Ferrowyllieite $(Na, Ca, Mn^{2+})_2(Fe^{2+}, Mn^{2+})(Fe^{2+}, Fe^{3+}, Mg)Al(PO_4)_3$

Crystal Data: Monoclinic. *Point Group:* $2/m$. Crude euhedral crystals, to 10 cm, in interlocking aggregates; rimming arrojadite.

Physical Properties: *Cleavage:* On {010}, perfect; on $\{\bar{1}01\}$, distinct. *Tenacity:* Very brittle. Hardness = > 4 D(meas.) = 3.601(3) D(calc.) = 3.60

Optical Properties: Transparent to opaque. *Color:* Deep bluish green, oily green, grayish green, greenish black; pale green in transmitted light. *Streak:* Dirty olive-green. *Luster:* Oily to submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Observable in thick plates; X = smoky bluish gray; Y = smoky bluish green; Z = green. *Dispersion:* $r < v$, strong. *Absorption:* $Z > Y \simeq X$.
$\alpha = 1.688(2)$ $\beta = 1.691(2)$ $\gamma = 1.696(2)$ 2V(meas.) = ∼50°

Cell Data: *Space Group:* $P2_1/n$. $a = 11.868(15)$ $b = 12.382(12)$ $c = 6.354(9)$ $\beta = 114.52(8)°$ Z = 4

X-ray Powder Pattern: Victory mine, South Dakota, USA.
2.693 (10), 2.674 (10), 6.15 (6), 3.449 (5), 2.498 (5), 8.12 (4), 3.047 (4)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	43.8	44.6	MgO	1.97	4.8
SiO_2	0.8	0.1	CaO	2.5	0.95
Al_2O_3	7.9	7.1	Li_2O	0.01	0.01
Fe_2O_3	0.33	4.8	Na_2O	8.0	7.1
FeO	29.2	20.2	K_2O	0.05	0.00
MnO	4.3	9.6	H_2O^+	0.70	0.60
ZnO	0.04	0.08	Total	99.6	99.94

(1) Victory mine, South Dakota, USA; H_2O by calorimetry, corresponds to $(Na_{1.25}Mn^{2+}_{0.30}Ca_{0.22}Fe^{2+}_{0.01})_{\Sigma=1.78}Fe^{2+}_{1.00}(Fe^{2+}_{0.96}Li_{0.03}Mg_{0.01})_{\Sigma=1.00}(Al_{0.75}Mg_{0.23}Fe^{3+}_{0.02})_{\Sigma=1.00}(PO_4)_3$. (2) G.E. Smith mine, New Hampshire, USA; corresponds to $(Na_{1.07}Mn^{2+}_{0.43}Ca_{0.08})_{\Sigma=1.58}(Fe^{2+}_{0.84}Mn^{2+}_{0.16})_{\Sigma=1.00}(Fe^{2+}_{0.48}Mg_{0.48}Li_{0.03})_{\Sigma=0.99}(Al_{0.65}Fe^{3+}_{0.28}Mg_{0.07})_{\Sigma=1.00}(PO_4)_3$.

Polymorphism & Series: Forms two series, with wyllieite, and with rosemaryite; $Fe^{2+} > Mn^{2+}$ in M(1); Fe^{2+} dominant in M(2a).

Occurrence: A primary phosphate in zoned granite pegmatites.

Association: Arrojadite, muscovite, schorl, plagioclase, quartz (Victory mine, South Dakota, USA).

Distribution: In the USA, from the Victory mine, four km northeast of Custer, Custer Co., South Dakota, and at the G.E. Smith mine, Newport, Sullivan Co., New Hampshire.

Name: As a mineral with dominant *ferrous* iron, and its relation to *wyllieite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 126318, 137244, 162555, 162556.

References: (1) Moore, P.B. and J. Ito (1973) Wyllieite, $Na_2Fe^{2+}_2Al(PO_4)_3$, a new species. Mineral. Record, 4, 131–136 [redefined to be ferrowyllieite]. (2) Moore, P.B. and J. Molin-Case (1974) Contribution to pegmatite phosphate giant crystal paragenesis: II. The crystal chemistry of wyllieite [= ferrowyllieite], $Na_2Fe^{2+}_2Al[PO_4]_3$, a primary phase. Amer. Mineral., 59, 280–290. (3) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (4) (1980) Amer. Mineral., 65, 810–811 (abs. ref. 3).