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GOLD FROM FLÅT

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Six grains of gold were found in a sample taken from heaps at the now disused Flåt Nickel Mine. The paragenesis of the sample is described. The reflectance values of the gold are presented and the silver content calculated based on these values. Silver content measured in this manner corresponds to that found when a microprobe is used.

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During a five-year Telemark project (1962 to 1967), Svend Pedersen mapped an area in the northern part of the Iveland-Evje amphibolite. It included Flåt, where some samples from heaps at the now disused Flåt Nickel Mine were collected. The samples were intended for use in making a petrographic comparison of the amphibolites in the area, but on examining one of a few polished sections which were made from the samples, the author found six grains of gold.

The ore mineral paragenesis of this hand specimen will be described below, and, in addition, the reflectance values of the largest gold grain and its silver content found on the basis of these values will be presented.

Finally a microprobe analysis of the gold grain will be given.

Ore mineral paragenesis of the hand specimen

The gold-bearing hand specimen shows the contact between amphibolite and ore. From a petrographic point of view the amphibolite corresponds rather closely to that described by Barth (1947: 26–30), (S. Pedersen, pers. comm.).

The mineralized part of the hand specimen consists of equal amounts of pyrite and silicates, a small percentage of ilmenite, and about 1 % chalcopyrite. The pyrite is faintly anisotropic and occurs as grains of up to 5 mm in diameter. They are subhedral but, as characteristic of pyrite, are there euhedral character in contact with chalcopyrite while mostly anhedral with silicates. Some inclusions of chalcopyrite and also sphalerite, ilmenite, and silicates are found in pyrite.

The ilmenite shows a granular intergrowth with silicates, and is also seen at the contact between pyrite and silicates. The grains of ilmenite are slightly curved in shape and are about 0.25 mm in size. In one grain a fair-sized particle of hematite showing exsolutions of ilmenite was found.

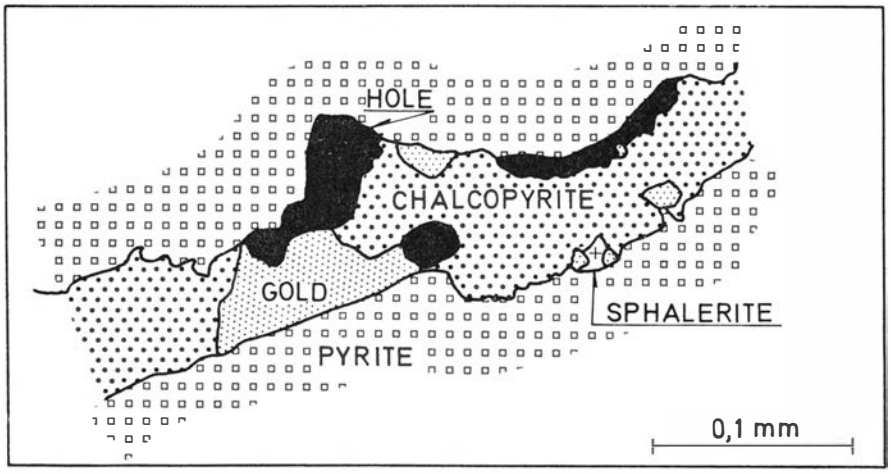

Fig. 1. Part of the gold bearing chalcopyrite vein showing the intergrowth of gold, chalcopyrite and sphalerite. Drawing from a photograph.

Chalcopyrite occurs between pyrite and silicates and also as inclusions within the silicates, or is interstitially placed among needle-shaped silicates. A small part of the chalcopyrite shows signs of being of more recent formation than the pyrite. It appears as thin veins along fissures in the pyrite or along the grain boundaries.

A few grains of sphalerite were seen in the chalcopyrite veins, and in one particular vein six grains of gold up to 0.1 mm in length were found (Fig. 1). The vein in which the gold was found also contained two grains of galena, each about 0.02 mm in diameter.

Bjørlykke (1947) has already described the paragenesis of the ore mineral from the Flåt Nickel Mine. Although he says that the contents of pyrite and chalcopyrite are higher in the disseminated than in the richer part of the ore, he is obviously right when in the same paper he draws attention to the fact that great variations in the ore make it quite impossible to obtain a hand specimen that is representative of the ore. One will quite naturally assume, because of the great difference in Bjørlykke's description of the paragenesis, that the hand specimen examined here must be considered as being uncommon in the Flåt area.

Ore minerals described by Bjørlykke:

Pyrite, pyrrhotite, pentlandite, violarite, millerite, chalcopyrite, ilmenite-hematite and magnetite.

Paragenesis of the hand specimen:

Pyrite, chalcopyrite, ilmenite-hematite, hematite-ilmenite, sphalerite, galena and gold.

Further emphasis of the difference between the two parageneses is found when their quantitative compositions are compared. The amount of pyrite

in the opaque minerals of the hand specimen was more than 90 %, while Bjørlykke found the pyrite content of the Flåt sulphide concentration to be only 3 %.

Reflectance values of gold and its silver content

The reflectance values of the largest grain of gold were:

NM	437	481	488	526	546	590	644
R %	35.5	56.0	60.0	72.0	76.4	82.5	86.2

These values are the averages of five measurements, the surface of the polished section being repolished from the 2.5 μm stage between each (for reproducibility, see below).

The reflectance standard referred to was SICA No. 85, calibrated by the National Physical Laboratory, London. No corrections for primary glare were necessary. Correction for secondary glare was based on the magnitude of secondary glare between neutral glass and the SICA standard, assuming linearity (Fig. 2). The correction curve for secondary glare (Fig. 2, curve No. 3) was found as follows: In the first place neutral glass was used as the standard in the measuring of SICA. The SICA reflectance value (at 481 NM) was found to be 22.3 R %, which is 1.3 R % higher than the absolute value. As shown in Fig. 2, these values are plotted on the graph in such a way that the absolute R-percents are the x-coordinates and the measured values the y-coordinates.

If the absolute value of neutral glass (4.51 R %) on the graph is connected with the measured value of SICA (23.3 R % – curve No. 1) and the absolute value of SICA (21.0 R % – curve No. 2), respectively, the magnitude of secondary glare can be read as the difference between the ordinates of curve Nos. 1 and 2. Neutral glass is the standard used here.

The reason SICA was chosen as the standard is explained below.

For R values higher than the SICA standard, the correction curve for secondary glare of measurements based on SICA was considered as being equivalent to the correction between neutral glass and SICA. Using SICA as the applied standard, and on the above assumption, the correction curve for secondary glare can be established by displacing curve No. 1 in Fig. 2 in such a way that the intersection between curve Nos. 1 and 2 is identical with the absolute value of SICA. This is how the correction curve for secondary glare was established (Fig. 2, curve No. 3). As the correction curve found was applicable to only one wavelength, it was necessary to establish a different curve each time a new wavelength was used for measuring.

In 1968, using equipment similar to that used here, Leow showed that the correction curve for secondary glare can be considered linear provided that the difference between the reflectance value of the standard and that of the specimen did not exceed 40 R %. Where differences were higher than

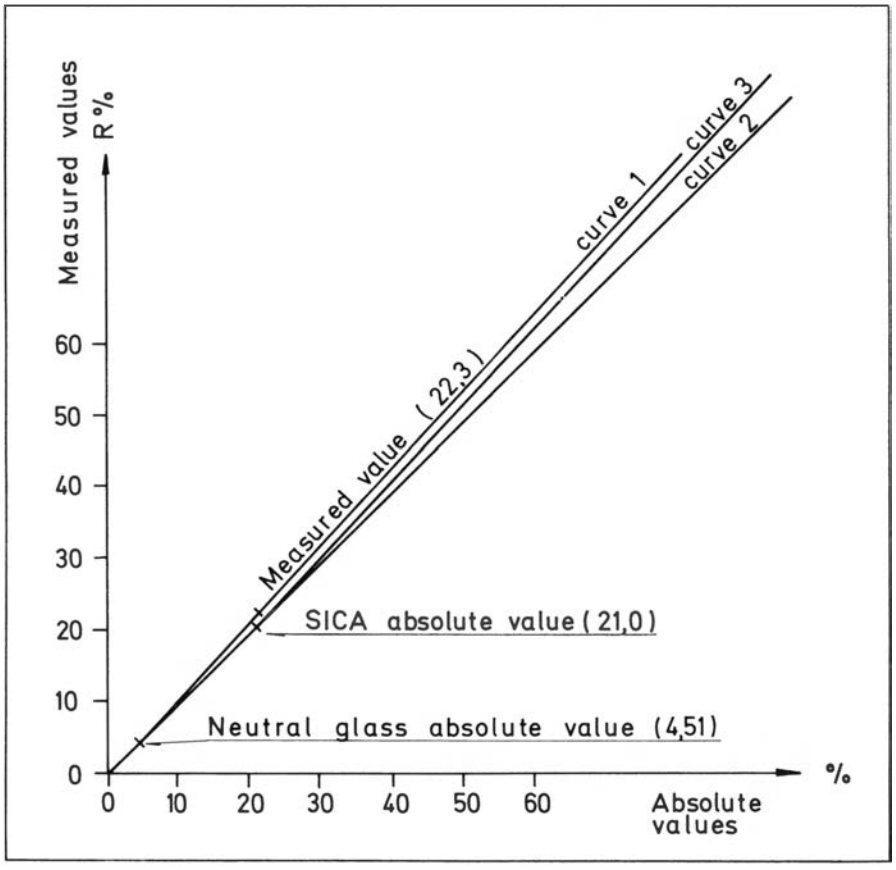

Fig. 2. Correction curve (curve 3) for secondary glare at 481 NM. For explanation see text.

40 R %, the exponential character of the correction curve for secondary glare should be taken into account.

Since the difference between neutral glass and gold is too great to allow a linear correction for secondary glare the use of SICA as the standard proved necessary in this particular case. The difference between SICA and gold is less than 40 R % between 437 and 488 NM and more than 40 R % between 526 and 644 NM. Consequently the reflectance values between 526 and 644 NM are a bit too high (Table 1). It is difficult to say how much, but the linear correction made for secondary glare within this interval seems to indicate that the difference hardly exceeds 1 or 2 R %.

One more lack of precision is found in the reproducibility of the measurements which is different at different wavelengths. Between 437 and 488 NM the margin of error is ± 2 R %. This phenomenon ought not be ascribed to the measuring technique, it is more likely due to an incorrect polishing process. In 1967, Eales discovered this and demonstrated that the reproducibility of measuring very much depends on the polishing process. He

Table 1. The silver content of gold.

NM	452	470	491
R %*	42.5	50.9	60.9
Silver content (percentage by weight) according to Eales (1967)	15.7	16.3	15.1
Microprobe analysis		15.93	

* The reflectance values are found by means of linear interpolation from the values measured.

found that the highest degree of reproducibility is obtained using wet polishing and that reproducibility decreases as the degree of dryness increases. He also found that, when using normal wet polishing, reproducibility is better at 470 NM than at 541 NM.

The polishing method applied to the process in this case can be described as a normal wet polishing. Diamond paste was the polishing agent and alcohol the lubricant. The grain sizes polished were 7 μm, 2.5 μm, 1 μm. The final polishing was performed in a water slurry of MgO. At this stage polishing did not go on for more than 2 minutes.

It has for long been well known that the reflectance value of gold rises as the silver content increases. On the basis of artificial materials, Eales established in 1967 how the reflectance values of gold vary in accordance with its silver content. From his investigations it appears that silver content is easiest determined between 452 and 491 NM since the greatest reflectance variation of silver content is found within this interval, which at the same time shows the best possible reproducibility of measuring. Calculation of the silver content of gold is therefore based on measurements within this interval only (Table 1).

As shown in Table 1 a microprobe analysis of the gold grain in question, carried out at the Metallurgical Institute of Danmarks tekniske Højskole, Lyngby, Danmark by R. Norbach, resulted in a silver content of 15.93 %. At the same time Cu and Pt metals were carefully looked for but none were found. These metals were obviously not present in the gold grain analysed.

The microprobe analysis was performed by means of an ARL-MICROPROBE, TYPE EMX. The standards used were pure gold and silver, and the measurement corrections were made according to a programme set up by Springer (1967).

Conclusions

The agreement in value between silver content determined by means of microprobe analyses and that found through reflectance measurements indicates that the latter can be a successful way of determining the silver content

of gold. This is noticeable when viewed in the light of the lack of international standards with high reflectance values and also of the satisfactory methods of polishing metals which involves great disadvantages.

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