ADAMITE FROM GOLD HILL, TOOELE CO., UTAH

LLOYD W. STAPLES, *Stanford University, California.*

This study of adamite was made on two individual contributions of material. In November 1932, a specimen from Gold Hill, Utah, with crystals of adamite attached was sent to the mineralogical laboratory of Stanford University by Mr. S. R. Wilson. About a year later a suite of specimens from the same locality was contributed by Dr. W. R. Landwehr. This material had been collected from an outcrop on the property of the Western Utah Copper Mining Company. Adamite previously collected from this locality by Dr. Landwehr was first identified by Professor A. L. Crawford[1] of the University of Utah.

Adamite, a basic zinc arsenate [$Zn_2(OH)AsO_4$], is a member of an interesting group of minerals, commonly referred to as the olivenite group. The group includes the following members:

Olivenite	$Cu_2(OH)AsO_4$
Libethenite	$Cu_2(OH)PO_4$
Adamite	$Zn_2(OH)AsO_4$
Descloizite	$PbZn(OH)AsO_4$
Mottramite	$PbCu(OH)AsO_4$
Higginsite	$CuCa(OH)AsO_4$

Bannister[2] has indicated that there is a complete isomorphous series between descloizite and mottramite and he suggests the use of the name mottramite for all members containing more than 10% CuO.

The mineral adamite was originally described and analyzed by C. Friedel,[3] who found it accompanying silver on a specimen from Chañarcillo, Chile. The geometrical crystallography was established by Des Cloizeaux[4] on material from the same locality, obtained from the collection of M. Adam, after whom the mineral was named. In the United States, adamite was first recognized by Means,[5] in the Tintic district of Utah, while he was engaged in preliminary work in the preparation of Professional Paper 107 of the U. S. Geological Survey. It was also noted from the same dis-

[1] Oral communication, June 21, 1934.

[2] Bannister, F. A., *Mineralog. Mag.*, vol. **23,** pp. 376–386, 1933.

[3] Friedel, C., *Compt. Rend.*, vol. **62,** p. 692, 1866.

[4] Des Cloizeaux, A., *Compt. Rend.*, vol. **62,** p. 695, 1866.

[5] Means, A. H., *Am. Jour. Sci.*, 4th ser., vol. **41,** p. 125, 1916.

trict by Butler.[6] Considering the world as a whole, there have been relatively few occurrences of adamite reported. In addition to the above mentioned occurrences it has also been found at Cap Garonne near Hyères, France; Laurium, Greece; Monte Valerio, Italy; Reichenbach, Schwarzwalde; Island of Thasos, Turkey; three localities in Algeria, and it has been thought to occur at Kiura, in Bungo, Japan. The mineral has been prepared artificially by A. de Schulten[7] exhibiting the forms: $\{101\}$, $\{010\}$ and $\{120\}$.

General Description of the Adamite.

The adamite at Gold Hill is found in the oxidized zone, lining small cavities in a gossan and sometimes coating it. The specimens examined in this study were taken from outcrops of the orebody. Associated with the adamite is an impure limonite, crystals of quartz and calcite, and the new mineral, austinite, recently described by the writer.[8]

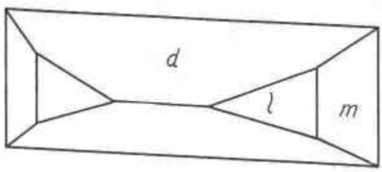

Fig. 1. Most common habit of the Gold Hill adamite showing the forms: $d\{101\}$, $m\{110\}$, and $l\{210\}$. Actual length of crystal is 1 mm.

The Gold Hill adamite occurs in two distinct habits, as individual, prismatic, orthorhombic crystals of the type shown in fig. 1, and in fan-shaped rosettes (fig. 2). The rosettes are nearly colorless while the individual crystals are more commonly pale honey yellow. However, the color is not sufficiently characteristic so that it always can be used with safety in distinguishing the adamite from its colorless associates. The crystals are elongated parallel to the *b*-axis and the forms present are: $d\{101\}$, $m\{110\}$, $b\{010\}$, $l\{210\}$, and $n\{120\}$. The luster is vitreous and the best cleavage is parallel to $d\{101\}$, with a poorer one parallel to $b\{010\}$. The average size of the crystals is 1 mm. but those that are good enough for measurements are usually only about half that size.

[6] Butler, B. S., et al, *U. S. Geol. Survey, Prof. Paper*, **111**, p. 114, 1920.
[7] de Schulten, A., *Bull. Soc. Fran. Mineral.*, tome **26**, pp. 91–94, 1903.
[8] Staples, L. W., *Am. Mineral.*, vol. **20**, pp. 112–119, 1935.

The rosettes tend to be semi-circular and have a radius of 1 mm. Because of the difference in color and habit, it was first thought that the rosettes were not the same mineral as the individual crystals, but they were shown by microchemical tests to have the same composition and their optical properties also proved them to be adamite.

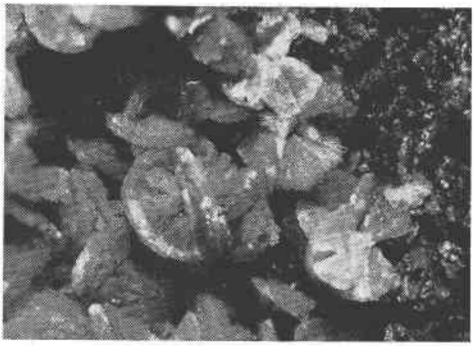

FIG. 2. Adamite occurring as rosettes. Magnification 10×.

CHEMICAL PROPERTIES

Qualitative chemical tests were made on the material, using small amounts and microchemical methods. Both the rosettes and the individual crystals gave good tests for zinc and the arsenate radical. The test for zinc was made with potassium mercuric thiocyanate [$K_2Hg(CNS)_4$], and the arsenate radical was shown to be present both by the $AgNO_3$ and the $(NH_4)_2MoO_4$ tests. No other elements were detected so the material is thought to be quite pure. The adamite is easily soluble in cold dilute HCl and advantage was taken of this property to produce etch figures. These form in two to three minutes on the prism faces in the principal zone [101] when the mineral is placed in very dilute HCl (1:6), and they indicate rhombic dipyramidal symmetry.

OPTICAL PROPERTIES

The indices of refraction of the Gold Hill adamite are:

$$n_\alpha = 1.711 \pm 0.003,\quad n_\beta = 1.732 \pm 0.003,\quad n_\gamma = 1.756 \pm 0.003.$$

They were determined with the aid of a Wratten orange screen (E 22) made by the Eastman Kodak Co. The mineral is optically positive, the plane of the optic axes is normal to $b\{010\}$, and the orientation is $a=\alpha$, $b=\gamma$, $c=\beta$. Although the crystals are usually slightly colored, the coloring is not deep enough to permit an observation of pleochroism, such as that noted in crystals from Chañarcillo by Spencer.[9]

Geometrical Crystallography

Over a hundred crystals of adamite from Gold Hill were carefully examined on the goniometer and the best of these were selected for measurement. The results of these measurements are given in the accompanying table.

Crystal Measurements on Adamite

Angle		No. of xls	No. of meas.	Limits	Aver. angle (weighted)	Calculated angle
dd'	$101\wedge\bar{1}01$	15	94	72° 5′– 72°12′	*72° 8′	
mm'''	$110\wedge 1\bar{1}0$	10	24	88 21 – 88 34	*88 30	
ll'''	$210\wedge 2\bar{1}0$	8	14	51 54 – 52 14	51 59	51°56′
nn'''	$120\wedge 1\bar{2}0$	2	8	125 34 –125 50	125 43	125 40
mb	$110\wedge 010$	8	20	45 41 – 45 48	45 44	45 45
md	$110\wedge 101$	1	4	65 5 – 65 6	65 5	65 3
ld	$210\wedge 101$	1	4	58 4 – 58 6	58 5	58 3

The axial ratio for the Gold Hill adamite, calculated from the angles marked with asterisks, is:

$$a:b:c=0.9742:1:0.7095.$$

The calculated angles for the unit faces are:

$$100\wedge 110=44°15'; \; 001\wedge 101=36°4'; \; 001\wedge 011=35°21.'$$

There has been considerable variation in the measurements made on adamite by former investigators. The probable cause for this is a slight variation in the chemical composition, but due to the lack of complete and adequate analyses, it has been impossible to make a detailed study of this point. A tabulation of the axial ratios obtained on adamite from various localities is given below. No attempt is made to average the ratios and to compare this value with that obtained on the new material, since if the variation in values is dependent on differences in chemical composition, any value obtained by averaging would be entirely artificial and meaningless.

[9] Spencer, L. J., *Mineralog. Mag.*, vol. **17**, pp. 114–115, 1914.

AXIAL RATIOS FOR ADAMITE

Investigator	*Locality*	*a:b:c*
Des Cloizeaux[10]	Chañarcillo	0.9733:1:0.7158
Laspeyres[11]	Laurium (1)	0.9958:1:0.7176
Laspeyres[11]	Laurium (2)	0.9958:1:0.6848
Aloisi[12]	Monte Valerio	0.9736:1:0.7013
Rosický[13]	Thasos	0.9764:1:0.7049
Ungemach[14]	Laurium	0.9770:1:0.7124
Staples	Gold Hill	0.9742:1:0.7095

A peculiarity of some of the crystals that might cause an error in angle determination may well be noted. In the case of three crystals, all of which appeared quite perfect and gave excellent reflected signals from all four faces in a prism zone, it was noted that opposite faces were not exactly 180° apart. The variation from true parallelism was the same for each pair of faces. This is mentioned to indicate the danger of obtaining incorrect values if only two of the faces in the zone were used to get the interfacial angle. To insure against this type of error, only those measurements were accepted that could be checked by signals from all the faces of any form.

A study of etch figures on the adamite crystals gave a further check on the propriety of placing it in the rhombic dipyramidal class of the orthorhombic system ($3A_2 \cdot 3P \cdot C$).

ACKNOWLEDGMENTS

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[10] Des Cloizeaux, A., *Op. cit.*, (Axial ratio calculated by the writer from Des Cloizeaux's measurements).

[11] Laspeyres, H., *Zeit. Kryst.*, vol. **2,** pp. 147–152, 1878.

[12] Aloisi, P., *Proc. verb. d. Soc. Toscana di Sc. Natur. in Pisa*, vol. **17,** pp. 4–8, 1907.

[13] Rosický, V., *Bull. international de l'Academie des Sciences de Bohême*, vol. **13,** 1908.

[14] Ungemach, H., *Bull. Soc. Fran. Mineral.*, tome **44,** p. 123, 1921.

References 12 and 13 not available to the writer.

Summary

The adamite from Gold Hill, Utah, occurs as individual crystals of a pale honey yellow color and as colorless rosettes. The indices of refraction are: $n_\alpha = 1.711 \pm 0.003$, $n_\beta = 1.732 \pm 0.003$, $n_\gamma = 1.756 \pm 0.003$, and the mineral is optically positive. The forms present are: $d\{101\}$, $m\{110\}$, $b\{010\}$, $l\{210\}$, $n\{120\}$. The axial ratio is, $a:b:c = 0.9742:1:0.7095$.