

Villyaellenite**(Mn, Ca)Mn₂(AsO₃OH)₂(AsO₄)₂(H₂O)₄**

Crystal Data: Monoclinic. *Point Group:* 2/m. Crystals tabular on {100}, to prismatic along [001], showing {100}, {110}, {011}, {010}, {101}, and {001}, to 4 cm; in rosettes and radial aggregates.

Physical Properties: *Cleavage:* Good on {100}. Hardness = ~4 D(meas.) = 3.20-3.69 D(calc.) = 3.339

Optical Properties: Transparent. *Color:* Pale rose-red, orange-pink, colorless; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.

Optical Class: Biaxial (-). *Pleochroism:* Moderate; X = very pale orange-pink; Y = exceedingly pale orange-pink; Z = pale orange-pink. *Orientation:* X = b; Y ∧ c = 30°-40°. *Absorption:* Z >> X > Y. α = 1.660-1.713 β = 1.670-1.723 γ = 1.676-1.729 2V(meas.) = 70.5°-76° 2V(calc.) = 75°-75.6°

Cell Data: *Space Group:* C2/c. a = 18.400(2) b = 9.4778(10) c = 9.9594(12) β = 96.587(3)° Z = 4

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.

3.297 (100), 8.476 (90), 3.132 (60), 4.606 (50), 4.761 (40), 3.811 (40), 3.025 (40)

Chemistry:	(1)	(2)
As ₂ O ₅	52.99	50.6
FeO		0.1
MnO	22.40	36.2
ZnO		2.9
CaO	13.58	0.5
H ₂ O	11.42	9.9
Total	100.39	100.2

(1) Sainte-Marie-aux-Mines, France; by electron microprobe, total Mn as MnO, H₂O by TGA; reducing H₂O to 10.7% by analogy to other group members, corresponds to (Mn²⁺_{2.74}Ca_{2.10})_{Σ=4.84}(H₂O)₄(AsO₃OH)_{2.31}(AsO₄)_{1.69}. (2) Mapimí, Mexico; by electron microprobe, average of five points over several crystals; total Mn as MnO, H₂O by moisture evolution analyzer; corresponds to (Mn_{4.62}Zn_{0.32}Ca_{0.08}Fe_{0.01})_{Σ=5.03}(AsO₄)_{2.08}(AsO₃OH)_{1.92}·4.04H₂O.

Polymorphism & Series: Ordered intermediate member of the sainfeldite-miguelromeroite series.

Occurrence: A rare post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Sainte-Marie-aux-Mines, France); on a museum specimen from the oxidized zone of an arsenic-rich base metal deposit (Mapimí, Mexico); on a single specimen from a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Fluckite, picroparmacolite, pharmacolite, arsenic (Sainte-Marie-aux-Mines, France); ogdensburgite, arseniosiderite, chalcophanite, adamite, Fe-Mn oxides (Mapimí, Mexico); manganoo calcite, willemite, franklinite (Sterling Hill, New Jersey, USA).

Distribution: From Sainte-Marie-aux-Mines, Haut-Rhin, France. At Jáchymov (Joachimsthal), Czech Republic. Large crystals at the Ojuela mine, Mapimí, Durango, Mexico. In the Veta Negra mine, Pampa Larga district, Tierra Amarilla, southeast of Copiapó, Chile. From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. At the Gozaisho mine, Iwaki, Japan.

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Type Material: Natural History Museum, Geneva, Switzerland, 435/76.

References: (1) Sarp, H. (1984) Villyaellenite, H₂(Mn, Ca)₅(AsO₄)₄·4H₂O un nouveau minéral de Sainte-Marie aux Mines (France). Schweiz. Mineral. Petrog. Mitt., 64, 323-328 (in French with English abs.). (2) (1986) Amer. Mineral., 71, 1547 (abs. ref. 1). (3) Kampf, A.R. and C.R. Ross II (1988) End-member villyaellenite from Mapimi, Durango, Mexico: descriptive mineralogy, crystal structure, and implications for the ordering of Mn and Ca in type villyaellenite. Amer. Mineral., 73, 1172-1178. (4) Kampf, A.R. (2009) Miguelromeroite, the Mn analogue of sainfeldite, and redefinition of villyaellenite as an ordered intermediate in the sainfeldite-miguelromeroite series. Amer. Mineral., 94, 1535-1540.