

BEYERITE FROM BISUNDNI PEGMATITE, BHILWARA DISTRICT, RAJASTHAN, INDIA

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ABSTRACT

Beyerite, not previously recorded from India, has been found as an accessory pegmatite mineral in Bisundni, Rajasthan, India. The recalculated analytical results are: Bi_2O_3 42.4%, PbO 36.2%, CaO 6.5%, and CO_2 14.9%. Differential thermal analysis shows an endothermic peak between 475°C and 588°C. These are close to the values for beyerite and bismutite. X-ray studies show that beyerite is mixed with another mineral giving the pattern of bismutite. There are indications of the presence of massicot, litharge and calcite. However, the chemical analysis, especially the high PbO and CO_2 , cannot be interpreted in terms of these associations. A similar situation exists in the case of the discredited species bokspjutite and further work will be required to elucidate the nature of the associated minerals.

INTRODUCTION

The name beyerite was given by Frondel (1943) to a new species of bismuth carbonate with an ideal formula $\text{Ca}(\text{BiO})_2(\text{CO}_3)_2$, which is distinct from bismutite and other secondary minerals. An occurrence of this rare mineral is reported in this paper.

GEOLOGIC SETTING

The mineral was encountered in the Bisundni pegmatite located about 6 km southwest of Sawar (25° 45' 30''N 75° 13'E) in Bhilwara district, Rajasthan, India. It is an accessory pegmatite mineral, which occurs as earthy pulverulent lumps with greyish yellow coatings within the quartz body of the unzoned composite pegmatite. The entire sample effervesced with cold dilute HCl. Preliminary X-ray diffraction patterns showed characteristic lines of beyerite and bismutite. Under the microscope the mineral appears as inequant xenomorphic grains without any clearly defined cleavages. It is non-pleochroic and uniaxial negative in character. The mineral occurs in intimate association with bismutite, but megascopically they cannot be distinguished from each other.

EXPERIMENTAL RESULTS

The specific gravity determined on different small lumps by means of a Berman balance was found to vary between 5.9 and 7.9. Results of chemical analysis of the overall sample is given in Table 1, column 2. The results in column 3 have been recalculated by neglecting constitu-

ents with quantities of less than 1 percent, and silica which occurred as grains of quartz. The analysis shows that the sample contains mainly minerals of bismuth, lead, and calcium in the form of carbonates.

TABLE 1. CHEMICAL ANALYSIS OF BEYERITE BEARING ROCK

	1	2
SiO ₂	2.68	
Fe ₂ O ₃	0.92	
TiO ₂	Trace	
Al ₂ O ₃	0.15	
Bi ₂ O ₃	40.15	42.4
Sb ₂ O ₃	0.66	
PbO	34.39	36.2
CaO	6.01	6.5
MgO	Trace	
MnO	Trace	
V ₂ O ₅	0.13	
CuO	Trace	
±H ₂ O	0.20	
S	Trace	
CO ₂	14.21	14.9
Cl	0.70	
Totals:	100.20	
O=Cl	- 0.32	
	99.88	100.00

1. Beyerite-bearing rock.

2. Recalculation to 100%; constituents less than 1% and SiO₂ have been neglected.

Chemical analysis by Dr. N. R. Sengupta, Geological Survey of India. Spectroscopic analysis by Drs. B. B. Mukherjee and B. Das Sharma of the Geological Survey of India showed presence of Bi, Pb, Ca, V as major constituents and Cu, Mg, Fe, Si, Sb, Mn & Cr as minor components. The authors are thankful to them for the analysis.

X-ray data from the overall sample is given in Table 2, column 1. A prominent feature of the X-ray pattern is the strong line with a spacing of 10.88 Å. Except for this line and additional weak lines at 3.15 Å and 3.09 Å the pattern conforms to that of a mixture of beyerite and bismutite. A strong line with a spacing of 10.1 Å has been reported for bismuthosphaerite as recorded in XRDF card 2-0046. Bismuthosphaerite has been considered to be bismutite itself (Fron del, 1943). However, the line at 10.1 Å cannot be indexed on the bismutite cell; tetragonal $a=3.867$, $c=13.686$ Å (Lagercrantz and Sillen, 1947). Also, many of the lines show close similarity to those of beyerite (Table 1, columns 3, 5,

and 7) and it would seem the "bismuthosphaerite" pattern is that of a mixture of beyerite and bismutite.

In an effort to get a purer fraction of beyerite, X-ray patterns of small pieces whose specific gravities were found to be different were taken. It was found possible to get a few small pieces whose specific gravity was close to 6.51. A powder X-ray pattern of this sample was taken with a 114.6 mm diameter cylindrical camera. It showed no trace of the 2.95 Å line, which is the strongest for bismutite. However, this line could be detected with the 5.73 mm diameter camera. This shows that the selected material is mainly beyerite. The pattern has been indexed in Table 3, with $a = 3.784$ Å, $c = 21.76$ Å, tetragonal, which compares well with values recorded in literature ($a = 3.788$ Å, $c = 21.814$ Å, Frondel, 1943; $a = 3.767$ Å, $c = 21.690$ Å, Lagercrantz and Sillen 1947; $a = 3.78$ Å, $c = 21.77$ Å, Heinrich, 1947A). The amount of sample was too small for detailed chemical analysis. Weight loss experiments showed loss of weight from about 350°C to about 750°C. On dry basis, total weight loss was 13.66 percent.

A DTA of the overall sample was made with 0.15 gram of sample mixed with 0.2 gram of calcined alumina, at a rate of heating of 8–10°C per minute on a Deltatherm unit (The authors are thankful to Mr. H. N. Siddiquie, Geological Survey of India, who made the analysis). The most prominent feature is a strong endothermic peak which starts at 475°C, peaks at 509°C, and ends at 588°C. For bismutite the strongest endothermic peak has been reported to start at 400–420°C, peak at 480–530°C and end at 520–530°C (Beck, 1950). The corresponding values for beyerite are: start 485°C, peak 570°C, and end 625°C (Beck, 1950). The first endothermic peak at 509°C for the present sample lies between the corresponding values for beyerite and bismutite. The start at 475°C, is closer to that of beyerite than that of bismutite. The curve is therefore somewhat between those of bismutite and beyerite and is the result of admixture.

DISCUSSION

The CO₂ content of the ideal beyerite is 14.42 percent. Assuming the sample contains only bismutite as an impurity, the amount of beyerite corresponding to 13.66 percent weight loss in the selected sample should be 87 percent. However, if it is assumed that the entire weight loss is due to beyerite associated with other minerals (not detected by X-rays) which do not contribute to the weight loss, the 13.66 percent weight loss will correspond to a beyerite content of about 95 percent in the selected sample. These are extreme cases and the selected sample can be taken to contain between 87 and 95 percent beyerite.

TABLE 2. X-RAY DIFFRACTION DATA

Sample <i>I</i>	<i>d</i> (Å)	Beyerite	Bismutite	Beyerite	Bismutite	Bismuthos-	Bokspite
		XRDF 4-0693	XRDF 4-0666	Fron del (1943)	Fron del (1943)	phaerite XRDF 2-0046	XRDF 2-0757 ^a
VS	10.88	—	—	—	—	10.1(100)	—
VW, br, d	6.82	—	—	—	6.903(7)	—	6.7(50)
VW	5.42	—	—	5.431(1)	—	5.2(40)	—
M	3.72	3.71(50)	3.72(70)	5.708(1)	3.708(7)	—	3.67(50)
W	3.62	3.62(70)	—	3.632(6)	—	3.60(60)	—
VVW	3.44	—	3.42(60)	—	3.402(3)	—	3.39(50)
S	3.35	3.34(70)	—	3.354(6)	—	3.33(60)	—
VVW sh ^b	3.15	—	—	—	—	3.13(60)	3.17(60)
VVW sh ^c	3.09	—	—	—	—	—	—
M, br, d ^c	2.94	—	2.95(100)	—	2.943(10)	2.99(40)	2.90(100)
VS	2.85	2.84(100)	—	2.851(10)	—	2.85(80)	—
M ^c	2.73	—	2.73(70)	—	2.724(8)	—	—
M	2.72	2.71(70)	—	2.721(9)	—	—	—
S	2.67	2.66(50)	—	2.636(2)	—	2.69(80)	2.69(20)
M	2.60	2.59(50)	—	2.598(1)	—	2.59(20)	—
VVW, i	2.54	—	2.54(40)	—	2.527(1)	—	2.52(20)
W	2.40	2.39(30)	—	2.403(1)	—	2.39(40)	—
VVW	2.18	2.17(50)	—	2.178(5)	—	—	—
M	2.15	2.14(80)	—	2.148(5)	—	2.15(60)	—
VVW, d	2.13	—	2.14(100)	—	2.134(8)	—	2.12(70)
VVW, i	2.10	—	—	—	—	—	—
W, br	1.93	—	1.93(80)	—	1.936(7)	—	1.93(70)
M	1.907	1.90(70)	—	1.913(5)	—	1.90(60)	1.90(50)
M	1.892	1.88(70)	—	1.892(4)	—	—	—
W	1.865	1.86(60)	1.86(50)	1.865(1)	1.857(2)	1.87(40)	1.85(20)
M	1.754	1.75(80)	1.75(80)	1.755(8)	1.745(9)	1.75(70)	1.74(90)
VVW, i	1.720	—	1.71(70)	—	1.715(4)	—	1.71(50)
M	1.689	1.68(80)	1.68(70)	1.688(7)	1.681(3)	1.68(60)	1.68(50)
VVW	1.679	1.67(50)	—	—	—	—	—
W	1.648	1.64(70)	—	—	—	1.64(20)	1.64(50)
VW, br	1.620	—	1.62(100)	—	1.616(9)	1.60(20)	1.62(90)
M	1.578	1.57(70)	—	1.575(6)	—	1.58(40)	1.59(20)
VW	1.554	1.55(50)	—	1.551(2)	—	1.55(20)	1.55(20)
VW	1.532	1.53(70)	—	1.530(8)	—	1.52(60)	—
VVW	1.487	1.48(50)	1.48(70)	1.483(1)	1.473(5)	1.49(20 d)	—
VVW	1.428	1.42(50)	1.42(70)	1.428(3)	1.413(6)	1.43(40)	—
VVW, i	1.360	1.35(50)	—	1.359(5)	1.366(5)	1.35(60)	—
VVW	1.338	1.33(50)	—	1.340(1)	—	1.34(20)	—
VVW	1.328	1.32(50)	—	1.326(1)	—	1.32(20)	—
VW	1.286	1.28(70)	—	1.286(1)	1.284(5)	1.28(50)	—
VVW, i	1.256	1.25(50)	—	1.255(1)	—	—	—
VVW	1.243	1.24(50)	—	1.242(1)	1.237(4)	—	—
VVW	1.212	1.21(70)	—	1.211(5)	1.222(6)	—	—
VVW, i	1.200	1.19(50)	—	1.198(1)	—	1.19(50)	—
VVW, br	1.190	1.19(70)	—	1.188(4)	—	—	—

br = broad., d = diffuse., i = ill-defined., sh = sharp.

^a Lines 3.53(20), 2.35(20d), 2.26(50), 1.98(20), 1.78(20) are also present.^b litharge., ^c massicot

Chemical analysis of the overall sample shows a very high percentage of lead. X-ray analysis has not conclusively proved the existence of any

TABLE 3. X-RAY DIFFRACTION DATA FOR BEYERITE

$d(\text{\AA})$	I	$1/d^2$, obs.	$1/d^2$, calc.	hkl
10.88	(9)	0.0085	0.0084	002
3.72	(3)	0.0723	0.0719	101
3.62	(2)	0.0763	0.0760	006
3.35	(8)	0.0891	0.0888	103
2.85	(10)	0.1231	0.1226	105
2.72	(2)	0.1352	0.1352	008
2.67	(7)	0.1403	0.1396	110
2.60	(3)	0.1479	0.1480	112
2.40	(2)	0.1736	0.1733	107
			0.1734	114
2.18	(1)	0.2104	0.2112	0, 0, 10
2.15	(7)	0.2163	0.2156	116
1.907	(5)	0.2750	0.2748	118
1.892	(5)	0.2794	0.2792	200
1.865	(2)	0.2875	0.2876	202
1.754	(5)	0.3250	0.3253	1, 0, 11
1.689	(6)	0.3505	0.3508	1, 1, 10
			0.3511	211
1.679	(1)	0.3547	0.3552	206
1.648	(5)	0.3682	0.3680	213
1.578	(7)	0.4016	0.4018	215
1.554	(2)	0.4141	0.4139	0, 0, 14
			0.4144	208
1.532	(4)	0.4261	0.4267	1, 0, 13
1.487	(1)	0.4522	0.4525	217
1.428	(1)	0.4904	0.4904	2, 0, 10
1.360	(1)	0.5407	0.5406	0, 0, 16
1.338	(1)	0.5586	0.5584	220
1.286	(5)	0.6047	0.6045	2, 1, 11
1.256	(5)	0.6339	0.6344	226
1.243	(1)	0.6472	0.6472	303
1.212	(1)	0.6808	0.6801	1, 0, 17
			0.6802	1, 1, 16
			0.6809	305
1.200	(1)	0.6944	0.6936	228
1.190	(1)	0.7062	0.7064	312

Tetragonal: $a = 3.784 \text{ \AA}$, $c = 21.76 \text{ \AA}$.

Density of specimen: 6.51 g/cc.

114.6 mm diameter cylindrical powder camera, filtered $\text{FeK}\alpha$ radiation.

lead mineral in the sample but Table 2 shows a few lines for litharge and massicot. 1.73 percent of lead has been reported by Palache, Berman, and Frondel (1951) to replace calcium in the beyerite structure. This is too little to account for the high proportion of lead in the sample. The DTA

curve shows a small endothermic peak at 910°C. This may be due to calcite, which was not detected by X-rays. According to Webb and Heystek (1957) X-ray analysis may fail to reveal the presence of as much as 5 percent of calcite. These data taken together, suggest that beyerite in the sample is admixed with other minerals, possibly bismutite, massicot, litharge, and calcite. But the results of chemical analysis, especially the high PbO and CO₂ cannot be interpreted in terms of these associated phases. A similar discrepancy between the X-ray and chemical analysis has been reported in the case of the discredited species bokspatite which yielded a bismutite pattern and contained a high percentage of lead (Mountain, 1935; Heinrich, 1947b). Further work will be needed to elucidate the true nature of the associated minerals.

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