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OTTA AREA, NORWAY

REPORT ON THE 1976 INVESTIGATIONS

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OTTA AREA, NORWAY

REPORT ON THE 1976 INVESTIGATIONS

Introduction

The main target for the Otta Malm / Outokumpu joint venture during 1975 was the Aasoren copper prospect at Otta, Norway. In the light of these investigations (Report HAR-17.5.76), the mineralization appeared far too small and erratic to be of economic significance in itself. Consequently, the program for the second year investigation was reduced with field work mainly restricted to the surroundings, i. e. the Myrum and Rapham areas (Encl. 1).

Present work

- (1) Data on the Aasoren copper mineralization have been analyzed and its potential for economic development evaluated by Outokumpu's specialists (KTR-group).
- (2) Geophysical anomalies (SMOY 1975) of the Myrum area have been ground checked and three (3) of them diamond-drill tested (Geobor).
- (3) Geological reconnaissance mapping of the copper mineralized Rapham area was carried out and followed up by a systematic geophysical (MAG-EM) survey.

(1) Aasoren

A prefeasibility study on possible development of the estimated Cu ore reserves is enclosed (Appendix 1). Although fairly optimistic parameters

were used in the calculations, the deposit is shown to be clearly non-economic.

The Kleiven EM-anomaly (SMOY S-7/75) was tested by diamond drilling (BH 41 - 119 m). Sulphide enrichment was not intersected. This extensive anomaly is interpreted to reflect a geological contact, with which it is coincident.

(2) Myrum

The main task of the 1976 work in this area was to check (explain) the electromagnetic anomalies revealed by work in 1973 and 1975.

The systematic survey carried out by Suomen Malmi Oy (1975) concluded that the anomalies were weak, none of them indicating a conductor of magnitude comparable with that of the Aasoren mineralized zone. Anomaly numbers below refer to the SMOY report (P. Mikkola 12.12.75).

SMOY 2: A long good conductor was test drilled in 1973 and explained by pyrrhotite bearing graphite schist horizons.

SMOY 10, 12, 13: These were excluded by geological ground checking, which revealed graphite bearing horizons accompanied by negligible amounts of sulphides.

SMOY 6, 8, 16: These were diamond-drill tested by six (6) holes, totalling 459 m. The work was carried out by Geobor A/S during May and October-November, 1976. The results were discouraging (Encl. 2).

Intersected sulphide mineralizations are insignificant and almost as a rule accompanied by graphite. The dominating sulphide mineral is pyrrhotite and none of the intersections are considered worth assaying.

(3) Rapham

Previous work

The occurrence of copper mineralization at Rapham has been known for centuries. Several prospect pits including two minor adits bear evidence of serious exploration efforts in the past. The sulphide showings occur within a 2 km² area, most of them in the Raphamhangen area. Examination reports from 1907-1919 (NGU, Bergarkivet reports 242, 2902, 1685 and 1686) generally conclude by recommending further work.

Minor reconnaissance work in the area was carried out by Otta Malm in 1971 and 1973. The company has two (2) claim points within the area.

Geology

Results of geological reconnaissance mapping are shown on the accompanying map (Encl. 3). The sulphide mineralization is associated with mafic volcanics of spilitic affinity. The majority of these "greenstones" appear to be of pyroclastic origin, but some varieties are interpreted as lavas. Other supracrustal rocks of the Rapham area are quartzrich sediments, some of which probably represent weathering products of the volcanics. Thus rocks with alternating bands of a spilitic tuffite and epidote rich quartzite as well as conglomerates with boulders of volcanics are found.

The main structures of the area are shown on the map. The general strike (foliation - layering) is WNW with a moderate dip to the S. Folding with well developed B-axial lineation (ESE/25°) is a characteristic feature of the Rapham area (Encl. 4). Thus the Raphamhangen hill, for example, constitutes a synform. Fluctuation of the present linear structures is indicated by a minority of WNW dipping structures. Other prominent structures of the area are NE striking and NW dipping fractures clearly reflected in the present day topography. Indications

of some faulting along these are found at the NE contact of the volcanics.

Sulphide mineralization

The 30-40 prospect pits at Rapham range in size from very small insignificant ones to the "Gamle grube" adit at southern Raphamhangen, which is a good 100 m long. The sulphide mineralizations occur within characteristically garnetiferous amphibolites (Amphibole (Akt) - Garnet - Chlorite - Epidote - Carbonate - Quart - Albite - Sphene - Apatite) generally of a banded appearance. The carbonate often appears as lenses whereas quartz (+ garnet) is found as irregular stripes (intercalations).

Sulphide enrichment is found in narrow (<1 m) generally 10-50 cm wide zones, usually accompanied by a high proportion of garnets (Encl. 5). The sulphide enrichments appear discontinuously along the strike, though they may well be confined to certain horizons (strata) of the volcanic host. The sulphides occur brecciating their host or as irregular dissemination. Chalcopyrite is clearly the dominant sulphide, only at some localities exceeded by the pyrrhotite content. Other registered sulphides (polished section microscopy) occurring in minor amounts only are pyrite, sphalerite, mackinavite and melnikovite (alteration of pyrrhotite). The only oxide observed is ilmenite.

Prospect pits located outside the "greenstones" as a rule only show small amounts of fine-grained iron sulphide dissemination.

Geophysics

A geophysical survey, covering roughly 2 km² of the Rapham area, was carried out in December 1976. The work - contracted by Suomen Malmi Oy - consisted of magnetic (PROT. -MAG) and electromagnetic (VLF as well as SHOOTBACK) surveys.

The field work was preceded by routine laboratory tests of some type rock samples, including the determination of density, susceptibility,

conductivity and frequency effect (IP). This work - done by Outokumpu, Exploration - revealed clearly anomalous conductivities for the target type of sulphide mineralization.

The results of the geophysical survey are discouraging, giving no clear indications of possible orebodies. None of the VLF-anomalies indicate good conductivity and several of them, e.g. the NE-striking long ones in the Raphamtjern area, are likely to be caused by electrolyte bearing shear zones and/or fracture controlled morphological features such as swamps. Nor do the shootback contour maps show any clear anomalies, indicating that there are no good conductors (e.g. massive sulphides) close to the surface (depth penetration 20-40 m) of the area.

The survey area is considered only weakly magnetized; anomalies do as a rule not exceed 400 nT (γ). There is no evident correlation between VLF-conductors and magnetic anomalies. The strongest magnetic zones seem to occur between conductors or intersecting them.

The report - SMOY/Pekka Mikkola 17.2.77 - on the geophysical survey is distributed separately.

Concluding remarks

The investigated exploration targets of the Otta area were chosen on the basis of known sulphide showings and/or abundant electromagnetic anomalies.

Economic exploitation of the main target - i.e. the Aasoren copper prospect - has been shown to be far beyond possibility at present.

The EM-anomalies at Myrum have revealed themselves as insignificant pyrrhotite-graphite bearing strata, with only subordinate contents of chalcopyrite.

At Rapham, the copper enriched portions are often rich, but appear to be of very restricted dimensions. They should not be regarded as potential

ores themselves but rather as indications of a possible hidden orebody. This hypothetical ore has not been indicated by a fairly detailed geophysical survey. Thus the existence of large-scale sulphide enrichment at Rapham is considered unlikely.

Esbo, February 18, 1977

H. A. Rosenqvist

HAR/kly

5 enclosures

1 appendix report



ANOMALY TEST DRILLING 1975 - MYRUM GRID

ANOMALY	DDH	APPROXIMATE COORD./DIRECTION		LENGTH	REMARKS / "ANOMALY EXPLAINED BY"
SMOY 6-75	BH 35	K≈30.210	270°/+50°	103 m	FEK ± SK (± CUK) impregnation and "schlieren" (48.90 - 50.10 m)
"	BH 36	K≈30.255	215°/+45°	80 m	Narrow (max. 30 cm) FEK ± SK (± CUK) impreg.
		L≈10.375			
		L≈10.305			
SMOY 8-75	BH 37	K≈30.280	215°/+45°	82 m	Narrow (appr. 50 cm) FEK (± CUK) enrichment
		L≈11.000			
SMOY 16-75	BH 38	K≈30.600	350°/+45°	30 m	FEK-graphite, drilled along dip
		L≈ 9.655			
"	BH 39	K≈30.585	350°/45°	45 m	Hole drilled along dip. - interrupted
		L≈ 9.730			
"	BH 40	K≈30.680	160°/ 45°	119 m	FEK-graphite "schlieren" (64.70 - 82.80 m)
		L≈ 9.580			
TOTAL				459 m	



LEGEND

- 245 MAFIC VOLCANICS OF SPILITIC AFFINITION (EVULK-SVULK-SLA-STU-VIK)
- A AGGLOMERATE
- ▲ TUFF
- L LAVA
- GARNETIFEROUS ROCK
- 31 SILICEOUS SEDIMENT (KVTL) IN THE SOUTH-EAST WITH VOLCANIC INTERCALATIONS
- CONGLOMERATE
- OUTCROP (OR GROUP OF OUTCROPS)
- - - GEOL. CONTACT
- 60 FOLIATION (LAYERING)
- 25 FOLD AXES
- 30 LINEATION
- JOINT (FRACTURE)
- PROSPECT PIT

OUTOKUMPU Oy
EXPLORATION

1:5000

HAR/LK 1977

RAPHAMN
OTTA NORWAY

3

GEOLOGY

OUTOKUMPU Oy
Malminetsintä

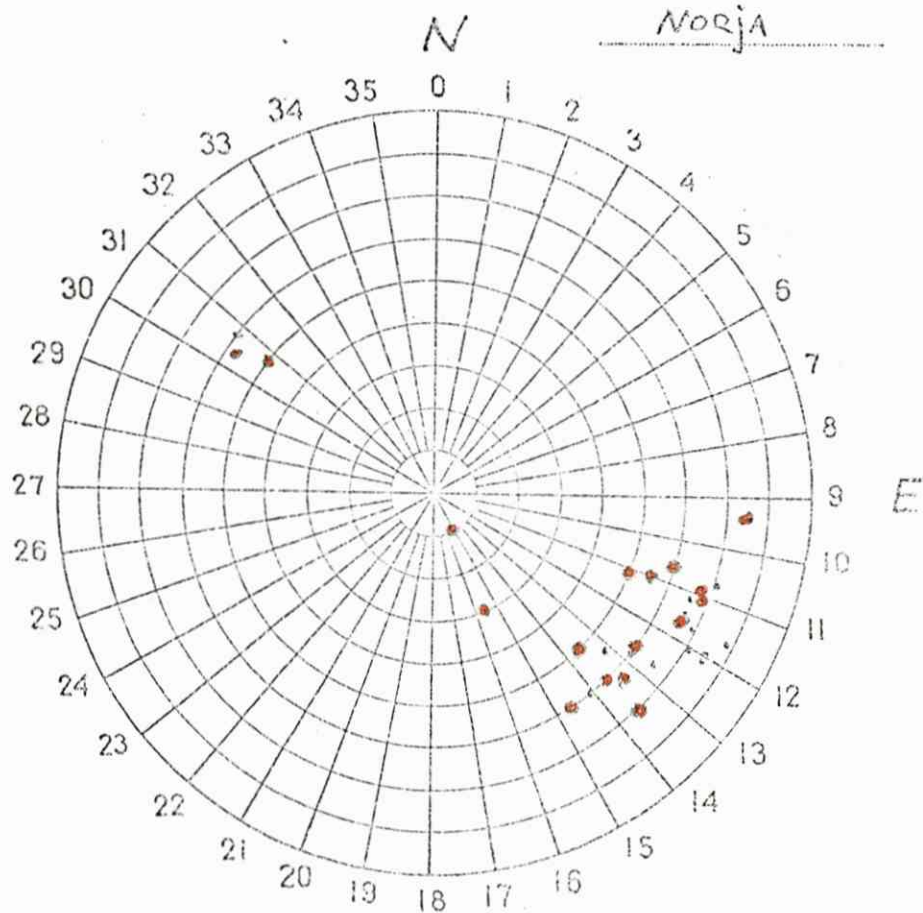
N:o _____

SUUNTADIAGRAMMI

SEKTORIJAKO 10°

Piirtämispäivä _____ Paikka RAPHAM

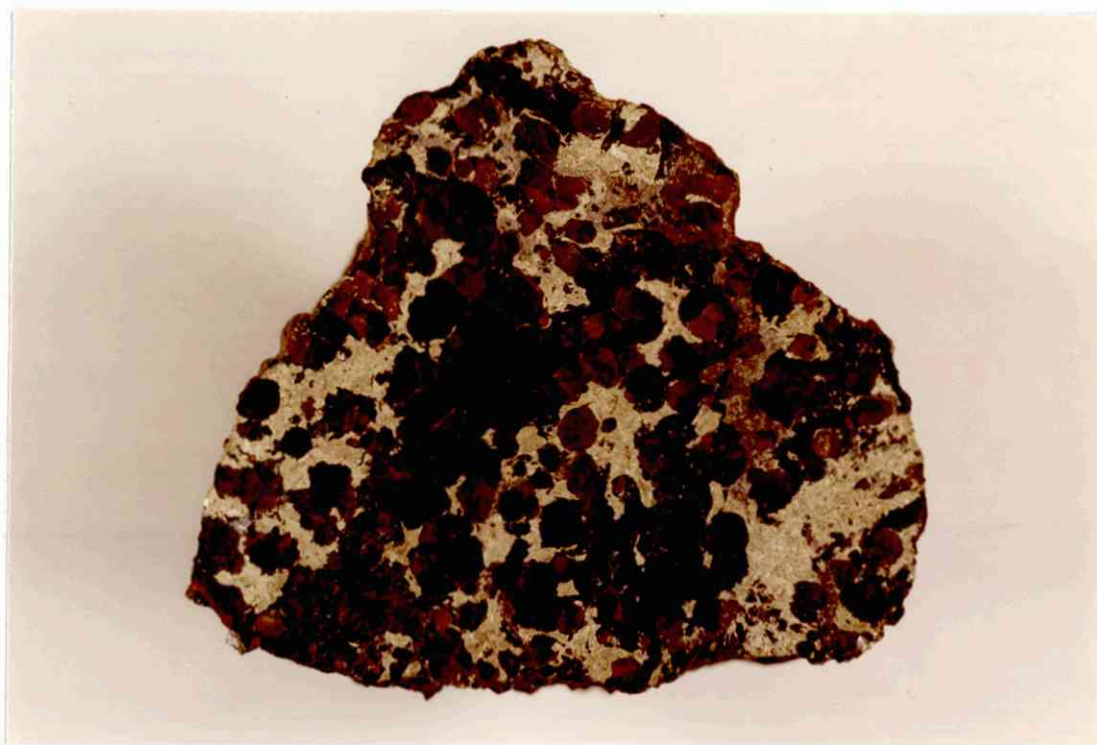
NORJA



Havaintopisteiden sektorimaksimi (n)	Mittauksen laatu ja määrä • FOLD AXIS • LINEATION
Asteyksikkö ($\frac{90}{n}$)	Paljastumat



5 cm



Garnetiferous chalcopyrite-pyrrhotite ore
"Export ore" from the Gamle Grube tip, Rapham.

8

9

10

11

12

13

14

15

16

17

Bilag 1.

Garnetiferous chalcopyrite-pyrrhotite ore
"Export ore" from the Gamble Grube tip, Rappahannock.



5 cm



8

9

10

11

12

13

14

15

16

17

Bilag 1.

AASOREN-PROJECT

Prefeasibility study

Helsinki

December 29th, 1976.

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1. ASSIGNMENT

The assignment was to make a rough examination regarding the profitability of the Aasoren ore deposit with as optimistic basis as possible in order to give instructions for any further investigations of the deposit.

2. SUMMARY

The assignment was to make an examination regarding the profitability of the exploitation of the Aasoren Cu-ore as well as whether further geological investigations of it are reasonable. This examination has been based on the ore estimate of 22nd May, 1976 made by Mr. H. Rosenqvist.

The ore reserves in situ are about 700 000 t and the grade 1.40 % Cu.

In the tentative planning the following investment and operating costs were obtained :

Investment costs (x 1000 Fmk)

Mine	5000, -
Concentrator	10000, -
Maintenance	1000, -
General	2000, -
<u>Reservation</u>	<u>4500, -</u>

In total 22,500,000, - Fmk
=====

When using the cut & fill method the operating costs are :

Operating costs (Fmk/t)

Mine	25, -
Concentrator	11, -
<u>General</u>	<u>5, -</u>

In total 41,00 Fmk/t
=====

On the basis of the profitability analysis made the stoping and exploitation of the Aasoren ore deposit do not yield a positive final result.

The result, internal rate of return - 36% , is so low that no reasonable changes of the parametres would give a positive final result.

(Cashflow and sensitivity analysis curves).

Aasoren Project

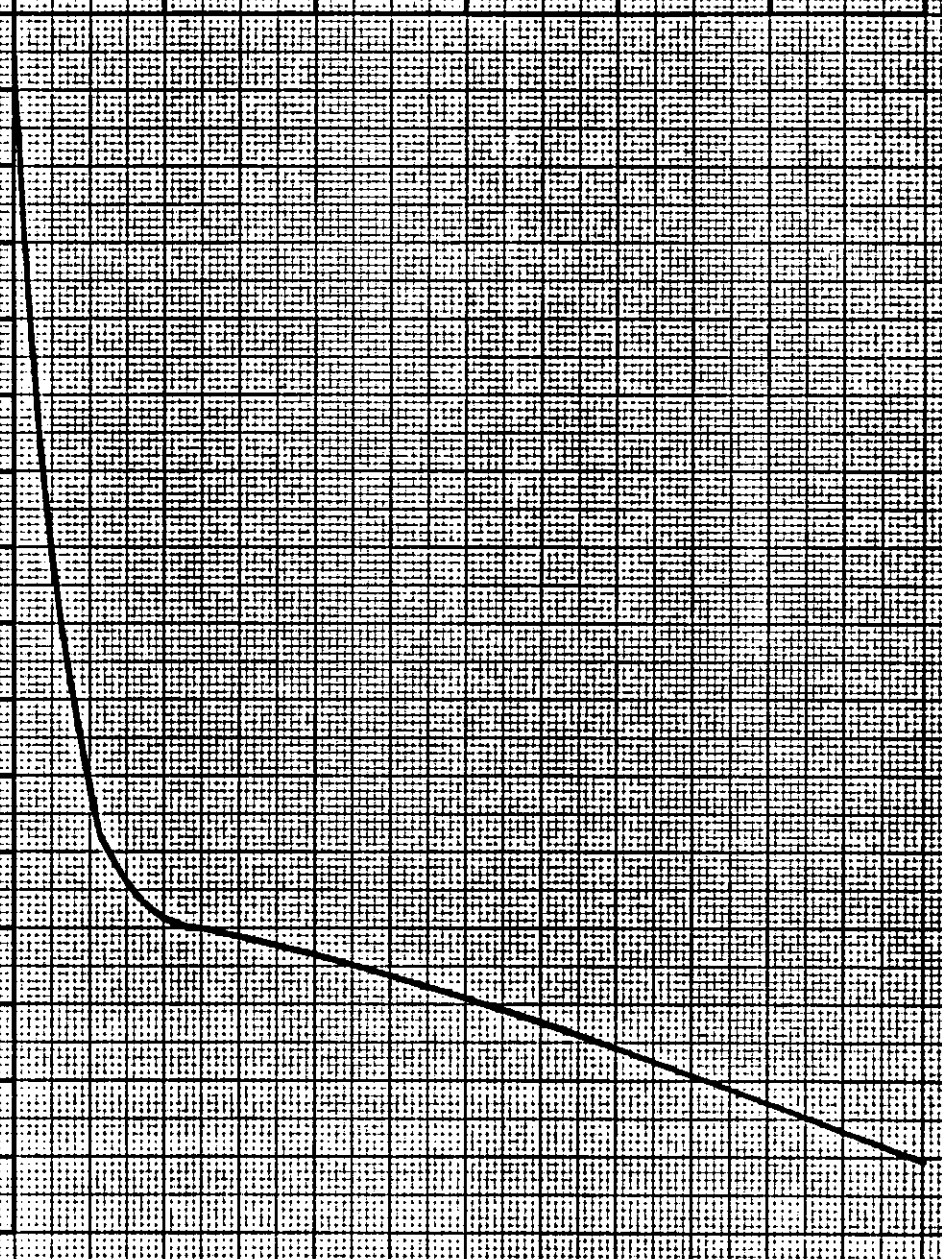
Cumulative Cashflow

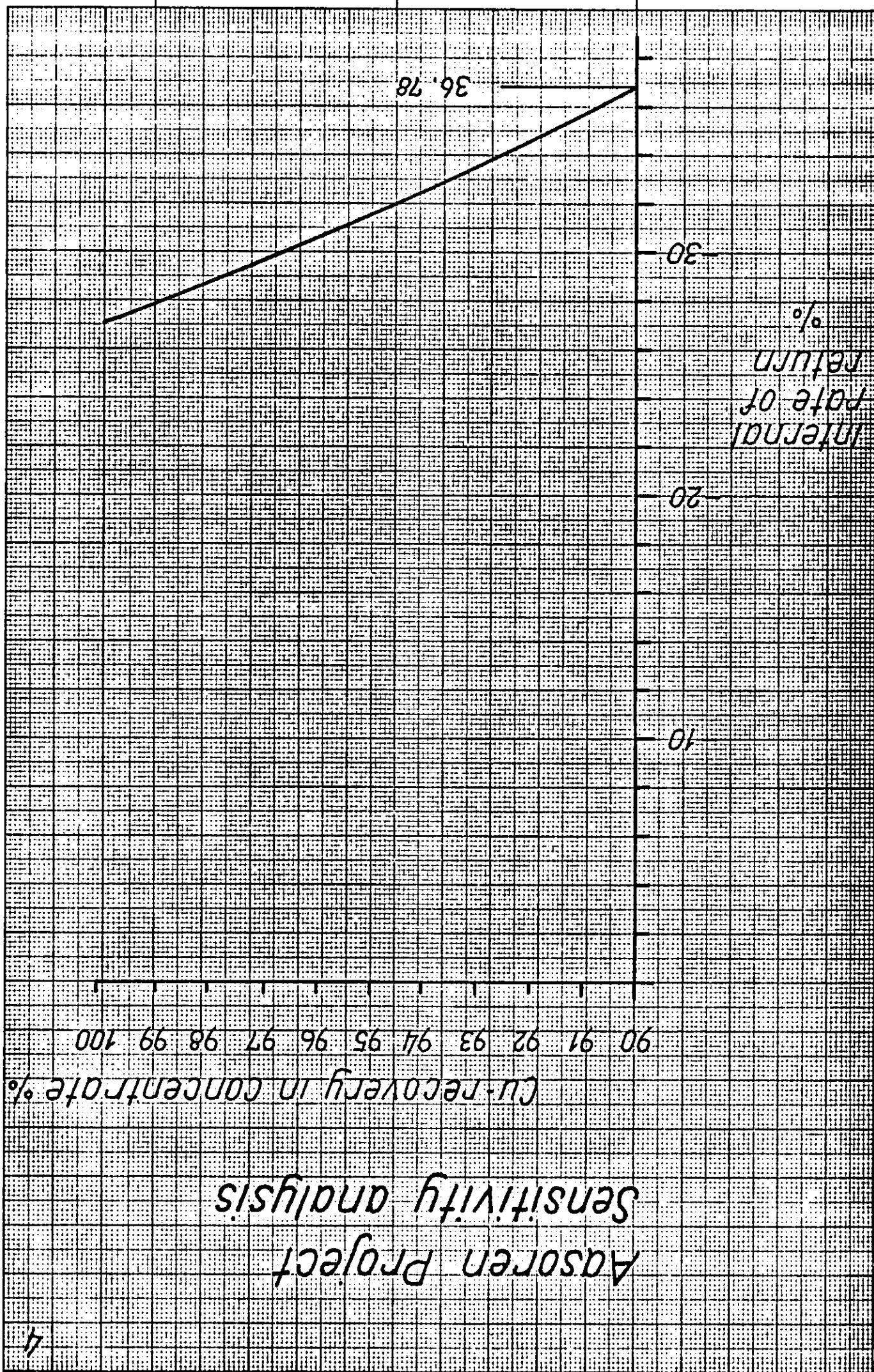
Interest 10 %

Years 0 1 2 3 4 5 6

2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32

Cumulative
cashflow
Million Fmk





Aasoren Project Sensitivity analysis

Investments Million Fmk

15.8 16.9 18.0 19.1 20.3 21.4 22.5

-30 -25 -20 -15 -10 -5

Chance in investments %

10

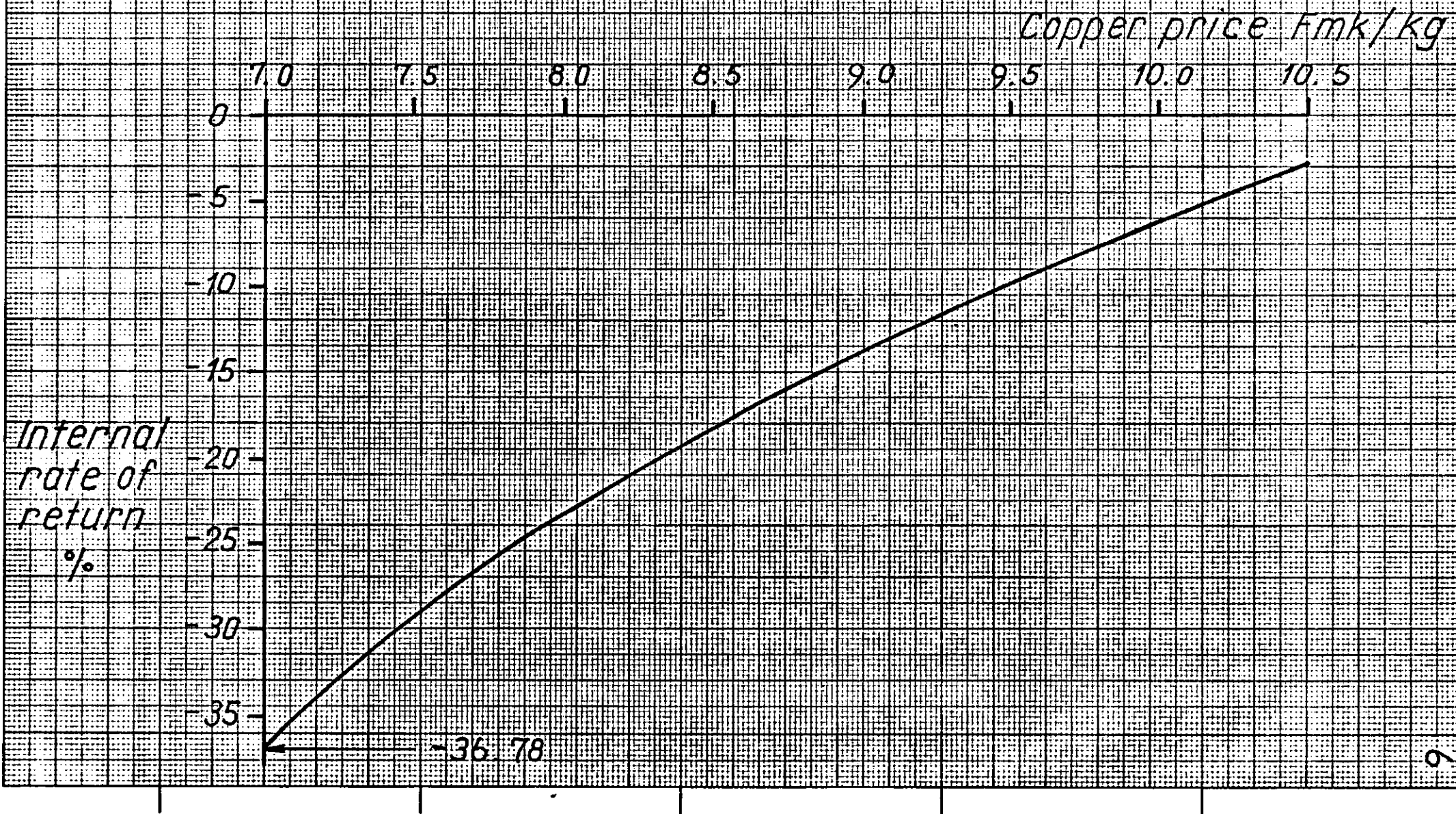
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Internal
rate
of return

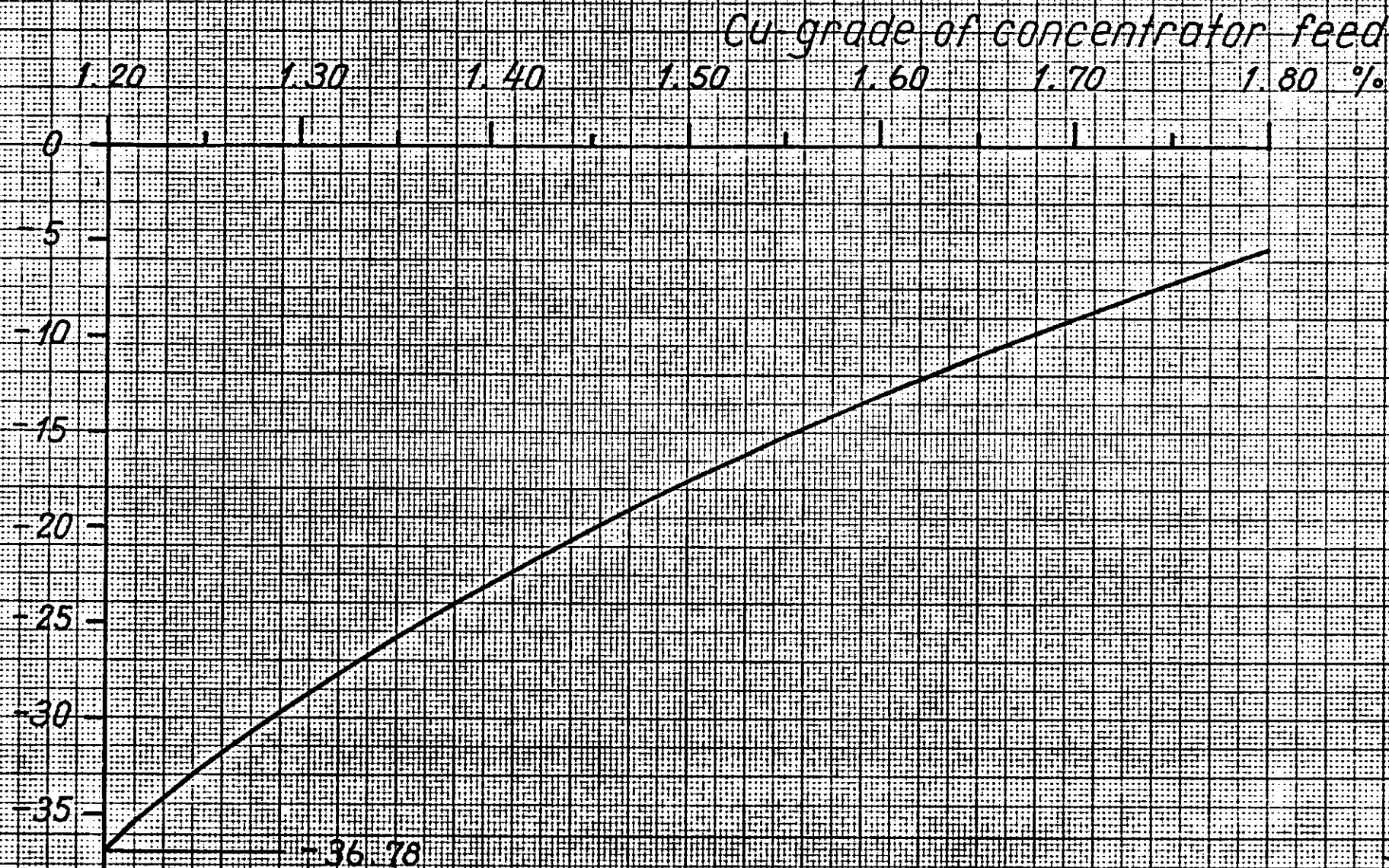
30

-36.78

Aasoren Project Sensitivity analysis

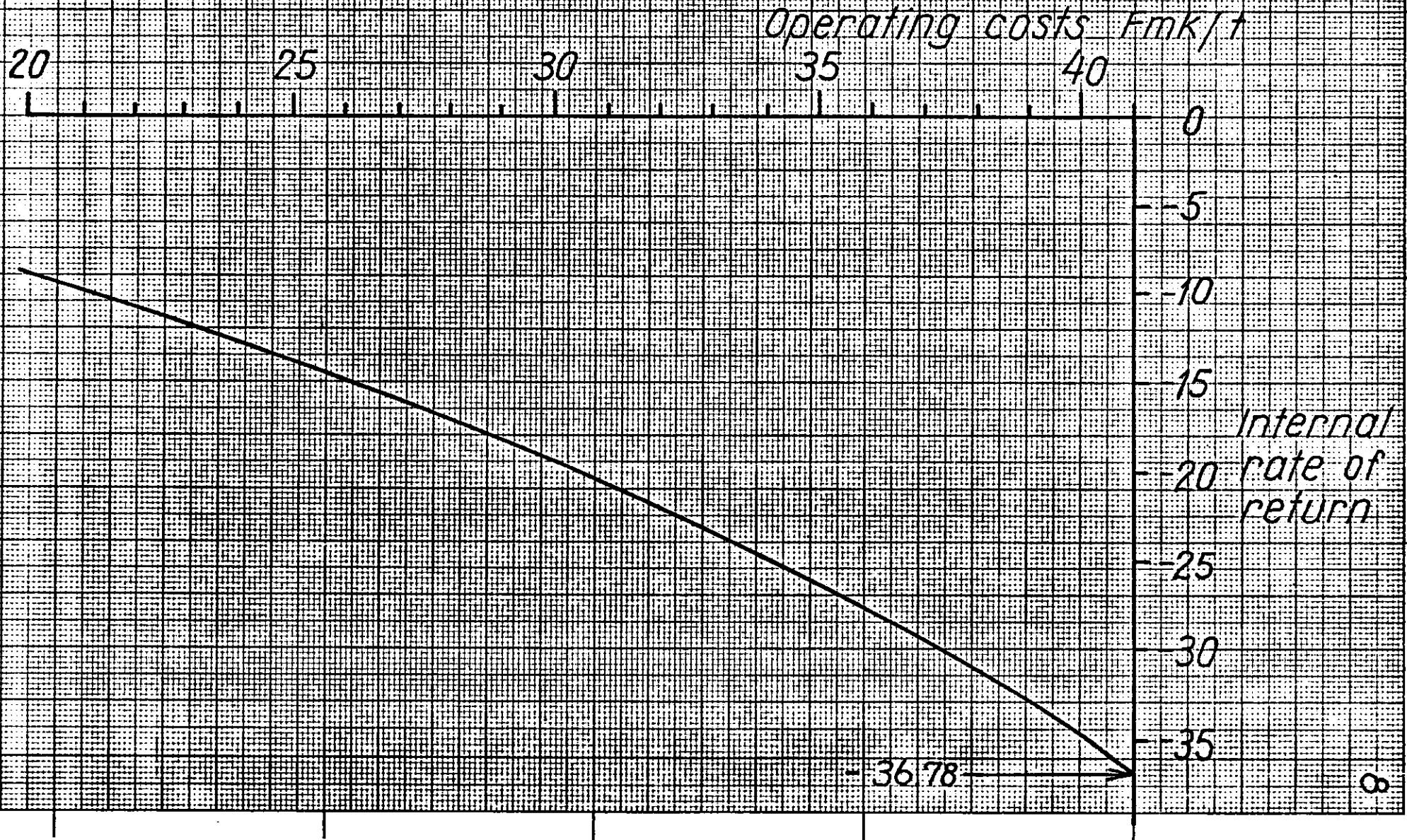


Aasoren Projects Sensitivity analysis



Aasoren Project

Sensitivity analysis



3. GENERAL

3.1 Location of the ore deposit and local conditions

The ore deposit is situated 200 km north of Oslo and ca. 6 km from the Oslo - Trondheim railway in the Otta center of settlement in the Sel commune.

The railway runs to the deposit.

The location of the deposit is good as to traffic communications as well as services available.

In this area the schist has been stoped as well as this orebody, whereof there are drifts and some kind of open pit still left.

The Sel commune belongs to development area.

The river is a conservation object and it must by no means be polluted.

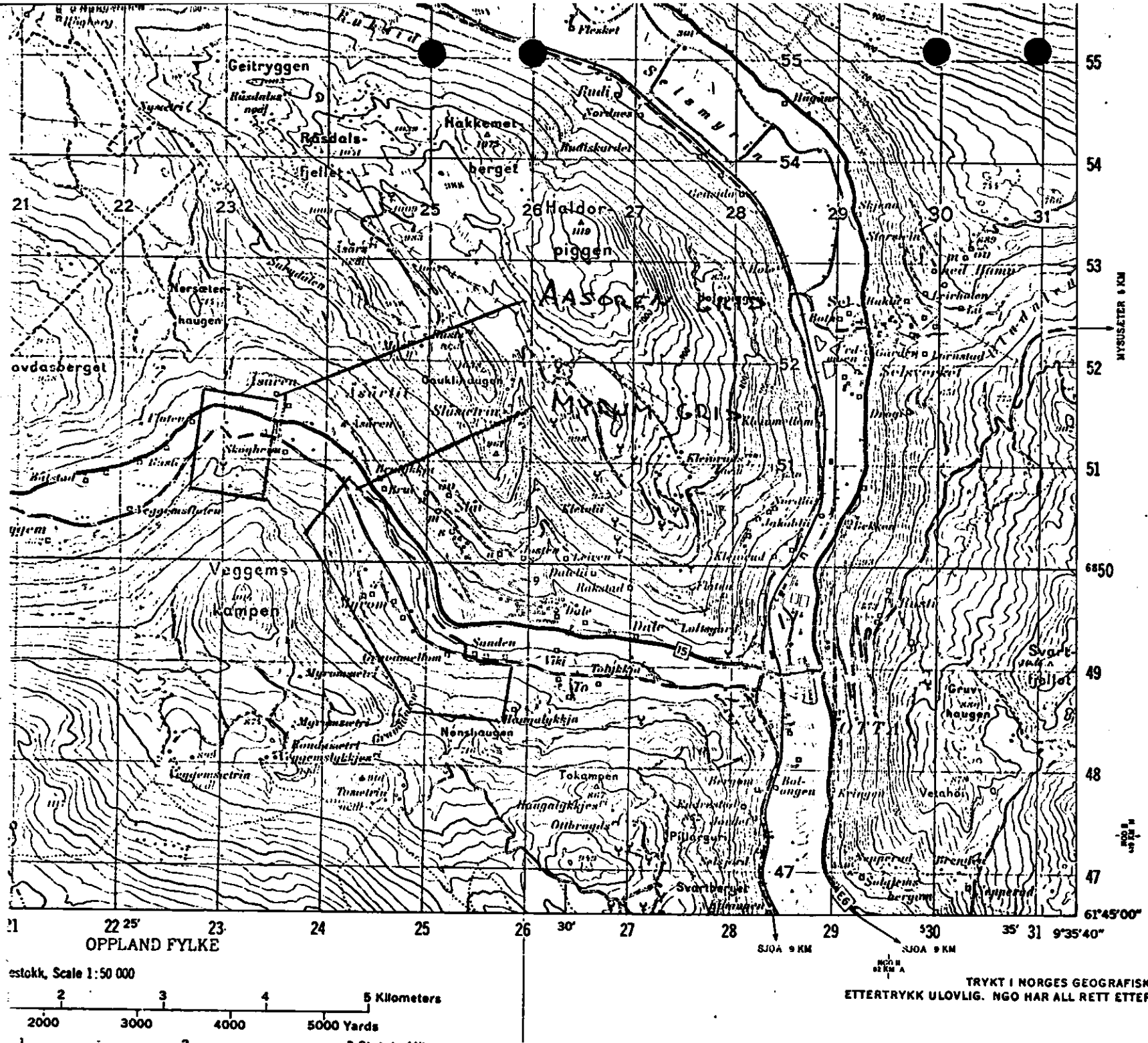
The nearest harbour is that of Åndalsnes 200 km off. A highway leads to this harbour.

The Tverrfjellet concentrating plant is situated at a distance of ca. 100 km. There is a highway connection to Tverrfjellet.

Orientation map (1: 50 000)

Fig 1

ORIENTATION MAP
1:50,000



TRYKT I NORGES GEOGRAFISKE OPPMÅLING 3-72.
ETTERTRYKK ULOVLIG. NGO HAR ALL RETT ETTER LOV OM ÅNDSVERK.

3.2 The ore and ore reserves

Mr. H. Rosenqvist has made an ore estimate of the orebody "The Aasoren Copper-Project, Norway, Report on 1975 investigations" .

In this connection only the following main factors that will have influence on the operating applications are mentioned :

- there are three main ore zones
 - the ores are ore lenses of ruler type
 - the thickness of the lenses is 2-3 m , width less than 100 m and length ca. 300 m.
 - the ore is really heterogenic as to quality as well as dimensions.
 - the total amount of the ore is according to the ore estimate in situ ca. 730 000 t 1.43 % Cu and max. 15 g/t Ag.
- The importance of silver is non-existent.
- the volume weight of the ore is ca. 3.3 t/m³
 - in strength technical respect the ore as well as the country rock are rather solid - the old drifts are well preserved.

4. BASIS FOR ECONOMICAL ESTIMATES

4.1 Persons involved in the assignment

Ore estimate and geology	Mr. H. Rosenqvist
Laboratory tests, concentration	Mr. M. Saari
Cost calculations, "-	Mr. E. Lehtonen
Maintenance	Mr. H. Harjunpää
Computer calculations of profitability	Mr I. Haapamäki
Mining technical estimates	Mr. R. Matikainen

4.2 Capacity

The inventoried ore amount is ca. 700 000 t . As basis for this examination an annual capacity of 100 000 t has been chosen as it can be reached with the cut & fill method. The operating time will thus be ca. 5 years when an ore loss of ca. 30 % is taken into consideration.

4.3 The process and plant description

As this is only a prefeasibility study no detailed stoping or plant plans have been made. The calculations are based on estimates obtained on the basis of Outokumpu Oy's practical experience.

Stoping

Mechanized cut & fill method or sublevel caving will be employed. The investments of the mine are mainly equipment investments as well as those of the developing work. In the cut & fill method the estimated waste rock dilution is 15 % and in sublevel caving 30 % .

Concentrating plant

The capacity of the concentrator has been estimated on the basis of concentrating tests made in the laboratory.

The estimated recovery of the concentrator is Cu 90 % when the concentrate includes 20 % Cu . The recovery of silver is 60 % and in the concentrate there will be 145 g/t .

The details of the tailing area have not been planned, though approximate area and dam reservations have been made for it. A complete water circulation is our target.

General services

such as maintenance have been restricted to a minimum as well as other investments, for instance office facilities a.o.

4.4 Investment and operating costs

Investments (Fmk)

Mine	5,000,000, -
Concentrator	10,000,000, -
Maintenance	1,000,000, -
General	2,000,000, -
<u>Reservation (25%)</u>	<u>4,500,000, -</u>
<u>In total</u>	<u>22,500,000, - Fmk (excl. reserv. 18,000,000, -)</u>

Operating costs (Fmk/t)

Mine	25,00 (sublevel caving 15,00)
Concentrator	11,00
<u>General</u>	<u>5,00</u>
<u>In total</u>	<u>41,00 Fmk/t</u>

The estimated freight of the concentrate to the nearest smelter
10 % H₂O moist is 100 Fmk/t.

Production can be started within one year of the first investments
and the operating time applied is 5 years.

4.5 Metal prices and calculation forms

For copper we have used the long-term price of Outokumpu Oy
7, - Fmk/kg and the following market price form for the Cu-
concentrate :

<u>Value of Copper</u> (200-10) x 7 mk/kg =	1330 mk/conc. t
Smelting costs	- 205 -"
Refining costs (200-10) x 0.7 mk/kg=	- 133 -"

The share of copper of the production
value

992 mk/conc. t

$$\frac{992 \text{ mk/conc. ton}}{190 \text{ kg/conc. ton}} = 5.22 \text{ mk/kg Cu (Cu-value in the concentrate)}$$

Value of silver $(145-30) \times 0.6 \text{ mk/kg} = 69 \text{ mk/conc. ton}$

$\frac{60 \text{ mk/conc. ton}}{0.145 \text{ kg/conc. ton}} = 476 \text{ mk/kg Ag (Ag-value in the concentrate)}$

Obs. the amount of silver in the ore and in the concentrate has been estimated very optimistically.

Freight of concentrate $100 \text{ mk/10\% moist conc. ton}$

$\therefore 111.11 \text{ mk/ dry conc. ton}$

5. PROFITABILITY CALCULATIONS

The profitability calculations have been made using the above mentioned calculation forms as well as on economic basis.

A computer programme of Outokumpu Oy has been used.

The internal rate of return as well as cashflow calculations with sensitivity analysis have been calculated on the basis of cut & fill method (appendices) . The result reads as follows :

Internal rate of return - 36 %

Cashflow before taxes - 16,750,000, - mk.

The investment does not pay itself back.

On the basis of the sensitivity analysis made it may be said that :

the investment cannot be made reasonable with

- any concentrator recovery value
- any reasonable price of copper
- any realistic feed content
- any realistic operating costs
- any realistic investment

The use of sublevel caving gives the same negative final result. (Appendices).

6. CONCLUDING REMARKS

The above stated calculations have lead to a completely negative result. As the investment and operating costs applied have been utmost optimistic an economical exploitation of the ore is not possible. In spite of reaching possibly an agreement with the Tverrfjellet concentrating plant the haulage and concentrating of the ore there would not be profitable.

29.12.1976

Raimo Matikainen/kp

Appendices