Joëlbruggerite, \( \text{Pb}_2\text{Zn}_3(\text{Sb}^{5+},\text{Te}^{6+})\text{As}_2\text{O}_{13}(\text{OH},\text{O}) \), the Sb\(^{5+}\) analog of dugganite, from the
Black Pine mine, Montana

STUART J. MILLS, \(^1\)* UWE KOLITSCH, \(^2\) RITSURO MIYAWAKI, \(^3\) LEE A. GROAT, \(^1\) and GLENN POIRIER\(^4\)

\(^1\)Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, British Columbia V6T 1Z4, Canada
\(^2\)Mineralogisch-Petrographische Abteilung, Naturhistorisches Museum Wien, Burgring 7, A-1010 Wien, Austria
\(^3\)Department of Geology, National Museum of Nature and Science, 3-23-1, Hyakunin-cho, Shinjuku, Tokyo 169-0073, Japan
\(^4\)Mineral Sciences Division, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario K1P 6M4, Canada

ABSTRACT

Joëlbruggerite, ideally \( \text{Pb}_2\text{Zn}_3(\text{Sb}^{5+},\text{Te}^{6+})\text{As}_2\text{O}_{13}(\text{OH},\text{O}) \), is a new arsenate mineral (IMA 2008-034) and the Sb\(^{5+}\) analog of dugganite, from the Black Pine mine, 14.5 km northwest of Philipsburg, Granite County, Montana. It is usually found perched on mimetite; other species that may be present include malachite, azurite, pseudomalachite, chalcocite, beudantite-corkite, duftite, dugganite, and koksitse, in milky quartz veins. Joëlbruggerite occurs as barrel-shaped or prismatic crystals up to about 50 \( \mu \)m across in various shades of purple. The crystals have an adamantine luster and a white streak. Mohs hardness is about 3. The fracture is irregular, and the tenacity is brittle. Joëlbruggerite crystals are uniaxial (\(-\)), with a calculated refractive index of \( n = 1.993 \), and weakly pleochroic: \( X = Y = Z = \) purple; absorption: \( Z > X > Y \). Crystals show straight extinction and are length-fast. The empirical chemical formula (mean of 5 electron microprobe analyses) calculated on the basis of 14 [O + OH] anions is \( \text{Pb}_{3.12(2)}\text{Zn}_{1.68(2)}\text{Fe}_{0.185(1)}\text{Si}_{0.160(1)}\text{Al}_{0.116(1)}\text{As}_{0.391(12)}\text{O}_{3.689(12)}\text{H}_{0.165(1)} \). Joëlbruggerite is trisegional, space group \( \text{P}3\overline{2}1 \), \( a = 8.4803(17) \) \( \text{Å} \), \( c = 5.2334(12) \) \( \text{Å} \), \( V = 325.94(12) \) \( \text{Å}^3 \), \( Z = 1 \). The five strongest lines in the powder X-ray diffraction pattern are [\( d_{\text{obs}} \) in \( \text{Å} \) (\( hkl \))]: 3.298 (100) (111), 3.008 (89) (021), 1.905 (39) (122, 131), 2.456 (36) (012, 121, 030), and 1.609 (30) (112, 132, 231, 140). The crystal structure was solved from single-crystal X-ray diffraction data and refined to \( R_{\text{I}} = 0.038 \) on the basis of 604 unique reflections with \( F > 4\sigma(F) \). It is composed of heteropolyhedral sheets of edge-sharing (Sb,Te)O\(_6\) octahedra and PbO\(_4\) tetrahedra, oriented parallel to (001). The sheets are cross-linked by AsO\(_4\) and ZnO\(_4\) tetrahedra, which share corners to form an interlinked, two- and three-connected two-dimensional net parallel to (001). The mineral is named for Joël Brugger (born 1967), Swiss-Australian mineralogist, for his contributions to mineralogy.

Keywords: Joëlbruggerite, new mineral, Sb\(^{5+}\), arsenate, Black Pine mine, dugganite, crystal structure, bond valence

INTRODUCTION

The semi-metals antimony (Sb) and tellurium (Te) have relatively low crustal abundances (200 and 1 ppb, respectively), however high levels of both metals can be found in various ore deposits worldwide (e.g., for Sb, Consolidated Murchison mine near Gravelotte, South Africa—Yager 2007; for Te, Cripple Creek, Colorado—Kelley et al. 1998). Their mineralogy and crystal chemistry tend to be complex, owing to the various oxidation states for both elements (Sb\(^{5+}\), Sb\(^{3+}\) and Te\(^{6+}\), Te\(^{4+}\), Te\(^{2+}\), and Te\(^{0}\)). Some 230 Sb and 140 Te minerals have so far been described, but only 10 contain both Sb and Te, and all these are sulfides or sulfosalts. The new mineral species joëlbruggerite, described here, appears to be the first mineral described where Sb\(^{5+}\) substitutes for Te\(^{6+}\) in the same site. The synthetic compound (H\(_2\)O)SbTeO\(_5\) (Turrillas et al. 1985; Alonso and Turrillas 2005) appears to be the only known example of Sb\(^{5+}\) replacing Te\(^{6+}\) in octahedral coordination, although some synthetic phases are known with Sb\(^{5+}\) replacing Te\(^{4+}\), e.g., Sb\(_7\)Te\(_6\)Cl \( (\text{Alonso et al. 1985}) \).

The type specimen of joëlbruggerite and associated material was collected in Spring 1993 by John Dagenais of Vancouver, British Columbia, Canada, at the Black Pine mine, 14.5 km NW of Philipsburg, Granite County, Montana \( (46\degree26′52″\text{N}, 113\degree21′56″\text{W}) \). The mineral is named for Joël Brugger (born 1967), Swiss-Australian mineralogist, for his contributions to mineralogy, in particular the description of new minerals (e.g., spriggite; Brugger et al. 2004), metamorphosed manganese deposits (e.g., Brugger and Meisser 2006), hydrothermal geochemistry (e.g., Brugger et al. 2007), and for his work on Te mineralogy (e.g., Grindler et al. 2008). The mineral and name have been approved by the IMA Commission on New Minerals, Nomenclature and Classification prior to publication (IMA 2008-034). The type specimen is preserved in the Department of Mineralogy, South Australian Museum (G32400), with the cotype specimen (probe mount) preserved in the Mineral Sciences Division, Canadian Museum of Nature (CMNMC 86061).

* E-mail: smills@eos.ubc.ca

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