THE GEOLOGY OF TVERRFJELLET

A preliminary report for Folldal Verk A/S

by

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THE GEOLOGY OF TVERRFJELLET

The rocks of the Tverrfjellet - Hjerkinn area are part of the lower Trondheim Schist series, most likely of Lower Ordovician age and are situated on the northern limb of a major syncline in the Caledonides. The general stratigraphy of the area is represented in Figure 1. where it is compared with the probable succession at Folldal, on the opposite side of the syncline. Trondheimites are seen in both areas. The entire sequence has been metamorphosed during the Caledonian orogenesis up to epidote - amphibolite grade and consequently most original structures have been destroyed.

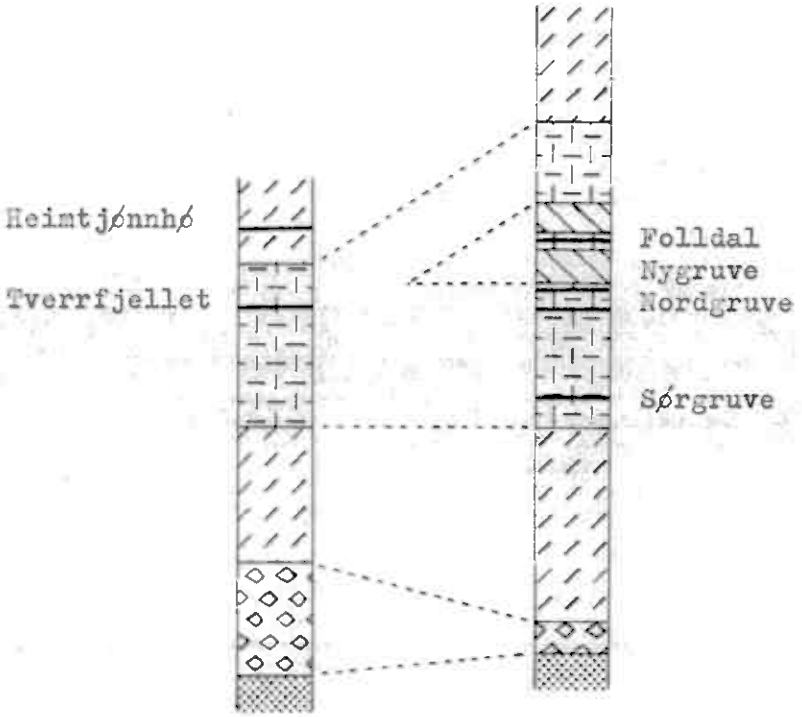
At least three distinct ore horizons are recognised in the Hjerkinn area and undoubtedly more will be found as the geophysical surveys are already suggesting. Stratigraphically the lowest horizon is that including the Tverrfjellet orebodies though this is, in fact, a multiple horizon and its relation with the Vesleknatten horizon is not quite certain. The middle horizon includes the Heimtjønnhø orebody and is probably that also seen at the Lispynten prospect and on the south side of Geitbergfjell (see Map 1.) as a band of graphite schists. Some small prospects at Raataasjøhø reveal graphite and sulphide schists which represent the third and highest horizon.

The surface geology was mapped in an area around Hjerkinn and the results are shown on Map 1.

THE GREENSTONE GROUP

This 2000m. thick group of rocks, of which only the upper part has been studied, appears to represent a volcanic sequence including basic lavas, acid pyroclastics, agglomerates and various basic tuffs mixed with sediments.

The dominant rock types are amphibolite and hornblende schists which grade into each other through a wide range of lithologies. There are also subordinate garnet schists, quartz-mica schists and chlorite schists. These probably represent waterlain sediments containing a variable proportion of volcanic material.



orebody

mica schists

greenstone

trondheimite

augen gneiss

sparagmite

Vert. scale - 1cm. = 1000m.

FIGURE 1

Stratigraphy of
Hjerkinn and Folldal

The basic lavas are well exposed on Tverrfjell where they form thick bands, often amygdoloidal and including some very scoriaceous horizons. However pillow lavas have not been observed as is characteristic of this group of rocks in Central Norway.

The common thick bands of quartzites are rather impure as they contain considerable proportions of various mafic minerals and sodic felspars. The precise genesis of these is at present in doubt.

The conglomerate which forms a clear marker horizon near the

top of the greenstone group is very likely of volcanic origin i.e. it is an agglomerate. It consists of large flattened white pebbles in a matrix of either a fine grey salic material or a coarser, darker and more femic schist. At the western end of the outcrop it thins and gets finer and then appears to pass into an amphibolite.

THE MICA SCHIST GROUP

Overlying the greenstone group is this series of quartz rich mica schists including and grading into thick bands of impure quartzite. These represent sandy waterlain sediments with a varying quantity of argillaceous material.

THE TVERRFJELLET ORE HORIZON

This composite group of ore horizons can be followed across much of the area studied (see Map 1.). To the East geophysical work has also traced the horizon as far as the Kvitadalen, along which very likely runs a major fault. However to the West a fault cuts the horizon at about 1300m. West of the mine shaft. The movement appears to displace the western block about 300m. to the South and a geophysical anomaly about one kilometer West of the fault may represent the continuation of the ore horizon.

The ore horizons have been traced very easily both in the mine and on the surface by using a number of marker rock types. The locations of these rocks can be seen on Maps 1 and 2 and they are briefly described below :-

Magnetite-quartz rock and black quartzite

These rock units are very abundant in the zone of multiple ore horizons stretching from the orebodies eastwards to just beyond the main road, E.6. They are very fine-grained, black magnetic rocks containing dominant quartz with abundant magnetite, muscovite and garnet. Due to their hardness they stand out as ridges on the buried rock surface and are usually rusty in outcrop.

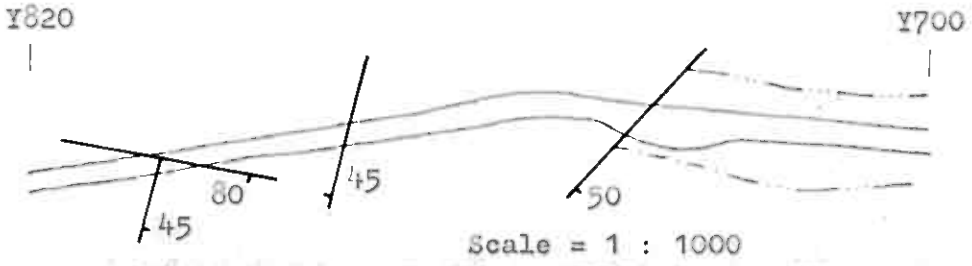


FIGURE 2 Faults on level 2 Tverrfjellet Mine

Sulphide schist and impregnation zones

Consisting basically of disseminated pyrite or pyrrhotite with chalcopyrite in typical hornblende schist, this lithology is very common throughout the area indicating a number of minor non economic ore horizons. These impregnated schists are particularly useful in tracing the ore horizon eastwards beyond the limits of the magnetite - quartz rocks. Even further away from the orebodies this lithology grades into a graphite-pyrrhotite schist of the type so common in the Folldal area.

White quartzite

In parts of the eastern end of the mine the ore horizons are only distinguishable by these bands of clean, white, relatively pure quartzite containing a variable amount of small disseminated pyrite and chalcopyrite.

Calcite schist

Carbonate-rich schists are commonly found in the mine (see Map 2.) and invariably are close to the ore horizons. In some cases large white calcite rhombs make the rock easily recognisable but in other cases the small grain of the calcite makes the rock indistinguishable from the common hornblende and mica schists.

It is probable that these rocks are all the result of peculiar contemporaneous sedimentary conditions close to the area of deposition of the sulphides which now form the orebodies. The first two types above represent respectively the oxidising and reducing phases of sediments only slightly oversaturated with iron.

THE TVERRFJELLET OREBODIES

Three lenticular orebodies are known at Tverrfjellet of which two are exposed in the mine (see Map 2.). The copper - poor orebody lies to the North on a stratigraphically lower horizon and consists dominantly of uniform fine-grained pyrite. The copper - rich orebody lies about 70m. stratigraphically higher and the Western, so far unexposed orebody, is probably on the same horizon. The mineralogy of these two orebodies is more variable and magnetite, chalcopyrite and pyrrhotite form a more significant proportion of the ore, while sphalerite appears in relatively constant amounts in all three orebodies. A band of banded quartz-magnetite-pyrite ore about 10m. thick and 30m. wide has a curved line through the centre of the copper - rich orebody and may represent an original sedimentary zoning of the ore.

The zone of faults which occur between Y=720-820 on level 2 and the Grop on the surface obscures the relationships between the orebodies on each side of them. The main faults seen on level 2 are shown in Figure 2. The inclination and large imbrication zone of the westernmost fault suggests it may be the same one as that in which the Grop has been formed and it is reasonable to expect this fault to have the most significant displacement of the group. Slickensides are only visible at one place, on the North - South striking fault at Y=805 on level 2, where they run down the dip of the fault plane, showing a purely vertical movement.

The possibility of the location of an orebody at and below level 2 to the West of the fault zone is of first importance economically. However with the nature of the faults so unexplored at present there is little evidence for forming any satisfactory hypotheses. However two important observations can be made :-

1) In borehole 10 the western orebody is about 25m. thick and yet this is only 40m. above level 2 where there is no ore. This rate of thinning is totally inconsistent with that observed on the other orebodies.

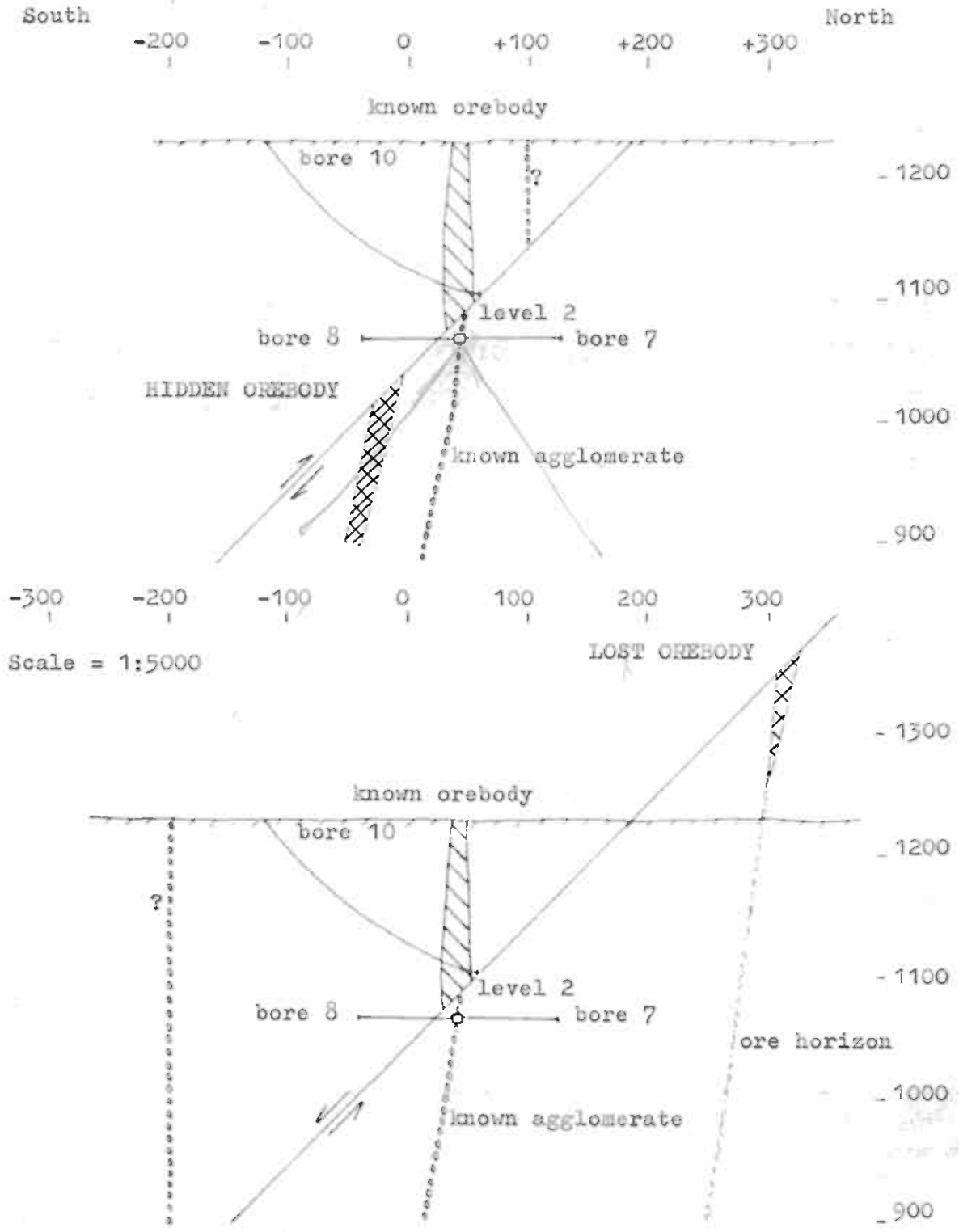


FIGURE 3 Two theoretically possible sections through West end of Tverrfjellet at Y=920.

2) Nowhere on level 2 or in boreholes from it are found any of the "marker rock types" (see above) associated with the continuation of the ore horizon beyond the limits of the other orebodies.

It therefore seems likely that there is a fault striking parallel to and passing just over level 2, and terminated at its eastern end by one of the younger faults in the main zone at Y=760. Evidence for the form of this fault can only be drawn from observations on level 2 and here the rocks are of a distinctive type. The dominant quartz hornblende and mica schists are typical of the whole area but a number of bands of coarse agglomerates similar to those seen at Hjerkinn station and a very coarse garnet amphibolite are quite distinctive. Nowhere else in the vicinity of the mine are there agglomerates of such a coarseness, abundance and thickness. In a structural region of this nature it is more likely that any fault will be steeply inclined and two possible structures are shown in Figure 3. In either case it will be seen that the location of the agglomerates at or near the surface would be a useful guide to the likelihood of any possible hidden orebody.

However the similarity of the agglomerates on level 2. with those at Hjerkinn station suggest a further possibility. This is that the agglomerates could be the same horizon and have been displaced to the mine by a horizontal or low angle thrust with a North - South movement of about 500m., again passing just over level 2. In this case any continuation of the western orebody at depth would lie under the ridge of Tverrfjell hill. However the presence of a large thrust like this with no visible association structures is a geological improbability.

THE HEIMTJØNNHØ - LISPYNTEN ORE HORIZON

This ore horizon lies about 500m. from the top of the greenstone group in the mica schist series (see Figure 1.). It is only visible at three localities and so it cannot even be certain that one continuous ore horizon exists.

At Heimtjønnhø an isoclinally folded, steeply dipping orebody

occurs in quartz-hornblende-garnet schists. There are two distinct varieties of ore, a typical coarse hornblende rich pyrite and a very fine-grained pure pyrite resembling, in hand specimen, that being mined at Løkken; however the relationships of the ore types is at present unknown. Then on the South side of Geitbergfjell (see Map 1.) is a zone of graphite schist with, as usual, a band of quartzite just below it. Further to the West, just above Vaalaasjø, at Lispynten, is a small old, weathered prospect revealing a small irregular body of very fine impure pyrite containing some chalcopyrite segregations. The wall rocks are quartzites and trondheimites but considerable remobilization has destroyed the precise stratigraphy.

The first two localities are on the same stratigraphic horizon but the Lispynten occurrence cannot be accurately located stratigraphically due to faulting and the interference of the trondheimite and gabbro. Further exploration of this horizon may reveal economic ore but work on the greenstones is likely to be more rewarding.

THE RAATAASJØHØ ORE HORIZON

Much higher still in the stratigraphic succession is an ore horizon so far only seen on the eastern side of Raataasjøhø. Here four small prospects have been excavated in an horizon of pyrrhotite bearing graphite schists lying close to bands of quartzite in a succession of hornblende and garnet schists. This feature is typical of ore horizons in the Folldal area but is very limited as a precise guide to economic orebodies.

CONCLUSIONS

The conclusions reached in this report may be summarised as follows :-

1) The greenstone group of metamorphosed rocks represent a

complex and varied volcanic sequence and are associated quite typically with sulphide orebodies.

2) Three widely separated ore horizons are recognised but all the evidence still points to the upper two horizons being economically unimportant beside the multiple Tverrfjellet horizon.

3) The western orebody in Tverrfjellet mine has been terminated at depth by a fault whose displacement is at present unknown but may be very large.

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