

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.

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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

TABLE I. Analyses of 'forbesite', annabergite, and erythrite, wt. %

| Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----------|------|------|------|------|------|------|------|------|
| Ni | 29.4 | — | 15.5 | — | — | — | 26.0 | 27.2 |
| Co | — | 29.5 | 7.3 | — | — | — | 2.5 | 1.9 |
| (Ni + Co) | 29.4 | 29.5 | 22.8 | 21.8 | 21.7 | 22.5 | 28.5 | 29.1 |
| Ni:Co | — | — | 2.1 | — | — | — | 10.4 | 14.3 |
| As | 25.0 | 25.0 | 28.7 | 27.8 | 27.7 | 28.6 | 26.2 | 25.8 |

1. Annabergite (theoretical).
2. Erythrite (theoretical).
3. Forbesite, Forbes's analysis (1863) recalculated to wt. %.
4. Forbesite, Forbes's formula (1863).
5. Forbesite, Dana's formula (1892).
6. Forbesite, Palache *et al.*'s formula (1951).

New analyses, using atomic absorption spectroscopic analysis.

7. Forbesite, sample 1, 20.5 mg analysed.
8. Forbesite, sample 2, 29.8 mg analysed.

infra-red spectra and an X-ray diffractometer trace identical with those obtained from authentic specimens of annabergite. No arsenolite absorptions or diffraction maxima were detected. Two small samples of the material, from separate veinlets, were analysed for Ni, Co, and As, using atomic absorption methods, by J. Woodward of Perkin-Elmer Ltd., Beaconsfield, Bucks., and the results are shown in Table I.

The new analyses can be seen to fit slightly cobaltoan annabergite rather than Forbes's formula or its later derivatives. The slight excess of arsenic and slight deficiency of (Co + Ni) could be explained by the presence of a little arsenolite, or perhaps by a small amount of cation substitution by Mg(II), which is very common in annabergite but was not looked for in the analyses. The differences between our analyses and those of Forbes may be due to differences in sampling, but more probably to incomplete separation of nickel and cobalt in Forbes's procedure, the latter leading to the wide difference in reported Ni:Co ratios.

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