

MINERALOGICAL NOTES

ENARGITE IN THE ZINC-LEAD DEPOSITS OF THE UPPER MISSISSIPPI VALLEY DISTRICT

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Arsenic is a minor element in the ores of several lead and zinc districts in the Mississippi Valley. In some districts arsenic minerals have been identified, such as cobaltite in the Upper Mississippi Valley district (Heyl *et al.*, 1959) and enargite in the Northern Arkansas (McKnight, 1935) and the Tri-State districts (Ransome, 1935). The identification of enargite from southwestern Wisconsin, therefore, not only adds to the knowledge of subtle mineralogic complexities of the ores in the districts of the Mississippi Valley, but it also adds to the growing list of geologic similarities already established between the Upper Mississippi Valley and the Northern Arkansas and Tri-State districts.

The Upper Mississippi Valley zinc-lead district in southwestern Wisconsin, northwestern Illinois and northeastern Iowa contains thousands of small lead mines, about 400 zinc mines, and a few copper, barite and pyrite mines. Since 1940 the district has been a major source of zinc and lead as well as of by-product sulfuric acid refined from pyrite and marcasite. Since 1943, new productive areas of zinc-lead ores have been found. One of these areas in the southwestern part of the district is east of Potosi, Grant County, Wis., at the village of Tennyson, where the Piquette Mining Company, in conjunction with the American Zinc, Lead, and Smelting Company, has opened and operated, at intervals since 1952, two mines called Piquette No. 1 and Piquette No. 2.

The enargite described in this paper occurs in the Piquette No. 2 (Heyl *et al.*, 1959), ore body which is in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 3 N., R. 3 W., Grant County, Wis. The mine is opened by a truck adit at the site of the Pleumer Level in the NW $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 3 N., R. 3 W., and was idle in 1964. The zinc-lead ores here are chiefly in the Prosser Member of the Galena Dolomite and the Ion Dolomite Member of the Decorah Formation, both of Middle Ordovician age. The dolomite, limestone and shale strata in the mineralized ground have been gently flexed, faulted and brecciated. The ore is in the form of veins, replacements, impregnations and breccia fillings in a complex connected system of vertical joints, strike-slip and reverse faults of small displacement, associated tectonic and solution-collapse breccias and opened bedding planes.

The primary minerals in their general order of deposition are quartz (jasperoid), dolomite, pyrite, marcasite, cobaltite, dark-brown and black sphalerite, galena, chalcopyrite, enargite, and calcite. Figure 1 shows the sequence of tectonic events and deposition of primary minerals in the

Upper Mississippi Valley district. The sequence is the same at the Piquette No. 2 mine, although barite is absent. The period of enargite deposition is short and late in respect to the associated ore and gangue minerals. The diagram is revised from that shown in Heyl and others (1959, Fig. 58) to include changes found by subsequent research.

The enargite occurs in minute crystals on sphalerite and chalcopyrite in small vugs; it is associated with clear colorless calcite, marcasite, galena, pyrite and a little millerite. It is uncommon and visible only un-

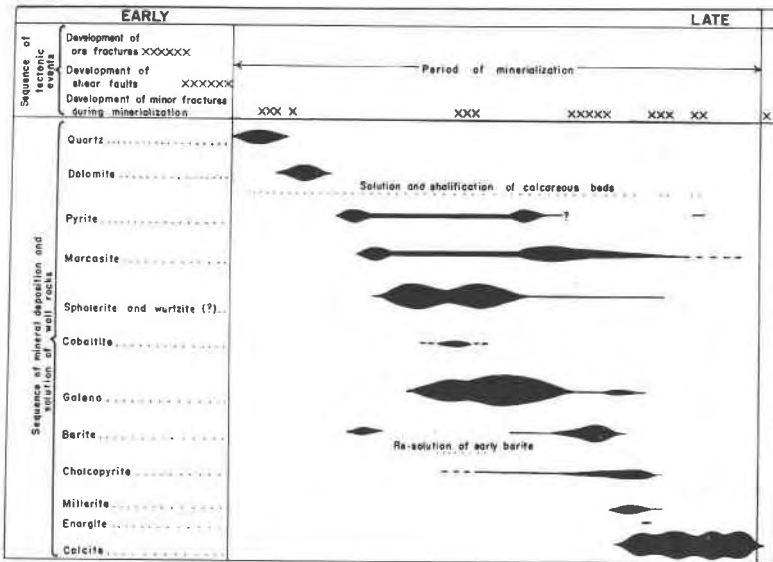


FIG. 1. Sequence of tectonic events and deposition of primary minerals in the Upper Mississippi Valley mining district.

der magnification. The crystals have a tabular prismatic habit. Most are tabular parallel to *a* (100), which varies in size from a small (Fig. 2) to a large face. The largest faces are *m* (110) of the prism, and in most samples the next largest face is the basal pinacoid *c* (001). A few crystals show small faces of *b* (010) and *s* (011). The maximum size of the crystals is about 0.5 mm. The occurrence and habit are very similar to those of enargite from the northern Arkansas and Tri-State districts, though the crystals are considerably smaller (E. T. McKnight, oral comm., 1963).

The quantity of enargite available was so small that normal quantitative analyses could not be made, but qualitative microchemical tests by E. T. McKnight for arsenic, sulfur and copper established the presence of all three elements. Arsenic was determined by the formation of good

envelope-type crystals of ammonium magnesium arsenate ($\text{NH}_4\text{MgAsO}_4 \cdot 6\text{H}_2\text{O}$) as described by Chamot and Mason (1940).

X-ray diffraction data for enargite from the Piquette No. 2 mine agree well with those of Berry and Thompson (1962). Powder films of the enargite from Wisconsin were compared visually with film prepared from enargite from the Blue Goose mine, Cardin, Okla., in the Tri-State district. The patterns of both minerals appear to be the same in d-spacings and intensities.

Very similar bluish-black lustrous crystals that are probably enargite on a sample collected from the Ivey or Grayville mine at Mineral Point,

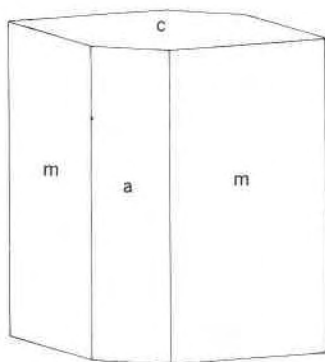


FIG. 2. Common crystal faces of enargite from Piquette No. 2 Tennyson, Grant County, Wis.

Wis., were shown to the author in 1963 by Mr. Roger Ivey, the owner and operator. The probable enargite here also occurs as minute prismatic crystals on sphalerite and chalcopyrite. Mineral Point is in the north-central part of the mining district about 28 miles east-northeast of Piquette No. 2 mine. The geology of the Ivey mine has been described by Allingham (1963, pl. 17).

The writer is indebted to E. T. McKnight for microchemical tests on the mineral, H. T. Evans for the crystal projection (Fig. 2), and to Michael Fleischer, Janice L. Jolly and Mary E. Mrose for assistance in identification. Mr. F. E. Piquette, operator of the Piquette No. 2 mine, was most helpful in all respects.

REFERENCES

- ALLINGHAM, J. W. (1963) Geology of the Dodgeville and Mineral Point quadrangles, Wisconsin. *U. S. Geol. Survey Bull.* **1123-D**, 169-241.
 BERRY, L. G. AND R. M. THOMPSON (1962) X-ray powder data for ore minerals. *The Peacock Atlas. Geol. Soc. Am. Mem.* **85**, p. 127.

- CHAMOT, E. M. AND C. W. MASON (1940) *Handbook of Chemical Microscopy*, 2nd ed. New York, *John Wiley and Sons, Inc.*, v. 2, p. 229.
- HEYL, A. V., JR., A. F. AGNEW, E. J. LYONS AND C. H. BEHRE, JR. (1959) The geology of the Upper Mississippi Valley zinc-lead district. *U. S. Geol. Survey Prof. Paper* 309.
- McKNIGHT, E. T. (1935) Occurrence of enargite and wulfenite in ore deposits of Northern Arkansas. *Econ. Geol.* **30**, 61-66.
- RANSOME, A. L. (1935) Enargite and plumbojarosite at Picher, Oklahoma. *Am. Mineral.* **20**, 799-805.

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X-RAY CRYSTALLOGRAPHY OF OMPHACITE

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INTRODUCTION

In recent years there has been much petrologic interest in omphacite and other minerals found in eclogites. This report describes the *x*-ray crystallography of chemically analyzed omphacite number 1725 from the Eiksundsdal Eclogite Complex, Hareidland, Sunnmøre, Norway, described by H. H. Schmitt (1963, p. 60).

Schmitt gives a chemical analysis of this sample (No. 1725, Table 2), which is reproduced in Table 1. The analysis is also recast in Table 1, as number of ions per six oxygens. The sample is approximately $\frac{2}{3}$ diopsidic-augite and $\frac{1}{3}$ acmitic-jadite. It should be noted that this omphacite is richer in ferric and ferrous iron than most omphacites.

EXPERIMENTAL PROCEDURES AND RESULTS

Single crystal *x*-ray photographs were taken of the sample, verifying the space group *C2/c* with *Z* equals 4 for omphacite. Indexing was done on the measurements from a FeK_α radiation powder photograph.

The reflection angle *2θ* was calculated for all allowed reflections with *h*, *k*, and *l* varying from 0 to 9, 0 to 9, and -5 to +5 respectively, using preliminary values of *a*, *b*, *c* and *β* derived from single crystal photos. The cell constants were refined and the calculation was repeated. Final indexing is shown in Table 2. I was not able to index lines 3 and 6. These lines are probably due to the oriented inclusions reported below.

Between ten and forty-two reflections were used in each refinement cycle. Several criteria were used to select which reflections and *hkl*'s were to be used in a given cycle. Refinement I was made by choosing the reflections that had the closest matching calculated and observed *2θ*

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