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BAMBOLLAITE [1], A NEW COPPER TELLURO-SELENIDE

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ABSTRACT

A copper telluro-selenide $Cu(Te,Se)_2$ with $Te : Se \simeq 1 : 2$. found in trace amounts on specimens from Mina La Moctezuma, Sonora, Mexico, has been determined to be a new mineral.

Bambollaite occurs in microcrystalline form associated with klockmannite, with which it is intimately associated and from which it is indistinguishable by sight, native tellurium, chalcomenite, tellurite, paratellurite, illite, quartz and calcite.

The *x*-ray powder pattern is similar to that of fluorite, but with many of the lines present as doublets suggesting a nearly-cubic tetragonal cell with dimensions $a = 5.466$, $c = 5.632$Å.

INTRODUCTION

During the investigation of a suite of mineral specimens obtained and studied at the Royal Ontario Museum in 1961 from Mina La Moctezuma (also known locally as Mina La Bambolla [4]), a gold-tellurium mine near the town of Moctezuma, Sonora, Mexico, five new tellurium minerals were noted by Mandarino & Williams (1961a,b). They also observed a "probably new" species on a number of specimens of which a representative collection was kindly loaned to the authors for this study. To date, three of the new tellurium minerals have been characterized : denningite (Mandarino *et al.* 1963), spiroffite (Mandarino *et al.* 1963) and zemannite (Mandarino *et al.* 1969). In addition, several other new species have been recently described from this locality : schmitterite (Gaines 1971), cliffordite (Gaines 1969), sonoraite (Gaines *et al.* 1968), poughite (Gaines 1968) and moctezumite (Gaines 1965). The latter paper gives an excellent account of the geology and mineralogy of the mine to which the reader is referred.

We propose to name the mineral bambollaite (pronounced bam.-boy.a.ite) in reference to the nickname of the mine in which it occurs. The type specimens are in the Royal Ontario Museum collection.

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[1] The name has been approved by the Commission on New Minerals and Mineral Names, I.M.A.

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[4] Meaning roughly "hot air" in reference to tales of rich gold ore which were considered by the local people to be exaggerated (priv. comm. by Richard Gaines, formerly Mexico, presently Penna., U.S.A.).

GENERAL DESCRIPTION

For this study, the specimens comprised four rock fragments, each measuring ½ to 1 inch in diameter and consisting of massive native tellurium and quartz encrusted by a thin layer of disseminated klockmannite, native selenium in traces, chalcomenite, tellurite, paratellurite, illite, calcite, and the unknown. Chalcomenite occurs as an alteration of klockmannite and the unknown, both of which are in contact with tellurium. Tellurite and paratellurite occur as an alteration of tellurium.

The unknown occurs sparsely as fine-granular aggregates and lenses. It closely resembles klockmannite, with which it is intimately associated, in colour and lustre. The material is so fine grained that only powder *x*-ray studies were feasible and no grinding was necessary to obtain a powder pattern with smooth arcs. The pattern is unique confirming that the mineral is new.

COMPOSITION

Sufficient material was concentrated under the microscope for a qualitative *x*-ray spectographic analysis of the chemical composition. This showed only three major elements with atomic proportions in the order Se>Cu>Te.

The chemical composition of the new mineral was next investigated by fusing the elements in evacuated silica glass tubes and testing the products by powder *x*-ray patterns. Attempts to synthesize the mineral by fusion of Cu and Se and of Cu and Te produced only compounds represented in nature by well-known minerals. The new mineral is readily synthesized by fusion of the three elements although never free of other phases, particularly Cu_3Se_2 (umangite) and Se. In polished section the mineral is creamy white, slightly anisotropic and exhibits a fine conchoidal fracture. An electron microprobe analysis by Professor J. C. Rucklidge, University of Toronto, of a clean grain gave the results :

	Wt. per cent	Atomic Proportions
Cu	25.1	.395 ~ 5
Te	31.0	.243 ~ 3
Se	44.5	.564 ~ 7
	100.6	

The composition is, therefore, $Cu_5Te_3Se_7$ or $Cu(Te,Se)_2$ with Te/Se ~ ½.

X-RAY CRISTALLOGRAPHY

The powder pattern has relatively few diffraction lines, somewhat diffuse at high 2θ angles. The pattern (Figure 1) is similar to that of fluorite but with many of the lines present as doublets suggesting a nearly-cubic tetragonal cell. On the basis of this assumption the pattern was indexed on an F tetragonal cell with $a = 5.466$, $c = 5.632$Å. The conventional I cell has $a = 3.865$, $c = 5.632$Å. The spacings (Table 1) calculated for these cell dimensions are in good agreement with the measured spacings except at high 2θ angles where the reflections tend to be diffuse. The I indices are compatible with only one space group, namely $I4_1/amd$ but the reflections are too few to assure an unambiguous determination of the space group.

During the fusion experiments, aggregates of tiny randomly-oriented, lath shaped, apparently-single crystals were found in the product of one of the charges. X-ray single crystal study showed that each consists of several individuals which proved too difficult to separate. However, one individual of each of a number of groups was oriented with precession protographs and used to obtain sets of films of four successive reciprocal levels with the lath-axis as precession axis. The films suggest a rhombohedral cell with $a = 3.88$, $c = 9.54$Å in which the c axis is the axis of crystal elongation. The powder reflections do not index well on this cell. We can account for the rhombohedral cell by assuming that the crystals are elongated parallel to the [111] axis of the nearly-cubic tetragonal F cell. The precession films then portray successive levels of the nearly-

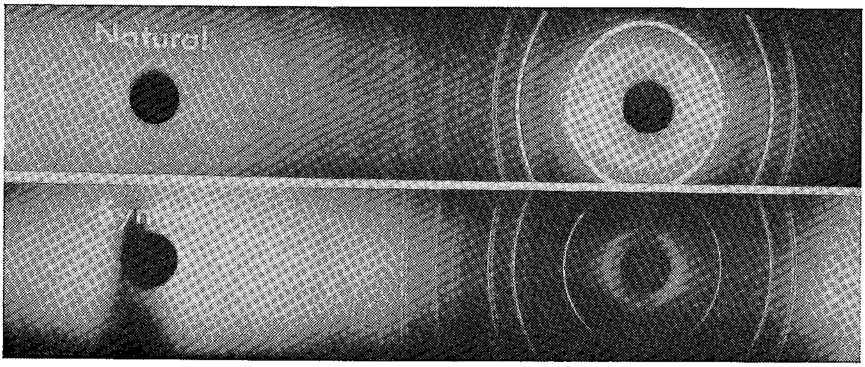

FIG. 1. X-ray powder contact prints of bambollaite and synthetic $Cu_5Te_3Se_7$: Ni filtered Cu radiation; camera diameter = 57.3 mm. Some of the lines in the pattern of the natural material are due to illite.

hexagonal (111)* planes. The calculated values for the [101] and [110] periods, which lie in the (111) planes of the *F* cell and should account for the *a* value of the rhombohedral cell are respectively 3.93 and 3.86Å. The calculated value for [111] is 9.47Å.

The contents of the *I* cell, calculated for the microprobe analysis and a density of 5.64 (measured on a macroscopically clean grain of the synthesized product) are $Cu_{1.1}Te_{0.7}Se_{1.6} \sim Cu(Te,Se)_2$ with Te/Se ≈ ½. The cell contents are incompatible with the space group indicating that it is in error or that the *I* cell is a sub-multiple of the true cell.

TABLE 1. BAMBOLLAITE $Cu(Te,Se)_2$, X-RAY POWDER DATA

$2\theta_{Cu}$	I	$d_{meas.}$	$(hkl)_F$	$(hkl)_I$	$d_{calc.}$
28.00	100	3.19Å	111	011	3.187Å
46.40	70	1.961	022	112	1.961
47.05	40	1.931	220	020	1.932
54.30	30	1.689	113	013	1.689
55.60	50	1.653	131	121	1.652
66.45	10	1.407	004	004	1.408
68.65	10	1.367	040	220	1.366
74.75	20	1.270	133	123	1.272
75.70	5	1.256	331	031	1.256
85.30	10	1.138	224	024	1.138
86.85	20	1.121	242	132	1.121
90.95	10	1.081	115	015	1.081
93.05	10	1.062	333	033	1.062
94.25	10	1.052	151	231	1.053
103.65	10	0.9806	044	224	0.9806
105.85	5	0.9663	440	040	0.9662
109.55	5	0.9437	135	125	0.9437
111.75	5	0.9312	153	233	0.9309
113.00	5	0.9245	351	141	0.9246
120.85	5	0.8863	026	116	0.8878
126.35	5	0.8638	260	240	0.8642
130.95	5	0.8473	335	035	0.8480
133.65	5	0.8386	353	143	0.8386
150.55	5	0.7971	444	044	0.7967

$d_{calc.}$ for F cell with a = 5.466, c = 5.632Å and I cell with a = 3.855, c = 5.632Å.

The new mineral is noteworthy in that it is the first known telluroselenide of copper.

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