

**Robertsite****Ca<sub>2</sub>Mn<sub>3</sub><sup>3+</sup>O<sub>2</sub>(PO<sub>4</sub>)<sub>3</sub>•3H<sub>2</sub>O**

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**Crystal Data:** Monoclinic, pseudo-hexagonal. *Point Group:* 2/m. Platy to wedge-shaped, pseudorhombohedral to barrel-shaped crystals, to 5 mm, showing {100}, {001}, {031}; fibrous, in botryoidal to feathery aggregates. *Twinning:* By rotation  $\perp$  {100}, common.

**Physical Properties:** *Cleavage:* On {100}, good. Hardness = 3.5 D(meas.) = 3.13–3.17 D(calc.) = 3.22

**Optical Properties:** Semitransparent. *Color:* Black, deep red, bronzy; dark reddish brown to deep blood-red in thin slivers. *Streak:* Chocolate-brown. *Luster:* Vitreous to resinous or waxy, silky in fibrous material.

*Optical Class:* Biaxial (-). *Pleochroism:* X = pale reddish pink; Y = Z = deep reddish brown. *Orientation:* X  $\simeq$   $\perp$  {100}. *Absorption:* Y = Z  $\gg$  X.  $\alpha = 1.775(5)$   $\beta = 1.82(1)$   $\gamma = 1.82(1)$  2V(meas.) =  $\sim 8^\circ$

**Cell Data:** *Space Group:* A2/a. a = 17.36(2) b = 19.53(5) c = 11.30(3)  $\beta = 96.0^\circ$  Z = 12

**X-ray Powder Pattern:** Tip Top mine, South Dakota, USA. 8.63(10), 2.749 (6), 5.61 (5), 1.623 (5), 3.27 (4), 2.590 (4), 2.876 (3)

Chemistry:	(1)		(2)	
	(1)	(2)	(1)	(2)
P <sub>2</sub> O <sub>5</sub>	35.6	34.57	CaO	17.9
Fe <sub>2</sub> O <sub>3</sub>	0.9		H <sub>2</sub> O	8.1
Mn <sub>2</sub> O <sub>3</sub>	38.1	38.45		8.77
			Total	100.6
				100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as Fe<sub>2</sub>O<sub>3</sub>, total Mn as Mn<sub>2</sub>O<sub>3</sub>, H<sub>2</sub>O by the Penfield method on a separate sample; corresponds to Ca<sub>1.93</sub>(Mn<sub>2.92</sub>Fe<sub>0.07</sub>)<sub>Σ=2.99</sub>O<sub>1.84</sub>(PO<sub>4</sub>)<sub>3.04</sub>•2.72H<sub>2</sub>O. (2) Ca<sub>2</sub>Mn<sub>3</sub>O<sub>2</sub>(PO<sub>4</sub>)<sub>3</sub>•3H<sub>2</sub>O.

**Polymorphism & Series:** Dimorphous with pararobertsite.

**Occurrence:** A late secondary mineral in complex zoned granite pegmatites; in a phosphate deposit in limestone, derived from bat guano.

**Association:** Rockbridgeite, ferrisicklerite, leucophosphite, jahnsite, montgomeryite, collinsite, huréaulite (Tip Top mine, South Dakota, USA); carbonate-fluorapatite, calcite, dolomite, quartz, clay minerals (Khoa Rang Kai, Thailand).

**Distribution:** In the USA, from the Tip Top mine, 8.5 km southwest of Custer, and the White Elephant mine, near Pringle, Custer Co., and the Gap Lode pegmatite, Pennington Co., South Dakota; in the White Picacho district, Yavapai Co., Arizona; at the Stewart mine, Pala, San Diego Co., California; in the Emmons quarry, Greenwood, Oxford Co., Maine. At Hagendorf, Bavaria, Germany. From Jebilet, Morocco. At the Rubicon pegmatite, south of Karibib, Namibia. In the Khoa Rang Kai phosphate deposit, near Chiang Mai, northwestern Thailand.

**Name:** To honor Professor Willard Lincoln Roberts (1923–1987), mineralogist, South Dakota School of Mines and Technology, Rapid City, South Dakota, USA, researcher of Black Hills minerals.

**Type Material:** National Museum of Natural History, Washington, D.C., USA, 127151.

**References:** (1) Moore, P.B. and J. Ito (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. II. Redefinition of overite, an isotype of segelerite. III. Isotypy of robertsite, mitridatite, and arseniosiderite. *Amer. Mineral.*, 59, 48–59. (2) Moore, P.B. and T. Araki (1977) Mitridatite, Ca<sub>6</sub>(H<sub>2</sub>O)<sub>6</sub>[Fe<sub>9</sub><sup>III</sup>O<sub>6</sub>(PO<sub>4</sub>)<sub>9</sub>]•3H<sub>2</sub>O. A noteworthy octahedral sheet structure. *Inorg. Chem.*, 16, 1096–1106. (3) Roberts, A.C., B.D. Sturman, P.J. Dunn, and W.L. Roberts (1988) Pararobertsite, Ca<sub>2</sub>Mn<sub>3</sub><sup>3+</sup>(PO<sub>4</sub>)<sub>3</sub>O<sub>2</sub>•3H<sub>2</sub>O, a new mineral species from the Tip Top pegmatite, Custer Co., South Dakota, and its relationship to robertsite. *Can. Mineral.*, 27, 451–455. (4) Van Kauwenbergh, S.J., M. Cooper-Fleck, and M.R. Williams (1988) The occurrence of robertsite in a sedimentary phosphate ore from Thailand. *Mineral. Mag.*, 52, 505–508.

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