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## BOUSSINGAULTITE FROM SOUTH MOUNTAIN, NEAR SANTA PAULA, CALIFORNIA<sup>1</sup>

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OCCURRENCE.—A small sample of mineral sent to the U. S. Geological Survey for identification by Mr. Charles R. Fletcher of Los Angeles, Calif., proved on microscopic examination to be the rare mineral boussingaultite.<sup>2</sup> According to information kindly furnished by Mr. Fletcher it was found on South Mountain, on the south side of the Santa Clara River, opposite Santa Paula, Ventura County, Calif. On the southern slopes of the mountain are two large crevices in disturbed sandstone and chalky shale, from which heated gas emanates continually; in these the boussingaultite forms, as stalactites and incrustations, at the openings.

TABLE 1.

PROPERTIES OF BOUSSINGAULTITE FROM SOUTH MOUNTAIN, CALIF., AND OF ARTIFICIAL BOUSSINGAULTITE.

	California	Tuscany <sup>3</sup>	Artificial <sup>4</sup>
Fusibility.....	1	—	1
Hardness.....	2	—	2+
Crystal system..	Monoclinic?	Monoclinic	Monoclinic
Crystal habit....	Fibers and crusts	Prismatic with (001) prominent	Nearly equant; (110) prominent
Optical character.	+	?	+
Dispersion.....	?	$\rho > \nu$ moderate	$\rho > \nu$ perceptible
Axial angle.....	moderate	$2E_D = 77^\circ 28'$	$2V = 50^\circ$ $2E(\text{calcd.}) = 76^\circ 50'$
$\alpha$	1.470	—	1.469
$\beta$	1.472	"1.47369" (1.474)	1.470
$\gamma$	1.479	—	1.479
Optical orientation	Extinction small to large	Y = b, Bx nearly parallel a.	Y = b, Z $\wedge$ c = small

<sup>1</sup> Published by permission of the Director of the U. S. Geological Survey and the Secretary of the Smithsonian Institution.

<sup>2</sup> Usually regarded as  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ .

<sup>3</sup> Data of Heusser.

<sup>4</sup> Data determined by E. S. Larsen, heretofore unpublished.

PHYSICAL PROPERTIES.—The boussingaultite is pure white in color and is in curved columns or worm-like aggregates, in small crusts, or in stalactites. It has a hardness of about 2. Its optical properties agree closely with those of artificial boussingaultite, formed by crystallization from a solution of  $MgSO_4$  and  $(NH_4)_2SO_4$  in equal molecular proportions; see Table 1.

CHEMICAL PROPERTIES.—Only the best fibrous crystals were used for the analysis. These were white in color and were somewhat translucent with a faint silky luster. The mineral was found to be unaltered by drying in a desiccator or by exposure to an extremely moist atmosphere. It has a sharp astringent-saline taste and is easily and completely soluble in water. The material analyzed, after deduction of 1.94 per cent. of insoluble material, yielded the results given in column 2, Table 2. While the results are not entirely in accord with the theoretical composition usually assigned to boussingaultite, they agree better with the theoretical values than do those of any previous analysis. In table 2 the theoretical values are compared with available analyses of boussingaultite.

TABLE 2  
ANALYSES OF BOUSSINGAULTITE

	1	2	3	4	5
$(NH_4)_2O$ . . .	14.4	10.86	9.38	9.32	5.03
MgO . . . . .	11.2	11.54	11.05	10.27	15.56
$Al_2O_3$ . . . . .		0.04			
$Fe_2O_3$ . . . . .		0.08			
$K_2O$ . . . . .		0.22			
$Na_2O$ . . . . .		0.60			
CaO . . . . .		trace			
$SO_3$ . . . . .	44.4	43.49	44.39	44.30	38.86
$H_2O$ . . . . .	30.0	31.48	35.16	34.67	40.55
Cl . . . . .		trace			
$CO_2$ . . . . .		trace			
	100.0	98.31	99.98	98.56	100.00

1. Theory for formula  $(NH_4)_2SO_4 \cdot MgSO_4 \cdot 6H_2O$ .
2. From South Mountain, Calif.; analysis by Shannon. The amount of material available for analysis was so small that it was impossible to check the ammonia determination, which may be sufficiently low to account for the failure of the analysis to total 100 per cent.
3. Monte Cerboli, Tuscany, recrystallized; anal. by Popp (Dana).
4. Monte Cerboli, Tuscany, as obtained; anal. by Popp.
5. Geyser region, Sonoma Co., Calif., anal. by Goldsmith.

The persistent failure of all the analyses of boussingaultite thus far published to show even approximately the theoretical value for ammonia, and the fact that the ammonium oxide and water vary reciprocally strongly indicate that a part of the water is constitutional. The composition can then be explained by writing the formula  $(\text{NH}_4, \text{H})_2\text{SO}_4 \cdot \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ . This interpretation is supported by the rate of dehydration of the present material at various temperatures, the results being as follows:

15 hrs.	over $\text{H}_2\text{SO}_4$	26°C.	loss $\text{H}_2\text{O}$	0.08
3 "		at 80°C.		2.24
7 "		at 150°C.		25.53
		Above 150°C.		3.63
			Total water	<u>31.48%</u>

### THE GOLDSCHMIDT TWO-CIRCLE METHOD. CALCULATIONS IN THE TETRAGONAL SYSTEM.

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The gnomonic projection of a tetragonal crystal is closely similar in type to that of the isometric system. There are, however, two main differences. One is that the poles of the form (101), 01 and 10, lie either within or without the circumference of the unit circle depending on the ratio  $a : c$ , which is never unity. The second is that since in this system the third index cannot be interchanged with the first two, no form has more than two face-poles in any one octant. Both of these have the same  $\rho$ , and complementary  $\varphi$  angles; hence a single pair of angles defines any form in the angle-table. Figure 25 shows a projection (based on the mineral vesuvianite) containing the face-poles of one each of the seven holohedral forms of the system. The position of a particular face in any octant may be indicated by its symbol (pq) with the proper signs or by the form letter written with exponents placed as in the figure.

#### CALCULATION OF AXIAL RATIO AND SYMBOLS FROM MEASURED ANGLES, $\varphi$ AND $\rho$

From the figure, and as in the preceding system, we have the equations:

$$x = \sin \varphi \tan \rho = pp_0 \quad y = \cos \varphi \tan \rho = qp_0$$