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Tittel

Rapport over undersøkelser av kobberfeltene i Bidjovagge 1956 - 1962

| Forfatter | Dato Ar | Bedrift |
|---|---|---|
| K. Skjerdal, P Holt, J. Kraft Johanssen, Karl Ingvaldsen | februar 1963 | Kautokeino Kobberfelter,<br>Statrens Undersøkelser, USB |

| Kommune | Fylke | Bergdistrikt | 1: 50 000 kartblad | 1: 250 000 kartblad |
|---|---|---|---|---|
| Kautokeino | Finnmark | | 18334 | Nordreisa |

| Fagområde | Dokument type | Forekomster |
|---|---|---|
| Geologi malmberegning | Rapport | Bidjovagge |
| **Råstoffgruppe** | **Råstofftype** | |
| Malm/metall | Cu( Au) | |

Sammendrag / innholdsfortegnelse

Rapporten gir et sammendrag av de resultater som undersøkelsene har gitt og en konklusjon fra det utvalg som har ledet undersøkelsene.

Undersøkelsesarbeidene i Bidjovagge er beskrevet detaljert i :
Kautokeino Kobberfelter - Teknisk rapport nr. I 1956-1960.
Kautokeino Kobberfelter - Teknisk rapport nr. II 1960-1962
(under bearbeiding)

Disse to rapporter inneholder en fullstendig fortegnelse over alle underrapporter, kart m.v. fra undersøkelsesarbeidene.

1 engelsk versjon finnes
1 duplikat

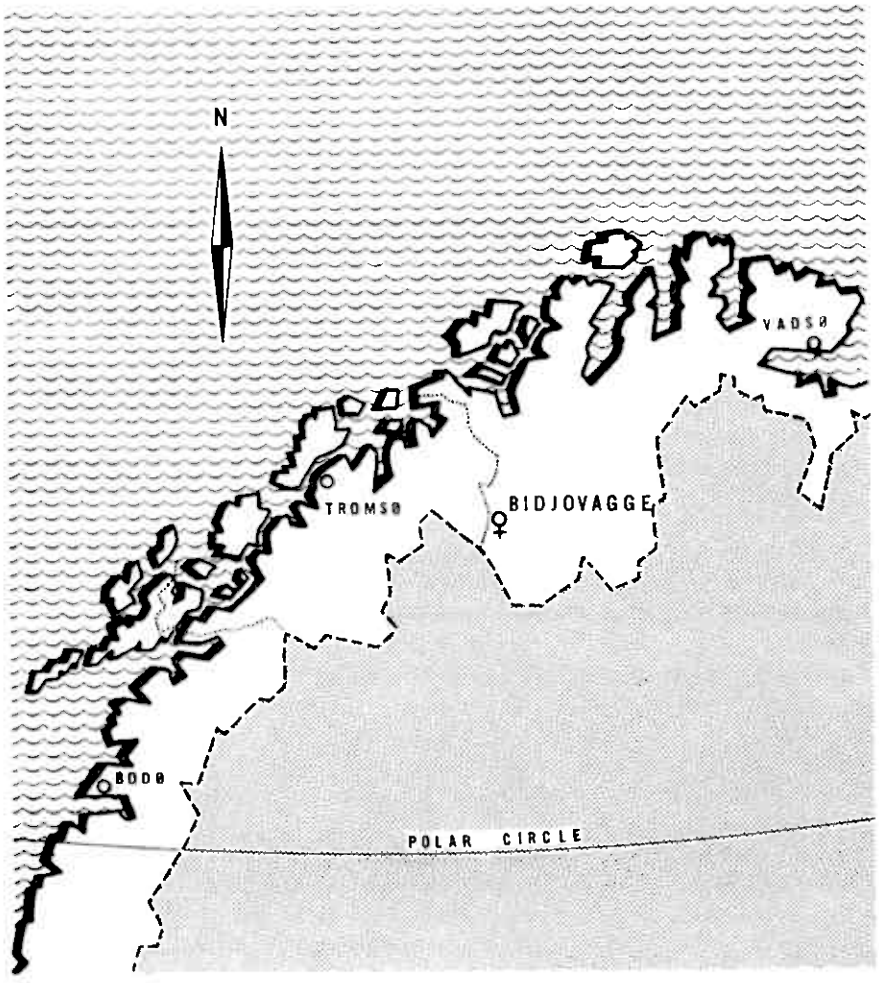
# REPORT

## INVESTIGATION OF THE COPPER-BEARING BIDJOVAGGE AREA

## KAUTOKEINO TOWNSHIP, FINNMARK COUNTY

## NORWAY

1956 - 1962




# KAUTOKEINO KOBBERFELTER

## STATENS UNDERSØKELSER

FEBRUARY 1963

KAUTOKEINO KOBBERFELTER
Statens Undersøkelser

Report

# Investigation of the copper-bearing Bidjovagge area. Kautokeino township, Finnmark county, Norway. 1956 - 1962

Contents

Preface.

Kautokeino Kobberfelter was established in February 1956 as a provisional administration under the Department of Industry with the investigation of the copper-bearing Bidjovagge area, Kautokeino township, Finnmark county as its specific mission.

Bidjovagge is situated on the northern slope of the mountain ridge Cascias, 40 km NNW of the village of Kautokeino. The altitude of the area is 600-700 m above sea level. See figure 1.

During the years 1956 - 1959 surface investigation including diamond drilling was carried out. Three ore bodies were deliniated and the results of the investigation were presented in a report of February 11, 1960. Further investigation underground in the largest of the three ore bodies was proposed. This report with its recommendations comprised the basis for St.prp. nr. 128 (1959-1960) in which the Storting acceded May 5, 1960. Underground work began in the summer of 1960 and was concluded in the fall of 1962. The present report reflects the entire investigation period 1956 - 1962.

The calculated ore reserves in Bidjovagge do not provide adequate basis for the establishment of an economically sound mining enterprise. There appears to exist, nevertheless, a reasonable chance that sufficient ore may be found to fulfill that goal. An exhaustive investigation of the area as a whole would at this stage be prohibitively expensive and can be practically accomplished only in association with a productive operation. Realization of a mining operation will depend on the investigation results summerized in this report and their evaluation in respect to the problems that the over-all development of inner Finnmark present.

The results of the investigation of the Bidjovagge area are described in detail in:

Kautokeino Kobberfelter - Technical Report I 1956 - 1960
Kautokeino Kobberfelter - Technical Report II 1960 - 1962 (under preparation)

These reports contain a complete list of all under reports, maps, etc.

Throughout its period of existence Kautokeino Kobberfelter has been led by a board of direction consisting of:

Departementsråd Karl Skjerdal, Department of Industry, chairman,
Fylkesmann Peder Holt, Finnmark
Director J. Kraft Johanssen, A/S Sydvaranger
Director Karl Ingvaldsen

The framework of direction was approved by the Department of Industry.

Kautokeino Kobberfelter has had as its director Karl Ingvaldsen. In addition its staff has consisted of a geologist, a technician, an office administrator, a secretary, and since 1959 a mining engineer. Since the fall of 1956 the offices have been located at Sverres gate 4, Trondheim.

Consultants have been employed within the fields of geology, mining, and milling. Such technical facets of the investigation as diamond drilling, geophysics, geochemistry, and assaying have been performed through contract. The work force has to a large degree been recruited from the district. Kautokeino Kobberfelter has planned, led and coordinated the various phases of the investigation.

Quarterly reports including statements of account were submitted the Department of Industry. "Riksrevisjonen", a state bureau, has acted as auditors.

## Surface Investigation 1956 - 1959.

As a result of St.prp. nr. 98 (1955) N.kr. 10 million of Marshall aid (counterpart funds) were appropriated for "Investigation of ore mineralization in Finnmark". Of this sum kr. 6 million were reserved for Bidjovagge.

In accordance with St.prp. nr. 129 (1955), 71 claims in Bidjovagge belonging to Consul Holmboe were acquired by the Department of Industry by contract signed September 15th and 19th, 1955.

An orientative survey of Bidjovagge conducted by Bolidens Gruvaktiebolag in 1952 and 1953 consisted of geological observations and geophysics. The report covering this work was purchased by the Norwegian State for N.kr. 647,190,-, which represents the cost of the survey. Kautokeino Kobberfelters investigation early in the field season of 1956 was in part laid up according to the results of that report.

Over the years 1956 - 1959 the area of ore mineralization at Bidjovagge was mapped in detail. Studies were made of rock types, ore types, structure, and the stratigraphic sequence. Also general geological

mapping was carried out over a larger area. The Bidjovagge ore bodies are hydrothermal deposits of chalcopyrite, pyrite, pyrrhotite, and magnetite in brecciated fault zones. The fault zones follow the eastern limb of a N-S anticline of mainly fine grained albite rock containing in part abundant graphite. Structure and the distribution of copper is complicated, making an exhaustive investigation of the area difficult.

In regional exploration the systematic search for mineralized outcrops and erratic ore boulders was expanded each year. Totally approximately 1000 $km^2$ have been covered reaching from Kautokeino north to the border of the overthrust younger rocks. Copper mineralization similar to that in Bidjovagge was found at Suovrarappat, ca. 15 km NE of Bidjovagge. Investigation involving diamond drilling has as yet not revealed significant amounts of ore, but neither have all possibilities been exhausted. Other than Suovrarappat, nothing has been found which seems to deserve closer scrutiny. In this large area workable ore bodies may nevertheless lie concealed beneath the heavy glacial overburden or in depth.

In Bidjovagge geochemical surveys have been carried out by several methods. Systematic sampling of humus and moraine gave pronounced copper anomalies, but these anomalies do not seem to have a deciferable relation to the copper mineralization of the bedrock. Stream sediment samples were taken over the same 1000 $km^2$ area covered by the boulder research. Several anomalies were produced, including Suovrarappat, but nothing of importance was revealed.

Geophysical surveys in and around Bidjovagge and Suovrarappat cover totally: electromagnetics 86.6 $km^2$, selfpotentials 16.9 $km^2$, and magnetics 10.7 $km^2$. These surveys have been of great significance in defining geological structure and thus revealing favorable cites for investigation. In addition to registration of the main anticline in which the Bidjovagge ore bodies occur, a parallel western anticline and an eastern fold area were found to exist. In connection with the regional boulder search several long selfpotential profiles were made. Independent of Kautokeino Kobberfelter's program 3500 $km^2$ of air-borne electromagnetics and magnetics were flown in 1959 centering on Kautokeino. This survey includes Kautokeino Kobberfelter's area of interest.

Diamond drilling totals 151 holes or 18,668 m. Of these, 117 holes or 15,135 m were drilled in the main anticline containing the ore

deposits. All cores have been described and photographed in color and, after specimens and assay samples were taken, stored.

In 1958 the overburden was removed from much of one ore body (A), and the ore zone systematically sampled by several means. Beyond providing additional data for the calculation of ore reserves, the purpose of this work was to enable a detailed study of the character of the ore. The results have been useful in subsequent planing and interpretation of drill hole data.

Amenability tests carried out on ore from this ore body produced chalcopyrite concentrates with a minimum of 25 % Cu and an extraction of 90 - 95 %.

The areal photography of Bidjovagge (series 788, scale 1:7000) provided for construction of a topographic map, scale 1:1000, with 1 m contours. The map covers 2.72 $km^2$ of the central area of interest and includes all the known ore bodies. Independently, a program for the areal photography, scale 1:20000, of the whole of inner Finnmark has been in progress. One of the earliest portions to be photographed was the area around Kautokeino and these photos played an important part in the execution of the regional investigation.

In the course of the four summer seasons 1956 - 1959 three ore bodies were blocked out. These have the designations A, B, and C, and all lie in the east limb of the main anticline at intervals of approximately a kilometer. See figure 2. The ore bodies dip steeply and ore zones vary in width usually between 10 and 20 m. Ore reserves calculated following the field season 1959 and included in St.prp.nr. 128 (1959-60) are summerized below.

Probable ore defined out by drilling:

| | Ton | % | Ton Cu |
|---|---|---|---|
| A: | 383,958 | 1.84 | 7,065 |
| B: | 252,610 | 1.83 | 4,623 |
| C: | 1,317,064 | 2.05 | 27,000 |
| | 1,953,632 | 1.98 | 38,688 |

Probable ore in extension of that defined out by drilling:

| | Ton |
|---|---|
| A: | 24,310 |
| B: | 54,360 |
| C: | 389,455 |
| | 468,125 |

Calculated reserves in total amounted to 2,4 million tons. In addition drilling had intersected promising mineralization in $a_2$, $a_3$, $b_2$, and $d_1$. The southern extension of the C ore body was not definitely established.

Drilling in the west anticline revealed a uniform mineralization of predominantly pyrrhotite and a few tenths of a percent copper. Drilling in the eastern fold area gave clearly negative results. A farther eastward extension, however, is but slightly explored.

Eventual undiscovered ore within five kilometers of Bidjovagge will in all probability be found to occur within the main anticline and its northern and southern extensions. The possibility for discovery of additional ore must be considered to be good. Especially promising is the area north of the ore body B where the anticline is apparently downfaulted, thus remaining in tact in depth. Furthermore there should be no reason for excluding the possibility of ore occuring in depth in the east limb of the anticline.

The ore bodies A and B and the mineralizations $a_2$, $a_3$, and $b_2$ lie within the area covered by 71 claim points acquired from Consul Holmboe. The ore body C and the mineralization $d_1$ are covered by claims taken out by Kautokeino Kobberfelter, as is the later discovery $d_2$.

The investigation of Bidjovagge 1956 - 1959 has cost N.kr. 5,791,097.13 and includes the purchace of Boliden's report.

The results of this phase of the investigation were submitted to the Department of Industry in the report of February 11, 1960. Calculations of a mining operation in Bidjovagge producing 150,000 tons of ore a year indicated that the value of ore reserves might be sufficient to ballance investment and production costs, providing that the various assumtions upon which these calculations were based were correct. It was agreed that an underground investigation in the largest of the ore bodies, C, would provide the information necessary for deciding the issue. The investigation would also provide indispensable information in the eventual choice of mining and milling methods. Pursuit of mineralization revealed in isolated drill holes was thus postponed.

Kautokeino Kobberfelter's board of direction recommended that the Department of Industry present the Storting with a proposal for appropriation of N.kr. 3 million toward an underground investigation in Bidjovagge.

Underground Investigation 1960 - 1962.

The proposed underground investigation calculated to take $1\frac{1}{2}$ - 2 years for completion at a cost of kr. 3 million was passed by the Storting May 31, 1960. The project was started in June 1960 and concluded in October 1962. An average force of 30 occupied Bidjovagge during this time.

In the early months of 1960 plans were drawn up as to how the investigation was to be carried out, and the various preparatory steps were taken for its facilitation. It was decided that maximum information would be gained from a system of drifts and cross cuts at a depth of 100 m (600 m above sea level) in ore body C, which approximates the center of the ore. An inclined shaft was to be sunk to that level and followed by 500 m of drift. In addition to detailed mapping and sampling, 3000 m of diamond drilling was to be carried out from that level. 500 m of drilling was to be undertaken from the surface.

The object of the investigation can be stated thus:

1. To check ore reserve calculations.
2. To gather data on crush zones, rock characteristics, amounts of water encountered, etc.
3. To map rock types, structure, mineral distribution, transition zones, and determination of the ore's possible extension in depth.
4. To provide graphitic ore for amenability tests.

The shaft which surfaces at 694 m above sea level was driven with dip $50^{o}$ east in profile S116 and has a section of 4 $m^2$. It lies in the crystalline core of the anticline. At level 600 m above sea level a cross drift was driven through the several ore zones into the hanging wall of greenstone. Between the W ore zone and the divided E ore zone a N-S drift was driven to enable systematic diamond drilling and sampling. In profile S112 cross cuts intersect both E and W ore zones. In profile S118 a cross cut intersects the E ore zone. See figure 3.

In total 140 m of shaft and 448 m of drift were driven. Twice intersection of water bearing zones caused flooding and halted operations for a total of five weeks.

From the N-S drift horizontal diamond drill holes east and west through the ore zones were spaced at 20 m and in part 10 m intervals. From cross cuts S112 and S125 deep holes were drilled. Supplementary drilling was also carried out from the surface. Of 3,116.45 m of drill hole 23 holes or 1,630.70 m were drilled underground and 14 holes or 1,485.75 m

were drilled from the surface. A detailed geological map was constructed of the mine. All drift walls were photographed in color.

Figure 3 shows the 600 m level of ore body C and includes drifts and cross cuts, diamond drill holes, the geology, ore zones, and crush zones. The ore section at this level is calculated at 4,374 $m^2$ with an average of 1.5 % Cu. Above the 600 m level lies the bulk of the ore with 2/3 of the tonnage and the highest tenor. Under this level the width of the ore and its tenor decrease with depth.

From aerial photographs there has been constructed a topographic map, scale 1:5000, with 5 meter contors covering 80 $km^2$ and including the whole length of the main Bidjovagge anticline and the area that will be effected by the milling operations of an eventual mine.

The budget and sums applied in the investigation in Bidjovagge June 1, 1960 to December 31, 1962 is thus summarized:

Budget: kr. 3,000,000.00

Applied: kr. 3,130,573.35 specified thus:

| | | | | |
|---|---|---|---|---|
| 1. | Administration | kr. | 495,218.86 | 15.8 % |
| 2. | Surface construction | " | 278,754.11 | 9.0 % |
| 3. | Equipment including operation and maintenance | " | 591,947.38 | 18.9 % |
| 4. | Work underground | " | 683,293.73 | 21.8 % |
| 5. | Aerial photography and topographic map construction | " | 45,615,- | 1.5 % |
| 6. | Geological mapping | " | 5,837.29 | 0.2 % |
| 7. | Diamond drilling | " | 175,554.74[x)] | 5.6 % |
| 8. | Assays | " | 46,467.60 | 1.5 % |
| 9. | Other investigation | " | 7,172.20 | 0.2 % |
| 10. | Drafting and calculation | " | 15,016.70 | 0.5 % |
| 11. | Freight and transport | " | 504,465.16 | 16.1 % |
| 12. | Housing | " | 44,124.99 | 1.4 % |
| 13. | Kitchen | " | 172,569.59 | 5.5 % |
| 14. | Social expenses | " | 63,151.20 | 2.0 % |
| 15. | Diverse | " | 1,384.80 | 0.0 % |
| | Sum | | kr. 3,130,573.35 | 100.0 % |

[x)] Additionally the Geological Survey of Norway has absorbed ca. kr. 100,000.- of drilling expenses.

This stage of the Bidjovagge investigation has cost somewhat more than the calculated kr. 3 million. Equipment orders could first be

placed after funds had been appropriated. The delivery of several large machines occured later than stipulated, necessitating that their transport in to Bidjovagge be delayed until the arrival of winter conditions. The large amount of mine water encountered caused considerable extra expense. Additionally kr. 290,000.- was placed at disposal by the Department of Finance in the summer of 1962.

The underground investigation has shown a larger portion of the ore to be graphitic than was earlier thought. A milling operation must be designed in accordance with the assumption that selective mining of graphitic portions of the ore is not practicable. The milling of a graphitic ore will necessarily be more complicated and more expensive than had the ore been mainly of the fels type. Amenability testing has, however, yielded satisfactory results involving primary flotation of the graphite. The graphite concentrate which contains approximately 50 % C can possibly be used as fuel. The necessity of graphite flotation has caused an increase in the calculation of investment costs above earlier calculations.

Due to the involvment of graphite in the flotation process, copper extraction is now calculated at 90 % in contrast to 94 % earlier, but with the same content of copper in the concentrate, 25 %. Pyrite and a minor amount of magnetite can also be extracted for sale.

The entire length of the east limb of the Bidjovagge anticline contains a series of wide crush zones in the graphite shale. These zones, which in ore body C occur mainly in connection with the east ore zone, will complicate and increase the cost of mining.

Where crush zones are involved, it is preferable that a method be developed whereby mining is not carried out from inside the stopes. Because fo these zones a certain amount of barren wall rock will accompany the ore mined.

The investigation of the 600 m level in ore body C has revealed that the crush zones contain abundant water. The amount of mine water appeared to be influenced by snow-melting, variation in frost-depth, and precipitation.

Information gathered underground shows this phase of the investigation to have been an important step in the projection of a mining operation in Bidjovagge. The results obtained from the investigation underground do not sustain the calculations in the 1960-report. Tonnage and tenor are somewhat less than earlier calculated. Crush zones and

graphite content in the ore will increase production costs. It was therefore natural in the summer of 1962 to revert attention to mineralization that had been detected by drill hole, but not followed up. The locality $d_1$, which lies between A and C, is structurally favourable for ore deposition and earlier drilling has revealed good ore. Two additional drill holes in 1962 showed marginal values over large thickness. An ore body of dimension seems to be indicated.

These two drill holes also cut an easterly 300-400 m long geophysical indication. The indication seems to be caused by promising chalcopyrite mineralization in fels not accompanied by graphite. This zone has been given the designation $d_2$. A detailed investigation was not, however, possible with the available funds remaining. A program for additional diamond drilling has been compiled and can be put into effect in the summer of 1963.

With the experience of 6 years of investigation in Bidjovagge it seems probable that the area contains considerable ore beyond that which has been calculated. Bidjovagge's total ore assets can first practically be revealed by investigation driven parallel to a mining operation.

Calculation of ore reserves.

Diamond drilling in 1960 and 1962 provides the basis for a new calculation of tonnages and tenor in ore body C. Calculation of ore reserves in the 3 ore bodies is presented in tabular form on page 11.

Characteristic for Bidjovagge is that copper distribution is clearly divided into zones of rich and poor ore. Ore bodies A and C are blocked out to a dgree that allows the independant calculation rich ore and poor ore. Ore body B is not blocked out sufficiently to allow such a calculation. Additional probable ore lies in extension of all three bodies. The amount is estimated at 500,000 tons and will likely show a similar division between rich and poor ore.

The Bidjovagge ore bears gold in highly varying amounts. Despite a considerable number of gold assays, the amount of gold calculated for the various ore bodies is not reliable. However, gold seems to be concentrated in the zones of rich fels ore.

In addition to the ore bodies A, B, and C promising ore mineralization has been registered through drilling in five other localities

Ore Calculation

Bidjovagge Area

February 1963

| Ore body | Ore defined by drilling | | | | | | | | | | | | Probable ore | Sum ore |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rich | | | | Poor | | | | Rich + Poor | | | | | |
| | ton | % Cu | g/t Au | ton Cu | ton | % Cu | g/t Au | ton Cu | ton | % Cu | g/t Au | ton Cu | ton | ton |
| A | 223,757 | 2.24 | 1.03 | 5,012 | 78,406 | 1.34 | 0.21 | 1,050 | 302,163 | 2.01 | 0.82 | 6,062 | 100,000 | |
| B | | | | | | | | | 252,610 | 1.83 | 0.45 | 4,623 | 50,000 | |
| $C^e$ | 428,681 | 2.35 | 0.85 | 10,074 | 438,909 | 1.38 | 0.03 | 6,056 | 1,175,249 | 1.81 | 0.44 | 21,256 | 350,000 | |
| $C_w$ | 127,377 | 2.34 | 1.08 | 2,980 | 180,281 | 1.19 | 0.01 | 2,146 | | | | | | |
| Sum | 779,815 | 2.32 | 0.94 | 18,066 | 697,596 | 1.33 | 0.03 | 9,252 | 1,730,022 | 1.85 | 0.51 | 31,941 | 500,000 | 2.2 mill. |

in Bidjovagge, which are but slightly investigated. Ore has been registered between A and C in the east fold limb ($d_1$) and in a fels-zone farther east ($d_2$), in the west fold limb ($a_2$) near ore body A, in a separate zone north of A ($a_3$), and in a zone north of B ($b_2$). See figure 2. These localities will through future investigation increase the reserve of calculated ore. Their inclusion in the present calculation cannot be made, however, from the present data.

In all probability the Bidjovagge area holds ore in addition to that indicated in the five previously mentioned localities.

A statistical analysis involving the individual assay values shows pronounced frequency maxima centering around 1 % and 3 % Cu. This reflects the distribution of rich and poor ore in the ore bodies, and suggests that other ore bodies found will be similarly divided.

Under diamond drilling of the Bidjovagge ore the core has a tendency to break where sulphide veins occur causing a greater loss of chalcopyrite than rock material. This results in that ore calculated assays less than had the core been unbroken. The magnitude of this source of error is unknown, but a visual impression of the cores implies that it is not inconsiderable.

Calculations involved in the projection of a mining operation.

Calculated ore reserves are less than the amount necessary to balance the investment costs involved in the establishment of a mining enterprise.

The Bidjovagge ore bodies consist conspicuously of rich and poor zones. For ore bodies A and C 53 % of the tonnage is calculated at 2.32 % Cu and 0.94 g/t Au. The remaining 47 % contains 1.33 % Cu and 0.03 g/t Au. At present only the richer portions of the ore bodies can be considered as ore. Those portions containing 1.3 % Cu can be considered as ore only after the capital investment has been written off.

It is reasonable to assume that ore body B and probable ore in extension of that blocked out are similarly divided between rich and poor zones. The following projection assumes that 1.1 million tons of the calculated ore reserves can be mined assaying 2.2 % Cu and 0.9 g/t Au. This is somewhat more than half the amount necessary to balance

investment costs. Ore of this quality has a calculated sales value of approximately kr. 69.50 per ton (90 % extraction). Assuming the saleability of pyrite and magnetite the value of the ore is increased by kr. 4,- per ton to kr. 73,50. With a production of 150,000 tons of ore of this quality per year, the full investment will be paid off in 12 years. Including mine-losses this requires ca. 2 million tons of ore.

In both A and C rich ore is concentrated in such a way as to allow these zones to be mined independently of the poor ore. To what extent mined ore will be contaminated by wall rock is difficult to estimate. Differential sulphide loss in diamond drilling is by far most pronounced in connection with the richer zones. Until more certain data exist, it is reasonable to assume that this assay depression balances the effect of wall rock contamination. Should mined ore nevertheless show a lower average assay than that calculated, there remains the possibility of increasing production to 180,000 tons per year and thus achieve a better economic result.

Extraction of copper and gold at 90 % is here calculated with, and contains ample margin in the mining of rich ore. For each 2 % extraction can be increased over 90 % ore value increases by kr. 1.- per ton.

A management policy based upon selective mining of rich ore until capital investement has been amortized, or in the case of insufficient reserves, as long as rich ore lasts, provides the best over-all economic result. It is of decisive influence on the result of a mining operation in Bidjovagge that continual exploration with diamond drilling be carried out parallel to mining.

An evaluation of conditions effecting the projection of a mining operation in Bidjovagge indicates a tunnel driven in from the southern foot of Caskias to be the appropriate solution. See figure 4. Such a tunnel would pass beneath virtually all of the known ore reserve and provide drainage. The terrain south of Caskias presents a favorable location for the necessary buildings and allows favorable disposal of tailings. An adequate supply of mill water will be inexpensive. Buildings will lie 150-200 m lower than the surface above the ore bodies, and close to the state highway which is planned to pass the north side of the lake Raisjavrre. The tunnel will play an important part in the further exploration of the area and will provide a natural link between known and undiscovered ores. A possible alternative to a tunnel is the sinking of a shaft.

It appears advantageous that all surface buildings involved in the project be united into as few as possible main units. It is recommended that the mill including workshop and stock-room be constructed as one block. Crushing-plant and silos should lie frostfree in bedrock. Transportation in the tunnel will be by rail, using overhead electric power. The tunnel, projected with a 10 $m^2$ section, is calculated to take 3-4 years to be driven as far as ore body C.

The anticlinal limb containing the ore bodies is accompanied by a series of zones of highly crushed rock holding considerable water, which will supply the mill with most of its annual requirement of ca. 6 $m^3$ per ton of ore, equivalent to almost 3 $m^3$ per minute. Water under pressure may be had by damming 2 small lakes 2 km north of the projected portal and 150 m higher.

A minimum of family lodgings have been calculated with. The work force, which for the most part will come from the surrounding districts, is to be housed in a unit of bachelor quarters. Family-housing for members of the staff should preferably be located in Kautokeino. Sørkjosen in Nordreisa, 110 km from Bidjovagge, remains preferable as port of shipment for concentrates.

The mine portal will lie ca. 1 km north of the projected inner route of state highway 50 between Nordreisa and Kautokeino. The projected distances from the county border to Kautokeino and Bilto in Nordreisa are respectively 38 km and 57 km. The Road Commission's cost calculations for these 2 distances amount to kr. 4.4 million and kr. 8.5 million. A power line from Nordreisa to Kautokeino is under construction and will be completed in the fall of 1963. It will pass the mine plant at a distance of 4 km.

Calculation of personnel:

| | |
|---|---|
| Mine | 55 |
| Mill | 10 |
| Wonkshop, electrical and mechanical | 15 |
| Stock-room and internal transportation | 4 |
| Laboratory | 3 |
| Diverse, exploration, etc. | 6 |
| Kitchen, cleaning, etc. | 19 |
| Port of shipment | 3 |
| Foremen | 10 |
| Administration | 5 |
| Office staff | 5 |
| Clinic | 1 |
| Sum | 136 |

With company administered transport of concentrates, total personnel will amount to approximately 150.

Mine efficiency is calculated at 4 tons of ore per man per day. This figure is relatively high compared with other Norwegian mines of similar size. A mining operation in Bidjovagge demands a high productivity and at day's technological level this should be possible.

Calculations are based upon ordinary crushing of the ore and ball grinding. If autogenous grinding proves practical, investment and production costs can be reduced. The calculation includes flotation capacity for primary separation of graphite and equipment for the production of pyrite and magnetite.

The present calculation of investment costs lies kr. 9 million above the calculation included in the report of 1960. Of this increase kr. 1 million is directed at exploration during the period of construction. Half of the increase reflects higher prices. Adjustments in the calculation based upon experience from the underground investigation, larger crushers, and extra installation for graphite flotation provides the rest of the increase. Interest on investment capital over the period of construction is approximately kr. 3 million. See page 16.

The transportation of copper concentrate to port of shipment can be accomplished through contract or by internal administration. The total costs involved in concentrate transport are therefore considered as production costs.

Production costs are calculated as follows:

| | Kr. per ton ore | Kr. per year |
|---|---|---|
| Mining | 15.- | 2,250,000 |
| Milling | 10.- | 1,500,000 |
| Transport of copper concentrate to port kr. 0.20 per ton km | 1.80 | 270,000 |
| Electric power, 12 million kWh at kr. 0.05 | 4.- | 600,000 |
| General expenses | 6.- | 900,000 |
| Exploration | 1.50 | 225,000 |
| Interest on operating capital, 5.5 % of kr. 5 mill. | 1.85 | 275,000 |
| Margin | 4.85 | 730,000 |
| Sum operating costs | 45.- | 6,750,000 |

Investment calculation for mine operating at 150.000 tons per year (capacity 180.000 tons):

| | | | |
|---|---|---|---|
| **Mine:** | | | |
| Tunnel 4,000 m to C (including track and electrical installations) at kr. 1,500.- per m | kr. | 6,000,000 | |
| Tunnel 2,000 m farther to A and B at kr. 1,200.- per m | " | 2,400,000 | |
| Drifts and ore chutes | " | 1,000,000 | |
| Diverse construction at tunnel level | " | 500,000 | |
| Mechanical equipment including installation | " | 2,000,000 | kr. 11,900,000 |
| **Mill:** | | | |
| Hall in bedrock for crushing plant, silos, and transportation belts, 10,000 $m^3$ at kr. 50.- | kr. | 500,000 | |
| Flotation-hall 20,000 $m^3$ at kr. 100.- | " | 2,000,000 | |
| Crushers, 3 stages | " | 1,600,000 | |
| Screens, belts and feeders | " | 350,000 | |
| Ball mill, flotation machines, etc. | " | 3,500,000 | |
| Dryers for concentrate | " | 250,000 | |
| Electrical motors and equipment inc. installation | " | 1,400,000 | |
| Mechanical installation | " | 700,000 | " 10,300,000 |
| **Additional construction and equipment:** | | | |
| Workshop, stock-room, etc. 8,000 $m^3$ at kr. 100.- | kr. | 800,000 | |
| Workshop equipment | " | 500,000 | |
| Supply of water and disposal of tailings | " | 500,000 | |
| Road from the state highway to the mine | " | 200,000 | |
| Offices, shift-room, and steam-plant | " | 1,000,000 | |
| Housing for personnel | " | 3,100,000 | |
| Silos and pier at port of shipment | " | 1,000,000 | |
| Motor-vehicles, exclusive of concentrate transport | " | 200,000 | |
| Freight expenses | " | 1,000,000 | |
| Exploration parallel with development | " | 1,000,000 | |
| Administration | " | 1,000,000 | " 10,300,000 |
| | | | kr. 32,500,000 |
| Margin | | | " 3,500,000 |
| | | | kr. 36,000,000 |

In relation to the report of 1960 mining costs are increased by kr. 3.- to kr. 15.- per ton in deference to conditions discovered through underground investigation. Milling costs are calculated at kr. 10.- per ton as before, and include flotation of pyrite and separation of magnetite. Power requirement has been increased by 20 %, while the kWh price has been decreased by 1 øre causing total power costs to remain as before, kr. 4.- per ton ore or kr. 600,000 per year. Exploration for kr. 225,000 per year or kr. 1.50 per ton ore has been included as a new post. Total operating expenses have thus increased by kr. 5.- to kr. 45.- per ton.

Average pay per employee, including benefits, is calculated at kr. 24,000 per year. Assuming internally managed transport of concentrate, total personnel will be ca. 150 and total wages exclusive of benefits will amount to somewhat more than kr. 3 million.

The 4 year (1959 - 1962) average of copper prices on the English metal market (£ per 1016 kg) was £ 237. The average for each of these years was £ 238, £ 246, £ 230, and £ 234. Calculations in this report are based on the current copper price, £ 234. This amounts to very nearly kr. 4,600.- per metric ton.

The price of gold has remained constant for many years at $ 35 per troy ounce (31.1 g), which amounts to kr. 8.- per gram.

Charges involved in the smelting and refining of a 25 % concentrate to wirebars plus freight expenses from Nordreisa amount to kr. 1,200.- per ton copper or kr. 290.- per ton concentrate.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Price for metallic copper | kr. | 4,600.- | per | t | Cu | = | kr. | 4.60 per kg Cu |
| Freight expenses plus smelting and refining charges | " | 1,200.- | " | " | " | - | " | 1.20 " " " |
| Net value of copper in concentrate | kr. | 3,400.- | per | t | Cu | = | kr. | 3.40 per kg Cu |

| | | | | | |
|---|---|---|---|---|---|
| Copper concentrate with 25 % Cu contains | 250.0 | kg | Cu | per | t concentrate |
| - 5 % loss in smelting and transport | 12.5 | " | " | " | " " |
| Net payable copper | 237.5 | kg | Cu | per | t concentrate |

The production of a copper concentrate with 25 % Cu and 90 % extraction is assumed. Nearly 3,000 tons of copper per year will thus be extracted from ore assaying 2.2 % Cu.

| | | |
|---|---|---|
| Ore: | 150,000 t / 2.20 % Cu | 100 % = 3,300 t Cu |
| Tailings: | 138,120 t / 0.24 % Cu | 10 % = 330 " " |
| Concentrate: | 11,880 t /25.0 % Cu | 90 % = 2,970 t Cu |

This copper concentrate containing 6 % water will weigh approximately 12,500 tons.

The value of copper and gold in the concentrate is as follows:

| | Value of 1 t concentrate | Value of 1 year's production 11,800 t |
|---|---|---|
| Copper: 237.5 kg / kr. 3.40 | kr. 807.50 | kr. 9,575,000 x) |
| Gold: 9 g / " 8.- | " 72.- | " 850,000 x) |
| Value of concentrate with 25 % Cu | kr. 879.50 | kr. 10,425,000 x) |

x) rounded values.

Ore containing 2.2 % Cu and 0.9 g Au per ton produces:

Ore value kr. 69.50 per ton $(\frac{10,425,000}{150,000})$

The milling of Bidjovagge ore can be expected to yield 20,000 tons of pyrite concentrate and 5,000 tons of magnetite concentrate per year. Provided it can be sold, the pyrite concentrate will net kr. 500,000.- per year based upon a f.o.b. value of kr. 50.- per ton in Nordreisa. Similarly magnetite concentrate will net kr. 125,000 yearly. This by-product can thus increase the ore value by kr. 4.- per ton.

The following table gives the value of various grades of ore with the corresponding estimated content of gold:

| Ore | | Ton conc. 25 % Cu. | Value of Cu and Au in ore | | Total value inc. pyrite and magnetite | |
|---|---|---|---|---|---|---|
| % Cu | g/t Au | | kr. per ton | kr. per year | kr. per ton | kr. per year |
| 1.2 | 0.0 | 6,480 | 35.- | 5,250,000 | 39.- | 5,850,000 |
| 1.4 | 0.1 | 7,560 | 41.50 | 6,225,000 | 45.50 | 6,825,000 |
| 1.6 | 0.3 | 8,640 | 48.- | 7,200,000 | 52.- | 7,800,000 |
| 1.8 | 0.5 | 9,720 | 55.50 | 8,325,000 | 59.50 | 8,925,000 |
| 2.0 | 0.7 | 10,800 | 62.50 | 9,375,000 | 66.50 | 9,975,000 |
| 2.2 | 0.9 | 11,880 | 69.50 | 10,425,000 | 73.50 | 11,025,000 |
| 2.4 | 1.1 | 12,960 | 77.- | 11,550,000 | 81.- | 12,175,000 |

According to the calculation of ore reserves it is possible to operate 7 years with ore containing 2.2 % Cu and 0.9 g/t Au. Including by-products the value of ore of this tenor is kr. 73.50 per ton, and a year's

production of 150,000 tons has a value of kr. 11,025,000. Operating expenses are calculated at kr. 45.- per ton or kr. 6,750,000 per year. The balance, kr. 4,275,000 per year, can be applied to amortization and taxes. After 7 years of operation the investment capital of kr. 36 million with 5.5 % annual interest can be amortized to kr. 17 million. A capital outlay of kr. 24 million can be amortized in the 7 years calcualted tonnage of rich ore provides. Annual payment on capital investment plus interest will thus amount to kr. 4,225,000.

After mining rich ore for 7 years the remainder of the present calculated ore reserves will be 1.1 million tons containing 1.3 - 1.4 % Cu and insignificant gold. Ore of so low assay will balance production costs only if unburdened by amortization expenses. Present calculations indicate ore reserves of this quality sufficient for 6 years of operation, producing 7,200 tons of copper concentrate containing a 25 % Cu, or 1,800 tons Cu per year.

The mine is calculated to operate 2 shifts per day and the mill 3 shifts, with both shut down on week-ends. An increase in production to 180,000 tons of ore per year, which is the calculated capacity of the mill, will effect greater efficiency. Total expenses will thus be reduced by ca. kr. 5.- per ton. The economic consequences of a yearly production of 120,000 tons has also been calculated. There is little to be saved in investment costs for a smaller plant and remuneration would therefore be reduced.

Royalty stipulated by contract with consul Holmboe, which at present involves A and B, has not been entered as a separate post in the preceding calculations. Extraction of 50,000 tons per year from these ore bodies will require an annual royalty of approximately kr. 20,000.

The present calculations do not include amortization of the cost of the Bidjovagge investigation 1956 - 1962, which totals somewhat more than kr. 9 million.

## Summary and Conclusion.

The investigation of Bidjovagge has led to the calculation of ore reserves for 3 ore bodies amounting to 2.2 million tons of copper ore. In ore bodies A and C 53 % of the tonnage assays 2.32 % Cu and 0.94 g/t Au and the rest of the tonnage 1.33 % Cu and 0.03 g/t Au. There is reason to

assume that ore body B and probable ore in extention of that calculated will show a similar distribution. Diamond drilling has revealed promising ore mineralization in 5 additional localities.

Of the calculated 2.2 million tons of ore, one half or 1.1 million tons assaying 2.2 % Cu and 0.9 g/t Au provides the basis for calculation of ore value, which at present prices amounts to kr. 69.50 per ton. The by-products pyrite and magnetite can add kr. 4.- per ton creating a total ore value of kr. 73.50. Investment in a mining operation based upon the extraction of 150,000 tons per year is calculated at kr. 36 million. Operating expenses are calculated at kr. 45.- per ton. The difference between ore value and operating costs, kr. 28.50 per ton, is assumed apllied to amortization and tax.

The ore basis of 1.1 million tons of rich ore will sustain operation for 7 years and allow amortization of kr. 19 million of the total investment capital of kr. 36 million, assuming 5.5 % annual interest, leaving a capital liability of kr. 17 million. An additional 5 years of operation based on ore of this quality will require 0.8 million tons and effect complete amortization. Operation based on ore of tenor lower than 2.2 % Cu will increase the amortization period and demand a greater amount of ore.

With one third of investment capital free of interest and amortization for 7 years, as for example in a form of stock, the remainder, kr. 24 million, will be amortized in this period.

Of the ore calculation's 2.2 million tons, the half containing 1.3 - 1.4 % Cu with an ore value of kr. 44.- per ton allows 6 years of balanced operation provided no capital liability exists. Ore of this quality effects the duration of mining operation.

The launching of a mining operation in Bidjovagge involves risks. Complete amortization of investment capital prescribes the existence of additional ore assaying at least 1.8 % Cu. Unforeseen difficulties may cause an increase in operation costs. Market conditions may make the sale of the by-products pyrite and magnetite difficult. Capital investment, operating costs, and ore value are dependant upon general economic developments.

Since ore has been encountered in localities other than the ore bodies A, B and C, it is evident that Bidjovagge harbors a greater tonnage than the present calculations indicate. This fact as well as a general evaluation of the area indicates reasonably good chances for the

discovery of ore sufficient to achieve a profitable mining enterprise. Continuous exploration by diamond drilling will therefore be decisive in determining the success of a such operation. Diamond drill should accompany such further projection efforts as may be undertaken.

The launching of a mining enterprise in Bidjovagge bears certain advantages from a national standpoint. The value of the calculated ore reserve of 2.2 million tons is at present prices kr. 100 million in hard currency. The labor source will derive principally from a region of unstable under-employment. Wages, based upon the present level, will amount to kr. 3 million per year. This provides an increase in national income which will benefit the region.

The conclusion of the board of direction is thus:

Calculated ore reserves in Bidjovagge do not provide a basis for remuneration of the capital investment involved in the establishment of a mining operation.

Bidjovagge possesses a potential which may provide sufficient ore for a profitable operation.

In valuating the project, the risks involved must be weighed against the advantages realization offers, from a national economic stand point and for the region.

Oslo, February 1963.

Karl Skjerdal
chairman

Peder Holt

J. Kraft Johanssen

Karl Ingvaldsen

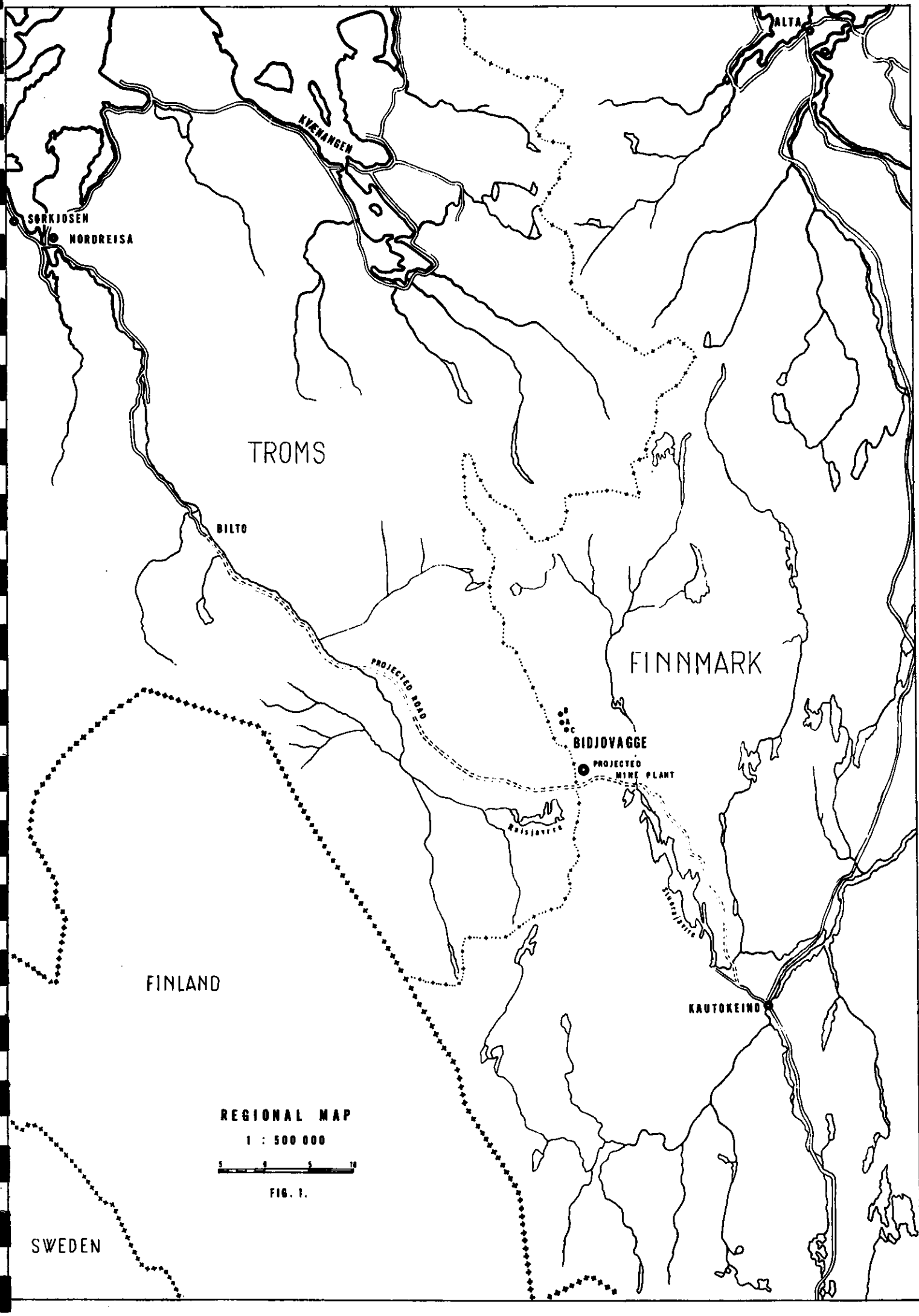

ALTA
KVÆNANGEN
SØRKJOSEN
NORDREISA
TROMS
BILTO
FINNMARK
PROJECTED ROAD
BIDJOVAGGE
PROJECTED MINE PLANT
RISJAVRE
SVAPPAVAARA
FINLAND
KAUTOKEINO
SWEDEN
REGIONAL MAP
1 : 500 000
5 0 5 10

FIG. 1.

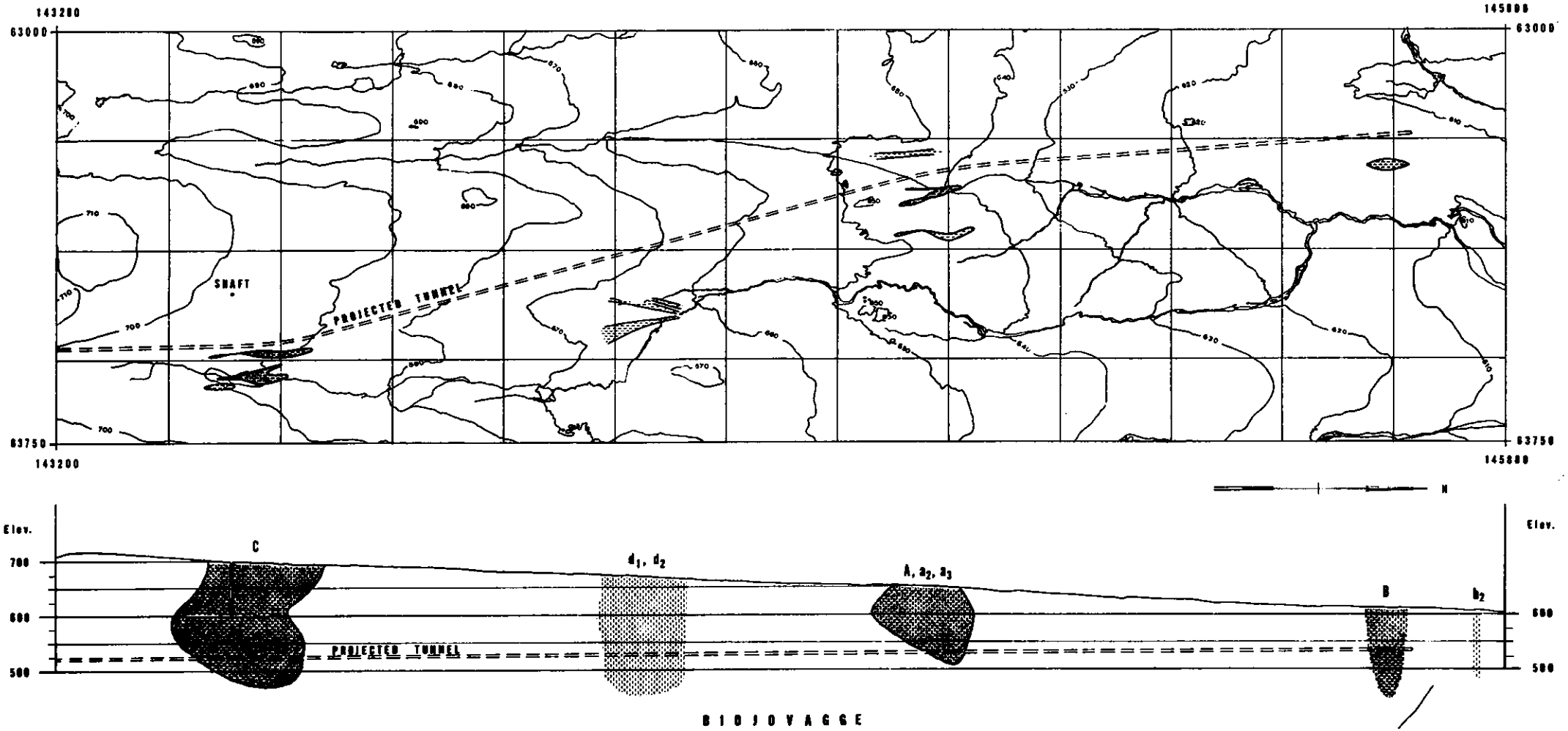

143280
145800
63000
63750
143200
145800
SHAFT
PROJECTED TUNNEL
N
Elev.
700
600
500
C
$d_1$, $d_2$
A, $a_2$, $a_3$
B
$b_2$
PROJECTED TUNNEL
Calculated ore
Slightly explored ore
BIOJOVAGGE
1:10000
200 100 0 200 400 m

Fig. 2.

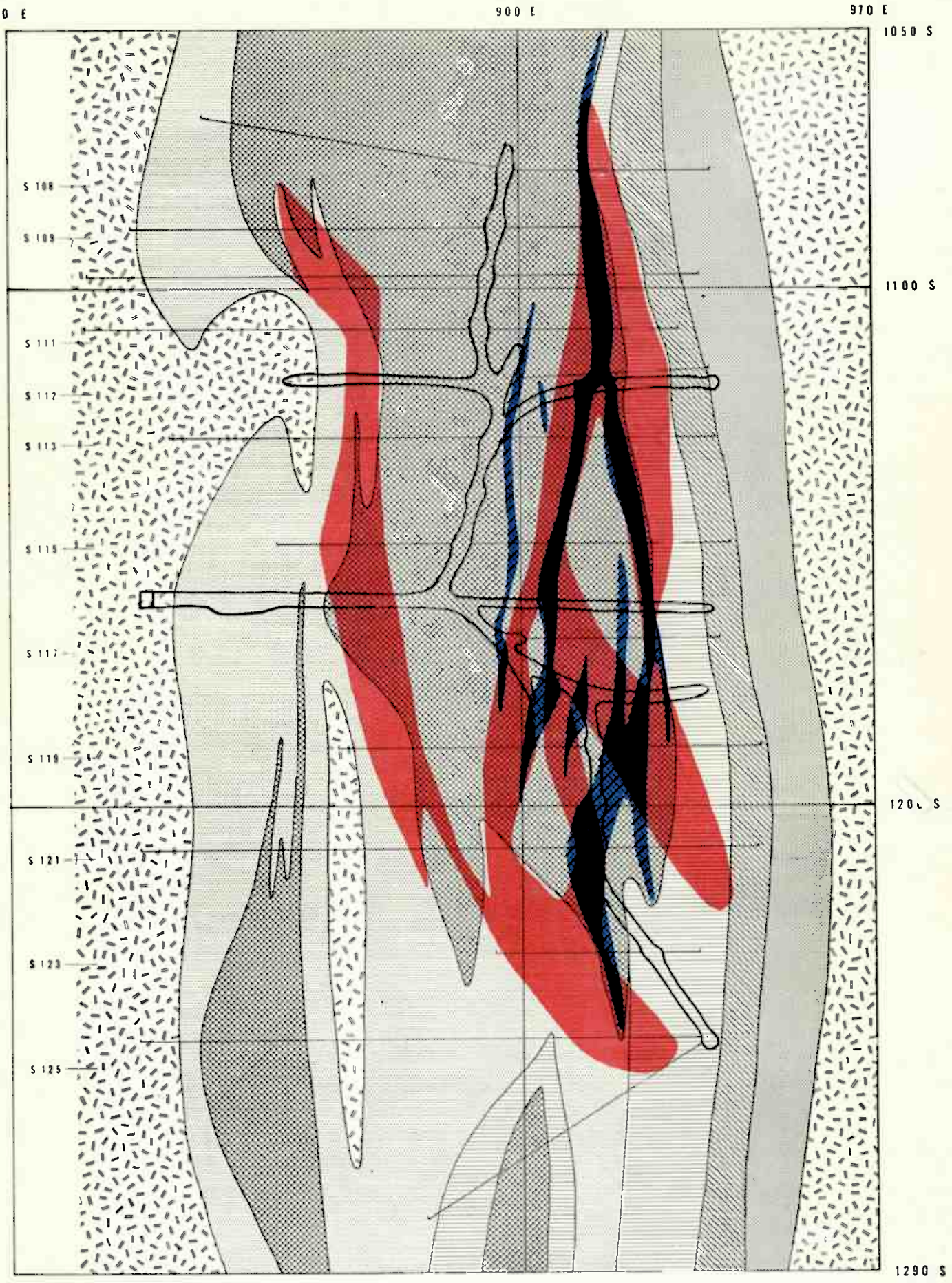
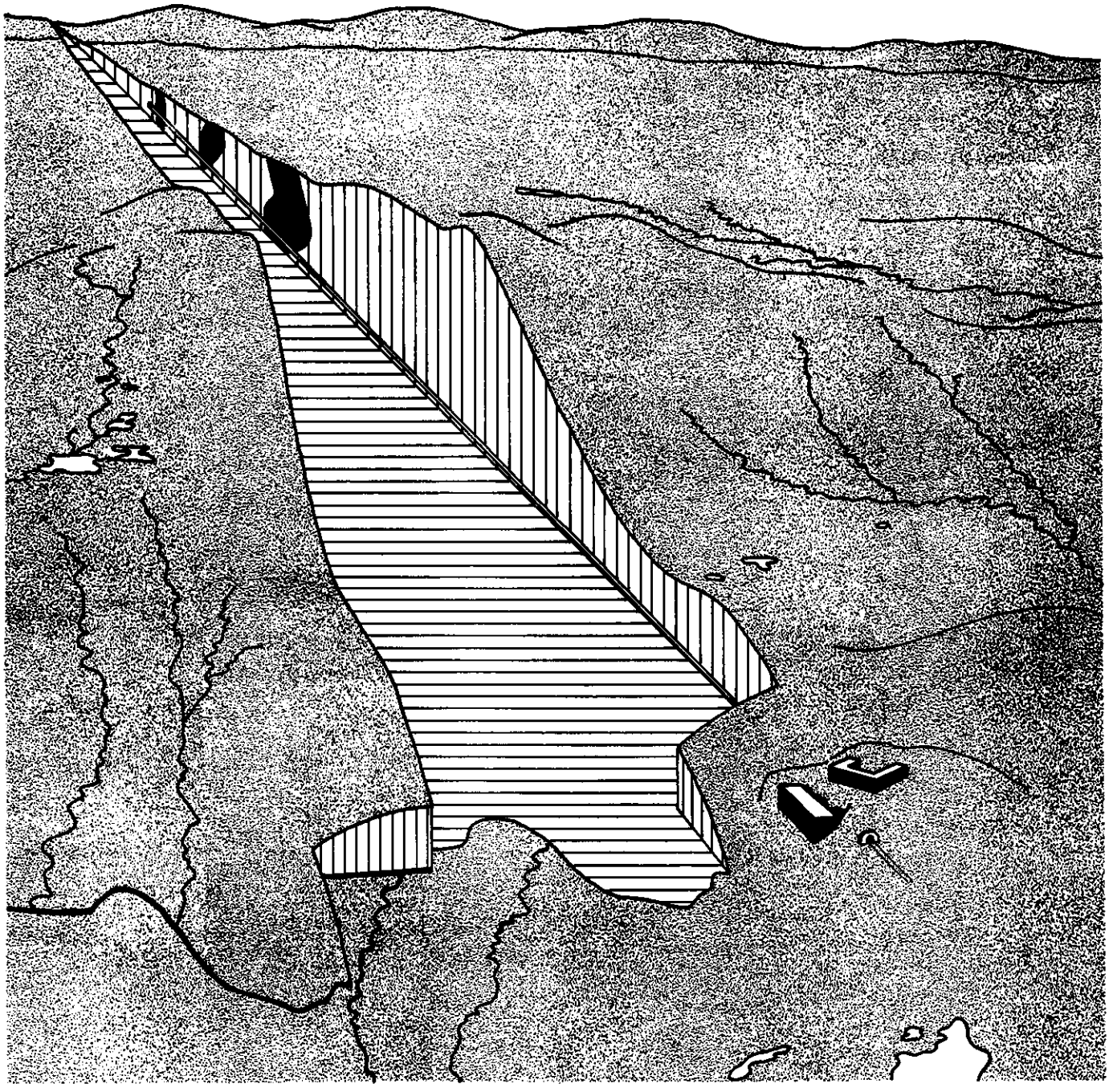

800 E
900 E
970 E
1050 S
1100 S
1290 S
S 108
S 109
S 111
S 112
S 113
S 115
S 117
S 119
S 121
S 123
S 125
BIDJOVAGGE
ORE BODY C
600 M LEVEL
1 : 1000
0 10 20 30 40 50 m
Crush zone
Ore zone
Fels
Graphite shale
Greenstone
Light graphitic greenstone
Scarn
Diabase

Fig. 3.



BIDJOVAGGE

PERSPECTIVE VIEW OF

PROJECTED MINE PLANT AND TUNNEL

Fig. 4.