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Footemineite, the Mn-analog of atencioite, from the Foote mine, Kings Mountain, Cleveland County, North Carolina, U.S.A., and its relationship with other roscherite-group minerals

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Abstract

Footemineite, ideally $Ca_2Mn^{2+}\square Mn^{2+}_2Mn^{2+}_2Be_4(PO_4)_6(OH)_4\cdot 6H_2O$, triclinic, is a new member of the roscherite group. It occurs on thin fractures crossing quartz-microcline-spodumene pegmatite at the Foote mine, Kings Mountain, Cleveland County, North Carolina, U.S.A. Associated minerals are albite, analcime, eosphorite, siderite/rhodochrosite, fairfieldite, fluorapatite, quartz, milarite, and pyrite. Footemineite forms prismatic to bladed generally rough to barrel-shaped crystals up to about 1.5 mm long and 1 mm in diameter. Its color is yellow, the streak is white, and the luster is vitreous to slightly pearly. Footemineite is transparent and non-fluorescent. Twinning is simple, by reflection, with twin boundaries across the length of the crystals. Cleavage is good on $\{0\bar{1}1\}$ and {100}. Density (calc.) is 2.873 g/cm^3. Footemineite is biaxial (–), $n_\alpha = 1.620(2)$, $n_\beta = 1.627(2)$, $n_\gamma = 1.634(2)$ (white light). $2V_{obs} = 80°$, $2V_{calc} = 89.6°$. Orientation: X ^ *b* ~ 12°, Y ^ *c* ~ 15°, Z ^ *a* ~ 15°. Elongation direction is *c*, dispersion: r > v or r < v, weak. Pleochroism: β (brownish yellow) > α = γ (yellow). Mössbauer and IR spectra are given. The chemical composition is (EDS mode electron microprobe, Li and Be by ICP-OES, Fe^{3+}:Fe^{2+} by Mössbauer, H_2O by TG data, wt%): Li_2O 0.23, BeO 9.54, CaO 9.43, SrO 0.23, BaO 0.24, MgO 0.18, MnO 26.16, FeO 2.77, Fe_2O_3 0.62, Al_2O_3 0.14, P_2O_5 36.58, SiO_2 0.42, H_2O 13.1, total 99.64. The empirical formula is $(Ca_{1.89}Sr_{0.03}Ba_{0.02})_{\Sigma 1.94}(Mn^{2+}_{0.90}\square_{0.10})_{\Sigma 1.00}(\square_{0.78}Li_{0.17}Mg_{0.05})_{\Sigma 1.00}(Mn^{2+}_{3.25}Fe^{2+}_{0.43}Fe^{3+}_{0.09}Al_{0.03})_{\Sigma 3.80}Be_{4.30}(P_{5.81}Si_{0.08}O_{24})[(OH)_{3.64}(H_2O)_{0.36}]_{\Sigma 4.00}\cdot 6.00H_2O$. The strongest reflection peaks of the powder diffraction pattern [*d*, Å (*I*, %) (*hkl*)] are 9.575 (53) (010), 5.998 (100) $(0\bar{1}1)$, 4.848 (26) (021), 3.192 (44) (210), 3.003 (14) $(0\bar{2}2)$, 2.803 (38) $(\bar{1}03)$, 2.650 (29) $(\bar{2}02)$, 2.424 (14) (231). Single-crystal unit-cell parameters are $a = 6.788(2)$, $b = 9.972(3)$, $c = 10.014(2)$ Å, $\alpha = 73.84(2)$, $\beta = 85.34(2)$, $\gamma = 87.44(2)°$; $V = 648.74$ Å^3, $Z = 1$. The space group is $P\bar{1}$. Crystal structure was refined to $R = 0.0347$ with 1273 independent reflections ($F > 2\sigma$). Footemineite is dimorphous with roscherite, and isostructural with atencioite. It is identical with the mineral from Foote mine described as "triclinic roscherite." The name is for the Foote mine, type locality for this and several other minerals.

Keywords: Footemineite, new mineral, roscherite-group, Mn-phosphate, crystal structure, atencioite, Foote mine, North Carolina