

**Manganoarrojadite-(KNa)** **$\text{KNa}_5\text{MnFe}_{13}\text{Al}(\text{PO}_4)_{11}(\text{PO}_3\text{OH})(\text{OH})_2$** 

**Crystal Data:** Monoclinic. *Point Group:* *m*. As slightly elongated grains to 1.5 cm.

**Physical Properties:** *Cleavage:* Good on {001}. *Tenacity:* Brittle. *Fracture:* Uneven, stepped. Hardness = 4.5 D(meas.) = n.d. D(calc.) = 3.53 Nonfluorescent.

**Optical Properties:** Transparent. *Color:* Olive-green. *Streak:* Pale green. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (-).  $\alpha = 1.658(2)$   $\beta = 1.666(2)$   $\gamma = 1.670(2)$   $2V(\text{meas.}) = 67(1)^\circ$   $2V(\text{calc.}) = 70^\circ$  *Absorption:*  $X \approx Y < Z$ . *Pleochroism:* Very weak,  $X = Y =$  very pale green,  $Z =$  pale green.

**Cell Data:** *Space Group:* *Cc*.  $a = 16.5345(3)$   $b = 10.0406(2)$   $c = 24.6261(5)$   $\beta = 105.891(2)^\circ$   $Z = 4$

**X-Ray Diffraction Pattern:** Palermo No. 1 mine, Grafton County, New Hampshire, USA. 3.048 (100), 2.704 (70), 3.208 (47), 5.902 (24), 5.025 (24), 2.758 (24), 3.401 (21)

Chemistry:	(1)	(2)	(1)	(2)
Na <sub>2</sub> O	6.97	7.25	Al <sub>2</sub> O <sub>3</sub>	2.43 2.39
K <sub>2</sub> O	1.78	2.20	P <sub>2</sub> O <sub>5</sub>	40.48 39.86
CaO	0.31		F	0.30
MgO	2.17		H <sub>2</sub> O	[1.32] 1.27
MnO	12.30	3.32	-O = F <sub>2</sub>	0.13
FeO	31.17	43.71	Total	99.10 100.00

(1) Palermo No. 1 mine, Grafton County, New Hampshire, USA; average electron microprobe analysis, H<sub>2</sub>O calculated from stoichiometry; corresponds to  $\text{K}_{0.80}\text{Na}_{4.73}\text{Mg}_{1.33}(\text{Mn}^{2+}_{0.88}\text{Ca}_{0.12})(\text{Fe}^{2+}_{9.1}\text{Mn}^{2+}_{2.80}\text{Mg}_{1.10})\text{Al}_{1.00}(\text{PO}_4)_{10.62}(\text{PO}_3\text{OH})_{1.38}(\text{OH})_2$ . (2)  $\text{KNa}_5\text{MnFe}^{2+}_{13}\text{Al}(\text{PO}_4)_{11}(\text{PO}_3\text{OH})(\text{OH})_2$ .

**Polymorphism & Series:** Forms a series with dickinsonite.

**Mineral Group:** Arrojadite group.  $\text{A}_2\text{B}_2\text{CaNa}_{2+x}\text{M}_{13}\text{Al}(\text{PO}_4)_{11}(\text{PO}_3\text{OH}_{1-x})\text{W}_2$ .

**Occurrence:** In a phosphate-bearing granite pegmatite.

**Association:** Vivianite, goyazite, quartz, calcite.

**Distribution:** At the Palermo No. 1 mine, Grafton County, New Hampshire, USA.

**Name:** *Arrojadite* indicates a member of the group with Fe<sup>2+</sup> dominant at the *M* site; two suffixes indicate the dominant cation of the dominant valence state at the *A* and *B* sites. The prefix, *mangano*, indicates Mn<sup>2+</sup> dominant at the *C* site. Honors Miguel *Arrojado* Ribeiro Lisbôa (1872-1932), Brazilian geologist.

**Type Material:** Canadian Museum of Nature, Ottawa, Ontario, Canada (CMNMC 47194).

**References:** (1) Lykova, I., R. Rowe, G. Poirier, K. Helwig, and H. Friis (2020) Manganoarrojadite-(KNa),  $\text{KNa}_5\text{MnFe}_{13}\text{Al}(\text{PO}_4)_{11}(\text{PO}_3\text{OH})(\text{OH})_2$ , a new arrojadite-group mineral from the Palermo No. 1 mine, New Hampshire, USA. *Mineral. Mag.*, 84, 932-940. (2) Cámara, F., R. Oberti, C. Chopin, and O. Medenbach (2006) The arrojadite enigma: I. A new formula and a new model for the arrojadite structure. *Amer. Mineral.*, 91, 1249-1259. (3) Chopin, C., R. Oberti, and F. Cámara (2006) The arrojadite enigma: II. Compositional space, new members, and nomenclature of the group. *Amer. Mineral.*, 91, 1260-1270.