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Apexite, $NaMg(PO_4)\cdot 9H_2O$, a new struvite-type phase with a heteropolyhedral cluster

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Abstract

Apexite (IMA2015-002), $NaMg(PO_4)\cdot 9H_2O$, is a new mineral from the Apex mine, Lander County, Nevada, U.S.A., where it occurs as a low-temperature secondary mineral on massive quartz matrix in association with andersonite, calcite, čejkaite, gaylussite, and goethite. Apexite forms colorless needles up to 0.5 mm in length. The streak is white. Crystals are transparent and have vitreous to satiny luster. The Mohs hardness is about 2, the tenacity is brittle, the fracture is curved, and crystals exhibit one perfect cleavage on {100}. The measured density is 1.74(1) g/cm^3 and the calculated density is 1.741 g/cm^3. Electron microprobe analyses provided: Na_2O 9.26, MgO 14.42, P_2O_5 23.31, H_2O 53.01 (structure), total 100.00 wt% (normalized). The empirical formula (based on 13 O apfu) is: $Na_{0.91}Mg_{1.09}P_{1.00}O_{13.00}H_{17.91}$. Apexite is triclinic, $P\bar{1}$, a = 6.9296(7), b = 11.9767(13), c = 14.9436(19) Å, α = 92.109(6), β = 102.884(7), γ = 105.171(7)°, V = 1160.9(2) Å^3, and Z = 4. The eight strongest lines in the X-ray powder diffraction pattern are [d_{obs} in Å(I)(hkl)]: 14.63(35)(001); 5.11(61)(021,$\bar{1}\,\bar{1}$1,110,$\bar{1}$20); 4.68(75)(0$\bar{2}$2,$\bar{1}\,\bar{1}$2,1$\bar{2}$1,0$\bar{1}$3); 4.301(96)(102,013,022,$\bar{1}$13); 4.008(44)($\bar{1}\,\bar{1}$3,1$\bar{2}$2); 2.876(46)(040); 2.762(100)($\bar{2}\,\bar{1}$3,2$\bar{3}$1,0$\bar{3}$4,$\bar{2}$04,015); and 2.507(30)(212,025,$\bar{2}\,\bar{2}$3). Apexite is a new struvite-type phase with a unique structure (R_1 = 4.44% for 1401 $F_o > 4\sigma F$) consisting of four components: (1) a $[Na_2Mg_4(H_2O)_{14}]^{10+}$ heteropolyhedral cation cluster; (2) a *trans* edge-sharing chain of $Na(H_2O)_6$ octahedra; (3) an isolated PO_4 group; and (4) an isolated H_2O group. The structural components are linked to one another only via hydrogen bonds. Its structure is related to that of hazenite.

Keywords: Apexite, new mineral, crystal structure, struvite-type, heteropolyhedral cluster, hazenite, Apex mine, Nevada