THE MINERALOGICAL MAGAZINE
AND
JOURNAL OF
THE MINERALOGICAL SOCIETY

No. 146. September, 1934. Vol. XXIII.

The form relations of the lead oxychlorides, laurionite, paralaurionite, and fiedlerite.

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[Read June 7, 1934.]

THE published data on these three minerals, first found in the Laurion lead slags, is well summarized in Hintze (Handb. Min., 1915, vol. 1, pp. 2632–2641). In studying the original papers for the purpose of recalculating the elements of each, LaForge was impressed with their close crystallographic relationship in certain respects and with the curious complexity of the form series of fiedlerite, which seemed to call for further observations. Accordingly, crystals of all three minerals from Laurion were studied on the goniometer, specimens loaned by the U.S. National Museum furnishing a welcome supplement to those found in the Harvard Mineralogical Museum. In the following pages the results of these studies will first be presented in brief form. Following this, the conclusion arrived at as to the most appropriate positions of the three minerals to bring out their mutual relationships will be stated.

[1] The author desires to acknowledge his indebtedness to his co-workers in this study. Dr. L. LaForge made the preliminary studies and calculated some of the tables. Dr. M. A. Peacock made some of the measurements and all of the drawings. Mr. H. Berman determined the optical properties of all three of the minerals.

Fig. 1 shows the relations of the angles given in the angle-tables:

$A = (hkl) : a\,(100)$; $B = (hkl) : b\,(010)$: $C = (hkl) : c\,(001)$.

$\phi\ \rho$: co-ordinate angles in normal position.

$\phi''\ \rho''$: ,, ,, ,, second inversion.

In the orthorhombic system $c(001)$ lies at the pole and $\rho = C$; in both the orthorhombic and monoclinic systems $\rho'' = B$.

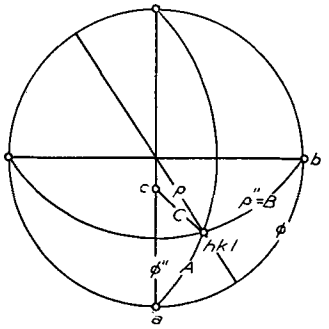

FIG. 1. Angular relations in the monoclinic system.

LAURIONITE—$PbCl_2.Pb(OH)_2$, orthorhombic.

LaForge computed the elements of laurionite from the measurements of Koechlin (1887), vom Rath (1887), Smith (1899), de Schulten (1897), Cesàro (1904), and Russell (1928), and obtained the values in the first line of table 1. Palache and Peacock measured ten crystals of laurionite on the two-circle goniometer and from the observations made on sixty faces of five forms (table 2) calculated the elements in the second line. Combining this new set of values (weighted as one) with those resulting from older measurements (weighted as four), the final values were obtained. These elements, transformed to the new position described below, were made the basis of the new table of calculated angles (table 3).

TABLE 1. *Laurionite. Elements.*

	$a : b : c.$	$p_o.$	$q_o.$
LaForge (computed) ...	0·7331 : 1 : 0·8304	1·1327	0·8304
Palache & Peacock ...	0·7354 : 1 : 0·8302	1·1288	0·8302
Weighted mean ...	0·7336 : 1 : 0·8304	1·1320	0·8304

TABLE 2. *Laurionite. Two-circle measurements on ten crystals.*

(Position and symbols of Koechlin.)

Form.		Number of faces.	Number of crystals.	Palache, measured $\phi''.$	Palache, measured $\rho''.$	LaForge, calculated from earlier observations $\phi''.$	LaForge, calculated from earlier observations $\rho''.$	Calculated from new elements $\phi''.$	Calculated from new elements $\rho''.$
$m(k)$	(110)	21	8	53° 45′	90° 0′	53° 45½′	90° 0′	53° 44½′	90° 0′
n	(120)	15	6	34 18	,,	34 17½	,,	34 16½	,,
d	(012)	8	6	0 0	22 40	0 0	22 33	0 0	22 33
q	(122)	9	4	34 21	45 6	34 17½	45 9	34 16½	45 8½
r	(132)	9	3	24 27½	53 44	24 27	53 50½	24 26	53 50

TABLE 3. *Laurionite. Angle-table.*

$a : b : c = 2{\cdot}4084 : 1 : 1{\cdot}7668.$

$p_o = c/a = 0{\cdot}7336, \quad q_o = c = 1{\cdot}7668.$

Form.	ϕ.	$\rho = C$.	ϕ''.	$\rho'' = B$.	A.
c(001)	—	0° 0′	90° 0′	90° 0′	90° 0′
a(100)	90° 0′	90 0	0 0	,,	0 0
d(110)	22 33	,,	,,	22 33	67 27
e(310)	51 14½	,,	,,	51 14½	38 45½
l(102)	90 0	20 8½	69 51½	90 0	69 51½
k(101)	,,	36 15½	53 44½	,,	53 44½
h(302)	,,	47 44	42 16	,,	42 16
n(201)	,,	55 43½	34 16½	,,	34 16½
o(111)	22 33	62 24	53 44½	35 4	70 8
u(312)	51 14½	54 40½	42 16	59 17	50 29½
q(211)	39 42½	66 28	34 16½	45 8½	54 9
r(311)	51 14½	70 29½	24 26	53 50	42 41½
p(812)	73 14½	71 55½	18 49	74 5½	24 27
s(411)	58 57	73 43½	,,	60 19	34 40½
t(511)	64 16½	76 12	15 15	65 4½	28 58

(hkl) (Palache) = ($l.h.2k$) (Koechlin).

The dominant habit of laurionite crystals is tabular parallel to a pinacoid taken by most observers as (010) and elongated in the direction of the vertical axis. Ktenas (1910) was the first to suggest a different orientation in which the dominant pinacoid is taken as (100) and the direction of elongation as the b-axis. This orientation is adopted in the present paper, and the following description is in terms of that position. The crystals are of three habits:

(1) Thin rectangular tables with dominant macropinacoid a, the edges of the tables truncated by narrow faces of the prism d and the macrodome k (fig. 2). Rectangular striations on a are due to oscillatory combination with p or some vicinal form near it (fig. 3).

(2) Thicker tabular crystals with the pinacoids a, c (narrow or missing), the macrodomes k and n, the prism d, and one or more of the pyramids o, q, r, s, t forming a diagonal striated zone (figs. 4 and 5). The form u was also found on a crystal of this type and the new form e(310), but these are not figured.

(3) Tabular or lath-shaped crystals with a, c, and k, the end spear-shaped, due to the development of p without the prism or with the point of the spear truncated by d (figs. 5 and 6). The form here indicated as p (812) is really a group of vicinal forms with large and brilliant faces which vary in position through a range of several degrees both in ϕ and ρ. They have been recorded by several observers and have been assigned symbols such as (812), (922), and (511) in our

notation. A large number of observations are shown in fig. 8 plotted in gnomonic projection. The plot shows that the symbol (812) expresses the simple rational position to which most of the observa-

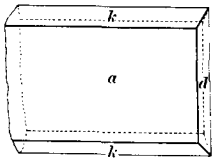

FIG. 2.

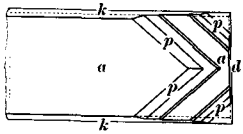

FIG. 3.

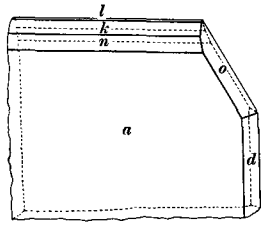

FIG. 4.

Crystals of laurionite.

tions were nearest. All considerations point, however, to vicinal development. Table 4 correlates the observations of various authors on laurionite.

TABLE 4. *Laurionite. Forms and symbols according to various authors.*

	vom Rath 1887.	Koechlin 1887.	Smith 1899.	Cesàro 1904.	de Schulten 1897 (artificial).	Palache 1934.
c(001)	*b*(010)	*a*(100)	*a*	h^1	—	*c*
a(100)	*a*(100)	*b*(010)	*b*	g^1	—	*a*
d(110)	*d*(108)	*d*(012)	*d*	e^2	*d*	*d*
**e*(310)	—	—	—	—	—	*e*
l(102)	*l*(190)	*l*(210)	—	—	—	*l*
k(101)	*n*(290)	*m*(110)	*m*	*m*	*m*	*k*
h(302)	—	—	—	$h^5(320)$	—	—
n(201)	*m*(490)	*n*(120)	*n*	g^3	*n*	*n*
o(111)	—	—	*o*(112)	—	—	—
u(312)	—	—	*u*(232)	—	—	—
q(211)	—	—	*q*(122)	—	—	*q*
r(311)	—	—	*r*(132)	—	—	*r*
p(812)	*o*(111)	—	*p*(141)	(141)	—	*p*
s(411)	—	—	*s*(142)	—	—	*s*
t(511)	—	—	*t*(152)	—	—	—
Uncertain Forms.						
(104)	—	(410) ?	—	—	—	—
(203)	—	(320) ?	—	—	—	—
(403)	—	(340) ?	—	—	—	—
(601)	—	(160) ?	—	—	—	—
(912)	—	—	—	(292)	—	?
(10.1.2)	—	*p*(151)	(151)	—	—	?

* New form.

The cleavage of laurionite has been variously described. Vom Rath stated that it was parallel to b(010), which in our position is (001), with which Dàna (System, 1892, p. 171) agrees. Cesàro gives

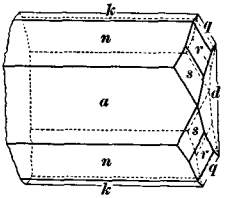

FIG. 5.

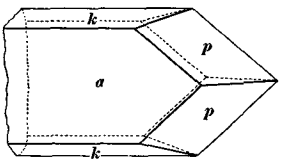

FIG. 6.

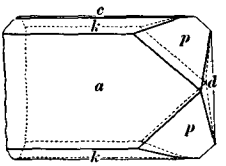

FIG. 7.

Crystals of laurionite.

the cleavage parallel to his m(110). This we found to be correct, and in the new orientation this becomes the macrodome k(101). Although the pinacoid a(100) has a pearly lustre which suggests cleavage in that direction, none could be discovered. Cesàro states that the plates are easily bent about the direction of the brachyaxis. Of this character, so prominent in paralaurionite, we were unable to find a trace. It seems likely that Cesàro mistook a crystal of paralaurionite for laurionite, which is very easily done.

The optical properties of laurionite were re-determined by Mr. Berman, whose observations are in essential agreement with those of Smith. Berman found by immersion in melts:

$$\alpha\, 2{\cdot}08,\ \gamma\, 2.16\ (\pm 0{\cdot}01).$$

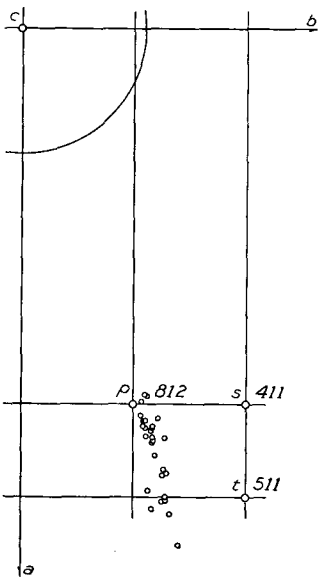

FIG. 8. Laurionite. Gnomonic projection of vicinal forms observed on seven crystals: interpreted as constituting the form p(812).

In the new orientation: $\alpha = c$, normal to cleavage cracks; $\beta = a$, normal to dominant pinacoid; $\gamma = b$, parallel to elongation. 2V is large and probably negative. The plane of the optic axes is parallel to a (100). Consequently, no optical figure can be obtained on the

ordinary crystals which are tabular parallel to a, in contrast to paralaurionite whose plates exhibit a characteristic optical figure.

PARALAURIONITE—$PbCl_2.Pb(OH)_2$, monoclinic.

Paralaurionite was first described from Laurion by G. F. H. Smith (1899) and simultaneously, under the name of rafaelite from Chile, by Arzruni (1899). The position and elements of Smith are satisfactory for this monoclinic mineral. LaForge has recalculated elements from all published angles of the observers named and has combined the results with those obtained from the measurements of five crystals from Laurion made in the present study. The resulting elements, practically the same as those derived by Smith, are the basis for computation of the angle-table shown below.

TABLE 5. *Paralaurionite. Angle-table.*

$a : b : c = 2{\cdot}7042 : 1 : 1{\cdot}8090$, $\beta = 62° 47\frac{1}{2}'$.

$p_0 = c/a = 0{\cdot}6687$, $q_0 = c \sin \beta = 1{\cdot}6088$.

Form.	ϕ.	ρ.	C.	B.	A.
c(001)	90° 0′	27° 12½′	0° 0′	90° 0′	62° 47½′
b(010)	0 0	90 0	90 0	0 0	90 0
a(100)	90 0	,,	62 47½	90 0	0 0
m(110)	22 34½	,,	79 53½	22 34½	67 25½
n(310)	51 16½	,,	69 6	51 16½	38 43½
e(201)	90 0	63 38½	36 25½	90 0	26 21½
f(401)	,,	74 9	46 56½	,,	15 51
$g(\bar{2}03)$	−90 0	0 44½	26 28½	,,	99 15½
$d(\bar{1}01)$	,,	13 22½	40 35	,,	103 22½
$h(\bar{2}01)$	,,	44 42	71 55	,,	134 42
$k(\bar{4}01)$	,,	68 9	95 21½	,,	158 9
$i(\bar{5}01)$	,,	72 52½	100 5	,,	162 52½
$l(\bar{6}01)$	,,	75 57½	103 10	,,	165 57½
$j(\bar{8}01)$	,,	79 42	106 54½	,,	169 42
p(111)	34 59½	65 38	52 43	41 43½	58 30½
y(411)	62 49	75 49½	52 15½	63 42½	30 24½
t(511)	67 3½	77 50½	53 12	67 36	25 48½

The paralaurionite crystals measured in our study yielded several new forms which have been included in table 5. The forms and average observed angles are shown in table 6 (p. 579).

The close agreement between measured and calculated angles is noteworthy. The crystals of this mineral are of an unusual degree of perfection. The habit of paralaurionite is markedly tabular, the broad plates being either rectangular, as in fig. 9, or wedge-shaped owing to the development of pyramid faces at the corners of the plates, as in figs. 10 and 11.

Twinning on (100) is wellnigh universal, the symmetrical contact-twins having full orthorhombic pseudosymmetry. Re-entrant angles between the two members were rarely observed. The twin crystals are generally simple contact-twins as shown in figs. 9, 10, 11, and in fig. 12, a more complex crystal. Figs. 13 and 14 illustrate beautifully symmetrical interpenetration-twins on the same law; they recall the type of twin crystal of albite from Roc Tourné in Savoy, figured

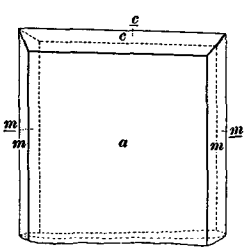

FIG. 9.

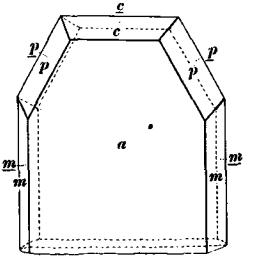

FIG. 10.

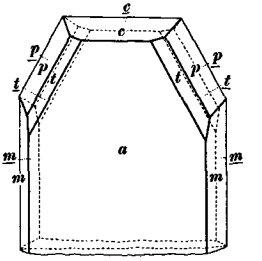

FIG. 11.

Symmetrical contact-twins of paralaurionite.

TABLE 6. *Paralaurionite. Measured and calculated angles.*

Form.	Number of faces.	Measured		Calculated	
		ϕ.	ρ.	ϕ.	ρ.
c(001)	7	90° 0′	27° 15½′	90° 0′	27° 12½′
a(100)	10	,,	90 0	,,	90 0
m(110)	10	22 34	,,	22 34½	,,
h(2̄01)	5	−90 0	44 37	−90 0	44 42
k(4̄01)	3	,,	68 12	,,	68 9
*i(5̄01)	1	,,	72 35	,,	72 52½
l(6̄01)	2	,,	75 56	,,	75 57½
*j(8̄01)	1	,,	79 20	,,	79 42
p(111)	10	35 1	65 40	34 59½	65 38
*t(511)	4	67 0	77 50	67 3½	77 50½

* New forms.

by G. Rose (Dana, System, 1892, p. 329, figs. 10, 11). The resemblance extends to the grooves on the pinacoid which are in these crystals bounded by faces of steep orthodomes. The cleavage is parallel to the base (001), and in the twins the two cleavages simulate closely the macrodome cleavage of laurionite save that the inclination of the cleavage to the vertical is less, 27° 15½′ in paralaurionite, 36° 15½′ in laurionite. The broad pinacoidal plates of paralaurionite bend so easily parallel to the b-axis that it is difficult to detach crystals from the matrix without distortion. The plates

break easily into slender ribbons parallel to b, the edges showing a fibrous silky cleavage surface much like the $(\bar{1}11)$ cleavage of gypsum.

The optical properties of paralaurionite were studied by Mr. Berman

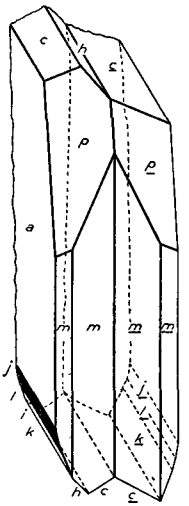

FIG. 12.

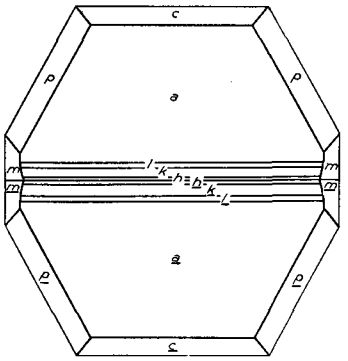

FIG. 13.

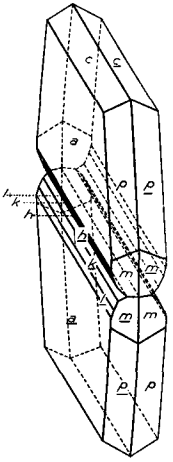

FIG. 14.

Twinned crystals of paralaurionite.

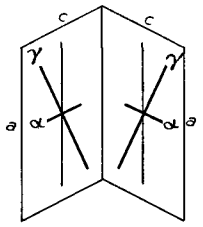

FIG. 15. Optical orientation of twinned paralaurionite.

with the aid of the Fedorov stage (fig. 15). On (100) the twin plates show a highly diagnostic abnormal interference-figure due to twinning. The optical axial plane is parallel to (010) and the extinction is 25° to the twin-plane (100), in the obtuse angle β; $\beta = b$, $\gamma : c = +25°$. Biaxial negative, 2V medium to large, $r < v$ strong.

α 2·05, β 2·15, γ 2·20 ($\pm$0·01).

The indices were obtained in melt immersions; the heat required for immersion produced a slight alteration in the substance revealed by a change of colour from white to light yellow. That this change is not a large one is indicated by the close agreement of the value found for β with that (2·146) measured by Smith without heating. There was also slight alteration in birefraction and axial angle after immersion in the melt.

FIEDLERITE—$2PbCl_2.Pb(OH)_2$, monoclinic.

Fiedlerite was first described from Laurion by vom Rath (1887) and again by Smith (1899). The complex indices of the forms reported by both observers invited a re-examination of the crystallography. This was made possible by the study of crystals found on a specimen from the Roebling collection, kindly loaned by the United States National Museum. Fiedlerite is generally tabular

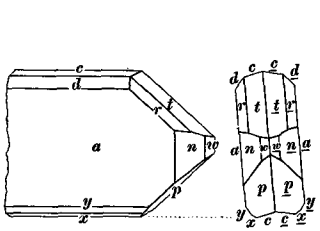

FIG. 16.

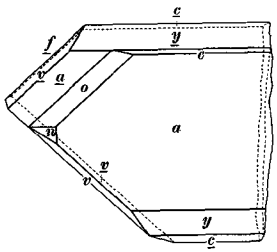

FIG. 17.

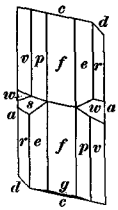

FIG. 18.

Crystals of fiedlerite.

parallel to (100) and elongated in the direction of the symmetry-axis. Five crystals were measured, their habit making it convenient to mount them on the two-circle goniometer with the orthodome zone as a prism-zone and the (missing) clinopinacoid as pole (second inversion). The measured and calculated angles are therefore given in that position (table 7).

Most of the crystals are twins on (100) as shown in figs. 16 and 17. One simple crystal, however, while its faces were not of the best, yielded new forms which permitted the choice of a new unit pyramid and a satisfactory simplification of the form series. This crystal, a left-hand end, is shown in fig. 18, projected on $(0\bar{1}0)$.

From the data of table 7 elements were calculated as follows:

$$a : b : c = 1{\cdot}0121 : 1 : 0{\cdot}8996, \quad \beta = 77° 39'.$$

Second inversion $p_o'' = 1{\cdot}1386$, $q_o'' = 1{\cdot}0121$.

Normal position $p_o = 0{\cdot}8888$, $q_o = 0{\cdot}8783$.

A graphical comparison of these elements with those employed by vom Rath and Smith showed that with our choice of units the symbols are considerably simplified. It proved that the equivalence of the elements could be expressed by the following transformations:

$\frac{5}{4}a$ (vom Rath) $= \frac{5}{4}a$ (Smith) $= a$ (Palache)

c ,, $= \frac{5}{4}c$,, $= c$,,

TABLE 7. *Fiedlerite. Measurements on five crystals.*

Form.	Number of faces.	Quality.	Measured Mean ϕ''.	Measured Mean ρ''.	Range ϕ''.	Range ρ''.	Calculated ϕ''.	Calculated ρ''.
$c(001)$	6	poor	77° 33½′	90° 0′	76° 43′—78° 19′	——	77° 30′	90° 0′
$a(100)$	8	very good	0 1	,,	0 0 — 0 6	——	0 0	,,
*$w(110)$	4	good	0 1	45 25	0 0 — 0 3	44° 30′—45° 56′	,,	45 0
$m(540)$	1	poor	0 0	51 2	——	——	,,	51 20
$n(320)$	2	,,	0 2	55 55	0 0 — 0 4	55 50 —56 0	,,	56 18½
*$g(015)$	1	fair	76 37	79 35	——	——	77 30	80 2½
*$f(011)$	1	,,	78 8	48 40	——	——	,,	48 43
$d(101)$	1	good	42 0	90 0	——	——	41 44½	90 0
$x(\bar{1}01)$	1	poor	−55 43	,,	——	——	−55 53	,,
$y(\bar{2}01)$	2	good	−32 30	,,	−32 23 —32 36	——	−32 23	,,
*$r(111)$	4	poor	41 31½	59 2	41 16 —41 57	58 45 —59 18	41 44½	59 5½
$e(144)$	5	good	66 13	50 40	64 42 —68 13	49 57 —51 2	65 56½	50 36½
*$t(122)$	3	fair	55 39	53 17	55 0 —56 19	53 12 —53 22	56 7½	53 15½
*$s(342)$	1	good	32 25	45 47	——	——	32 29½	45 59½
$p(\bar{1}22)$	3	,,	−75 14½	49 0	−74 32 —76 40	48 52 —49 8	−77 10	48 45
*$v(\bar{3}44)$	2	poor	−65 52	50 44	−65 48 —65 56	50 33 —50 55	−65 39	50 40½

* New forms.

Transforming the elements of each observer accordingly and averaging the values with our own with equal weights we obtain :

vom Rath	... $a=0{\cdot}8192$	$\frac{5}{4}a=1{\cdot}0240$	—	$c=0{\cdot}8915$	$\beta=77°\ 20'$
Smith	... $a=0{\cdot}8299$	$\frac{5}{4}a=1{\cdot}0372$	$c=0{\cdot}7253$	$\frac{5}{4}c=0{\cdot}9066$	$\beta=77\ 31$
Palache	... —	$a=1{\cdot}0121$	—	$c=0{\cdot}8996$	$\beta=77\ 39$
	Mean (adopted)	$a=1{\cdot}0244$		$c=0{\cdot}8992$	$\beta=77\ 30$
		$p_o=0{\cdot}8778$		$q_o=0{\cdot}8779$	

Table 8 is calculated from these mean elements.

TABLE 8. *Fiedlerite. Angle-table.*

$a:b:c=1{\cdot}0244:1:0{\cdot}8992$, $\beta=77°\ 30'$.

$p_o=c/a=0{\cdot}8778$, $q_o=c\sin\beta=0{\cdot}8779$.

Form.	ϕ.	ρ.	ϕ''.	$\rho''=B$.	C.	A.
$c(001)$	90° 0′	12° 30′	77° 30′	90° 0′	0° 0′	77° 30′
$a(100)$	,,	90 0	0 0	,,	77 30	0 0
$l(140)$	14 2	,,	,,	14 2	86 59½	75 58
$w(110)$	45 0	,,	,,	45 0	81 12	45 0
$m(540)$	51 20	,,	,,	51 20	80 16	38 40
$n(320)$	56 18½	,,	,,	56 18½	79 37½	33 41½
$g(015)$	50 57½	15 56	77 30	80 2½	9 57½	77 41½
$f(011)$	13 51	42 48	,,	48 43	41 17	80 38½
$d(101)$	90 0	48 15½	41 44½	90 0	35 45½	41 44½
$x(\bar{1}01)$	−90 0	34 7	−55 53	,,	46 37	−55 53
$y(\bar{2}01)$	,,	57 37	−32 23	,,	70 7	−32 23
$r(111)$	51 15½	55 10	41 44½	59 5½	45 47½	50 11½
$e(144)$	26 24½	45 7	65 56½	50 36½	40 47	71 38
$t(122)$	36 44½	48 17½	56 7½	53 15½	41 44	63 28½
$o(544)$	56 15	58 17½	36 37	61 47½	48 13	44 59
$u(322)$	60 12½	61 4½	32 29½	64 13	50 27½	40 34½
$s(342)$	41 7½	67 16½	,,	45 59½	59 22½	52 39
$p(\bar{1}22)$	−14 13	42 51	−77 10	48 45½	47 11	−80 23
$v(\bar{3}44)$	−26 43	45 11½	−65 39	50 40½	51 23	−71 24

For the symbols of forms in the three positions the following transformations serve :

vom Rath.	Smith.	Palache.
(hkl)	$(5h.5k.4l)$	$(5h.4k.4l)$
$(4h.4k.5l)$	(hkl)	$(5h.4h.5l)$
$(4h.5k.5l)$	$(4h.5k.4l)$	(hkl)

The crystals of fiedlerite are poor and the angles for any given form show considerable variation as all observers have remarked. With the adoption of the new elements on which the angle-table is based the form series is clarified as may be seen from table 9 in which the forms and symbols of each observer are compared.

The reason for changing vom Rath's symbols is that the new symbols are required by the transformation determined by his unit o (111). In all cases, but that of u, calculation showed that the angles corresponding to the symbols obtained by transformation are as close to the measured angles as those given by vom Rath's symbols. We have no explanation for the lack of agreement in the case of u.

TABLE 9. *Fiedlerite. Correlation of forms.*

	vom Rath.	Smith.	Palache.
c	(001)	(001)	(001)
a	(100)	(100)	(100)
l	—	(150)*	(140)‡
w	—	—	(110)
m	(110)	(110)	(540)
n	(650)	(650)	(320)
g	—	—	(015)
f	—	—	(011)
d	—	(101)	(101)
x	($\bar{4}$05)†	($\bar{1}$01)	($\bar{1}$01)
y	($\bar{8}$05)†	($\bar{2}$01)	($\bar{2}$01)
r	—	—	(111)
e	(155)†	(154)	(144)
t	—	—	(122)
o	(111)	(554)	(544)‡
u	(655)†	(654)	(322)‡
s	—	—	(342)
p	($\bar{2}$55)†	($\bar{2}$54)	($\bar{1}$22)
v	—	—	($\bar{3}$44)

* Observed by Lacroix (1908).

† These symbols differ from those given by vom Rath as follows:

x($\bar{4}$05)	vom Rath ($\bar{5}$06)	u(655)	vom Rath (544)
y($\bar{8}$05)	,, ($\bar{5}$03)	p($\bar{2}$55)	,, ($\bar{5}$.12.12)
e(155)	,, (5.24.24)		

‡ Not observed by Palache.

Fiedlerite has a good cleavage parallel to (100) which is also the twin-plane and the dominant crystal-form. Twins are the rule in our crystals. The optical properties were determined by Mr. Berman, using the universal stage and immersion melts (fig. 19).

$\gamma = b$, $\beta : c = -34° \pm 1°$ in the acute angle β.

a 1·98, β 2·04, γ 2·10 ($\pm$0·01).

Biaxial negative. 2V large. $r < v$ perceptible.

Due to twinning most of the crystals fail to show complete extinction on (100).

Gnomonic projections of the three minerals under consideration are shown drawn to the same scale in figs. 20, 21, and 22. Fiedlerite, which has a composition different from the other two, is distinct from them in elements and forms series. Laurionite, orthorhombic, and paralaurionite, monoclinic, show many points of similarity, the homeomorphism being better expressed by the new choice of position and elements of laurionite. Both are tabular parallel to a(100). The cleavage, k(101) in laurionite and c(001) in paralaurionite, is similar in attitude. The prism-zone of each exhibits the same

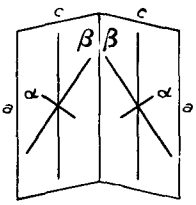

FIG. 19. Optical orientation of twinned fiedlerite.

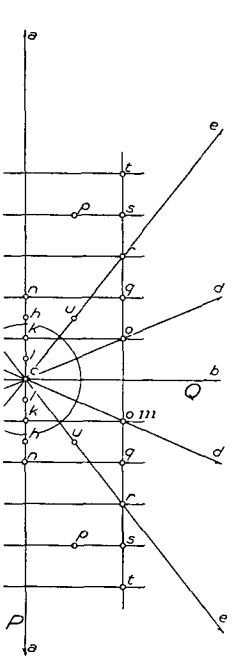

FIG. 20.

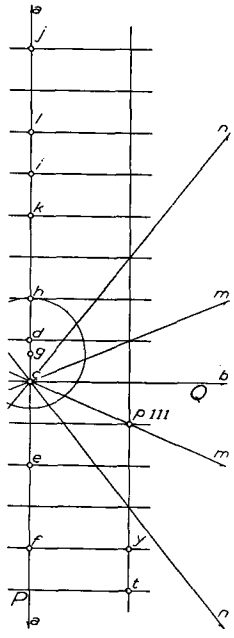

FIG. 21.

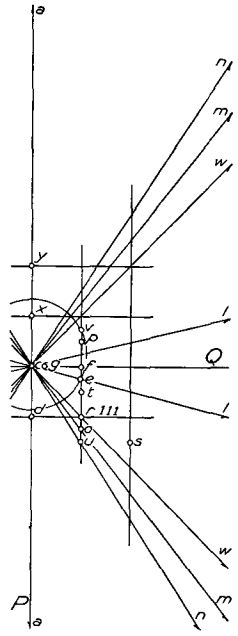

FIG. 22.

Gnomonic projections of the confirmed forms of laurionite (fig. 20), paralaurionite (fig. 21), and fiedlerite (fig. 22).

forms, both are chiefly developed in two zones, domal and pyramidal; and the spacing of the poles in both the P and Q directions is nearly the same.

Laurionite ... $p_o = 0{\cdot}7336$, $q_o = 1{\cdot}7668$.
Paralaurionite ... $p_o' = 0{\cdot}7520$, $q_o' = 1{\cdot}8090$.

The resemblance of the projections is increased greatly when we have a twin of paralaurionite on a(100) with perfect orthorhombic pseudosymmetry. Nevertheless the contention of Ktenas that the two minerals are identical, the orthorhombic symmetry of laurionite being due to 'molecular' twinning of monoclinic individuals of paralaurionite, finds no support in observation. No evidence of twinning is visible in laurionite; the cleavage and optical properties are entirely distinct; and the position angles of the forms are consistently, although slightly different. The dimorphism of laurionite and paralaurionite is clearly established.

Summary.—New observations on laurionite, paralaurionite, and fiedlerite are presented. The separate identity of each of the first two minerals is confirmed and their homeomorphism is exhibited by a reorientation of laurionite. The form series of fiedlerite has been simplified by the choice of a new unit form. New forms are described on all three minerals. The crystallography of all three species is summarized in new angle-tables and their habits are illustrated by a series of drawings.

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—— Note on the identity of paralaurionite and rafaelite. Ibid., p. 183.