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Postboks 3021, N-7441 Trondheim

Rapportarkivet

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7359				
Kommer fra ..arkiv	Ekstern rapport nr	Oversendt fra F.M. Vokes	Fortrolig pga	Fortrolig fra dato

Tittel

A report concerning an inspection of the disused Skutterud cobalt mines at Modum, together with a discussion of the results thereof and reflections on the structural control of the ore-deposition

Forfatter	Dato År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Vokes Frank M.	1956	NGU

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Modum	Buskerud		17141	Skien

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geologi Mineralogi		Modumfeltet Skutterud muggerud skjerp Middagshvile skjerp Bennece stoll Ludwig Eugen stoll Klara stoll Nordgruven Troegerort Svartfjell gruve
Råstoffgruppe	Råstofftype	
Malm/metall	Co, As, Cu, Ni	

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Engelsk tekst.

Den generelle geologien blir gjennomgått i sammenheng med områdets strukturer i tilknytning til strøk/fall og lineasjoner.. Det blir spesielt gått inn på fahlbåndsonene.

Likesa bliranalyser av malmen vurdert. Det blir tatt en del prøver.

Dannelse av malmen og malmkontrollen blir diskutert. Forfatteren er helt bestemt på at fahlbåndsystemet er uttatt til bunnen på strekningen Skutterud-Svartfjell gruve. Det meste av mineraliseringen er borte som følge av erosjon på et nivå i det sub-Cambriske peneplan.

Vedlagt papirkopier og tracinger av av en rekke snitt samt et senere lengdesnitt gjennom malmsonen.

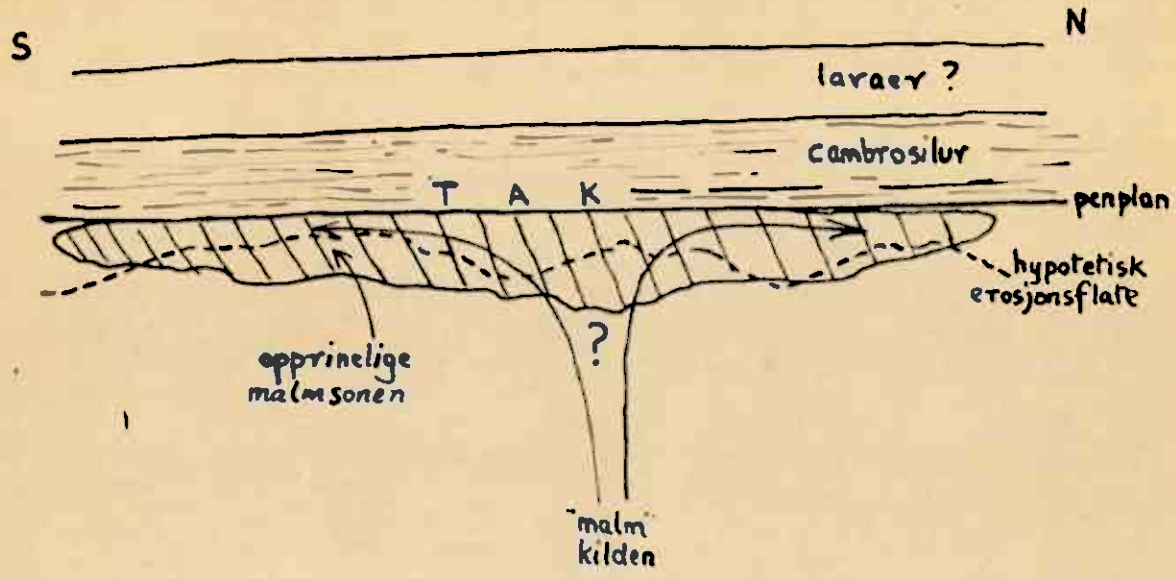
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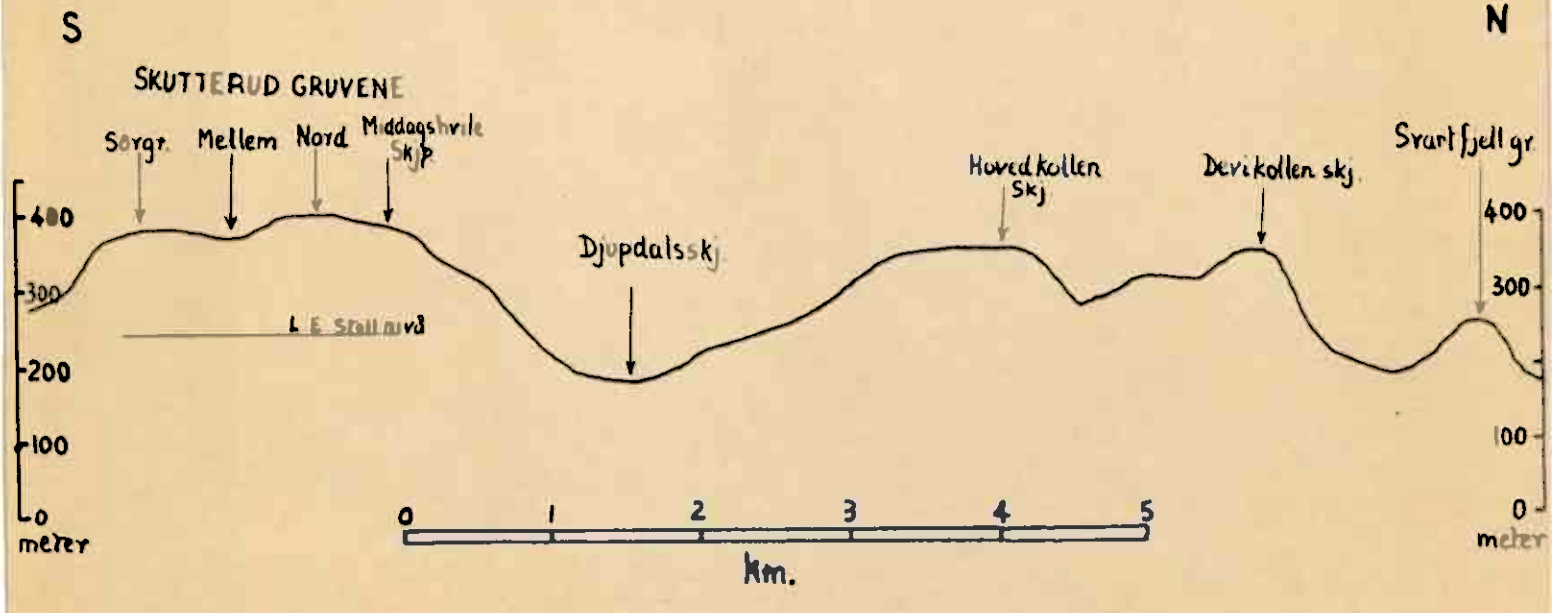
FIG. C.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SKUTTERUD GRUVENE
Sorgr.
Mellem
Nord
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FIG. D.

A Report concerning an inspection of the disused Skutterud cobalt mines at Modum, together with a Discussion of the results thereof and Reflections on the structural control of the ore-deposition

by

F. M. Vokes.

Report of inspection.

The inspection took place in the period from 15th to 23rd June 1936. The writer cooperated in part with the NGU party under Th. Siggerud who were carrying out a radioactive survey of the area.

Object of the inspection was to examine the surface workings of the Skutterud mines and all safely accessible underground workings, with a view to deducing any structural controls which may have been operative during the deposition of the ores. The information gained from the field data and their analysis was to be used to assess the possibilities of discovering further ore. Proposals for future exploration work were then to be made.

Area inspected. All the suface workings between Muggerud Skjerp and Middagshvile Skjerp were examined. Special weight was placed on the main mines from Bennecke Stoll to the north end of Nordgruven (see longitudinal section). The underground workings inspected comprised Klara Stoll (x-cut and drive north); the stopes Östre No. 11, Vestre No. 11 and part of Vestre No. 10; Ludwig Engen Stoll (x-cut and drives N and S); Nordgruven (open cast and all drives off this); Upper and Lower Bærum Stolls and Bennecke Stoll.

Use was made of the old mine plans, and especially of those contained in the report of Bergingeniör Heltzen (October 1952).

Results of inspection (see discussion). The results obtained from the inspection show that the ores at the Skutterud mines occurred in ~~flat-lying~~ steply-dipping, horizontally elongated shoots having small vertical, as compared with horizontal, dimensions. No structures, (or other indications) can be found which give rise to the

possibility of the continuation of the ores in depth. On the contrary the general geological conditions strongly suggest that the ores have been deposited closely under the sub-Cambrian peneplane and that the deposits worked in the past represented erosion-remnants of an original ribbon-like zone of mineralization, having a large N-S strike elongation but little vertical depth.

The grade of the mineralization still left in the bottoms of the workings is at the present uneconomic and it seems that the bottom of the mineralization was reached by the old miners.

The writer does not, on the basis of the geological facts and deductions from them, consider it advisable to go to the expenditure necessary in order to carry out a full exploration programme. This would necessarily involve a large amount of diamond drilling and the targets are too weak and vague to justify this.

Geological Discussion.

General Geology. This report will not touch on the general geology of the area since the writer has little first-hand knowledge of this, and other people have dealt with it. In particular, I. Rosenqvist (1949) has described and discussed the petrology of the "fahlbånd" (ore-zone) rocks. The reader is referred to the bibliography at the end of Rosenqvist's publication for a list of works dealing with the area.

The report, therefore, presupposes a familiarity with the area's general geology. It will deal mainly with the structures in the old mining area, and, in lesser detail with the grade of the mineralization.

Structure. As is well known, the ores worked at Modum occurred as bodies of cobalt sulphides and impregnations in a so-called "fahlbånd-zone" which can reach up to 300 meters in width, but which is normally about 100 m. wide. Rosenqvist (op.cit.) distinguishes in the fahlbånd-zone at Mellom Gruve (see longitudinal section) three distinct fahlbånds which he calls Troegerort

fahlbånd, Midlere fahlbånd and Vestre fahlbånd (see section cc). Rosenqvist states that these various fahlbånds are separated from each other by comparatively narrow amphibolite bands.

The main strike of the rocks within and on either side of the fahlbånd zone is N-S, and the dip is nearly always with 10° or 20° of the vertical, mostly to the east.

The length of the main fahlbånd zone in the area is about 11 Km, but the writer's inspection was confined to the section of the Skutterud mines, from Bennecke Stoll in the south to Ludwig Stoll (Nordgruven) in the north — a distance of about 1700 metres.

Strike and dip. There are very few deviations from the overall N-S strike of the fahlbånd-zone and few of these can be correlated with the main ore-bodies as shown by the old workings.

There is a slight evidence of a coincidence between a worked part of the zone and a swing in strike direction in the most southerly open-cast of Sörgruven (on the westerly fahlbånd here). The strike of the footwall rocks here swings from N 20°W to N 10°E from the south to the north of the working, which is up to 20 metres wide.

North of the Bærum "stolls" the strike swings to a direction about 20°W of N for about 100 metres, but then swings back, so that at the southern extremity of the Mellomgruve workings it has a direction of a few degrees E of N. This value is maintained fairly constantly as far as the north end of Nordgruven

As will be seen from the section along the workings the area of the above-described swing in strike is apparently a barren one. The old trenches along the fahlbånd-zone here reveal only weak rusting. Also a drive south from Klara Stoll x-cut along the "Midlere fahlbånd" encountered no ore in depth in this area.

The rocks along the walls of the large open cast of Nordgruven also show a very slight swing in strike, from about

N 10°W at the southern end to N 20°E at the northern.

On the other hand the large open stope of Mellomgruven gives no evidence of other than constant strike - her almost N-S.

Thus the correlations between swing in strike and thicker ore are very unsure and it does not seem as though there has been any ore-control t is way.

Local variations in the values of dip are numerous but all are within 20° of vertical, the majority being within 10°. As can be seen from the sections across the ore zone, the dip as a whole is generally to the east.

Linear structures. An attempt was made to deduce any linear trends in the ore-shoots along the fahlbånd-zone in order that these might be used to point to further ore. As can be seen from the longitudinal section, the outlines of the old workings are not very helpful in determining ore-shoot directions. They indicate almost horizontal shoots, with a comparatively small vertical dimension in relation to the horizontal one. The greatest vertical depth of the main workings in Mellomgruven is 110-120 metres; in the other two mines, the workings did not extend more than 50-70 metres below the outcrop.

It is general experience in ore-geology that ore-shoots are often elongated in the lineation, or stretch direction, of the enclosing rocks when these are schistose or gneissose. Thus measurements were made along the outcrop of the fahlbånd-zone and in the accessible underground workings of the linear elements in the rocks.

These were two types:

1. A preferred orientation of the elongated minerals, especially hornblende and biotite.

2. A grooving or large-scale slickensiding along the planes of schistosity, especially well seen on the walls of some of the old stopes, e.g. the west wall of the large open cast at Mellom-gruven. This linear element indicates movement along these planes

Rosenqvist (op. cit.) mentions the phenomenon briefly under the heading of "Glidestriper".

Careful measuremnts and comparisons showed that the two linear elements coincide in direction, and thus they were mapped as one "lineation direction".

The lineation measurements have been plotted on the longitudinal section of the workings, and the general trends of the lineation inserted.

The section shows that the plunge of the lineation is everywhere fairly flat, usually never more than 20°; only occasionally were values as high as 40° recorded.

The measurements along the surface workings showed a steadily N-plunging lineation of the order of 20° from Bennecke Stoll to a point about 150 metres north of the Bærum Stolls. This latter point appears to be the centre of a depression of the lineation, and north of here the plunge becomes south at values of 15°-20°.

Just north of the midpoint of Mellomgruven there occurs a marked culmination of the linear structures and the plunge resumes its northerly direction. This continues with slight variations in magnitude to the north and of Nordgruven, (and, incidentally, at least as far as Middagshvile Skjerp, 500 metres north of Nordgruven).

The lineation measurements in the underground workings agree fairly well with those on the surface. However, those taken along Ludwig Fügen Stoll show a shift to the north of the depression and culmination seen on the surface. The plunge here is much flatter, but it can be clearly seen that the culmination of the lineation occurs about 150 metres horizontally north of its position at the outcrop. This means the crest of the culmination plunges at about 40° to the N. If one similarly examines the depression of the lineation to the south of the culmination it can be seen that its trough plunges north at about 30°.

The structural significance of these plunges of the depression and culmination are not easy to see. They would seem to imply the action of a couple on rocks already possessing a uniformly N-plunging lineation (see Fig. A). This couple would seem to be due to an overriding pressure from the north.

From a point of view of correlation with the ore-bodies it can be seen that all the main stopes of Mellom Gruve lie between the lines of plunge of the two lineation features (see section). This might be taken to imply that there was an ore-bearing zone plunging north at about 30° in this area (see Fig. B). However, as will be stated again, later examination has shown that the mineralization at the Ludwig Engen Stoll level is definitely uneconomic. There is, of course, always the possibility of further ~~flat-lying~~ elongated "fishes" of ore beneath the level of Ludwig Engen Stoll, as suggested in Fig. B.

This structural evidence of a continuation of ore in depth is so weak that it is not considered worth the expenditure of money needed to test it. The only method would be by means of an inclined hole from the Ludwig Engen x-cut, a hole at about 45° dip in a due westerly direction.

It will be suggested later that there is good circumstantial evidence that the mineralization at Modum is of only shallow depth. It is the writer's opinion that this evidence is of more weight than that afforded by the linear structures.

Cross-structures. No E-W structures, e.g. faults, major points etc., were observed in the area of the mines, which might have had a localizing effect on the ore-bodies.

Grade of ore. As stated previously all accessible underground workings were inspected. Particularly careful attention was paid to the floors and walls of the stopes in the system, Östre No. 11 - Vestre No. 11, and the backs and sides of the drives ex. Ludwig Engen Stoll in order to obtain an idea of the nature

of the mineralization under the deepest workings.

As a generality it can definitely be said that none of the workings showed megascopically visible sulphides. Even close inspection of hand specimens with a hand-lens only revealed very occasionally a small speck of cobalt sulphides or odd spots of chalcopyrite. Cobalt bloom (erythrite) was noticed in places along the backs of some of the drives at various levels, but examination of the rock beneath it did not show any noticeable sulphides.

A comparison of the mineralization seen during the inspection with large specimens of the original ore, now in the Geologisk Museum, Oslo, indicates very clearly that no more "ore" remains to be taken out of the old workings.

As a confirmation, random chip and grab samples were taken in the course of the work. These have been analysed (spectrographically) for Co and Cu, as follows:

		% Co	% Cu
RSM 1	Nordgruven, chip sample of pillar in the main open cast	-	0.08
RSM2	Nordgruven, grab sample of spoil in south end of easterly stope, open cast	-	0,03
RSM 3	Vestre Nr. 11 Stope, chip sample south of x-cut from Östre Nr. 11.	0,02	0,08
RSM 4	Östre Nr. 11 Stope, grab sample from broken ore near top of stope	0,01	0,02
RSM 5	Klara stoll. Drive south ex x-cut at 70 metres N of Klara x-cut in the "Vestre Fahlbånd"	0,02	0,01

(Analyst: Sentralinstituttet.)

The above values are of the same order as those found by Rosenqvist and Heltzen, but rather lower in magnitude.

Rosenqvist estimates the original ore at Modum to have contained 0,08 % - 0,1 % Co. The values given in the report by Heltzen lie between 0,01 and 0,1 % Co, with the majority below 0,05 %.

Mineralization with such low metal values does not seem to the present writer to constitute workable ore. In spite of Rosenqvist's assertion that "the mine is by noe means exhausted" it does not seem possible to restart working under present conditions with such a low metal content.

Conclusions.

It is clear from the evidence in this report and from that of previous workers that the Modum ores formed long, shallow ore-shoots with no preferential plunge direction, apparently closely connected with the present erosion surface.

This fact (according to Rosenqvist) led A. Bugge to make the suggestion that the cobalt mineralization was due to secondary enrichment of a primary Precambrian metallization under the sub-Cambrian peneplane. Rosenqvist (op.cit. p. 210) gives figures showing a fall in the Co values with depth under the present surface to support this line of thought. The present writer also agrees that the form of the deposit indicates some sort of horizontal control not too far distant from the present erosion surface. However, the mineralogy of the ores is not one which would result from processes of secondary enrichment and cementation; cobaltite, skutterudite and arsenopyrite (danaite) are primary hydrothermal minerals. As far as the writer is aware, cobalt is not known to form secondary, enriched, sulphides in a manner analogous to, say copper. The results of the weathering of cobalt ores seem to be confined to erythrite (when As-bearing) and cobalt "wad" (asbolane). We have, for instance, the authority of Goldschmidt (1954, p. 669) that "cobalt arenide ..... weathers readily forming the arsenate erythrite". The ores worked in the upper levels of Modum mines were, to judge by the many specimens in the Geologisk-Mineralogisk Museum, certainly not erythrite ores. They were primary, hydrothermal sulphide ores and the cause of

long, flat form of the ore-shoots must be sought in structures controlling this primary deposition.

Rosenqvist (op.cit. p. 211) states that " the occurrence of a series of cobalt-bearing sulphides shows unequivocally that an ore-mineralization took place in Precambrian times ....", without giving any evidence for this assertion.

The present writer proposes that a Permian age is much more reasonable for the Modum ores. This would bring them in line with the similar, though not identical, ores of the Kongsberg area, only some 40 kms. to the SSW. The evidence afforded by these latter ores seems to show quite clearly their Permian age (see, e.g. Bugge, 1917 and Neumann, 1944). The ores of both areas would seem to belong to a silver-cobalt-nickel metallogenetic province along the immediate western borders of the Oslo Eruptive province. Their genesis seems undoubtedly connected with the emplacement of the deep eruptives in this province during Permian times. (Neumann suggests a genetic connection with the Drammens granite.)

If we can presuppose a Permian age for the Modum mineralization, we are in a position to explain quite simply the long, flat form displayed by the ore-shoots. As Rosenqvist points out (p. 210), the present erosion-surface is not very far beneath the original position of the sub-Cambrian peneplane. In Permian times this peneplane was covered by a thick layer of Cambro-Silurian sediments, mostly impermeable shales. Any mineralization coming up the zone of weakness now represented by the fahlbånd rocks would become "dammed-up" by this roof of shales and would spread out longitudinally (N and S) ~~horizontal~~ along the zone. Since the controlling roof was horizontal, or nearly so, the resulting ore-shoot (or series of ore-shoots) would be horizontal too (see Fig. C).

This type of control is well-known in ore geology. Just as one example may be cited the long, ribbon-like lead-ore

bodies of the Pennines in England. These are located along faults in limestone just beneath a roof of impermeable shale.

The implecations of the above suggestions are thus that the Modum ores are not of great depth, and that the poor mineralization seen in, e.g., Ludwig Fügen Stoll is due to the fact that the ores have been "bottomed" by the workings.

As McKinstry (1949) points out every ore-body or system of ore-bodies must have an "inlet", a feeding channel which gave access to the ore-forming solutions. The relative concentrations of ore in the Skutterud mines, especially Mellom Gruve, suggest this channel may be located somewhere in this area. It could even be that the N-plunging structure described on p. 6 is this feeding channel. If so, it might be expected to contain some ore to greater depths, but the strike length would be very short, probably not more than 300 metres and the prospects do not warrant any expenditure in looking for this hypothetical ore.

Since the ore-controls (as postulated) seem to have produced a long, shallow ore-body, or series of such, search in depth is not to be recommended. This leaves the question of the search for further ore-bodies along the strike of the fahlbånd. Here the topography plays a large role, since the original ore-bearing zone will only be preserved where erosion has not lowered the land surface too much. Fig. D is a topographical profile along the line of the fahlbånd. It shows how nearly all the old workings and certainly all the important ones lay at or near the highest points along the fahlbånd, supporting the idea of some topographic control of the ore-deposition. It, therefore, does not seem likely that further worth while ore-finds can be expected in the topographical depressions along the fahlbånd.

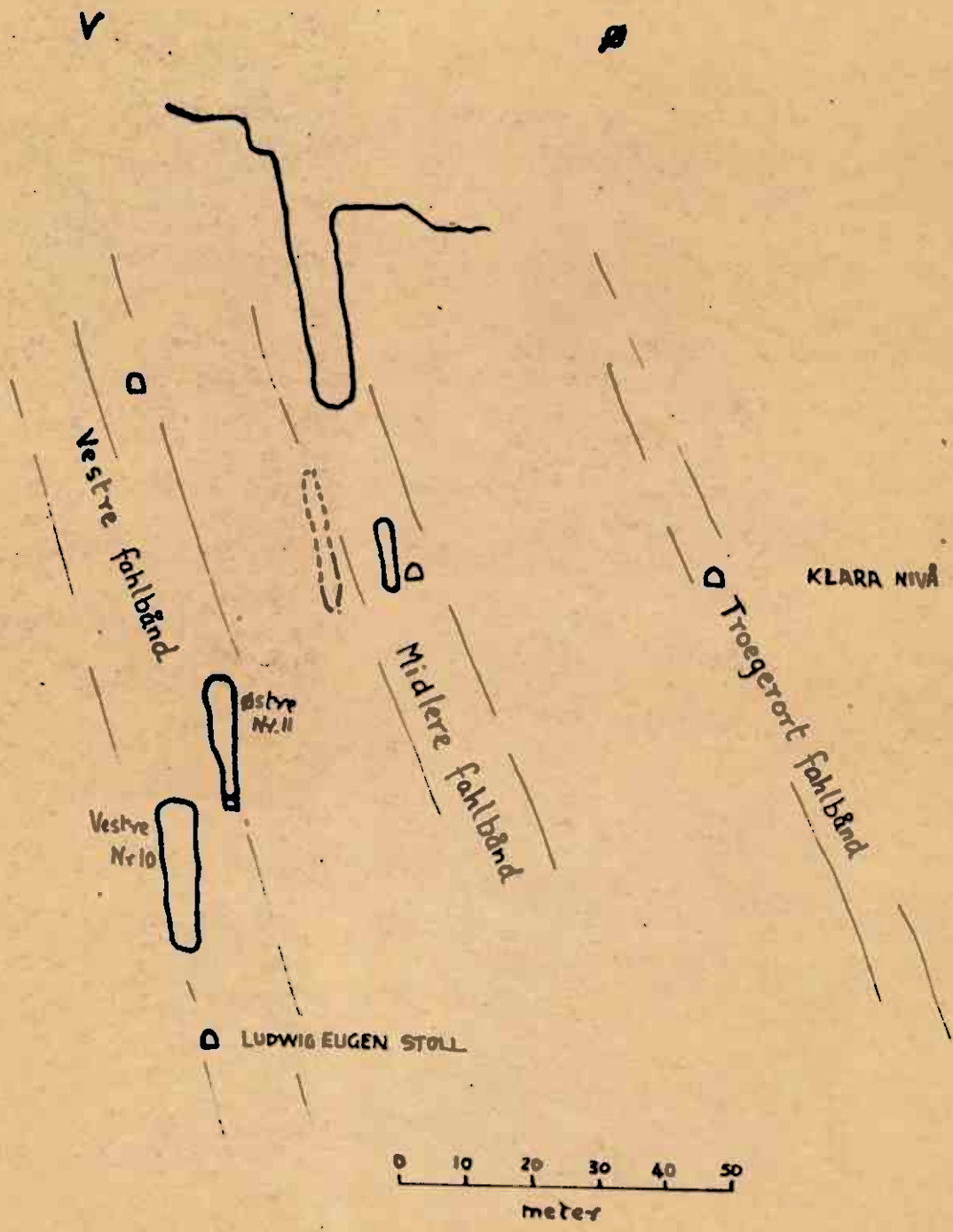
The writer is led quite firmly to the conclusion that the ore-mineralization along the main fahlbånd between Skutterud

mines and Svartfjell mine has been "bottomed", and that most of the ore deposited has been removed by erosion beneath the level of the sub-Cambrian peneplane.

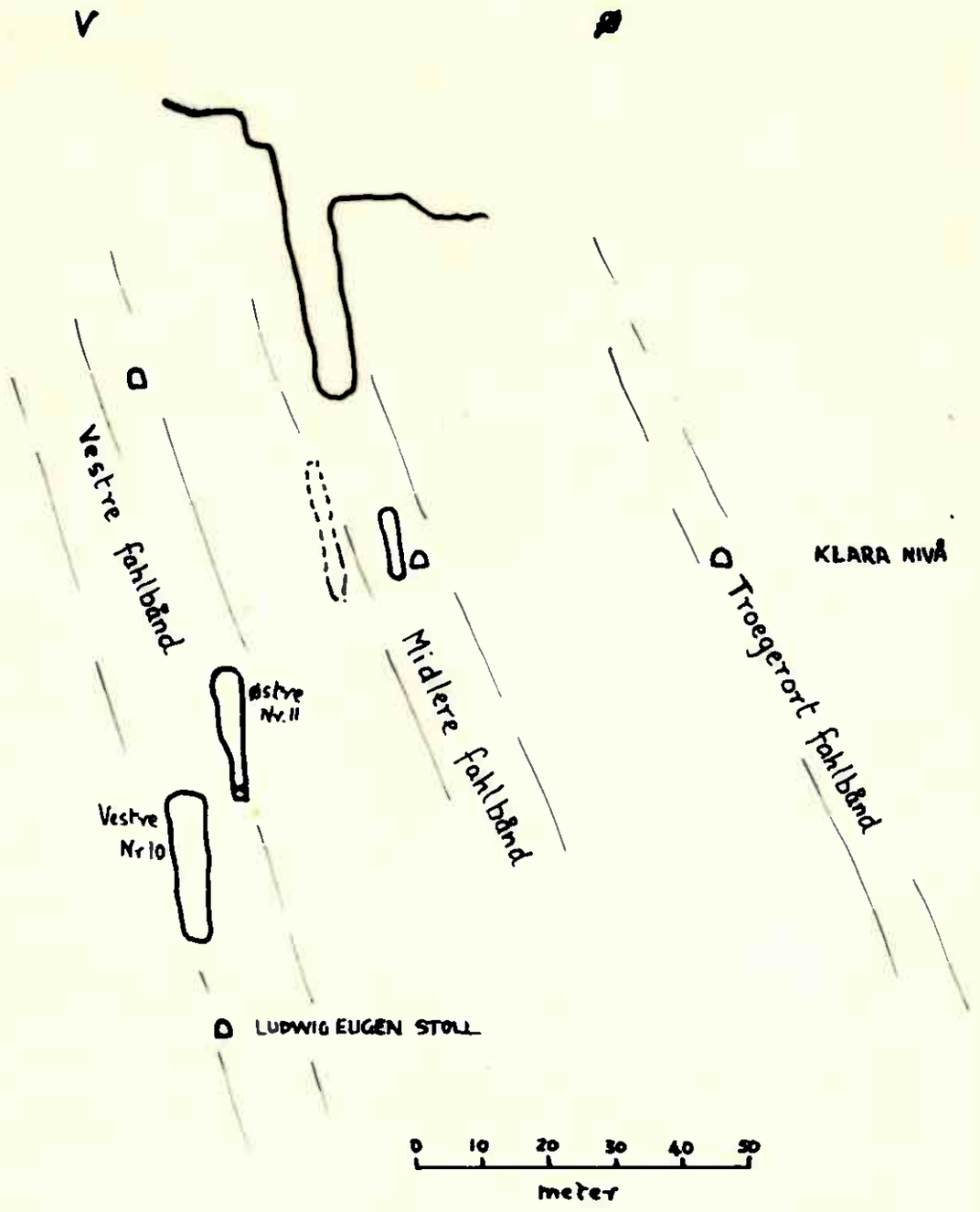
Literature references.

Bugge,C. 1917. Kongsbergfeltets geologi. N.G.U. 82.
McKinstry,H.E. 1949. Mining Geology. New York, Prentice Hall,Inc.
Neumann,H. 1944. Silver deposits at Kongsberg. N.G.U. 162.
Rosenqvist, I.Th. 1949. Noen observasjoner omkring Modum koboltgruver (Nedl.). N.G.T. 27,187-216.

Tversnitt C-C



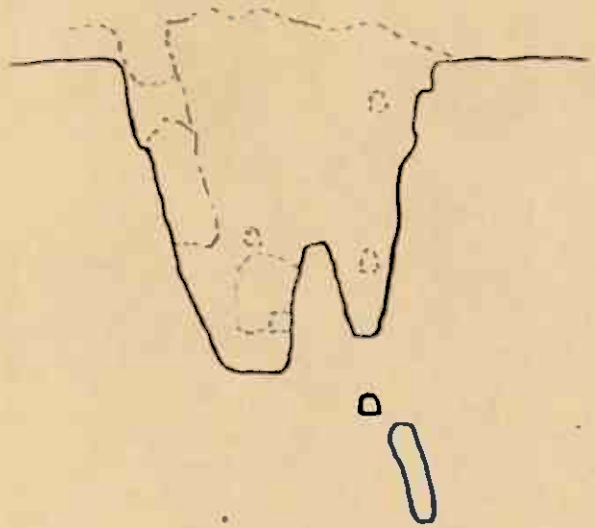
Tversnitt C-C



TVERSNITT A-A

V Ø

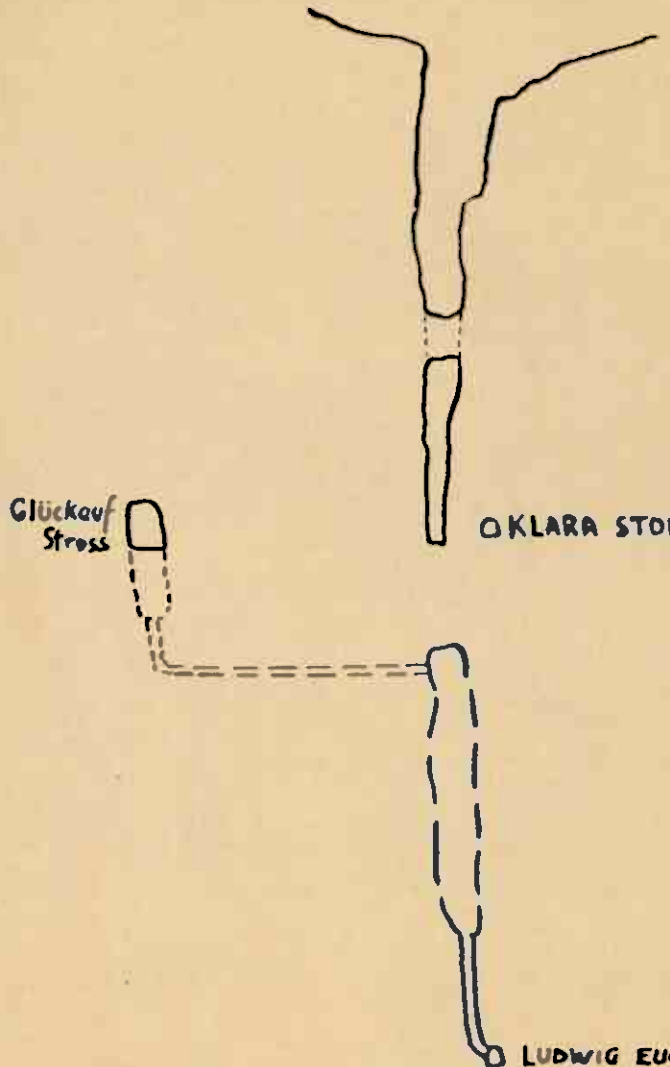
NORDGRUBEN DAGÅPNING



KLARA STOLL

TVERSNITT B-B

V MELLOM GRUVE Ø



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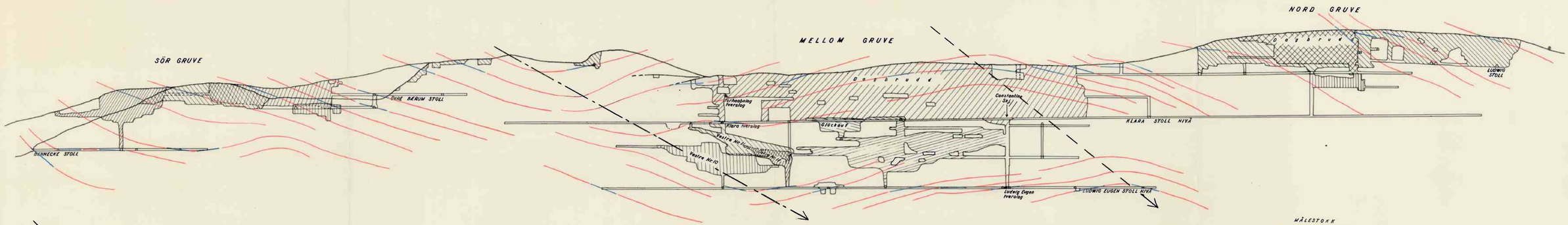

Stupning av kulminasjonen

Stupning av depresjonen

De gamle strossene er skravert.

Observert lineasjonsretning

Antatt forløp av lineasjonen

MODUM KOBOLT GRUVER
Skutterud Gruvene

LENGDE PROFIL S-N

Tegnet efter de gamle gruvekarter og egne observasjoner; sommeren 1956.

F.M.V. Jan. 57

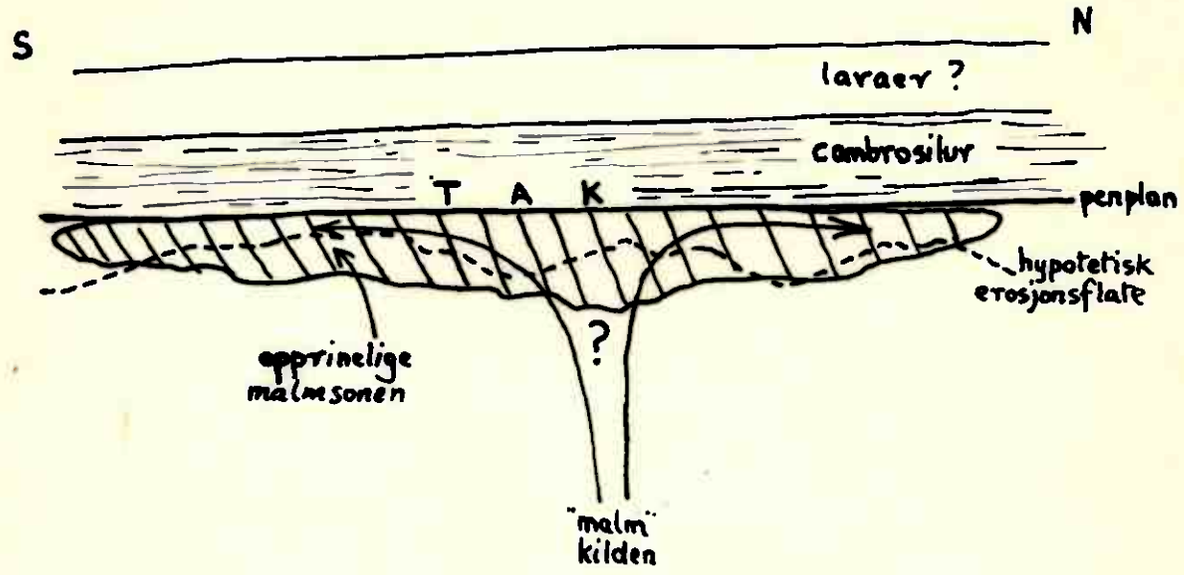
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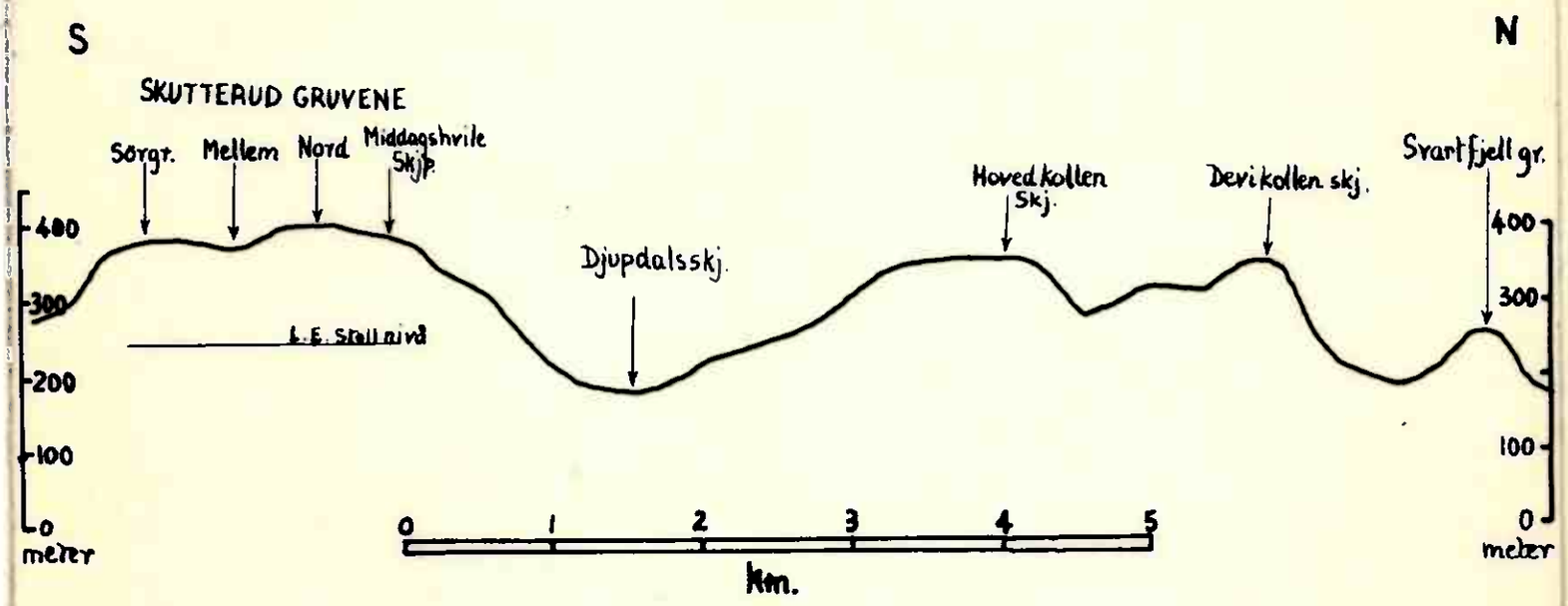
FIG. C.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SKUTTERUD GRUVENE
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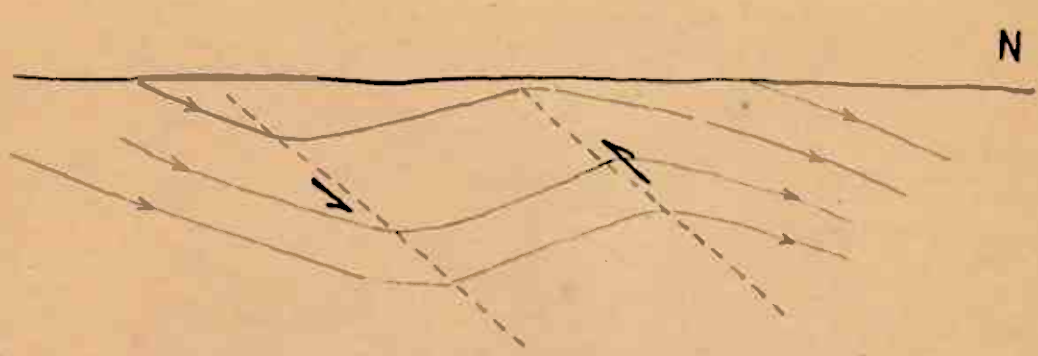
FIG. D.

(i) Den opprinelige stupnings-retningen for lineasjonen.



(ii) Virkningen av kraft-paret

FIG. A.

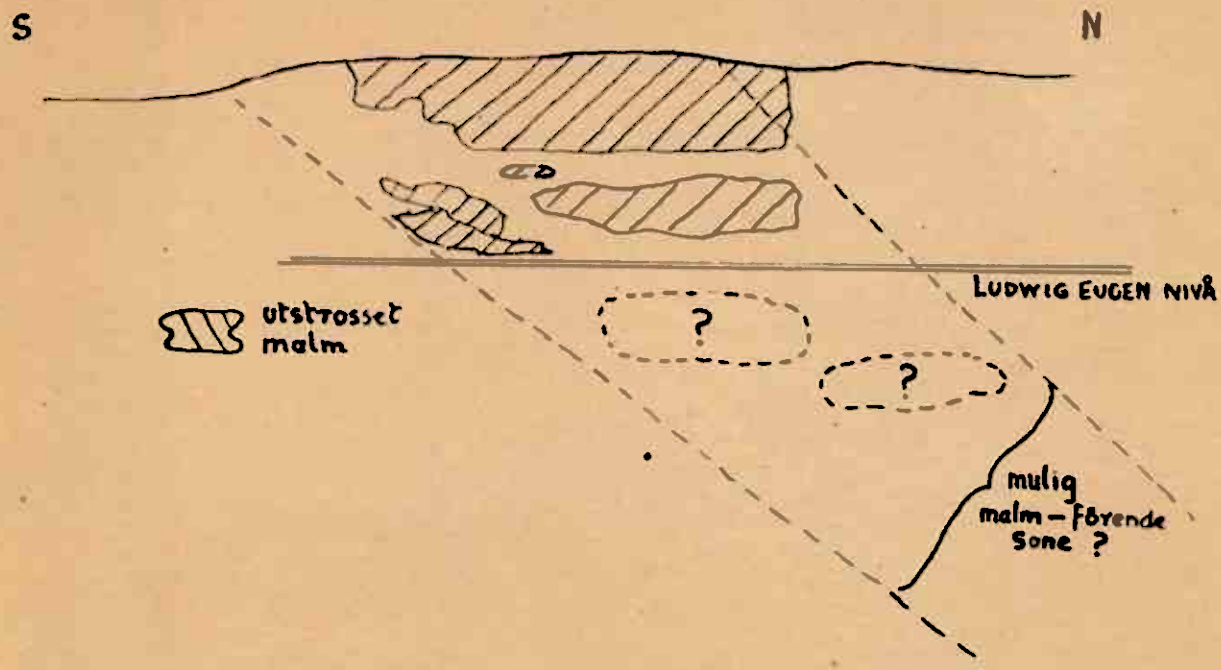
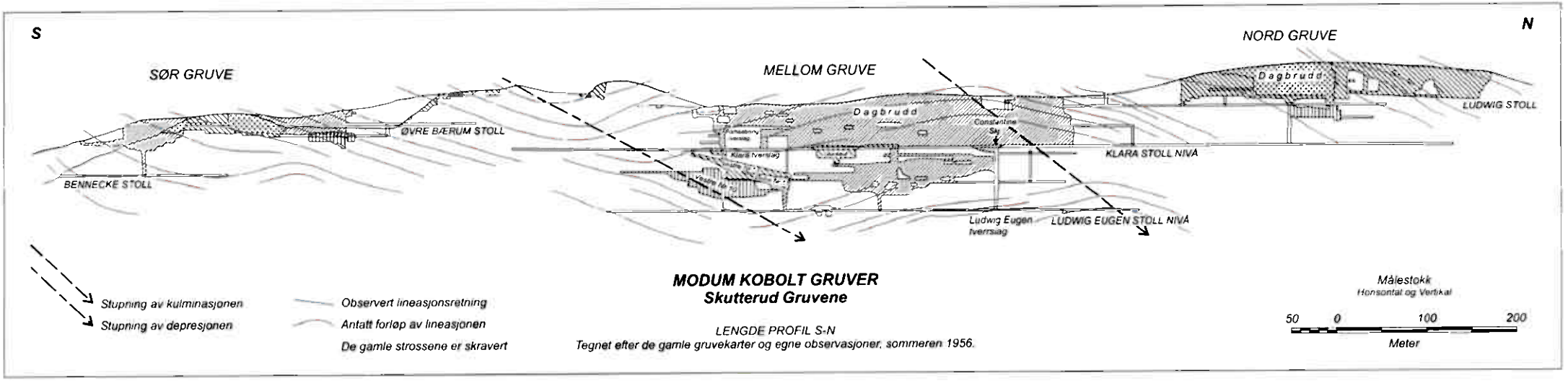
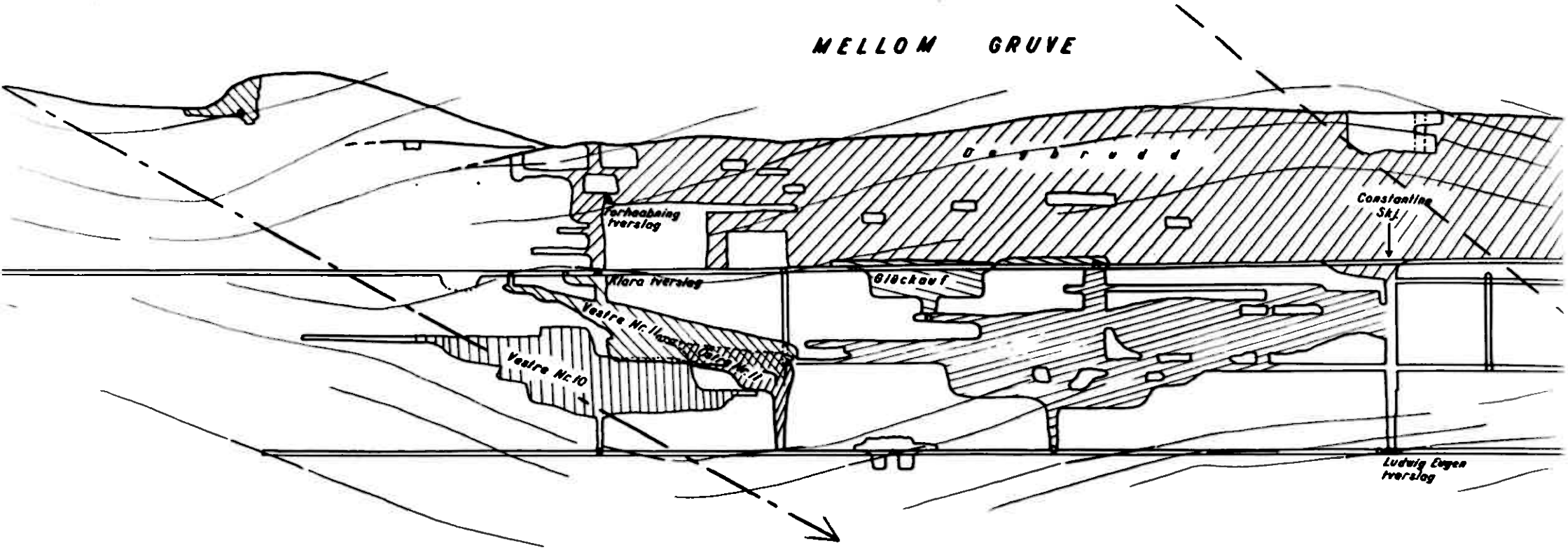


FIG. B.



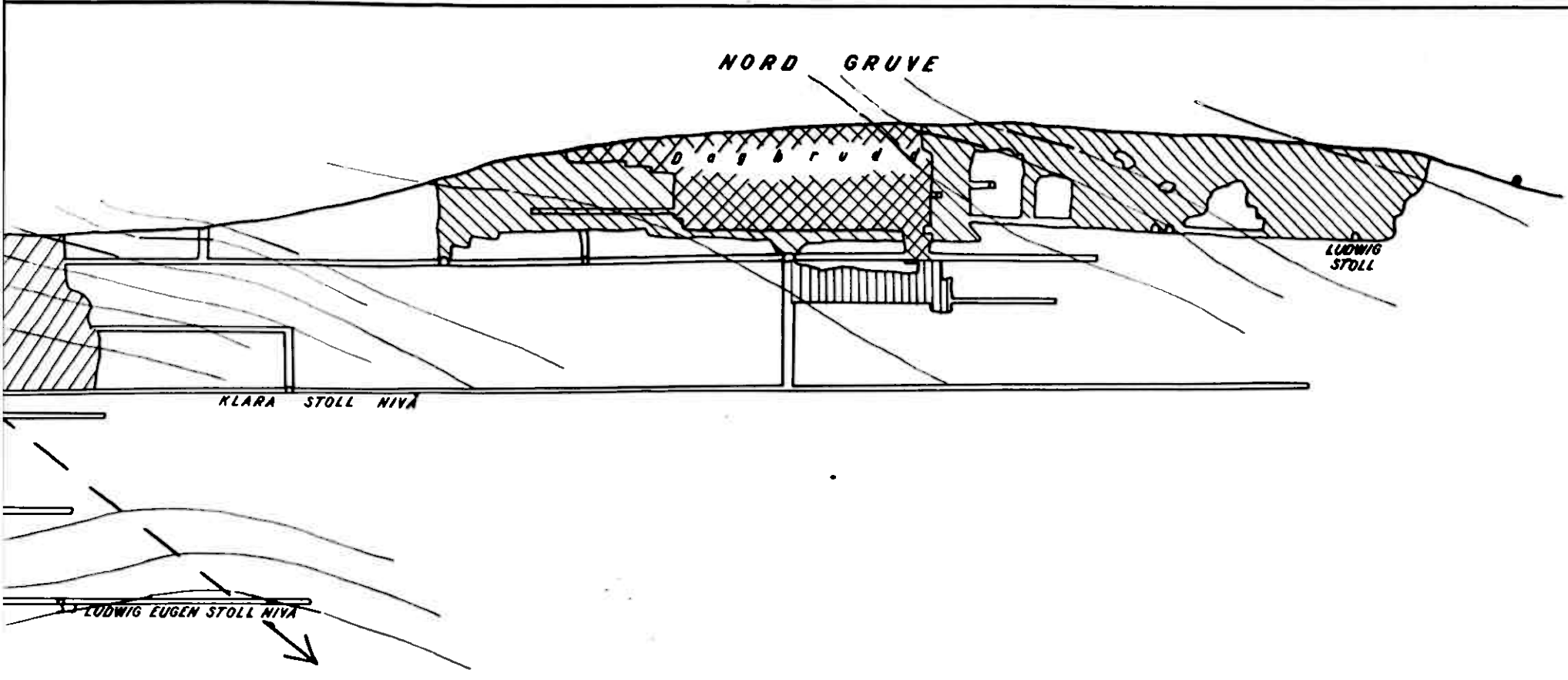


MODUM KOBOLT GRUVER

Skutterud Gruvene

LENGDE PROFIL S-N

Tegnet efter de gamle gruvekarter og egne observasjoner, sommeren 1956.



MÅLESTOKK

Horisontal og Vertikal

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Meter

F.M.V. Jan. 57

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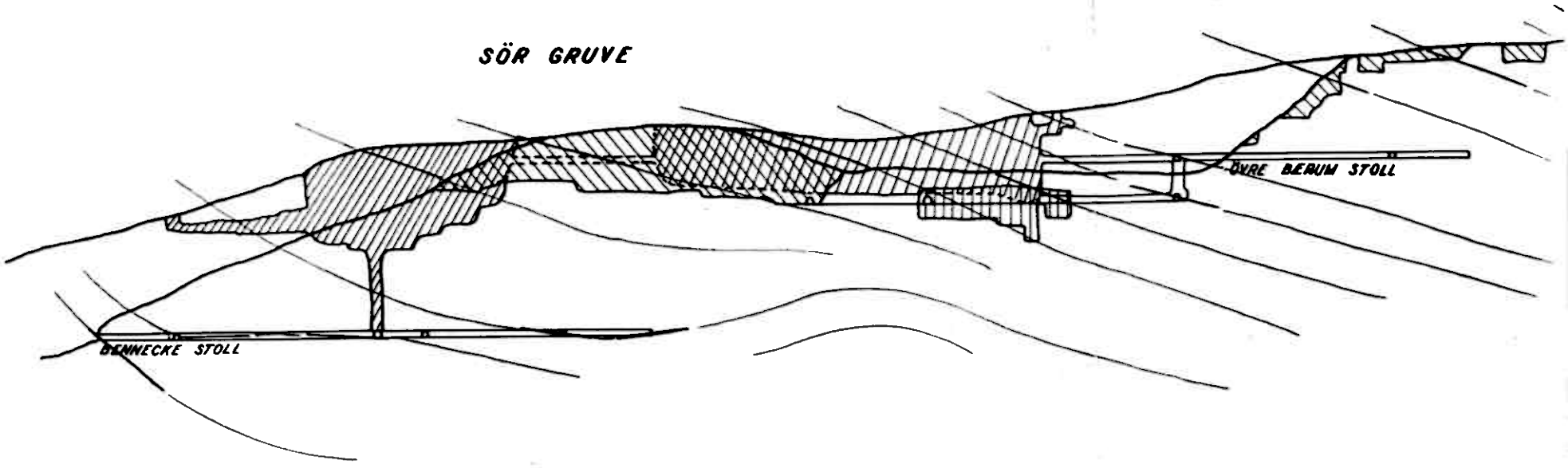

Stupning av kulminasjonen

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De gamle strossene er skravert.

Observert lineasjonsretning

Antatt forløp av lineasjonen