On laurionite and associated minerals from Cornwall.

By Arthur Russell.
With a note on paralaurionite.
By Prof. A. Hutchinson, M.A., Ph.D., F.R.S.

[Read January 10, 1922.]

THE two exceedingly interesting specimens which form the subject of the present notes came under my observation in the following manner. In 1905 there was sold by public auction in London an old and very fine collection of minerals, mostly Cornish, which had been formed by John Hawkins, F.R.S. (b. 1758, d. 1841), of Trewithen, Probus, Cornwall; a gentleman well known in his day both as a scientist and traveller. The major part of the collection unfortunately left this country, having been purchased by the dealer F. Krantz of Bonn. A few lots were, however, bought by myself, and one of these contained the first specimen to be here described.

This specimen consists of one-half of a small geode 7×5 cm. formed of brown and velvety black limonite, some partially altered chalybite, ferruginous crystalline quartz, and a little galena. In this geode and upon the limonite are emplanted several very brilliant crystals of phosgenite, one large tabular crystal of anglesite, and numerous smaller crystals of laurionite. The specimen had no label, but besides being certainly Cornish, it came, almost without doubt, from the silver-lead mine of Wheal Rose in the parish of Sithney. With this specimen there were others of cerussite labelled Wheal Pool (a neighbouring mine). Further, the geode exactly resembles similar geodes containing cerussite and anglesite which have been found by myself on one of the old dumps at Wheal Rose. The limonite on all of the specimens is exceedingly characteristic of the locality, showing evidence of being pseudomorphous after chalybite.

The other specimen, which is in the Brooke collection at Cambridge, (no. 2302) is especially referred to by Greg and Lettsom under cromfordite (phosgenite) as being the only specimen of that mineral known

to be from Cornwall. An idealized figure of one of the crystals is given and it is stated that the locality is believed to have been Huel Confidence, New Quay, St. Columb Minor,[1] this locality, as also measurements of one of the phosgenite crystals, being recorded in H. J. Brooke's notebook which is preserved along with the collection. Through the kindness of Professor A. Hutchinson I was able to examine the specimen, when it was at once seen that it very closely resembles the one previously described. It likewise consists of a portion of a small geode of velvety black limonite, in which are several very well-defined crystals of phosgenite exactly similar in habit and presenting the same forms as those on the specimen from the Hawkins collection. In addition, however, to the phosgenite there are platy crystals of a mineral which Professor Hutchinson readily undertook to examine and which he has proved to be the rare species paralaurionite, described by Dr. Herbert Smith as a new mineral in 1898. There is no laurionite upon this specimen, the only other mineral present being a little pyromorphite on the outside of the geode. The particulars as to the paralaurionite which follow have been contributed by Professor Hutchinson.

Laurionite.

[$PbCl_2 . Pb(OH)_2$. Orthorhombic, $a : b : c = 0{\cdot}7385 : 1 : 0{\cdot}8346$.[2]]

The crystals of laurionite are colourless and translucent and bladed in form, attaining a length of 4 mm. Fig. 1 represents the general habit which closely resembles one of the figures (fig. 3) given by Köchlin of Laurion crystals.[3] Two crystals were measured, one a detached one, the other on the specimen. The following forms are present: b (010), m(110), n(120), d(012), and the prominent but somewhat doubtful form p(141). The principal angles observed compared with those on Laurion crystals described by Dr. Herbert Smith are given in the following table:

Angle.	Calculated.	Observed mean Laurion.	Observed Cornwall.
(010) : (120) ...	34° 0′	34° 6′	34° 10′
(010) : (110) ...	53 33	53 45	53 46½
(010) : (012) ...	67 20	67 21	66 28½
(010) : (141) ...	24 19½	19 0–27° 12′	22 27–22° 46½′

[1] R. P. Greg and W. G. Lettsom, 'Manual of the Mineralogy of Great Britain and Ireland', 1858, pp. 421–423.

[2] The axial ratios given are those deduced by Dr. G. F. Herbert Smith from measurements on crystals from Laurion, Min. Mag., 1899, vol. 12, p. 102.

[3] R. Köchlin, 'Ueber Phosgenit und ein muthmasslich neues Mineral von Laurion'. Ann. naturhist. Mus. Wien, 1887, vol. 2, pp. 188–190.

The faces as a whole appeared to be etched and afford multiple images, with the exception of $m(110)$ which gives good reflections. As in the case of the Laurion crystals the faces of $b(010)$ are striated parallel to their intersection with the pyramid $p(141)$, the latter being possibly a vicinal form as suggested by Dr. Herbert Smith. The edges formed by the intersection of the faces $p(141)$ are always more or less curved, thus giving rise to the bladed form.

No interference-figure can be seen looking through (010). The

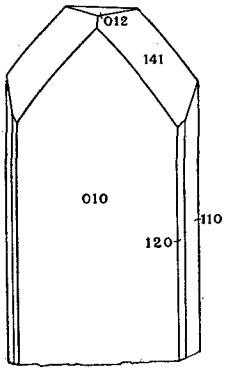

FIG. 1. Crystal of Laurionite, from Wheal Rose, Sithney, Cornwall.

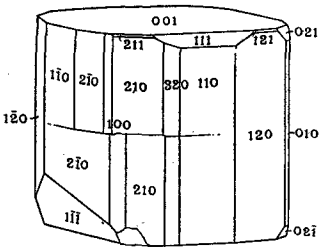

FIG. 2. Crystal of Phosgenite, from Wheal Rose, Sithney, Cornwall.

crystals when powdered are partially soluble in boiling water. The presence of lead and chlorine was determined.

Of the three associated minerals, laurionite, phosgenite, and anglesite, the laurionite appears to have been the last formed, and partially invests the other two.

PARALAURIONITE (by Prof. A. Hutchinson).

[$PbCl_2.Pb(OH)_2$. Monoclinic, $a:b:c = 2{\cdot}7036:1:1{\cdot}8019$, $\beta = 62°\,47'$.[1]]

The identification as paralaurionite of the platy crystals on the Brooke collection specimen no. 2302, referred to above, rests on the following observation:

The crystals are long narrow thin plates without for the most part any terminal faces and when measured gave angles consistent with the supposition that they are crystals of paralaurionite elongated along the symmetry-axis and twinned about $a(100)$ with the faces of a large and

[1] G. F. H. Smith, Min. Mag., 1899, vol. 12, pp. 108, 183.

those of $c(001)$ small. Thus on one crystal the following angles were observed: $ac = 62° 50'$, $c\underline{c} = 53° 54'$, $\underline{c}\,\underline{a} = 63° 21'$, $\underline{a}\,c' = 62° 45'$, $c'\underline{c}' = 54° 15'$, $\underline{c}'a = 62° 55'$, which agree well with the angle $ac = 62° 47'$ and the consequent angle $c\underline{c} = 54° 26'$ given by Herbert Smith. There is an excellent cleavage parallel to $c(001)$. Indications of other faces in the zone ac were observed, and it is probable that $h(\bar{2}01)$ is present on some crystals as a very narrow face.

The important face $m(110)$ mentioned by Herbert Smith was not observed, but a face making an angle of 24° 24′ with a was found instead. Simple indices cannot be assigned to this face ((510) would correspond to an angle from a of 25° 38′) and it is probable that it is an accidental face produced where one crystal has come in contact with another. It was, however, sufficiently plane to enable a rough determination of the refractive index for light vibrating parallel to the symmetry-axis to be made, by using as a prism this face and $a'(\bar{1}00)$. The result for sodium-light is 2·118, which is somewhat smaller than the value 2·146 given by Herbert Smith.

On examining one of the thin plates in convergent monochromatic (sodium) light an interference-figure was seen transverse to the length of the plate and similar to that given by a twinned diopside. The same phenomenon was noted by Herbert Smith in the case of paralaurionite and was mentioned by him as specially characteristic of this substance and as affording the best means of distinguishing it from laurionite and fiedlerite. The fact that this character is exhibited so clearly by the Cornish material provides strong confirmative evidence that the identification with paralaurionite is correct.

Phosgenite.

[$PbCO_3 . PbCl_2$. Tetragonal, $c = 1·0889$.[1]]

The crystals of phosgenite on the specimen from the Hawkins collection are exceptionally beautiful, being almost transparent, possessing a high lustre, and lying on a black background of limonite. The largest measures 6 mm. along the vertical axis. Fig. 2 represents one of the crystals which was measured on the specimen, and is an accurate representation, with the exception of the back where it is attached to another crystal. The forms present are $c(001)$, $a(100)$, $m(110)$, $l(320)$, $u(210)$, $o(201)$, $x(111)$, $s(211)$. It will be seen from the drawing that the

[1] Axes and letters of forms as in V. Goldschmidt, 'Atlas der Krystallformen', 1920, vol. 6, p. 150.

crystal is in part an intergrowth of two individuals one overlapping the other, the faces of the two individuals, though unequally developed, being in parallel position. The prism-faces, though brilliant, are all vertically striated and afford banded images. The following were the principal angles observed:

Angle.	Calculated.	Observed.
(100) : (210)	26° 34′	26° 32½′
(100) : (320)	33 41	34 8
(100) : (201)	24 40	24 16½
(110) : (111)	33 0	33 0
(210) : (211)	22 20	22 17

In the William Phillips collection at Liverpool are several small loose aggregates of crystals of phosgenite which are described in the Sale Catalogue dated 1829 as 'No. 1232, Murio-carbonate of lead in detached transparent crystals. Huel Confidence, near New Quay, Cornwall.' Accompanying these are Phillips's freehand drawings and rough measurements of three of the crystals. The habit is nearly the same as that of the two specimens already described, the forms present being also the same. One of the aggregates shows a little attached limonite and chalcopyrite. It was probably from this source that the Brooke specimen had ascribed to it the locality Huel Confidence.

Anglesite.

[$PbSO_4$. Orthorhombic, $a : b : c = 0{\cdot}7852 : 1 : 1{\cdot}2894$.[1]]

One large colourless and transparent crystal of anglesite 1 cm. in length has grown across the bottom of the geode on the Hawkins specimen. It is tabular parallel to $a(100)$, and is bounded by narrow faces of $m(110)$ and $d(102)$, fig. 3. A small crystal growing from the large one was detached for measurement and identification. A specimen collected from the mine dump by myself in 1921 shows a rough etched prismatic crystal of anglesite 1½ cm. in length, occupying a small cavity, lined with deep-brown crystals of quartz, in limonite with some galena.

Thanks to Mr. George Penrose, Curator of the Royal Institution of Cornwall Museum, Truro, I have been able to examine two specimens of anglesite from Wheal Rose, belonging to the Philip Rashleigh collection. The first of these, no. 405 in the MS. catalogue of the Rashleigh collection, is described as 'White four-sided tabular crystals of lead with parallelogram form, with edges replaced, on iron ore. Huel Rose.' It shows

[1] Axes and letters of forms as in Dana's 'System', 6th edition, 1892.

numerous white translucent crystals up to 5 mm. in length scattered over the interior of a limonite geode, with spots of chalcopyrite. A typical crystal was measured. It is tabular parallel to $a(100)$ and shows the forms $a(100)$, $m(110)$, $n(120)$, $d(102)$, fig. 4. The second specimen no. 352 is described as 'Transparent crystals of lead ore with six-sided

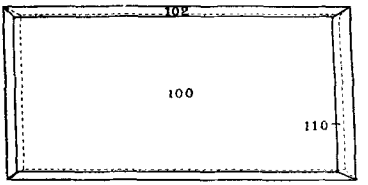

FIG. 3.

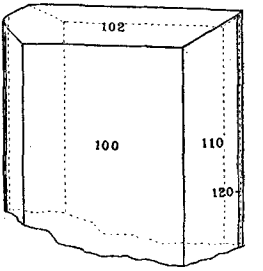

FIG. 4.

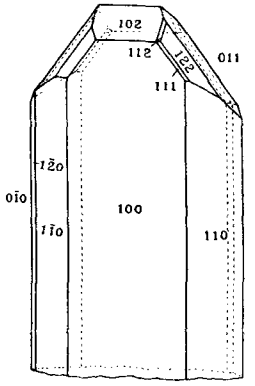

FIG. 5.

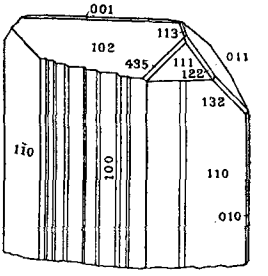

FIG. 6.

FIGS. 3–6. Crystals of Anglesite, from Wheal Rose, Sithney, Cornwall.

prisms near flat beviled pyramids. Huel Rose, G.C.F.'[1] It shows slightly brownish flat bladed crystals of anglesite up to 5 mm. in length occupying a cavity in brown limonite with a little quartz and chalcopyrite on the back of the specimen. Two crystals were selected for measurement. Fig. 5 shows the forms $a(100)$, $b(010)$ one face only, $m(110)$, $n(120)$, $d(102)$, $o(011)$, $r(112)$, $z(111)$, $y(122)$; Fig. 6 the forms $a(100)$, $b(010)$, $c(001)$, $m(110)$, $d(102)$, $o(011)$, $g(113)$, $z(111)$, t(435), $y(122)$, $s(132)$. The prism-faces on this crystal are deeply furrowed owing to repeated alternations of (100) and (1$\bar{1}$0). A narrow face was

[1] George Croker Fox, Senior.

also observed lying between (435) and (111), the angle to (111) being 4° 13′; to this, however, no definite indices can be assigned. A specimen labelled anglesite from Wheal Rose in the Penzance Museum proved on examination to be cerussite.

Cerussite.[1]

Beautiful specimens may still occasionally be found by breaking open geodes of limonite which lie on the small and now nearly overgrown dump at the northernmost shaft. The interior of these geodes consists of mamillary velvet black limonite upon which are implanted thin flat translucent twinned crystals of cerussite up to 8 mm. in length. These crystals are tabular parallel to $b(010)$, twinned on $m(110)$, and show the forms $b(010)$, $m(110)$, $i(021)$, $p(111)$, fig. 7. Small acicular crystals also occur and more rarely bipyramidal crystals, combinations of $p(111)$ with $i(021)$ and $m(110)$, showing polysynthetic growths and measuring up to $1\frac{1}{2}$ cm. along the vertical axis.

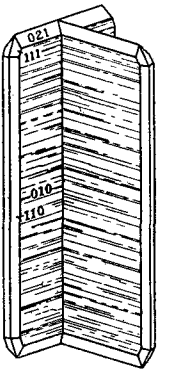

Fig. 7. Twin-crystal of Cerussite, from Wheal Rose, Sithney, Cornwall.

Pyromorphite.

This mineral occurred at Wheal Rose in some abundance. It forms small (up to 6 mm. in length) bright *grass-green to greenish-yellow* hexagonal prisms often partly hollow or slightly barrel-shaped, $m(10\bar{1}0)$, with occasionally narrow faces of $a(11\bar{2}0)$. It incrusts sugary quartz, and invests pyramidal crystals of quartz or more rarely pseudomorphous lenticular crystals of limonite after chalybite.

Wheal Rose[2] and the adjoining mines Wheal Penrose and Wheal Pool are probably the oldest lead mines in Cornwall, records of their working

[1] Axes and letters of forms as in Dana's 'System', 6th edition, 1892.

[2] J. Carne, Trans. Roy. Geol. Soc. Cornwall, 1822, vol. 2, p. 344.

'Notes on the Excursions of the Helston Branch of the Miners' Assoc. Cornwall and Devon', 1864, p. 11.

H. Stephens, 'Mineral phenomena of Huel Rose'. Ann. Rep. Roy. Cornwall Polytechnic Soc., 1871, no. 39, pp. 77–80.

In 'The Geology of the Lizard and Meneage', Mem. Geol. Survey, 1912, pp. 257–258, a misquotation respecting this mine appears—it is stated that 'small vugs containing phosphate and arseniate of iron were found', whereas it should read 'phosphate and arseniate of lead'. This error is repeated in 'The Special Reports on the Mineral Resources of Great Britain', 1921, vol. 21, p. 10.

dating back to 1625. The main lode at Wheal Rose has a direction nearly due north and south magnetic, and outcrops on the low cliff three-quarters of a mile south-east of Porthleven (6-inch ordnance map, 76 SW.). The mine was worked to a depth of 54 fathoms, the southern levels extending under the sea and the mine water being extremely salt. The upper portion of the lode consists of limonite and comby crystallized quartz with galena, and a little chalcopyrite and blende. In depth the limonite changed to chalybite and this during the last working, about 1864, was mined as an iron ore. The galena contained 60 ounces of silver to the ton.

Several small lead mines were formerly worked on lodes outcropping in the cliffs near New Quay and one of these may once have been known as Wheal Confidence. A search of old mining records has only established the fact that there was a Wheal Confidence at work in Cornwall during the years 1830–1, but whether a lead mine and where situated is not stated.

There can be little doubt that both the Hawkins and Brooke specimens here described came from the same locality. In connexion with the origin of the two oxychlorides it is significant that at Wheal Rose salt water had access to the lead lode. At Laurion, Greece, the minerals laurionite, paralaurionite, phosgenite, and anglesite have all been formed in ancient lead slags which for some 2,000 years have been exposed to the action of sea-water.