

# GINORITE AND SASSOLITE FROM DEATH VALLEY, CALIFORNIA\*

ROBERT D. ALLEN,† *U. S. Geological Survey, Claremont, California*  
AND HENRY KRAMER,‡ *U. S. Geological Survey, Washington, D.C.*

## ABSTRACT

Ginorite,  $2\text{CaO} \cdot 7\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ , and sassolite,  $\text{B}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , have been found closely associated in efflorescent masses in colemanite-veined basalt near the head of Twenty Mule Team Canyon, Death Valley.

The ginorite is in rhomb-shaped plates, less than 0.02 mm. in diameter, with acute angle about  $79^\circ$  and the following indices of refraction:  $\alpha_{\text{Na}}$  1.520 (parallel to short diagonal)  $\gamma_{\text{Na}}$  1.580 (parallel to long diagonal). Pycnometric specific gravity is 2.07. Chemical analysis, ginorite,  $\text{B}_2\text{O}_3$  65.21 (per cent),  $\text{CaO}$  14.56,  $\text{SrO}$  1.10,  $\text{H}_2\text{O}$  19.13; sassolite,  $\text{B}_2\text{O}_3$  57.19,  $\text{H}_2\text{O}$  42.81. The strongest lines of an  $x$ -ray diffractometer pattern of ginorite are as follows:  $7.10 \text{ \AA}$  10;  $5.36 \text{ \AA}$  3;  $3.27 \text{ \AA}$  2;  $3.18 \text{ \AA}$  2;  $2.08 \text{ \AA}$  2.

Sassolite is in pearly plates, usually less than 1 mm. in diameter, with the following optical properties:  $\alpha_{\text{Na}}$  1.340;  $\beta_{\text{Na}}$  1.457;  $\gamma_{\text{Na}}$  1.459;  $2V_{\text{calc}}$   $14^\circ$ ; wavy extinction. The strongest lines of an  $x$ -ray diffractometer pattern are as follows:  $3.18 \text{ \AA}$  10;  $6.03 \text{ \AA}$  1;  $1.590 \text{ \AA}$  1.

## INTRODUCTION

Ginorite,  $2\text{CaO} \cdot 7\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ , and sassolite,  $\text{B}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , occur together in the Death Valley area, California. This is the third reported occurrence of ginorite in the world and the first reported occurrence of sassolite in the Death Valley area.

## OCCURRENCE

These two boron minerals were collected by James F. McAllister of the U. S. Geological Survey in October 1954 at the Mott open-cut colemanite prospect in a minor tributary to Furnace Creek Wash near the head of Twenty Mule Team Canyon, northwest of and downstream from the Corkscrew diversion channel in SW $\frac{1}{4}$  sec. 9, T. 26 N., R. 2 E., San Bernardino base and meridian, Inyo County, California. The ginorite and sassolite are closely associated, both minerals occurring in soft, white to pale yellowish brown efflorescent masses in weathered basalt within 50 cm. of the surface; the underlying altered basalt contains veins of colemanite and is associated with colemanite-bearing limestone.

The ginorite occurs in white pellets which average about 1 to 2 mm. in diameter and are embedded in a pale yellowish brown matrix of sassolite and clay. In this matrix pearly sassolite plates as much as 1 mm. in diameter are present. An unidentified mineral, present in very minor

\* Publication authorized by the Director, U. S. Geological Survey.

† Present address: Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.

‡ Present address: Pyrotechnics Laboratory, Samuel Feltman Ammunition Laboratories, Picatinny Arsenal, Dover, New Jersey.

amount, was observed under the microscope by W. T. Schaller, U. S. Geological Survey; it has the following optical characteristics:  $\alpha$  about 1.465;  $\gamma$  about 1.505; uniaxial (or biaxial with very small  $2V$ ) negative; six-sided plates with parallel (or nearly parallel) extinction. Minute grains of celestite and of quartz are sporadically distributed in the efflorescence.

Ginorite was first found in the Clinton Quarry (inaccessible in 1948—private communication from W. T. Schaller), Windsor, Nova Scotia, Canada, associated with mirabilite along the gypsum-anhydrite contact and described by How (1861) under the name cryptomorphite. Its identity with the better described hydrous calcium borate named ginorite, occurring with calcite in veins in sandstone at Sasso Pisano, Tuscany, Italy (D'Achiardi, 1934), was determined by Hey and Bannister (1952) who suggested that the name ginorite be used.

No American occurrence of sassolite is listed in the seventh edition of Dana's System of Mineralogy (Palache, Berman, and Frondel, 1944).

#### GINORITE

##### *Optical Properties*

At all three occurrences the ginorite is in minute rhomb-shaped plates. Those from the Death Valley area are nearly equilateral and range in diameter between 0.001 and 0.020 mm. The acute angle of the rhombs is about  $79^\circ$ , the average of 30 measurements, ranging from  $75^\circ$  to  $83^\circ$ . The rhombs, whose extinction directions are approximately parallel to their diagonals, show positive elongation. The indices of refraction for sodium light are:  $\alpha$ (parallel to short diagonal) =  $1.520 \pm 0.003$ ;  $\gamma$ (parallel to long diagonal) =  $1.580 \pm 0.003$ . Similar indices of refraction are reported for ginorite from the other two localities.

D'Achiardi (1934) gives for Tuscany ginorite:  $\alpha = 1.517$ ;  $\beta = 1.524$  (calc.);  $\gamma = 1.577$ ;  $2V = 42^\circ$ ; positive; extinction angle,  $\alpha$  to elongation of the "lozenges,"  $51^\circ$ ; acute angle of lozenges,  $78^\circ$  to  $80^\circ$ . The lozenges are thought to be monoclinic plates parallel to  $\{010\}$ . Hey and Bannister (1952) report similar optical properties for ginorite from Nova Scotia and Tuscany:  $n_1 =$  about 1.526;  $n_2 =$  about 1.579; rhombic plates with acute angle  $77^\circ$  (Tuscany) to  $79^\circ$  (Nova Scotia); positive elongation; extinction directions parallel to rhomb diagonals. Hey and Bannister suggest that the symmetry of ginorite may be orthorhombic rather than monoclinic as proposed by D'Achiardi.

##### *Chemical Composition*

The water insoluble ginorite from the Death Valley area was purified by solution of the sassolite in warm water and drying the residual ginorite

in an oven at 105° C. Microscopic examination after the treatment showed no measurable change in the mineral.

In Table 1 the analysis of ginorite from the Death Valley area is compared with three analyses of ginorite from Sasso Pisano, Tuscany

TABLE 1. GINORITE—CHEMICAL ANALYSES AND CALCULATION OF FORMULA

	Death Valley area, California Ginorite		Tuscany Ginorite 1		Tuscany Ginorite 2		Tuscany Ginorite 3	
	(per cent)		(per cent)		(per cent)		(per cent)	
	Orig.	Recalc.	Orig.	Recalc.	Orig.	Recalc.	Orig.	Recalc.
B <sub>2</sub> O <sub>3</sub>	64.47	65.21	63.00	64.42	64.06	64.49	58.54	63.64
CaO	14.39	14.56	15.40	15.75	16.00	16.11	14.75	16.03
SrO	1.09	1.10	—	—	—	—	—	—
Na <sub>2</sub> O	—	—	—	—	—	—	0.16	0.17
H <sub>2</sub> O (+)	18.91	19.13	19.40	19.83	19.27	19.40	18.54	20.16
Rem.	1.48	—	2.20	—	1.22	—	8.34	—
Total	100.34	—	100.00	—	100.55	—	100.33	—
Less rem.	1.48	—	2.20	—	1.22	—	8.34	—
Total	98.86	100.00	97.80	100.00	99.33	100.00	91.99	100.00
Analyst:	Henry Kramer		Gallori		Rossoni		Hey	
	Molecular proportions (Death Valley area)		Oxygen atoms		Atomic ratios		Atomic ratios on basis of 31 O's	
B <sub>2</sub> O <sub>3</sub>	0.9364		2.8092		B 1.8728		14.019	
CaO	0.2596		0.2596		Ca 0.2596		1.943	
SrO	0.0106		0.0106		Sr 0.0106		0.079	
H <sub>2</sub> O	1.0616		1.0616		H 2.1232		15.897	
							} 2.022	
Formula: (Ca,Sr) <sub>2</sub> B <sub>14</sub> O <sub>23</sub> ·8H <sub>2</sub> O or 2(CaO,SrO)·7B <sub>2</sub> O <sub>3</sub> ·8H <sub>2</sub> O								

(D'Achiardi, 1934; Hey and Bannister, 1952). The formula derived from our analysis is 2(CaO,SrO)·7B<sub>2</sub>O<sub>3</sub>·8H<sub>2</sub>O. Except for the presence of strontium, this formula agrees with D'Achiardi's formula, 2CaO·7B<sub>2</sub>O<sub>3</sub>·8H<sub>2</sub>O. It should be noted that neither the analyses published by D'Achiardi nor the analysis of Hey are in close agreement with this formula. According to W. T. Schaller strontium is present in more than trace amount in

typical Italian ginorite, and, if the assumption is made that 1 per cent SrO is present (as it is in the Death Valley area material), the molecular proportions calculated from the three analyses of Italian ginorite are closer to the formula  $2(\text{CaO}, \text{SrO}) \cdot 7\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$  than they are without this assumption.

Spectrographic analysis by Hal W. Johnson, Pacific Spectrochemical Laboratory, Los Angeles, Calif., gave the following additional determinations, in per cent:  $0.X = \text{Mg}, \text{Si}, \text{Na}, \text{Fe}$ ;  $0.0X = \text{Al}$ ;  $0.000X = \text{Cu}$ .

A pycnometric specific gravity determination at  $25^\circ \text{C}$ . gave 2.07, close to the value of 2.09 given by D'Achiardi (1934) for ginorite from Tuscany.

### SASSOLITE

#### *Optical Properties*

The optical properties of California sassolite are compared with those published for Italian and synthetic sassolites in Table 2.

TABLE 2. OPTICAL PROPERTIES OF SASSOLITE

	California	Italy (Larsen, 1921)	Synthetic (Kracek, Morey and Merwin, 1938)
$\alpha_{\text{Na}}$	$1.340 \pm 0.005$	$1.340 \pm 0.005$	1.337
$\beta_{\text{Na}}$	$1.457 \pm 0.003$	$1.456 \pm 0.003$	1.461
$\gamma_{\text{Na}}$	$1.459 \pm 0.003$	$1.459 \pm 0.003$	1.462
Optic sign	Negative	Negative	Negative
$2V_{\text{calc.}}$	$14.0^\circ$	$17.0^\circ$	$9.6^\circ$
Orientation	X angle base is very large	X angle base is nearly $90^\circ$	X angle base is $88^\circ$
Other	Plates lack regular outlines and show wavy extinction		

#### *Chemical Composition*

Sassolite, contaminated with ginorite and clay, was analyzed for water-soluble  $\text{B}_2\text{O}_3$  and water-insoluble material. The recalculated analysis is compared with the theoretical combining proportions for boric acid in Table 3.

### X-RAY DIFFRACTION PATTERNS

X-ray powder patterns were prepared for ginorite and sassolite with nickel-filtered copper radiation over the range  $2\theta = 5^\circ$  to  $90^\circ$ , being scanned with a Geiger counter spectrometer at  $1^\circ$  per minute. In Table 4 the pat-

TABLE 3. SASSOLITE—CHEMICAL ANALYSIS

	Death Valley Sassolite	Boric acid (theoretical)
	(per cent)	(per cent)
B <sub>2</sub> O <sub>3</sub>	57.19	56.39
H <sub>2</sub> O	42.81 (by differ- ence)	43.61
Total	100.00	100.00

TABLE 4. X-RAY PATTERNS: INTERPLANER SPACINGS AND RELATIVE INTENSITIES  
Nickel-filtered copper radiation

Ginorite California		Ginorite, Italy (Hey and Bannister, 1952)		Sassolite, California		Boric acid, C.P.	
<i>d</i> (Å)	<i>I</i>	<i>d</i> (Å)	<i>I</i>	<i>d</i> (Å)	<i>I</i>	<i>d</i> (Å)	<i>I</i>
7.14	10	7.18	vs	6.02	1	6.04	2
5.36	3	5.36	s	5.89	<1	5.91	<1
4.89	<1	4.92	vw	4.59	<1	4.60	<1
4.66	1	4.68	w	4.20	<1	4.21	<1
—		4.29	vvw	4.04	<1	4.06	<1
4.06	1	4.08	w	3.52	<1	3.52	<1
3.90	1	3.90	mw	3.18	10	3.18	10
3.58	1	3.57	mb	—		3.03	1
3.43	<1	3.42	vvw	2.95	<1	2.95	<1
3.27	2	3.28	m	2.92	<1	2.92	1
3.18	2	3.18	vvw	—		2.84	<1
3.12	1	3.12	mw	2.71	<1	2.72	<1
2.98	1	2.98	w	2.64	<1	2.64	1
2.87	1	2.88	w	2.56	<1	2.56	<1
2.80	1	2.81	vw	—		2.53	<1
2.72	<1	2.73	vw	—		2.50	<1
2.65	<1	—		—		2.30	<1
2.61	<1	2.62	vw	2.23	<1	2.23	<1
2.58	<1	2.58	vvw	—		2.10	<1
2.54	<1	2.53	vvw	—		2.04	<1
2.46	<1	2.47	vw	1.949	<1	1.949	<1
—		2.36	vwb	—		1.905	<1
2.29	<1	2.28	vw	—		1.888	<1
2.23	<1	2.24	w	—		1.692	<1
2.15	<1	2.16	w	—		1.670	<1
2.11	<1	—		—		1.642	<1
2.08	2	2.09	s	1.590	1	1.591	2
2.02	<1	2.03	vw	—		—	
1.965	<1	1.96	wb	—		—	
—		1.92	vvw	—		—	
—		1.821	vvw	—		—	

terns for ginorites from California and Italy (Hey and Bannister, 1952) are in essential agreement. The pattern for analytical reagent boric acid, which is more completely developed than the pattern for sassolite from California, confirms the identity of this mineral.

Fred A. Hildebrand, U. S. Geological Survey, verified ginorite and identified sassolite in an earlier *x*-ray pattern of the first sample of efflorescence collected.

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*Manuscript received May 7, 1956.*