Enargite.

By L. J. Spencer, B.A., F.G.S.,

Assistant in the Mineral Department of the British Museum.

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LITERATURE.

A. Breithaupt,	1850.	Pogg. Ann., LXXX., 383.—Characters, Peru.
C. F. Plattner,	1850.	Pogg. Ann., LXXX., 386.—Analysis, Peru.
H. Dauber,	1854.	Pogg. Ann., XCII., 237.—Crystallography, Peru.
F. A. Genth,	1857.	Amer. Jour. Sc., XXIII., 420.—Analysis, S. Carolina.
W. J. Taylor,	1858.	Proc. Ac. Philad., 168, 1857.—Anal., Columbia.
F. Field,	1859.	Amer. Jour. Sc., XXVII., 52, 387; (Phil. Mag., XVII., 232).—"Guayacanite," Anal., Chili.
J. v. Pettko,	1863.	Magyar Ak. Éstesitö, IV., 141; Lotos, 20, 1867.—Anal., Cryst., Parád.
F. v. Kobell,	1865.	Ber. Ak. Münch., I., 161; (J. pr. Chem., 489).—Anal., Coquimbo.
C. Rammelsberg,	1866.	Zeit. geol. Ges., XVIII., 241.—Anal., Cryst, Mexico.
B. S. Burton,	1868.	Amer. Jour. Sc., XLV., 34.—Anal., Colorado.
E. W. Root,	1868.	Amer. Jour. Sc., XLVI., 201.—Anal., California.
C. Zerrenner,	1869.	Berg.-Hütt. Ztg., 105, 118, 435.—Cryst., Luzon.
B. Silliman,	1873.	Amer. Jour. Sc., VI., 126.—Anal., Utah.
A. Stelzner,	1873.	Min. Mitth., 240.—Anal., Famatina.
F. Sandberger,	1874-5.	Neues Jahrb. Min., 960, 1874; 382, 1875.—"Clarite."
A. Knop,	1875.	Neues Jahrb. Min., 69.—Anal., Luzon.

J. Szabó,	1875.	Földtani Közlöny, V., 158.—Hungary.
G. vom Rath,	1877.	Sitz. ber. niederrh. Ges. Bonn, 148; (Zeits. Kryst., IV., 426, 1880). — Cryst., Famatina.
K. Nendtvich,	1877.	Math. Természet. Közlem., XIV., 33.—Anal., Parád.
A. Raimondi,	1878.	Minéraux du Pérou, 121.—Anal.
P. Groth,	1878.	Min.-Samml., Strassburg, 70.
I. Domeyko,	1879.	Min., 3rd ed., 226.—Anal., Chili.
V. v. Zepharovich,	1879.	Zeits. Kryst., III., 600; (Verh. geol. Reich., 182).—Cryst., Tyrol.
Zettler,	1880.	Neues Jahrb. Min., I., 159.—Cryst., Luzon.
T. Egleston,	1882.	School of Mines Quart., IV., 5.—Metallurgical Treatment.
W. Semmons,	1884-5.	Min. Mag., V., xxvi. ("Garbyite"); VI., 49, 124.—Anal., Montana.
R. de Neufville,	1891.	Zeits. Kryst., XIX., 75.—Anal., Atacama.
L. V. Pirsson,	1894.	Amer. Jour. Sc., XLVII., 212; (Zeits. Kryst., XXIII., 114).—Cryst., Colorado.
A. J. Moses,	1895.	School of Mines Quart., XVI., 229—Large crystals, Montana.

Also as describing or mentioning occurrences:—

Tyrol.—A. Pichler, Jahrb. geol. Reich., XIX., 215, 1869 (referred to Stephanite).

Hungary.—F. v. Andrian, Jahrb. geol. Reich., XVIII., 520, 1868; Verh. geol. Reich., 169, 1867; M. Tóth, Minerals of Hungary, 178, 1882.

Luzon.—C. Simon, Berg.-Hütt. Ztg., 37, 1865: A. Frenzel, Min. Mitth., 1877, 302; A. Breithaupt, Berg.-Hütt. Ztg., 82, 1869.

Argentina.—L. Brackebusch (Las Especies Min. de la Rep. Argentina), Anal. Soc. Cient. Argentina, 112, 1878; H. D. Hóskold, Mémoire général et spécial sur les mines, &c., dans la Rep. Argentina (Exposition de Paris, 1889), p. 126, analyses and maps; Catálogo oficial of the Argentine minerals at the Paris Exhibition, 58, 1889; Argentine Rep., Philadelphia Exhibition, 1876, pp. 197, 193; A. Sella, Nachr. d. k. Ges. d. Wiss. zu Göttingen, 317, 1891 (specific heat).

Peru.—A. Kenngott, Ber. Ak. Wien, X., 183, 1853 (density).

U.S.A.—Mineral Resources of U.S.A., 708, 1887; 382, 1883-4; Report of State Mineralogist of California, 107, 1886; R. Pearce, Proc. Color. Sci. Soc., II., 134, 1886 (alteration); Dana, Min., 6th ed., Catalogue of American Localities.

The following is a complete *list of the forms* of enargite; those present on the British Museum specimens are indicated by one asterisk, while new forms are indicated by two. The letters are those used by Dana (*Min.*, 6th Ed.) and Goldschmidt (*Index der Krystallformen*, I., 551, 1886).

* *a* 100. Usually large and roughly striated vertically; rarely horizontally (Coquimbo).

* *b* 010. Recorded by most authors, but on the Museum specimens very rare as a face of any size, being generally only detected by the goniometer, and then not frequently.

* *c* 001. Usually large and bright with faint, or sometimes deep, striæ parallel to the macrodiagonal; rarely parallel to the brachydiagonal (Coquimbo).

** *y* 610. Doubtful, only observed by means of the δ-eyepiece of the Fuess goniometer: (Famatina).

* *r* 310. p^3 of Rammelsberg. Bright and narrow, fairly common.

** *f* 520. Bright and narrow, on two crystals from Willis Gulch, Colorado.

* *d* 210. p^2 of Rammelsberg, *v* of Pirsson. Bright and narrow, fairly common.

x 320. Twin plane, not a recorded form; some very doubtful measurements seem to indicate its presence.

** *i* 540. Narrow: Luzon and Colorado.

* *m* 110. *g* of Dauber and Goldschmidt, *p* of Rammelsberg. Usually large, often deeply striated vertically; rarely horizontally (Coquimbo).

** *N* 230. Narrow: Silverton, Colorado, also Willis Gulch.

* *h* 120. *n* of vom Rath. Bright and narrow, common.

* *l* 130. Bright and narrow, often present.

** *t* 108. Narrow: Famatina.

** *A* 207. Narrow: Famatina and Luzon.

* λ 103. Bright and narrow, not common: Famatina and Luzon.

* *n* 102. Bright and narrow, fairly common.

** *w* 709. Narrow: Parád, Hungary.

* *k* 101. Bright, often fairly large, common.

e 403. (Dauber?). This is given by Goldschmidt as 034 instead of 304.

* μ 201. *m* of Dauber and Goldschmidt. Very narrow: Famatina.

** *u* 301. Large and bright, somewhat rounded, and striated horizontally: Famatina. This is probably the steep dome mentioned by Stelzner (*l. c.* p. 241).

** *B* 601. Doubtful, only observed with δ-eyepiece: Famatina.

E 012. *e* of Pirsson.

* *s* 011. Small and bright, not frequent.

** *K* 054. Large and rough, striated parallel to the brachydiagonal Willis Gulch.

θ 051. (Zettler).

q 115. (Zepharovich). Scattered images were observed about this position; also scattered images near the positions of (113) and (114), but very doubtful; these were only present on two Famatina crystals as rough, narrow roundings.

p 112. (Dauber).

o 111. (Dauber and Zettler).

L 132. (Dauber ?).

z 134. (Pirsson).

The following table gives the measurements establishing the new forms:—

	Measured.	Limits.	No.	Calculated from *mm* 82°0½′ and *ck* 43°42′.
a : *y* 610	8° 38′	..	..	8° 14½′
f 520	19 4½	18°56′—19° 47′	5	19 11
i 540	34 22	34 17 —34½	2	34 49
N 230	52 28	51 0 —54¾	4	52 31
c : *t* 108	6 42	6 38 — 6 46	2	6 49
A 207	14 58	..	..	15 16¼
w 709	36 18	36 0½—36 25	2	36 38
u 301	71 12	70 46 —71 44	3	70 46
B 601	80 1	..	..	80 6½
K 054	45 47	..	..	46 5

Owing to the striated nature of faces in the prism zone, and of the macrodomes, few of the measurements are really good, while the reflections from the cleavage surfaces are often somewhat blurred; nevertheless, from the results obtained by the measurement of forty crystals and cleavage fragments, it would seem that the value of the prism angle (*mm*) of 82° 7′, as given by Dauber, is somewhat too high. The measurements of this angle gave the following results:—

82°0½′	mean of 26 best, from crystal faces;	limits	81°17′–82°34′
82°0′	„ „ 11 „ „ cleavages;	„	81°46′–82°16′
82°1′	„ „ 123, all measurements;	„	80°32′–82°39½′
82°0′	„ „ 10, cleavages of "clarite";	„	81°10′–82°45′

Also the published measurements for this angle are all lower than that given by Dauber. Breithaupt gives 81°49¼′ as the mean of his measurements of the cleavage angle, with the remark that the error cannot be more than one minute. Rammelsberg gives 81°50′ and 82°15′; v. Pettko and v. Kobell both give 82°; Neufville 82°2′ as the mean of several cleavage angles, with a variation of 8′. The means of those given by other authors are :—

	Dauber.	v. Zepharovich.	Pirsson.	L. J. S.		
				Mean.	Limits.	No.
mm, 110 : $1\bar{1}0$	*82° 7½′	81° 48′	81° 52½′	*82° 0½′	See above.	
ck, 001 : 101	43 39	43 32	43 1	*43 42	42°55′—44°19′	14
cs, 001 : 011	*39 31	39 31	39 24½	39 42½	39 39—39 45	3

Both 43° 42′ and 39° 42½′ are good measurements, and *cs* is calculated from 43° 42′ and 82° 0½′ as 39° 43¼′, this agreeing very closely with the observed angle. These angles (*mm* and *ck*) give the parameters :—

$$a : b : c = 0{\cdot}8694 : 1 : 0{\cdot}8308.$$

Dauber's measured angles for *ck*, *cp*, *cn* and *co* are much nearer to the angles calculated from these parameters than to those calculated from his own (0·8711:1:0·8248); but his determination of *cs*, which is the mean of five angles, with variation of only 7′, and v. Zepharovich's measurement of the same angle, seem to indicate that there is not the same justification in attaching a new value to the *c* axis as to the *a* axis.

Habits.—All the crystals examined were elongated in the direction of the prism zone, and terminated at the unattached end by the bright basal plane; most of them consisted only of the forms *a*, *m* and *c*, forming a six-sided prism. The forms *a* and *m* are usually equally developed, but sometimes *a* is small or absent, or at times it is large, giving rise to tabular crystals. Other prism forms are only present as narrow faces. Domal forms, of which *k* is the most common, are comparatively rare, and are usually present as narrow faces, rarely influencing the habit of the crystals by excluding the basal plane; *k*, however, often seems to be developed as a large face on crystals from Luzon. In no case was a definite pyramid face observed.

Twinning.—The only mode of twinning which has been detected on the Museum specimens is that first described by vom Rath, in which the horizontal axes (*a* and *b*) of the different individuals cross each other at approximately 60°, as in the twins of chalcocite, aragonite, chrysoberyl, &c. Such twins are frequent on specimens from Parád (Hungary) and Famatina (Argentina), and on "clarite" from Schapbach (Baden), but seem to be rare from other localities; only a single crystal, consisting of two individuals, having been noticed on any of the other specimens (Coquimbo). Zettler, however, mentions twins from Luzon, for which he gives the twin plane as *x*(320) in preference to *h*(120).[1] The twin crystals nearly always show only the *c* and *m* faces with sometimes narrow *h* and *a* planes, but apparently never any of the domes, though these are often present on the simple crystals. The basal planes of the different individuals form together one large bright plane, on which, according to vom Rath's figure, are to be seen the traces of the planes of combination. Such has, however, not been observed on the Museum specimens, and the twins examined appear rather to be of the nature of interpenetration twins. The following angles were those observed between the *m* faces in going round the prism zone of a twin crystal from Parád, consisting of three individuals, with very bright prism faces. The angles are calculated from *mm* 82° 0½′ (82° 0′ was the mean of the observed angles on this crystal); the twin planes being inclined to each other.

Measured.	Calculated twin plane *x* (320).	Calculated twin plane *h* (120).
38° 26′	38° 23½′	38° 11½′
21 31	21 48½	22 12½
37 46	37 47½	37 35½
22 19	22 24½	22 12½
37 47	37 47½	38 11½
60 25	60 12	59 48½
21 47	21 48½	22 12½
59 42½	59 36	59 48½

The magnitudes of the measured angles, as well as the order in which they occur, thus show that *x*(320) and not *h*(120) is the twin plane. G. vom Rath gave *x* as the twin plane and plane of combination, but remarked that *h* could be equally well taken as such (the plane of combination being perpendicular thereto), as the striated nature of the prism zone rendered it impossible to distinguish between the two by measurement. The non-existence of the twin plane *x* as a crystal-form is remarkable.

[1] The twin crystals from Brixlegg (Dana, *Min.*, 6th ed.) are not mentioned by v. Zepharovich.

Twinning on the *m* (110) plane has been mentioned, but contradicted by vom Rath. J. v. Pettko says that staurolite-like twins occur at Parád; if these resemble the staurolite twins which have the individuals crossing at approximately 60°, they would probably be the ordinary *x* twins of enargite. Groth mentions as doubtful, twins on a macrodome on crystals from Emma mine, Utah.

Parallel growth (?) *of Enargite and Barytes.*—On a macropinacoid face of a crystal of enargite from Famatina was a minute tabular crystal of barytes, the basal planes of the two minerals reflecting light together, and as far as could be judged by the eye the prism planes (which have about the same cleavage angle) were parallel. The *a*, *b* and *c* axes of the two minerals are therefore respectively parallel. This was, however, only once observed, although on some specimens there were many crystals of barytes.

THE IDENTITY OF "CLARITE" WITH ENARGITE.

A specimen in the British Museum labelled "Clarit, Schapbach, Baden, 1874," was examined, and seen to consist of radiating bushy groups of earthy, bluish covellite containing bright specks of copper pyrites; only very little of the original mineral, after which the covellite is pseudomorphous, was present; this showed bright cleavage surfaces, and had all the appearance of enargite. The specimen thus agrees with the description given by F. Sandberger (*Neues Jahrb. Min.*, 960, 1874; 382, 1875) of the mode of occurrence and alteration of "clarite."

Eight small cleavage fragments of the fresh mineral were measured on the goniometer, the images not being good, the δ-eyepiece of the Fuess instrument had to be used. Generally two or three large cleavage surfaces were present, while all round the zone were many (sometimes 8 or 9) small bright cleavages, apparently belonging to small individuals intergrown in twin position in the main crystal. These cleavages corresponded in position to the perfect *m* cleavage of enargite, a less perfect one being at the position of *a*, while *b* was not observed. In the following table, the calculated angles are those which exist between the *m* cleavages when the crystals II. and III. are twinned on the two *x*(320) planes of the crystal I. respectively, the angle *mm'* being taken as 82°0½'.

	Calculated.	Measured.	Limits.	No.
$m_I\ m_{II}$	37° 47½′	37° 39′	37° 17′–38° 3′	7
,,	21 48½	21 38	20 57–22 13	10
$m_{II}\ m_{III}$	38 23½	38 28	37 47–39¼	8
,,	22 24½	22 38	22¼ –23¼	9
$m\ m$	82 0½	82 0	81 10–82 45	10

The measured angles agree better with the calculated angles when *x* (320) is taken as the twin plane, than when *h* (120) is taken, and when III is twinned on I instead of on II. The measurement of these fragments thus not only shows that "clarite" is identical with enargite, but indicates that *x* (320) is to be taken as the twin plane in preference to *h* (120), a point which was left as somewhat doubtful by vom Rath.

Sandberger mentions in his paper that after much trouble he succeeded in isolating an imperfect crystal which had an end face (0*P*) steeply inclined to the prism zone, and showed a perfect cleavage (∞ P̀ ∞) and a less perfect one (∞ P̄ ∞) perpendicular to the last. This crystal was too much altered on the surface for measurement, and not even the cleavage angle could be determined on the goniometer. It is mentioned that the crystal resembles the figures given by Zepharovich for the oblique freieslebenite[1]; these figures, however, refer to rhombic diaphorite and not to freieslebenite. From the above data he concluded that the crystal was oblique, and not rhombic, as he at first thought[2]; they do not, however, appear to afford sufficient grounds for this conclusion, as the two pinacoid cleavages of a rhombic crystal would naturally show different degrees of perfection, while the end face, which is a dome in Zepharovich's figures, may be one face of the dome developed to the exclusion of the basal plane of a rhombic crystal and of the other face of the dome; such has been observed in the case of the form *k* (101) on crystals of enargite from Parád, Hungary. This position of the crystal would, however, not agree with the perfect *m* cleavage of enargite. The end face may then possibly have been one face of a pyramid (pyramidal forms seem, however, to be rare on enargite), and the cleavages may have been the *m* cleavage of enargite with an angle of 82°, in which case ∞ P̀ ∞, ∞ P̄∞, ∞ P, 0P of Sandberger would correspond to *m*, *m*, *a* and *b*, and a pyramid face respectively.

The only other points of distinction emphasised are, the dark lead-gray

[1] *Ber. Ak. Wien*, LXIII., I., 1871, Pl. II., Figs. 6 and 7.

[2] *Neues Jahrb. Min.*, 960, 1874.

colour, this is, however, called dark steel-gray in the preliminary notice (*Neues Jahrb. Min.*, 960, 1874); and the hardness of 3·5 instead of 3: the density and composition being the same as those of enargite. In the preliminary notice it is stated that copper, antimony, arsenic and sulphur were detected qualitatively, with the remark that such a combination of elements is only known in fahlerz; such, however, is not the case, nor was it in 1874. It was apparently on these grounds that the name was in the first instance given, as the mineral was then said to be apparently rhombic.

Several other minerals, with a composition similar to that of enargite, have at one time and another been described. Of these, guayacanite and garbyite are mere synonyms of enargite, the names having been withdrawn by their authors. *Luzonite*,[1] however, from its absence of cleavage and its reddish colour, seems to differ from enargite, though its chemical composition and density are the same. The first mention of this mineral was made by Zerrenner[2] ("brauner Kies"); and it was stated by F. W. Fritzsche,[3] who made a qualitative analysis of it, to be massive dufrenoysite (binnite of Des Cloizeaux). Two[4] of the three analyses that have been made of *binnite* agree with the enargite formula, though the earliest,[5] which is the one usually accepted, does not. The mineral also shows an absence of cleavage, and has a brownish colour on the fractured surfaces. Moreover, as it has the same density as luzonite, these two minerals may possibly be identical, luzonite being the massive form of binnite.

A. D'Achiardi's *regnolite*,[6] which was first described as occurring in isometric tetrahedra resembling sandbergerite, and having a composition somewhat similar to enargite, may possibly be referred to binnite, though the composition is not in close agreement.

The isodimorphous series as given by F. Klockmann[7] would then become:—

Cu_3AsS_4, Enargite, rhombic	Binnite (and Luzonite), cubic.
Cu_3SbS_4, unknown	Famatinite do. (?).

[1] A. Weisbach, *Min. Mitth.*, 257, 1874.

[2] *Berg-Hütt. Ztg.*, 106, 1869.

[3] *Berg-Hütt. Ztg.*, 438, 1869.

[4] Stocker-Escher, *Kenngott's Uebers.* 1856-7, 174, 1859; R. W. E. Macivor, *Chem. News*, XXX., 103, 1874.

[5] Uhrlaub, *Pogg. Ann.*, XCIV., 115, 1855.

[6] *Il Nuovo Cimento*, 314, 1870; *I Metalli*, I., 293, 294, 1883.

[7] *Zeits. Kryst.*, XIX., 271, 891; cf. Abst., *Min. Mag.*, X., 337, 1894.

Enargite usually contains no, or only one or two per cent. of antimony, but the three published analyses with six per cent. (Root, Domeyko, and E. Bittsanszky quoted by v. Pettko) show a transition of enargite towards the unknown member of the series, while the famatinite analysed by Frenzel[1] is half way between binnite and famatinite.

Frenzel's *lautite* has been considered by Weisbach to be a mechanical mixture of native arsenic with a sulpho-salt near enargite. It is therefore placed by Dana[2] under enargite, though it is not placed in such a position by Groth.[3] The specimens from Lauta, Marienberg, Saxony, were examined, and on the bright cleavage surfaces could be seen no trace of the native arsenic mentioned by Weisbach, the substance having all the appearance of a definite mineral. One perfect cleavage is present giving rise to a platy separation of the mineral. There are also two or more other less perfect cleavages, which give scattered images, and on the goniometer no consistent measurements could be obtained; but none of the angles, on the several fragments measured, agreed with those of enargite.

Localities of Enargite.—A complete list not having been before compiled, the following may be of use:—

Saxony.—Junge hohe Birke mine, Freiberg? (Breithaupt, *Pogg. Ann.*, LXXX., 386, 1850; not confirmed).

Baden.—Clara mine, Schapbach ("Clarite").

Silesia.—Kupferberg? (H. Fiedler, *Min. Schlesiens*, 1863).

Tyrol.—Matzenköpfl, Brixlegg.

Hungary (Matra Mts.).—Gabe Gottes mine and Katharina mine, near Parád; Recsk.

Philippine Islands.—Mancayan, District Lepanto, Luzon.

Colorado.- Gilpin Co.—Mines near Black Hawk (Willis Gulch) and Central City; Russel Gulch, particularly Power's mine.

Rio Grande Co.—Ida mine, Summit District.

San Juan Co.—National Belle mine, Red Mtn.; Silverton (from a label in the British Museum).

Park Co.—Missouri mine.

Utah.—Juab Co. (Tintic District)—Copperopolis mine (American Eagle mine) and Mammoth mine.

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[1] *Neues Jahrb. Min.*, 679, 1875.

[2] *Min.*, 6th Ed.

[3] *Tab. Uebers. Min.*, 3rd ed.

Millard Co.—Shoebridge mine; Dragon mine.

Salt Lake Co.—Emma mine; Oxford and Geneva mine.

Montana.—Silver Bow Co.—Several mines near Butte (Liquidator, Gagnon, Parrot, Colusa).

Lewis and Clarke Co.—Marysville (*Min. Mag.* VI., 124).

Missoula Co.—Bell and Stow mine.

South Carolina.—Chesterfield Co.—Brewer's mine.

California.—Alpine Co.—Morning Star mine; Stella mine.

Mexico.—Milpillas, Chihuahua [on A. del Castillo's mining map of Mexico this is Minillas].

Peru.—Prov. Junin: Morococha, Tarma (San Francisco mine and mine of Señor de la Carcel); Cerro-de-Pasco.

Cajamarca: Comotera mine, Cajabamba.

Chili.—Prov. Coquimbo: Hediondas mine, Elqui (this, according to Domeyko, is the locality for Field's "guayacanite"; it is not far from the smelting works after which the name is given).

Santiago: San-Pedro-Nolasco mines.

Atacama: Cerro Blanco mines.

Mine de la Ung (from a label in the British Museum).

Columbia, S. A.—Mines of Santa Anna.

Argentina.—Prov. La Rioja: Several mines in the Sierra Mejicana, Sierra Famatina (*e.g.* Upulungos, Mejicana, Verdiona, Anduesa, San Pedro Alcántara, Compañia, Coquimbana, &c.).

Catamarca: Capillitas.

San Juan: Guachi.

New South Wales.—(A. Liversidge, Minerals of N. S. Wales, 62, 1888; Catalogue of Minerals in the Australian Museum, Sydney, 1885).