

**Kleemanite****ZnAl<sub>2</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>2</sub>•3H<sub>2</sub>O**

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**Crystal Data:** Monoclinic. *Point Group:* 2/*m* or 2. As thin veins, to 2 mm thick, and matted coatings of very fine-bladed acicular crystals. *Twinning:* Multiple twinning parallel to fiber elongation probable.

**Physical Properties:** Hardness = 3 D(meas.) = 2.84 D(calc.) = 2.76

**Optical Properties:** Transparent. *Color:* Colorless to pale brownish yellow. *Luster:* Bright [sic].

*Optical Class:* Biaxial. *Orientation:* Inclined extinction up to 40° in opposite directions in adjacent crystals.  $\alpha = 1.598(2)$   $\beta = \text{n.d.}$   $\gamma = 1.614(2)$  2V(meas.) = n.d.

**Cell Data:** *Space Group:* P2/*m*, P2<sub>1</sub>/*m*, P2, or P2<sub>1</sub>.  $a = 7.274\text{--}7.290$   $b = 7.185\text{--}7.194$   $c = 9.788\text{--}9.762$   $\beta = 110.20^\circ\text{--}110.244^\circ$  Z = 2

**X-ray Powder Pattern:** Iron Monarch quarry, Australia.  
4.76 (10), 3.09 (8), 9.09 (6), 3.30 (6), 5.66 (5), 3.88 (5), 3.64 (5)

| Chemistry:                     | (1)   | (2)    | (3)    |
|--------------------------------|-------|--------|--------|
| P <sub>2</sub> O <sub>5</sub>  | 35.7  | 34.76  | 35.72  |
| Al <sub>2</sub> O <sub>3</sub> | 24.4  | 24.38  | 25.66  |
| Fe <sub>2</sub> O <sub>3</sub> | 1.1   |        |        |
| Mn <sub>2</sub> O <sub>3</sub> | 1.3   |        |        |
| FeO                            |       | 0.67   |        |
| ZnO                            | 20.7  | 20.79  | 20.48  |
| H <sub>2</sub> O               | 18.2  | 19.79  | 18.14  |
| Total                          | 101.4 | 100.39 | 100.00 |

(1) Iron Monarch quarry, Australia; Al, Fe, Mn, and Zn by AA, 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 TGA; corresponding to Zn<sub>1.01</sub>(Al<sub>1.90</sub>Mn<sub>0.07</sub>Fe<sub>0.06</sub>)<sub>Σ=2.03</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>2.08</sub>•2.98H<sub>2</sub>O. (2) Baokeng, China; by electron microprobe, average of five analyses, H<sub>2</sub>O by TGA; corresponding to Zn<sub>1.02</sub>(Al<sub>1.96</sub>Fe<sub>0.04</sub>)<sub>Σ=2.00</sub>(PO<sub>4</sub>)<sub>1.95</sub>(OH)<sub>2.01</sub>•3.14H<sub>2</sub>O. (3) ZnAl<sub>2</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>2</sub>•3H<sub>2</sub>O.

**Occurrence:** A rare secondary mineral in the weathering zone of manganese iron ore.

**Association:** Jacobsite (Iron Monarch quarry, Australia); turquoise (Broken Hill, Australia).

**Distribution:** In Australia, in the Iron Monarch quarry, Iron Knob, South Australia, and at Broken Hill, New South Wales. In the Baokeng manganese deposit, Guangdong Province, China.

**Name:** Honors Dr. Alfred William Kleeman (1913–1982), mineralogist, University of Adelaide, Adelaide, Australia.

**Type Material:** Museum Victoria, Melbourne, M34218; Division of Mineral Chemistry, CSIRO, Melbourne, Australia, MC637; National Museum of Natural History, Washington, D.C., USA, 145805.

**References:** (1) Pilkington, E.S., E.R. Segnit, and J. Watts (1979) Kleemanite, a new zinc aluminum phosphate. *Mineral. Mag.*, 43, 93–95. (2) (1979) *Amer. Mineral.*, 64, 1331 (abs. ref. 1). (3) Lai Lairen and Sun Yanyan (1993) The discovery of kleemanite, a zinc aluminum phosphate in China. *Yanshi Kuangwuxue Zazhi* [*Acta Petrologica et Mineralogica*], 12(3), 279–283 (in Chinese with English abs.).