Manganoarrojadite-(KNa) $KNa_5MnFe_{13}Al(PO_4)_{11}(PO_3OH)(OH)_2$

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(meas.) = 67(1)° 2V(calc) = 70° *Absorption*: $X \approx Y < Z$. *Pleochroism*: Very weak, $X = Y$ = very pale green, Z = pale green.

Cell Data: *Space Group*: *Cc*. $a = 16.5345(3)$ $b = 10.0406(2)$ $c = 24.6261(5)$ $\beta = 105.891(2)°$ 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_2O	6.97	7.25	Al_2O_3	2.43	2.39
K_2O	1.78	2.20	P_2O_5	40.48	39.86
CaO	0.31		F	0.30	
MgO	2.17		H_2O	[1.32]	1.27
MnO	12.30	3.32	$-O = F_2$	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_2O calculated from stoichiometry; corresponds to $K_{0.80}Na_{4.73}Mg_{1.33}(Mn^{2+}_{0.88}Ca_{0.12})(Fe^{2+}_{9.1}Mn^{2+}_{2.80}Mg_{1.10})Al_{1.00}(PO_4)_{10.62}(PO_3OH)_{1.38}(OH)_2$. (2) $KNa_5MnFe^{2+}_{13}Al(PO_4)_{11}(PO_3OH)(OH)_2$.

Polymorphism & Series: Forms a series with dickinsonite.

Mineral Group: Arrojadite group. $A_2B_2CaNa_{2+x}M_{13}Al(PO_4)_{11}(PO_3OH_{1-x})W_2$.

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^{2+} 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^{2+} 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), $KNa_5MnFe_{13}Al(PO_4)_{11}(PO_3OH)(OH)_2$, 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.