American Mineralogist, Volume 106, pages 862–871, 2021

Magnesio-lucchesiite, $CaMg_3Al_6(Si_6O_{18})(BO_3)_3(OH)_3O$, a new species of the tourmaline supergroup

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Abstract

Magnesio-lucchesiite, ideally $CaMg_3Al_6(Si_6O_{18})(BO_3)_3(OH)_3O$, is a new mineral species of the tourmaline supergroup. The holotype material was discovered within a lamprophyre dike that cross-cuts tourmaline-rich metapelites within the exocontact of the O'Grady Batholith, Northwest Territories (Canada). Two additional samples were found at San Piero in Campo, Elba Island, Tuscany (Italy) in hydrothermal veins embedded in meta-serpentinites within the contact aureole of the Monte Capanne intrusion. The studied crystals of magnesio-lucchesiite are black in a hand sample with vitreous luster, conchoidal fracture, an estimated hardness of 7–8, and a calculated density of 3.168 (Canada) and 3.175 g/cm^3 (Italy). In plane-polarized light, magnesio-lucchesiite is pleochroic (O = dark brown, E = colorless) and uniaxial (–); its refractive index values are $n_\omega = 1.668(3)$ and $n_\varepsilon = 1.644(3)$ (Canada), and $n_\omega = 1.665(5)$ and $n_\varepsilon = 1.645(5)$ (Italy). Magnesio-lucchesiite is trigonal, space group $R3m$, $Z = 3$, with $a = 15.9910(3)$ Å, $c = 7.2224(2)$ Å, $V = 1599.42(7)$ Å^3 (Canada) and with $a = 15.9270(10)$ Å, $c = 7.1270(5)$ Å, $V = 1565.7(2)$ Å^3 (Italy, sample 1). The crystal structure of magnesio-lucchesiite was refined to $R_1 = 3.06\%$ using 2953 reflections with $F_o > 4\sigma(F_o)$ (Canadian sample; 1.96% / 1225 for the Italian sample) The Canadian (holotype) sample has the ordered empirical formula $^{X}(Ca_{0.60}Na_{0.39}K_{0.01})_{\Sigma 1.00}$ $^{Y}(Mg_{2.02}Fe^{2+}_{0.62}Fe^{3+}_{0.09}Ti_{0.25}V_{0.01}Cr_{0.01})_{\Sigma 3.00}$ $^{Z}(Al_{5.31}Fe^{3+}_{0.69})_{\Sigma 6.00}[^{T}(Si_{5.98}Al_{0.02})_{\Sigma 6.00}O_{18}](BO_3)_3$ $^{V}[(OH)_{2.59}O_{0.41}]_{\Sigma 3.00}$ $^{W}(O_{0.78}F_{0.22})_{\Sigma 1.00}$. The Italian (co-type) material shows a wider chemical variability, with two different samples from the same locality having ordered chemical formulas: $^{X}(Ca_{0.88}Na_{0.12})_{\Sigma 1.00}$ $^{Y}(Mg_{1.45}Fe^{2+}_{0.40}Al_{0.79}Fe^{3+}_{0.36})_{\Sigma 3.00}$ $^{Z}Al_6[^{T}(Si_{5.05}Al_{0.95})_{\Sigma 6.00}O_{18}](BO_3)_3$ $^{V}[(OH)_{2.90}O_{0.10}]_{\Sigma 3.00}$ $^{W}(O_{0.98}F_{0.02})_{\Sigma 1.00}$ (sample 1) and $^{X}(Ca_{0.71}Na_{0.21}\square_{0.08})_{\Sigma 1.00}$ $^{Y}(Mg_{2.49}Fe^{2+}_{0.41}Ti_{0.10})_{\Sigma 3.00}$ $^{Z}(Al_{5.44}Fe^{3+}_{0.46}Mg_{0.09}V_{0.01})_{\Sigma 6.00}[^{T}(Si_{5.87}Al_{0.13})_{\Sigma 6.00}O_{18}](BO_3)_3$ $^{V}(OH)_3$ $^{W}[O_{0.61}(OH)_{0.39}]_{\Sigma 1.00}$ (sample 2). Magnesio-lucchesiite is an oxy-species belonging to the calcic group of the tourmaline supergroup. It is related to lucchesiite by the homovalent substitution $^{Y}Fe \leftrightarrow {}^{Y}Mg$, and to feruvite by the homovalent and heterovalent substitutions $^{Y}Fe \leftrightarrow {}^{Y}Mg$ and $^{Z}Al^{3+} + {}^{W}O^{2-} \leftrightarrow {}^{Z}Mg^{2+} + {}^{W}(OH)^{1-}$. The new mineral was approved by the International Mineralogical Association Commission on New Minerals, Nomenclature and Classification (IMA 2019-025). Occurrences of magnesio-lucchesiite show that its presence is not restricted to replacement of mafic minerals only; it may also form in metacarbonate rocks by fluctuations of F and Al during crystallization of common uvitic tourmaline. High miscibility with other tourmaline end-members indicates the large petrogenetic potential of magnesio-lucchesiite in Mg,Al-rich calc-silicate rocks, as well as contact-metamorphic and metasomatic rocks.

Keywords: Magnesio-lucchesiite, new mineral species, lamprophyre dike, O'Grady Batholith, San Piero in Campo, Elba Island; Lithium, beryllium and boron: Quintessentially crustal