Arrojadite $\mathbf{KNa_4Ca(Fe^{2+},Mn^{2+})_{14}Al(PO_4)_{12}(OH)_2}$

Crystal Data: Monoclinic. *Point Group:* $2/m$. As cleavable masses, to 15 cm.

Physical Properties: *Cleavage:* On {100}, good; on {102}, poor. *Fracture:* Uneven to subconchoidal. Hardness = 5 D(meas.) = 3.527 D(calc.) = 3.586

Optical Properties: Translucent. *Color:* Dark green, bottle-green, yellowish green. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = colorless to pale green; Z = pale yellow-green. *Orientation:* $X = b$; $Y \wedge c = 18°$–$21.5°$. *Dispersion:* $r < v$, strong.
$\alpha = 1.662$–1.664 $\beta = 1.668$–1.670 $\gamma = 1.672$–1.675 2V(meas.) = 80°–86°

Cell Data: *Space Group:* $A2/a$. $a = 24.692(4)$ $b = 10.031(2)$ $c = 16.453(2)$ $\beta = 105.72(9)°$ Z = 4

X-ray Powder Pattern: South Dakota, USA; close to dickinsonite. (ICDD 34-149).
3.042 (100), 2.714 (85), 3.222 (45), 2.774 (30), 2.852 (25), 2.751 (25), 2.550 (25)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	40.00	39.67	Na_2O	6.40	5.77
Al_2O_3	2.66	2.37	K_2O	1.74	2.19
FeO	28.22	23.42	F	0.80	
MnO	15.78	23.13	H_2O	0.91	0.84
MgO	1.04		$-O = F_2$	0.34	
CaO	2.46	2.61	insol.	0.11	
Li_2O	0.09		Total	99.87	100.00

(1) Nickel Plate mine, South Dakota, USA. (2) $KNa_4Ca(Fe,Mn)_{14}Al(PO_4)_{12}(OH)_2$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with dickinsonite.

Occurrence: A high-temperature (≈ 800 °C) primary mineral in granite pegmatites.

Association: Graftonite, cassiterite, spodumene, beryl, muscovite (Nickel Plate mine, South Dakota, USA).

Distribution: In Brazil, from the Serra Branca pegmatite, 13 km south of Pedra Lavrada, Picuí, Paraíba; in the Énio pegmatite mine, northeast of Galiléia, and the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais. In the USA, in New Hampshire, from the G.E. Smith mine, Newport, Sullivan Co., and at the Rice, Nancy #2, and Palermo #1 mines, near North Groton, Grafton Co.; in South Dakota, from the Nickel Plate and White Cap mines, near Keystone, Pennington Co., and in the Victory mine, four km northeast of Custer, Custer Co. From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In the Mangualde pegmatite, near Mesquitela, Portugal. From Glenbuchat, Aberdeenshire, Scotland. In the Norrö pegmatite, on Rånö Island, Sweden. At Sidi-Bou-Kritcha, Morocco. In Zimbabwe, from Ruwanzi Ranch, Karoi East, Miami, and on the Star Twin, Pearl and Chiwya claims, Urungwe district. In the Buranga pegmatite, near Gatumba, Rwanda.

Name: To honor Miguel Arrojado Ribeiro Lisbôa (1872–1932), Brazilian geologist.

Type Material: The Natural History Museum, London, England, 1927,1145; National Museum of Natural History, Washington, D.C., USA, 105948, 105949.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 679–681. (2) Moore, P.B., T. Araki, S. Merlino, M. Mellini, and P.F. Zanazzi (1981) The arrojadite-dickinsonite series, $KNa_4Ca(Fe,Mn)^{2+}_{14}Al(OH)_2(PO_4)_{12}$: crystal structure and crystal chemistry. Amer. Mineral., 66, 1034–1049. (3) Merlino, S., M. Mellini, and P.F. Zanazzi (1981) Structure of arrojadite, $KNa_4CaMn_4Fe_{10}Al(PO_4)_{12}(OH,F)_2$. Acta Cryst., 37, 1733–1736.