Wayneburnhamite, Pb$_2$Ca$_2$(Si$_2$O$_7$)$_3$(SiO$_4$)$_3$, an apatite polysome: The Mn-free analog of ganomalite from Crestmore, California

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ABSTRACT

Wayneburnhamite (IMA2015-124), Pb$_2$Ca$_2$(Si$_2$O$_7$)$_3$(SiO$_4$)$_3$, is a new mineral from the Commercial quarry, Crestmore, Riverside County, California, where it occurs as a metasomatic mineral on fracture surfaces in vesuvianite/wollastonite rock. Wayneburnhamite crystals are sky-blue hexagonal tablets and prisms up to 0.5 mm in maximum dimension. The streak is white. Crystals are transparent to translucent with vitreous to resinous luster. The Mohs hardness is 3½, the tenacity is brittle, the fracture is conchoidal, and there is no cleavage. The calculated density is 5.271 g/cm$^3$. The mineral is optically uniaxial (+), with $\omega = 1.855(5)$, and $\epsilon = 1.875(5)$ (white light). The pleochroism is $E$ sky blue and $O$ lighter sky blue; $E > O$ weak. Raman and infrared spectra are consistent with the crystal structure, but suggest a very minor hydrous component. The empirical formula (based on 9 Si apfu) is (Pb$_{3.1}$Si$_{0.06}$O$_{3.03}$)$_{29.08}$(Ca$_{0.05}$Cu$^{2+}_{0.23}$)$_{29.03}$Si$_{3.33}$Ca$_{1.3}$Si$_{2.2}$O$_{32.24}$Cl$_{0.07}$. Wayneburnhamite is hexagonal, $P6_3$, $a = 9.8953(9)$, $c = 10.2054(7)$ Å, $V = 865.40(17)$ Å$^3$, and $Z = 1$. The eight strongest lines in the X-ray powder diffraction pattern are $d_{101}$ Å($h0l$): 4.95(52)(110); 4.45(64)(111); 3.550(77)(112); 3.232(54)(120); 3.086(100)(121); 2.847(60)(300); 2.798(48)(113); and 2.734(83)(212). The structure determination ($R_1 = 3.01\%$) for 1063 $F_0 > 4\sigma F_0$ shows wayneburnhamite to be an apatite polysome isostructural with ganomalite, differing only in that the site occupied dominantly by Mn in the structure of ganomalite is occupied dominantly by Ca in the structure of wayneburnhamite. The structure refinement of wayneburnhamite appears to represent a rare case in which the approximate locations of the Pb$^{2+}$/Ca$^{2+}$ lone-electron pairs can be seen as electron density residuals.

Keywords: Wayneburnhamite, new mineral, crystal structure, spectroscopy, apatite polysome, ganomalite, lone-electron pairs, Crestmore, California

INTRODUCTION

Ganomalite was first described from Långban, Sweden, by Nordenskiöld (1876, 1877). In 1899, Penfield and Warren conjectured that ganomalite was the hydroxyl analog of nasonite, Pb$_2$Ca$_2$(Si$_2$O$_7$)$_3$Cl$_2$, and this relation was generally accepted until 1972, when Engel showed that, based upon its similarity in symmetry and cell parameters to several synthetic phases, ganomalite probably had a structure intermediate between those of nasonite and apatite. Dunn et al. (1985) noted that chemical analyses of material from Långban and Jacobsberg, Sweden, and from Franklin, New Jersey, U.S.A., all exhibited significant contents of Mn. Furthermore, the preliminary crystal structure data of Dunn et al. (1985) showed that Mn and Ca are ordered in the structure and that Mn is dominant in one site, making it an essential element in ganomalite, which has the ideal formula Pb$_2$Ca$_2$MnSi$_2$O$_{13}$. This formula can be recast as Pb$_2$Ca$_2$Mn(Si$_2$O$_7$)$_3$(SiO$_4$)$_3$ to indicate the presence in the structure of both sorosilicate and nesosilicate groups. In 1997, Carlson and Norrestam provided a full crystal structure determination for ganomalite from Jacobsberg, Sweden, which confirmed the findings of Dunn et al. (1985). More recently, Baikie et al. (2010) presented a formal description of apatite polysomes with the general formula $A_2B_2O_{16+X}$$_{2N}$, where $A$ designates the large cations in the framework ($A'$) and in the tunnels ($A''$), $B$ designates the cation in the tetrahedral site, and $X$ designates the anion (if any) in the tunnel; $N = 2$ for pyromorphite [Pb$_2$(PO$_4$)$_2$Cl$_2$], $N = 3$ for ganomalite [Pb$_2$Ca$_2$(Si$_2$O$_7$)$_3$(SiO$_4$)$_3$], and $N = 4$ for nacrite [Pb$_2$Ca$_2$(Si$_2$O$_7$)$_3$Cl$_2$].

Ganomalite was reported as “gray coatings and druses” from the Commercial quarry at Crestmore, California, by DeVito et al. (1971) based upon a personal communication from Joseph Murdoch, but no chemical analysis was reported. Fred DeVito had collected excellent hexagonal prismatic blue crystals at Crestmore in 1964, which were only later identified as ganomalite. We examined two of the specimens collected in 1964 by DeVito and found the crystals to correspond to ganomalite in all respects, except that they contain, at most, a trace of Mn. The Crestmore crystals, therefore, correspond to a new species, distinct from ganomalite and with the ideal formula Pb$_2$Ca$_2$(Si$_2$O$_7$)$_3$(SiO$_4$)$_3$. The new mineral is named wayneburnhamite in honor of American geochemist-petrologist C. Wayne Burnham (1922–2015). Burnham had a long and illustrious career as Professor at Pennsylvania State University from 1955–1986 and then as Adjunct Professor of Geology at Arizona State University for many years. He is best known for his seminal research on the role of volatiles.