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Tsilaisite, $NaMn_3Al_6(Si_6O_{18})(BO_3)_3(OH)_3OH$, a new mineral species of the tourmaline supergroup from Grotta d'Oggi, San Pietro in Campo, island of Elba, Italy

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Abstract

Tsilaisite, $NaMn_3Al_6(Si_6O_{18})(BO_3)_3(OH)_3OH$, is a long-expected new mineral of the tourmaline supergroup. It occurs in an aplitic dike of a LCT-type pegmatite body from Grotta d'Oggi, San Pietro in Campo, island of Elba, Italy, in association with quartz, K-feldspar, plagioclase, elbaite, and schorl. Crystals are greenish yellow with a vitreous luster, a white streak, and show no fluorescence. Tsilaisite has a Mohs hardness of approximately 7; it is brittle with a sub-conchoidal fracture, and has a calculated density of 3.133 g/cm^3. In plane-polarized light, tsilaisite is pleochroic, O = pale greenish yellow, E = very pale greenish yellow; it is uniaxial negative, $\omega = 1.645(5)$, $\varepsilon = 1.625(5)$. Tsilaisite is rhombohedral, space group $R3m$, $a = 15.9461(5)$, $c = 7.1380(3)$ Å, $V = 1571.9(1)$ Å^3, $Z = 3$. The strongest eight X-ray-diffraction lines in the powder pattern [d in Å(I)(hkl)] are: 3.974(100)(220), 2.942(94)(122), 2.570(79)(051), 2.034(49)(152), 4.205(41)(211), 6.329(22)(101), 2.377(21)(003), and 1.592(21)(550). Analysis by a combination of electron microprobe, secondary ion mass spectrometry, and optical absorption spectroscopy gives $SiO_2 = 36.10(3)$, $TiO_2 = 0.32(4)$, $Al_2O_3 = 37.10(5)$, $MnO = 9.60(10)$, $CaO = 0.09(4)$, $Na_2O = 2.11(7)$, $K_2O = 0.03(1)$, $F = 0.79(3)$, $B_2O_3 = 10.2(6)$, $Li_2O = 0.8(1)$, $H_2O = 3.1(2)$, sum 99.95 wt%. The unit formula is $^{X}(Na_{0.67}\square_{0.30}Ca_{0.02}K_{0.01})^{Y}(Mn^{2+}_{1.34}Al_{1.14}Li_{0.54}Ti_{0.04})^{Z}Al_6{}^{T}(Si_{5.94}Al_{0.06})B_{2.91}O_{27}{}^{V}(OH)_3{}^{W}(OH_{0.39}F_{0.41}O_{0.20})$. The structure, refined also taking into account the positional disorder of the O1 and O2 anions, converged to statistical indices $R1$ for all reflections of about 2%. The resulting site populations indicate that the Z site is occupied by Al and that the Y site is dominated by Mn^{2+}. Aluminum is incorporated at Y through two types of substitutions: $^{Y}Al+{}^{W}O^{2-} \rightarrow {}^{Y}Mn^{2+}+{}^{W}OH$, which has the result of replacing OH at the W site by O^{2-}, and $^{Y}(Al+Li)+{}^{W}F \rightarrow 2{}^{Y}Mn^{2+}+{}^{W}OH$, which relates fluor-elbaite to the tsilaisite component. Infrared absorption spectra measured in the principal OH-stretching region were interpreted on the basis of local arrangements consistent with the short-range bond-valence requirements. A compositional trend from fluor-elbaite to tsilaisite is observed in samples from Elba Island. The occurrence of tsilaisite is very rare in nature, as a consequence of both the requirement of extraordinary petrogenetic conditions and limited structural stability.

Keywords: Tsilaisite, tourmaline, new mineral species, crystal-structure refinement