CONTRIBUTIONS TO THE MINERALOGY OF NORWAY

No. 7. Cassiterite in the Bleikvassli ore.

BY

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Bleikvassli Gruber A/S in Nordland fylke, some 50 kilometres south of Mo i Rana, (Fig. 1) is at the present mining about 100,000 tons per year of pyritic lead-zinc ore. Economic products are lead, zinc and pyrite concentrates. During the course of a systematic mineralogical examination of samples of the ore, the writer detected the presence of small, rounded to euhedral grains of a brown mineral in the heaviest, non-magnetic fractions. Optical and x-ray powder determinations proved this mineral to be cassiterite (SnO_2)[1]. Following this, cassiterite was observed and studied in thin sections of the Bleikvassli ore. Colorimetric determinations of the SnO_2 content of the ore were also made on more than 30 samples. At the same time, a large sample of the mine tailings was examined mineralogically and chemically. Cassiterite, being non-flotable or nearly so, would not be recovered in any of the concentrates being produced at the mine and would therefore report in the tailings. These are at the present time being allowed to fill up a small lake and thus would be available for re-treatment if the amount of tin in them should prove to be economically recoverable.

[1] Subsequently the writer was informed by ing. Henning Fangel, of Bleikvassli Gruber A/S, that cassiterite had been previously detected during metallurgical experiments with the Bleikvassli ore in the laboratories of American Cyanamid.

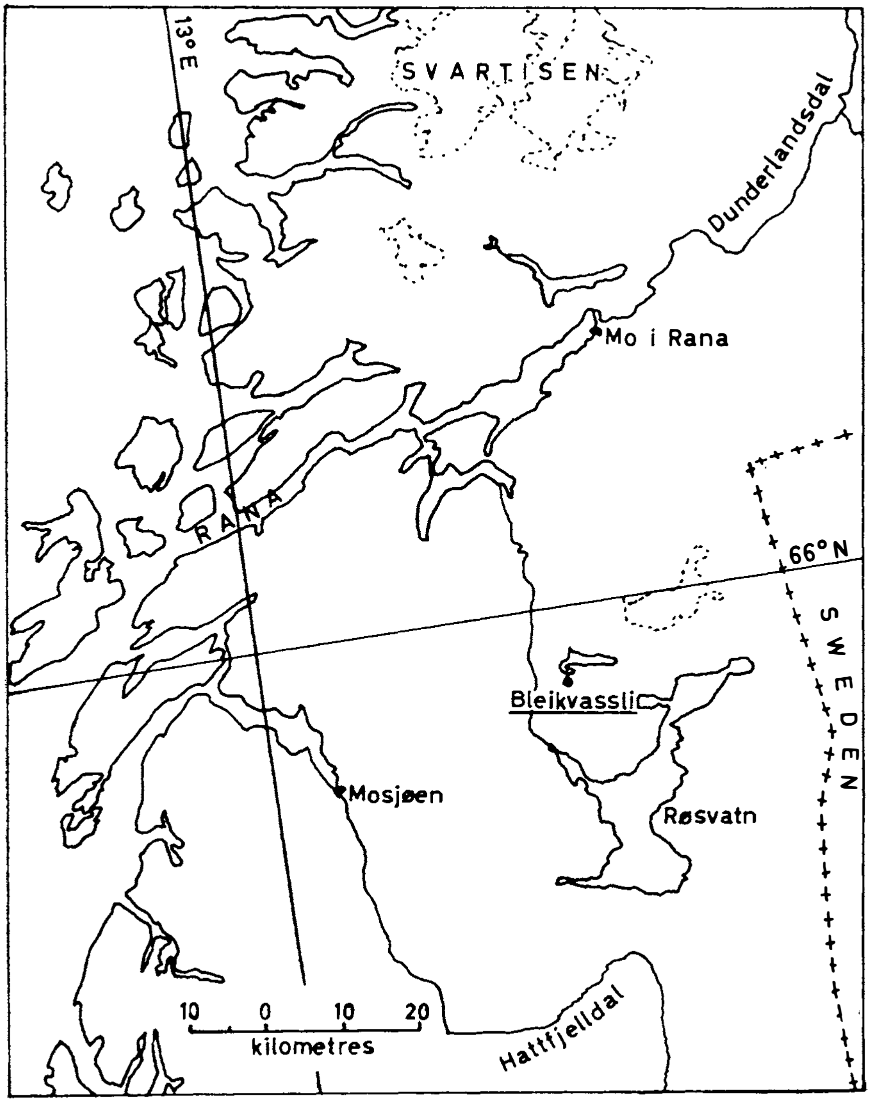

Fig. 1. Map of part of Nordland county, Norway, showing the location of Bleikvassli mine.

Apart from the economic possibilities, the presence of cassiterite in the Bleikvassli ore is of considerable scientific interest. Cassiterite is, on the whole, a rather rare mineral in Scandinavia. In Norway it has only been reported from one other locality, Tørdal in Telemark, where cassiterite occurs together with cleavelandite, quartz and lepidolite in a granite pegmatite (OFTEDAL, 1942). MAGNUSSON (1953) mentions the occurence of cassiterite in granite pegmatites, including lithium-rich types, at several localities in Sweden, while LANDERGREN (1943) reports the possible presence of the mineral in iron ore at Grängesberg.

On a world-wide scale the presence of cassiterite in pyritic lead-zinc sulphide ores is not at all common. Perhaps the most well-known example of the association is the ore at the Sullivan mine, Kimberley, British Columbia (PENTLAND, 1943). Here cassiterite is recovered as a by-product from an ore with an average content of about 0.05 % Sn.

LEA and RANCOURT (1958) mention the presence of cassiterite in the pyritic lead-zinc-copper ores of the Brunswick Mining and Smelting Company in Gloucester County, New Brunswick, but give no details regarding its mode of occurrence.

General Geology.

The ore body at Bleikvassli is a series of interconnected and branching "plates" or lenses of solid sulphides lying concordantly between mica schists and gneisses, which form part of the Caledonian mountain chain. In the northern part of the mine a microcline-biotite-quartz gneiss forms the footwall. The ore has been opened up and worked along a strike length of about 400 metres, while the deepest exploration workings now extend to about 200 metres below the surface outcrop. The ore "plates" vary considerably in thickness up to a maximum of about 10 metres. Along the strike in both directions the plates thin out to mere stringers of sulphides some few centimetres thick. The general strike of the country rocks is roughly NE, while dips are to the west of the order of 50°—60°, locally steepening to vertical.

The ore-forming minerals are, in order of relative abundance, pyrite, sphalerite, galena, pyrrhotite and chalcopyrite. Molybdenite occurs as a very minor constituent in most of the ore (0.0028 to 0.0094 % MoS_2 in 11 samples) and other, as yet unidentified, sulphides have been seen in polished section in even smaller quantities. Some of these latter may prove to be tin-bearing minerals, but they seem to be quantitatively unimportant.

Grains of scheelite ($CaWO_4$) were identified by means of x-ray diffraction patterns in separated fractions of the ore. They were quite rare, and no scheelite has been observed in thin section. No wolfram could be determined spectrographically in the Bleikvassli ore samples (limit of detection 0.005 %).

The ore may be divided into two main types, on the basis of mineralogy and texture. The by far the most abundant type consists of granular, sub- to euhedral pyrite with a grain size of the order of ½ to 2 mm, interstitial to which are variable quantities of sphalerite, galena, pyrrhotite and chalcopyrite as well as gangue (non-sulphide) minerals. The pyrrhotite content of this main ore type is usually below 5 per cent and only exceptionally does it rise to over 10 per cent.

The other type of ore, which is very subordinate quantitatively, is almost or wholly lacking in pyrite, the place of which has been taken by pyrrhotite. The other minerals seem to have the same general ranges of abundance. The texture of this type of ore is very much finer grained than that of the pyritic type. The texture is also very irregular and the included gangue fragments show evidence of strong deformation. The pyrrhotite rich ore occurs in part of one ore "plate" in the central part of the mine and as strips along the hanging or foot walls of the "normal" ore in several different parts of the workings. This ore type may be primary or it may have resulted from the metamorphism of the pyritic type. It is hoped that the study of the Bleikvassli ore now in progress will enable this problem to be solved.

Cassiterite in the ore.

The study of the cassiterite is made difficult by its scarcity (average 0.04 % SnO_2 in 38 ore samples) and by the small grain size of the mineral. So far none has been recognised in hand specimen, even with the aid of a binocular microscope. In crushed and separated fractions of the ore cassiterite can be seen as rounded to subhedral grains, often showing poorly developed crystal faces (Fig. 2). The colour ranges from nearly colourless to dark brown and often it shows distinct variations within an individual grain.

The mode of occurrence of the cassiterite in the ore is best studied by means of thin sections. The high refractive indices, high birefringence and the usually irregular colour zoning make it normally easy

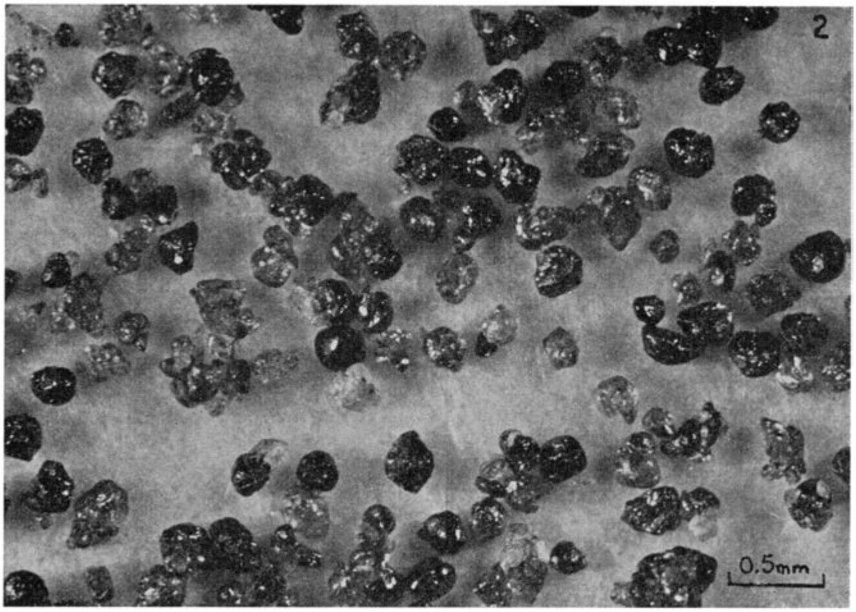

Fig. 2. Cassiterite grains separated from a crushed sample of the Bleikvassli ore.

to detect. Most thin sections of the massive sulphide ore contain at least two or three grains, in many it is much more abundant.

The maximum dimensions of fifty grains of cassiterite measured in thin sections ranged from 0.03 to 0.50 mm, with an average of 0.20 mm.

The grains show mainly subhedral to irregular cross sections with a greater tendency towards euhedral forms where they occur in patches of the quartz-mica gangue. Knee shaped twins were observed in a few instances, e.g. Fig. 3. A few other grains show short prismatic forms, but the majority tend to be equidimensional and rounded in outline. (Fig. 4). The cassiterite shows a very high relief and may be evenly colourless, or may show irregular streaks or patches of a light brown colour, normally dichroic. The coloured patches are often very indistinct and fade gradually into the colourless parts of the grains. The most common form of colouration is an indefinite annular ring with a colourless centre and rim; some few grains show a zonal colouration.

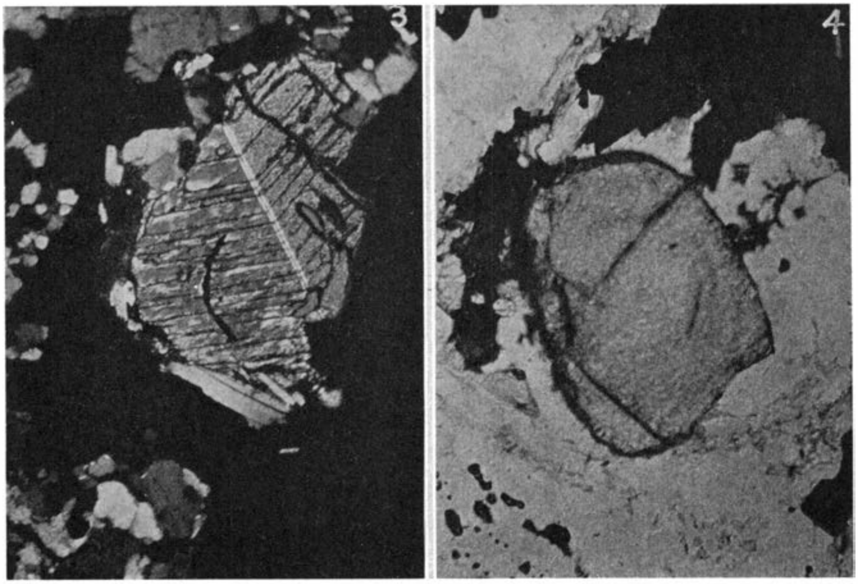

Fig. 3. Twinned grain of casiterite surrounded by sulphides, (black) mica and quartz. Crossed nicols. x130.
Fig. 4. Rounded grain of cassiterite in groundmass of quartz and sulphides. Ordinary light. x130.

The cassiterite is associated with all the main minerals in the ore, but statistically the majority of the grains occur in the quartz-mica gangue. They usually occur in an area of anhedral quartz mosaic and in most cases it is very striking that the grain size of the cassiterite is several times larger than the grain size of the quartz enclosing it.

Less often the grains of cassiterite occur isolated within the much larger grains of sulphide minerals, especially within idiomorphic pyrite grains.

Textural relations.

The full interpretation of the textures of the Bleikvassli ore is yet to be made. It is not yet clear whether they represent a paragenetical sequence of deposition or a crystalloblastic series resulting from metamorphism. The following remarks concern the apparent crystallisation relations of the cassiterite with respect to the other minerals without implying anything regarding the mode, or order, of introduction of the metallic components of the ore.

There is little or no evidence indicating a marked time difference of crystallisation between the cassiterite and the quartz and mica of the gangue of the ore. On the other hand there are indications that the main sulphides crystallised somewhat later than the gangue and the cassiterite. As far as the latter mineral is concerned this evidence consists mainly of fragments and irregular grains of the cassiterite set in grains and crystals of sulphides in a manner suggesting that the latter have surrounded and partly replaced the former. In one crystal of pyrite were seen three fragments of cassiterite in close proximity to each other, which were probably originally parts of a single grain. Cassiterite also occurs in small patches of the quartz-mica gangue which are clearly replacement residuals. In extreme cases of this type the cassiterite, with one or two attached quartz grains or mica flakes, occurs in the middle of a homogeneous mass of sulphides.

In addition a large grain of cassiterite was seen showing a prominent irregular fracture in which was deposited a thin veinlet of opaque sulphide.

Little direct evidence is at hand regarding the age relationship between the cassiterite and the molybdenite. Polished section work indicates that the molybdenite may have crystallised earlier than the major sulphides. Since scheelite has not yet been identified in thin section, nothing can be said of its place in the mineral paragenesis. However, it seems not unreasonable that the cassiterite, molybdenite and scheelite may be roughly of the same, somewhat early, age of crystallisation. There is, however, nothing to suggest that the metallic constituents of the ore were *introduced* at different stages. It seems most probable that they were all introduced simultaneously, but that some minerals crystallised before the others.

Discussion.

Pentland (op. cit. p. 20) mentions that in the Sullivan ore chalcopyrite, present in small amounts, may be taken as an indicator of tin values. Also pyrrhotite is more closely associated with the cassiterite than are the other common ore minerals. In the Bleikvassli ore no sympathetic relationship has so far been observed between the amount of tin and any other element or any mineral. (However, available analyses seem to indicate that there is a slight tendency towards a lower tin content in the pyrrhotite-rich type of ore described above). In addition no systematic variation in the cassiterite content has been observed along the strike or down the dip. There is however, a general tendency for the SnO_2 content to be higher in the wider parts of the ore. In samples taken across the ore body there is a tendency for the tin mineral to be concentrated towards the hanging-wall. This tendency seems to be more strongly pronounced where the sulphides occur in bands, separated by intervening, concordant, bands of schist. The study of the chemistry of the Bleikvassli ore is proceeding and a fuller report on the distribution of the tin values will be prepared.

The ore body at Bleikvassli is one of the large class of concordant sulphide bodies occurring in the Caledonian metallogenetic province in Norway. Normally the minerals pyrite, chalcopyrite, sphalerite, in very variable proportions, are typical for these ore bodies. However in certain sub-provinces, especially in southern Nordland and in the Ofoten district, galena makes its appearance, sometimes with a corresponding diminution in the content of chalcopyrite. The Bleikvassli ore belongs to this lead-enriched type, as do the ores at the Mofjell mine, Mo i Rana, and at several other, at present unworked, deposits.

It is not yet known how many more, if any, of these latter contain cassiterite. However, the scientific and possible economic interest attaching to the problem seems to warrant an extensive investigation of the mineralogy and geochemistry of the sulphide ores, and possibly also the granites, of the northern Caledonides as a whole, in order to determine whether the occurrence at Bleikvassli is of only restricted mineralogical interest or whether there is a widespread tin mineralization in the region.

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