

## ANALYSIS OF HAMLEY BORNITE FROM SOUTH AUSTRALIA

E. G. ZIES AND H. E. MERWIN,  
*Geophysical Laboratory, Carnegie Institution  
of Washington, Washington, D. C.*

### ABSTRACT

The physical and chemical analysis of a bornite from the Hamley Mine, Moonta, South Australia, is given. The composition of the selected sample conforms very closely indeed to that demanded by the formula  $\text{Cu}_5\text{FeS}_4$ .

The analysis of bornite given in this paper was made at the request of J. W. Greig and H. E. Merwin of this Laboratory, who, after its purity was established, used it in connection with their work on the Cu—Fe—S system. This material was selected for them by W. F. Foshag and bears the U. S. National Museum number R702. It came from the Hamley Mine, Moonta, South Australia.

Preliminary microscopic examination revealed the presence of small amounts of quartz and of a reddish alkali feldspar, and microscopic examination of polished areas showed the presence of a very small amount of a second opaque mineral as minute irregularly shaped particles in the bornite. An adequate sample was coarsely crushed by gentle tamping and the coarse gangue removed by hand-picking. The tamping was continued until all particles passed through a 30 mesh bolting cloth; everything finer than 118 mesh was rejected. Examination with the microscope had shown that this range of particle size was just about right to yield by means of an electromagnet almost complete separation of the bornite and fine-grained gangue. This size was also well adapted for the chemical analysis, especially so since the error introduced by oxidation of finely divided sulfides was avoided.

Several hundred grains of the purified sample were mounted, polished, and examined in polished section. The only opaque substance, other than bornite, found in the grains was a whitish mineral, which a careful count showed was present to the extent of 0.1%. This impurity has not been identified and hence is not accounted for in the analysis given in Table 1. Its amount is, however, too small to significantly affect the results.

X-ray analysis of the selected material by J. V. Smith showed that its pattern was identical with that of bornite ( $\text{Cu}_5\text{FeS}_4$ ). Since neither the microscopic examination nor the x-ray analysis proves that this bornite does not contain material in solid solution, or sets a limit to the possible content of such material, the sample was subjected to chemical analysis.

The procedures used in determining the various constituents were essentially those given by Hillebrand, Lundell, Bright, and Hoffman (1953). It should be mentioned, however, that since no method for analyzing bornite is given in this book we feel that it is desirable to give a few salient analytical details. It is, of course, well known that a substance is rarely completely precipitated in a chemical analysis. For this reason we tried to recover as well as possible the amounts that escaped into the filtrates. We found that the sulfur in bornite can be completely oxidized to sulfate, without separation of free sulfur, by the Allen and Bishop method for pyrite (see Hillebrand *et al.*, 1953, p. 712). When the sample was completely decomposed, the oxidizing acids were destroyed in the usual manner with hydrochloric acid. The small amount of residue

TABLE 1. ANALYSES OF HAMLEY BORNITE

	1	2	3	4	5	Average
Cu	63.10 <sup>a</sup>	62.99 <sup>b</sup>		62.92 <sup>b</sup>	62.93 <sup>b</sup>	62.99
Fe	11.07 <sup>c</sup>	11.12 <sup>c</sup>		11.20 <sup>d</sup>	11.16 <sup>d</sup>	11.14
Co						0.05 <sup>b</sup>
Ni						0.01 <sup>b</sup>
S			25.46	25.54	25.44	25.48
Residue <sup>e</sup>	0.18	0.25	0.28	0.23	0.23	0.23
Sum						99.80

<sup>a</sup> Weighed as metallic Cu after separating from Fe with H<sub>2</sub>S.

<sup>b</sup> Weighed as CuCNS and corrected for its solubility.

<sup>c</sup> Through KMnO<sub>4</sub> after reduction with H<sub>2</sub>S.

<sup>d</sup> Weighed as Fe<sub>2</sub>O<sub>3</sub>.

<sup>e</sup> Examined microscopically before ignition and found to consist of quartz and alkali feldspar.

<sup>f</sup> Determined on a separate sample.

insoluble in acids was determined by ignition and weighing in the same manner as for silica. When viewed under the microscope before ignition it was found to consist of quartz and a flecked alkali feldspar. Additional brief details of the analytical procedure are given in the footnotes to Table 1. In addition we should like to mention that especial attention was given to the determination of the sulfur content of the bornite. As can be seen in the case of analyses 4 and 5, all three constituents and the residue were determined in the same sample. This is possible because copper and iron can be almost completely separated from SO<sub>4</sub> in boiling solution by a double precipitation with a slight excess of measured amounts of a solution of pure sodium carbonate. The end point is reached when the precipitate turns black. The filtrate is essentially a

solution of sodium sulfate. It is diluted to 500 ml., acidified to the extent of 1.0% HCl and barium sulfate precipitated in boiling solution. It is well known that the weight of barium sulfate is subject to a plus error. The correction is easily applied by the C. E. Waters method (see Hillebrand *et al.*, 1953, p. 721). The SO<sub>4</sub> content is determined for a solution that contained an amount of pure sodium sulfate equivalent to the sodium carbonate used in the precipitation of the copper and iron. The procedure used in making this determination must be the same as for the unknown. The difference between the theoretical and the found values is, of course, the correction.

If we deduct the residue and recalculate the average values we obtain:

	Hamley bornite	Cu <sub>5</sub> FeS <sub>4</sub> *
Cu	63.13	63.31
Fe	11.18	11.13
Co	0.05	
Ni	0.01	
S	25.54	25.56
Sum	99.51	100.00

\* Values based on International Atomic Weights of 1951.

It is obvious that the chemical analysis of this bornite selected from the sample obtained from the Hamley Mine in South Australia conforms closely to the accepted formula Cu<sub>5</sub>FeS<sub>4</sub> and agrees well with the analyses of the purest bornites given in *Dana's System of Mineralogy* (1944, p. 196). We also wish to state that our evidence agrees with the opinion so well expressed by E. T. Allen in 1916: "Aside, then, from those slight variations in composition which are so common throughout the mineral kingdom, and which are due to foreign admixtures or to solid solution, there is, in my opinion, no satisfactory evidence that natural bornite is variable in composition, or that it is ever of any other composition than that expressed by the formula Cu<sub>5</sub>FeS<sub>4</sub>."

#### REFERENCES

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