THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF
THE MINERALOGICAL SOCIETY

No. 175 December, 1941 Vol. XXVI

On a crystal of augelite from California.

By M. A. Peacock, M.A., Ph.D., D.Sc.

Associate Professor of Mineralogy, University of Toronto,

and D. A. Moddle, M.A.

Ontario Department of Mines.

[Read June 5, 1941.]

AUGELITE was originally described from Sweden by Blomstrand (1868) who obtained the composition $2Al_2O_3.P_2O_5.3H_2O$ from a massive mineral with cleavage in three directions. No further description of this inadequately defined mineral appeared until Prior and Spencer (1895) gave their complete and exact characterization of well-crystallized material from Machacamarca, department Potosi, Bolivia, supplemented by observations by Spencer (1898, 1907) on further finds at Tatasi, department Potosi, and at Oruro, Bolivia.

Lemmon (1935) first recognized augelite as cleavage masses in the commercial deposit of andalusite at White Mountain, Mono County, California, and gave determinative observations which established the identity of the mineral. In this locality Kerr (1932) had noted corundum, diaspore, pyrophyllite, alunite, lazulite, and rutile, associated with the andalusite. In addition to these minerals Professor Joseph Murdoch of the University of California at Los Angeles, has found small, white, tabular crystals of apatite in a specimen carrying augelite.[1] Crystals of augelite from this deposit, with a number of new forms, were mentioned by Pough (1936) in an inconspicuous notice which we did not see until our work was nearly done.[2]

---

[1] Personal communication, March 22, 1941.

[2] In answer to an inquiry Dr. Pough kindly sent us the draft of an unpublished description of the crystals, with permission to use his observations. Since Dr. Pough may find a future occasion to add to the morphology of augelite we will not

In a collection of uncut stones belonging to Mr. G. G. Waite of Toronto one of us noticed a large, clear, well-developed crystal described as augelite from White Mountain, California. Mr. Waite kindly placed this crystal at our disposal before condemning it to the lapidary's wheel, enabling us to supplement the specific description of augelite with some further observations on the geometrical crystallography and optics and to make X-ray photographs giving the unit cell and powder pattern of the mineral.

Morphology.

Our crystal of augelite measures 15 × 8 × 6 mm. in the directions of the axes *a*, *b*, *c*, respectively. In the conventional position the right side is entirely bounded by faces of good quality meeting in sharp or slightly abraded edges; the left side is formed mainly by an over-developed plane $(1\bar{1}0)$ of the perfect prismatic cleavage. An uneven surface, partly following the more difficult cleavage $(\bar{2}01)$ in our notation, also mars part of the upper-rear surface of the crystal. The drawing (fig. 1) shows the relative development of the larger forms with the left side symmetrically restored.

The crystal was measured on the two-circle goniometer with reference to *b*(010) as the pole-face, and plotted in gnomonic projection for reconsideration of the choice of the geometrical elements. In spite of the large size of most of the faces generally very good reflections were obtained, leading to the identification of most of the forms found by Spencer and a number of additional forms the majority of which, as we subsequently found, had been noted by Pough.

As regards the question of choosing axial ratios the outlook has somewhat changed in recent years. Formerly an acceptable choice was made by taking axial directions exhibiting the full symmetry of the crystal and axial lengths giving the simplest symbols for the cleavage planes and the principal forms. Nowadays it is rather generally agreed that the crystal form should be referred to axial ratios directly comparable to the dimensions of the properly chosen unit cell of the crystal lattice, as given by X-ray measurements. Often well-developed pseudo-symmetry will suggest the choice of a simple multiple lattice cell as the basis of both the geometrical and the structural descriptions. The change to the structural lattice cell usually leads to a definite simplification of the geometrical presentation; occasionally a cleavage receives more compli-

---

draw on his material, except to mention his two illustrations: one represents a prismatically developed crystal with *a*(100) developed as a large face; the other shows a crystal tabular on *c*(001) with unlike (*hhl*) forms on the right and left sides.

cated indices, as in the classic case of calcite; but never, to our knowledge, is a systematic complication of notation introduced.

This change of outlook has led to renewed interest in the relation of crystal form to crystal structure. A long step towards a solution of this problem was taken by Donnay and his associates (Donnay and Harker, 1937; Donnay, 1938) who have found that the importance (size and frequency) of a crystal face (*hkl*) is in good approximation proportional to the spacing of the structural planes (*hkl*), where the indices (*hkl*) conform to the systematic extinctions of the space-group. This important generalization, which may justly be called Donnay's law, is a generalization of the law of Bravais, which stated that the importance of a crystal plane is proportional to the spacing (or the reticular density) of the corresponding lattice planes, and is therefore affected by the systematic halving (or division by 3) in the centred lattices. Donnay's law recognizes that the importance of forms is further dependent on the additional halving (or division by 3, 4, 6) of the spacings of structural planes (axial planes and planes in special zones) caused by the symmetry of the space-group. As a consequence of Donnay's law the geometrical form of the crystal lattice and the space-group may be inferred from the crystal morphology. Recently this was strikingly shown by Taylor (1940) who correctly predicted the space-group of stephanite from the morphology and then showed, from X-ray measurements in this laboratory, that the previous röntgenographic determinations were inadequate.

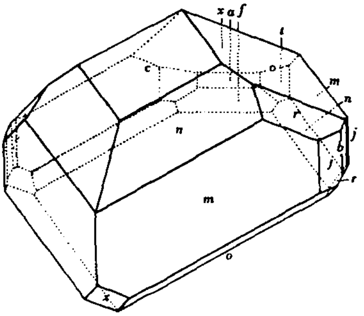

FIG. 1

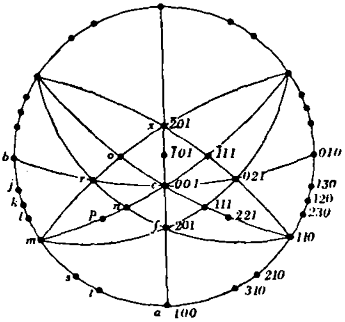

FIG. 2

FIG. 1. Augelite: crystal from California, restored, omitting very small faces.

FIG. 2. Augelite: stereographic projection (structural setting) of the forms observed on a crystal from California.

In the present case it was interesting, therefore, to seek the crystal lattice and space-group from the morphology before taking the X-ray photographs. Using an inspective method which relies on the known relative importance of the crystal forms, a measure of interplanar spacings as given by the gnomonic projection, and a knowledge of the possible extinction conditions, we were led unambiguously to the following conclusion: the geometrical equivalent of the structural lattice is obtained by halving the c-axis of Spencer; the morphological extinctions, indicated by systematically subdued form-importance, are expressed by the rule: (hkl) present only with $(h+k)$ even; the lattice is therefore base-centred and there is no further space-group condition. Consequently the 'aspect' (Donnay and Harker, 1940) is $C*$ and the possible space-groups are Cm, $C2$, $C2/m$, according to the crystal class. As shown later the X-ray measurements lead to the same result. On a subsequent occasion Professor Donnay inspected the morphological data and quickly came to the same conclusion.

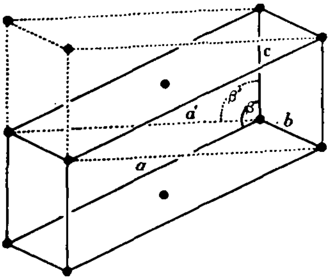

FIG. 3

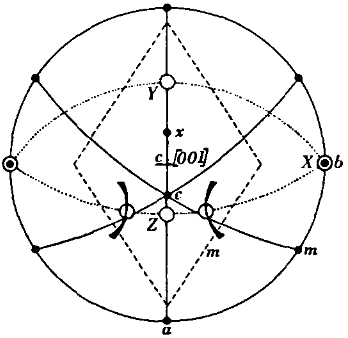

FIG. 4

FIG. 3. Augelite: crystal lattice, showing the adopted base-centred cell (full lines) and the alternative pseudo-orthorhombic body-centred cell (dotted lines).

FIG. 4. Augelite: observed optical orientation.

Since our angular measurements agree closely with the more numerous measurements of Spencer, we have taken Spencer's elements as the basis of the new geometrical values:[1]

$$a:b:c = 1{\cdot}6419:1:0{\cdot}6354; \beta = 112^\circ\ 26\tfrac{1}{2}'.$$

Spencer's symbols are correspondingly transformed by halving the last index to give the notation used throughout this paper.

A possible alternative setting deserves brief mention. The lattice we

---

[1] We prefer to define the monoclinic interaxial angle as the angle between the positive ends of the a- and c-axes, as in the general (triclinic) case, giving the obtuse form of the angle β.

have found might be defined by the nearly rectangular body-centred cell (a' b c β') in fig. 3. This setting would be justified if the crystal habit were clearly pseudo-orthorhombic. It is true that the quasi-symmetrical planes c and x are sometimes nearly equally developed (Spencer, 1895, p. 19), but the typical habit is tabular on $c(001)$ and the distribution of forms (fig. 2) shows pronounced lack of orthorhombic pseudo-symmetry. Since, furthermore, a face-centred monoclinic cell (a b c β) is preferred to a body-centred cell in structural crystallography, the former is indicated in the present case.

The goniometric results are summarized in table I, in which the forms and cleavages marked with an asterisk are new, or provide confirmation of forms previously reported as uncertain or without measurements. The forms observed on the crystal are also shown in the stereographic projection, fig. 2.

Some notes on the new or confirmed forms follow:

j(130). Noted by Pough. Good faces of medium size (fig. 1).
k(120), *l*(230). New. Minute faces on the edges *j*/*m*.
s(210). Noted by Pough. Minute faces on the edge *m*/*t*.
t(310). Noted as doubtful by Spencer and observed by Pough. Fair face of medium size between *a* and *m* (fig. 1).
p(221). Noted by Pough. Good narrow face on the edge *m*/*n*.

The previously recorded cleavages of augelite are (110) perfect, ($\bar{2}01$) good. On our crystal the cleavage (110) is perfect and easy; ($\bar{2}01$) also shows perfect surfaces but is distinctly difficult to develop, as we found when preparing short cleavage prisms for optical and X-ray work. In addition to these cleavages the crystal showed imperfect cleavages (001) and ($\bar{1}01$) giving reflecting steps in good position on the broken part between c and x.

All the forms reported on augelite, by Prior and Spencer (1895), Spencer (1898), Pough (1936), and the present authors, are given in table II, with elements and angles in a standard style for the established forms.[1] In this table we have given the letter q to the form (441), noted as doubtful by Spencer and observed again by Pough.

Since the application of Donnay's law led to the structural lattice and space-group the case of augelite affords confirmation of the law. The verification can be shown more definitely by comparing the sequence of

---

[1] A number of Spencer's calculated angles (1895) compare directly with calculated angles in our table; these show the expected agreement except for three angles, $cn = 31°\ 07\frac{1}{2}'$, $an = 54°\ 53'$, $co = 39°\ 11\frac{1}{2}'$ (Spencer), for which we obtain $30°\ 55\frac{1}{2}'$, $54°\ 56'$, $38°\ 54'$, respectively.

structural planes (*hkl*) in order of decreasing spacing (*d*) with the relative importance of the known forms:

(*hkl*)	(110)	(200)	(001)	$(\bar{2}01)$	$(\bar{1}11)$	(020)	(310)	(111)
d (Å.)	6·66	6·06	4·68	4·66	4·27	3·98	3·60	3·50
Form	*m* (cl.)	*a*	*c* (cl.)	*x* (cl.)	*o*	*b*	*t*	*n*
(*hkl*)	$(\bar{3}11)$	(201)	$(\bar{4}01)$	(021)	$(\bar{2}21)$	(130)	$(\bar{2}02)$	(221)
d (Å.)	3·48	3·17	3·15	3·03	3·03	2·59	2·53	2·48
Form	—	*f*	—	*r*	—	*j*	(cl.)	*p*

Among the first sixteen planes in the theoretical list only three are not known as crystal forms or cleavages, the first gap appearing in the ninth place. The remaining six established forms are separated by more numerous gaps farther down the list. All the forms on our crystal appear in the list given, except three new or confirmed forms; in space-group notation these are *k*(240), *l*(460), *s*(420), the relatively complicated indices and small spacings corresponding to the minute size of the faces. From the available drawings *m*, *c*, *x* are clearly the most important forms of augelite, and the order of importance of the remaining forms, so far as can be judged, is tolerably represented by the order of their spacings. There is only one noteworthy exception: (200) takes second place, even with halved spacing, whereas *a* is generally an unimportant form. On the other hand, one of Dr. Pough's unpublished drawings shows *a* comparable in size with *m* and *c*.

TABLE I. Augelite: mean measured two-circle angles.

Form.	No. of faces.	ϕ_2.	ρ_2.	Form.	No. of faces.	ϕ_2.	ρ_2.
c(001)	2	67° 35′	89° 58′	**t*(310)	1	0° 01′	63° 13′
*–(001) cl.	1	67 31	90 00	*r*(021)	2	67 46	40 25½
b(010)	1	—	0 00	*f*(201)	1	38 35	90 04
a(100)	1	0 01	90 01	*–$(\bar{1}01)$ cl.	1	90 17	90 00
**j*(130)	2	0 01½	12 21½	*x*$(\bar{2}01)$	2	112 49½	89 59
**k*(120)	2	0 01½	18 12	*n*(111)	2	50 14	63 54½
**l*(230)	2	0 01½	23 35½	**p*(221)	1	38 47	51 28
m(110) cl.	2	0 01½	33 21	*o*$(\bar{1}11)$	2	90 21½	57 32½
**s*(210)	1	0 01	52 49				

Thus Donnay's law (or actually in this case Bravais' law, since there is no space-group condition beyond that imposed by the lattice) predicts the relative form-development very fairly and explains, for example, why (110) is larger than (100) or (010); why (130) is larger than (120), (310) larger than (210); why (021) is present and (011) is absent, (201) present, (101) absent, and so forth. All these relations are inexplicable according to the old working rule that form importance is directly related to simplicity of indices; but if we write the form symbols to suit the extinction conditions of the space-group, in this case with $(h+k)$ even, the weaker forms have the more complicated indices and the old rule regains significance as the rule of simplest structural indices.

TABLE II. Augelite—$Al_2PO_4(OH)_3$.

Monoclinic; prismatic—$2/m$

$$a:b:c = 1{\cdot}6419:1:0{\cdot}6354;\ \beta = 112^\circ\ 26\tfrac{1}{2}'$$
$$p_0:q_0:r_0 = 0{\cdot}6589:1:1{\cdot}7027;\ \mu = 67^\circ\ 33\tfrac{1}{2}'$$
$$p_0' = 0{\cdot}4187,\ q_0' = 0{\cdot}6354,\ x_0' = 0{\cdot}4130$$

Form.	ϕ.	ρ.	ϕ_2.	ρ_2 = B.	C.	A.
c(001)	90° 00′	22° 26½′	67° 33½′	90° 00′	0° 00′	67° 33½′
b(010)	0 00	90 00	—	0 00	90 00	90 00
a(100)	90 00	90 00	0 00	90 00	67 33½	0 00
j(130)	12 23½	90 00	0 00	12 23½	85 18	77 36½
k(120)	18 14	90 00	0 00	18 14	83 08½	71 46
l(230)	23 43	90 00	0 00	23 43	81 10	66 17
m(110)	33 23	90 00	0 00	33 23	77 52½	56 37
s(210)	52 48½	90 00	0 00	52 48½	72 17½	37 11½
t(310)	63 10	90 00	0 00	63 10	70 05	26 50
g(910)	80 25½	90 00	0 00	80 25½	67 53½	9 34½
r(021)	18 00	53 11½	67 33½	40 24½	49 35½	75 40½
f(201)	90 00	51 21	38 39	90 00	28 54½	38 39
x($\bar{2}$01)	−90 00	23 00	113 00	90 00	45 26½	113 00
n(111)	52 37½	46 18½	50 15	63 58	30 55½	54 56
d(332)	47 31½	54 41	43 51	56 34	40 10½	53 00
p(221)	44 32	60 42½	38 39	51 33½	46 42½	52 17
q(441)	39 24	73 05½	25 35½	42 19½	59 57½	52 36½
o($\bar{1}$11)	−0 31	32 26	90 19½	57 34	38 54	90 16½

Doubtful, or reported without angles: (530), (510), (102), ($\overline{16}$.0.1), (112), (223), (445), (443), (12.12.5), (661), ($\bar{1}$13), ($\bar{2}$41).

Optics.

From plates and prisms cut in known directions in crystals of augelite from Machacamarca Prior and Spencer (1895) obtained complete optical data which may be stated as follows:

X = *b*[010]	α 1·5736 (Na)	Positive
Y : c[001] = −56°	β 1·5759	2V = 50° 49′ (meas.), 47° 56′ (calc.)
Z : c[001] = +34°	γ 1·5877	No dispersion observed

A slight ambiguity in the statement of the optical orientation was removed in a later footnote (Spencer, 1898, p. 3).

The optical constants given by Lemmon (1935) agree with those of Spencer within the limits of error; but Lemmon's optical orientation, as given in his figure 2, shows the optical axial plane in the symmetry plane whereas Spencer clearly states that the plane of the optic axes is perpendicular to the plane of symmetry. Since Lemmon does not comment on this important difference of orientation one may doubt if it was actually observed.

To decide the question of the optical orientation of the Californian augelite short cleavage prisms were examined in temporary mounts on the ordinary stage and in a permanent mount on the universal stage. The optic axial plane was found to lie perpendicular to the symmetry plane, with Z, the acute bisectrix, inclined to the vertical at 34½° in the obtuse angle β, and 2V 52° measured between sharp optic axis figures on the universal stage. The principal refractive indices were not measured again, in view of the exact agreement in the existing values. These observations confirm Spencer's optical orientation, which is unaffected by the new crystallographic setting. To leave no question regarding the observed orientation fig. 4 (p. 108) is given, showing the optical elements in relation to the crystal forms *a b c m x*, the axis *c*[001], and the outline of the prismatic cleavage form.

Unit cell.

The unit cell of augelite was determined from X-ray photographs with Fe-radiation, using a short (110) cleavage prism turning around the axis of symmetry. The rotation photograph gave the period $b = 7{\cdot}96 \pm 0{\cdot}04$ Å.; Weissenberg resolutions of the zero and first layer-lines gave the spacings $d_{100} = 12{\cdot}11 \pm 0{\cdot}02$ Å., $d_{001} = 4{\cdot}677 \pm 0{\cdot}01$ Å., and the angle $(100):(001) = 67^\circ\ 43' \pm 20'$, corresponding to the geometrical angle $ac = 67^\circ\ 33\frac{1}{2}'$. The quasi-equivalent angle $(\bar{1}00):(\bar{2}01)$ measured $66^\circ\ 46' \pm 20'$ on the films as compared with the geometrical angle $a'x = 67^\circ\ 00$. Thus the pseudo-symmetrical diffractions $(00l)$ and $(\overline{2h}.0.h)$ were definitely distinguished. Combining these spacings with the more exact geometrical axial angle we obtain the cell dimensions:

$$a = 13{\cdot}10,\ b = 7{\cdot}96,\ c = 5{\cdot}06\ \text{Å.};\ \beta = 112^\circ\ 26\tfrac{1}{2}'$$

giving the ratios:

$$a:b:c = 1{\cdot}646:1:0{\cdot}636$$

as compared with the geometrical ratios:

$$a:b:c = 1{\cdot}6419:1:0{\cdot}6354$$

With reference to this cell the systematic extinctions are given by the condition: (hkl) present only with $(h+k)$ even. The unit cell is therefore base-centred and the space-group is $C^3_{2h} = C2/m$, if augelite is holohedral. This is precisely the result previously obtained from morphological considerations. Furthermore, it is noteworthy that the adopted unit cell would have been chosen from purely structural considerations, since a base-centred cell is taken rather than a body-centred cell; and, of the alternative base-centred cells, the one with less oblique axes, which corresponds to the geometrical elements, is preferred.

In regard to the point group symmetry (crystal class) of augelite the evidence is inconclusive. Spencer (1895) noted etch-effects suggesting hemihedrism (domatic class) but obtained no pyroelectric effect by Kundt's method. One of Dr. Pough's unpublished drawings shows different (*hhl*) forms right and left, indicating hemimorphism (sphenoidal class); but we in turn obtained no evidence of polarity of the symmetry axis using the pyroelectric test described by Martin (1931), under conditions that gave a strong reaction with tourmaline. In view of such cases as diamond, sulphur, and topaz, which have yielded holohedral structures in spite of some external evidence of merohedry, and the recognized possibility that etch-figures may have symmetry lower than that of the crystal structure, it seems probable that augelite belongs to the holohedral (prismatic) class.

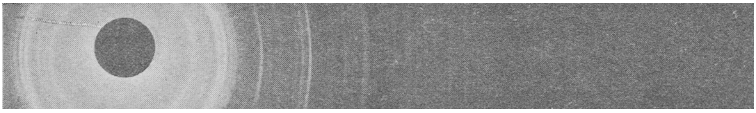

FIG. 5. Augelite: full-size print of an X-ray powder photograph; Cu-$K\alpha$ radiation; 1 mm. on film = 1°θ.

From the composition $2Al_2O_3.P_2O_5.3H_2O$ confirmed by Prior, and the specific gravity 2·696 measured by Spencer, the unit cell of augelite contains $Al_8P_4O_{16}(OH)_{12} = 4[Al_2PO_4(OH)_3]$, which gives the calculated specific gravity 2·704. This cell content is compatible with the equivalent positions in the holohedral space-group *C*2/*m*.

Powder pattern.

To aid in the identification of augelite the X-ray powder spectrum, obtained with Cu-radiation (Ni-filter) in a camera with radius $360/4\pi$ mm., is reproduced in fig. 5. In table III are given the visual intensities of the powder rings *I*(Cu) and the planar spacings *d* (meas.), with the indices (*hkl*) and the calculated spacings *d* (calc.), so far as the indexing could be carried with reasonable certainty. The intensities of the corresponding Weissenberg spots *I*(W) are added for the diffractions that lay in the range of the Weissenberg photographs.

TABLE III. Augelite: X-ray powder spectrum.

I(Cu).	d (meas.).	(hkl).	d (calc.).	I(W).
s	4·71 Å.	(001)	4·68	s
		$(\bar{2}01)$	4·66	s
w	4·30	$(\bar{1}11)$	4·27	m
s	3·99	(020)	3·98	—
vs	3·50	(111)	3·50	s
		$(\bar{3}11)$	3·48	s
vs	3·32	(220)	3·33	—
m	3·16	$(\bar{4}01)$	3·15	s
w	3·03	(400)	3·03	s
s	2·47	(221)	2·48	—
		(311)	2·48	m
		$(\bar{4}21)$	2·47	—
vw	2·35	$(\bar{3}12)$	2·36	m
		(002)	2·34	s
vw	2·18	(131)	2·19	—
		$(\bar{3}31)$	2·19	—
vw	2·05	$(\bar{5}12)$	2·07	s
w	1·986	(040)	1·990	—
m	1·930	(202)	1·946	s
		$(\bar{6}02)$	1·937	vs
vw	1·890	(240)	1·890	—
s	1·854	(331)	1·858	—
		$(\bar{5}31)$	1·854	—
vw	1·705	(312)	1·713	m
vw	1·676	(241)	1·684	—
		$(\bar{4}41)$	1·682	—
m	1·586	$(\bar{5}13)$	1·591	vs
vw	1·506	$(\bar{8}21)$	1·512	—
m	1·471	(151)	1·474	—
		(441)	1·472	—
		$(\bar{3}51)$	1·472	—
		$(\bar{6}41)$	1·470	—
w	1·419 Å.			
vw	1·385			
vw	1·354			
w	1·327			
w	1·268			
w	1·268			
vw	1·238			
vw	1·211			
vw	1·176			
vw	1·158			
m	1·134			
w	1·089			
vw	1·074			
w	1·065			
vw	1·008			
vw	0·951			
vw	0·940			
vw	0·932			
vw	0·916			
vw	0·905			
vw	0·895			

Summary.

A large well-formed crystal of augelite from the andalusite deposit on White Mountain, Mono Co., California, shows the forms *c*(001), *b*(010), *a*(100), *j*(130), *k*(120), *l*(230), *m*(110), *s*(210), *t*(310), *r*(021), *f*(201), *x*$(\bar{2}01)$, *n*(111), *p*(221), *o*$(\bar{1}11)$, with $a : b : c = 1·6419 : 1 : 0·6354$, $\beta = 112° 26\frac{1}{2}'$ (Spencer, in the structural setting); the forms *j k l s t p* are new or confirmatory. Cleavages (110), $(\bar{2}01)$, also new (001), $(\bar{1}01)$. Spencer's optical orientation is confirmed; *Z* (acute bisectrix): $c = +34\frac{1}{2}°$; 2V = 52°. The unit cell with *a* 13·10, *b* 7·96, *c* 5·06 Å., $\beta = 112° 26\frac{1}{2}'$, contains $4[Al_2PO_4(OH)_3]$. The space-group obtained from the morphology by Donnay's law, and independently from the X-ray extinctions, is $C^3_{2h} = C2/m$, accepting the holohedral class indicated by the absence of pyroelectricity (Martin's method). The X-ray powder spectrum is reproduced and partially indexed.

REFERENCES.

BLOMSTRAND (C. W.), 1868. Om Westanå Mineralier. Öfvers. Vetensk.-Akad. Förh. Stockholm, vol. 25, pp. 197–212.

DONNAY (J. D. H.), 1938. Le développement des zones cristallines. Ann. Soc. Géol. Belgique, vol. 61, pp. 260–287. [M.A. 7–242.]

—— and HARKER (D.), 1937. A new law of crystal morphology extending the law of Bravais. Amer. Min., vol. 22, pp. 446–467. [M.A. 7–241.]

—— —— 1940. Nouvelles tables d'extinctions pour les 230 groupes de recouvrements cristallographiques. Naturaliste Canadien, vol. 67, pp. 33–69. [M.A. 8–4.]

KERR (P. F.), 1932. The occurrence of andalusite and related minerals at White Mountain, California. Econ. Geol., vol. 27, pp. 614–643. [M.A. 5–288.]

LEMMON (D. M.), 1935. Augelite from Mono County, California. Amer. Min., vol. 20, pp. 664–668. [M.A. 6–288.]

MARTIN (A. J. P.), 1931. On a new method of detecting pyroelectricity. Min. Mag., vol. 22, pp. 519–523.

POUGH (F. H.), 1936. New York Mineralogical Club, American Museum of Natural History, New York City, May 20, 1936. Amer. Min., vol. 21, p. 536.

PRIOR (G. T.) and SPENCER (L. J.), 1895. Augelite. Min. Mag., vol. 11, pp. 16–23.

SPENCER (L. J.), 1898. Augelite from a new locality in Bolivia. Min. Mag., vol. 12, pp. 1–4.

—— 1907. Notes on some Bolivian minerals (jamesonite, andorite, cassiterite, tourmaline, &c.), with chemical analyses by G. T. PRIOR. Min. Mag., vol. 14, pp. 308–344.

TAYLOR (E. D.), 1940. Stephanite morphology. Amer. Min., vol. 25, pp. 327–337. [M.A. 8–7.]