Hetaerolite $ZnMn_2^{3+}O_4$

Crystal Data: Tetragonal. *Point Group:* $4/m2/m2/m$. As pyramidal crystals, to 1 cm; also as botryoidal to stalactitic aggregates, and fibrous. As exsolution lamellae in franklinite. *Twinning:* On {112}, producing fivelings, very rare.

Physical Properties: *Cleavage:* {001}, indistinct; two additional, probably on {112} and {011}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6 VHN = 528–707 (100 g load). D(meas.) = 5.18 D(calc.) = [5.21]

Optical Properties: Opaque, transparent through thin edges. *Color:* Brownish black to black; deep reddish brown in transmitted light; gray under reflected light. *Streak:* Dark brown. *Luster:* Metallic to submetallic.
Optical Class: Uniaxial (–). *Absorption:* Faint; $E > O$. $\omega = 2.34(2)$ $\epsilon = 2.14(2)$
Anisotropism: Strong.
R_1–R_2: (400) 19.3–25.8, (420) 18.3–24.0, (440) 17.3–22.2, (460) 16.5–21.0, (480) 15.8–20.1, (500) 15.4–19.4, (520) 15.0–18.9, (540) 14.7–18.4, (560) 14.5–18.1, (580) 14.2–17.8, (600) 14.0–17.6, (620) 13.9–17.4, (640) 13.7–17.2, (660) 13.6–17.0, (680) 13.5–16.9, (700) 13.4–16.8

Cell Data: *Space Group:* $I4_1/amd$. a = 5.75 c = 9.22–9.23 Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.462 (100), 2.707 (90), 3.040 (80), 1.5209 (70), 2.855 (50), 1.5634 (50), 2.019 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.18			ZnO	32.46	32.6	34.02
Mn_2O_3	64.21	67.2	65.98	MgO	0.49		
Fe_2O_3	0.24	0.17		H_2O	0.19		
MnO	1.86			Total	99.63	99.97	100.00

(1) Sterling Hill, New Jersey, USA; corresponds to $(Zn_{0.94}Mn^{2+}_{0.06})_{\Sigma=1.00}(Mn^{3+}_{1.93}Fe^{3+}_{0.10}Si_{0.01})_{\Sigma=2.04}O_{3.92}\bullet 0.02H_2O$. (2) Kennack Sands, England; by electron microprobe, total Mn as Mn_2O_3, total Fe as Fe_2O_3; corresponds to $Zn_{0.95}Mn_{2.03}O_4$. (3) $ZnMn^{3+}_2O_4$.

Occurrence: A secondary mineral associated with other manganese minerals, primarily in hydrothermal ore deposits.

Association: Franklinite, chalcophanite, hodgkinsonite, willemite, hemimorphite, manganite, romanechite, calcite.

Distribution: In the USA, from Sterling Hill, Ogdensburg, and Franklin, Sussex Co., New Jersey; in Arizona, in Cochise Co., at the Lucky Cuss mine, Tombstone, and the Campbell and Junction mines, Bisbee; the 79 mine, Banner district, Gila Co.; and the Domeroy property, Pioneer district, Pinal Co. From the Contact mine, Grant Co., New Mexico; in the Mohawk mine, San Bernardino Co., California; and the Wolftone mine, Leadville, Lake Co., Colorado. In Romania, at Rodna. At Moresnet, Belgium. On Mont Chemin, Valais, Switzerland. From Kennack Sands, Cornwall, England. In the Maruyama and Oe mines, Aomori Prefecture, Japan. From the EZ mine, near Beltana, South Australia. Other occurrences are known.

Name: From the Greek for *companion*, for its occasional association with chalcophanite.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 134145.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 715–717. (2) Frondel, C. and E.W. Heinrich (1942) New data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Frondel, C. and C. Klein, Jr. (1965) Exsolution in franklinite. Amer. Mineral., 50, 1670–1680. (4) Bevins, R.E., R.F. Symes, J.M. Horák, and V. Holyer (1987) Hetaerolite from Eastern Cliff, Kennack Sands, Cornwall: the first British occurrence. Mineral. Mag., 51, 172–173. (5) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 597–599.