

## NOTES AND NEWS

### ENARGITE AND PLUMBOJAROSITE AT PICHER, OKLAHOMA

ALFRED L. RANSOME, *Stanford University.*

For many years the presence of an interesting assemblage of minerals in the lead-zinc deposits of the Tri-State District has been known and many papers have been published concerning this locality, but not until recently has there been any mention of the



FIG. 1. Photograph of a portion of the specimen from the Barr Mine. The black crystals of enargite can be seen on the calcite crystals in the center of the picture.

presence of the mineral enargite in this region.<sup>1</sup> It is further believed that plumbojarosite has never been described from the district.

The basis for the following presentation is a very interesting and rather unusual specimen collected by the author from one of the numerous caves in the Barr Mine, located in the Picher District,

<sup>1</sup> McKnight, E. T., Occurrence of enargite and wulfenite in ore deposits of Northern Arkansas: *Econ. Geology*, vol. 30, p 61, 1935.

Oklahoma, during one of the excursions connected with the International Geological Congress of 1933.

This specimen measuring about  $8\frac{1}{2}$  by 5 by 3 inches was obtained from the roof of the cave which itself was completely covered by the minerals described in the following paragraphs. The surface originally attached to the roof of the cave, otherwise referred to as the back surface, is a typical chert breccia more heavily mineralized than usual. The few chert fragments are surrounded by sphalerite which together form the greater part of the specimen. The remaining portion consists primarily of masses of chalcopyrite crystals and calcite crystals which formed on the sphalerite, together with some gypsum, marcasite, covellite, sulphur, quartz, ruby blende (secondary sphalerite), dolomite, galena, anglesite, plumbojarosite, and enargite. The accompanying photograph (Fig. 1) gives a general view of a portion of the specimen. The scale is shown by the large banded calcite crystal which is slightly more than  $1\frac{1}{2}$  inches in actual length.

#### *Sphalerite*

Forming the main mass of the specimen, the sphalerite occurs as large intergrown crystals enclosing the chert fragments (not visible in photograph). The color varies from amber through brown to reddish-brown, and the luster is characteristically adamantine. Recognizable on the sphalerite is  $\{111\}$  twinning, but the crystal faces are malformed.

There is a second generation of sphalerite of a deep reddish color, known as ruby blende, present on the back surface of the specimen. The crystal size of the ruby blende is from 1–3 mm.

#### *Chalcopyrite*

Covering most of the upper surface of the specimen, the chalcopyrite occurs as masses of intergrown crystals of varying sizes up to one-fourth to three-eighths inches. In each individual mass there is a roughly parallel growth of crystals. The surface is coated with a very thin oxidation product of a brownish-yellow color.

These crystals consist of the tetragonal bisphenoid  $p\{111\}$  modified by  $z\{201\}$ , both of which show striations, and a line face  $\{100\}$ . These striations are possibly the cause of a sheen on the crystal surfaces noticeable when they are turned at an angle to the light.

### *Calcite*

One of the most interesting of all minerals in the Tri-State District is calcite which occurs in unusually large crystals. The lower part of the cave was covered with these large crystals many of which reached a size of two to three feet. The calcite crystals on the specimen are small, varying in size from one-half to two inches in length, but are exactly the same in form as the large ones, being ditrigonal scalenohedrons,  $v\{21\bar{3}1\}$ . The color varies from colorless to white and amber. These crystals are well shown in the photograph.

Some of the transparent crystals reveal inclusions of chalcopyrite. When viewed with a hand lens these crystals show the double refracting property of the calcite, a double image being clearly discernible.

### *Gypsum*

The basal portion of the majority of the calcite crystals are covered with a thin coating which is very soft and easily scraped off with the fingernail. Examination under the microscope showed thin tabular and platy crystals recognized as gypsum. A chemical test as well as the determination of the index of refraction of these crystals gave further positive proof.

This mineral is replacing the calcite as shown by small pits under the coating, and it is probable that oxidation products of the sulphides reacted with the calcite to form the coating of gypsum.

The white color of the pure gypsum grades through green into a deep brown towards the base of the calcite crystals. Inspection showed that these bands are merely stains on the gypsum most likely caused by copper and iron from the chalcopyrite. The gypsum as well as the banded effect of the staining is well shown in the photograph.

### *Enargite*

Many tests were made before this mineral was decided conclusively to be enargite ( $\text{Cu}_3\text{AsS}_4$ ). The crystals are formed mainly on the calcite and are in places partially imbedded. Numerous crystals can be seen on the calcite in the center of the photograph. They are also present on the chalcopyrite. This has been noted on several specimens beside the one in question.

The enargite occurs as small rhombic crystals, averaging from 2-3 mm. in length, which are columnar in form and have a good

cleavage parallel to the length. The value for the angle  $110 \wedge \bar{1}\bar{1}0$  was determined with a reflection goniometer, taking an average of twenty readings, and found to be  $81^{\circ}49'$  as compared with the recorded figure of  $82^{\circ}07'$ .<sup>2</sup> This is the average of readings from all the *m* faces. One angle measured  $82^{\circ}06'$  which is very close to the recorded value.

An open tube test was made which resulted in fumes of  $\text{SO}_2$ , a very faint sulphur sublimate, and a white sublimate consisting of very minute crystals of  $\text{As}_2\text{O}_3$  having an adamantine luster. A borax bead test gave a clear light blue color indicating the presence of copper.

#### *Marcasite*

A comparatively small amount of this mineral was found in a few places on the chalcopyrite. The crystals are small measuring not over four mm. in the line of greatest dimension and are tabular orthorhombic with the structure typical of marcasite. The following forms were recognized:  $c\{001\}$ ,  $m\{110\}$ , and  $\{0kl\}$ . The color is a pale brass yellow with a dull surface tarnish.

#### *Covellite*

A very thin indigo-blue coating on the sphalerite between the clusters of chalcopyrite and occasionally on the chalcopyrite and the base of the calcite is thought to be the copper mineral covellite. A test for copper was not made because of the difficulty of obtaining pure material which was not contaminated with small particles of the surrounding chalcopyrite.

#### *Sulphur*

Another product of oxidation, sulphur, occurs as a very large number of minute orthorhombic crystals on the chalcopyrite and sphalerite. Of a pale yellow-green color, these crystals are clear with an adamantine luster. They are soluble in carbon disulphide.

#### *Quartz*

A few very small prismatic crystals of secondary quartz were found on the back surface of the specimen deposited on the sphalerite. The recognizable crystal forms are:  $m\{10\bar{1}0\}$ ,  $r\{10\bar{1}1\}$ , and  $z\{01\bar{1}1\}$ .

<sup>2</sup> Dana, E. S., *System of Mineralogy*, 6th edition, p. 147, 1904.

*Dolomite*

A small amount of dolomite is also present on the sphalerite near the quartz and ruby blende. The crystals are small saddle-shaped rhombohedrons, pink in color.

*Galena*

The large crystals of galena common in this district are not well represented on the specimen. Only a few highly oxidized nodules are present on the sphalerite. A few remnants of original faces show them to be octahedral crystals with the form  $o\{111\}$ , some showing the usual cubic form  $a\{100\}$ . There is a definite cubic cleavage.

*Anglesite*

The anglesite occurs as a thin gray film on the galena. Positive tests were made both for the lead and the sulphate radical.

It is possible that some cerussite is also present associated with the galena but no determination was made because of the difficulty of obtaining material upon which to make a test.

*Plumbojarosite*

This member of the alunite group, new to the district, was found in only two places on the specimen occurring as a brownish colored earthy material covering nodules having a center of galena.

Under the microscope a small amount of this earthy material in suspension in water showed numerous very minute platy crystals (approximately .01 mm. in diameter) which had the hexagonal shape and yellow color suggesting a member of the alunite group.

A test of an HCl solution with potassium iodide gave a positive reaction for lead producing platy hexagonal crystals with a yellow color, and of larger size than the original crystals found in the water solution. On addition of a few particles of calcite to the HCl solution and heating, microchemical gypsum was formed indicating the presence of the sulphate radical and definitely establishing the mineral as plumbojarosite.

## ORDER OF SEQUENCE

It is impossible to list the above minerals in a definite order of sequence that will show the relation of each mineral to the other. However, it is evident that the sphalerite was succeeded by the calcite, chalcopryrite, and dolomite which were formed at approxi-

mately the same time. The enargite as far as can be determined followed soon after.

Galena and marcasite probably were formed next but in what order is not known. Covellite was precipitated after the chalcopyrite, following which the sulphur was formed. The gypsum replaced the calcite, and the lead minerals developed from the galena.

The quartz was deposited on the sphalerite followed by the ruby blende. Whether these two were formed early or late in the sequence is not easily determined and any statement one way or the other would be merely a guess.

#### DISCUSSION

The presence of such an assemblage of minerals in one specimen is quite unusual. The mineral enargite is most interesting from the standpoint of the origin of the deposits which has been a much debated question for many years.

The most recent theory to be advanced is that the deposits were formed by thermal solutions originating from a magmatic source. Newhouse, from his work with inclusions in sphalerite, has contributed data which greatly supports this theory.<sup>3</sup> Inclusions of an aqueous solution of NaCl containing a bubble were heated until the bubble disappeared thereby giving the temperature of formation of the sphalerite. By this method Newhouse deduced that the temperature of formation of the ore minerals at Picher, Oklahoma, was from 125°–130°C.

Also in support of the magmatic theory is the recent evidence of the existence of known intrusive rocks in the vicinity of the ore deposits of the Tri-State District. This has been emphasized by Weidman as being closely related to the structure of the region as well as the ore deposits.<sup>4</sup> This fact eliminates what was considered the great weakness of the magmatic theory, namely, the absence of such intrusives in the vicinity of the ores.

The occurrence of tourmaline in the jasperoid has been described by Weidman who considers it as additional evidence for the above theory.<sup>5</sup> He definitely states that the small crystals are not detrital

<sup>3</sup> Newhouse, W. H., Temperature of formation of Mississippi Valley lead zinc deposits: *Econ. Geology*, vol. 28, pp. 744–750, 1933.

<sup>4</sup> Weidman, Samuel, The tri-state zinc-lead region: *16th International Congress, Guidebook 2*, pp. 74–91, 1933.

<sup>5</sup> Weidman, Samuel, Tourmaline in jasperoid of the Miami-Picher zinc-lead district: *Geol. Soc. Amer.*, Preliminary list of titles and abstracts of papers to be offered., 46th ann. meeting, Dec. 1933.

or clastic, but crystallized from solutions at a temperature of from 200°–300°C.

Enargite, as compared with the tourmaline, is generally considered to be a mineral formed at an intermediate temperature, at least higher than that usually associated with deposition by meteoric waters. Such a mineral by itself might not be of much significance, but when accompanied by such evidence as stated above, the presence of enargite may also be of importance in supporting this recent theory.

#### ACKNOWLEDGMENT

The minerals described above were determined in the mineralogical laboratories of Stanford University with the kind assistance of Prof. A. F. Rogers and Dr. L. W. Staples.

#### THULITE IN NEW MEXICO

STUART A. NORTHROP, *University of New Mexico, Albuquerque, New Mexico.*

Since thulite has been reported in North America from only two localities, at Hampton, Maryland,<sup>1</sup> and at Haddam, Connecticut,<sup>2</sup> its occurrence in New Mexico is worthy of record. Thule is an ancient name of Norway; the mineral has been found at three localities in Norway, at one locality in Austria, and at one in Italy. There are probably few American mineralogists who have seen thulite in the field.

The new locality is just south of Pilar Post Office (village formerly known as Cieneguilla), Taos County, New Mexico, approximately in the N.E.  $\frac{1}{4}$  Sec. 2, T. 23 N., R. 11 E., on the east bank of the Rio Grande. From Pilar the Rio Grande flows southwestward for about six miles and has cut down through pre-Cambrian metamorphics, leaving a steep cliff facing northwestward. The main highway between Santa Fe and Taos lies at the foot of the cliff along the east bank of the river. The locality is northwest of the Copper Hill or Picuris mining district and northeast of the Glenwoody district.

According to Graton,<sup>3</sup> the pre-Cambrian rocks of the region in-

<sup>1</sup> Lee, John W., *Am. Jour. Sci.*, vol. 11, pp. 171–172, 1901.

<sup>2</sup> Foye, Wilbur G., *Am. Mineral.*, vol 11, pp. 210–213, 1926.

<sup>3</sup> Graton, L. C., *The Ore Deposits of New Mexico: U. S. Geol. Survey, Prof. Paper 68*, pp. 89–91, 1910.