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Quetzalcoatlite, $Cu_4Zn_8(TeO_3)_3(OH)_{18}$, a new mineral from Moctezuma, Sonora

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SUMMARY. Quetzalcoatlite is a new mineral from the Bambollita mine in the Sierra La Huerta near Moctezuma, Sonora, Mexico. The colour is Capri blue (R.H.S. 120A) with a pale streak. H = 3; G meas. = 6·05±0·3; G calc. = 6·12. Crystals up to 0·4 mm long were not measurable but are acicular to prismatic, hexagonal, with fair cleavage on {10$\bar{1}$0}; *a* 10·097 Å, *c* 4·944, space group $C6_32$. Z = 1. Strongest lines are 8·752 (100), 2·748 (70), 2·520 (42B), 3·531 (40), 3·273 (31), 1·766 (28), 5·054 (21), 2·250 (20). Electron probe analysis gives: CuO 20·3%, 18·9, 20·9; ZnO 41·2, 38·2, 38·7; TeO_2 29·4, 31·3, 30·6. Water by Penfield method on 2·265 mg gave 10·1 %. Empirical cell contents are $Cu_{4.01}Zn_{7.73}Te_{3.04}O_{8.88}(OH)_{17.89}$ or $Cu_4Zn_8(TeO_3)_3OH_{18}$. Pleochroic with ϵ = colourless, ω = pale blue-green; uniaxial (−) with ϵ_D = 1·740, ω_D = 1·802. Named for the Toltec god Quetzalcoatl.

Occurrence. Quetzalcoatlite was first obtained by Herbert A. Mendoza from a small stockpile of rich silver ore stored at Nacozari, Sonora. Thanks to the kindness of Sr. Roderico Soto I was given permission to comb through this pile and obtain another dozen specimens in addition to the original one. The remainder of this ore has, unfortunately, been smelted since. The mine that produced the ore is the Bambollita (now La Oriental), which I have visited twice in search of more material. Ore of identical character occurs in the mine—but no quetzalcoatlite was found. It must be a rare mineral in the vein, for of many seemingly identical pieces examined from the mine and stockpile, only a tiny fraction exhibit the characteristic blue quetzalcoatlite.

Quetzalcoatlite was found only in the very richest pieces of ore. Usually these are spectacular masses or nuggets of hessite with minor galena and bornite. The gangue is rhyolite so severely altered that only a variety of clays (kaolinite, dickite, and two unidentified) and quartz remain. The primary ore grains replace this altered rock or are embedded in thin, anastomosing stringers of coarse baryte. Incipient oxidation has occurred in these samples. Galena is thinly rimmed with cerussite, brilliant azurite crystals film bornite, and pitted surfaces on hessite grains are implanted with chlorargyrite and stubby prisms of teineïte. Quetzalcoatlite occurs in such material as minute crystalline crusts or sprays of needles in thin fractures. Often these fractures are filled with dickite, which is stained a pea green colour with an amorphous Cu–Te compound. This compound corrodes and partly replaces quetzalcoatlite according to thin section evidence.

Physical properties. Quetzalcoatlite is a lovely blue colour, the name Capri blue (R.H.S. 120A) seems quite appropriate. I think the mineral is more similar in colour to spangolite than to any other mineral. The powdered mineral is almost white. Crystalline masses are brittle with a hardness on Mohs scale of 3. There is a fair cleavage on the prism $\{10\bar{1}0\}$, which is best seen in thin section owing to the minuteness of the crystals. No fluorescence was noted in long or short wave-length ultraviolet light. Using about 1 mg on the Berman balance (in tetrabromethane) the specific gravity was 'estimated' as $6{\cdot}05 \pm 0{\cdot}3$ (four trials).

Chemistry. Microchemical tests showed only Cu, Zn, and Te and a spectrogram confirmed this. So too did qualitative electron probe work prior to quantitative analysis. Three grains were analysed (20 point counts each) and the results are given in Table I. The analytical work leads to the formula $Cu_4Zn_8(TeO_3)_3(OH)_{18}$ with empirical cell contents $Cu_{4\cdot01}Zn_{7\cdot73}Te_{3\cdot04}O_{8\cdot88}(OH)_{17\cdot89}$. Although irregularities in the three probe analyses could be taken as an indication of possible Cu/Zn substitution, all three analyses are closest to Cu:Zn = 4:8 (where Cu+Zn = 12).

TABLE I. *Electron-probe analysis of quetzalcoatlite*

	1	2	2	Mean		4	5
Cu	16·2	15·1	16·7	16·0	CuO	20·0	19·76
Zn	33·1	30·7	31·1	31·6	ZnO	39·4	40·43
Te	23·5	25·0	24·5	24·3	TeO_2	30·4	29·74
					H_2O	10·1	10·07
					Sum	99·9	100·00

1–3. Analyses by R. F. Symes (British Museum (Natural History)); pure metals were used as standards.

4. Oxide equivalents of the means; water by Penfield method on 2·265 mg (water was observed in the tube).

5. Theory for $Cu_4Zn_8(TeO_3)_3(OH)_{18}$.

Quetzalcoatlite is easily soluble in cold acids (1:6 HCl, 1:7 HNO_3) but seemingly unaffected by cold 40 % KOH. It decomposes in this reagent when warmed, however. It is insoluble in water, hot or cold.

Crystallography. No measurable single crystals could be found. The largest crystals (0·4 mm long) were fibrous with pearly or dull faces. Brilliant crystals do occur, but invariably in jumbles of closely packed crystals with perhaps one or two reflecting surfaces belonging to any given crystal. Thin section and X-ray study suggests that crystals are simple prisms bounded only by $\{10\bar{1}0\}$ and $\{0001\}$. A cleavage on $\{10\bar{1}0\}$ may be seen in thin section.

In thin section quetzalcoatlite looks greener than would be expected and resembles brochantite. It was noted most often in thin veinlets as mutually interfering sprays of slender prisms, usually with their *c* axes lying nearly parallel with the veinlet. Replacement or corrosion by a pea-green amorphous compound could be easily seen. Prisms show parallel extinction and are length fast; basal sections give a sharp uniaxial (–) interference figure. Birefringence is moderately strong (0·062) and the refractive indices (NaD) are $\epsilon = 1{\cdot}740$, $\omega = 1{\cdot}802$. Pleochroism is $\epsilon =$ almost colourless, $\omega =$ blue green.

The powdered mineral gives crisp powder patterns and the indexed pattern is given in Table II. Study by rotation and Weissenberg methods verified hexagonal symmetry and cell dimensions (refined from powder data) are $a = 10{\cdot}097$Å $\pm 0{\cdot}025$, $c = 4{\cdot}944 \pm 0{\cdot}008$. The space group is $C6_32$ and, if Z = 1, the calculated specific gravity is 6·12.

TABLE II. *Indexed powder data for quetzalcoatlite*
114 mm camera, Cr-Kα radiation

I	$d_{obs.}$	$d_{calc.}$	$hk\bar{i}l$	I	$d_{obs.}$	$d_{calc.}$	$hk\bar{i}l$
100	8·752	8·744	$10\bar{1}0$	16	2·472	2·472	0002
21	5·054	5·049	$11\bar{2}0$	12	2·425	2·425	$31\bar{4}0$
18	4·302	4·304	$10\bar{1}1$	12	2·381	2·379	$10\bar{1}2$
40	3·531	3·532	$11\bar{2}1$	20	2·250	2·248	$22\bar{4}1$
31	3·273	3·275	$20\bar{2}1$	11	2·180	2·186	$40\bar{4}0$
70	2·748	2·748	$21\bar{3}1$			2·177	$31\bar{4}1$
42B	2·520	2·511	$22\bar{4}0$	16	2·007	2·006	$32\bar{5}0$
		2·524	$30\bar{3}1$	28	1·766	1·766	$22\bar{4}2$

Plus 14 additional lines to $d = 1{\cdot}200$ Å, none with $I > 17$.

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Miscellany. Quetzalcoatl was an important god of the Toltecs (González Blackaller and Guevera Ramírez, 1967). The name literally means plumed serpent (Toro y Gisbert, 1970). He returned to the sea and might some day come back. Quetzalcoatlite is named for this god of the sea in allusion to its lovely Capri blue colour. The name should be pronounced Kĕtsĕlkwă·tlāit. Type specimens will be at the British Museum (Natural History) and the University of Paris 6.

REFERENCES

GONZÁLEZ BLACKALLER (C. E.) and GUEVARA RAMÍREZ (L.), 1967. *Síntesis de Historia de México.* Editorial Herrero, S.A. Mexico, D.F.

TORO Y GISBERT (M. DE), 1970. *Pequeño Larousse Ilustrado.* Ed. Larousse, Paris.

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