Toturite Ca$_3$Sn$_2$Fe$_2$SiO$_{12}$—A new mineral species of the garnet group

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Abstract

A new Sn-rich garnet, toturite Ca$_3$Sn$_2$Fe$_2$SiO$_{12}$, occurs as an accessory mineral in high-temperature altered carbonate-silicate xenoliths in ignimbrite of the Upper Chegem structure in the Northern Caucasus, Kabardino-Balkaria, Russia. The empirical formula of toturite from the holotype sample is Ca$_2$[(Sn$_{0.66}$Zr$_{0.34}$)Fe$_{2+}$SiO$_{12}$]$_{0.33}$Mg$_{0.01}$Al$_{0.00}$Na$_{0.00}$Cr$_{0.00}$($Fe^{3+}$)$_{2.99}$Al$_{0.01}$Si$_{0.01}$Ti$_{2.90}$Fe$_{0.09}$Zr$_{0.01}$O$_{12}$. The mineral forms thin regular growth zones and irregular spots in the Fe$^{3+}$-dominant analog of kimzeyite. Toturite is cubic, $Ia3d$, $a = 12.55$ Å, as is confirmed by electron backscatter diffraction (EBSD) data. The strongest lines of the calculated powder diffraction pattern are [d, Å (hkl)]: 2.562 (422) 100, 1.677 (642) 91, 3.138 (400) 74, 4.437 (220) 67, 1.146 (10.4.2) 31, 1.046 (884) 25, 1.984 (620) 23. Raman spectra of toturite are analogous to those of kimzeyite and shows the following diagnostic bands (cm$^{-1}$): 244, 301, 494, 497, 575, 734. The association of toturite with larnite, rondorlite, waldalite, magnesiowillite, lakargite, and cuspidine indicates a high temperature ($>800$ °C) of formation. The mineral name is given after the Totur River situated in Eltyubyu village, also Totur is the name of a Balkarian god.

Keywords: Garnet, toturite, Fe$^{3+}$-dominant analog of kimzeyite, Sn, Sb, Raman spectroscopy, EBSD, Lakargi Mountain, Russia

Introduction

Toturite, Ca$_3$Sn$_2$Fe$_2$SiO$_{12}$, is a structural analog of kimzeyite (Ca$_3$Zr$_2$Al$_2$SiO$_{12}$) and schorlomite (Ca$_3$Ti$_2$Fe$_2$SiO$_{12}$). It was discovered in altered carbonate-silicate xenoliths from ignimbrites of the Upper Chegem caldera, Kabardino-Balkaria, Russia. Unusual compositions of garnet from the altered xenoliths are represented by the complex solid solution Ca$_3$(Sn$_{1-x}$Zr$_x$)$_2$Fe$_2$SiO$_{12}$ in which SnO$_2$ content reaches 38.51 wt%. For determination of the totalite end-member for Ca$_3$Sn$_2$Fe$_2$SiO$_{12}$ (IMA2009-009), and CaUO$_2$ (IMA2007-002) from calcium olivine as garnet in altered xenoliths in the area of Lakargi Mountain. Several new minerals have been discovered in the xenoliths near Lakargi Mountain: calcio-olivine $\gamma$-Ca$_3$SiO$_4$ (Zadov et al. 2008), lakargite CaZrO$_3$ (Galuskina et al. 2008), chegernite Ca$_4$(SiO$_4$)$_2$(OH)$_2$ (Galuskina et al. 2009), kunytyubeite Ca$_4$(SiO$_4$)$_2$F$_2$ (Galuskina et al. 2009), KNa$_3$Li(Mg,Fe)$_2$Ti$_2$Si$_2$O$_{14}$ (IMA2009-009), and CaUO$_2$ (IMA2002-032). Other new garnet species from these xenoliths were also recently approved. These are elbrousite-(Zr) Ca$_3$U$^{4+}$ZrFe$_2$O$_{12}$ (Galuskina et al. 2010b), bitikite-(SnAl) Ca$_3$Sb$_2$SnAl$_2$O$_{12}$, and bitikite-(ZrFe) Ca$_3$Sb$_2$ZrFe$_2$O$_{12}$ (Galuskina et al. 2010a). These garnet species form solid solutions with toturite. A more widespread garnet in altered xenoliths in the area of Lakargi Mountain, and that also forms a solid solution with toturite, is Ca$_3$Zr$_2$Fe$_2$SiO$_{12}$ (IMA2009-009) originally described from the Kerimasi volcano (Tanzania) recently approved by the CNMNC IMA. This garnet, which is the Fe$^{3+}$ analog of kimzeyite Ca$_3$Zr$_2$Al$_2$SiO$_{12}$ (Milton et al. 1961; Munno et al. 1980), has already been described from the kimzeyite type locality at Magnet Cove, U.S.A. (Whittle et al. 2007), and other localities, namely, Anguillara, Italy (Schingaro et al. 2001), and Wilay, Russia (Galuskina et al. 2005).

tin in natural garnet has been reported only as a minor constituent in andradite (as SnO$_2$): 2.9 wt% [Gumble, New South Wales, Australia; Mulholland (1984)]; 3.5 wt% [El Hamman, Central Morocco; Sonnet (1981)]; 5.8 wt% [David Ost, South West Africa; McIver and Mihálik (1975)]; 6.01 wt% [Tyrnauza, Russia; Kononov et al. (1989)]. Amthauer et al. (1979) suggested that Sn is incorporated in Sn-bearing andradite via Sn$^{4+}$Fe$^{3+} = 2Fe^{2+}$.

We did not find in the extensive literature on synthetic garnet any information about the synthesis of the Sn analog of kimzeyite (Ca$_3$Sn$_2$Al$_2$SiO$_{12}$) or its Fe$^{3+}$ analog (Ca$_3$Sn$_2$Fe$_2$SiO$_{12}$). Mössbauer investigations of synthetic Y-Sn garnet Ca$_3$Y$_2$Sn$_2$Fe$_2$O$_{12}$ for...