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BAKERITE CRYSTALS

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ABSTRACT

Bakerite crystals have been found at the Sterling Borax Mine, Los Angeles County, California. Rough goniometric measurements have been made on these, showing that the mineral is monoclinic, with two distinct habits: stout prismatic with {001} and {$\bar{1}$11} only; and thin tabular with {001} dominant and {$\bar{1}$11} and {012} as narrow modifying faces. Bakerite is biaxial negative, with 2V=85°; Z∧c=44°; Y=b. Indices of refraction, α 1.624, β 1.635, γ 1.654.

Single crystal x-ray study shows the following cell dimensions; a 4.82 Å, b 7.60 Å, c 9.60 Å; β 90°12′±; space group $P2_1/c$. These data confirm the suggested close structural relationship of bakerite to datolite and herderite.

The x-ray powder pattern agrees closely with those previously published, and has been satisfactorily indexed down to 1.50 Å. Spacings of stronger lines, with their intensities, are as follows: 3.11—10, 2.85—6, 2.236—6, 3.74—5, 2.51—5, 2.18—5, 2.99—4.

Bakerite, a basic calcium borate-silicate, has been so far known only in extremely fine-grained aggregates, and has been reported as such from several localities in California, notably from Inyo, San Bernardino and Los Angeles Counties. Kramer and Allen (1956) have confirmed the originally proposed formula of Giles (1903), and determined the α and γ refractive indices. They were unable to measure β, or 2V, because of the minute size of the grains. The close structural relationship of this mineral to datolite, herderite and homilite has been pointed out by Palache *et al.* (1951 p. 363), using x-ray powder data. Strunz (1936) had previously shown the isostructural relationship of datolite and herderite.

Some little time ago, the writer, in collecting at the Sterling Borax Mine, Tick Canyon, Los Angeles County, California, was fortunate enough to find very small, but reasonably well-formed crystals of bakerite from which it has been possible to complete the optical and x-ray description of this mineral, and roughly to determine its morphology. The crystals of bakerite occur as a coating on the surface of massive bakerite or of a mixture of pellets of bakerite in a matrix of clay-like material. This matrix occurs as porous or vuggy masses, grayish in color and often showing irregularly laminar crustification. Most of the bakerite surfaces are fine-grained, botryoidal and drusy crusts, but in favorable localities clusters of recognizable individuals, or single crystals are present. The crystals were identified as bakerite from the x-ray powder pattern, which exactly matches that of the usual massive material.

CRYSTALLOGRAPHY

The crystals of bakerite occur in two distinct habits, which are normally separate, but may occur together in the same aggregate. One

type appears as a stout rhombic prism with oblique termination (Fig. 1a), and the other as relatively thin diamond shaped tablets (Fig. 1b). The prismatic crystals are sometimes clear and colorless, sometimes translucent or even opaque, due to the presence of disseminated claylike inclusions. The tabular crystals are clear and colorless, but often with a core or base of opaque material which apparently represents the foundation on which the crystals have grown. None of the crystals is much over 0.2 mm in the largest dimension, and most are considerably smaller. Prismatic crystals may be up to 0.2×0.1 mm, and the tabular up to 0.2×0.2×0.05 mm.

Examination showed that the crystals are monoclinic. All faces are of rather poor quality, giving only vague signals from which it was possible to make approximate readings, which could however be interpreted in the light of the *x*-ray information. Forms recognized in the chosen orientation were {001}, {$\bar{1}$11}, {012}, and less commonly {110}. For type *a* crystals the forms are {001} and {$\bar{1}$11}, almost equally developed. For type *b*, {001} is dominant, modified by {012} and {$\bar{1}$11}, narrow but always present, and {110} rare. The following angle table has been computed from the *x*-ray data.

TABLE 1

Monoclinic			Space Group $P2_1/c$			
$a:b:c$ 0.6342::1:1.2632			β 90°12′	$p_0:q_0:r_0$ 1.992::1.2632:1		
$r_2:p_2:q_2$ 0.6411::1.5767:1			μ 89°48′	p_0' 1.9922 q_0' 1.2632 x_0' 0.0035		
forms	ϕ	ρ	ϕ_2	ρ_2=B	C	A
c 001	90°00′	0°12′	89°48′	90°00′	—	89°48′
m 110	57 37	90 00	0 00	57 37	89 59	32 23
t 012	0 19	32 16	89 48	57 32	32 09	89 50
n $\bar{1}$11	−57 33	66 59	153 17	60 24½	67 09	140 57

OPTICAL DATA

From individual crystals, the following optical information was derived for bakerite: Biaxial (−), 2V 87°−88°; Y=b, X∧c=44°; optic plane *a*–*c*. Indices of refraction: α 1.624, β 1.635, γ 1.654. α and γ as determined agree with the values of Kramer and Allen (1956).

X-RAY POWDER DATA

X-ray powder patterns were made of crystals of both types and also of the crusts underlying each, using nickel-filtered copper radiation.

TABLE 2. X-RAY POWDER DATA. COPPER RADIATION, NICKEL FILTER, $\lambda = 1.5418$ Å

Bakerite			Datolite		Herderite	
d/n	I	*hkl*	d/n	I	d/n	I
5.98	½	011	5.94	1	5.99	2
4.82	2	100, 002	4.84	2	4.77	2
3.74	5	111, $\bar{1}11$	3.75	5	3.79	3
—			—		3.65	1
3.40	3	102, $\bar{1}02$	3.42	3	3.43	5
—			—		3.33	½
3.11	10	112, $\bar{1}12$	3.12	10	3.14	10
2.99	4	013, 022, 120	2.98	4	3.00	6
2.85	6	121, $\bar{1}21$	2.86	7	2.86	8
—			—		2.75	½
2.51	5	113, $\bar{1}13$	2.52	5	2.55	6
2.45	½	023, 031	—		2.46	2
2.395	1	004	2.41	½	2.40	1
2.29	½	014, 210	2.30	½	2.34	3
2.236	6	032, 104, 130, $\bar{1}04$, 211, $\bar{2}11$	2.246	6	2.26	5
2.18	5	123, 131, $\bar{1}23$, $\bar{1}31$	2.19	5	2.20	7
2.153	½	104, 202, $\bar{2}02$	2.15	2	2.11	1
2.074	1	212, $\bar{2}12$	2.072	½	2.05	1
2.03	½	024, 132, 220, $\bar{1}32$	2.03	½	—	
1.987	4	033, 221, $\bar{2}21$	1.996	3	2.00	4
—			—		1.957	½
1.907	½	040	1.896	½		
1.86	4	015, 213, $\bar{2}13$	1.869	4	1.88	4
1.764	1	042, 140	1.768	1	1.781	4
—			1.744	½	1.749	1
1.710	2	025, 231, $\bar{2}31$	1.715	2	1.722	3
1.657	2	142, 214, $\bar{1}42$, $\bar{2}14$	1.665	1	1.664	1
1.639	4	232, $\bar{2}32$	1.639	4	1.650	5
1.610	½	300, 125, $\bar{1}25$	1.614	½	—	
1.560	½	016, 224, $\bar{2}24$	1.558	½	1.573	½
1.515	1	302, $\bar{3}02$	1.524	1	—	
1.494	½	106, $\bar{1}06$	1.480	½	—	
—			1.466	½	1.465	½
—			—		1.443	½
1.425	½		1.427	½	—	
1.411	½		1.416	½	1.419	½
+15 lines, all under ½						

Bakerite, Sterling Borax Mine (J.M.).
Datolite, New Jersey (J.M.).
Herderite, Topsham, Main, (A.S.T.M. card 6-0338).

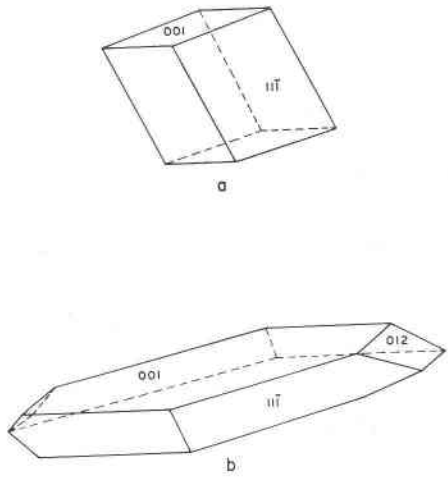

FIG. 1. Bakerite crystals. a. Stout prismatic habit. b. Thin tabular habit.

These patterns were all identical, and matched with Kramer and Allen's, and also with that of Frondel (private communication). This pattern has been satisfactorily indexed down to 1.494 Å, using single crystal data. Table 2 shows a comparison of powder patterns of bakerite with datolite and herderite, and it is shown that there is a very close correspondence of the three both in spacings and intensities.

X-RAY SINGLE CRYSTAL STUDY

Orientation of the crystals was selected to correspond with those of datolite and herderite. Rotation photographs were taken about all three axes, and also Weissenberg equator, first and second layer line, for both types of crystals, which yielded consistent results. Systematic extinctions lead to space group $P2_1/c$ and the following cell dimensions were arrived at:

$$a\ 4.82,\quad b\ 7.60,\quad c\ 9.60\quad \beta\ 90°12'$$

From these data the values of Table 1 have been calculated, since the crystallographic measurements were too poor to be reliable. The close relationship of bakerite to datolite and herderite, shown by the powder patterns, is further confirmed on inspection of the single crystal data for the three minerals. The following data have been taken for bakerite from this paper, and from Strunz (1936) and Gossner and Mussgnug (1929), for datolite and herderite.

Grossner and Mussgnug reversed a and c, but their cited values were interchanged and used by Strunz.

TABLE 3

	a	*b*	*c*	*β*
Bakerite	4.82	7.60	9.60	90 12′
Datolite	4.82	7.62	9.64	90 09′
Herderite	4.63	7.68	9.80	90°06′

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