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THE AMERICAN MINERALOGIST, VOL. 44, NOVEMBER-DECEMBER, 1959

AN OCCURRENCE OF PSEUDOMALACHITE AT SAFFORD, ARIZONA

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Occurrence

Occurrences of the basic copper phosphate—pseudomalachite—have been recorded in only a few instances from United States localities, and some of the better known of these include the following: the Wheatley Mines, Chester Co., and the Ecton and Perkiomen Mines, Montgomery Co., Pennsylvania, Carbarrus Co., N. Carolina (Palache *et al.* 1951, p. 800); Black Pine Tungsten Project, Maxville, Montana (Kauffman *et al.* 1950, p. 19); the Empire-Nevada Mine, Yerrington, Nevada (Berry, 1950, p. 367). Other localities at which this mineral may have been recognized include the Calavada Mine, Nevada where Goudey (1945, p. 640) has described dihydrite, and the Silver Bell Mine, Lincoln, Nevada where Kauffman *et al.* (1950, p. 15) have noted the occurrence of a mineral described by them as tagilite. Dihydrite and tagilite are included here since most of the minerals so named and studied by Berry (1950) have been shown by him to have the properties of pseudomalachite.

Examination of the minor accessory minerals in some metasomatized latites, andesites and similarly altered volcanic rocks from Safford, Graham Co., Arizona, has led to the recognition of a number of interesting minerals, one of which is pseudomalachite. In view of the comparative rarity of this mineral in the United States it seems desirable that the occurrence be placed on record.

The copper phosphate is associated with the following minor constituents: malachite, brochantite, antlerite, carbonate-apatite, chrysocolla, jarosite, lepidocrocite, and a variety of other oxides of iron, covellite, chalcopyrite, pyrite, and a deep blue cupriferous mineral that has not been satisfactorily diagnosed so far.

PHYSICAL PROPERTIES

Pseudomalachite is found in centrifuged concentrates as broken prismatic crystals, many of which are almost hair-like in size, and occasional fragments appear to be portions of radiating aggregates with wavy extinction. The mineral has a more decidedly green color than that of the associated brochantite with which it may be easily confused upon first inspection. The mineral is notably attracted and concentrated, but not exclusively so, by the Frantz Separator at approximately 0.6 amps (slope 15°, tilt 8°), and for material concentrated in this way the following optical properties and other physical data have been determined:

$\alpha = 1.791 \pm 0.002$. X = pale green
$\beta = 1.856$ Z = green with a trace of a bluish tinge in some instances.
$\gamma = 1.867$ $Z > X$, marked.
$\gamma - \alpha = 0.076$ S. G. (22°C.) $= 4.32 \pm 0.02$
$2V = 48°\ (-)$ Dispersion very faint with $\rho < v$.

These data agree quite closely with those reported by Barth and Berman (1930, p. 32, Table 3, No. 5) for ehlite from Ehl-on-Rhine and by Chukhrov (1950) for colloform ehlite (=pseudomalachite) from Altyntyube, Kazakhstan. Furthermore, the absence of arsenic, as shown by microchemical tests, supports the conclusion that the phosphate is an end-member of the pseudomalachite-cornwallite series.

In view of the dominant form displayed by crystal fragments of the mineral, some care was taken to prepare a specimen for *x*-ray diffraction so that the powder pattern yielded by the mineral would not exhibit any preferred orientation effects whatsoever. The pattern yielded by the Safford mineral is set out in Table 1, and it is compared there with the powder data recorded by Berry (1950, p. 377) for pseudomalachite from three localities in Germany. At angles greater than about 72° 2θ the reflections become very faint and quite diffuse, but nevertheless sufficient density was developed to permit a check on film shrinkage.

The *d*-spacings and estimated intensities of the two powder patterns are very similar, with the following exceptions:

(1) The films yielded by pseudomalachite from Safford exhibit several faint reflections that are not listed by Berry (1950, p. 377), but it must be noted that that writer specifically states that he omitted on purpose, from his table, a few weak reflections that were observed by him on one film.

(2) The intensity of the reflection at $d = 3.02$ Å. (<1) in the film yielded by the Safford mineral is very much weaker than that for the corresponding line listed by Berry, *viz.* 3.04 (2).

(3) Berry lists a single line at 2.42 Å with an intensity of 6; in films of Safford pseudomalachite a distinct doublet may be observed at this point,

and this situation is also the case for the present writer's films of pseudomalachite from Rheinbreitbach, Germany (Specimen No. 22,188).

Prismatic fragments mounted for rotation about the length of the crystals yielded *b*-axis photographs, but the particles were found to con-

TABLE 1. *X*-RAY POWDER PATTERNS OF PSEUDOMALACHITE

Camera diameter: 114.59 mm. Cuk$_\alpha$=1.5418 Å. Spacings corrected for film shrinkage. Cut-off=18 Å approximately.

1		2		1		2	
d meas.	I	*d* meas.	I	*d* meas.	I	*d* meas.	I
8.51	<1	—	—	1.855	3	1.854	2
4.78	1	4.75	$\frac{1}{2}$	1.816	1	—	—
4.49	10	4.48	10	1.791	1	—	—
3.46	5	3.46	5	1.765	4	1.763	4
3.34	<1	—	—	1.730	5	1.728	5
3.256	<1	3.27	$\frac{1}{2}$	1.703	1	—	—
3.11	4	3.12	2	1.692	1	—	—
3.05	3	3.09	4	1.670	2	1.670	2
3.02	<1	3.04	2	1.624	2	1.624	1
2.98	4	2.97	4	1.595	3	1.597	2
2.92	3	2.93	3	1.575	1	—	—
2.867	1	2.85	1	1.560	4	1.559	4
2.832	1	—	—	1.527	3	1.527	2
2.724	3	2.72	3	1.505	2	1.498	2
2.700	1	—	—	1.492	1	1.491	2
2.561	2	2.56	1	1.464	2	1.462	1
2.468	3	—	—	1.433	3	1.431	3
2.443	6	2.42	6	1.417	2	1.419	3
2.418	6			1.395	3	1.392	4
2.386	7	2.39	8	1.384	1	—	—
2.324	5	2.32	5	1.366	1	1.365	1
2.234	4	2.23	5	1.347	2	1.350	2
2.196	1	2.19	1	1.332	3	1.335	3
2.129	1	2.12	1	1.320	1	1.319	2
2.094	2	2.09	3	1.310	2	1.310	3
2.018	1	2.01	1	1.212	1	1.212	1
1.993	1	—	—	1.197	1	1.196	1
1.961	1	1.963	2	1.075	1	1.076	$\frac{1}{2}$
1.945	<1	1.939	1	1.040	2	1.039	3
1.906	<1	—	—	—	—	1.014	3

1. Pseudomalachite, Safford, Graham County, Arizona. A number of faint, diffuse lines follow after the last spacing listed but they could not be measured with precision.
2. Pseudomalachite (Berry 1950, p. 377, Table 8). Average of measurements from three films yielded by the phosphate from German localities. Berry lists fifteen additional spacings after the line at 1.014 Å.

sist of bundles of fibers, rather than fragments of single crystals, with common *b*-axes and *a* and *c* in disorientation. Measurements of the rotation films gave an uncorrected value of 5.77 Å, but Weissenberg films for the same axis of rotation could not be interpreted.

ACKNOWLEDGMENTS

The writer is much indebted to Mr. Annan Cook and to the Directors of the Kennecott Copper Corporation for permission to record the data set out herein.

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THE AMERICAN MINERALOGIST, VOL. 44, NOVEMBER-DECEMBER, 1959

ON THE STABILITY AND SYNTHESIS OF UVAROVITE, $Ca_3Cr_2Si_3O_{12}$*

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Although uvarovite is not one of the common garnets, even a relatively scarce mineral may be a valuable indicator of P-T conditions prevailing during the formation of assemblages containing that mineral. The stability limits of the indicator mineral must, of course, be known. Thus the experimental mineralogist has advanced his goal from the mere synthesis of naturally-occurring minerals to determining the P-T-X stability limits of the phase. To this end, experimenters have a wide variety of equipment permitting studies to be made at high temperature, high pressure, or at simultaneous high pressures and high temperatures. The synthesis of a mineral at some convenient pressure and temperature, however, does not necessarily provide any meaningful information. This is true in the case of several recent reports dealing with the synthesis of uvarovite.

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