Paralaurionite[1]

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Abstract: Paralaurionite from a new locality, the Mammoth mine, Arizona, is described. X-ray study and chemical analysis confirm the original characteristics of the mineral as described in 1899 by G. F. Herbert Smith. Measurements are given which establish new forms on crystals from Arizona and also on crystals from a South American locality. A complete angle table for twenty-eight forms is presented.

THIS rare oxychloride of lead was first described from the lead slags of Laurium, Greece, by G. F. Herbert Smith in this magazine in 1899. In the same year the mineral rafaelite was reported by Arzruni from Mina San Rafael, Sierra Gorda, Chile, but Smith quickly established the identity of the two substances. It proved to be not uncommon at Laurium, as shown by Descloizeaux and others. The proposal of Ktenas to consider it identical with laurionite whose orthorhombic form he thought due to submicroscopic twinning of plates of paralaurionite has not been accepted. Russell described its sparse occurrence at a locality in Cornwall. Except for a review of previous studies with some new observations by the writer, nothing has since been added to our knowledge of paralaurionite. This review, which includes full references to all papers above mentioned, appeared in this magazine in vol. 23, p. 573, 1934.

About 1942 paralaurionite was identified in a suite of minerals from the Mammoth mine, Tiger, Arizona. It was fairly abundant and was well crystallized. The following pages present the results of a study of these specimens; at the same time measurable crystals of so-called rafaelite were found on a specimen of percylite labelled Caracoles, Bolivia (?), in the Harvard Mineralogical Museum, and the measurements made upon them are also presented here.

Paralaurionite from the Mammoth mine.

The complex of lead and copper minerals found in the Collins vein of the Mammoth mine between the 300-foot and the 700-foot levels was preserved in very numerous specimens of which the Harvard Museum secured a fairly representative series. It includes galena and chalcocite, the original ores, in the form of remnants surrounded by oxidation products; for the most part the minerals present are secondary and in bewildering variety. No description of the suite as a whole has appeared

[1] Contribution from the Department of Mineralogy and Petrography, Harvard University.

in print; Dr. Harry Berman and the writer were engaged in their study when war intervened and Berman's untimely death in 1944 brought our work to an end. Only the three species diaboleite (1), dioptase (2), and wherryite (3) have been described in any detail. An alphabetical list will at least give some idea of the paragenesis but none at all of the brilliant colours, superb crystallization, and infinitely varied groupings of these minerals. Besides the primary sulphides and quartz there have been found:

Anglesite	Cerussite	Hemimorphite	Paralaurionite
Atacamite	Descloizite	Hydrocerussite	Phosgenite
Azurite	Diaboleite	Leadhillite	Vanadinite
Boleite	Dioptase	Linarite	Wherryite
Brochantite	Embolite	Malachite	Willemite
Caledonite	Fluorite	Matlockite	Wulfenite

Paralaurionite is one of the later minerals in this series. It occurs in slender isolated needles in cavities of cerussite; and in coarser crystal aggregates, especially with leadhillite. The most notable specimen in our collection (101132) shows a surface 3 by 2 inches covered with bladed crystals of paralaurionite up to an inch in length and half an inch thick, which show well the characteristic fibration due to gliding under pressure. On them is a later generation of leadhillite.

No twin crystals were observed, a marked contrast to those from Laurium; and, too, the crystals, unlike the flat plates of Laurium, are elongated in the direction of the symmetry axis either as needles or as plates parallel to the pinacoid (100). Nine crystals were measured, all being set on the goniometer with the symmetry or *b*-axis vertical; that is, in the position of second inversion so that the resulting measurements are the angles ϕ_2 and ρ_2 of the form table. Their very high lustre resulted in reflections of the finest quality, so that even most minute facets gave accordant readings.

Paralaurionite, 'rafaelite', from Caracoles, Bolivia (?)[1]

The specimen is a fairly large fragment consisting of massive dark blue percylite mixed with siliceous gangue matter; in small cavities tiny crystals of paralaurionite project from the walls. They have the pale lilac colour described as characteristic of the original rafaelite and the same elongation parallel to the symmetry axis. They were measured in the same position as were the Arizona crystals.

[1] The label of specimen no. 95812 is so given, but Bolivia is believed to be a mistake for Chile. No such locality as Caracoles was discoverable on our maps of Bolivia. On the other hand, the well-known mining locality of that name in Chile was probably the source of the original rafaelite.

Tabular presentation of the results of crystal measurements.

Table I shows the combinations of forms observed on the nine crystals from Arizona and the seven from South America measured. The last column gives the relative abundance of each form, including the only other important locality for the mineral, Laurium, Greece. The eleven new forms include several that are as common as those previously known.

TABLE I. Paralaurionite: combinations and frequency of forms.

Form.		Measured crystals.																General frequency, all localities.
		Arizona 9 cryst.									Chile 7 cryst. 'Rafaelite'.							
c	001	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	On all crystals
b	010				x	x			x	x								Very rare
a	100	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	On most crystals
r*	140		x									x	x			x	x	Rare
m	110		x		x	x		x	x	x	x	x	x	x	x	x	x	On most crystals
n	310										x	x	x	x	x	x	x	Rafaelite only
s*	203										x			x				,, ,, v. rare
e	201											x		x	x	x	x	,, ,,
f	401											x				x	x	,, ,,
u*	$\bar{1}02$													x	x			,, ,, v. rare
g	$\bar{2}03$	x	x		x	x		x				x			x	x	x	Common form
d	$\bar{1}01$	x	x		x			x	x	x	x	x		x	x	x	x	,, ,,
v*	$\bar{4}03$	x			x	x		x									x	Rare
h	$\bar{2}01$	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	On most crystals
w*	$\bar{3}01$	x			x	x		x	x	x								Arizona only
k	$\bar{4}01$	x	x	x	x	x					x			x	x	x		Common form
i	$\bar{5}01$			x														Very rare
l	601	x	x	x	x	x			x	x				x		x		Common form
o*	112		x		x	x				x								Arizona only—rare
p	111	x	x	x	x	x			x	x	x	x	x	x	x	x	x	On most crystals
O*	$\bar{1}12$				x			x	x	x	x					x		Common form
P*	$\bar{1}11$	x	x		x		x		x	x	x							,, ,,
y	411										x	x	x	x	x	x	x	Rafaelite only, common
t	511							x	x									Rare form
S*	$\bar{3}11$				x	x					x	x	x		x	x		Common form
T*	$\bar{5}11$			x	x	x	x	x	x	x								Arizona only
U*	$\bar{7}11$										x	x	x	x		x		Rafaelite only

* Indicates forms new to the species.

Table II contains the mean measured angles of the new forms, together with the range in position of each. Observed angles of forms previously known are not given. They were in excellent agreement with calculated angles.

TABLE II. Paralaurionite: measured angles of new forms (in position of 2nd inversion)

Form.		No. of faces.	Qual.	Mean Position. ϕ_2	Mean Position. ρ_2	Range. ϕ_2	Range. ρ_2
r	140	5	good	0°00′	5°57′	0 00	5°50′–6°11′
s	203	3	good	44 26	90 00	44°34′–45°30′	90 00
u	$\bar{1}02$	3	fair	820 7½	90 00	82 00–82 08	90 00
v	$\bar{4}03$	5	poor	115 45	90 00	115 32–115 50	90 00
w	$\bar{3}01$	8	fair	149 54	90 00	149 30–150 10	90 00
o	112	4	poor	48 20	56 03	48 07–48 38	55 45–56 25
O	$\bar{1}12$	4	good	82 06½	48 13	81 33–82 43	47 55–48 36
P	$\bar{1}11$	5	good	103 13	29 43	102 48–103 38	29 28–30 17
S	$\bar{3}11$	7	good	150 06	48 00	149 25–151 01	47 48–48 14
T	$\bar{5}11$	7	v. good	162 45	61 59	162 23–162 57	61 47–61 58
U	$\bar{7}11$	6	good	168 03	69 29	167 28–168 34	69 00–69 40

TABLE III. Paralaurionite, Pb(OH)Cl; angle table.

Monoclinic prismatic, $2/m$.

$a : b : c = 2{\cdot}7052 : 1 : 1{\cdot}8090$, $\beta = 117° 12\frac{1}{2}'$; $p_0 : q_0 : r_0 = 0{\cdot}6687 : 1{\cdot}6088 : 1$;
$r_2 : p_2 : q_2 = 0{\cdot}6216 : 0{\cdot}4157 : 1$, $\mu = 62° 47\frac{1}{2}'$; p_0' 0·7519, q_0' 1·8090, x_0' 0·5142.

Forms		ϕ	ρ	ϕ_2	$\rho_2 = B$	C	A
c	001	90°00′	27°12½′	62°47½′	90°00′	—	62°47½′
b	010	0 00	90 00	—	0 00	90°00′	90 00
a	100	90 00	90 00	0 00	90 00	62 47½	0 00
r*	140	5 56	90 00	0 00	5 56	87 17½	84 04
m	110	22 34½	90 00	0 00	22 34½	79 53½	67 25½
n	310	51 16½	90 00	0 00	51 16½	69 06	38 43½
s*	203	90 00	45 26½	44 33½	90 00	18 14	44 33½
e	201	90 00	63 38½	26 21½	90 00	36 26	26 21½
f	401	90 00	74 09	15 51	90 00	46 56½	15 51
u*	$\bar{1}02$	90 00	7 52½	82 07½	90 00	19 20	82 07½
g	$\bar{2}03$	90 00	0 44½	89 15½	90 00	26 28½	89 15½
d	$\bar{1}01$	−90 00	13 22½	103 22½	90 00	40 35	103 22½
v*	$\bar{4}03$	−90 00	26 01½	116 01½	90 00	53 14	116 01½
h	$\bar{2}01$	−90 00	44 42	134 42	90 00	71 54½	134 42
w*	$\bar{3}01$	−90 00	60 08	150 08	90 00	87 20½	150 08
k	$\bar{4}01$	−90 00	68 09	158 09	90 00	95 21½	158 09
i	$\bar{5}01$	−90 00	72 52½	162 52½	90 00	100 05	162 52½
l	$\bar{6}01$	−90 00	75 57½	165 57½	90 00	103 10	165 57½
j	$\bar{8}01$	−90 00	79 42	169 42	90 00	106 54½	169 42
o*	112	44 32½	51 45½	48 19½	55 57½	36 38½	56 34
p	111	34 59½	65 38	38 18	41 43½	52 43	58 30½
O*	$\bar{1}12$	8 41½	42 27½	82 07½	48 08½	45 21	84 09
P*	$\bar{1}11$	−7 29	61 16½	103 22½	29 36½	67 58	96 33½
y	411	62 49	75 49½	15 51	63 42½	52 15½	30 24½
t	511	67 03½	77 50½	13 10	67 36	53 12	25 48½
S*	$\bar{3}11$	−43 54½	68 17	150 08	47 59	88 01½	130 07
T*	$\bar{5}11$	−60 52	74 56	162 52½	61 57½	81 07	147 30½
U*	$\bar{7}11$	−69 09	78 52	168 06½	69 33½	104 20	156 29

Table III is a complete angle table for paralaurionite, none of this type having hitherto been printed. It will be observed that the position and values of the crystal elements are those originally chosen by Smith, the correctness of this choice having been established by X-ray study.

The constants of the unit cell were determined by C. W. Wolfe (1945), in the Harvard Laboratory by the Weissenberg method. Space-group $C\,2/m$; $a_0 = 10{\cdot}77$, $b_0 = 3{\cdot}97$, $c_0 = 7{\cdot}18$kX, $\beta = 117°\,13'$, hence $a_0 : b_0 : c_0 = 2{\cdot}713 : 1 : 1{\cdot}809$. Compare with these figures the morphological axial ratio $a : b : c = 2{\cdot}7052 : 1 : 1{\cdot}8090$, $\beta = 117°12\tfrac{1}{2}'$. Unit-cell contents $Pb_4(OH)_4Cl_4$.

Chemical composition.

The chemical composition of the Arizona paralaurionite was established by the analysis of column I below, made in 1948 by F. A. Gonyer of the Harvard staff. The calculated composition for the accepted formula, Pb(OH)Cl is given in column II.

	I	II
Pb	77·75	79·80
O	6·00	3·08
Cl	12·84	13·65
H_2O	3·51	3·47
	100·10	100·00

I am indebted to Dr. C. W. Wolfe for the drawing of the crystal and for the X-ray measurements; and to Mr. Forest A. Gonyer for the chemical analysis.

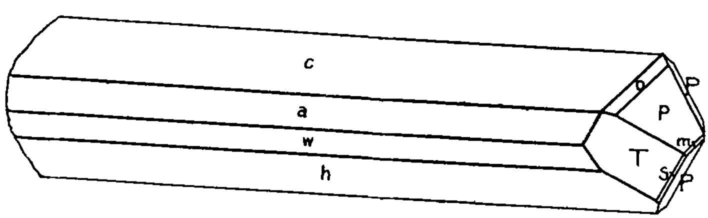

FIG. 1. Crystal of paralaurionite from Arizona. Forms: *c* 001, *a* 100, *m* 110, *h* $\bar{2}01$ *w* $\bar{3}01$, *o* 112, *p* 111, *P* $\bar{1}11$, *S* $\bar{3}11$, *T* $\bar{5}11$, of which *w*, *o*, *P*, *S*, and *T* are new.

References: (1) Diaboleite. C. Palache. Amer. Min. 1941, vol. 26, p. 605. [M.A. 8–215.]
(2) Dioptase. F. W. Galbraith and T. H. Kuhn. Ibid., 1940, vol. 25, p. 708. [M.A. 8–224.]
(3) Wherryite. J. J. Fahey, E. B. Daggatt, and S. G. Gordon. Ibid., 1950, vol. 35, p. 93. [M.A. 11–127.]