

Observations at Raipas Mine, Alta, Finnmark.

BY

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With 5 text-figures.

Situation (see fig. 1).

The disused copper mine of Raipas lies in Alta kommune, Finnmark, about 5 kilometres southeast of Bossekop. Access to the mine is afforded by 14 kilometres of motor road from Bossekop, plus an additional 2 kilometres of mine road which are at present not fit for motor traffic.

The adit entrance to the mine lies at an elevation of about 260 metres o.s.l., near the top of the steep eastern slopes of the irregular ridge known as Lille Raipas.

History.

Raipas mine was worked by the English company of Alten Copper Works Ltd. during a 30 year period in the 19th century. During this time some 12 500 tons of ore were mined, containing an average of 6.3 % Cu. From specimens in the Geologisk Museum, Oslo, the ore minerals were bornite and chalcopyrite.

Exploration work, including some diamond drilling, was undertaken during the period 1900—06.

The investigation which formed the basis of this account was undertaken in April 1954. Due to inaccessibility it was not possible to visit all the old workings. However, sufficient work could be done to allow the main geological features to be deduced and certain general conclusions drawn up.

General Geology.

The mine is situated near the eastern border of the «window» of the Raipas formation which is exposed beneath the flat-lying

Caledonide Schists in the area surrounding Alta. According to Høltedahl (1, page 135) this formation appears in a series of tectonic windows in west Finnmark. It is a supracrustal formation consisting in part of sediments and in part of eruptive rocks. The Raipas deposit occurred in the Lower Raipas Series, a greenstone, slate and dolomite division. The rocks of the formation are strongly folded. They have marked dips, sometimes vertical, and a somewhat variable strike, which in the Kåfjord—Bossekop area is almost N—S. Høltedahl (op. cit. p. 136) figures a map showing the distribution of the rocks within the Alta window and the location of the mine.

Raipas Mine — Stratigraphy and lithology.

The rocks exposed in the mine workings may be tabulated as follows:

- | | |
|-----------------------------------|------------------------------|
| 5. Mudstone | unknown thickness |
| 4. Upper dolomite | min. 25 metres |
| 3. Mudstone | 10—14 metres |
| 2. Lower Dolomite | ca. 20 metres |
| 1. Striped argillaceous dolomite. | unknown, min. ca. 60 metres. |

Only the three central units are concerned in the ore zones.

The Striped argillaceous dolomite is only seen along the so-called «Deep Adit» and for a short distance along the 10 fm level. About 10—20 metres before reaching the first stope on this level it has graded into the lower dolomite. Lithologically it consists of bands of extremely fine-grained pale pink or white dolomite 1 to 5 cm. thick, separated by much thinner irregular layers of argillaceous material. The striped appearance of the whole rock is very striking. Its disappearance up the succession appears to be a normal sedimentary change whereby the argillaceous layers become less and less abundant until the rock is pure crystalline dolomite.

The Lower dolomite is a fairly homogeneous rock of fine to medium crystallinity ranging in colour from deep pink to pale orange. The bedding where observable is fairly massive, the individual units being from 0.5—1 meter thick. This dolomite, even in the ends and on the walls of the old stopes, appears very solid and fresh, and was apparently unaffected by the orebearing solutions away from the actual ore-bodies. A noticeable feature, especially on the 20

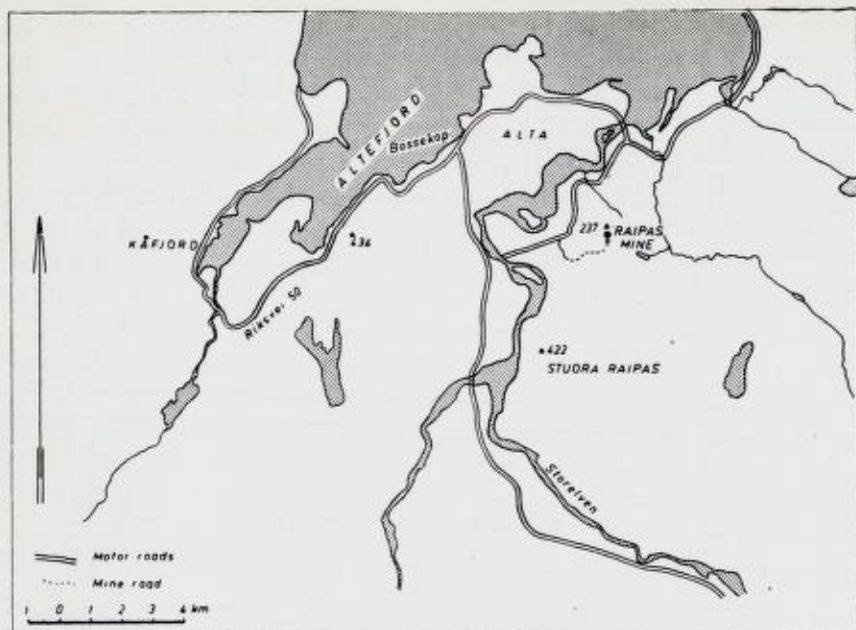


Fig. 1. Map showing location of Raipas Mine.
Kart som viser beliggenheten av Raipas gruve.

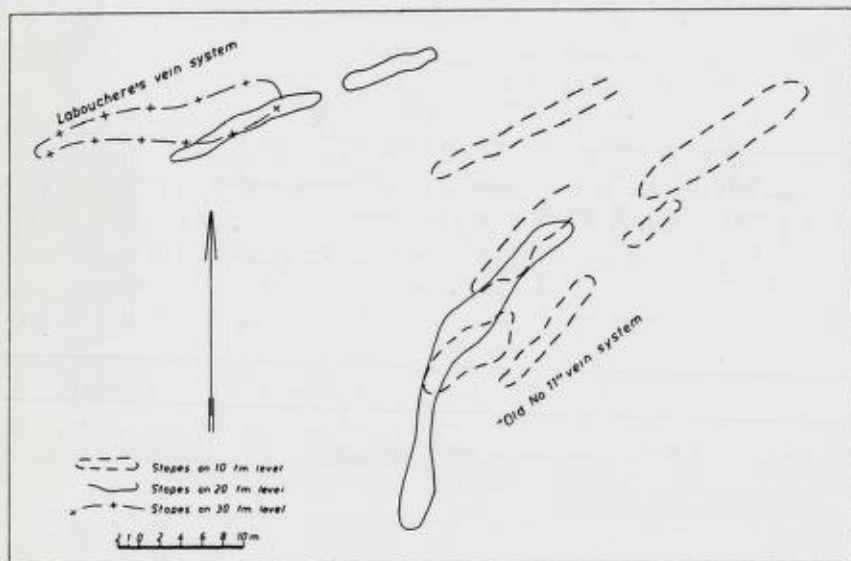


Fig. 2. Vein systems in the lower dolomite, as shown by old stipes.
Kart over strossene (i forskjellige nivåer) i den undre dolomitt, som viser forløpet av gangene der.

and 30 fm levels is the large amount of quartz in the rock, characteristically as clean, straight-walled veins 1—5 cm. wide, possibly occupying joints. The vein quartz is so widespread that it is reasonable to class it as a regional feature, and not as one solely accompanying the mineralisation.

The Mudstone division forms a consistent band of rock having, in general, normal sedimentary contacts with the upper and lower dolomite divisions. Lithologically it is very fine-grained, dark grey, non-schistose, apparently derived from a fine, black mud, breaking with a characteristic subconchoidal fracture.

Within the division there occur two or three bands of more dolomitic appearance, concordant with each other and with the sedimentary contacts of the mudstone. These are apparently sedimentary bands and are composite in detail, having a central «rib» of white dolomite, sometimes with fine red banding. On both the hanging- and footwalls of this rib are bands of a reddish type of the mudstone. This latter is probably a transitional type of sedimentation since it was noticed at the bedded contacts between the mudstone and the enclosing dolomites. The junction between the mudstone and the lower dolomite as seen on the 10 fm and 30 fm levels is a normal sedimentary one. The change-over takes place through a transition zone 1—2 metres thick consisting of a very fine reddish mudstone very like that seen on the borders of the dolomitic bands within the body of the mudstone.

The upper junction of the mudstone is also non-tectonic and quite sharp, with no transitional facies.

The Upper dolomite unit is much more varied in lithology than the lower one, though it is not possible to give a complete account of the variations. The unit has been very much affected tectonically and by the ore forming solutions and, especially on the upper levels, it was difficult to detect any bedding. The dolomite types are mainly white or yellow in colour. Near the old stopes the rocks are considerably veined by irregular quartz stringers, and often softened and stained along planes of fracture, or marked joints. The upper dolomite as a whole appears more affected by solutions, more shattered and less competent than the lower one. It seems as if the whole rock has been crushed, and partly decomposed due to a spreading out of solutions whereas in the lower dolomite these have been concentrated along definite clear-cut zones.

Structures — Country rock.

The strike of the country rocks is roughly N 20° W (360° circle) over the area covered by the mine workings and the dip varies between 40° and 85° to the west. This variation in dip is probably due to large-scale folding, though limited exposure makes it difficult to deduce the exact form of the folds. Close, intricate folding occurs in the striped argillaceous dolomite along the Deep Adit but dies out before the lower dolomite is reached. The close-banding of dolomitic and argillaceous units in the rock seems to have rendered it incompetent, allowing deformation by folding to take place.

In the more competent, solid lower dolomite deformation has taken place by faulting and brecciation, producing structures favourable to the presence of ore.

It may be mentioned here that there appears to be a marked difference in the way the two dolomite units have responded to the deforming forces. The lower unit has responded much more 'cleanly' and thus contains more definite vein-structures than the upper one. The two vein systems investigated in the lower dolomite, marked as «Old No. 11» and «Labouchères» respectively on the old mine plans are definite tabular bodies which in thickness and areal extent far surpass anything observed in the upper dolomite. The so-called «Heavy-spar lode» may belong to the upper unit but this was inaccessible at the time of investigation.

The ore bodies in the upper dolomite appear to have been irregular in the extreme.

Vein structures. (I) Lower dolomite.

There are two main vein systems in the lower dolomite with a much less important vein between them (see fig. 2). They possess certain features in common which may be conveniently mentioned first.

Both seem to consist of zones of breccia or crush of varying widths. In these zones occurred the bodies of worked ore which are now represented by the empty stopes. Within each zone remain pillars and other remnants of the original crush zone which did not contain sufficient values to be worked. It is only by these somewhat scarce remnants that the natures of the vein systems can now be determined.

The breccias consist of an unsorted mass of fragments of all sizes occurring in roughly tabular vein-like forms varying between one and three or four metres in width. The constituents in most of the exposures visited are predominantly pieces of crushed mudstone, even where the walls on either side are of solid dolomite. Other constituents are minor in amount and comprise quartz, dolomite and a conspicuous red calcite. Cementing material is sometimes an iron carbonate, but more often it is lacking and the breccia is cemented by the products of its own attrition. The breccias are in many places intersected by irregular, rusty shear planes representing late movements along the veins.

Loose blocks of ore occurring sparsely in the old stopes, and specimens in the Geologisk Museum, Oslo, indicate that in the worked parts of the veins the copper sulphides occurred as cementing material in the breccia, and that a greater proportion of the fragments consisted of dolomite.

The actual mechanics of the faulting which presumably produced the breccias is not clear. Although the zones strike at high angles (60° — 90°) to the bedding of the country rocks, mapping did not reveal any displacement of the sedimentary contacts along the vein zones. Also the presence of a breccia of mudstone fragments within vein walls of solid dolomite finds no easy explanation.

Within the vein systems the ore-shoots, as represented by the worked stopes, show well-defined plunges. Figures 3 and 4 are longitudinal sections showing the ore-shoots in each of the two main veins in the lower dolomite. These figures also show the traces of the base of the mudstone, and it can be seen that the upper boundary of the ore-shoots coincides with this fairly well. The workable bodies were to a large extent confined to the dolomite and died out rapidly as the vein systems entered the mudstone. In some instances the old stopes terminate abruptly at the footwall of the mudstone, e.g. the stopes belonging to the «Old No. 11» system on the 10 fm level.

«*Labouchères Lode*». This vein which is the most northerly one on the property and which lies approximately 30 metres north of Monk's shaft, has a strike of $N 40^{\circ} E$. The workings on it are mainly confined between the 20 and 30 fm levels. Below the 30 fm level the ore shoot has been followed for a vertical distance of ca. 15 metres, at which distance it apparently bottomed.

The old stopes vary in width between one and four metres, the

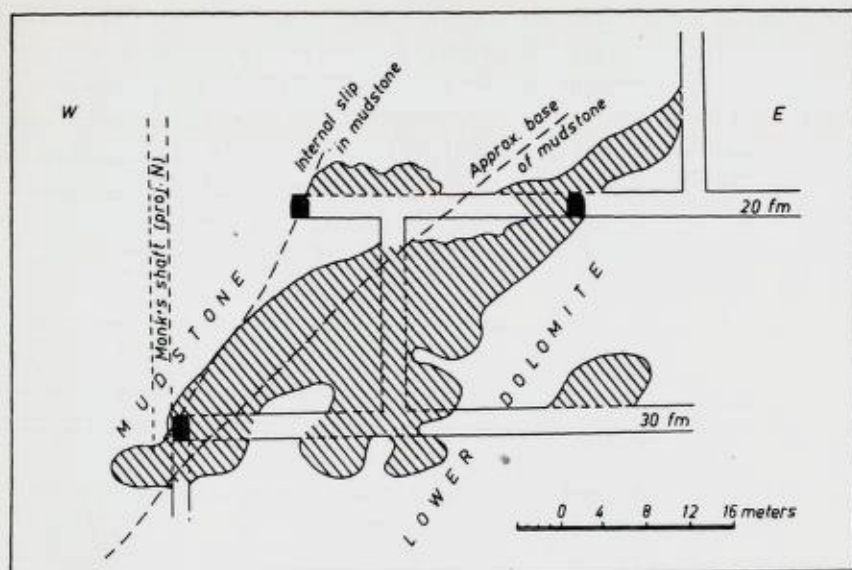


Fig. 3. Ore-shoot pattern on «Labouchères Lode» in the lower dolomite.
 Lengdesnitt gjennom malmkroppen i «Labouchères gang» i den undre dolomitt.

greatest widths occurring in a vertical part between the 20 and 30 fm levels. Above the 20 fm level the somewhat narrower (1—2 m) stope has a dip of 65° to the north. As the stopes widen out beneath the 20 fm level they become practically vertical until the level below. Beneath here, there is a small, narrow stope in which the dip has flattened to 35° . In the very bottom the dip steepens again to 55° . It cannot be deduced what has caused the marked changes of dip beneath the 30 fm level, but whatever it was it has resulted in a pinching out of the oreshoot and Labouchères lode can be considered to have bottomed within 20 metres below the 30 fm level.

«Old No. 11 Lode». The longitudinal section of this vein system (Fig. 4) shows that it is confined entirely to the lower dolomite, the footwall of the mudstone forming a clear upper boundary to the ore-shoots. Several parallel and separate ore-bodies have been worked in the lode, varying in width from 4 metres to ca. 1 metre. On the 20 fm level there are stopes along both sides of the level drive and, in the east, along the drive itself. A stoped area north of the drive can be little studied due to its being almost full of ice, but it appears to have been up to 3 metres wide, and

rises above the level, underneath the footwall of the mudstone. The stopes to the south of, and over the drive are rather irregular, and it appears they represent bodies of ore within the breccia zone which here must have been 5 to 6 metres wide. It is probable, especially in the most easterly of the stopes, that working was not confined to the breccia alone, but that a certain amount of the dolomite walls has been taken out too. This might indicate that there was a certain amount of impregnation ore in the walls. However, the present walls of the stopes are completely free from sulphides.

The stopes on this system fall almost vertically to the 20 fm level, where they are combined into one continuous working about 35 metres long and 2 to 3 metres wide. The strike of this working changes rather markedly from N 45° E in the eastern part to nearly N 15° E in the westerly part.

The cross-cut east from Monk's shaft to this working reveals anomalies in the geological structure, particularly in the relation of the mudstone to the dolomite. The upper boundary of the mudstone and the dolomitic bands within it dip to the west, consistent with the general dip of the rocks in the mine. However, about 2 metres from the stope there occurs a sharp faulted junction, between mudstone and overlying pink dolomite, dipping 27° to the east.

It is considered that this flat-dipping fault has been responsible for the abrupt termination of the «Old No. 11» structure below the 20 fm level and has been responsible for the non-appearance of the normal sedimentary footwall of the mudstone. The displacement indicated is a down-throw of the footwall, i.e. it has been a reverse fault. This leads to the interesting possibility that there is a faulted continuation of Old No. 11 vein below the 20 fm level. If so, this continuation would lie somewhat to the east of the exploratory drives and cross-cuts of the 30 fm level.

The workings on the «Old No. 11 Lode» above the 10 fm level were inaccessible at the time of the investigation, and no firsthand knowledge of them could be obtained. From the old mine sections and plans it appears that this lode has been ore-bearing right from the surface, through a vertical distance of some 50 metres. The true width of the ore-shoot on it was about 25 metres and it plunged at about 50°. A rough estimate of the tonnage of this vein, the largest ore-producer on the property, gives about 7000 tons, a little over half the total tonnage from the mine.

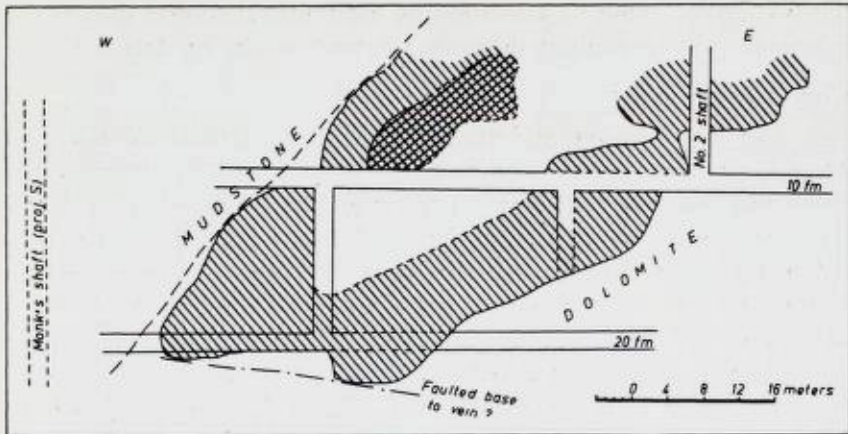


Fig. 4. Ore-shoot pattern on «Old No. 11 Lode» in the lower dolomite.
 Lengdesnitt gjennom malmkroppen i «Old No. 11 gang» i den undre dolomitt.

(II) Upper Dolomite. (Fig. 5).

The orebodies worked in the dolomite lying above the mudstone, in so far as they could be investigated, appear in marked contrast to those in the underlying dolomite. They exhibit no regular system, and do not appear to form continuations of the veins in the lower dolomite. It is evident that the ore occurred as irregular, roughly equidimensional blocks or masses scattered at random in the country rock. These masses varied in maximum horizontal dimensions between 10 metres and 2 to 3 metres. The workings on them are in the shape of irregular 'rooms' up to 10—12 metres high. One such room having roughly equal horizontal dimensions of about 5 metres extends between the 10 and 20 fm levels in the section to the north of Monk's shaft. Mapping indicates that these irregular bodies were interconnected by fractures or perhaps major joints along which the ore-forming solutions circulated. These openings are now represented by decomposed, rusty, often malachite-stained breaks and these formed guides for the mine workers in discovering the ore-bodies. No system can be deduced in these fractures, they seem to be the result of a through-going failure of the dolomite. This difference in response to tectonics between the two dolomites is one of the most striking features of the geology of Raipas and must be due to an initial difference, either chemical or structural, between

the two layers. Due to alteration of the upper dolomite during the mineralization this initial difference cannot easily be detected.

Conclusions.

The investigation and study of the Raipas mine do not give great hopes that further ore bodies can be found by development from the present workings. The vein structures have evidently bottomed at or about the 30 fm level and evidence from winzes below this level must be considered to indicate no continuation in depth. An interesting possibility is a faulted continuation of one of the veins, but the target appears too small to warrant the expense of drilling or development to test this.

The value of the investigation has been that an idea has been obtained of the structural controls of ore in the mine which can be used as guides in a wider survey of the potentialities of the Raipas formation as a whole, particularly the sedimentary portions of the formation. The following facts emerge as regards the control of the ore bodies in Raipas mine:

a) dolomite layers are hosts to the ore which dies out rapidly in adjoining mudstone bands.

b) the dolomite layers vary in their favourability.

c) the most promising targets are tabular bodies occupying breccia zones almost at right angles to the strike of the enclosing sediments and plunging at the angle of dip of the sediments.

d) widths of oreshoots may not be more than 20—25 metres and, e.g., borehole spacing should take account of this.

e) thicknesses of ore-bodies vary between 1 and 5 metres.

f) the ore-bodies appear to bottom structurally and not by any change of mineralization.

Literature.

- 1) Holtedahl, O. 1953: Norges Geologi. Norges Geologiske Undersøkelse Nr. 164.

Sammendrag:

Iakttagelser ved Raipas gruve i Alta.

Raipas gruve i Alta kommune er en gammel gruve som tilhørte det engelske gruveselskapet Alten Copper-works Ltd. i det 19de århundre. Den produserte 12 500 tonn koppermalm à 6,3 % Cu i en 30 års periode, men har ikke blitt drevet siden.

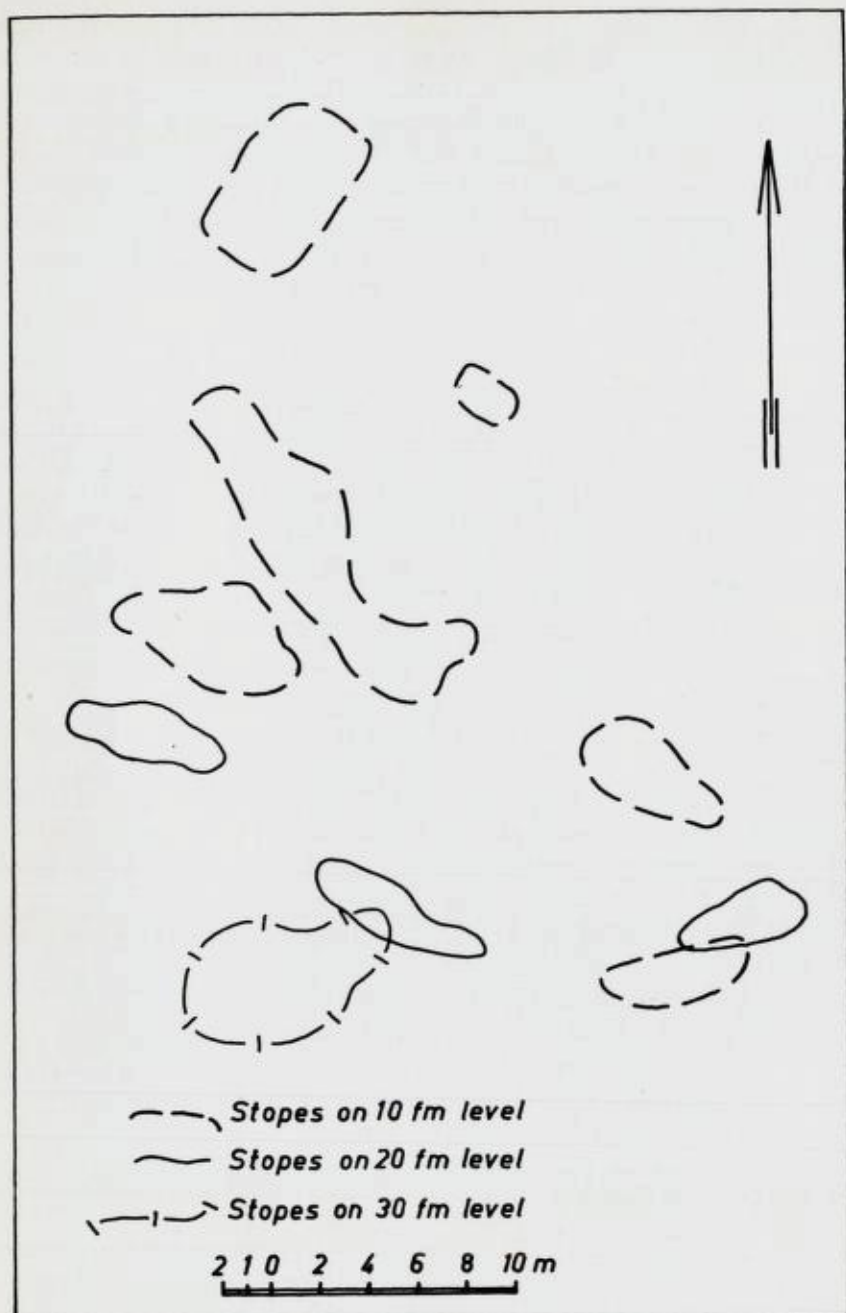


Fig. 5. Irregular ore bodies in the upper dolomite as shown by old stopes.
Kart over strossene (i forskjellige nivåer) i den øvre dolomitt, som viser de uregelmessige malmkroppene der.

Forekomsten forekommer i undre del av Raipasformasjonen som i området omkring bunnen av Altefjorden danner et tektonisk vindu under de flattliggende kaledonske skifre. Formasjonen består av grønnstein, skifer og dolomitt som er tydelig foldet, og står på skrå, til dels loddrett, med noe vekslende strøk.

Inne i selve gruen består bergartene av to dolomittlag, ca. 20—25 meter tykke, med et leirsteinlag innimellom, 10—14 meter tykt. Strøket er ca. N 20° V med et fall mellom 40° og 85° vestover.

Malmsonene står i forbindelse med de to dolomittlag, men har vært tydeligere, mere gjennomgående og viktigere i den nedre dolomitten. Her har det vært to hovedsoner som bestod av tavleformete, nesten loddrette breksjesoner med tykkelser mellom en og fem meter. Retningen av dem var nesten rettvinklet på strøket av bergarten. Det finnes ingen malmrester i gruen, men prøver fra den tidlige driften viser at ertsmineralene, kopperkis og broget kopper forekom innimellom de breksjerte stykker av dolomitt. Malmkroppene i den nedre dolomitten er blitt skarpt begrenset av leirsteinen. Malmkroppene i den øvre dolomitten var forholdsvis små, og ganske uregelmessige.

Konklusjoner.

Raipas-undersøkelsen gir ikke håp om at mere malm kan finnes fra den gamle gruen. Den viser at malmkroppene har blitt drevet helt ut og at hovedgangstrukturene ikke fortsetter under de nåværende strossene. Undersøkelsen har gitt en del kjennskap til malmkroppenes form og mektighet, og kan kanskje brukes i et fremtidig program for Raipasformasjonen som en helhet.

a) dolomittlag er mest lovende for malmdannelsen og gangene fortsetter ikke i leirsteinlag.

b) alle dolomittlag er ikke like lovende.

c) de mest lovende «targets» er tavleformete kropper som ligger i breksjesoner som skjærer de steiltstående sedimentlag i en nesten rett vinkel. «Ore shoots» stuper ned med en «plunge» som svarer til bergartenes fall.

d) bredden av malmkroppene er sannsynligvis ikke mer enn 25 meter — dette må det tas hensyn til i et eventuelt borprogram.

e) tykkelsen av malmkroppene varierer mellom 1 og 5 meter.

f) grunnen til forsvinningen av malmkroppene er strukturell. Det vises ingen forandring i malmmineraler i dybden.