AFWILLITE FROM CRESTMORE, CALIFORNIA[1]

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ABSTRACT

Afwillite, $3CaO \cdot 2SiO_2 \cdot 3H_2O$, has been found as crusts of small crystals along cracks in blocks of contact rock on the floor of the 910-foot level of the Commercial Quarry, Crestmore, near Riverside, California. Analysis gave: SiO_2 34.65, CaO 48.94, MgO trace, H_2O (+) 16.08, H_2O (−) 0.01, F=0.18, less O=F 0.10; total 99.76. Measurement of four crystals gave: $a:b:c=2.0712:1:2.3513$; $\beta=98°50'$. Crystals elongated parallel to [010], tabular parallel to {101}. The new forms {045}, {013}, {$\bar{3}$02}, {$\bar{1}$12}, {121}, {211}, {$\bar{2}$13} {$\bar{3}$12} were noted. Optically biaxial (+), 2V=55°, $\alpha=1.616$, $\beta=1.619$, $\gamma=1.631$, $X \wedge c=30°$. Cleavage {001} perfect, {100} good. Hardness 3. Specific gravity 2.62. Color white or colorless. *X*-ray powder data are given. Occurs with quartz and thaumasite on matrix of merwinite, gehlenite, and calcite.

INTRODUCTION

The marble, contact, and intrusive rocks at Crestmore, near Riverside, California, contain an unusually large variety of minerals. More than 100 different minerals have been identified from this area. Among the minerals is a series of hydrous calcium silicates—centrallassite, crestmoreite, hillebrandite, okenite, and riversideite.

A cross-section through the Commercial Quarry has been described in detail by Woodford, Crippen, and Garner (1941). Their paper lists all of the species then known to occur at Crestmore, as well as 14 additional unidentified species, tentatively designated by letters. A more recent summary of the geology and mineralogy of the Crestmore locality by Woodford (1943) gives more detailed information about these unidentified species. One of these unknowns, designated as *Mineral P*, has now been identified as afwillite, $3CaO \cdot 2SiO_2 \cdot 3H_2O$, another in the series of hydrous calcium silicates.

Afwillite was first described as a new species by Parry and Wright (1925). It was found in small quantity, associated with apophyllite, calcite, and natrolite, in a dolerite inclusion in kimberlite between the 500 and 750 foot levels of the Dutoitspan diamond mine, Kimberley, South Africa. A second occurrence was noted at Scawt Hill, Larne County, Antrim, Ireland, by Tilley (1930), where afwillite was found as small crystals with calcite in a spurrite rock. The Crestmore afwillite becomes the third known occurrence and the first in the Western Hemisphere.

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Chemistry

A chemical analysis of afwillite from Crestmore is given in Table 1, along with one of the type material from Dutoitspan. The agreement between the analyses is good, and the Crestmore material is very close to the formula $3CaO \cdot 2SiO_2 \cdot 3H_2O$.[2]

Table 1. Chemical Analyses of Afwillite

	1	2	3	4
SiO_2	35.10	34.65	0.577=2×0.289	35.13
R_2O_3	0.05	None		
CaO	49.00	48.94	0.873=3×0.291	49.09
MgO	0.02	Trace		
$H_2O(+)$	15.81	16.08	0.893=3×0.298	15.78
$H_2O(-)$	0.01	0.01		
F		0.18		
	99.99	99.86		100.00
Less O=F		0.10		
		99.76		

1. Afwillite from Dutoitspan mine, Kimberley, South Africa. H. S. Washington, analyst (Parry and Wright, 1925).
2. Afwillite from 910-foot level of the Commercial Quarry, Crestmore, San Bernardino County, California. G. Switzer, analyst. F determined by C. Warshaw (U.S.N.M. 105851).
3. Molecular ratios of analysis 2.
4. Theoretical composition for $3CaO \cdot 2SiO_2 \cdot 3H_2O$.

Crystallography

The unit cell dimensions of afwillite from South Africa were determined by Gottfried (1933), who obtained the following results:

$a = 11.39$ kX
$b = 5.47$ kX
$c = 13.09$ kX
$\beta = 98°26'$ (from Parry and Wright, 1925)
$a:b:c = 2.08:1:2.39$

[2] Recent work on the crystal structure of afwillite by Megaw (1949) shows that the silicon atoms occur in SiO_4 groups, each sharing one edge and two corners with the oxygen polyhedra surrounding neighboring calcium atoms, with some OH directly linked to silicon. The details of this work have not yet been published.

Gottfried found plates of afwillite cut perpendicular to the *b* axis to be distinctly piezoelectric, and hence assigned the mineral to the monoclinic-sphenoidal class (C_2). Etch tests made by Parry and Wright show no evidence of hemihedry, judging from their drawing of etch figures on (001).

X-ray powder photographs of type afwillite from South Africa and the Crestmore mineral are identical. The *d* spacings of the South African afwillite are given in Table 2 (measurements by Switzer by photographic methods using a camera of 114.6 mm. diameter, intensities estimated visually).

TABLE 2. X-RAY POWDER DATA ON AFWILLITE FROM DUTOITSPAN MINE, KIMBERLEY, SOUTH AFRICA, COPPER RADIATION, NICKEL FILTER

No.	*I*	*d*	No.	*I*	*d*	No.	*I*	*d*
1	9	6.61	13	2	2.67	25	6	1.95
2	1	5.75	14	2	2.59	26	2	1.91
3	4	5.10	15	1	2.43	27	4	1.85
4	4	4.67	16	6	2.34	28	5	1.80
5	2	4.13	17	2	2.32	29	5	1.77
6	1	3.87	18	1	2.28	30	1	1.72
7	2	3.74	19	1	2.18	31	4	1.70
8	7	3.28	20	7	2.15	32	3	1.68
9	9	3.18	21	1	2.12	33	2	1.62
10	3	3.05	22	3	2.05	34	4	1.60
11	10	2.83	23	1	2.01	35	4	1.59
12	9	2.73	24	3	1.98	36	2	1.58

Afwillite from Crestmore is in part massive and in part crystallized. The crystals, which are colorless and transparent, range in length from less than 0.5 mm. to about 3 mm. They are well formed, with faces of a quality suitable for goniometry.

Table 3 gives a summary of the measurements obtained on four selected crystals from Crestmore, in the original setting of Parry and Wright (1925). The axial ratio in this setting, using measurements obtained on the Crestmore crystals, is $a:b:c=2.0712:1:2.3513$; $\beta=98°50'$. This ratio compares favorably with the figures obtained from *x*-ray measurements by Gottfried (1933) and is probably more precise than that determined by Parry and Wright (1925) on the Dutoitspan crystals, which were large and somewhat imperfect.

Of the forms listed in Table 3, the following are new: {045}, {013}, $\{\bar{3}02\}$, $\{\bar{1}12\}$, {121}, {211}, $\{\bar{2}13\}$ and $\{\bar{3}12\}$.

The appearance of a typical crystal is shown in Fig. 1. All the crystals are elongated parallel to [010], and most are tabular parallel to {101}.

TABLE 3. MEASUREMENT OF AFWILLITE CRYSTALS FROM CRESTMORE; (010) AS POLE (IN SETTING OF PARRY AND WRIGHT, 1925)

	Number of		Quality	ϕ_2 from (001)	ρ_2	Range	
	Crystals	Faces				ϕ_2	ρ_2
001	4	6	E to P	0°00′	90°00′	0°00′ to 0°45′	89°40′ to 90°15′
100	4	5	G to P	98 50	90 00	98 30 to 99 05	89 36 to 90 21
110	4	7	E to P	98 50	26 02½	98 31 to 99 05	25 56 to 26 38
310	3	4	G	98 50	55 42	98 29 to 98 52	55 35 to 56 03
011	4	7	G to VP	0 00	23 18	0 00 to 4 08	23 08 to 24 13
045	1	1	G	0 00	28 17½	0 06	27 17
013	1	1	P	0 00	52 15	1 22	52 06
101	4	6	E to P	136 19	90 00	134 06 to 136 09	89 30 to 90 00
$\bar{1}01$	4	7	E to VP	53 39	90 00	52 54 to 54 00	90 00 to 90 32
$\bar{3}02$	1	1	P	66 18	90 00	63 36	90
$\bar{1}12$	4	5	G to VP	31 34	42 41	30 57 to 31 48	42 14 to 43 02
121	1	1	G	136 19	19 16	136 35	19 19
211	1	2	G	121 01	48 24½	119 19 to 121 05	48 16 to 48 24
$\bar{2}13$	3	3	F to VP	40 14	56 13	39 56 to 41 50	56 15 to 56 27
$\bar{3}12$	1	1	P	66 18	57 42	67 02	56 35

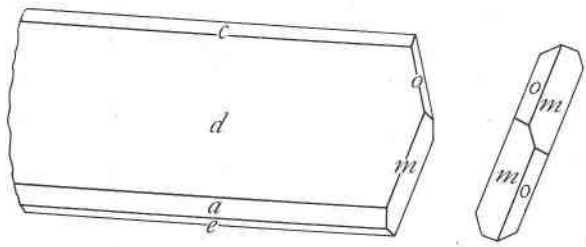

FIG. 1. Crestmore afwillite crystal showing typical habit: tabular parallel to $d\{101\}$ and elongated parallel to [010]. Forms present are $c\{001\}$, $d\{101\}$, $a\{100\}$, $e\{\bar{1}01\}$, $o\{011\}$, and $m\{110\}$.

PHYSICAL PROPERTIES

The optical properties of afwillite from Crestmore are essentially the same as those reported for material from other localities. They are as follows:

$$\left.\begin{aligned}\alpha &= 1.616\\ \beta &= 1.619\\ \gamma &= 1.631\end{aligned}\right\} \pm 0.002$$

Biaxial (+) $2V = 55° \pm 3°$

$Y = b$, $X \wedge c = 30°$

Other properties are: {001} cleavage perfect, {100} cleavage good; $H = 3$; Sp. gr. $= 2.62 \pm 0.01$.

OCCURRENCE AND ASSOCIATIONS

Afwillite (*Mineral P*) was found in small quantity as thin crusts and crystals along cracks in loose blocks of contact rock on the floor of the

910-foot level of the Commercial Quarry. Associated with it are small crystals of quartz, as well as stout hexagonal prisms of thaumasite (referred to as *Mineral K* by Woodford, Crippen, and Garner, 1941).

The afwillite crusts and crystals occur on a matrix of granular, light-gray contact rock composed chiefly of merwinite, gehlenite, and calcite, with smaller amounts of spurrite, idocrase, monticellite, garnet, and brucite. This matrix has the typical appearance of the frequently occurring merwinite-gehlenite mixture of the locality.

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