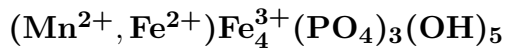


Frondelite

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Crystal Data: Orthorhombic. *Point Group:* 222. Rarely as euhedral crystals, showing {100}, {010}, {110}, {101}; typically fibrous, to 8 cm, elongated along [001], radiating, in crusts, botryoidal and drusy masses.

Physical Properties: *Cleavage:* {100}, excellent; {010}, good; {001}, fair. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.453 D(calc.) = [3.35]

Optical Properties: Subtranslucent. *Color:* Dark brown, ocher-yellow, red-brown, orange, greenish brown; commonly zoned lengthwise. *Luster:* Vitreous to dull.

Optical Class: Biaxial (-). *Pleochroism:* X = pale yellow-brown; Y = Z = orange-brown.

Orientation: X = c. *Dispersion:* r > v. *Absorption:* Z > Y > X. $\alpha = 1.860$ $\beta = 1.880$ $\gamma = 1.893$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* B22₁2. a = 13.810(1) b = 17.968(3) c = 5.182(1) Z = 4

X-ray Powder Pattern: Sapucaia mine, Brazil. (ICDD 35-625).

3.191 (100), 3.381 (85), 3.615 (40), 3.445 (25), 3.046 (20), 1.5953 (19), 6.91 (17)

Chemistry:

	(1)	(2)
P ₂ O ₅	31.28	32.82
Al ₂ O ₃	1.31	
Fe ₂ O ₃	48.85	49.23
Mn ₂ O ₃	1.75	
FeO	0.00	5.54
MnO	7.74	5.47
MgO	0.20	
CaO	0.02	
Na ₂ O	0.98	
K ₂ O	0.12	
H ₂ O	7.52	6.94
insol.	0.32	
Total	100.09	100.00

(1) Sapucaia mine, Brazil; corresponds to $(\text{Mn}_{0.70}^{2+}\text{Na}_{0.20}\text{Mg}_{0.03}\text{K}_{0.02})_{\Sigma=0.95}(\text{Fe}_{3.94}^{3+}\text{Mn}_{0.16}^{3+}\text{Al}_{0.16})_{\Sigma=4.26}(\text{PO}_4)_{2.84}(\text{OH})_{5.38}$. (2) $(\text{Mn}^{2+}, \text{Fe}^{2+})\text{Fe}_4^{3+}(\text{PO}_4)_3(\text{OH})_5$ with $\text{Mn}^{2+}:\text{Fe}^{2+} = 1:1$.

Polymorphism & Series: Forms a series with rockbridgeite.

Occurrence: An alteration product of primary phosphates in complex granite pegmatites.

Association: Triphylite, vivianite, heterosite-purpurite, cyrilovite, phosphosiderite, leucophosphite (Sapucaia mine, Brazil).

Distribution: From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. At the Fletcher mine, near North Groton, Grafton Co., New Hampshire, and in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., USA. From Hagedorf, Bavaria, Germany. At the Buranga pegmatite, near Gatumba, Rwanda. From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: To honor Dr. Clifford Frondel (1907–2002), American mineralogist, Professor of Mineralogy, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 100808; National Museum of Natural History, Washington, D.C., USA, 105946.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 867–869. (2) Lindberg, M.L. (1949) Frondelite and the frondelite-rockbridgeite series. *Amer. Mineral.*, 34, 541–549. (3) Lindberg, M.L. (1960) Crystal habit of frondelite, Sapucaia pegmatite mine, Minas Gerais, Brazil. *U.S. Geol. Surv. Prof. Paper* 400B, 429–430.

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