	-	-
23-75	184.70-.95	gbr	40	95	31.6	101	129	-	37.6	0.12
23-75	184.70-.95	gbr	40	33.7	31.6	17.4	-	5.20	-	-
21-75	220.00-.20	vik	-	95	31.2	262	343	-	48.4	0.17
21-75	220.00-.20	vik	-	33.0	31.2	26.8	-	8.29	-	-

x) klol = chlorite schist
vik = greenstone
vil = green schist
gbr = gabro

Outokumpu Oy

APPENDIX B

PRELIMINARY STUDY ON CONCENTRATABILITY OF THE AASOREN ORE

MATTI SAARI
KARI SALMINEN
(OKM)

Sample data

In November 1975 a small lot of drilling samples (approx. 10 kg) was received from Outokumpu Oy's Exploration Department, with assignment to determine possibilities to concentrate the Aasoren ore.

Sample analysis

Cu	1.3	%	$Ca^=$	2-3	%	$Ni^=$	0.02	%
Zn	0.28	"	$Na^=$	1-1.5	"	$Sb^=$	<0.02	"
Fe	23.6	"	$Ti^=$	0.8-1.2	"	$Cd^=$	<0.01	"
S	7.0	"	$Mn^=$	0.25-0.35	"	$Mo^=$	0.03	"
$Pb^=$	0.003	"	$As^=$	<0.1	"	$Bi^=$	<0.003	"
$Si^=$	15-25	"	$Cr^=$	0.05	"	Ag	1.7	ppm
$Al^=$	8-12	"	$V^=$	0.04	"	Au	0.05	"
$Mg^=$	6-8	"	$Co^=$	0.03	"			

The sample lot consists of the following core samples:

20/13-15	(OKME	75-25527-25529)
20/20-21	("	75-25534-25535)
21/6-8	("	75-25544-25546)
24/8-10	("	75-25572-25574)
18/1	("	75-25582)

The main minerals appearing are pyrrhotite (59.5 - 60.5 % Fe), chalcopyrite and magnetite and to a lesser extent sphalerite (4.8 - 8.8 % Fe, average 6.9 % Fe) and pyrite. The chalcopyrite appears partly as fine-grained disseminations in sphalerite (Fig. 3, Encl. 6). Only part of the magnetite can be separated through magnetic separation.

Concentration tests, general

The Cu-flotation suffers from pyrrhotite which tends to float very easily, and the sphalerite floats quite easily also when the amount of collecting agent increases (without $CuSO_4$ activation). The pyrrhotite can be controlled with cyanide, which has to be used both in rough and cleaning flotation, with Na_2SO_3 it is possible to depress solely pyrrhotite selectively (in the tests, the pH was lowered to 5 with H_2SO_4, producing HSO_3^-, which apparently is an influential component).

In Cu-flotation the sphalerite can be depressed with $ZnSO_4$. The results of Cu-flotation have been satisfactory using the above methods (approximate Cu-recovery 90 %).

Due to the poor Zn-content of the ore, the zinc flotation is questionable. It is possible to obtain an appr. 60 % recovery of zinc into proper concentrate, but raising the Zn-content to acceptable commercial level poses difficulties.

The Cu and Zn-contents of the products or the ore cannot be significantly improved with magnetic separation.

Test results

Grinding

The grinding should be relatively fine; in view of end results, the tests proved a particle size of appr. 80 % - 74 μm to be most advantageous. With coarser material there are difficulties in raising the Cu-content while maintaining satisfactory recovery. The grindability of the sample material was quite good; the above indicated fineness of grinding was achieved with an energy consumption of 12 kWh/t (43 MJ/t).

Cu-flotation

A 20 % Cu-concentrate is obtained with a 90-92 % recovery using the following reagent combinations:

1st method

Roughing:	$Ca(OH)_2$		1 kg into grinding
	NaCN		20 g/t into grinding and conditioning
	$ZnSO_4 \cdot 7H_2O$		400 g/t into conditioning
	KAX		50 g/t, pH 11.5, conditioning 2-5 min
Cleaning:	I cl.	NaCN	10-15 g/t, pH 11.5
	II-III cl.	NaCN	5-10 g/t

The portioning of NaCN in the cleanings is quite critical, even a slight excess addition depresses chalcopyrite also, when amounts are reduced the Cu-content drops sharply. The Zn-content in the copper concentrate is 0.2-0.3 %.

2nd method

Roughing:	$Na_2SO_3 \cdot 7H_2O$	1 kg/t into grinding and conditioning
	H_2SO_4	1.6 kg/t, pH 5, conditioning 5 min
	$Ca(OH)_2$	1.6 kg/t, pH 11.5 } conditioning 5 min
	KAX	50 g/t } conditioning 5 min
	($ZnSO_4 \cdot 7H_2O$	400 g/t to depress sphalerite, was
	not used in the tests)	
Cleaning:	$Na_2SO_3 \cdot 7H_2O$	appr. 100 g/t, pH 11.5

1 kg/t Na_2SO_3 depresses pyrites more strongly than 20 g/t NaCN:

	Cu - rough concentrate			
	Cu %	Cu-recov. %	Fe-recov. %	Weight %
NaCN 20 g/t + $ZnSO_4 \cdot 7H_2O$ 400 g/t	6.1	96.5	38.3	20.6
$Na_2SO_3 \cdot 7H_2O$ 1 kg/t	11.3	94.5	17.6	10.7

Using Na_2SO_3, the sphalerite rose mainly into the Cu-concentrate (22.8 % Cu, 2.3 % Zn), but probably ZnS can be depressed using $ZnSO_4$ 400-500 g/t in the conditioning stage; due to exhaust of sample this could not be studied.

Zn-flotation

The sphalerite was easily activated. In Zn-flotation it sufficed to use 75 g/t $CuSO_4 \cdot 5H_2O$, 25-50 g/t KAX. The Zn-flotation is questionable due to low Zn-content (0.28 %) of the ore and to active pyrrhotite. The test program included only one normal cleaning test in pH 12, which did not produce a satisfactory result (3 cleanings). If the flotation of Zn-concentrate is to be further studied, the methods to use would mainly be high-temperature flotation or separate pyrrhotite flotation prior to zinc flotation.

Results of most favourable tests

Test results, method 1: (scheme 1, enclosure 3)

	Cu-III clean. conc.[1]	Cu rough conc.	Zn rough conc.	Tail.	Cu-I clean. conc.[2]	Cu-II clean. conc.[2]
Cu %	15.3	6.1	0.30	0.03	18.5	25.6
Cu-recovery %	89.3	96.5	0.5	1.7	87.9	63.4
Zn %	0.22	0.23	6.0	0.10	0.30	0.28
Zn-recovery %	6.0	17.4	48.5	26.1	6.7	3.2
Fe %	45.8	44.8	24.2	17.7	38.9	34.6
Fe-recovery %	14.5	38.3	2.3	53.7	10.4	4.8
S %	34.3	28.3	14.4	0.33	31.0	31.9
S-recovery %	37.1	82.8	4.6	3.4	27.7	14.9

[1] In Cu-cleanings NaCN 10/5/5 g/t
[2] In Cu-cleanings NaCN 15/10/10 g/t

Test results, method 2: (scheme 2, enclosure 4, $ZnSO_4$ not used)

	Cu-III clean. conc.	Cu rough conc.	Zn rough conc.	Tailing
Cu %	22.8	11.3	0.2	0.04
Cu-recovery %	87.3	94.5	6.7	2.4
Zn %	2.3	1.5		0.08
Zn-recovery %	43.9	64.3		24.4
Fe %	36.7	39.6		18.3
Fe-recovery %	7.5	17.6		59.3
S %	32.2	28.2		0.75
S-recovery %	23.3	44.8		8.7

Results of Zn-cleaning

	Zn-III clean. conc.	Zn-II clean. conc.	Zn-I clean. conc.	Zn rough conc.
Zn %	29.0	13.4	8.6	3.9
Zn-recovery %	38.7	46.7	49.6	52.0
Cu %	0.17	0.19	0.19	0.15
Cu-recovery %	0.05	0.1	0.2	0.4
Fe %	21.6	24.9	23.7	20.4
S %	26.1	19.4	14.8	8.0

Magnetic separation tests

Chute separator, starting material ore, ground to 75 % -74 µm.
Separator's field strength increases M1 -> M5

	M1	M1-3	M1-5	EM(M1-M5)
Cu %	0.78	0.80	0.83	1.4
Cu-recovery %	3.7	4.3	5.4	94.6
Zn %	0.18	0.23	0.28	0.31
Zn-recovery %	3.7	5.5	8.1	91.9
Fe %	61.4	59.8	56.6	21.3
Fe-recovery %	15.9	17.6	20.4	76.6
S %	9.9	10.9	12.7	6.1
S-recovery %	9.4	11.7	16.7	83.3
Weight	6.3	7.2	8.8	91.2

Carpco-separator, starting material ore, 75 % -74 um.

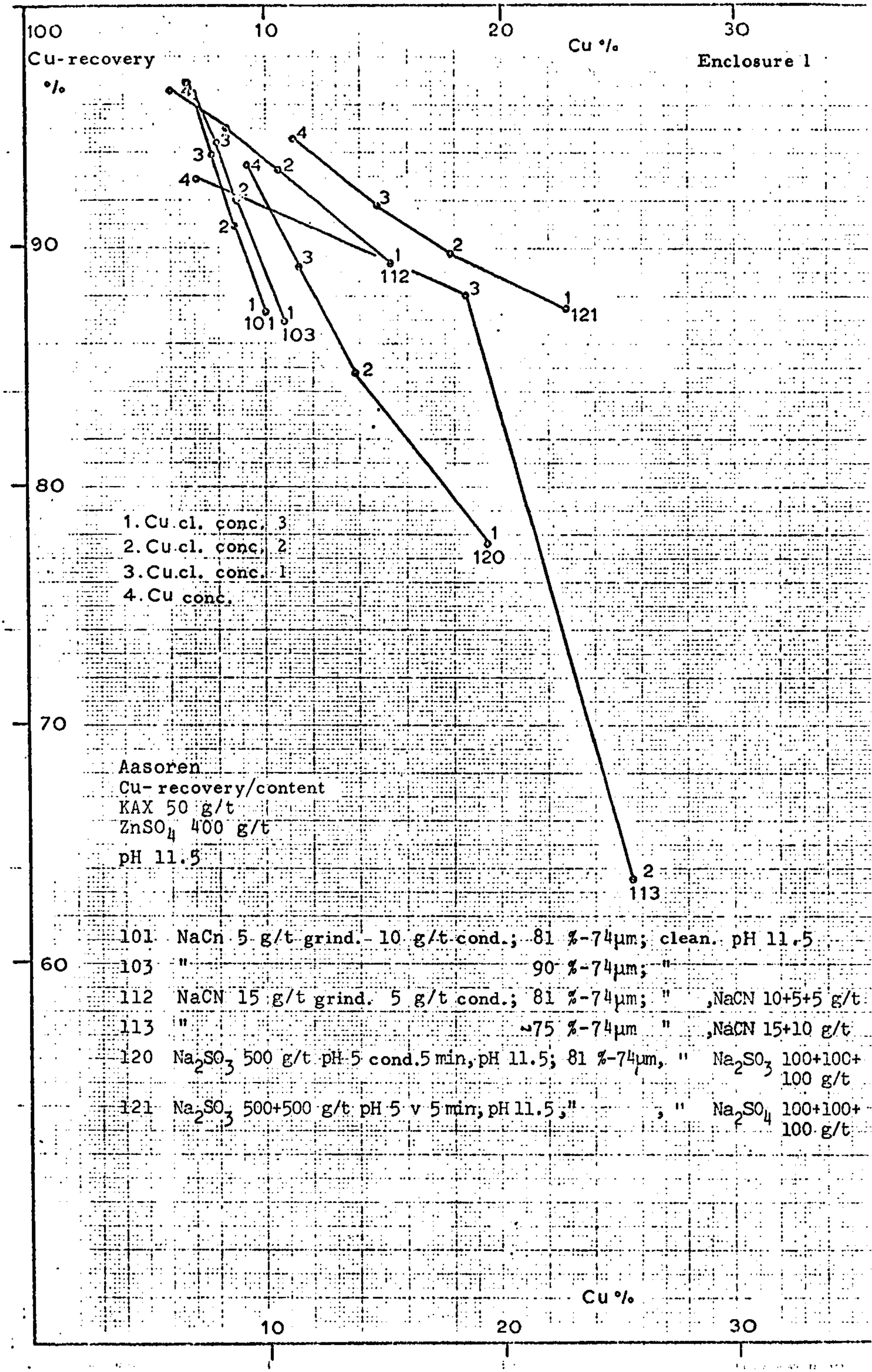
The non-magnet fraction of the separation has been multiplied by a value appr. double that of the magnetizing current (0.2 ... 5.6 A).

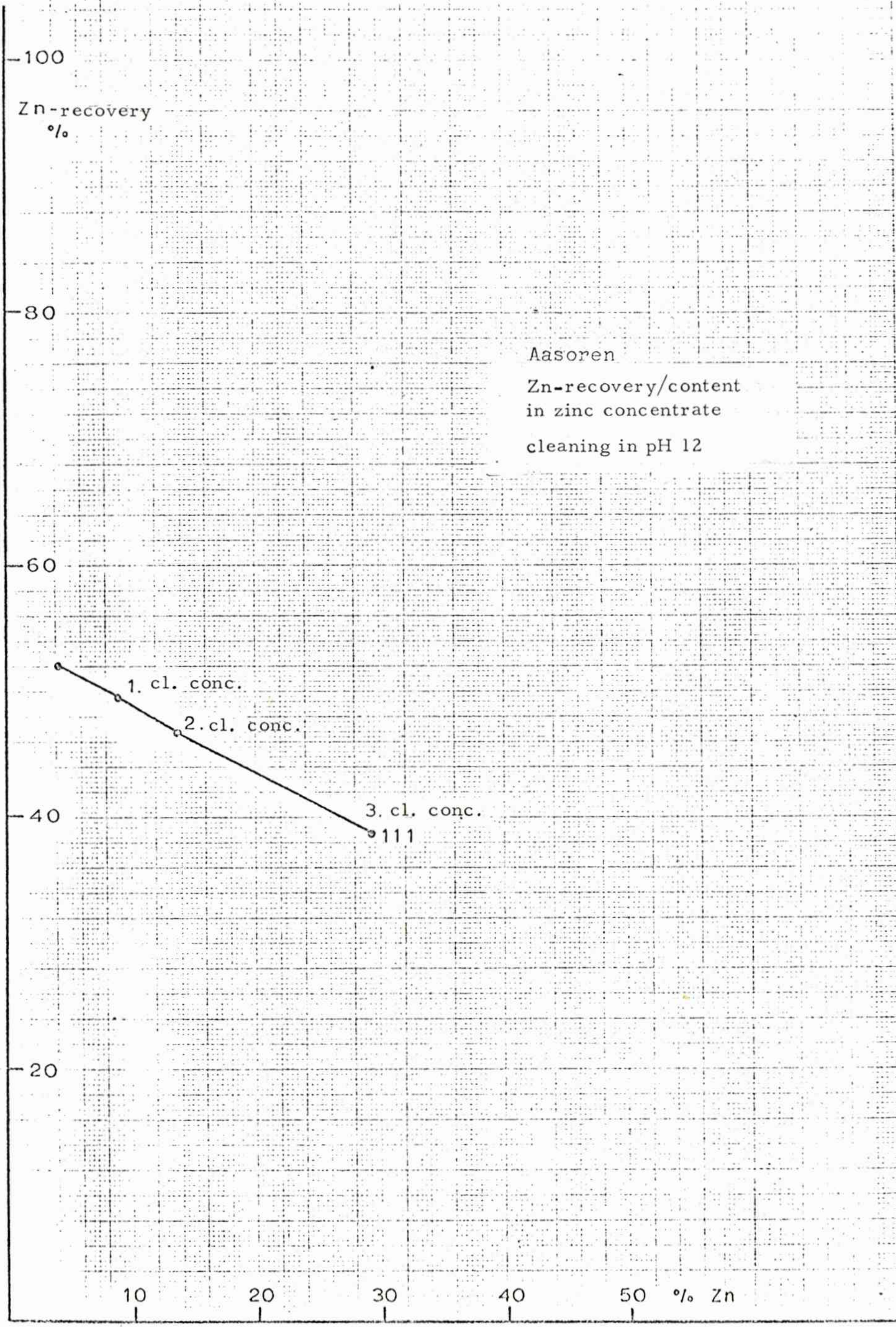
	M/ 0.2 A	M/ 0.2-0.4 A	M/ 0.2-0.8 A	M/ 0.2-1.6 A	M/ 0.2-3.2 A	M/ 0.2-5.6 A	EM/ 0.2-5.6 A
Cu %	0.65	0.69	0.66	0.62	0.58	0.57	1.8
Cu-r. %	3.4	5.2	6.4	8.8	11.8	15.7	84.3
Zn %	0.26	0.33	0.35	0.33	0.33	0.31	0.35
Zn-r. %	5.5	9.9	13.6	18.4	26.7	34.4	65.5
Fe %	54.6	50.9	46.9	41.0	36.2	32.9	18.7
Fe-r. %	16.2	21.4	25.7	32.5	41.3	50.9	49.1
S %	10.7	11.6	11.9	10.8	9.8	8.9	5.9
S-r. %	10.8	16.7	22.2	29.3	38.0	47.1	52.9
Weight%	7.1	10.1	13.2	19.0	27.4	37.0	63.0

Chute separation, starting material cleaned Cu-concentrate. Recoveries and weight-% calculated from ore.

	Cu cl. conc. 3	Cu cl. conc. 3 EM	Cu cl. conc. 3 M1-5
Cu %	9.2	10.1	1.4
Cu-recovery %	92.2	90.6	1.6
Zn %	0.21	0.21	0.23
Zn-recovery %	10.2	9.0	1.2
Fe %	52.0	51.2	58.4
Fe-recovery %	29.4	25.9	3.5
S %	36.0	36.3	36.4
S-recovery %	68.7	61.8	2.1
Weight %	13.3	11.9	1.4

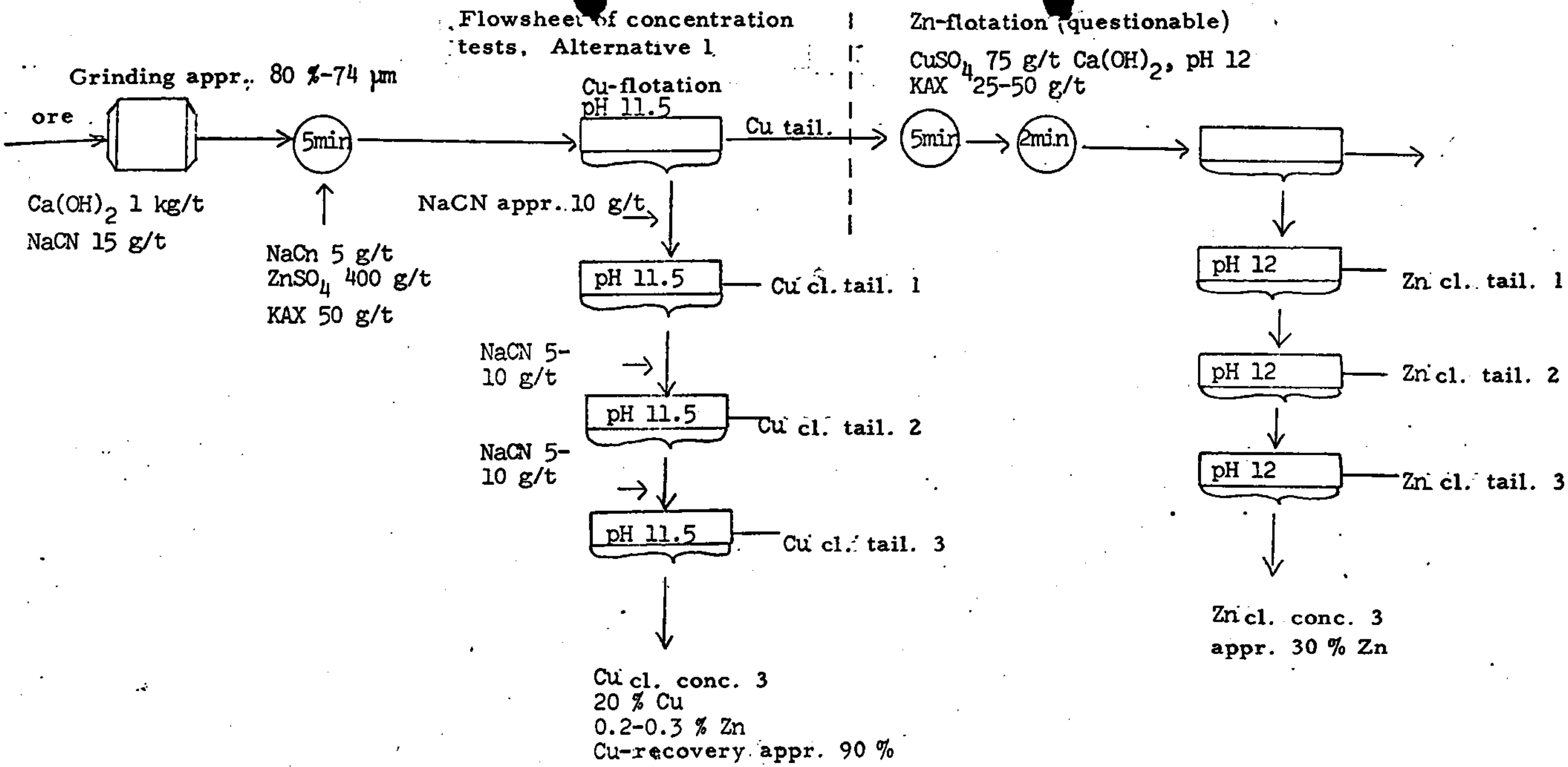
Enclosure 1


100
Cu-recovery
%
90
80
70
60
10
20
30
Cu %
101
103
112
113
120
121
1. Cu cl. conc. 3
2. Cu cl. conc. 2
3. Cu cl. conc. 1
4. Cu conc.
Aasoren
Cu- recovery/content
KAX 50 g/t
$ZnSO_4$ 400 g/t
pH 11.5
101 NaCn 5 g/t grind. - 10 g/t cond.; 81 %-74µm; clean. pH 11.5
103 " 90 %-74µm; "
112 NaCN 15 g/t grind. 5 g/t cond.; 81 %-74µm; " ,NaCN 10+5+5 g/t
113 " ~75 %-74µm " ,NaCN 15+10 g/t
120 Na_2SO_3 500 g/t pH 5 cond. 5 min, pH 11.5; 81 %-74µm, " Na_2SO_3 100+100+100 g/t
121 Na_2SO_3 500+500 g/t pH 5 v 5 min, pH 11.5, " , " Na_2SO_4 100+100+100 g/t
Cu %
10
20
30


100
80
60
40
20
Zn-recovery
%
Aasoren
Zn-recovery/content
in zinc concentrate
cleaning in pH 12
1. cl. conc.
2. cl. conc.
3. cl. conc.
111
10
20
30
40
50
% Zn

Aasoren

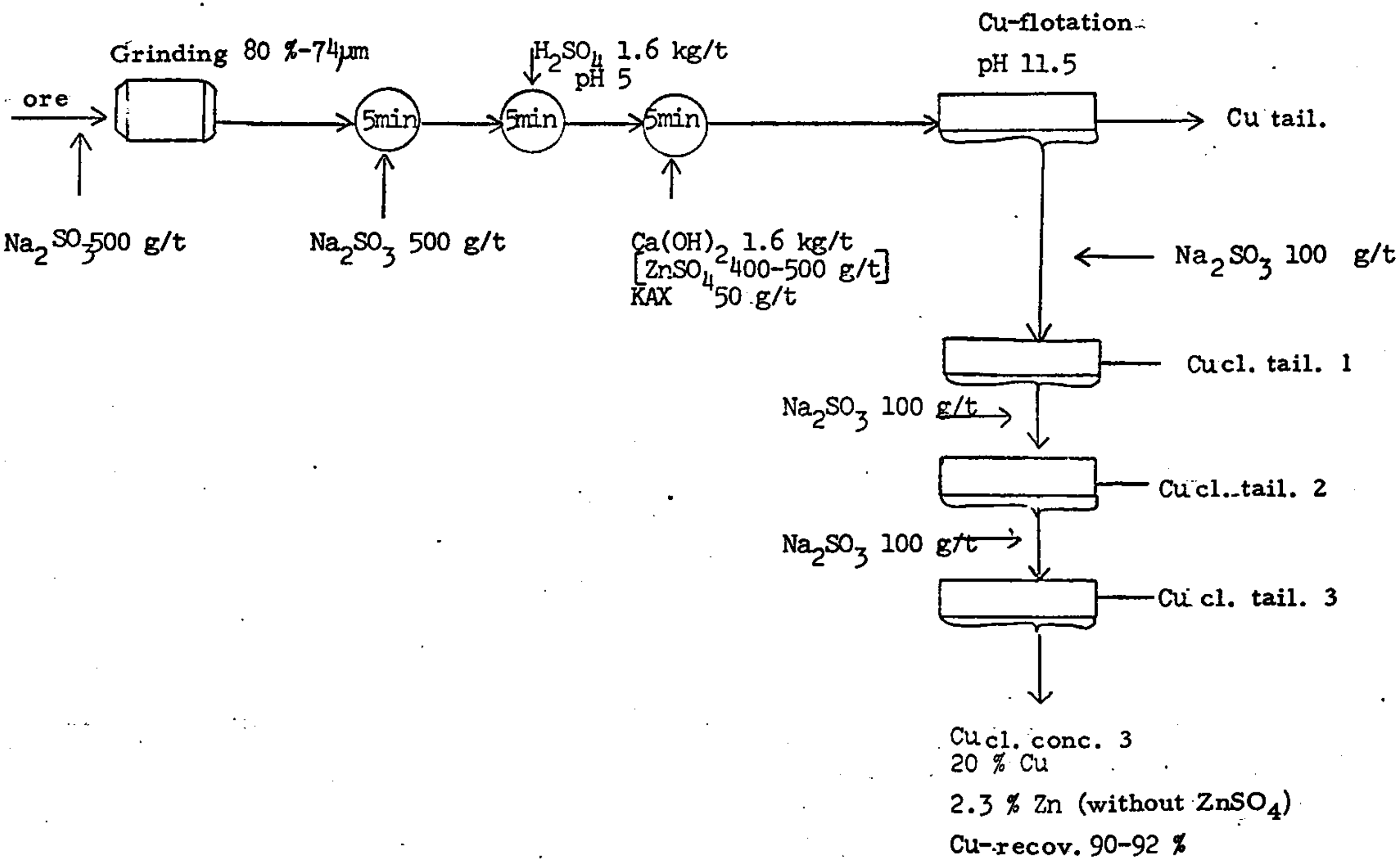
Flowsheet of concentration tests, Alternative 1



Enclosure 3

Aasoren

Flowsheet of concentration tests, Alternative 2



Enclosure 4

Picture 1
Aasoren
Cu-concentrate (3 clean.)
x 130

15.3 % Cu

0.22 % Zn

45.8 % Fe

34.3 % S

Picture 2

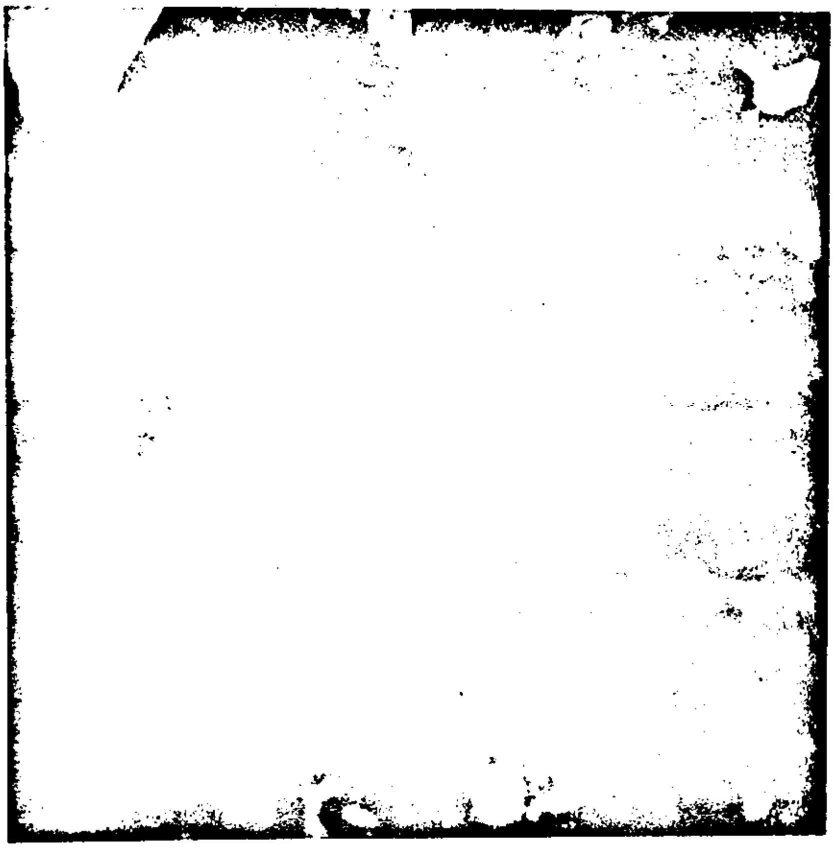
Aasoren
Cu 3rd. clean. tailings
x 130

1.3 % Cu

0.18 % Zn

55.0 % Fe

34.4 % S



Picture 3
$CuFeS_2$ in sphalerite
x 530

Picture 4
Cleaned zinc concentrate
x 130
29.0 % Zn
0.17 % Cu
21.6 % Fe
26.1 % S