On the occurrence of Cotunnite, Anglesite, Leadhillite, and Galena on fused lead from the wreck of the fire-ship 'Firebrand' in Falmouth Harbour, Cornwall.

By Arthur Russell.

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THE specimens which form the subject of the present notes were contained in a collection of minerals formed by the late Mr. Alfred Fox, of Falmouth, and which was acquired by myself in 1909. According to an old label with them, they are described as 'Murio-carbonate of lead taken up the 4th March, 1846, from the wreck of the fire-ship *Firebrand*, which was burnt in Falmouth Harbour about the year 1780. They were found under the lead pump, most of which appeared to be melted and mixed with charcoal.'

In 1779–1780 this country was at war with France, Spain, and America, and Falmouth Harbour was an important rendezvous and place of sortie for ships of the fleet. Fire-ships, it may here be mentioned, at that time still played an important part in naval warfare. They consisted of old vessels filled with combustible materials, such as reeds and brushwood, and were so arranged that they could be rapidly ignited, when, on a suitable opportunity arriving, they closed by means of grappling irons with a ship in the enemy's line, and so set it on fire.

The specimens, eight in number, consist of slag-like, rounded, and more or less cavernous masses of metallic lead which has evidently been fused, and in which are included pieces of charcoal, while on one there still adhere some barnacles. Upon the surface and in the interstices of the lead, which is of a dull-grey colour, are numerous exceptionally well-defined and brilliant crystals of cotunnite and anglesite, two of the specimens also showing small crystals of leadhillite, and one, minute crystals of galena.

COTUNNITE.

[$PbCl_2$. Orthorhombic, $a:b:c = 0{\cdot}5952:1:1{\cdot}1872$.[1]]

All the specimens show very numerous crystals of this mineral, which are perfectly colourless and transparent, with brilliant faces affording excellent images on the goniometer. The crystals are nearly always elongated in the direction of the *a* axis, a few being doubly terminated, and the largest measuring 3 mm. in length. The habit is somewhat variable owing to the very unequal development of the faces. Fig. 1 represents a fairly typical example, the form (111) being always very largely developed with smaller (112). The forms (011) and (021) are often repeated, giving rise to re-entrant angles; the form (101) is rare.

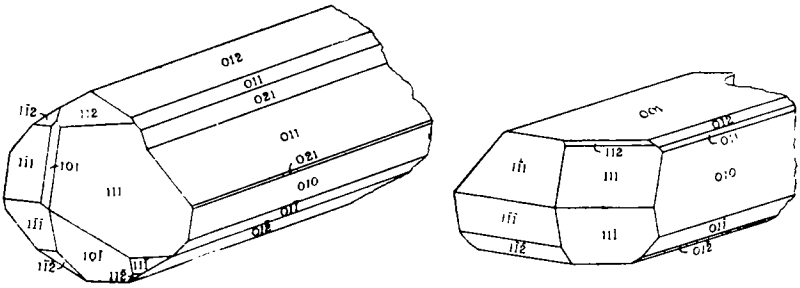

FIG. 1. FIG. 2.

Crystals of Cotunnite from wreck of fire-ship.

In fig. 2 the base (001) is largely developed, as also (010), the crystals presenting a somewhat tabular appearance. Fig. 3 represents a curious development, giving the crystal a distinctly tetrahedral aspect. The forms (112) and (111) are in this case in repeated alternation.

The forms observed are *b* {010}; *c* {001}; *q* {021}; *o* {011}; *r* {012}; *v* {101}; *p* {111}; *t* {112}. No evidence of twinning was detected. The following table gives the principal observed and calculated angles:—

[1] The parameters given are those used by Lacroix and deduced by him from angles measured on artificial crystals by Stöber. Lacroix takes Stöber's *p* (001) as g^1 (010). F. Stöber, Notice cristallographique sur la cotunnite artificielle. Bull. Acad. Belgique, 1895, vol. 30, pp. 345–364. A. Lacroix, Minéralogie de la France, 1910, vol. 4, p. 889.

Angle.	Calculated.	Observed Mean.	Limits.	No. of readings.
(001) : (012) ...	30° 42′ ...	30° 42′ ...	30° 38½′ - 30° 45′ ...	8
(001) : (011) ...	49 53 ...	49 48 ...	48 42 - 50 2½ ...	9
(001) : (021) ...	67 9 ...	67 6 ...	66 42 - 67 25 ...	3
(010) : (012) ...	59 18 ...	59 17 ...	59 3½ - 59 22 ...	11
(010) : (011) ...	40 7 ..	40 6 ...	39 57½ - 40 11½ ...	12
(010) : (021) ...	22 51 ...	22 59 ...	22 45 - 23 19½ ...	5
(001) : (112) ...	49 19 ...	49 17 ..	49 13½ - 49 19½ ...	4
(001) : (111) ...	66 42 ...	66 42 ...	66 39 - 66 50 ...	6
(001) : (101) ..	63 25 ...	63 22 ...	—	1

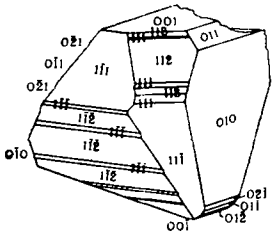

FIG. 3. Crystal of Cotunnite from wreck of fire-ship.

Cotunnite is completely volatile when heated in the closed tube, and is soluble in hot water.

ANGLESITE.

Next to the crystals of cotunnite those of anglesite are the most abundant on all the specimens. The crystals are of rectangular habit, are colourless or black, probably from included lead sulphide, and attain a length of 5½ mm. Fig. 4 represents a typical crystal, the forms present being $a\{100\}$, $c\{001\}$, $m\{110\}$, $o(011)$, $d\{102\}$, $y\{122\}$. On a few crystals there are also present narrow faces of $g\{113\}$ between (102) and (011). The faces (100) are vertically striated from an oscillatory combination with (110).

LEADHILLITE.

[$4PbO . SO_3 . 2CO_2 . H_2O$. Monoclinic, $a:b:c = 1{\cdot}7515:1:2{\cdot}2261$, $\beta = 89° 32'$ (E. Artini, 1890).]

The crystals of leadhillite occupy crevices in two of the specimens. They are of a light waxy brown colour, translucent, and form thin, six-sided plates, fig. 5, with a tendency to aggregate parallel to the base. They attain a diameter of 1 mm. The forms observed are $w\{101\}$,

u {201}, f {$\bar{1}$01}, e {$\bar{2}$01}, t {112}, x {111}, v {$\bar{1}$12}, r {$\bar{1}$11}. The faces in most cases afford poor images. The crystals are optically uniaxial and positive.

GALENA.

One of the specimens rich in anglesite also shows a few minute, though sharp cubo-octahedra of galena of a dark-grey colour, directly implanted on nodules of fused lead. The largest of these crystals is about 1 mm. in diameter.

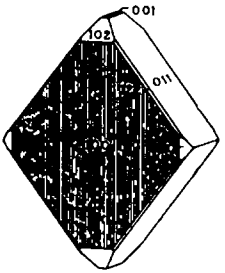

FIG. 4. Crystal of Anglesite from wreck of fire-ship.

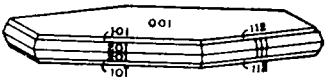

FIG. 5. Crystal of Leadhillite from wreck of fire-ship.

At Laurium, in Greece, as is well known, the sea-water acting on ancient lead slags for some 2,000 years has resulted in the formation of various lead compounds, such as the oxychlorides laurionite, paralaurionite, fiedlerite, penfieldite, with phosgenite, cerussite, and anglesite, while A. Lacroix, in 1910,[1] described an occurrence of cotunnite which so closely resembles the present one as to warrant my quoting the following interesting particulars.

In 1907 sponge-fishers working off Mahdia on the coast of Tunis discovered, at a depth of 40 metres, the wreck of an ancient wooden ship, containing a miscellaneous cargo of marble columns, bronze statues, vases, &c. The ship had apparently been bound from Greece to Rome, and sank probably in the second half of the first century B.C. Among other things found were some lead plates which had evidently been affixed to the outside of the ship, and these, where folded over so as to leave interstices free from mud and sand, were found to be coated with a crystalline crust, and in some cases crystals of cotunnite. These cotunnite crystals showed the forms b {010}, c {001}, q {021}, o {011}, r {012}. The surface of

[1] A. Lacroix, Compt. Rend. Acad. Sci. Paris, 1910, vol. 151, p. 276, and Minéralogie de la France, 1910, vol. 4, p. 890.

the lead plates was darkened by powdery lead sulphide, and some crystals of phosgenite were also found in a cavity in a copper nail, while other of the nails were completely converted into covellite and chalcocite.

At Laurium, the slags lie for the most part on the seashore, and have therefore been exposed to the action of both sea-water and air, thus resulting in the formation of oxychlorides, chlorocarbonate, carbonate, and sulphate. At Mahdia and Falmouth the lead has been exposed to the sea-water only and has given rise to the simple lead chloride, sulphate, and sulphato-carbonate; the galena, covellite, and chalcocite resulting from the reducing action of the charcoal and organic matter. In connexion with leadhillite it may be mentioned that L. J. Spencer has described the occurrence of this mineral in lead slags of Roman age from the Mendip Hills, Somersetshire.[1]

Though derived from an artificial source the cotunnite here described may, I think, be allowed to rank as an addition to the list of species recorded from the British Isles.

[1] L. J. Spencer, Leadhillite in ancient lead slags from the Mendip Hills. Rep. British Assoc., 1899, sixty-eighth meeting (1898), p. 875: reprint in Geol. Mag., 1899, pp. 71–72.