SENGIERITE FROM BISBEE, ARIZONA

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ABSTRACT

The hydrated copper uranyl vanadate, sengierite, has been recognized as efflorescent patches on chalcocite from Cole Shaft, Bisbee, Arizona. It occurs as very minute greenish-yellow rhombic platelets, tabular parallel to (001); $\alpha=1.77, \pm 0.01$, $\beta=1.935$, $\gamma=1.960$, $\gamma-\alpha=0.190$; $2V=38°$ (−). *X*-ray diffraction powder patterns correspond almost exactly with that yielded by type material from the Belgian Congo. Copper and uranium were detected by microchemical methods but calcium appears to be absent.

INTRODUCTION

Recently Mr. Scott Williams of Scottsdale, Arizona, very kindly brought to the writer's attention some specimens of chalcocite on the outer surfaces of which are pockets of radioactive greenish-yellow efflorescences tentatively identified as tyuyamunite. However, Mr. Williams' keen sense of observation led him to the conclusion that the color of the mineral in question was rather distinct from that of tyuyamunite, hence an investigation was made, the outcome of which is reported here.

The specimens studied were selected from a small collection purchased by Mr. Williams from Mr. William P. Crawford, now retired, but formerly Superintendent of Mines at Bisbee, Arizona, who in turn discovered the material about November of 1935, some 25 ft. above the 1100 ft. level in a small pod of massive chalcocite with which was associated minor amounts of malachite. I am grateful to Mr. Williams and Mr. Crawford for these data and also for the following information relating to the occurrence and environment of sengierite: "Sengierite occurred in one of a series of five sulfide-oxide veins which extended from the 800 ft. level to the 1300 ft. level of the Cole Shaft. The veins were in a very compact limestone of the Escabrosa Series. The richest part of the sulfide ore body containing the sengierite was between the 1000 ft. and the 1100 ft. levels. The ore was a mixture of chalcocite, covellite, malachite, with pockets of cerargyrite, and it assayed 35% copper and 250 oz. of silver per ton. Uranium mineralization was present in the limestones as tyuyamunite which occurred as small yellow crystals lining cracks and fissures in the limestone country rock adjacent to the massive chalcocite-covellite ore bodies. Above the 1000 ft. level the ore-bearing vein (containing sengierite) turned to oxide ore (primarily malachite, azurite, and clay). The copper and silver values ran out at the 800 ft. level. The area was mined out and abandoned in 1940."

Optical and *x*-ray diffraction studies of the mineral in question have shown conclusively that it is sengierite, and therefore, this is the first

record of this mineral in the United States; the only other occurrences are at Haut-Katanga, Belgian Congo (Vaes and Kerr, 1949, Donnay and Donnay, 1955), and the Argana Bigoudine Region, Morocco (Chervet and Branche, 1955, pp. 90–91).

Mineralogy

Sengierite occurs in small pockets and patches up to 20 mm. in diameter, as quite minute rhombic-shaped platelets, the longer diagonals of which do not exceed 0.03 mm., but average less than 0.02 mm. This simple rhombic outline is due to the dominance of the unit prism and the crystals are tabular parallel to the basal plane. In some crystals small faces bevel the acute angles of these platelets, and rare crystals exhibit re-entrant angles, possibly due to twinning.

The color is yellow with a greenish tinge. Refractive indices have been determined by means of white phosphorus-sulphur liquids, since high refractive arsenical liquids reacted immediately with sengierite modifying color to brownish-green and at the same time refractive indices changed most noticeably. The following data were determined: $\alpha = 1.77$, ± 0.01, $\beta = 1.935$, $\gamma = 1.960$, $\gamma - \alpha = 0.19$. It was most difficult to determine the least refractive index with accuracy owing to the habit of the mineral, and the value reported should be considered less accurate than the other data. Basal plates do not appear to be pleochroic but for the mineral generally X = colorless to very palest greenish-yellow, Y = greenish-yellow, Z = greenish-yellow, with absorption $Z = Y > X$. A very low birefringence and strong anomalous interference tints are pronounced for basal sections; this is the preferred orientation of crystals of sengierite in liquid mounting media. Satisfactory interference figures were not obtained from the minute crystals but Fedorov stage measurements gave $2V = 38°$, $\pm 3°$, with negative optic sign; $r < v$.

X-ray diffraction data for Bisbee, Arizona sengierite (column 1) are shown in the accompanying Table 1 and it will be noted that the similarity between these data and those for sengierite from the Belgian Congo (column 2) is very close indeed, and almost the sole discrepancy is the definite absence of the strong reflection at 3.179 Å in the writer's films of Bisbee material; an explanation for this circumstance is not clear. Further it should be noted that there is a very fine splitting of the lines at 9.80 Å and 4.91 Å and although specimens were prepared in several ways with considerable care, this effect, which may be due to absorption, could not be avoided.

Although insufficient material was available for quantitative analytical work, microchemical tests showed that copper and uranium are present; calcium appears to be absent.

TABLE 1. *X*-RAY DIFFRACTION POWDER PATTERNS OF SENGIERITE
Camera diameter 114.59 Å. Radiation CuKα = 1.5418 Å

	hkl	1		2		3	
		d. (*Obs.*) Å	*I*	*d.* (*Obs.*) Å	*I*	*d.* (*Obs.*) Å	*I*
	001	9.80	10	9.82	v.v.st.	9.883	10
	—	—	—	—	—	6.566	1
	$11\bar{1}$	5.72	2	5.75	m	5.736	1
	111	5.02	1	5.02	w	—	—
	002	4.91	9	4.91	v.st.	4.915	10
	201	4.175	3	4.179	m	4.160	2
	020	4.035	4	4.037	m	4.020	3
	021	3.73	6	3.735	st.	3.710	3
	003	3.26	<1	3.262	w	—	—
	202	3.21	6	3.197	st.	—	—
220,	$22\bar{1}$	—	—	3.179	st.	—	—
310,	022	3.15	7	3.144	st.	3.153	10
	$11\bar{3}$	3.10	7	3.094	st.	—	—
	$31\bar{2}$	2.96	3	2.970	m	2.951	2
	221	2.91	<1	2.901	v.w.	—	—
	311	2.839	2	2.832	m	2.836	2
	113	2.739	1	2.744	w	2.721	1
$13\bar{1}$,	023	2.556	4	2.550	m	2.549	3
$32\bar{2}$,	131	2.500	<1	2.495	v.w.	—	—
	312	2.435	3	—	—	2.433	3
	213	—	—	2.398	w	—	—
	$21\bar{4}$	2.349	<1	2.345	v.w.	—	—
	231	2.269	<1	2.267	v.w.	2.252	1
420,	322	2.165	<1	2.163	w	—	—
	330	2.126	3	2.124	m	2.128	3
402,	033	2.089	3	2.087	m	2.086	3
	$51\bar{1}$	2.053	1	2.051	w	2.052	1
	$42\bar{3}$	2.013	4	2.009	m	2.001	4
$41\bar{4}$,	$14\bar{1}$	1.973	1	1.971	v.w.	—	—
$11\bar{5}$,	$21\bar{5}$	1.952	<1	1.951	v.w.	—	—
015,	$43\bar{1}$	1.900	<1	1.898	v.w.	—	—
	$24\bar{1}$	1.877	2	1.881	w	—	—
	$43\bar{2}$	1.848	3	1.850	w	1.857	3
	$12\bar{5}$	1.806	<1	1.808	v.w.	1.802	1
$60\bar{2}$,	$43\bar{3}$	1.758	4	1.756	m	1.760	3
$61\bar{1}$,	043	1.721	3	1.724	v.w.	1.715	2
	423	1.6665	3	1.666	v.w.	1.667	1
	006	1.634	<1	1.637	v.w.	1.632	1
	342	1.587	1	1.586	v.w.	1.588	1
	$12\bar{6}$	1.553	<1	1.553	v.w.	—	—
144, 251,	$34\bar{4}$	1.511	<1	1.509	v.w.	1.508	1
	$53\bar{4}$	1.496	<1	1.495	v.w.	—	—

1. Cole Shaft, Bisbee, Arizona.
2. Haut-Katanga, Belgian Congo (Donnay and Donnay, 1955, pp. 23–26).
3. Haut-Katanga, Belgian Congo (Vaes and Kerr, 1949).

N.B. Additional lines can be recognized in the film of Bisbee, Arizona, sengierite, but they are too weak and diffuse to measure with acceptable accuracy.

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