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Lakebogaite, $CaNaFe_2^{3+}H(UO_2)_2(PO_4)_4(OH)_2(H_2O)_8$, a new uranyl phosphate with a unique crystal structure from Victoria, Australia

Stuart J. Mills,[1,2,3,*] William D. Birch,[2] Uwe Kolitsch,[4] W. Gus Mumme,[3] and Ian E. Grey[3]

[1]School of Earth Sciences, University of Melbourne, Parkville, Victoria, 3010, Australia
[2]Geosciences, Museum Victoria, GPO Box 666, Melbourne, Victoria, 3001, Australia
[3]CSIRO Minerals, Box 312, Clayton South, Victoria, 3169, Australia
[4]Mineralogisch-Petrographische Abt., Naturhistorisches Museum Wien, Burgring 7, A-1010 Wien, Austria

Abstract

Lakebogaite, ideally $CaNaFe_2^{3+}H(UO_2)_2(PO_4)_4(OH)_2(H_2O)_8$, is a new Ca–Na–Fe uranyl phosphate mineral from a quarry in Upper Devonian granite near Lake Boga, northern Victoria, Australia. It is associated with Na-analogue of meurigite (IMA 2007-024), torbernite, and saléeite on a matrix of microcline, albite, smoky quartz, and muscovite. Lakebogaite occurs as bright lemon-yellow transparent prismatic crystals up to 0.4 mm across. The crystals have a vitreous luster and a pale yellow streak. Mohs hardness is about 3. The fracture is even to conchoidal. In transmitted light, the mineral is pale yellow with very weak pleochroism: X = yellow, Y = grayish yellow, Z = grayish yellow: dispersion $r > v$, strong. Lakebogaite crystals are biaxial (+), with slightly variable refractive indices within the ranges: $n_\alpha = 1.650(2)–1.652(2)$, $n_\beta = 1.660(4)–1.664(3)$, $n_\gamma = 1.681(3)–1.686(2)$, measured using white light, and with $2V_{meas} = 80–85°$ and $2V_{calc} = 70–74°$. Orientation: Y = **b**; crystals are elongated along [010], resulting in straight extinction. The empirical chemical formula (mean of nine electron microprobe analyses) calculated on the basis of 30 anions is $(Ca_{1.00}Na_{0.80}Sr_{0.10})_{\Sigma 1.90}(Fe^{3+}_{1.85}Al_{0.30})_{\Sigma 2.15}(UO_2)_{1.80}(PO_4)_{4.07}(OH,H_2O)_{10.12}$. Lakebogaite is monoclinic, space group *Cc*, $a = 19.6441(5)$, $b = 7.0958(2)$, $c = 18.7029(5)$ Å, $\beta = 115.692(1)°$, $V = 2349.3(7)$ Å^3, $Z = 4$. The seven strongest reflections in the powder X-ray diffraction pattern are [d_{obs} in Å (*I*) (*hkl*)]: 6.60 (100) (110), 3.16 (40) (51$\bar{4}$, 60$\bar{4}$), 4.07 (20) (40$\bar{4}$), 3.80 (20) (31$\bar{4}$), 3.56 (20) (020, 312), 3.31 (20) (114, 220), 2.797 (20) (006). The crystal structure was solved from single-crystal X-ray diffraction data and refined to $R_1 = 0.038$ on the basis of 5222 unique reflections with $F > 4\sigma F$. It comprises pairs of edge-shared UO_7 pentagonal bipyramids that are inter-linked via corner-sharing with PO_4 tetrahedra, to form chains parallel to the **c**-axis. Each UO_7 polyhedron also shares one of its edges with another PO_4 tetrahedron. The $(UO_2)_2(PO_4)_4$ chains are cross-linked via corner-sharing between the PO_4 tetrahedra and $Fe^{3+}O_4(OH)_2$ octahedra. The octahedra join together by corner-sharing via OH anions to form chains parallel to **b**. The Na^+ and Ca^{2+} cations, and 4 water molecules occupy eight-sided channels along [010]. The remaining water molecules occupy large ten-sided channels directed along [001] and intersecting the [010] channels. The mineral is named for the nearest township.

Keywords: Lakebogaite, new mineral, uranyl phosphate, Lake Boga quarry, north-western Victoria, Australia, crystal structure, $(UO_2)_2(PO_4)_4$ chains