Massive sulphide occurrences in the Birtavarre Mining Field

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For Scandinavian Resources AB

Birtavarre Mining Field

Scandinavian Resources AB was granted exploration licences covering the Birtavarre Mining Field in 2011. The purpose of this report is to make a short summary of historical exploration and geology of the area.

The Vaddas – Birtavarre area includes several Caledonian semi-massive to massive sulphide deposits at four stratigraphic levels in the Oksfjord Group of the Vaddas Nappe in the Upper Allochton of the Reisa Nappe Complex. The lower boundary of the Oksfjord Group is marked by unconformity to the underlying metasedimentary Kvænangen Group, whereas the upper boundary is a thrust contact to the overlying Kåfjord Nappe. The Oksfjord Group is dominated by pelitic metasediments, but also includes a greenstone unit, the Loftani Greenstone Member, which partly comprises pillow basalts. The greenstone unit is situated in the lower part of the group in the area around Vaddas, where it attains a thickness up to 500m.

The mines and prospects of the Birtavarre area are scattered over a belt some 30 km long and 12 km wide. The main concentration lies in the south-east and contains the most important of the old workings, namely the mines at Moskogaissa, Skaide and Sabetjok. Separated from these (in Kåfjorddalen) are a small number of mines and prospects in the valleys of Skardalen and Manndalen.
The first recorded find of ore in Kåfjorddalen occurred in the 1860`s when a small sample load was excavated and sent to Alten Copperworks (Kåfjord in Alta, Finnmark). In 1894 the deposit later to be called Sabetjok mine was discovered and the mining investor Chr. Anker got hands on the claims. A prospecting programme resulted in the finding of a series of similar deposits. Anker was joined by an English company to found the Norwegian Copper Mines Ltd. which put up a smelter in Ankerlia in 1898, started production in Moskogaissa and constructed a ropeway between the mine and the smelter, followed by construction of a 12 km long horse railway from Ankerlia to the sea and an electric power station. The mined ore was hand-sorted and exported either as lump ore or as matte.
Following a destructive fire at the Moskogaissa 115 mine in 1903, the company was declared bankrupt and the English Venture Corporation took over the mines. In 1907 A/S Sulitjelma carried out diamond drilling in the area. In 1908 the roof of Moskogaissa 117 collapsed and the workings filled with mud and water, in which condition they have remained to the present day.
A new company, A/S Birtavarre Gruber, was formed in 1909 by Venture Corp and Norwegian interests, and Moskogaissa 115 was brought into production again in 1910. During the second period (1910-1919) the mines at Sabetjok and Skaide were brought into operation and in 1914 the company was transferred entirely to Norwegian hands. In 1919 the smelting works burned down, as a result of which the operations had to cease.
The total amount of ore produced in Kåfjorddalen is approximately 200 000 tons at an average grade of 3.8 % Cu.

The operations were based on the mining and smelting of a rich sorting-ore. During the last years a small dressing plant using primitive bulk flotation methods was set up, more in the nature of a pilot plant. Concentrated ore did not contribute in any appreciable way to the

mines` total production. Some of the prospects were not developed because they consisted mainly of `concentrating ores` with cupper content between 2-3 %. In this class come some of the Sabetjok and Skaide ore, and the prospects of Birtavarre Høyfjell and Monte Carlo.

Renewed interest for the Birtavarre Mining Field after WWII resulted in that Kåfjord Herred (municipality) claimed all known occurrences in 1949 and in the period 1952-1955 the area was investigated by NGU by means of geological mapping, geophysical surveys and diamond drilling (Padget 1955 and Vokes 1957). It seemed clear at the beginning of this 4-years survey that a present-day industry could not be based on the small, irregular, high-grade ores (typical for the Birtavarre Mining Field), such as those worked in the past. Attention was therefore focused on proving or disproving the existence of workable quantities of ore which could be treated by modern ore-dressing methods (Vokes 1957), and such is our focus today, having in mind that most of the lower-grade, concentrating ore was left by the early miners, leaving a hope that these could be significant enough to possibly exploit.

However, ending a 4-years exploration programme, Vokes (1957) leave a negative conclusion: “The total amount of copper-bearing sulphides contained within the Ankerlia Series in the Birtavarre district probably reaches considerable proportions. However, it is clear from the geological account that these sulphides are dispersed along a number of horizons within the schists (roughly concordant with the bedding and schistosity of the schists), each having a large areal extent and being separated from the ones above and below by up to several hundreds of metres. It appears that in no one horizon have the sulphides been concentrated enough to give an ore-body big enough to form the basis for a mining operation. This is a direct result of the weak controls acting during ore deposition. Nowhere was there any control, structural or otherwise, which was strong enough to arrest and impound the ore-bearing solutions. Consequently these spread out and dispersed along the several zones of breccia and shear. The conclusion must be reached, therefore, that under foreseeable conditions of price and supply of copper metal, a mining industry could not be restarted in the Birtavarre district.”

Vokes (1957) favoured an epigenetic model for the Birtavarre sulphide accumulations, where the ore solutions were emplaced along late-stage thrust- and shear-planes in the schists. He classifies the mineralisations in two types: the more or less massive sulphide-cemented breccias, breccia ore, and impregnation ore, where the deformation of the country rocks produced sheared and crushed zones instead of definite breccias, and the sulphide-bearing solutions found their way along what openings and cracks were available to them.
Vokes describes the texture of the impregnation ore to be very irregular, from dispersed sulphide disseminations to alteration rocks like garnet-chlorite schist where the sulphides, often coarse-grained, have been deposited in between the chlorite foliae, and have molded themselves around the euhedral garnets. This could resemble stringer zones occurring below VMS- or sedex-deposits, and could suggest an alternative to the epigenetic model, i.e. that the sulphide layers represent reworked sedimentary-exhalative deposits of the Besshi-type.

The Birtavarre mineralisations occur as very irregular plates, greatly elongated along one axis, and of very variable dimensions, in fact described as extreme variations in thickness over short distances. Concerning the ore mineralogy, Vokes (1957) says: “Pyrrhotite and

chalcopyrite together probably constitute 95 % of the sulphides in the area, with subordinate sphalerite and accessoric galena. Pyrite is only present in the Sabetjok-Birtavarre Høyfjell area. Sphalerite shows an erratic distribution. While present in all the ores to some extent, it is only a significant mineral at Moskogaissa 125, Skaide, and at Moskodal mine (in the Vaddas region)." This statement, concerning the zinc content, is incorrect, which is shown by the Ore Database assays (see below). They prove the Zn grade to be significant in many of the deposits along Kåfjorddalen (in addition to Skaidi). His view could have been influenced by the older reports, which strongly underestimates the zinc content. Alteration associated with mineralisation includes assemblages as anthophyllite, garnet-anthophyllite, garnet-anthophyllite-staurolite and garnet-chlorite schists.

To continue where we left three chapters above, before Vokes` negative and realistic conclusion, in order to locate the possible lower-grade ore left behind by the earlier miners, some short comments on each deposit:

Sabetjok and Birtavarre Høyfjell
As earlier mentioned, the deposits are found in different stratigraphic levels within the Ankerlia Formation (partly associated with small greenstone bodies), the stratigraphically lowermost being Sabetjok. Only 14 000 t of ore was mined from the deposit before it was considered exhausted and abandoned. According to old reports the thickness varied between few cm to 3 m with average content of 1-1.6 % Cu. Poulsen (1940) states that Zn is enriched in the southernmost deposits, and the assays of the Sabetjok Ore Database samples show 0.2-0.4 % Zn, which is not enhanced compared to the deposits to the NW, rather contrary (see below).

At the same level, about 2 km ESE of Sabetjok, is the small working known as Birtavarre Høyfjell. It is a great variability concerning the thickness in the old reports, while agreement prevails about 100 m length. Thesen (1937) maintains 1-8 m thickness and Quale (1916) 2-6 m. Vokes (1957) refers to "old reports speaking of an old drill hole intersecting 10 metres of 2 % Cu ore, but the location of the borehole was not given. Apparently the type of ore was not suited to direct smelting and no production was attempted in the period of activity at the beginning of this century". He concludes: "The investigations indicate a rather localized body of fairly rich quartz-sulphide ore. Indications are that it is not more than 100 metres long, 50-70 m wide and from less than a metre to perhaps 5 m thick." 2 bulk samples taken by NGU in 1954 assayed 2.74 and 1.37 % Cu respectively.
Samples from the Ore Database assayed 0.1-0.2 % Zn and 270-600 ppb Au. Thesen (1937) maintains that no Au or Ag was found in any ore assays from any of the deposits, while on the other hand the Bessemer copper assayed approximately 13 g/t Au and 120 g/t Ag.

A 1500 metres drilling program in 1955, based on a Turam survey, was laid out primarily to cover a main conductor between Sabetjok and Birtavarre Høyfjell and identified possible resource of 300 000-400 000 t at 1.20 % Cu with an average thickness of 1.4 m (both thickness and copper contents vary very markedly) (Vokes 1957).

24 drill cores totalling 2110 m are stored at Løkken under the name Birtavarre Høyfjell – some of them could possibly originate from Moskogaisa.

Vokes mentions a rust zone occupying a level 150 m below Sabetjok and Birtavarre Høyfjell. It can be followed over several kilometres as a rusty shear zone with sulphide impregnation. 1.5 km ENE of Birtavarre Høyfjell insignificant excavations expose parts of this zone, showing dissemination of chalcopyrite, sphalerite and malachite (and up to 213 ppb Au) in both amphibolite, Ankerlia schist and hydrothermal quartz over approximately 2 m thickness (*Loapmi*, the Ore Database).

Skaide

The Skaide deposit is associated with amphibolites stratigraphically above the Sabetjok level. It is situated distant to the other deposits, 10.5 km NE of Moskogaissa 115. Probably because of the distant location and scarcity of exposures, the mineralisation was first discovered in 1911. About 24 000 t of ore with 4.4-6.2 % Cu was produced between 1911 and 1919 of a total initial resource of 56 000-84 000 t (Vokes 1957). The Skaide ore contained much more zinc than the other deposits (?), and was also richer in copper and lower in pyrrhotite. Samples from the Ore Database assay 4,1-7.6 % Zn, up to 0.7 % Pb, and are anomalous in a variety of analysed elements compared to the other deposits.

Reports give the length of the outcropping mineralisation to 300 m, of which 200 m was said to be continuos. Of this length only 70 m constituted workable ore under the conditions prevailing at the time (a rough estimate of the average thickness in the old stoped areas is between 1.5 and 2 m). The rest showed concentrating or (2-2.5 % Cu) and was left in the ground.

A Turam survey at Skaide in 1954 revealed several fairly weak electro-magnetic indications. The main conductor was about 500 m long and up to 200 m wide. This lays with its long axis east-west and its southern boundary almost coinciding with the northern edge of the old mine workings. After due considerations it was decided that the indications found at Skaide did not warrant the expenditure of money for diamond drilling – the resources available were concentrated on the much clearer and stronger indication at Sabetjok (Vokes 1957).

4 km east of Skaide a small stringer mineralisation is outcropping (*Geatkkutoaivvit*, the Ore Database). Stringers of chalcopyrite and thin quartz bands are bound to a 30-40 cm thick amphibol schist which is hosted in metagreywacke. 0.6 % Cu and 0.14 % Mn. This is supposedly close to the level of the Sabetjok-Birtavarre Høyfjell zone which is 8-10 km to the SSW and/or the *Loapmi* rust zone, which occupies a level 150 m below the Sabetjok-Birtavarre Høyfjell zone.

Moskogaissa

There were three mines or workings in the area of which only one, Moskogaissa 115, had any noteworthy production. This was the largest of the mines in the Birtavarre area, mining an ore plate about 300 m long and 60 m wide. Even shortly after the start-up of mining, when the ore mined seems to have been exceptionally rich, reports stressed the sharp variations in thickness (0-5m) which led to an unusual amount of development in order to follow the ore successfully. With an average thickness of in excess of 1 m, approximately 60-70 000 t of copper ore with 5-6 % and up to 8 % Cu was extracted (Vokes 1957).

According to Aronsen & Hunger (1919) the mineralisation consists of two separate layers with 5-6 m thick schist between.

The mine is flooded and the workings cannot be inspected at all, and most of the surrounding area is covered by thick moraine.

About 1200 m to the west is Moskogaissa 117, which produced some 3000 t of ore with 6 % Cu, and 900 m to the east is Moskogaissa 111, which produced only 1800 t of Cu ore. According to Vokes (1957) magnetite-rich schist occur 600 m west of no 117 and at no 120 (consisting of a 1-2 m thick horizon of altered schist with weak sulphide impregnation), where magnetite-bands appear in the schist. Within the bands the subhedral to anhedral magnetite grains were intimately intergrown with the silicates, strongly suggesting simultaneous crystallisation. Speculations can be made, if this is distal exhalations, i. e. iron formations.

Geophysics and drilling in the area in 1953-54 revealed no new resources, and also showed that an old estimate of 100 000 t of resources in the Moskogaissa 111 deposit probably does not exist (Vokes 1957). The drilling results again illustrated the extremely erratic nature of the sulphide mineralisation.

Monte Carlo
Thesen (1937): Consists of impregnation ore with 2 % Cu and is therefore not well known. Outcropping along 120 m length, about 4 m thick.
The Ore Database: Sulphide-impregnated altered schist within shear zone, up to 10 m thick (thickening at the hinge of anticline).
Resource calculation by Quale (1916): 96 000 t.

Borsejok
Thesen (1937): Mainly impregnation type of little interest during the mining period. Outcropping length almost 150 m, variable thickness from 4.5 m with about 4.5 % Cu to 0.5-1 m of 2 % Cu. Resource calculation by Quale (1916): 27 750 t at 2.75 % Cu.
The Ore Database: Covered by scree. Atypic mineralisation with zinc dominating copper. Up to 7.2 % Zn and 1.5 % Pb.

Little is known about the size of the following occurrences:

Olderneset øst
10-30 cm thick breccia mineralisation. Ore Database assays: up to 10 % of each Cu and Zn, 0.5 g/t Au, “no” Pb.

Olderneset west
Dissemination and stringers of pyrrhotite and chalcopyrite in the entire thickness of a 7 m thick shear zone, but are concentrated in the upper 1-1.5 m. Sulphides hosted in both chlorite schist and quartz vein. 0.5-0.7 % Cu.

Goikegårsa
Ore Database assays up to 3.5 % Cu, 2.4 % Zn and 0.09 % Pb.

Hanskijohka
Up to 30 cm thick pinch-and-swell shear zone with pyrrhotite, chalcopyrite, sphalerite and galena. Gossan. Up to > 10 % Cu, 1.9 % Zn, 2.1 % Pb.

Somewhat separated from the Birtavarre mining district are a small number of mines and prospects in the valleys of Skardalen and Manndalen. Very few records exist from these areas.
8-10 km NW of the Moskogaissa area, a mineralised horizon outcrops in the steep sides of the deeply eroded valley of Skardalen, where ore was won from two mines on the western slopes of the valley, while small diggings occur a few other places.

Brattfjellet
The mine was worked in the periods 1906-08 and 1915-18 and produced about 500-700 t ore containing 4.5-6.0 % Cu each year. The mineralisation has a strike length of 140 m and 4 adits, up to 110 m long, are driven into the cliff.
Within a 5-6 m thick shear zone the altered schist contain stringers of pyrrhotite and chalcopyrite, varying between 5 and 20 cm, though in places irregular clumps of massive sulphides of much bigger dimensions (1-2 m thick) occur. Brecciation occurs locally, with sulphide infill between fragments.
According to Haslum (1918) the massive ore zone is 0.3-2.5 m thick, containing 6-8 % Cu, with an impregnation zone above, containing 1-4 % Cu.
Ore Database samples assay up to 0.7 g/t Au.

Skarfjellet
According to Vokes (1957) the mineralised zone is of very variable width, varying between 5-50 cm and is apparently concordant with the surrounding schists. The zone is brecciated and sheared schist and quartz which has been infilled by sulphides. Metasomatic alteration of the schists above the sulphides has produced up to 20 cm of garnet-anthophyllite rock.
According to Haslum (1918) the mineralisation contains 9-10 % Cu, and according to the Ore Database Skarfjellet is distinctly enhanced in Zn (up to 0.6 %) and depleted in Au compared to the nearby Brattfjellet.

Toppfjellet
Chloritic garnet-amphibole-biotite schist is within 1-2 m thickness sheared and rusty, carrying patches of pyrrhotite and chalcopyrite. In a narrow band, 10.20 cm thick, near the top of the rust zone, shearing and chloritisation is more pronounced and the stringer-mineralisation is stronger, up to 0.5 % Cu (Ore Database).

Skardalen
The greatest thickness of sulphide observed is about 1 m and this decreases fairly rapidly along strike in each direction. It is typically 10-20 cm thick massive breccia mineralisation overlain by 40-50 cm thick mica schist with sulphide dissemination.
Assays from the Ore Database show even > 10 % Cu and up to 1.5 % Zn.

Drill cores from the Birtavarre district stored at Løkken

Cores from 24 holes totalling 2110 m are stored at Løkken under the name Birtavarre Høyfjell – some of them could possibly originate from Moskogaisa.

Recommendations

The above stressed irregular mineralisation geometries and the limited sizes of the presently known ones in the Birtavarre mining field does not encourage and justify heavy exploration efforts in this area.
However, one should consider drilling at Skaide based on the existing Turam survey, to define the size of the left behind concentrating ore with 2-2.5 % Cu and assumed considerable amounts of Zn.

In the western claim area, Skardalen, due to limited “ore” sizes, the common great variation in geometry and in any case the steep hillsides making diamond drilling almost impossible, no follow-up is recommended.

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