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Tittel

Report on developing ore deposits in depth north of Lake Langvann in Sulitjelma. Nordgruvefeltet.

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Sammendrag

Ei vurdering av mulighetene for dypmalm i Nordgruvefeltet. Alle mineralogiske, morfologiske og strukturelle observasjoner indikerer nye malmfunn mot dypet. Vurdering av plassering av nye sjakter i forhold til forventa malmakser. Dypmalmprospektering.

Report ~~re-opening of~~ on developing ore deposits in depth north of Lake Langvann in Sulitjelma.

By Professor, Dr. Torolf Vogt.

On request of the Sulitjelma Company, A/S Sulitjelma Gruber, I shall in the following give my opinion about the planned opening operations in depth north of Lake Langvann.

As regards geological conditions, reference is made to my work on Sulitjelma (Sulitjelmafeltets geologi og petrografi. Norges Geologiske Undersøkelse No 121, Oslo 1927), especially to the geological map Pl. XXXV and to the profile plates Pl. XXXVI and XXXVII. A key map showing the position of the profiles is found on p. 141 (fig. 52). The three plates mentioned above are enclosed under No.s 1 - 3.

General points of view.

As is known, practically all ore production in Sulitjelma derives from one single main ore ~~level~~ zone located along the bottom of the Sulitjelma gabbro, with its amphibolites, olivines and chlorite schists. Most of the ore deposits lie in mica schists a little under the chlorite contact, up to about 50 meters apart from this contact, although odd deposits are located in the contact zone itself. To this main ~~level~~ zone belong the known deposits Bursi - Charlotta - Giken with Sture - Hankabakken - Ny-Sulitjelma - Valdis north of Langvann, and Furuhaugen - Sagmo - Jakobsbakken - Anna (-Såki) south of Langvann, and - as I have formerly established - also Baldoaive and Stålhaugen west of the Baldoaive synklinal. As will be seen from the map, encl. No. 4, we hereby have a big mineralized ore ~~level~~ zone of about 22 km in length, width varying from abt 6 km to 9 - 10 km. In addition to this main ~~level~~ zone, there is also a less important ~~level~~ zone up in the amphibolite (olivine) itself, following the bearing Mons Petter - Lapphelleren - Fjellgruben with only a little working in the Mons Petter during the first years.

To this comes the slightly examined and probably unimportant Kong Oscars field in a much deeper ~~level~~ zone, and without connection with the proper Sulitjelma gabbro.

In the following, the main ~~level~~ zone only will be treated. As mentioned, this ~~level~~ zone is exposed to view following three lines, Bursi - Valdis line, Furuhaug - Anna line and Stålhaug - Baldoaive line. These lines represent lines of intersection between ore level and surface; in proportion to the orebodies, it must be said that these lines of intersection are ~~are~~ incidental. It is, of course, not probable that all orebodies in the ore ~~levels~~ zones particularly should be tied to these chance intersections. On the contrary, the presumption is that other intersections, on higher or deeper levels, would have exposed other deposits. Also, the surface intersects the different orebodies in different ways. Giken and Sagmo carried comparatively small quantities of ore in the surface, but expanded greatly in depth; I suppose that these bodies are cut through the uppermost parts, so that practically the complete original orebody was kept in the rock. Jakobsbakken has full ~~breadth~~ width in the surface, but smaller extent in the surface than further down, and must, presumably, also have been cut at any rate in the upper parts. Ny-Sulitjelma has its full extent in the surface, and may presumably have been cut about in the middle. Of Furuhaugen, only small remnants remain of a perhaps considerable body; conditions here are such that if the erosion had only worked 50 m below the present surface, only insignificant traces of ore would have been left. The single deposit which can be said having been found inside the rock, without reaching surface, is Charlotta east; however, this orebody possibly is part of a greater Charlotta (Charlotta - Sture).

It is a quite natural conclusion to point out that hitherto unknown orebodies must exist in the ore zone inside the massif. A look at the map, encl. no. 4, and at the scale, considering that in the deepest mines the distance from surface to the innermost working places is about one kilometer, also must make it obvious that the quantity of the unknown ore deposits probably is far bigger than the known quantities, all ore production till now included. Even if the deepest of these orebodies are of no actual interest owing to technical and economical reasons, this point of view in my opinion forms a base for a justified optimism regarding future ore reserves in Sulitjelma.

The question is whether regularities can be established, which may facilitate the searching for these orebodies. Here also comes in the question about the origin of the ores, the question of where to find the ores' "root". This will be dealt with below, whilst more special regularities will be treated in the following chapter.

It seems that the ore-solutions which have formed the deposits in the ore zone have been carried from abt. north-east, and that they have moved on the whole towards south-west. What especially favours this presumption is the following:

1. The gabbro-magma must have been carried from the north, most probably from north-west. The ore solutions have been separated from this gabbro magma. The gabbro is the mother rock of the ores. The direction of the ores' "root" in north-east, about points to the part which can be considered the supply channel, or "root", of the gabbro magma.

2. Even if the known ore quantities (total of ore production and opened ore bodies) are of the same size on both sides of Langvann, still the mines north of Langvann are in the first line in this respect. And when we get as far to the west as to Baldoaive and Stålhaugen, these deposits are in comparison obviously far less important. The ore quantities seem to increase towards north-east, towards the "source",

3. The pure pyrotite - chalcopyrite - deposits Valdis, Anna (and the probably quite unimportant Såki), with Baldoaive and Stålhaugen occur peripherically in relation to the pyritecarrying deposits. Now it is a common experience, also from Sulitjelma, that the pyrites generally occupy the central parts of each single deposit, and the pyrotites the peripheric ones. The pyrotite ores have accordingly moved the farthest out towards the periphery, a fact which seems to stand in relation to the earlier crystallisation of the pyrites. The latter mineral was kept back, while the still floating pyrotite was pressed further on. The most western deposits Baldoaive and Stålhaugen occupy also with regard to the mineral composition a "peripheric" position in relation to the Langvann deposits. The zincblende too belongs to the late crystallized minerals, often peripherically enriched. When Jakobsbakken is so much richer

in zincblende than the deposits north of Langvannet (and also than Sagmo), this can be seen from the same point of view.

The factors mentioned above together, in my opinion, decidedly lead to the view that the ore originates from the district north of Langvann, and by preference from north-east. The lines entered in encl. 4 are, of course, only outlines; north of Langvann they can very well curve some more to the north than shown in the sketch. But in general, there is reason to expect good unknown ore deposits in the depth north of Langvann. On the distances which for technical reasons can come into question here, we also can presume that the physical conditions (higher temperature etc.) cannot have changed to the disadvantage of ore formation.

Special surveys and view-points.

Here we first have the question of the longitudinal direction of the separate ore-deposits, which obviously is of importance to the ~~opening-operations~~ developments. The longitudinal direction of the deposits have not been easy to establish in Sulitjelma. Opinions have also changed in the course of years, which can be seen on the longitudinal directions of the main shafts. It is, too, first lately, when the deposits have been worked to a considerable depth, that we have got more certainty as to this question.

In order to get into a system ~~xxxxxxx~~ the longitudinal direction of the known orebodies as well as of the possible, unknown deposits, I have used a geological method, which has given certain results. I refer to the measuring of the direction of certain structures in the rock, structures which depend on the pressure dispersion in the rock at the time when the ore deposits were formed. At this time, the rock was to a certain degree plastic, and the pressure dispersion effected an orientation of mineral grains and also effected plastic deformations, giving structures apt to be measured. A ball for instance will be rolled to a rod or an oblong plate. The rock structures mentioned have somewhat figuratively been called stretchings, a word which will also be used here. It may be mentioned that →

was convinced of the absolute regular connection between the longitudinal direction of the pyrite deposits and the stretching while ~~surveying~~ exploring in Rana some years ago. It seemed here that the longitudinal direction of the ores at Bossmo and at Mofjell were paralell with the stretching, and that the longitudinal direction of the Malmhaug deposit could be predicted on account of the stretching, (later it was confirmed by electrical ore searching methods). In Rana the stretching was extremely pronounced, and the ore deposits were also pronouncedly stick-formed. By Røros too, I have used this method in the later years, and everywhere found the stretching in accordance with the longitudinal direction of the mines.. Here the stretching was not so pronounced, and the deposits normally more flatly "linear-formed" (linealformet). In the Sulitjelma field the stretching is still less pronounced than by Røros, corresponding to more diffuse longitudinal directions of the ores, anyway by shorter deposits.

The stretching is independent of the foldings, anyway of foldings of the kind occurring in the Sulitjelma field. It has accordingly the same direction independent of the bearing and fall of the rock. It may keep constant over great areas, but can then comparatively quickly change direction. In Rana the stretching is constant around the end of the Rana fjord and up the valley for about 20 km, but is changing, as far as I remember, about 70° a little west of Malmhaug. By Røros it is constant over the whole central area around Kongens and Storvarts gruber, but is changing about 45° south of Mugg-gruben. By Sulitjelma, too, we find similar conditions.

Here we can refer to the map, encl. 5, where the observations regarding the stretching are entered. It seems that the precision is about ± 5°, partly owing to measurement errors, partly because the direction itself may turn about the same number of degrees in neighbouring localities. Therefore we cannot determine the longitudinal direction of the mines precisely on the degree on account of these measurements, but perhaps with a precision of ± 5°. We must also be aware that the longitudinal direction of the orebody is somewhat diffuse at Sulitjelma, and cannot be given with absolute precision, even where it is best known. On the map the place of observation is marked with a circle. The arrow indicates the direction towards which the stretching is

falling. Where there is no arrow, the stretching lies horizontally. Figures indicate deviation from direction west (0 = due west, 10 N = W 10° N, 5 S = W 5° S).

As will be seen, all observations fit into a stable system with smooth passages. Below, I shall add some remarks concerning the direction in the different mines.

By Jakobsbakken, the most and best measurements show abt. W 5° S, a direction a little more northward than the direction of the main shaft. According to the mining engineers, the direction can fit in rather well. Between Jakobsbakken and Helsingborg the direction is turning some, from abt. W 5° S to abt. W 10° N.

By Sagmo we have abt. W 10° N, which is about in accordance with the present main shaft. The same direction obviously continues about unchanged further northwards, to the area around Furuhaugen and Bursi.

By Furuhaugen, which consists of folded-in parties, the direction W 10° N may fit in well, especially to the rather marked south limit.

By Bursi we have the peculiar case that the present direction of the mine is about N W, whilst the main direction of the orebody should be about W 10° N, if basing the axis direction on the stretching in the schist. The ~~breadth~~ width will then also correspond to a rather normal mine ~~breadth~~ width in Sulitjelma.

It may seem as is we in Bursi mine only have remaining a small end of the main deposit, ~~xxxxx~~ as the ore more or less seems to stop towards east. In that case most of the ore presumably has been located above the present ~~xxxxx~~ surface, W 10° N, where it has been eroded. ~~However, xxxxx~~ However, we cannot ignore the possibility that there can still be found some ore in direction 10° S, or that perhaps the main orebody may be located here. The eastern limit of the mine, which has not a normal form of dwindling ~~xxx~~ at the end of a deposit, might perhaps indicate that there can still be found ore towards 10° S. Anyway, it seems to me that there can be reason to examine the deposit more closely from this view-point, either by diamond drilling or by ~~opening~~ driving from the mine. By electric ore searching methods we will hardly get indications on the Bursi ore itself in direction 10° S owing to screening from a ore zone situated above. In this connection, also see discussion under Charlotta mine.

To the west, towards Hellarmo, the stretching turns more due west, whilst it changes a little in the opposite direction towards east, to W 15 - 20° N by Furulund.

By Charlotta conditions are not quite clear, either. Judging by the mine map, representing working in previous days, the direction of the mine is about NW, whilst the stretching shows W 15 - 20° N. However, if we count Charlotta east and Sture, lying completely in the same horizon as Charlotta, to this deposit, we get an main direction more in accordance with that of the stretching. This might encourage to continued diamond drilling from Giken in the roof following the Charlotta lode, for inst. between co-ordinates 1000 and 1400 east, where no drilling seems to have been done. But even if it should appear that there is more ore in the Charlotta zone, we have, anyway, big, barren parts between Charlotta and Sture. In addition, Sture has the same main direction as Charlotta. As both these deposits (with Charlotta east) are the only ones located in the chlorite ~~xxkixt~~ contact itself, the possibility exists that these ores have been formed according to other rules. These deposits, possibly also Bursi, are, however, the only ones which do not fit into the system right away.

Coming to Giken, the stretching shows W 15 - 20° N, and Giken very distinctly turns about the same direction. Further eastwards the stretching now becomes steadily more to the north.

By Hankabakken the stretching gives W 20 ± 25° N, whilst the axis direction of the orebody is ~~entered~~ drawn with a line in W 22.5° N on a map with diamond drillings, ~~entered~~. Otherwise this deposit is little known in depth.

By Ny-Sulitjelma west ("Femman") the stretching is about W 30° N, and probably with an about corresponding axis direction of the ore in this part.

By Ny-Sulitjelma main part the stretching turns to about W 45° N, a direction very much in accordance with especially the upper parts here, and with Gudrun - Holmsen mines. One feature is to be especially pointed out, viz. that the stretching, and with that the axis direction of the ore, will turn in a more western direction in depth, as indicated with the red arrow on the map. Thereby The main shaft of Ny-Sulitjelma mine will ~~thereby~~ by and by get outside of the orebody, even if the ore should continue further on to great depths.

It appears, consequently, that the stretching in the mica schist is very much in accordance with the axis direction of the orebodies located in the schist. As will further be seen on the map encl. 5, all schist deposits north of Langvann and Furuhaugen south of Langvann fit into a common great ore system. Here it seems that Giken and Furuhaugen lie on about the same axis, and the same is the case with Hankabakken and Bursi. We should, however, not conclude too much from this, even though this establishment seems to be of interest. Especially, we cannot presume that the ore is continuous along these axis. These conditions do perhaps only indicate that the deposits are located comparatively near each other in this system. If the orebodies were somehow evenly dispersed, several orebodies might then easily happen to lie, to some extent, in the same axis direction.

The development

~~Opening~~ northwards.

The ~~opening~~ development northwards is intended to be made as a deep shaft of about 1000 m length along the ore zone in northern direction. The question is where to start this shaft most favourably.

As known, the main quantity of ore today is north of Langvann in the ~~field~~ region Charlotta to Ny-Sulitjelma (see also encl. 4). There may be reason to presume that this ~~lode~~ zone continues inward in north-easterly direction, and the deep shaft then ought to be within this part with its terminal point. This gives an approximate limitation to the west, which is indicated on the map encl. 7.

In order to obtain closer knowledge of how the ore is distributed in the Charlotta - Ny-Sulitjelma area, mining engineer Hofseth has on my request worked out a survey concerning this question. (See encl. 6). Number of tons of ore taken out and opened is calculated in bands of 100 m ~~breadth~~ width in strike perpendicular going north/south. Quantity, in tons, of copper and sulphur contents are also calculated.

It may be of interest to point out how continously mineralized with productive ore this zone is. Between Giken and Hankabakken there is, as will be seen, a barren part of abt. 150 m, and a corresponding part of 350 m between Hankabakken and Ny-Sulitjelma. Otherwise the 4400 m long part is mineralized with productive ore. If we imagine that this part was located inside the massif and was to be opened by means of a deep shaft to the north, this shaft would meet strike

ore over 3900 m and rock only over 500 m. In fact, the chances to strike ore would probably be still greater, as Hankabakken seems to have had the greater part of its ore in the eroded part in S 20° S, which would then have covered also the barren part of 350 m.

Mining engineer Hofseth further has calculated the center of gravity xxxtx respectively for ore, sulphur contents and copper contents over the same distance. Gravity centers are on the following co-ordinates east:

Ore	Sulphur contents	Copper contents
2400	2300	2050

Of greater interest to the present question are perhaps the centers calculated so that there are the same quantities of ore etc. on either side of the center. These centers are on the following co-ordinates east:

Ore	Sulphur contents	Copper contents
2550	1700	1400

I suppose that the average of the two figures for sulphur- and copper contents, on respectively co-ordinate 2175 and 1550 east, are of greatest interest here. These points are therefore entered on the map encl. 7. The points are also entered 1000 m inward in north-easterly direction, along the supposed main axis. Further, it can be pointed out that the direction of the deep shaft should be about vertical to the axis direction of the orebodies. This for two reasons. First, the distance to the orebodies will be the shortest possible when cutting through the barren parts vertically on their direction. Secondly, the barren parts between the orebodies in depth will be smallest possible, thereby offering the best chances to strike ore. A shaft from lower Giken from about co-ordinate 1000 east should, according to this, have a direction N 15° E. The same direction will also go for xkx shafts more to the west, while the direction turns more to the east for the eastern parts. A shaft, for inst. from the inner part of Grunnstollen to Ny-Sulitjelma, by co-ordinate 2500 east., thus should have a direction N 22 - 23° E.

It is difficult to say anything more definite about the distribution of ore deposits in depth. It has been pointed out that the known ore deposits on a whole stop along a straight line, entered with blue colour on the map encl. 5.

Thus the Ny-Sulitjelma ore goes out in the main shaft on about co-ordinate 1360 north, and the Giken ore i shaft 2 on about co-ordinate 1240 north. We might then imagine a ~~xxxxxx~~ train of ore deposits similar to the Charlotta - Ny-Sulitjelma also in depth. This might be supported ~~xxxxx~~ on the base that Furuhaugen and Sagmo lie on a similar line, the southern limitation of which is also indicated. On the other hand, it has to be mentioned, however, that Hankabakken, in any case according to what we know to-day, seems to disappear already by the Giken - Ny-Sulitjelma (found) drift, i.e. by co-ordinate 1000 north. This is the one alternative.

Another ~~one~~ explanation may be, that the ore zone is covered ~~to~~ some degree regularly with deposits in distances more or less corresponding to the mutual distances between the known deposits near the surface. It may also be that the line Sagmo - Giken - Charlotta is of importance. Whatever the distribution of ore in depth be, in my opinion a deepshaft is very much to recommend. A suitable opening by field drifts, especially a long field drift in great depth, is of course desirable. As starting point for a deep shaft, the lower parts of Giken have been mentioned, to which I subscribe. The shaft should be located west of the gravity center, (average point); Furuhaugen and Bursi should justify this. The most easterly of the alternatives entered on encl. 6 seems the best to me. This shaft occupies a more central location in the area of greatest ore quantity than the other one, lies nearer to the Sagmo - Giken line, and will also have to pass a somewhat shorter distance through known areas.

There may be a question of working the shaft either in the chlorite along the schist contact, or a little down into the schist. Of these alternatives, the first seems to be the best, in my opinion. Thereby it should be possible to keep the geological level with most certainty. The chlorite is also ~~more~~ as a whole a little mineralized, and not much more intensified mineralized parts are ~~mineralising~~ is necessary to give ore parts which can help pay the cost of the shaft. By diamond drilling at regular intervals, for inst. every 25 or 50 m, possible ore in the schist floor can be opened. Following the other alternative, regular diamond drilling in roof as well as in floor would be required. At all events, over the lower parts of Giken here in question, the chlorite is firm and resistant against slides. If inferior chlorite roof should occur, there will be no difficulty in laying the shaft in a nearby level.

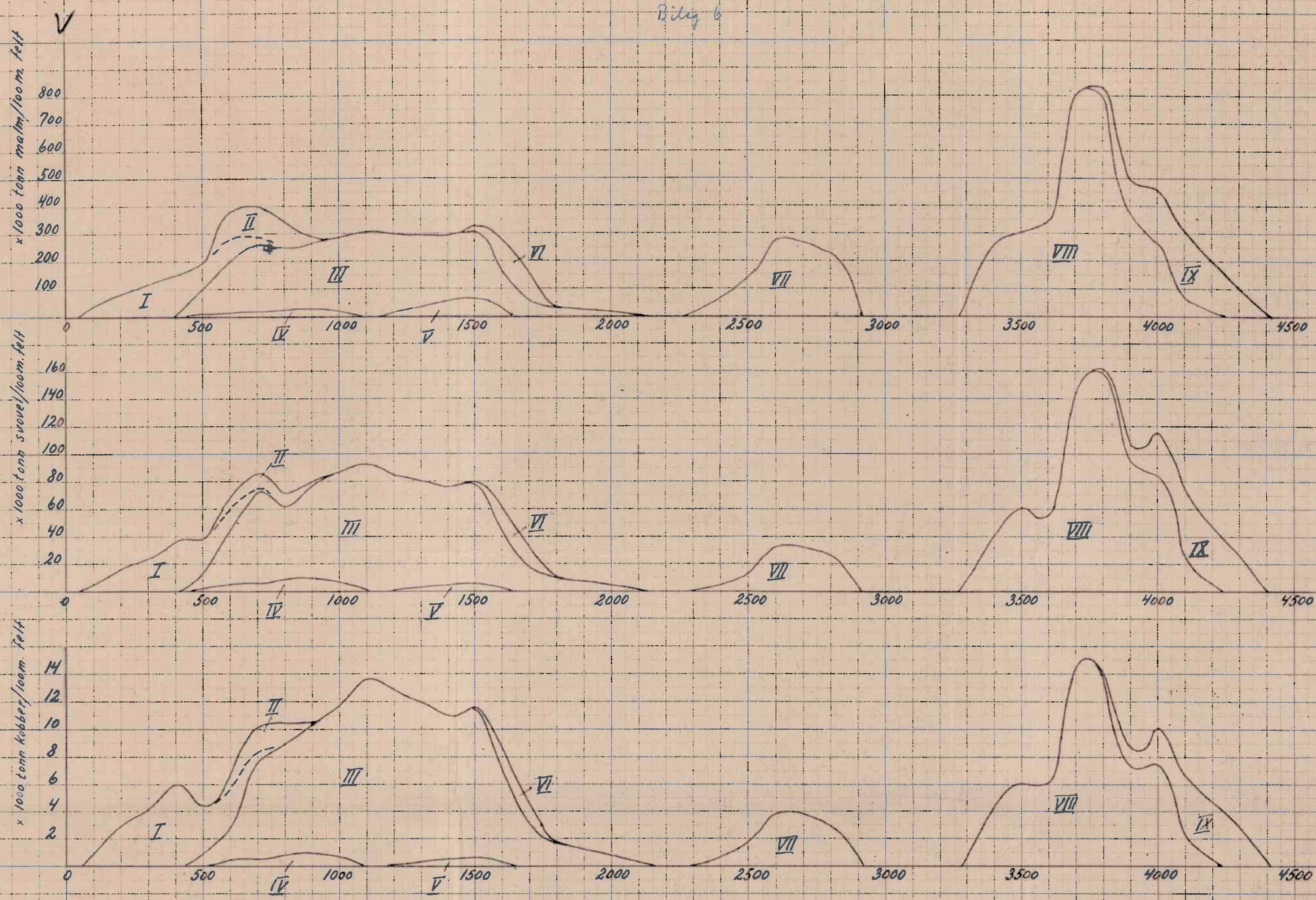
Thorvald Vogt

pt. Sulitjelma, 3. Sept. 1944.

Bilag 6

V

0



I Charlotta vest
II —"— øst
III Giken hovedmalm
IV Analysen-Synk III
V Palmberg
VI Sture
VII Hankabakken
VIII Ny-Sulitelma
IX Holmsen-Gudrun

M. 1:10000

Fordelingen av malm-, svovel- og kobber-tyngdene i det vest-østgående felt mellom Charlotta vest og Holmsen-Gudrun.

Sulitjelma 3 sept. 1941. A. Hofseth

Bilag 7

Kobbertoppen

Fjelds grube

Dikenelv

Bruvollen

Storlia

Storliklubben

Glasstuen

Furuhaugen

Bursi

Mons Petter

Furulund

Harlotta

Siken

Hankabakken

Ny Sulitelma

Sandnes

Granhei

Kisthammeren

Fagerli

Sagmo

Helsingborg

Jakobsbakken

Anna

Daja

Kjelvann

Gjertrudfjell

Sagmo–Sulitelma-linjen

Granhei elv

Sulitelma–Ny Sulitelma-linjen

Smolik

Bakni

Vakkenjokk

Lommi elv

Midtpunkt for 2 og 3

Tyngdepunkt for 2 og 3

Thorolf Vogt Sulitjelma 3. sept 1941

FORSLAG TIL DYP-UTLÖSNING AV HOVEDGRUBENE I SULITJELMA

GRUBERUMMENES KONTURER AJOURFÖRT PR. 30/6 40

SKALA 1:20000

0 0,5 1 1,5 2 Km.

Ekvidistanse 20 m.

Grubekartenes koordinatsystem. Nullpunkt for höidekurver: Vannspeil Langvann. Langvanns höide o.h. = 141 m.

Riley 5

FORSLAG TIL DYP-UTLÖSNING AV HOVEDGRUBENE I SULITJELMA

Thorolf Vogt Sulitjelma 3. sept 1941

GRUBERUMMENES KONTURER AJOURFÖRT PR. 3% 40

SKALA 1:20000

0 0,5 1 1,5 2 Km.

Ekvidistanse 20 m.

Grubekartenes koordinatsystem. Nullpunkt for höidekurver: Vannspeil Langvann. Langvanns höide o.h. = 141 m.

Bilag 4

N

Fahlbrainjektionens antatte retning

Malminjektionens retning

Sulitjelma-gabbroen

Riksgrensen

Ved Sørkis-Kobberkis-malm

Bare Magnetkis-Kobberkis-malm

Topp Lea

Malmlag

Ø 7

3

64

3

H.

H3

Fa

H

J

Ia

I S

Ft I

B I

Målestokk 1:100 000

10 km

Oversikt over Malminjeksjonens retning

Thorolf Vogt

p.t. Sulitjelma 3. sept 1941

Bilag 1

XII

XIII

XIV

GEOLOGISK OVERSIKTSKART
over
SULITELMAFELTET
ved THOROLF VOGT

Utarbeidet på grunnlag av egne iagttagelser
og tidligere geologiske karter av: Hj. Sjøgren,
P. J. Holmquist og O. Nordenskjöld samt av J. Rekstad og G. Holmsen.

Målestokk 1:100.000

0 1 2 3 4 5 6 7 8 9 10 km.

FARVEFORKLARING

- Baldoaive-avdelingen med { Rötindskifre i nord. / Skaitiskifre i syd.
- Furulund-avdelingen.
- { Muorki-skifre i øst. / Skjönstågneis i vest.
- Skifre uten særbetegnelse.
- Kalksten og dolomit. Pieski-kalkstenen i øst.
- Gabbrobergarter og amfiboliter.
- Graniter.
- Utgående av malmforekomster.

⅓ COPIA, LITH. OSLO.