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Cornubite, a new mineral dimorphous with cornwallite.

By G. F. Claringbull, B.Sc., Ph.D., A.Inst.P., M. H. Hey, M.A., D.Sc. and R. J. Davis, M.A., D.Phil.

Dept. of Mineralogy, British Museum (Natural History).

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Summary. A new copper arsenate, dimorphous with cornwallite, has been found on specimens from five localities in Cornwall, one in Devon, and one in Cumberland. The name *cornubite* (from Cornubia, the medieval Latin name for Cornwall) is proposed for the new mineral. Chemical analyses of cornubite and cornwallite agree well with $Cu_5(AsO_4)_2(OH)_4$; sp. gr. cornubite 4·64, cornwallite 4·52. X-ray study suggests that the unit-cell of cornubite has a volume of 228 Å.^{3} or a simple multiple thereof. New X-ray data for cornwallite (a 17·33, b 5·82, c 4·60 Å., β 92° 13′) agree well with L. G. Berry's except for a. Powder data for both are given.

DURING an examination of some copper phosphates and arsenates from Cornwall in 1955, one specimen belonging to Sir Arthur Russell was found to give an X-ray powder pattern different from any known copper mineral; on further study this has proved to be a new mineral, dimorphous with cornwallite, for which we propose the name cornubite, from Cornubia, the Roman name for Cornwall. The specimens from Wheal Carpenter, Gwinear, Cornwall, carry well-crystallized quartz, coated with dark green fibrous cornwallite, on which there are apple-green patches of botryoidal fibrous cornubite. Subsequently we have found several further specimens of cornubite: one, B.M. 42818, from St. Day, Cornwall, was labelled chenevixite and carries light to dark green massive porcellaneous cornubite with crystals of olivenite; a second, B.M. 1956,460, carries massive light apple-green cornubite with crystals of liroconite, and according to Sir Arthur Russell must have come from Wheal Gorland, Gwennap, the only known Cornish locality for liroconite; one from Wheal Muttrell, Gwennap, B.M. 1958,771, carries green massive cornubite with olivenite, malachite, and an unidentified bright green mineral on rusty quartz; two come from Wheal Phoenix, Linkinhorne, Cornwall, one, B.M. 1958,778, with bright green glassy botryoidal cornubite and pale green drusy cornwallite on quartz, the other, B.M. 1958,769, with green glassy and also porcellaneous cornubite, olivenite, and stained feldspar on rotten granite; one, B.M. 1958,767, from the Marquis shaft, Bedford United mines, Tavistock, Devon, has

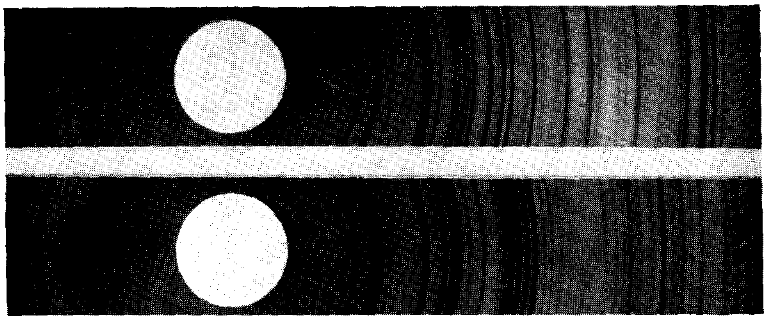

FIG. 1. X-ray powder photographs of cornubite (above) and cornwallite (below) from Wheal Carpenter.

green glassy botryoidal cornubite with olivenite, malachite, and cuprite; and two, B.M. 1958,122 and 779, from Potts Gill mine, Caldbeck, Cumberland, carry light and dark green botryoidal cornubite, with on the latter specimen a bluish skin of cornwallite. All the last six specimens were collected and presented by Mr. A. W. G. Kingsbury.

We have not been able to isolate single crystals of cornubite; one fibrous fragment from Sir Arthur Russell's type specimen gave a good fibre pattern, but was unfortunately lost and repeated attempts to find equally well-crystallized material on any of the above specimens failed. The fibre photograph showed a layer-line spacing of $9{\cdot}0 \pm 0{\cdot}2$ Å. with every third layer-line stronger than its neighbours. The zero layer-line of this pattern could readily be indexed to well within the experimental error of measurement on the basis of d_{100} 5·35 Å., d_{010} 4·72 Å., γ^* 88°, with very few absent diffractions, and from this data we can calculate an apparent cell-volume of 228 Å.^{3}; the true cell-volume must be an integral multiple of this. Attempts to index the non-zero layer-lines and so derive complete unit-cell data, using V. Vand's method,[1] indicate that the mineral is almost certainly anorthic, and that probably both d_{100} and d_{010} should have double the above values, although there are now many absences and still a few unindexable lines, so that the true cell may be even larger.

[1] Acta Cryst., 1948, vol. 1, p. 290.

TABLE I. X-ray powder data for cornubite (B.M. 1958,122, from Potts Gill, Caldbeck, Cumberland). Cu-$K\alpha$ radiation, camera diameter 11·46 cm. Third (l) index by comparison with a fibre photograph (layer-line spacing 9·0 Å.). B, broad.

d (meas.)	I.	l.	d (meas.)	I.	l.	d (meas.)	I.	l.
5·35	6	0	2·265	2	? 1	1·492	7	3
5·22	1	—	2·240	4	1, 3	1·467	5	3
4·88	1	—	2·180	2	0	1·457	1	—
4·72	10(1)	0	2·143	4	0, ? 3	1·442	2 B	0
4·53	1	—	2·090	6	3	1·408	2	? 0
4·31	4	2	2·071	5	3	1·392	1	? 0
3·93	2	2	2·027	1 B	—	1·373	6	0
3·59	6	0	1·973	4	3	1·353	1	—
3·49	8	0	1·957	6	3	1·340	4	0
3·42	1	? 3	1·919	4	3	1·321	1	—
3·33	6	2	1·899	1	—	1·308	4	—
3·10	6	2	1·853	1	—	1·300	5	0
3·05	6	2	1·829	4	—	1·281	2	—
2·98	6	1	1·797	4	0	1·269	1	—
2·932	6	2	1·747	6	0	1·241	1 B	—
2·868	7	1	1·720	2	3	1·227	2	—
2·688	9	0	1·696	1	—	1·217	2	—
2·616	2	? 2	1·662	4 B	3	1·203	4 B	? 0
2·562	10(2)	3	1·630	1	—	1·190	1	—
2·525	1	—	1·608	1	—	1·181	2	—
2·489	10(3)	3	1·593	5	3	1·172	2	—
2·443	4	? 2	1·575	7	0, 3	1·158	1	—
2·390	4 }	? 1	1·544	1	—	1·151	4	0
2·358	5 }	0	1·524	7	3			
2·303	7	0	1·515	6	3			

The X-ray powder pattern (table I) correlates well with the fibre pattern, and l indices can be assigned to most of the low-angle powder lines. Identical powder patterns were given by both the light green and the dark green crusts on Sir Arthur Russell's specimen, and also by material from the other Cornish specimens; material examined from one Cumberland specimen (B.M. 1958,122) included both light and dark green crusts and also a thin light green layer under the dark green—all yielded identical patterns.

A microchemical analysis on 6·6 mg. of cornubite from Sir Arthur Russell's specimen gave the results shown in table II, where they are compared with a new analysis of cornwallite from the same specimen and with the theoretical composition for $Cu_5(AsO_4)_2(OH)_4$; the densities and empirical unit-cell contents are also included in table II. The cited percentage of water in the cornubite is obtained by difference. The mineral only lost 2·8 % H_2O at 450° C., and was then still bright green;

in view of the small amount of material available, the sample was not further heated lest some arsenic might be volatilized. Despite this difficulty, there is clear evidence that cornubite is a polymorph of cornwallite, and that the structural unit of volume 228 Å.^{3} contains $Cu_5(AsO_4)_2(OH)_4$. The observed specific gravity is some 3 % lower than the calculated, but this is not an unduly great difference for crypto-crystalline material.

TABLE II. Chemical analyses and specific gravities of cornubite (A) and cornwallite (B) from Wheal Carpenter compared with the theoretical composition for $Cu_5(AsO_4)_2(OH)_4$ (calc.); together with the atomic contents of the unit cell or pseudo-cell of cornubite (volume 228 Å.^{3}) (A′) and of the unit cell of cornwallite (B′), and the calculated densities for the ideal formula.

	A.	*B.*	*Calc.*		*A′.*	*B′.*
CuO	59·86	60·29	59·94	Cu	4·8	9·70
As_2O_5 ...	35·07	33·97	34·63	As	1·95	3·82
H_2O	[5·07]	5·80	5·43	O	7·9	15·12
Insol. ...	—	0·82	—	OH	3·6	8·24
Total ...	[100·00]	100·88	100·00			
				O+OH	11·5	23·36
$D_{4°}^{20°}$	4·64	4·52				
$D_{4°}^{20°}$ calc. ...	4·8	4·645				

A new analysis of cornwallite was also made (table II), and an X-ray powder study (table III) of material from the same specimen. The powder photographs agree excellently with one another and with L. G. Berry's data,[1] and were readily indexed; the new data are somewhat fuller than Berry's and are therefore listed (table III). Berry's cell-dimensions were confirmed, except for the *a*-dimension, for which we find a value of 17·33 Å., appreciably lower than Berry's value of 17·61 Å. (see table III). The new analysis confirms the formula $Cu_5(AsO_4)_2(OH)_4$; it seems probable that, as Berry suggests, the high water content shown in many analyses of cornwallite is due to non-crystalline impurities, and that our material was purer than most. We have been able to obtain a new specific gravity for cornwallite, and while still appreciably lower than the calculated value the discrepancy is not serious considering that the mineral is finely fibrous. It is interesting that, despite these discrepancies, the observed densities in table II are in the order predicted from the X-ray unit-cell volumes.

[1] Amer. Min., 1951, vol. 36, p. 490.

TABLE III. X-ray powder data for cornwallite from Sir Arthur Russell's specimen of cornubite (Wheal Carpenter, Gwinear, Cornwall). Cu-$K\alpha$ radiation, camera diameter 11·46 cm. Indices and d calc. based on a cell with a 17·33, b 5·82, c 4·60 Å., β 92° 13′. [L. G. Berry found a 17·61, b 5·81, c 4·60 Å., β 92° 15′.] B, broad; D, doublet; T, triplet.

d (meas.)	I.	hkl.	d (calc.)
8·76	4	200	8·673
5·47	5½	110	5·506
4·82	7	210	4·827
4·60	8 B	001	4·598
4·35	1	400	4·336
4·11	2	$\bar{2}01$	4·134
		310	4·097
—	—	201	3·996
3·91	1	—	—
—	—	011	3·606
3·53	9 T	$\bar{1}11$	3·552
		111	3·508
		410	3·475
3·36	2 ?D	$\bar{2}11$	3·368
—	—	211	3·293
3·22	10	$\bar{4}01$	3·218
3·10	9 D	401	3·121
		$\bar{3}11$	3·101
3·02	8 ?D	311	3·019
2·974	2	510	2·978
—	—	020	2·905
2·890	5	600	2·891
—	—	120	2·865
2·817	1	$\bar{4}11$	2·815
2·740	6	220	2·755
		411	2·750
2·590	4	320	2·596
		610	2·589
2·539	5	$\bar{5}11$	2·539
2·478	8 B ?T	$\bar{6}01$	2·492
		511	2·462
		021	2·458
—	—	$\bar{1}21$	2·439
—	—	121	2·424
2·414	9 D	420	2·414
		601	2·405
—	—	$\bar{2}21$	2·377
2·350	6 D	221	2·350
2·292	7B	002	2·298
		$\bar{6}11$	2·290
		710	2·280
		$\bar{3}21$	2·277
—	—	321	2·244
—	—	$\bar{2}02$	2·243
2·223	5	520	2·229
		611	2·222
—	—	202	2·201
2·177	6	800	2·168
—	—	$\bar{4}21$	2·156
2·141	1		
2·112	4		
2·064	2		
2·001	1 BD		
1·880	5		
1·831	5		
1·798	4½		
1·772	6		
1·753	2		
1·729	5		
1·700	1		
1·683	4		
1·646	6		
1·612	4		
1·598	1		
1·580	5		
1·555	5		
1·523	5 B		
1·506	2		
1·490	2		
1·456	5 D		
1·437	4		
1·425	5		
1·407	4		
1·398	4		
1·380	4		
1·369	5		
1·346	6		
1·333	4		