

META-ALUMINITE, A NEW MINERAL
FROM TEMPLE MOUNTAIN, UTAH¹

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ABSTRACT

The new species meta-aluminite, $\text{Al}_2(\text{SO}_4)(\text{OH})_4 \cdot 5\text{H}_2\text{O}$, occurs abundantly associated with basaluminite and gypsum in veinlets in sandstone at the Fuemrole mine, Temple Mountain, Emery County, Utah. It forms microcrystalline masses of a pure white color and silky luster. Monoclinic. Optically biaxial negative, with α -1.497 \pm 0.001, β -1.512 \pm 0.001, γ ~1.513 and $2V$ small. The extinction angle Y (?) to the elongation of the minute laths is 43° with Z (?) = b . Specific gravity 1.85 \pm 0.02. X-ray powder diffraction data are distinctive. The four darkest X-ray powder lines are d 4.48 (I 100), 8.35 (79), 4.36 (67), 6.85 (53). Meta-aluminite is formed when aluminite, $\text{Al}_2(\text{SO}_4)(\text{OH})_4 \cdot 7\text{H}_2\text{O}$, is heated in air at 55°C. Neither this phase nor aluminite or basaluminite was observed by Bassett and Goodwin (1949) in their study of the system Al_2O_3 - SO_3 - H_2O at 25°C.

INTRODUCTION

Basaluminite and a new basic aluminum sulfate for which the name meta-aluminite is proposed occur abundantly in the vicinity of the Fuemrole mine at Temple Mountain, Emery County, Utah. Temple Mountain is located on the southeastern flank of the San Rafael Swell about 47 miles southwest of Green River. The region is arid and has been dissected into a rough terrain of hogbacks and mesas. Asphaltic and vanadiferous uranium ores have been mined in the area for many years. The Fuemrole mine, for which the name Fumarole was intended when the claim was filed, is a series of small open prospect pits for uranium located at the foot of the west slope of Temple Mountain. It is the type locality for abernathyite. The geology of the immediate area has been described by Keys (1956) and by Kerr *et al.*, (1957). The Fuemrole mine is on the periphery of a brecciated zone apparently produced by rising heated waters that have locally dissolved large volumes of carbonate from the country rock and caused the collapse of the overlying strata. Accompanying mineralization of this zone, described by Kelley and Kerr (1957, 1958), introduced pyrite together with As and other metals. The basic aluminum sulfates probably have been formed by the reaction of acid sulfate solutions, resulting from oxidation of the pyrite, with clay minerals in the sandstones. The alunogen and iron sulfates described by Rosenzweig and Gross (1955) from the Dexter #7 mine in the San Rafael Swell have originated in a similar manner.

¹ Mineralogical Contribution No. 443.

Meta-aluminite. The basic aluminum sulfates here noted occur together with gypsum as discontinuous veinlets up to a few centimeters thick in the sandstone and conglomerate of the Shinarump formation, of Triassic age, in which the mine workings are situated. The gypsum forms columnar to coarse fibrous aggregates and constitutes the bulk of the vein material. Meta-aluminite occurs abundantly as nodular aggregates and irregular masses embedded in the gypsum. The material is microcrystalline, quite soft and pure white in color. It resembles the aluminite from Halle, Saxony, but has a somewhat silky appearance. The specific gravity was determined by suspension in bromoform as 1.85 ± 0.02 , slightly higher than aluminite. The hardness could not be determined.

Under the microscope the mineral appears as minute laths with inclined extinction on the plane of flattening and parallel extinction when the laths are viewed on edge. The laths are only a few microns in thickness and often are warped or have a composite or feathery structure. The terminations of the laths are rough. Interference figures could not be obtained. The indices of refraction are $\alpha = 1.497 \pm 0.001$, $\beta = 1.512 \pm 0.001$, $\gamma \sim 1.513$; the substance hence is biaxial negative with small $2V$. The vibration direction X is in the plane of the laths, but the other direction in this plane, making an angle to the elongation of 43° , could not be identified with certainty as Y or as Z . It probably is Y , with Z then perpendicular to the very thin laths and coinciding with the b -axis in a monoclinic interpretation.

X-ray powder spacing data for meta-aluminite are given in Table 1. The pattern is distinctive. It differs entirely from that of aluminite, for which spacing data are given by Hollingworth and Bannister (1950), and from the patterns of the synthetic lower hydrates of the aluminite type described by Bassett and Goodwin (1949).

A chemical analysis of the mineral, cited in Table 2, conforms very

TABLE 1. X-RAY POWDER DATA FOR META-ALUMINITE*

<i>I</i>	<i>d</i>	<i>I</i>	<i>d</i>	<i>I</i>	<i>d</i>
8	9.22	8	4.22	6	2.990
79	8.35	25	2.739	4	2.805
53	6.85	35	3.708	10	2.691
14	6.07	30	3.669	8	2.590
10	5.69	34	3.596	6	2.488
6	5.54	26	3.513	18	2.258
100	4.48	15	3.454	8	1.886
67	4.36	22	3.327	8	1.804

* Copper radiation, nickel filter, in Angstrom units. Relative peak heights in arbitrary chart units.

TABLE 2. CHEMICAL ANALYSIS OF META-ALUMINITE

	1	2	3	4
Al ₂ O ₃	33.25	33.59	1.004	33.09
Fe ₂ O ₃	0.53			
SO ₃	25.99	26.25	1	25.98
SiO ₂	0.77			
H ₂ O, below 100°	13.34			
H ₂ O, 100°-230°	22.16	39.75	40.15	7.002
H ₂ O, over 230°	4.25			
	100.29	100.00		100.00

1. Meta-aluminite. Jun Ito, analyst, 1956. Cl, Br, Ca, Mg, Mn, Ti and alkalis present in trace amounts.

2. Recalculated to 100 after deducting admixed SiO₂ and Fe₂O₃.

3. Molecular quotients for Al₂O₃, SO₃ and H₂O.

4. Theoretical weight percentages for Al₂(SO₄)(OH)₄·5H₂O.

closely to the ratio Al₂O₃·SO₃·7H₂O. The formula may be written Al₂(SO₄)(OH)₄·5H₂O. This compound was found here by X-ray study to be formed when aluminite, Al₂(SO₄)(OH)₄·7H₂O, is heated in air to 55°C. The name meta-aluminite¹ is appropriate for this substance, since it is a lower hydrate than aluminite and can be formed from that substance. Specimens of meta-aluminite kept in the open air at room temperature for about 10 years remained unchanged in optical properties and X-ray pattern.

The present phase was not observed by Bassett and Goodwin (1949) in their thermal study of aluminite, who noted only the formation of Al₂(SO₄)(OH)₄·3H₂O at 100°-110°C and of lower hydrates at higher temperatures. The study by these investigators of the system Al₂O₃-SO₃-H₂O at 25°C shows that the stable fields of existence of the more basic aluminum sulfates occupy a small area in the neighborhood of the water point. A great variety of phases are present in the system, but Al₂(SO₄)(OH)₄·5H₂O (meta-aluminite) and Al₂(SO₄)₂(OH)₂·9H₂O (lap-parentite) were not observed and efforts to synthesize Al₂(SO₄)(OH)₄·7H₂O (aluminite), Al₄(SO₄)(OH)₁₀·5H₂O (basaluminite) and Al₄(SO₄)(OH)₁₀·36H₂O (hydrobasaluminite) were unsuccessful. The reported synthetic compound Al₁₀(SO₄)₈(OH)₁₈·37H₂O is fairly close in composition to meta-aluminite. It is monoclinic with extinction angles up to 34°, but the X-ray data given by Bassett and Goodwin (1949) for it and for a lower hydrate with 31H₂O do not correspond to meta-aluminite.

¹ The name has the approval of the Commission on New Mineral Names of the International Mineralogical Association.

Some thermal data for aluminite also are given by Meroshnikov and Shcheglova (1959).

A mineral thought to be an alteration product of aluminite, from Green River, Utah, has been briefly mentioned by Larsen (1921). The optical properties, however, do not agree with meta-aluminite. It was said to be biaxial with large extinction angles and large $2V$, with β 1.500 ± 0.003 . The X-ray and optical data given by Fabre (1956) for an unidentified basic Al sulfate from Calingosta, Argentina, do not correspond to meta-aluminite.

Basaluminite. This mineral occurs locally in the veinlets as dense aggregates and crusts. It differs from meta-aluminite in having a dull luster and chalky appearance, and breaks down at the point of a needle to small clods and not to fluffy aggregates. The color is white, with a faintly brownish tinge. Under the microscope, the basaluminite is very fine grained and composed of shreds and flakes that between crossed nicols show mottled and irregular extinction. The mean index of refraction is about 1.525. The X-ray powder diffraction pattern of the mineral is identical with that of the type material from Irchester, Northamptonshire, England, as described by Hollingworth and Bannister (1950). Several unidentified minerals with indices of refraction near 1.5 were observed in trace amounts in association with basaluminite. Efforts to concentrate these phases by heavy liquids failed. Basaluminite was also identified here by X-ray study as composing a nodular mass labelled aluminite from Newhaven, England. A similar but diffuse X-ray pattern was given by basaluminite from Marshall County, Tennessee. The poorly known minerals winebergite and doughtyite are near in composition to basaluminite. An authentic specimen of doughtyite gave an X-ray pattern unlike that of basaluminite; X-ray data are lacking for winebergite. The paragenetic relations of the basaluminite and meta-aluminite at the Fuemrole mine could not be determined, although both minerals sometimes occur on the same specimen.

REFERENCES

- BASSETT, H. AND T. H. GOODWIN (1949) The basic aluminum sulfates. *J. Chem. Soc. London*, 2239-2279.
- FABRE, J. F. V. (1956) An aluminum sulfate from Calingosta, Argentina. *Rev. Asoc. Geol. Argentina* 11, 104.
- HOLLINGWORTH, S. E. AND F. A. BANNISTER (1950) Basaluminite and hydrobasaluminite, two new minerals from Northamptonshire. *Mineral. Mag.* 29, 1.
- KELLEY, D. R. AND P. F. KERR (1958) Urano-organic ore at Temple Mountain, Utah. *Geol. Soc. Amer. Bull.*, 69, 701-756.
- KELLEY, D. R. AND P. F. KERR (1957) Clay alteration and ore, Temple Mountain, Utah. *Geol. Soc. Amer. Bull.* 68, 1101-1116.

- KERR, P. F., M. W. BODINE, D. R. KELLEY AND W. S. KEYS (1957) Collapse features, Temple Mountain uranium area, Utah. *Geol. Soc. Amer. Bull.* **68**, 933-981.
- KEYS, W. S. (1956) Deep drilling in the Temple Mountain collapse, San Rafael Swell, Utah. *Proc. Int. Conf. Peaceful Uses Atomic Energy, vol. 6: Geol. of Uranium and Thorium*, 371.
- LARSEN, E. S. (1921) Microscopic determination of the non-opaque minerals. *U. S. Geol. Surv. Bull.* **679**, 38.
- MEROSHNIKOV, L. D. AND O. S. SHCHEGLOVA (1959) *Zap. Vses. Mineral. Obshch.* **88**, 686-692.
- ROSENZWEIG, A. AND E. B. GROSS (1955) Goldichite, a new hydrous potassium ferric sulfate from the San Rafael Swell, Utah. *Amer. Mineral* **40**, 469-480.

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