

## THE BAVENITE PROBLEM\*

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### ABSTRACT

Published analyses of bavenite, beryllium calcium aluminosilicate, indicate a wide range of BeO content, but it is probable that all of the early analyses of bavenite gave incorrect figures for the BeO content. A new chemical analysis of bavenite from California shows 7.66 per cent BeO, in good agreement with the analysis of duplexite by Rowledge and Hayton; duplexite is bavenite.

### INTRODUCTION

Rowledge and Hayton (1948) described two new beryllium calcium aluminosilicate minerals, named by them duplexite and bowleyite, from the Londonderry feldspar quarry near Coolgardie, Western Australia. Study of their data and of the data in the literature indicated that duplexite is closely related to bavenite, as Rowledge and Hayton suggested, or identical with it.

Further study of these minerals by spectrographic and x-ray methods was therefore made. The mechanism of substitution in beryllium-bearing silicates is very imperfectly understood, and it seemed likely that useful data might be obtained from a study of the bavenite-duplexite series, in which the BeO content was reported to range from 2.48 to 7.72 per cent. As reported below, however, it turned out that the BeO content is much less variable than had been reported.

Bowleyite and bityite (the latter described from Madagascar by Lacroix, 1908) are also closely related, but preliminary work has indicated the need for a new chemical analysis of bityite, and single crystal x-ray study of both. This work is being continued and will be reported on at a later date.

### THE BAVENITE PROBLEM

Bavenite was first described from Baveno, Italy, by Artini (1901), but the presence of beryllium was overlooked by him. Schaller and Fairchild (1932) described bavenite from the Himalaya mine, Mesa Grande, California; Fairchild's analysis gave BeO 2.67 per cent, and spectrographic study by George Steiger on two samples from Baveno is cited as indicating that the Italian bavenite contained fully as much BeO as the California material. Schaller and Fairchild deduced the

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TABLE 1. ANALYSES OF BAVENITE

	1	2	3	4	5	6	7	8	9
SiO <sub>2</sub>	56.93	58.40	56.19	57.40	57.11	57.25	58.92	59.13	57.64
Al <sub>2</sub> O <sub>3</sub>	15.42	12.16	12.49	12.08	9.60	9.89	6.88	7.00	6.46
Fe <sub>2</sub> O <sub>3</sub>	—	0.10	—	—	0.11	0.10	0.07	none	—
BeO	—	2.67	3.12	2.48	6.60	6.33	7.72	7.14	7.66
CaO	24.47	23.73	25.12	25.76	24.30	24.35	23.26	23.90	23.96
MnO	—	—	—	—	—	—	0.01	0.01	—
MgO	0.12	—	—	—	—	—	0.13	0.05	—
Na <sub>2</sub> O	0.29	—	—	—	—	—	0.44	0.10	—
H <sub>2</sub> O+	2.49	2.90	2.74	3.00	1.87	1.90	2.41	2.46 <sup>a</sup>	3.56 <sup>b</sup>
H <sub>2</sub> O-	—	—	—	—	—	—	0.06	0.06	0.32
Other	—	—	—	—	0.31 <sup>c</sup>	0.31 <sup>c</sup>	0.04 <sup>d</sup>	0.16 <sup>e</sup>	—
	99.72	99.96	99.66 <sup>f</sup>	100.72	99.90	100.13	99.94	100.01	99.60
Sum Al <sub>2</sub> O <sub>3</sub> + Fe <sub>2</sub> O <sub>3</sub> +BeO	15.42	14.93	15.61	14.56	16.31	16.32	14.67	14.14	14.12

1. Artini (1901), from Baveno, Italy; Artini, analyst.

2. Schaller and Fairchild (1932), from Mesa Grande, Calif.; Fairchild, analyst.

3, 4. Grill (1941), from Baveno; 3. G. Pagliani, analyst; 4. T. Bianchi, analyst.

5, 6. Kutukova (1946) from Malshevsky mine; 5. V. S. Saltukova, analyst; 6. M. E. Kazakova, analyst.

7, 8. Rowledge and Hayton (1948), from Londonderry; W. Australia; Hayton, analyst.

9. From Mesa Grande, Calif. M. K. Carron, analyst; new analysis on same sample as No. 2 above; analysis corrected by spectrographic determination, by Janet D. Fletcher, of Be in AlPO<sub>4</sub> and Al in BeO (USNM 104299).

<sup>a</sup> Ignition loss minus 0.06 per cent H<sub>2</sub>O-, Cl 0.02; CO<sub>2</sub> 0.03, C 0.11 per cent.

<sup>b</sup> Ignition loss minus H<sub>2</sub>O-.

<sup>c</sup> B<sub>2</sub>O<sub>3</sub> 0.31 per cent.

<sup>d</sup> K<sub>2</sub>O 0.04 per cent.

<sup>e</sup> Cl 0.02, CO<sub>2</sub> 0.03, C 0.11 per cent.

<sup>f</sup> Given in original as 99.47 per cent.

formula Ca<sub>4</sub>Al<sub>2</sub>BeSi<sub>9</sub>O<sub>25</sub>(OH)<sub>2</sub>. This was confirmed by two new analyses from Baveno, published by Grill (1941), and was shown by Ksanda and Merwin (1933) to fit satisfactorily the orthorhombic unit cell they found for bavenite, calculation giving Z = 1.004 molecules of the above formula in the unit cell. Claringbull (1940) found that the unit cell of bavenite had a volume exactly four times as great as that given by Ksanda and Merwin. He states, "Carbon arc spectra of the type material from Baveno and that from Muotta Nera (Switzerland) indicate the presence of similar quantities of beryllium in each."

Thus the composition of bavenite seemed to be well established. In 1946, however, Kutukova published two analyses showing 6.60 and 6.33 per cent BeO, and later Rowledge and Hayton (1948) published two analyses showing 7.72 and 7.14 per cent BeO on material from the Londonderry quarry, Western Australia, to which they gave the name duplexite. They called attention to the close resemblance in optical properties to bavenite, but, apparently unaware of the work of Kutukova, thought the composition sufficiently different to justify a new name.

TABLE 2. OPTICAL PROPERTIES OF BAVENITE

	1	2	3	4	5	6	7	8	9	10
$\alpha$	—	1.578	1.580	1.580	1.579	1.580	1.583-1.584	1.583	1.586	1.582
$\beta$	1.580	1.579	1.582	—	1.581	—	1.585	—	1.588	1.584
$\gamma$	—	1.583	1.590	1.588	1.589	1.587	1.590	1.589	1.593	1.593
$\gamma-\alpha$	—	0.005	0.010	0.008	0.010	0.007	0.006-0.007	0.006	0.007	0.011
2V	47°	Small	—	—	—	58°	—	—	60°	22°
Sign	+	+	+	...	+	+	+	+	+	+
Elong.	—	—	Neg.	Neg.	Neg.	Neg.	—	—	Pos.	Neg.
Ext.	2°	Very small	—	—	2°	—	0°	—	—	2-5°
Sp. Gr.	2.72	—	—	—	—	—	2.74 <sub>s</sub>	2.74	2.733	2.71

1. Artini (1901), from Baveno, Italy.
2. Larsen (1921), from Baveno.
3. Schaller and Fairchild (1932), from Baveno.
4. Schaller and Fairchild (1932), fibers from Mesa Grande, Calif.
5. Schaller and Fairchild (1932), crystals from Mesa Grande.
6. Ross quoted by Schaller and Fairchild (1932), fibers from Mesa Grande.
7. Ksanda and Merwin (1933), crystals from Baveno.
8. Claringbull (1940), from Muotta Nera and Val Casaccia, Switzerland.
9. Kutukova (1946), from Malshevsky emerald mine.
10. Rowledge and Hayton (1948), from Londonderry, W. Australia.

The analyses are compiled in Table 1; in analyses 2 to 8, the BeO content ranges from 2.48 per cent to 7.72 per cent, a very large range for a constituent with so low a molecular weight; the sum of  $\text{Al}_2\text{O}_3 + \text{BeO}$  does not, however, vary greatly. The optical data, as shown in Table 2, show but little variation, and this seems to be random and not closely related to the apparent differences in composition.

It seemed desirable to check the apparent variation. Selected small samples including one from a new locality, Amelia, Virginia, were analyzed in the spectrographic laboratory of the U. S. Geological Survey with the results shown in Table 3.

In view of these results, a new sample was prepared from the specimen studied by Schaller and Fairchild. Its analysis by M. K. Carron of the Geological Survey is given in Table 1, column 9. The analysis was made by the method of Stevens and Carron (1946), and the weights of the precipitates of  $\text{AlPO}_4$  and BeO were checked by spectrographic determi-

TABLE 3. SPECTROGRAPHIC DETERMINATIONS OF BERYLLIUM IN BAVENITE

Locality	Per cent BeO	Analyst
Baveno, Italy (USNM R-4158)	5.4±0.5	E. L. Hufschmidt
Mesa Grande, Calif. (USNM 104299)	7.8	J. D. Fletcher
Rutherford mine, Amelia, Va. (USNM 106718)	8.0	J. D. Fletcher

nation of Be in the  $\text{AlPO}_4$  and of Al in the BeO. The analysis agrees very well with the analyses by Rowledge and Hayton, who used the 8-hydroxyquinoline method to separate beryllium and aluminum. Kutukova does not state what methods were used in the analyses of the Russian material, but does state that the purity of the BeO and  $\text{Al}_2\text{O}_3$  weighed were checked spectrographically.

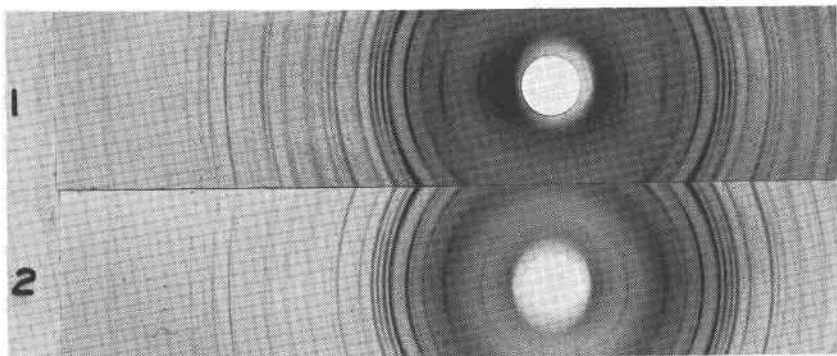


FIG. 1. 1. Duplexite, Coolgardie, Western Australia. USNM 105929.  
2. Bavenite, Baveno, Italy. USNM C 3475.

It seems probable that all of the early analyses are in error, part of the BeO being reported as  $\text{Al}_2\text{O}_3$ . A new analysis of Baveno material is highly desirable to check the figure for BeO given in Table 3. The data available suggest that there is not a great range in BeO content and that bavenite contains about as much BeO as the material from Australia named duplexite. X-ray powder photographs of bavenite and duplexite, as shown in Figure 1, are identical. The latter name should therefore be dropped.

Recalculation of analyses 8 and 9, table 2, gave the following results:



If the specific gravity is assumed to be 2.73, the unit cell determined by Claringbull contains 4.06 formula weights of the formula above derived from analysis 8, 3.91 formula weights of the formula above derived from analysis 9. If one assumes 4 formula weights in the unit cell, the calculated specific gravity is 2.69 for analysis 8, 2.79 for analysis 9.

X-ray powder data for bavenite (duplexite) from Australia, measured by Dr. K. Norrish, are given in Table 4.

*Bavenite from Amelia, Va.*—A single specimen of bavenite from the Rutherford mine, Amelia, Va., was collected by Ned Blandford of McLean, Va. The optical properties and x-ray powder pattern of the

TABLE 4. X-RAY POWDER DATA BY K. NORRISH

Bavenite (duplexite)		
d/n	I	hkl
11.46	m	010
7.36	m	110
4.86	w.d.	120, 200, 001
4.32	vw	210
4.14	m-S	111
3.81	vw	021, 030
3.701	m-S	220
3.332	S	211
3.180	m	300
3.062	vw	310, 031
2.992	m-S	230, 221
2.826	w	320, 040
2.716	vw	301
2.632	vw	311
2.538	m-S	002
2.457	vw	102, 321, 330, 240
2.394	w	400, 112
2.271	m	050, 122
2.223	w	241, 331, etc.
2.147	vw	401
2.072	w.m.d.	250, 222, 132
1.965	w	341, 312
1.926	w	500, 232
1.862	w	142, 350
1.810	vw	520
1.755	m	161
1.730	m	441
1.695	vvw	003
1.655	m	450, 113
1.615	w	170
1.562	w-m	071, 361
1.530	vw	062, 302, 133
etc.		

Virginia material are identical with those from Mesa Grande, Calif.; its BeO content, determined spectrographically, is given in Table 3. The bavenite was found as rosettes of thin, colorless plates, having a maximum size of 0.5 mm. in a small cavity in albite (cleavelandite). Emplanted on the bavenite are a few minute crystals of bertrandite.

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