

## New Mineral Names\*†

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This New Mineral Names has entries for 10 new minerals, including barikaite, deveeroite-(Ce), hizenite-(Y), kobyashevite, leverettite, magnesiokoritnigite, mössbauerite, shimazakiite (4*M* and 4*O* polytypes), takanawaite-(Y), and veblenite.

#### BARIKAITE\*

- D. Topa, E. Makovicky, H. Tajedin, H. Putz, and G. Zagler (2013) Barikaite,  $\text{Pb}_{10}\text{Ag}_3(\text{Sb}_8\text{As}_{11})_{\Sigma 19}\text{S}_{40}$ , a new member of the sartorite homologous series. *Mineralogical Magazine*, 77(7), 3039–3046.
- D. Topa and E. Makovicky (2013) The crystal structure of barikaite. *Mineralogical Magazine*, 77(8), 3093–3104.

Barikaite (IMA 2012-055), ideally  $\text{Pb}_{10}\text{Ag}_3(\text{Sb}_8\text{As}_{11})_{\Sigma 19}\text{S}_{40}$ , is a new antimony-containing species of the sartorite homologous series discovered at the Barika Au-Ag deposit, Azarbaijan Province of Western Iran. The lens-like deposit ~150 m long and up to 20 m thick consists of massive banded pyrite and barite ores accompanied by locally developed silica bands. Pyrite, sphalerite, galena, tetrahedrite-tennantite, and stibnite were deposited during the synvolcanogenic hydrothermal activity of Cretaceous age. Fractures host veinlets with Ag-As-Sb-Pb-rich sulfosalts: tetrahedrite-tennantite, stephanite, pyrargyrite, trechmannite, smithite, miargyrite, andorite, geocronite, seligmannite, guettardite and realgar and Ag-Au alloys. Barikaite is always found in association with guettardite in quartz veins hosting irregular thin veinlets and nests of sulfosalts in a mass of quartz and baryte. The mineral occurs as anhedral grains with no twinning. It has been replaced by guettardite, resulting in corroded remnants of what was a solid barikaite aggregate. The mineral is grayish black, opaque, metallic with dark gray streak. It is brittle with irregular fracture and no cleavage or parting. The microhardness  $\text{VHN}_{50} = 200$  (192–212)  $\text{kg/mm}^2$  corresponds to ~3 of Mohs scale. The density could not be measured due to admixture of guettardite;  $D_{\text{calc}} = 5.34$   $\text{g/cm}^3$ . In reflected light barikaite is grayish white with distinct pleochroism from white to dark gray. Internal reflections are absent. Anisotropism is distinct with rotation tints in shades of gray. The reflectance spectrum was measured in air between 400 and 700 nm with 20 nm interval. The values for COM wavelengths are [ $R_{\text{min}}$ ,  $R_{\text{max}}$  % (nm)]: 37.0, 39.3 (470); 34.1, 36.9 (546); 33.1, 36.2 (589); 31.3, 34.1

(650). The average of 5 electron probe WDS analyses is [wt% (range)]: Ag 5.80 (4.93–5.87), Pb 35.77 (35.50–39.21), Sb 18.33 (17.49–18.37), As 15.64 (15.18–15.77), Tl 0.15(0.07–0.22), S 24.00 (23.65–23.92), total 99.69. The empirical formula on the basis of 32Me + 40S = 72 apfu is  $\text{Pb}_{9.31}\text{Ag}_{2.90}\text{Tl}_{0.04}(\text{Sb}_{8.12}\text{As}_{11.26})_{\Sigma 19.36}\text{S}_{40.37}$ . The single crystal X-ray study shows barikaite is monoclinic with space group  $P2_1/n$  and unit-cell parameters  $a = 8.533(1)$ ,  $b = 8.075(1)$ ,  $c = 24.828(2)$  Å,  $\beta = 99.077(6)^\circ$ ,  $V = 1689.2$  Å<sup>3</sup>;  $Z = 1$ . The X-ray powder data was not be obtained due to paucity of pure material. The strongest lines of the calculated X-ray powder diffraction pattern [ $d$  Å (%;  $hkl$ )] are: 3.835 (63; 022), 3.646 (100; 016), 3.441 (60; 212), 3.408 (62;  $\bar{2}14$ ), 2.972 (66;  $\bar{2}16$ ), 2.769 (91; 222), 2.752 (78;  $\bar{4}24$ ), 2.133 (54; 402). The crystal structure of barikaite contains 8 cation sites and 10 anion sites. Four of the cation sites have mixed occupancies: the split sites As2-Sb2, As3-Sb3, Ag5-As5, and the site Me6 with three cations involved. Two sites, Pb1 and Pb2, have tricapped trigonal prismatic coordination and alternate along *a*. They form zigzag walls parallel to (001). There are 3 distinct [100] columns of alternating cations, As1-(As,Sb)2, Sb4-(As,Sb)3, (As,Ag)5-(Pb,Sb)6, which together form trapezoidally configured single (013) layers. These layers aggregate into tightly bonded double layers, separated by lone electron pair micelles. The predominantly As- and Sb-occupied sites are in a chess-board order. Barikaite is a member of the sartorite homologous series. The empirical values of homolog order *N* derived from the chemical analyses are in fair agreement with the crystallographic value  $N = 4$ . Barikaite is a close homeotype of rathite and less closely related to dufrénoysite (distinct, pure arsenian  $N = 4$  members) and completes the spectrum of Sb-rich members of the sartorite homologous series. The mineral is named for the type locality. The holotype specimen is deposited in the Natural History Museum Vienna, Austria. **D.B.**

#### DEVEROITE-(CE)\*

- A. Guastoni, F. Nestola, P. Gentile, F. Zorzi, M. Alvaro, A. Lanza, L. Peruzzo, M. Schiazza, and N.M. Casati (2013) Deveroite-(Ce): a new REE-oxalate from Mount Cervandone, Devero Valley, Western-Central Alps, Italy. *Mineralogical Magazine*, 77(7), 3019–3026.

\* All minerals marked with an asterisk have been approved by the IMA CNMMC.  
† For a complete listing of all IMA-validated unnamed minerals and their codes, see <http://pubsites.uws.edu.au/ima-cnmmc/>.

Deveroite-(Ce) (IMA 2013-003), ideally  $\text{Ce}_2(\text{C}_2\text{O}_4)_3 \cdot 10\text{H}_2\text{O}$ , is a new mineral and the third natural oxalate discovered in the alpine fissures of Mount Cervandone, overlooking the Devero Valley, Piedmont, Italy. The area is characterized by swarms of pegmatite dikes crosscutting metamorphic rocks and hosted by leucocratic gneisses. These dikes containing Ba-Y-REE-As minerals [aeschnite-(Y), agardite-(Y), Nb-anatase, As-fergusonite-beta-(Y), cervandonite-(Ce), chernovite-(Y), crichtonite-senaite, fluorite, gadolinite-(Y), monazite-(Ce), parniite-(Y), synchysite-(Ce), and xenotime-(Y)] as well as meter-long quartz veins crosscutting pegmatite dikes. Deveroite-(Ce) crystallization related to circulation of meteoric waters enriched with oxalic acid. A source of oxalate is provided by incomplete oxidation of organic material such as decaying plant remains. A source of REE is provided by the hosting mineral, cervandonite-(Ce), and not completely described REE-arsenosilicate. Deveroite-(Ce) occurs only on crystals of cervandonite-(Ce) and is associated with agardite-(Ce), asbecasite, cafarsite, K-feldspar, muscovite, and quartz. It forms sprays of colorless elongated tabular or acicular prisms up to  $\sim 50 \mu\text{m}$ . It has a white streak, vitreous luster and a perfect cleavage along  $\{010\}$ . The mineral is brittle with Mohs hardness of  $\sim 2\text{--}2\frac{1}{2}$ . Density was not measured due to the size of crystals;  $D_{\text{calc}} = 2.352 \text{ g/cm}^3$ . Fluorescence was not observed. Deveroite-(Ce) is non-pleochroic, optically biaxial (–) with  $2V$  of  $\sim 77^\circ$ , and the extinction angle ( $Y^\wedge c$ ) of  $\sim 27^\circ$ . No twinning was observed. The refractive indexes were not measured but proposed to be very close to that of synthetic  $\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 10\text{H}_2\text{O}$ :  $\alpha = 1.473$ ,  $\beta = 1.548$ ,  $\gamma = 1.601$ . The average of 11 electron probe EDS analyses [wt%, (range)] is CaO 0.34 (0.25–0.44),  $\text{C}_2\text{O}_3$  (by stoichiometry) 29.7,  $\text{Y}_2\text{O}_3$  1.66 (1.19–2.04),  $\text{La}_2\text{O}_3$  7.29 (6.60–8.40),  $\text{Ce}_2\text{O}_3$  22.8 (22.03–24.28),  $\text{Pr}_2\text{O}_3$  2.53 (2.10–2.88),  $\text{Nd}_2\text{O}_3$  7.53 (7.14–7.90),  $\text{Sm}_2\text{O}_3$  0.24 (0.13–0.43),  $\text{PbO}_2$  1.24 (1.42–2.53),  $\text{ThO}_2$  0.29 (0.22–0.35),  $\text{UO}_2$  1.05 (0.86–1.19),  $\text{H}_2\text{O}$  (by stoichiometry) 24.8; total 99.47. The empirical formula based on 22 O pfu is  $(\text{Ce}_{1.01}\text{Nd}_{0.33}\text{La}_{0.32}\text{Pr}_{0.11}\text{Y}_{0.11}\text{Sm}_{0.01}\text{Pb}_{0.04}\text{U}_{0.03}\text{Th}_{0.01}\text{Ca}_{0.04})_{\Sigma 2.01}(\text{C}_2\text{O}_4)_{\Sigma 2.99} \cdot 9.99\text{H}_2\text{O}$ . The strongest lines of the X-ray powder diffraction pattern [ $d \text{ \AA}$  ( $I\%$ ;  $hkl$ )] are: 10.266 (100; 100), 4.816 (35; 21 $\bar{1}$ ), 3.415 (28; 300), 5.125 (25; 200), 4.988 (23; 111). The unit-cell parameters refined from powder data are:  $a = 11.2725(9)$ ,  $b = 9.6109(9)$ ,  $c = 10.346(1) \text{ \AA}$ ,  $\beta = 114.539(7)^\circ$ ,  $V = 1019.621 \text{ \AA}^3$ . The small size of the crystal ( $13 \mu\text{m} \times 3 \mu\text{m} \times 1 \mu\text{m}$ ) did not allow to obtain reliable structural data, but allow to find the deveeroite-(Ce) is monoclinic, space group  $P2_1/c$ ,  $a = 11.240(8)$ ,  $b = 9.635(11)$ ,  $c = 10.339(12) \text{ \AA}$ ,  $\beta = 114.41(10)^\circ$ ,  $V = 1019.6 \text{ \AA}^3$ ;  $Z = 2$ . Deveroite-(Ce) is named for the type locality at Devero valley and Devero Natural Park. The holotype material is deposited in the Museum of Mineralogy, Department of Geosciences at the University of Padova, Italy. **D.B.**

#### HIZENITE-(Y)\*

Y. Takai and S. Uehara (2013) Hizenite-(Y),  $\text{Ca}_2\text{Y}_6(\text{CO}_3)_{11} \cdot 14\text{H}_2\text{O}$ , a new mineral in alkali olivine basalt from Mitsukoshi, Karatsu, Saga Prefecture, Japan. *Journal of Mineralogical and Petrological Sciences*, 108(3), 161–165.

Hizenite-(Y) (IMA 2011-030), ideally  $\text{Ca}_2\text{Y}_6(\text{CO}_3)_{11} \cdot 14\text{H}_2\text{O}$ , is a new mineral discovered at Mitsukoshi, Karatsu, Saga Prefecture, Japan. It occurs in small cavities in Higashimatsuura

Neogen alkali olivine basalt closely associating with lokkaite-(Y), tengerite-(Y), and kimuraite-(Y). The mineral forms platy crystals up to  $50 \times 0.2 \mu\text{m}$  forming radial spherical aggregates up to 1 cm. Hizenite-(Y) is white with a white streak and vitreous to silky luster. The cleavage is perfect on  $\{001\}$ . The hardness, optical properties and density were not measured;  $D_{\text{calc}} = 2.98 \text{ g/cm}^3$ . The average of 5 electron probe EDS analyses [wt% (range)] is  $\text{Y}_2\text{O}_3$  27.61 (26.20–29.60),  $\text{La}_2\text{O}_3$  1.11 (0.95–1.41),  $\text{Pr}_2\text{O}_3$  0.65 (0–0.89),  $\text{Nd}_2\text{O}_3$  5.80 (4.69–6.72),  $\text{Sm}_2\text{O}_3$  1.68 (1.04–1.97),  $\text{Eu}_2\text{O}_3$  0.73 (0–1.56),  $\text{Gd}_2\text{O}_3$  3.82 (2.85–4.70),  $\text{Tb}_2\text{O}_3$  0.24 (0–0.79),  $\text{Dy}_2\text{O}_3$  3.10 (2.75–3.54),  $\text{Ho}_2\text{O}_3$  0.47 (0–0.93),  $\text{Er}_2\text{O}_3$  1.58 (1.02–1.83),  $\text{Tm}_2\text{O}_3$  0.04 (0–0.22),  $\text{Yb}_2\text{O}_3$  0.10 (0–0.51), CaO 5.93 (5.38–6.42),  $\text{CO}_2$  29.55 (28.78–30.32),  $\text{H}_2\text{O}$  15.03 (14.85–15.21), total 97.44. The contents of  $\text{H}_2\text{O}$  and  $\text{CO}_2$  were obtained by a CHN analyzer. The empirical formula based on 47 O pfu is  $\text{Ca}_{1.76}(\text{Y}_{4.08}\text{Nd}_{0.58}\text{Gd}_{0.35}\text{Dy}_{0.28}\text{Sm}_{0.16}\text{Er}_{0.14}\text{La}_{0.11}\text{Pr}_{0.07}\text{Eu}_{0.07}\text{Ho}_{0.04}\text{Tb}_{0.02}\text{Yb}_{0.01})_{\Sigma 5.91}(\text{CO}_3)_{11.2} \cdot 13.9\text{H}_2\text{O}$ . The strongest lines of the X-ray powder diffraction pattern [ $d \text{ \AA}$  ( $I\%$ ;  $hkl$ )] are: 15.57 (20; 004), 10.63 (100; 006), 6.384 (77; 0.0.10), 3.962 (51; 0.0.16), 3.821 (27; 029, 1.0.13), 2.060 (23; 306, 0.4.13). The orthorhombic unit-cell parameters refined from the powder data are:  $a = 6.295(1)$ ,  $b = 9.089(2)$ ,  $c = 63.49(1) \text{ \AA}$ ,  $V = 3632(1) \text{ \AA}^3$ ,  $Z = 4$ . Single-crystal X-ray diffraction study was not performed due to the small crystal size. Unit-cell data were obtained using TEM electron diffraction and then refined using XRD data. Hizenite-(Y) structure model suggests the alternating of Y-corrugated sheets and Ca- $\text{H}_2\text{O}$  layers along  $c$  axes. The structure is related to that of kimuraite-(Y), lokkaite-(Y), and tengerite-(Y). The name is for “Hizen” the old name of the mineral type locality between 7th and 16th century. The type specimen is deposited in Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan. **D.B.**

#### KOBYASHEVITE\*

I.V. Pekov, N.V. Zubkova, V.O. Yapaskurt, D.I. Belakovskiy, N.V. Chukanov, A.V. Kasatkin, A.M. Kuznetsov, and D.Yu. Pushcharovsky (2013) Kobyashevite,  $\text{Cu}_5(\text{SO}_4)_2(\text{OH})_6 \cdot 4\text{H}_2\text{O}$ , a new devilline-group mineral from the Vishnevye Mountains, South Urals, Russia. *Mineralogy and Petrology*, 107, 201–210.

Kobyashevite (IMA 2011-066), ideally  $\text{Cu}_5(\text{SO}_4)_2(\text{OH})_6 \cdot 4\text{H}_2\text{O}$ , is a new mineral from the Kapital'naya mine (pyrochlore ore mine operated for Na and Ta) at the Vishnevye Mountains, South Urals, Russia. It occurs as a supergene mineral in cavities of calcite-quartz vein with minor pyrite and chalcopyrite, cutting fenites of the Vishnevogorsky alkaline complex. Kobyashevite forms elongated crystals up to 0.1 mm, rarely 0.2 mm, which show a prismatic habit and are typically curved or split, divergent on calcite and quartz surfaces. Crystals are transparent, bluish-green to turquoise colored, with bluish-green streak and a vitreous luster. It does not fluoresce on UV or cathode rays. Mohs hardness is  $\sim 3$ .  $D_{\text{calc}} = 3.155 \text{ g/cm}^3$ . Kobyashevite is optically biaxial (–), with  $\alpha = 1.602(4)$ ,  $\beta = 1.666(5)$ , and  $\gamma = 1.679(5)^\circ$  (light not reported;  $\lambda = 589 \text{ nm}$ ),  $2V_{\text{meas}} = 50(10)^\circ$  and  $2V_{\text{calc}} = 47^\circ$ . Dispersion is  $r < v$ , strong;  $Z$  is close to the crystal elongation direction. Pleochroism is medium  $Z > Y > X$ , changing only intensity of the bluish-green tint. The average of 4 electron probe

EDS analyses [wt% (range)] is: CuO 57.72 (56.7–58.4), ZnO 0.09 (0.0–0.2), FeO 0.28 (0.2–0.4), SO<sub>3</sub> 23.52 (22.2–24.7), H<sub>2</sub>O (by difference), total 100.00. The empirical formula based on 18 O apfu is: Cu<sub>4.96</sub>Fe<sub>0.03</sub>Zn<sub>0.01</sub>S<sub>2.01</sub>O<sub>8.04</sub>(OH)<sub>5.96</sub>·4H<sub>2</sub>O. The strongest lines of the X-ray powder diffraction pattern [ $d \text{ \AA}$  ( $I\%$ ;  $hkl$ )] are: 10.84 (100; 010), 5.399 (40; 020), 5.178 (12; 110), 3.590 (16; 030), 2.691 (16; 20 $\bar{1}$ , 040, 002), 2.653 (12; 04 $\bar{1}$ , 02 $\bar{2}$ ), 2.583 (12; 2 $\bar{1}$ 1, 201, 2 $\bar{1}$  $\bar{1}$ ), 2.425 (12; 03 $\bar{2}$ , 211, 131). Unit-cell parameters refined from the powder data are:  $a = 6.08(4)$ ,  $b = 11.07(8)$ ,  $c = 5.51(4)$  Å,  $\alpha = 102.8(2)$ ,  $\beta = 92.4(2)$ ,  $\gamma = 92.5(2)^\circ$ ,  $V = 360(2)$  Å<sup>3</sup>. X-ray single-crystal diffraction study on a crystal fragment 150 × 80 × 10 μm shows the mineral is triclinic, space group  $P\bar{1}$ ;  $a = 7.8702(7)$ ,  $b = 15.8081(6)$ ,  $c = 6.6389(14)$  Å,  $V = 821.06(19)$  Å<sup>3</sup>;  $Z = 8$ . The crystal structure of kobyashevite [refined to  $R_1 = 0.0399$  for 1218 unique  $I > 2\sigma(I)$  reflections] is almost identical to its synthetic equivalent and contains [Cu<sub>4</sub>(SO<sub>4</sub>)<sub>2</sub>(OH)<sub>6</sub>] corrugated layers coplanar to **ac**. Each layer is built up of a cationic sheet of edge-sharing Cu-centered octahedra. Layers are linked by Jahn-Teller highly distorted [CuO<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>] octahedra which share two vertices corresponding to the longest distances with SO<sub>4</sub> tetrahedra. The structure of kobyashevite can be also considered as a combination of brucite-like octahedral layers linked by trimers formed by one Cu-centered octahedron and two SO<sub>4</sub> tetrahedra. Hydrogen positions were observed in the Fourier difference and added to the model and refined with soft constrains. The number of O–H-stretching bands observed in the IR spectrum (8) coincides with the number of different hydrogen bonds. Kobyashevite is a devilline-group mineral and is named in memory of the Russian mineralogist Yuriy Stepanovich Kobyashev (1935–2009), a specialist on mineralogy of the Urals. The type specimen of kobyashevite is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **F.C.**

#### LEVERETTITE\*

A.R. Kampf, M.J. Sciberras, P.A. Williams, M. Dini, and A.A. Molina Donoso (2013) Leverettite from the Torrecillas mine, Iquique Province, Chile: the Co-analogue of herbertsmithite. *Mineralogical Magazine*, 77(7), 3047–3054.

Leverettite (IMA 2013-011), ideally Cu<sub>3</sub>CoCl<sub>2</sub>(OH)<sub>6</sub>, is a new mineral from Torrecillas mine, Salar Grande, Iquique Province, Chile. It occurs as a supergene alteration phase in association with akaganeite, anhydrite, chalcophanite, goethite, halite, manganite, pyrite, quartz, and todorokite, and forms steep rhombohedra to 1mm with prominent {101} modified by {001}, with infrequent V-shaped twins by reflection on {10 $\bar{2}$ }, and finger-like, parallel-stacked growths parallel to **c**. Crystals are transparent, deep green colored with green streak and a vitreous luster. Crystals have a perfect cleavage on {101}, conchoidal fracture and are brittle. Mohs hardness is ~3;  $D_{\text{meas}} = 3.64(2)$  g/cm<sup>3</sup> (by flotation in Clerici solution),  $D_{\text{calc}} = 3.709$  g/cm<sup>3</sup>. Leverettite is optically uniaxial (–), with  $\omega$  and  $\epsilon > 1.8$  and exhibits pleochroism with O (bluish green) > E (slightly yellowish green). The average electron probe WDS analyses [wt% (range)] is: CuO 62.80 (56.44–67.65), CoO 7.49 (5.64–9.85), NiO 1.23 (0.51–2.77), MnO 2.72 (0.78–3.68), MgO 0.06 (0.00–0.12), Cl 15.40 (14.58–15.80), H<sub>2</sub>O 12.57 (calculated

on the basis of O+Cl = 8 apfu), –Cl=O 3.47, total 98.80. The empirical formula based on O+Cl = 8 apfu is: Cu<sub>3</sub>(Co<sub>0.43</sub>Cu<sub>0.40</sub>Mn<sub>0.17</sub>Ni<sub>0.07</sub>Mg<sub>0.01</sub>)<sub>Σ1.08</sub>Cl<sub>1.87</sub>O<sub>6.13</sub>H<sub>6</sub>. The strongest lines of the X-ray powder diffraction pattern [ $d \text{ \AA}$  ( $I\%$ ;  $hkl$ )] are: 5.469 (90; 101), 4.701 (18; 003), 2.905 (22; 021), 2.766 (100; 113), 2.269 (66; 024), 1.822 (26; 033), 1.711 (33; 220), 1.383 (23; 128). Unit-cell parameters refined from the powder data are:  $a = 6.8383(9)$ ,  $c = 14.081(2)$  Å,  $V = 570.2$  Å<sup>3</sup>. X-ray single-crystal diffraction study on a crystal fragment 150 × 100 × 90 μm shows the mineral is trigonal, space group  $R\bar{3}m$ ;  $a = 6.8436(6)$ ,  $c = 14.0637(10)$  Å,  $V = 570.42(8)$  Å<sup>3</sup>;  $Z = 3$ . The crystal structure of leverettite [refined to  $R_1 = 0.0226$  for unique  $I > 2\sigma(I)$  reflections] is analogous to the structure of herbertsmithite and gillardite. Optically and crystallographically it would be difficult to distinguish a crystal of leverettite from the other analogs (herbertsmithite, haydeelite, and gillardite) without recourse to chemical analyses. Leverettite extends upon the known substitution series for naturally occurring members of the paratacamite group. The mineral is named in honor of Peter Leverett (b. 1944), professor of Chemistry at the University of Western Sydney, in recognition of his contributions to research and teaching in chemistry and chemical geology. Four type specimens are retained in the Natural History Museum of Los Angeles County, Los Angeles, California, U.S.A. **F.C.**

#### MAGNESIOKORITNIGITE\*

A.R. Kampf, B.P. Nash, M. Dini, and A.A. Molina Donoso (2013) Magnesiokoritnigite, Mg(AsO<sub>3</sub>OH)·H<sub>2</sub>O, from the Torrecillas mine, Iquique Province, Chile: the Mg-analogue of koritnigite. *Mineralogical Magazine*, 77(8), 3081–3092.

Magnesiokoritnigite (IMA 2013-049), ideally Mg(AsO<sub>3</sub>OH)·H<sub>2</sub>O, is a new mineral from Torrecillas mine, Salar Grande, Iquique Province, Chile. It occurs as a secondary alteration phase in association with anhydrite, chudobaite, halite, lavendulan, quartz, and scorodite, and forms colorless to pale-pink 2 mm long laths elongated on [001] and flattened on {010}, as well as in dense deep-pink intergrowths. Crystals are transparent, with vitreous luster and white streak. They are brittle, with conchoidal fracture and perfect cleavage on {101}. Mohs hardness is ~3;  $D_{\text{meas}} = 2.95(3)$  (by flotation in Clerici solution),  $D_{\text{calc}} = 2.935$  g/cm<sup>3</sup>. Magnesiokoritnigite is optically biaxial (+), with  $\alpha = 1.579(1)$ ,  $\beta = 1.586(1)$ ,  $\gamma = 1.620(1)^\circ$  (white light),  $2V_{\text{meas}} = 50(2)^\circ$ , and  $2V_{\text{calc}} = 50^\circ$ . Dispersion is  $r < v$ , medium and the optical orientation is  $Y \approx \mathbf{b}$ ;  $Z \wedge \mathbf{c} = 36^\circ$  in obtuse  $\beta$ . The mineral is slowly soluble in concentrated HCl or HNO<sub>3</sub> and very slowly soluble in concentrated H<sub>2</sub>SO<sub>4</sub>. The average of 9 electron probe WDS analyses [wt% (range)] is: MgO 19.88 (19.27–20.54), CaO 0.36 (0.12–0.72), MnO 0.90 (0.40–1.46), CuO 1.03 (0.74–1.24), As<sub>2</sub>O<sub>5</sub> 58.02 (57.40–58.74), H<sub>2</sub>O 15.11 [calculated on the basis of (Mg+Ca+Mn+Cu) = 1, charge balance and 5 O apfu], total 95.30. The empirical formula based on 5 O apfu is: (Mg<sub>0.94</sub>Cu<sub>0.03</sub>Mn<sub>0.02</sub>Ca<sub>0.01</sub>)<sub>Σ1.00</sub>As<sub>0.96</sub>O<sub>5</sub>H<sub>3.19</sub>. The strongest lines of the X-ray powder diffraction pattern [ $d \text{ \AA}$  ( $I\%$ ;  $hkl$ )] are: 7.96 (100; 020), 4.80 (54; 101), 3.791 (85;  $\bar{2}10, 210, \bar{1}31, \bar{1}31$ ), 3.242 (56;  $0\bar{1}2, \bar{2}\bar{2}1, 012$ ), 3.157 (92;  $2\bar{1}1, \bar{2}30, 230$ ), 3.021 (61;  $1\bar{4}1, 141, \bar{2}21, 221$ ), 2.798 (41;  $0\bar{3}2, 032$ ) and 1.908(43; multiple). Unit-cell parameters refined from the powder data are:  $a = 7.868(7)$ ,  $b = 15.838(7)$ ,  $c = 6.626(7)$  Å,  $\alpha = 91.064(18)$ ,  $\beta$

= 96.394(17),  $\gamma = 90.02(3)^\circ$ , and  $V = 820.4 \text{ \AA}^3$ . X-ray single-crystal diffraction study on a crystal fragment  $150 \times 80 \times 10 \text{ \mu m}$  shows the mineral is triclinic, space group  $PT$ ;  $a = 7.8702(7)$ ,  $b = 15.8081(6)$ ,  $c = 6.6389(14) \text{ \AA}$ ,  $V = 821.06 \text{ \AA}^3$ ;  $Z = 8$ . The crystal structure of magnesiokoritnigite [refined to  $R_1 = 0.0574$  for 2360 unique  $F > 4\sigma(F)$  reflections] is isostructural with those of koritnigite and cobaltkoritnigite and consists of zigzag edge-sharing chains of  $\text{MgO}_5(\text{H}_2\text{O})$  octahedra running parallel to  $[10\bar{1}]$  that are joined by corner-sharing with  $\text{AsO}_3(\text{OH})$  tetrahedra to form sheets parallel to  $\{010\}$ . Sheets are linked in the  $[010]$  direction only by hydrogen bonds. The mineral is named as the Mg analog of koritnigite. One holotype and two cotype specimens are deposited in the Natural History Museum of Los Angeles County, Los Angeles, California, U.S.A. **F.C.**

### MÖSSBAUERITE\*

J.-M.R. Génin, S.J. Mills, A.G. Christy, O. Guérin, A.J. Herbillon, E. Kuzmann, G. Ona-Nguema, C. Ruby, and C. Upadhyay (2014) Mössbauerite,  $\text{Fe}_6^{3+}\text{O}_4(\text{OH})_8[\text{CO}_3] \cdot 3\text{H}_2\text{O}$ , the fully oxidized 'green rust' mineral from Mont Saint-Michel Bay, France. *Mineralogical Magazine*, 78(2), 447–465.

Mössbauerite (IMA 2012-049), ideally  $\text{Fe}_6^{3+}\text{O}_4(\text{OH})_8[\text{CO}_3] \cdot 3\text{H}_2\text{O}$ , is a new mineral found in intertidal gleys from Mont Saint-Michel Bay, France, where it occurs intimately intergrown with trébeurdenite along with quartz, feldspars, and clay minerals as a consequence of the oxidation of the other members of the fougèrite group. It forms micrometer-scale platelets in gleys with restricted access to atmospheric O and decomposes rapidly when exposed to air. Mössbauerite has not been identified visually but individual crystallites in pure synthetic material are  $<0.2 \text{ \mu m}$  wide and show distinct hexagonal outlines in TEM images, where the forms  $\{001\}$ ,  $\{100\}$ , or  $\{110\}$  can be discerned. Pure synthetic mössbauerite is orange in color. Detailed optical and other physical properties could not be determined because of the small platelet size and instability. Mohs hardness is probably 2–3.  $D_{\text{calc}} = 2.950 \text{ g/cm}^3$ . It was not possible to analyze natural mössbauerite directly, as it is inevitably intergrown with the closely related mineral trébeurdenite. Chemical analyses of areas approximately  $0.5 \text{ mm} \times 0.4 \text{ mm}$  on a pressed chip of the gley yielded totals of 55–64%. Synchrotron X-ray data indicate that the natural material is a nanoscale intergrowth of  $2T$  and  $3T$  polytypes; the latter probably has the  $3T_7$  stacking sequence. The corresponding maximum possible space group symmetries are  $P\bar{3}m1$  and  $P3m1$ , respectively. The strongest lines of the X-ray powder diffraction pattern of synthetic mössbauerite- $3T$  [ $d$  (°);  $hkl$ ] are: 22.79 (80; 001), 7.471 (81; 003), 2.806 (5; 008), 2.663 (5; 010), 2.557 (38; 012), 2.263 (16; 015) and 1.482 (5; 00.15). Unit-cell parameters refined from the powder data are:  $a = 3.032(17)$ ,  $c = 22.258(4) \text{ \AA}$ , and  $V = 177.17 \text{ \AA}^3$ . Mössbauer spectroscopy at 78 K indicates that two distinct  $\text{Fe}^{3+}$  environments exist in a 2:1 ratio, interpreted to be ordered within each layer, but without the development of a three-dimensional super lattice. Mössbauerite undergoes gradual magnetic ordering at 70–80 K to a ferromagnetic state. It is inferred that there is short-range coupling of interlayer carbonate anions with respect to the octahedral layers while a 2D long-range order of carbonates in interlayers remains unchanged. Mössbauerite is a layered double

hydroxide (LDH) mineral, with a structure in which  $\text{Fe}^{3+}$  cations in the center of octahedra with ( $\text{OH}^-$  and  $\text{O}^{2-}$ ) anions lying at vertices share edges to form a stacking of brucite-like layers with a net positive charge, with carbonate and water in the interlayers. Carbonate "green rust" with varying overall oxidation ratio corresponds to intimate mixtures of three fixed-composition phases with  $x = \text{Fe}^{3+}/(\text{Fe}^{2+} + \text{Fe}^{3+}) = 1/3, 2/3, \text{ and } 1$ . The formulas of these phases all correspond to  $\text{Fe}_{6-6x}^{2+}\text{Fe}_{6x}^{3+}\text{O}_{4x}(\text{OH})_{12-4x}(\text{CO}_3) \cdot 3\text{H}_2\text{O}$  and correspond to fougèrite ( $x = 1/3$ ), trébeurdenite ( $x = 2/3$ ), and mössbauerite ( $x = 1$ ), which form the fougèrite group of the hydroxalite supergroup. The mineral is named after Rudolf Ludwig Mössbauer (1928–2011) who discovered the resonance of  $\gamma$  rays that bears his name, for which he was awarded the 1961 Nobel Prize in physics. Without this technique, the very existence of this mineral in gleys and the true nature of the "green rust" compounds could not be understood. One wet holotype sample sealed in a glass jar is preserved in the collections of Museum Victoria, Melbourne, Australia. Other samples are now hosted in the Mineralogical Museum of Eötvös University (Budapest, Hungary), the Mineralogical Collection of the École des Mines (Paris, France), and the Collection of the Université Catholique de Louvain-la Neuve (Belgium). **F.C.**

### SHIMAZAKIITE\* (4M AND 4O POLYTYPES)

I. Kusachi, S. Kobayashi, Y. Takeuchi, Y. Nakamuta, T. Nagase, K. Yokoyama, K. Momma, R. Miyawaki, M. Shigeoka, and S. Matsubara (2013) Shimazakiite-4M and shimazakiite-4O,  $\text{Ca}_2\text{B}_2\text{O}_5$ , two polytypes of a new mineral from Fuka, Okayama Prefecture, Japan. *Mineralogical Magazine*, 77(1), 93–105.

The new mineral shimazakiite (IMA 2010-085a), ideally  $\text{Ca}_2\text{B}_2\text{O}_5$ , was discovered in two polytypes: shimazakiite-4M and shimazakiite-4O in an irregular vein in crystalline limestone near gehlenite-spurrite skarns at Fuka mine, Okayama Prefecture, Japan. The mineral is closely associated with takedaite and calcite formed during the post-metasomatic stage of primary skarn mineralization. Associated minerals include sibirskite, parasibirskite, olshanskyite, nifontovite, and an uncharacterized hydrous calcium borate. Gehlenite and spurrite occur as pyrometasomatic alteration products of the limestone. Shimazakiite forms aggregates up to 3 mm where shimazakiite-4M tends to occur in nanometer-sized twin lamellae and shimazakiite-4O in micrometer-sized lamellae. The new mineral is grayish white with white streak and vitreous luster. It is brittle with an uneven fracture and with no observed cleavage. The microhardness  $\text{VHN}_{50} = 549$  (516–566) for shimazakiite-4M and 598 (480–701)  $\text{kg/mm}^2$  for shimazakiite-4O, corresponding to  $\sim 4$  of the Mohs scale. For shimazakiite-4O  $D_{\text{meas}} = 2.81(2) \text{ g/cm}^3$  (by flotation in Clerici solution) while for shimazakiite-4M it was not measured due to the paucity of pure material;  $D_{\text{calc}} = 2.78$  and  $2.77 \text{ g/cm}^3$  respectively. Both polytypes are transparent in the transmitted light with no pleochroism. The mineral is biaxial (–),  $\alpha = 1.586(2)$ ,  $\beta = 1.650(2)$ ,  $\gamma = 1.667(2)^\circ$ ,  $2V_{\text{calc}} = 53^\circ$  for shimazakiite-4M and  $\alpha = 1.584(2)$ ,  $\beta = 1.648(2)$ ,  $\gamma = 1.670(2)^\circ$ ,  $2V_{\text{calc}} = 54.88^\circ$  for shimazakiite-4O ( $\lambda = 589 \text{ nm}$ ). No fluorescence was observed. The IR spectrum of shimazakiite-4M has an OH-stretching band at  $3440 \text{ cm}^{-1}$ , and strong bands 1360, 1170, 1000, 730,

680, 620, and 320  $\text{cm}^{-1}$  due to the borate group. The means of electron probe WDS analyses (28 for 4*M* and 25 for 4*O* polytypes) are respectively [wt% (range)]: CaO 61.09 (60.51–61.46) and 61.30 (60.85–61.50), B<sub>2</sub>O<sub>3</sub> 36.39 (34.61–37.76) and 36.51 (35.61–37.35), H<sub>2</sub>O (by stoichiometry) 1.19 and 1.20; total 98.67 and 99.01. The empirical formulas on the basis of 5 O apfu are Ca<sub>2</sub>B<sub>1.92</sub>O<sub>4.76</sub>(OH)<sub>0.24</sub> for both polytypes. Chemically shimazakiite varies from almost no H<sub>2</sub>O and no B deficiency compositions to those with a B deficiency and corresponding H<sub>2</sub>O content. The low analytical total for the B-deficient material suggests substitution of 3(OH)<sup>-</sup> for (BO<sub>3</sub>)<sup>-</sup>. Therefore the formula can be written as Ca<sub>2</sub>B<sub>2-x</sub>O<sub>5-3x</sub>(OH)<sub>3x</sub>, with  $x = 0-0.2$ . The strongest lines of the powder-diffraction pattern obtained using Gandolfi camera with  $d = 114.6$  mm are [ $d$  Å ( $I\%$ ;  $hkl$ )]: 6.03 (27; 011), 3.84 (30; 014), 3.02 (84; 022), 2.92 (100; 104), 2.81 (56; 104), 2.76 (32; 113), 1.880 (32; 118, 126, 126, 118) for shimazakiite-4*M* and 6.03 (19; 011), 3.84 (33; 014), 3.02 (42; 022), 2.86 (100; 104), 2.79 (29; 113), 1.903 (44; 126, 118) for shimazakiite-4*O*. The single-crystal X-ray diffraction studies on a crystals of 0.2 × 0.1 × 0.03 mm show for shimazakiite-4*M*, the space group  $P2_1/c$ ,  $a = 3.5485(12)$ ,  $b = 6.352(2)$ ,  $c = 19.254(6)$  Å,  $\beta = 92.393(13)^\circ$ ,  $V = 433.6$  Å<sup>3</sup>,  $Z = 4$ . For shimazakiite-4*O*, the space group  $P2_12_12_1$ ,  $a = 3.55645(8)$ ,  $b = 6.35194(15)$ ,  $c = 19.2534(5)$  Å,  $V = 434.941$  Å<sup>3</sup>. The crystal structure of shimazakiite [refined to  $R_1 = 0.1273$  and 0.0142 for 843 and 995 unique  $I > 2\sigma(I)$  reflections respectively for 4*M* and 4*O* polytypes] consists of a layer containing B<sub>2</sub>O<sub>5</sub> units (two near-coplanar triangular corner-sharing BO<sub>3</sub> groups) and sixfold- and sevenfold-coordinated Ca atoms. Different sequences in the  $c$  direction of four layers are observed in the polytypes. The name is for Hidehiko Shimazaki (b. 1939), Emeritus Professor at the University of Tokyo, in recognition of his outstanding contribution to skarn mineralogy. The type specimen of shimazakiite has been deposited in the collections of the National Museum of Nature and Science, Tokyo, Japan. **D.B.**

### TAKANAWAITE-(Y)\*

D. Nishio-Hamane, T. Minakawa, and Y. Ohgoshi (2013) Takanawaite-(Y), a new mineral of the M-type polymorph with Y(Ta,Nb)O<sub>4</sub> from Takanawa Mountain, Ehime Prefecture, Japan. *Journal of Mineralogical and Petrological Sciences*, 108(6), 335–344.

Takanawaite-(Y) (IMA 2011-099), a new natural monoclinic polymorph of Y(Ta,Nb)O<sub>4</sub> was discovered at Takanawa Mountain, Ehime Prefecture, Japan. It was found in allanite-fergusonite-zircon-biotite pegmatites within the granites. The new mineral is closely associated with gadolinite-(Y) and zircon at the boundary between quartz and feldspar. Other associated minerals include muscovite and allanite-(Ce). Takanawaite-(Y) forms dark brown submetamict single crystals of a tabular habit up to 5 mm or radial aggregates of fine crystals. The internal cracks in the crystals are filled with Ca- and Ta-rich oxide. The crystals are of {010} habit with {100} and {001} forms and are striated along [101] on {010} faces. The fracture is conchoidal and no cleavage observed (result of metamictization). The Mohs hardness is 5½;  $D_{\text{calc}} = 6.97$  g/cm<sup>3</sup>. No other physical properties given. The average of 5 electron probe EDS analyses [wt% (range)] is: Y<sub>2</sub>O<sub>3</sub> 27.07 (26.46–27.67), Gd<sub>2</sub>O<sub>3</sub> 1.16 (0.36–2.50),

Dy<sub>2</sub>O<sub>3</sub> 4.64 (3.60–5.50), Yb<sub>2</sub>O<sub>3</sub> 2.90 (1.40–4.50), UO<sub>2</sub> 2.77 (2.40–3.31), TiO<sub>2</sub> 0.51 (0.37–0.68), FeO 0.39 (0.26–0.58), Nb<sub>2</sub>O<sub>5</sub> 19.22 (18.43–19.63), Ta<sub>2</sub>O<sub>5</sub> 40.49 (40.10–41.27), total 99.15. The empirical formula of takanawaite-(Y) based on 4 O apfu is (Y<sub>0.75</sub>Dy<sub>0.08</sub>Yb<sub>0.05</sub>Gd<sub>0.02</sub>U<sub>0.03</sub>Ti<sub>0.02</sub>Fe<sub>0.02</sub>)<sub>Σ0.97</sub>(Ta<sub>0.57</sub>Nb<sub>0.45</sub>)<sub>Σ1.02</sub>O<sub>4</sub>. The Ta/(Ta+Nb) ratio varies between 0.55 and 0.57. The X-ray powder diffraction pattern before the heating is extremely broad with a few intensities at ~3.0, 2.6, 1.8, and 1.6 Å considered to be a traces of *M* phase. After the heating in air at 600 °C for 24 h, the powder turned to reddish-brown. The reflections appeared in XRD pattern were indexed in tetragonal unit-cell, space group  $P4_2/nmc$ ,  $a = 3.658(4)$ ,  $c = 5.393(9)$  Å [*T'* phase which differs from formanite-(Y)]. After the heating in air at 1000 °C for 24 h, the powder turned to dull pale green and XRD pattern became consistent (after subtracting peaks of calcitantite and microlite) with monoclinic (*M*) phase, space group  $I2/a$ , unit-cell parameters  $a = 5.3182(8)$ ,  $b = 10.9583(13)$ ,  $c = 5.0595(7)$  Å,  $\beta = 94.993(14)^\circ$ ,  $V = 293.74(7)$  Å<sup>3</sup>,  $Z = 4$  ( $D_{\text{calc}} = 6.97$  g/cm<sup>3</sup>). The strongest lines of that powder XRD pattern [ $d$  Å, ( $I\%$ ;  $hkl$ )] are 3.133 (100; 121), 2.953 (85; 121), 2.739 (29; 040), 2.649 (21; 200), 1.912 (24; 202), 1.905 (39; 240), 1.855 (26; 042), 1.568 (19; 242). Another monoclinic (*M'*) phase equal to the mineral iwashiroite-(Y) did not appear during the experiment. After a consecutive 24 h reheating at 600 °C, the *T'* phase did not reappear indicating its metastability and XRD pattern showed only the presence of *M* phase. The results of X-ray powder diffraction study were confirmed by TEM electron diffraction. Several monoclinic phases crystallized after heating metamict YTaO<sub>4</sub> at 900 to 1000 °C were previously described as formanite-(Y): from Siberia, Russia (Kornetsova and Kazakova, 1964); from type locality of formanite-(Y) (Lima de Faria 1964); from amazonite pegmatite of Western Keivy, Kola Peninsula, Russia (Voloshin et al. 2003). The XRD pattern and composition for the last one show the similarity to takanawaite-(Y) as defined here. The mineral was named after its type locality. The type specimen is deposited at the National Museum of Nature and Science, Tokyo, Japan. **D.B.**

**Comment:** The relationships between natural Y(Ta,Nb)O<sub>4</sub> polymorphs are still not completely clear. Formanite-(Y) described as tetragonal (Palache et al. 1944) was later mentioned as monoclinic (see above) and also described by Shi and Peng (1981, not cited in the abstracted paper) from Gan Xian, Jiangxi Province, China, with unit-cell parameters and space group identical (heated and unheated) to a later described iwashiroite-(Y). The space group for an orthorhombic(?) ytrotantalite-(Y) remains unknown. The study of type specimens is required to clear. The case is particularly tangled since in most cases the natural material is metamictic.

### References cited

- Hori, H., Kobayashi, T., Miyawaki, R., Matsubara, S., Yokoyama, K., and Shimizu, M. (2006) Iwashiroite-(Y), YTaO<sub>4</sub> a new mineral from Suishoyama, Kawamata Town, Fukushima Prefecture, Japan. *Journal of Mineralogical and Petrological Sciences*, 101, 170–177.
- Lima de Faria, J. (1964) Identification of metamict minerals by X-ray powder photographs. *Junta de Investigações do Ultramar, Estudos, Ensaios e Documentos*, 112, 1–130.
- Kornetsova, V.A., and Kazakova, M.E. (1964) Discovery of formanite in the USSR. *Doklady Akademii Nauk SSSR*, 154, 359–362 (in Russian).
- Palache, C., Berman, H., and Frondel, C. (1944) Dana's System of Mineralogy,

7th ed., Vol. I, p. 757–763. Wiley, New York.

- Shi, N., and Peng, Z. (1981) Mineralogical investigation on formanite. Chinese Science Bulletin (Kexue Tongbao), 26(6), 548–551 (in English).
- Voloshin, A.V., Lyalina, L.M., Savchenko, Ye.E., and Bogdanova, A.N. (2003) Formanite-(Y) from amazonite randpegmatites of Western Keivy Tundras (Kola Peninsula). Zapiski Vserossiyskogo Mineralogicheskogo Obshchestva, 132, 82–94 (in Russian with English abstract).

### VEBLENITE\*

- F. Cámara, E. Sokolova, F.C. Hawthorne, R. Rowe, J.D. Grice, and K.T. Tait (2013) Veblenite,  $K_2\Box_2Na(Fe_3^{2+}Fe_4^{3+}Mn_7^{2+}\Box)Nb_3Ti(Si_2O_7)_2(Si_8O_{22})_2O_6(OH)_{10}(H_2O)_3$ , a new mineral from Seal Lake, Newfoundland and Labrador: mineral description, crystal structure, and a new veblenite  $Si_8O_{22}$  ribbon. Mineralogical Magazine, 77(7), 2955–2974.

The new mineral veblenite (IMA 2010-050), ideally  $K_2\Box_2Na(Fe_3^{2+}Fe_4^{3+}Mn_7^{2+}\Box)Nb_3Ti(Si_2O_7)_2(Si_8O_{22})_2O_6(OH)_{10}(H_2O)_3$  was discovered in the holotype specimen of niobophyllite #M26148 (Royal Ontario Museum, Toronto, Canada) originated from Ten Mile Lake, Seal Lake area, Newfoundland, and Labrador, Canada. Veblenite occurs in a band of paragneiss (consisting mostly of albite and arfvedsonite) among interbedded volcanic rocks and gneisses intruded by alkaline syenite. It forms red-brown single laths and fibers up to a few hundreds of micrometers long in albite. Associated minerals include niobophyllite, aegirine-augite, barylite, eudymite, neptunite, Mn-rich pectolite, pyrochlore, sphalerite, and galena. Veblenite is translucent with a very pale brown streak and a vitreous luster. It has a perfect cleavage on  $\{001\}$ , splintery fracture and no parting. The hardness and density were not measured;  $D_{calc} = 3.046 \text{ g/cm}^3$ . No fluorescence under 240–400 nm UV radiation was observed. In the transmitted light the mineral is pleochroic  $X$  and  $Y = \text{black} > Z = \text{orange-brown}$ . It is biaxial (–) with  $\alpha = 1.676(2)$ ,  $\beta = 1.688(2)$ ,  $\gamma = 1.692(2)^\circ$  ( $\lambda = 590 \text{ nm}$ ),  $2V_{meas} = 65(1)^\circ$ ,  $2V_{calc} = 59.6^\circ$ , and no discernible dispersion. Optical orientation is:  $X^{\wedge}a = 87.8^\circ$ ,  $X^{\wedge}b = 92.3^\circ$ ,  $X^{\wedge}c = 126.7^\circ$ ,  $Y^{\wedge}a = 96.0^\circ$ ,  $Y^{\wedge}b = 168.2^\circ$ ,  $Y^{\wedge}c = 36.9^\circ$ ,  $Z^{\wedge}a = 173.6^\circ$ ,  $Z^{\wedge}b = 78.5^\circ$ ,  $Z^{\wedge}c = 93.0^\circ$ . The IR spectrum of veblenite shows bands ( $\text{cm}^{-1}$ ): broad with maximum at 3525 (OH and  $H_2O$  groups); 1637 (H-O-H bending); sharp intense at 958 with shoulders at 1070, 1031, and 908 (stretching modes of the  $SiO_4$  groups); weak at 654, 550, 531, and 453 (lattice modes). The chemical composi-

tion by electron probe in WDS mode (number of analyses and ranges are not given) is (wt%):  $Nb_2O_5$  11.69,  $TiO_2$  2.26,  $SiO_2$  35.71,  $Al_2O_3$  0.60, FeO total 20.94 [FeO 11.58, and  $Fe_2O_3$  10.40 (calculated from the structure refinement)], MnO 12.84, ZnO 0.36, MgO 0.08, BaO 1.31, SrO 0.09, CaO 1.49,  $Cs_2O$  0.30,  $K_2O$  1.78,  $Na_2O$  0.68,  $H_2O$  (by structure refinement) 4.39, F 0.22,  $-O=F_2$  0.09, total 95.69. Li and Be were sought by LA-ICP-MS but not detected. The low total is probably due to the thinness of the crystal. The empirical formula based on 20 (Al+Si) pfu is  $(K_{0.53}Ba_{0.28}Sr_{0.03}\Box_{0.16})_{\Sigma 1}(K_{0.72}Cs_{0.07}\Box_{1.21})_{\Sigma 2}(Na_{0.72}Ca_{0.17}\Box_{1.11})_{\Sigma 2}(Fe_{5.32}^{2+}Fe_{4.13}^{3+}Mn_{5.97}^{2+}Ca_{0.70}Zn_{0.15}Mg_{0.07}\Box_{0.66})_{\Sigma 17}(Nb_{2.90}Ti_{0.93}Fe_{0.17}^{3+})_{\Sigma 4}(Si_{19.61}Al_{0.39})_{\Sigma 20}O_{77.01}H_{16.08}F_{0.38}$ . The simplified formula is  $(K, Ba, \Box)_3(\Box, Na)_2(Fe^{2+}, Fe^{3+}, Mn^{2+})_{17}(Nb, Ti)_4(Si_2O_7)_2(Si_8O_{22})_2O_6(OH)_{10}(H_2O)_3$ . The strongest lines of the X-ray powder diffraction pattern [ $d$  Å ( $hkl$ )] are: 16.89 (100; 010), 18.20 (23; 0 $\bar{1}$ 1), 11.66(8)(001), 4.271 (9;  $1\bar{4}1, 040$ ), 4.404 (3;  $1\bar{3}2, 1\bar{4}2$ ), 4.056 (3; 031,  $1\bar{1}2, 1\bar{5}2$ ), 2.721 (3;  $1\bar{9}5$ ), 3.891 (2; 003). The triclinic unit-cell dimensions refined from a powder data are:  $a = 5.41(3)$ ,  $b = 27.36(5)$ ,  $c = 18.62(3)$  Å,  $\alpha = 140.17(8)$ ,  $\beta = 93.3(2)$ ,  $\gamma = 95.6(1)^\circ$ ,  $V = 1719 \text{ Å}^3$ . The cell parameters obtained from X-ray single crystal study are:  $a = 5.3761(3)$ ,  $b = 27.5062(11)$ ,  $c = 18.6972(9)$  Å,  $\alpha = 140.301(3)$ ,  $\beta = 93.033(3)$ ,  $\gamma = 95.664(3)^\circ$ ,  $V = 1720.96 \text{ Å}^3$ ;  $Z = 1$ . The crystal structure was solved in space group  $P\bar{1}$  by direct methods and refined to  $R_1 = 9.09\%$  for 3329 independent reflections with  $F_o > 4\sigma F$ . In veblenite, the main structural unit is an *HOH* layer, which consists of the octahedral (*O*) and two heteropolyhedral (*H*) sheets. The *H* sheet is composed of  $Si_2O_7$  groups, veblenite  $Si_8O_{22}$  ribbons and Nb-dominant *D* octahedra. This is the first occurrence of an eight-membered  $Si_8O_{22}$  ribbon in a mineral crystal structure. In the *O* sheet,  $(Fe^{2+}, Fe^{3+}, Mn^{2+})$  octahedra share common edges to form a modulated *O* sheet parallel to (001). *HOH* layers connect via common vertices of *D* octahedra and cations at the interstitial *A*(1,2) and *B* sites. In the intermediate space between two adjacent *HOH* layers, the *A*(1) site is occupied mainly by K; the *A*(2) site is partly occupied by K and  $H_2O$  groups, the *B* site is partly occupied by Na. The crystal structure of veblenite is related to several *HOH* structures: jinshajiangite, niobophyllite (astrophyllite group), and nafertisitite. The mineral is named in honor of David R. Veblen (b. 1947) in recognition of his outstanding contributions to the fields of mineralogy and crystallography. **D.B.**