Kleemanite $ZnAl_2(PO_4)_2(OH)_2 \cdot 3H_2O$

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. $\alpha = 1.598(2)$ $\beta =$ n.d. $\gamma = 1.614(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2/m$, $P2_1/m$, $P2$, or $P2_1$. $a = 7.274$–7.290 $b = 7.185$–7.194 $c = 9.788$–9.762 $\beta = 110.20°$–$110.244°$ 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_2O_5	35.7	34.76	35.72
Al_2O_3	24.4	24.38	25.66
Fe_2O_3	1.1		
Mn_2O_3	1.3		
FeO		0.67	
ZnO	20.7	20.79	20.48
H_2O	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_2O_3, total Mn as Mn_2O_3, H_2O by TGA; corresponding to $Zn_{1.01}(Al_{1.90}Mn_{0.07}Fe_{0.06})_{\Sigma=2.03}(PO_4)_2(OH)_{2.08} \cdot 2.98H_2O$. (2) Baokeng, China; by electron microprobe, average of five analyses, H_2O by TGA; corresponding to $Zn_{1.02}(Al_{1.96}Fe_{0.04})_{\Sigma=2.00}(PO_4)_{1.95}(OH)_{2.01} \cdot 3.14H_2O$. (3) $ZnAl_2(PO_4)_2(OH)_2 \cdot 3H_2O$.

Occurrence: A rare secondary mineral in the weathering zone of manganiferous 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.).