

MINERALOGICAL MAGAZINE, VOL. 45, 1982, PP. 283-4

## A microprobe study of Ni-Co distribution about a schreibersite body in the Tocopilla mass of the North Chile hexahedrite [BM 1931, 13]

SCHREIBERSITE,  $(\text{Fe,Ni})_3\text{P}$ , is one of the oldest established and most extensively distributed of meteoritic minerals. It is encountered to a greater or less extent in most iron meteorites, in which it grows by solid-state exsolution from the metallic alloy matrix. Buchwald (1977) reported schreibersite to contain variable proportions of Ni in the range 10-50% and with the Ni content inversely proportional to crystal size. He reported that 'Cobalt is also present, but usually on a much lower level of 0.15-0.5%.' Morphologically, schreibersite may be present as massive crystals of low nickel content and of regular or irregular outline; as macroscopic laths, called 'Brezina lamellae'; as complex growths within plessite or upon pre-existing minerals or at the boundaries of the alloy phases kamacite and taenite; or as microscopic needles, called 'rhabdites'. It is a brittle mineral and if its size and shape are suitable it provides an easy pathway for the propagation of cracks when iron meteorites are subjected to impact.

Fig. 1 shows an array of schreibersite laths radiating from a central body of sulphide within the kamacite of the Tocopilla mass of the North Chile hexahedrite. The sulphide body, which is

slightly cracked, is composed of alternate thin plates of troilite, FeS, and daubréelite,  $\text{FeCr}_2\text{S}_4$ . The average composition of the mixed sulphide body is Fe 34.19, Co 0.05, Cr 24.19, S 41.58%. The average composition of the metallic matrix, kamacite, measured well away from the phosphide laths, is Fe 94.51, Co 0.41, Ni 5.05%.

The small particles of phosphide that have formed at the sulphide-kamacite interface have a nickel content of 26.8% with no detectable cobalt. The radiating laths have variable nickel contents in the range 25-29% and with cobalt ranging from 0.15% down to undetectable proportions. Since the average composition of the metallic matrix is ~5% Ni, 0.4% Co, it is to be expected that the growth of the high-Ni, low-Co, phosphide within the metal would modify the local composition of that metal and fig. 2 illustrates the Ni, Co variation by microprobe analysis at selected points within the kamacite of fig. 1 that lies between the schreibersite laths. It will be seen that there is a general tendency for these analyses to be enriched in Co and depleted with respect to Ni when compared with the average kamacite composition (represented by the large symbol in fig. 2). Axon

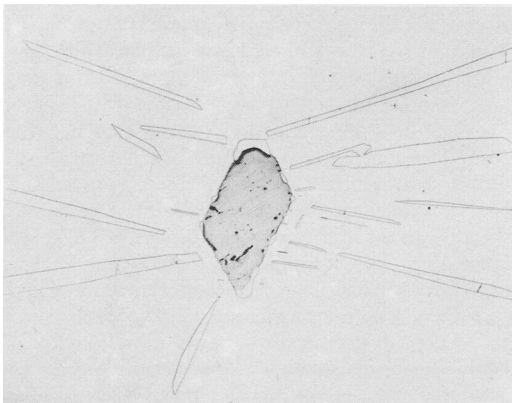


FIG. 1. Central mass of sulphide (dark, striated) with swathing schreibersite (light) and schreibersite laths radiating within a matrix of kamacite,  $\alpha$  Fe-Ni alloy. Reflected light, Nital etch, field of view  $1.1 \times 0.85$  mm. [BM 1931, 13].

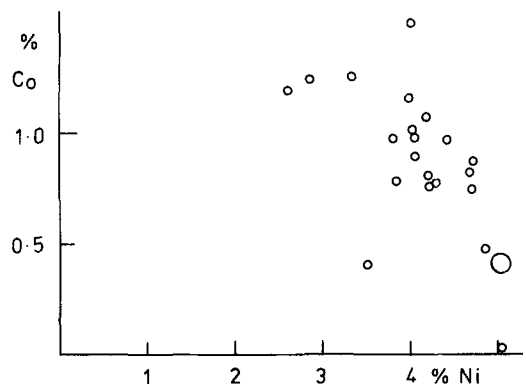


FIG. 2. Microprobe point analyses for Ni and Co obtained from the kamacite between the schreibersite laths of fig. 1. The large data point represents the average kamacite composition away from fig. 1. Note that the usually accepted 'Meteoritic' range of Ni-Co contents lies to the right, beyond the large data point on this figure.

*et al.* (1980) have drawn attention to this effect and have noted that the areas of metal bounded by the laths of brittle phosphide are of size appropriate to the small volumes of metal encountered in lunar soils. Thus there is a mechanism by which the growth of the mineral schreibersite within iron meteorites may pervert the local Ni, Co composition of small areas of metal from the values that are usually regarded as 'meteoritic' and the mutual disposition of the metal and phosphide may also be such as to allow metal of perverted composition to break away preferentially into small fragments.

*Acknowledgement.* We are grateful to the British Museum (Natural History) for the opportunity to examine the fragment of the 2.5 kg holding of BM 1931, 13.

## REFERENCES

- Axon, H. J., Nasir, M. J., and Knowles, F. (1980) *Phil. Trans. R. Soc. A* **297**, 7-13.  
 Buchwald, V. F. (1977) *Ibid.* **286**, 453-91.

© Copyright the Mineralogical Society

*Metallurgy Department, University of Manchester, Manchester M1 7HS*

H. J. AXON  
 M. J. NASIR

MINERALOGICAL MAGAZINE, VOL. 45, 1982, PP. 284-5

## A re-examination of the type forbesite

'FORBESITE' was collected, described and analysed by D. Forbes\* (1863) as a 'hydrous bibasic arseniate of nickel and cobalt' from a locality 'about 20 leagues to the eastward of the port of Flamenco' in Chile, and was named by Kenngott (1868). The formula proposed by Forbes,  $(\text{Ni},\text{Co})_2(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$ , was modified by Dana (1892) to  $\text{H}_2(\text{Ni},\text{Co})_2(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$ , and further by Palache *et al.* (1951) and Fleischer (1971) to the  $7\text{H}_2\text{O}$  hydrate, all on the basis of Forbes' original analysis.

Mrose *et al.* (1976) examined a topotype specimen of forbesite by qualitative scanning electron microscopy, infra-red spectroscopy, and X-ray diffraction, and showed their sample to consist of a mixture of cobaltoan annabergite with arsenolite. Unfortunately these authors could not find the whereabouts of the type specimen of forbesite and did not analyse their material quantitatively, using Forbes' original analytical data in their interpretation, giving a Ni:Co ratio of approximately 2:1, although their published X-ray intensity against energy profile suggests a much higher ratio, more in line with our results (see Table I).

The type specimen of forbesite is in the D. Forbes Collection in the Manchester Museum, and bears

\* David Forbes (1828-76) was a well-known chemical geologist and Fellow of the Royal Society, who travelled widely in South America in search of Ni and Co ores. On his death, his mineral collection passed to the Manchester Museum.

the acquisition number N8649. The specimen is accompanied by Forbes's label, undated, bearing the inscription 'Chanaralite (new species Forbes), a Hydrous Bibasic Arseniate of Nickel and Cobalt, near Chanaral, Desert of Atacama, Chile, South America'. Chemical analytical results are appended, in Forbes's handwriting, and are identical with those published (1863). The  $7 \times 6 \times 3$  cm specimen consists of an interlacing network of pale greenish-grey transversely fibrous veinlets about 2 mm wide, in a yellowish-grey clayey matrix; no silvery 'metallic' minerals are present (the specimen examined by Mrose *et al.* (1976) carries rammelsbergite). The veinlet material matches Forbes's description of his 'new species'. Comparable specimens in the same collection have somewhat different labels. One, dated 1858 has 'Arseniate of Nickel and Cobalt, between Tres Puntas and Puerto Flamenco, Desert of Atacama, Chile', and one, now in the author's collection (RSWB 67-159), dated 1859, has 'Arseniate of Cobalt and Nickel, mine near Monte Cristo between Tres Puntas and Flamenco, Desert of Atacama, Chile'. Mrose *et al.* (1976) identify the locality as one now known as 'Potrerillos mine'.

Samples of the fibrous veinlets from the type specimen were crushed, and purified by flotation using bromoform and diiodomethane, the material being heavier than the former but floating on the latter, followed by selection of pure-looking fibres under the microscope. The resulting material gave