

## New Mineral Names\*

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In this New Mineral Names, we present alexandrovite, arsenohopeite, åskagenite-(Nd), bassoite, beaverite-Zn, carlosbarbosaite, cryptophyllite, cuprokalinitite, davidlloydite, florencite-(Sm), natrotitanite, and shlykovite from journals around the world.

#### ALEXANDROVITE\*

L.A. Pautov, A.A. Agakhanov, V.Yu. Karpenko, and F.G. Gafurov (2010) Aleksandrovite  $\text{KLi}_3\text{Ca}_7\text{Sn}_2[\text{Si}_6\text{O}_{18}]_2\text{F}_2$ —a new tin mineral. *Novye dannye o mineralakh*, 45, 5–16 (in Russian). *New data on minerals*, 45, 5–16 (in English).

A new member of proposed baratovite group, alexandrovite (the tin analogue of baratovite) was discovered at the Darai-Pioz glacier, at the junction of Turkestan, Zeravshan, and Alay Mt. Ranges (Tajikistan) in a zonal microcline-calcite vein with aegirine-hedenbergite, quartz, and albite in a moraine boulder of intensively altered clay schist. Alexandrovite found within that vein in one of fine-grained quartz–albite segregations with miserite. Other associated minerals are: baratovite, katayamalite, Zr- and hydroxyl-analogues of alexandrovite, fluorite, Sn-titanite, bazirite, pabstite, Sn-sogdianite, sugilite, turkestanite, and fluorapatite. The new mineral occurs as a lamellae up to 50–70  $\mu\text{m}$  with no detectable zoning and as zoned crystals up to 0.8 mm and aggregates of zoned and sectorial grains where separate zones represented by alexandrovite, baratovite, or katayamalite. All data on physical properties of alexandrovite were obtained on un-zoned grains. The mineral is colorless, transparent, vitreous, or pearly on cleaved surfaces. It has a white streak, perfect cleavage by  $\{001\}$ , Mohs hardness 4–4.5,  $\text{VHN}_{50} = 300$  (276–319)  $\text{kg}/\text{mm}^2$ ,  $D_{\text{meas}} = 3.05(2)$ ,  $D_{\text{calc}} = 3.07(2)$   $\text{g}/\text{cm}^3$ . The mineral fluoresces light-blue under short-wave (254 nm) UV radiation. Alexandrovite is biaxial, optically negative,  $\alpha = 1.629(2)$ ,  $\beta = 1.635(4)$ ,  $\gamma = 1.638(2)$  (for  $\lambda = 589$  nm),  $2V_{\text{calc}} = -70.3^\circ$ . Dispersion of optical axes is strong,  $r > v$ ; elongation is positive. The IR spectrum is very similar to baratovite; the major absorption bands are ( $\text{cm}^{-1}$ ): 1084, 1024, 974, 950, 673, 607, 568, 520, 470, and 440. Chemical composition was determined by EDS on a CamScan 4D and by WDS on Camebax microbeam microprobe. The content of Li was measured using ICP OES Vista MPX. For un-zoned grains the

average (range) of 17 analyses gave:  $\text{SiO}_2 = 48.01$  (47.32–48.79),  $\text{Al}_2\text{O}_3 = 0.07$  (0.01–0.27),  $\text{TiO}_2 = 2.86$  (0.88–3.89),  $\text{SnO}_2 = 12.84$  (10.73–16.03),  $\text{ZrO}_2 = 1.27$  (0.18–3.01),  $\text{Nb}_2\text{O}_5 = 0.11$  (0.00–0.28),  $\text{Fe}_2\text{O}_3 = 0.27$  (0.01–0.74),  $\text{Ce}_2\text{O}_3 = 0.04$  (0.00–0.23),  $\text{MgO} = 0.05$  (0.01–0.25),  $\text{CaO} = 25.52$  (24.98–25.87),  $\text{SrO} = 0.39$  (0.01–0.48),  $\text{Na}_2\text{O} = 0.20$  (0.01–0.56),  $\text{K}_2\text{O} = 2.91$  (2.76–3.06),  $\text{Li}_2\text{O} = 3.01$ ,  $\text{F} = 1.71$  (1.10–2.01),  $\text{H}_2\text{O}$  (calculated) = 0.39,  $(-\text{O} = \text{F}_2) = -0.72$ , total 99.10 wt%. The empirical formula of alexandrovite based on 38 anions  $(\text{K}_{0.93}\text{Na}_{0.10})_{1.03}\text{Li}_{3.02}(\text{Ca}_{6.82}\text{Sr}_{0.06}\text{Mn}_{0.04}\text{Mg}_{0.02})_{\Sigma 6.94}(\text{Sn}_{1.28}\text{Ti}_{0.54}\text{Zr}_{0.15}\text{Fe}_{0.05}\text{Nb}_{0.01})_{\Sigma 2.03}(\text{Si}_{11.98}\text{Al}_{0.02})_{12}\text{O}_{36.00}[\text{F}_{1.35}(\text{OH})_{0.65}]_{2.00}$ . Idealized formula:  $\text{KLi}_3\text{Ca}_7\text{Sn}_2\text{Si}_{12}\text{F}_2$ . The chemistry of zoned crystals was studied by EMPA and shows a wide isomorphism of octahedral cations: Ti, Sn, and Zr. Some analysis shows the presence of Zr analog of baratovite and alexandrovite. The content of additional anions (F, OH) also varies. The brief historical review of baratovite and its hydroxyl analogue katayamalite is given in the paper. A few analysis of alexandrovite show the predominance of OH group over F. Formally it is the hydroxyl analogue of alexandrovite. The Zr-OH analogue might be found potentially. It is suggested to unify those known and potential new minerals into the baratovite group. Powder X-ray data were obtained using powder diffractometer DRON-2 (filtered  $\text{FeK}\alpha_1$  radiation) and Debye-Scherrer camera  $D = 57.3$  mm. The strongest lines on the diffraction pattern [ $d_{\text{obs}}$  in  $\text{Å}$  ( $I_{\text{obs}}$ ,  $hkl$ )] include: 4.86 (21, 31 $\bar{1}$ ), 3.712 (33, 312), 3.234 (100, 006), 3.206 (34, 223), 3.039 (28, 025), 2.894 (42, 314), 2.425 (42, 008), 1.950 (25, 426). The powder pattern is very similar to that of baratovite and was indexed by analogy with it in monoclinic system, space group  $C2/c$ . The unit-cell parameters:  $a = 17.01(2)$ ,  $b = 9.751(6)$ ,  $c = 21.00(2)$   $\text{Å}$ ,  $\beta = 112.45(8)^\circ$ ,  $V = 3219(7)$   $\text{Å}^3$ ,  $Z = 4$ . The mineral is named in honor of the well-known Russian geochemist, geologist, and mineralogist Stanislav Mikhailovich Aleksandrov (born in 1932) for his great contribution in geology, geochemistry, and mineralogy of tin. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2009-004). The holotype specimen has been deposited at the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow. **D.B.**

\*All minerals marked with an asterisk have been approved by the IMA CNMNC.

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## ARSENOHOPEITE

F. Neuhold, U. Kolitsch, H.-J. Bernhardt, and C.L. Lengauer (2012) Arsenohopeite, a new zinc arsenate mineral from the Tsumeb mine, Namibia. *Mineral. Mag.*, 76(3), 603–612.

Electron microprobe analysis yielded: ZnO 44.92, Fe<sub>2</sub>O<sub>3</sub> 0.92, MnO 0.51, MgO 0.20, CuO 0.02, As<sub>2</sub>O<sub>5</sub> 45.84 (wt%), corresponding to (Zn<sub>2.80</sub>Fe<sub>0.06</sub>Mn<sub>0.04</sub>Mg<sub>0.03</sub>)Σ2.93(As<sub>1.01</sub>O<sub>4</sub>)<sub>2</sub>·4H<sub>2</sub>O, on the basis of 12 oxygen atoms. Arsenohopeite occurs as a single colorless to blue polycrystalline grain, with some indistinct crystal faces. The streak is white, the luster vitreous. It is brittle, and with cleavage perfect on {010}, good on {100} and poor on {001}.  $H \sim 3$ ,  $D_{\text{calc}} = 3.42 \text{ g/cm}^3$  ( $Z = 4$ ). Optically, it is biaxial negative, not pleochroic and not fluorescent (in sw- and lw-ultraviolet light), with  $\alpha = 1.598(2)$ ,  $\beta = 1.606(2)$ , and  $\gamma = 1.613(2)$  (spindle stage), and  $2V_{\text{calc}} = 86^\circ$ . The crystal structure of arsenohopeite was solved by direct methods and refined in the space group  $Pnma$  to  $R_1 = 0.0353$ , with  $a = 10.804(2)$ ,  $b = 19.003(4)$ ,  $c = 5.112(1) \text{ \AA}$ , and  $V = 1049.5(4) \text{ \AA}^3$ . All hydrogen atoms but one were located and their position refined. Hydrogen bonding topology leads to a weak hydrogen bond scheme, as confirmed by Raman spectroscopy. Zinc is present both in octahedral and tetrahedral coordination. Strongest calculated powder diffraction lines are [ $D_{\text{obs}}$  in  $\text{Å}$  ( $I_{\text{obs}}$ ,  $hkl$ ): 9.502 (100, 020), 2.926 (95, 241), 4.937 (50, 011), 4.110 (48, 230), and 3.567 (31, 240).

Arsenohopeite is a supergene mineral formed by alteration of tennantite-rich ore in the oxidized zone of the famous Tsumeb mine, a dolostone hosted polymetallic hydrothermal ore deposit at Tsumeb, Namibia. It is associated to other supergene zinc- and arsenic-bearing minerals that are typical of the mine including köttigite, adamite, leiteite, and schneiderhöhnite. Precise origin of the type material (acquired by one of the authors contained in a vial) and the exact locality in Tsumeb is not known. The mineral name is for the relationship to hopeite [Zn<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>·4H<sub>2</sub>O] (IMA 2010-069). The hydrogen-bonding scheme in arsenohopeite recalls that of the  $\alpha$ -hopeite, while a synthetic triclinic polymorph of arsenohopeite is known and a copper-bearing one has been recently described as davidlloydite. Type material is deposited in the collection of the Natural History Museum, Vienna, Austria (N 8167). **F.C. and G.D.G.**

## ÅSKAGENITE-(Nd)\*

N.V. Chukanov, J. Göttlicher, S. Möckel, Z. Sofer, K.V. Van, and D.I. Belakovskiy (2010) Åskagenite-(Nd) Mn<sup>2+</sup>NdAl<sub>2</sub>Fe<sup>3+</sup>(Si<sub>2</sub>O<sub>7</sub>)(SiO<sub>4</sub>)O<sub>2</sub>, a new mineral of the epidote supergroup. *Novye dannye o mineralakh*, 45, 17–22 (in Russian). *New data on minerals*, 45, 17–22 (in English).

A new member of epidote supergroup åskagenite-(Nd) was discovered in the specimens collected in the beginning of the 20th century from a granite pegmatite in a small pit near Åskagen quarry, mining village Torskebäcken about 12 km east of Filipstad, Värmland, Sweden. Åskagenite-(Nd) found in association with potassic feldspar, quartz, bastnäsite, thorite, Nd-dominant analogue of allanite-(Ce), brookite, gadolinite-(Y), and allophane. The new mineral forms coarse prismatic, sometimes flattened crystals with rectangular outlines up to 1 × 4 cm in size. Åska-

genite-(Nd) is black (brown in translucent thin fragments), resinous with a brown streak. It is brittle with Mohs hardness 6. The fracture is conchoidal with no cleavage observed.  $D_{\text{meas}} = 3.737(5)$  (for a metamict sample);  $D_{\text{calc}} = 4.375 \text{ g/cm}^3$  (for a sample heated at 600 °C during 1 hour in nitrogen). Åskagenite-(Nd) is optically isotropic,  $n = 1.712(2)$ . The mineral is slightly radioactive. The IR spectrum of åskagenite-(Nd) contains two strong bands ( $\text{cm}^{-1}$ ) at 469 and 1000 and a very weak band at 1623  $\text{cm}^{-1}$  (trace amounts of H<sub>2</sub>O). The absence of distinct bands in the range 550–900  $\text{cm}^{-1}$  is typical for most of metamict silicates. The IR spectrum of heated åskagenite-(Nd) is similar to the spectra of allanite group minerals. Chemical composition was determined by EDS on Tescan Vega II XMU electron microscope. The water content was obtained by Alimarin method. The ratio Fe<sup>+3</sup>/Fe<sup>+2</sup> = 1.06 obtained from Mössbauer spectrum and manganese valency state Mn<sup>+2</sup> had been confirmed by XANES spectroscopic data. CO<sub>2</sub> was not analyzed because of the absence of bands corresponding to C-O vibrations on the IR spectrum. The average (range) of 4 analyses gave: CaO 0.27 (0.00–1.43), Y<sub>2</sub>O<sub>3</sub> 2.27 (2.02–2.82), La<sub>2</sub>O<sub>3</sub> 0.44 (0.40–0.49), Ce<sub>2</sub>O<sub>3</sub> 7.99 (7.83–8.15), Pr<sub>2</sub>O<sub>3</sub> 1.76 (1.47–1.90), Nd<sub>2</sub>O<sub>3</sub> 11.21 (11.06–11.45), Sm<sub>2</sub>O<sub>3</sub> 3.01 (2.823.33), Yb<sub>2</sub>O<sub>3</sub> 0.21 (0.00–0.48), ThO<sub>2</sub> 0.72 (0.58–0.77), MnO 7.98 (7.79–8.48), FeO 7.75 (15.85–16.13 for total iron measured as FeO), Fe<sub>2</sub>O<sub>3</sub> 9.16, Al<sub>2</sub>O<sub>3</sub> 15.85 (15.60–15.97), SiO<sub>2</sub> 29.51 (29.32–29.90), H<sub>2</sub>O 0.55, total 98.75 wt%. The empirical formula based on 13 atoms of oxygen is: (Mn<sub>0.69</sub><sup>2+</sup>Fe<sub>0.26</sub><sup>2+</sup>Ca<sub>0.03</sub>)Σ0.98(Nd<sub>0.41</sub>Ce<sub>0.30</sub>Y<sub>0.12</sub>Sm<sub>0.10</sub>Pr<sub>0.07</sub>La<sub>0.02</sub>Yb<sub>0.01</sub>Th<sub>0.02</sub>)Σ1.05(Al<sub>1.90</sub>Fe<sub>0.70</sub><sup>3+</sup>Fe<sub>0.40</sub><sup>2+</sup>)Σ3.00Si<sub>2.99</sub>O<sub>12.63</sub>(OH)<sub>0.37</sub>. The simplified formula: Mn<sup>2+</sup>NdAl<sub>2</sub>Fe<sup>3+</sup>(Si<sub>2</sub>O<sub>7</sub>)(SiO<sub>4</sub>)O<sub>2</sub>. X-ray powder diffraction data were collected using a PANalytical X'Pert PRO diffractometer with Soller slit and X'Cellerator detector (filtered CuK $\alpha_1$  radiation). The X-ray powder-diffraction pattern of metamict åskagenite-(Nd) contains only a broad halo with the maximum near 3 Å. After heating in a nitrogen atmosphere (heating rate 5 °C per minute up to 600 °C, then one hour at a constant temperature of 600 °C, then with rapid cooling to room temperature) the strongest lines on the diffraction pattern [ $d_{\text{obs}}$  in  $\text{Å}$  ( $I_{\text{obs}}\%$ ,  $hkl$ ): 3.50 (46,  $\bar{2}11$ ), 3.22 (50,  $\bar{2}12$ , 201), 2.897 (100,  $\bar{3}01$ ), 2.850 (73, 020), 2.687 (73, 120), 2.121 (48,  $\bar{4}03$ ), 1.630 (59, 124). The parameters of monoclinic unit-cell are:  $a = 8.78(1)$ ,  $b = 5.710(6)$ ,  $c = 10.02(1) \text{ \AA}$ ,  $\beta = 114.6(2)$ ,  $V = 456.7(8) \text{ \AA}^3$ ; space group  $P2_1/m$ ;  $Z = 2$ . According to the new rules of the standardization of mineral group hierarchies, epidote group was renamed into epidote supergroup (Mills et al. 2009), whereas clinozoisite (epidote), allanite, and dollaseite subgroups were renamed into corresponding groups. Åskagenite-(Nd) is the first representative of a new group in epidote supergroup with a general formula  $A1^{2+}A2^{3+}M1^{3+}M2^{3+}M3^{3+}(Si_2O_7)(SiO_4)O_2$ . Accordingly its empirical formula can be given as (Mn<sub>0.69</sub><sup>2+</sup>Fe<sub>0.26</sub><sup>2+</sup>Ca<sub>0.03</sub>)Σ0.98(Nd<sub>0.41</sub>Ce<sub>0.30</sub>Y<sub>0.12</sub>Sm<sub>0.10</sub>Pr<sub>0.07</sub>La<sub>0.02</sub>Yb<sub>0.01</sub>Th<sub>0.02</sub>)Σ1.05(Al<sub>1.90</sub>Fe<sub>0.70</sub><sup>3+</sup>)Σ1.00Al<sub>1.00</sub>(Fe<sub>0.60</sub><sup>3+</sup>Fe<sub>0.40</sub><sup>2+</sup>)Σ1.00Si<sub>2.99</sub>O<sub>11</sub>[O<sub>0.63</sub>(OH)<sub>0.37</sub>]Σ1.00. The name was given for the locality and reflects the predominance of Nd over other REE and Y in the site A2. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2009-073). Type material is deposited at the collections of the Technische Universität, Bergakademie Freiberg, Germany; inventory numbers are 82194 and 82218. The holotype fragment also deposited at the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow; catalog number 92949. **D.B.**

**BASSOITE\***

L. Bindi, C. Carbone, R. Cabella, and G. Lucchetti (2011) Bassoite,  $\text{SrV}_3\text{O}_7 \cdot 4\text{H}_2\text{O}$ , a new mineral from Molinello mine, Val Graveglia, eastern Liguria, Italy. *Mineral. Mag.* 75(5), 2677–2686.

Bassoite (IMA 2011-028), ideally  $\text{SrV}_3\text{O}_7 \cdot 4\text{H}_2\text{O}$ , is a new mineral from the Molinello manganese mine, Val Graveglia, eastern Liguria, northern Apennines, Italy. The name honors Riccardo Basso (b. 1947), full professor of Mineralogy and Crystallography at the University of Genova. Electron microprobe analyses produce a chemical formula ( $\text{Sr}_{0.97}\text{Ca}_{0.02}\text{Na}_{0.01}$ )  $\text{V}_{3.00}\text{O}_7 \cdot 4\text{H}_2\text{O}$ , on the basis of  $(\text{Sr}+\text{Ca}+\text{Na})=1$ , taking the results of the structure refinement into account. Bassoite is black in color and has a black streak. It is opaque with a sub-metallic luster and it is brittle without fracture or cleavage. It occurs as black euhedral to subhedral grains up to 400  $\mu\text{m}$  across, closely associated with rhodonite, quartz, and braunite. In plane-polarized incident light, bassoite is weakly birefractant and very weakly pleochroic with color varying from gray to dark green. With crossed polars, bassoite is anisotropic, without characteristic rotation tints. The density could not be determined experimentally because of the small grain size. The calculated density is  $2.940 \text{ g/cm}^3$  (on the basis of the empirical formula and X-ray single-crystal data). The micro-indentation measurements, carried out with a VHN load of 100 g, gave a mean value of  $150 \text{ kg/mm}^2$  (range: 142–165), corresponding to a Mohs hardness of 4 to 4.5. Reflectance percentages ( $R_{\text{min}}$  and  $R_{\text{max}}$ ) for the four standard COM wavelengths are 18.5%, 19.0% (471.1 nm); 17.2%, 17.8% (548.3 nm); 16.8%, 17.5% (586.6 nm); and 16.2%, 16.8% (652.3 nm), respectively. Bassoite is monoclinic, space group  $P2_1/m$ , with unit-cell parameters:  $a = 5.313(3)$ ,  $b = 10.495(3)$ ,  $c = 8.568(4)$ ,  $\beta = 91.14(5)^\circ$ ,  $V = 477.7(4) \text{ \AA}^3$ ,  $a:b:c = 0.506:1:0.816$ , and  $Z = 2$ . The crystal structure was refined to  $R1 = 0.0209$  for 1148 reflections with  $F_o > 4\sigma(F_o)$  and it consists of layers of  $\text{VO}_5$  pyramids (with vanadium in the tetravalent state) pointing up and down alternately with Sr among the layers (in ninefold coordination). The nine most intense X-ray powder-diffraction lines [ $D_{\text{obs}}$  in  $\text{Å}$  ( $I_{\text{obs}}$ ,  $hkl$ )] are: 8.5663 (100, 001); 6.6363 (14, 011); 3.4399 (14,  $\bar{1}21$ ); 3.4049 (17, 121); 2.8339 (15,  $\bar{1}22$ ); 2.7949 (11, 122); 2.6550 (15, 200); 2.6237 (11, 040), and 1.8666 (15, 240).

The crystal structure of bassoite consists of layers parallel to  $\{001\}$  consisting of edge-sharing  $\text{V}^{4+}\text{O}_5$  square pyramids, with the Sr between the layers in ninefold coordination. Holotype material is deposited in the mineralogical collection of the Dipartimento per lo Studio del Territorio e delle sue Risorse, Università di Genova, Italy, under catalogue number M0480. **K.T.**

**BEAVERITE-(Zn)**

Sato, E., Nakai, I., Terada, Y., Tsutsumi, Y., Yokoyama, K., Miyawaki, R., and Matsubara, S. (2011) Beaverite-(Zn),  $\text{Pb}(\text{Fe}_2\text{Zn})(\text{SO}_4)_2(\text{OH})_6$ , a new member of the alunite group, from Mikawa Mine, Niigata Prefecture, Japan *Mineralogical Magazine*, 75(2), 375–377.

Data reported in the publication already published in Sato et al. (2008). Electron microprobe analysis yielded: PbO 31.94,  $\text{Fe}_2\text{O}_3$  22.46, ZnO 10.15, CuO 3.59,  $\text{Al}_2\text{O}_3$  0.78,  $\text{SO}_3$  23.95,  $\text{H}_2\text{O}$  (by difference to 100%) 7.22 (wt%), corresponding to  $\text{Pb}_{0.95}(\text{Fe}_{1.88}\text{Al}_{0.10})(\text{Zn}_{0.83}\text{Cu}_{0.30})(\text{SO}_4)_2[(\text{OH})_{5.36}\text{O}_{0.38}]$ , on the basis of  $S = 2$  apfu. Ideal chemical formula is  $\text{Pb}(\text{Fe}_2\text{Zn})(\text{SO}_4)_2(\text{OH})_6$  (note a printing error on the formula reported in the title of the article, which has been corrected in one *erratum* two issues after). Beaverite-(Zn) occurs as a powdery or earthy crust. It is transparent and brownish yellow-to-yellow color, the streak is yellow ochre, the luster vitreous to subadamantine. It is brittle. Cleavage, parting, and fracture not observed. Hardness not measured,  $D_{\text{calc}} = 4.25 \text{ g/cm}^3$  ( $Z = 3$ ). It is birefringent, with  $n > 1.800$  ( $\lambda = 589 \text{ nm}$ ), pleochroism pale to dark yellow (with no indication of directions reported). Rietveld full-profile fit ( $R_{\text{wp}} = 4.54$ ,  $R_p = 2.83$ ,  $R_F = 3.95$ ), obtained with a 114.6 mm Gandolfi camera and synchrotron radiation ( $\lambda = 2.0765 \text{ \AA}$ ), confirmed a trigonal symmetry, with space group  $R\bar{3}m$  and  $a = 7.3028(2)$ ,  $c = 17.0517(4) \text{ \AA}$ , and  $V = 787.56(4) \text{ \AA}^3$ . The strongest powder diffraction lines are [ $d$  in  $\text{Å}$ , ( $l$ ), ( $hkl$ )]: 5.930 (100)(101), 3.651 (39)(110), 3.110 (43)(021), 3.072 (61)(113) and 2.273 (39)(107). FT-IR spectrum in reflection mode yielded absorption bands at  $3400 \text{ cm}^{-1}$  and at 1060 and  $1100 \text{ cm}^{-1}$  and were interpreted as due to (OH) groups and  $(\text{SO}_4)$  groups, respectively.

Beaverite-(Zn) is a secondary mineral in the oxidized zone of the hydrothermal Cu-Pb-Zn ore deposits formed during volcanic activities in mid Miocene age. It is found at the Mikawa mine located at Mikawa, Aga-machi, Higashikanbara-gun, Niigata Prefecture, Japan (37.47° N, 139.27° E). It occurs on the surface or in the crack or cavity of aggregates of anglesite, galena, pyrite, sphalerite, and quartz. The mineral name was first proposed as “zincbeaverite” to IMA-CNMNC, but the proposal was rejected and data were published by Sato et al. (2008) as for a “Zn-bearing beaverite.” After the revision of the nomenclature scheme for the alunite group introduced by Mills et al. (2009) and the approval of nomenclature of the alunite supergroup by IMA (Bayliss et al. 2010), Zn-beaverite was renamed in the later as “beaverite-(Zn)” and considered as a potential new species. The proposal of the new mineral was then revised and approved (IMA 2010-086). Beaverite-Zn is the Zn-analogue of beaverite-(Cu)  $[\text{Pb}(\text{Fe}_2\text{Cu})(\text{SO}_4)_2(\text{OH})_6]$ . Zinc substitutes for Cu at the octahedrally coordinated  $G$  site. Substitution with respect to jarosite is  $(\text{Pb}^{2+}\text{Zn}^{2+})(\text{K}^+\text{Fe}^{3+})_{-1}$ . The substitution of divalent Cu for 1/3 of the trivalent Fe in the octahedral  $G$  site charge balances the accompanying substitution of  $\text{Pb}^{2+}$  for  $\text{K}^+$  at the  $D$  site. The type specimen is deposited in the collections of the National Museum of Nature and Science, Tokyo, Japan, with the registered number NSM-M28910. **F.C. and G.D.G.**

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**CARLOSBARBOSAITE\***

D. Atencio, A.C. Roberts, M.A. Cooper, L.A.D. Menezes Filho, J.M.V. Coutinho, J.A.R. Stirling, K.E. Venance, N.A. Ball, E. Moffatt, M.L.S.C. Chaves, P.R.G. Brandão, and A.W. Romano (2012) Carlosbarbosaite, ideally  $(\text{UO}_2)_2\text{Nb}_2\text{O}_6(\text{OH})_2 \cdot 2\text{H}_2\text{O}$ , a new hydrated uranyl niobate mineral with tunnels from Jaguarauçu, Minas Gerais, Brazil: description and crystal structure. *Mineral. Mag.* 76, 75–90.

Carlosbarbosaite IMA 2010-047 is a new hydrated uranyl niobate from the Jaguarauçu pegmatite, Minas Gerais, Brazil, where it is a late-stage cavity filling in albite and is associated with muscovite, zircon, kaolinite, and columbite-(Fe). It occurs as cream to pale-yellow, transparent, and fibrous crystals up to 0.12 mm long and 0.002–0.005 mm thick, elongated along [001] and flattened on (100), and having recognizable {001}, {100}, and {010} pinacoidal forms. It has a vitreous luster and white streak. Too little material was available for direct density determination.

Optically, carlosbarbosaite is biaxial (+) with principal refractive indices  $\alpha = 1.760$ ,  $\beta = 1.775$ ,  $\gamma = 1.795$ , and  $2V = 70^\circ$ . Optic orientation is  $X||a$ ,  $Y||b$ , and  $Z||c$ . It is weakly pleochroic (yellow/green).

The compositions (wt%) determined by electron microprobe (WDS) on two samples are: (sample 1/sample 2)  $\text{UO}_3$  54.52/41.83,  $\text{CaO}$  2.07/2.10,  $\text{Ce}_2\text{O}_3$  0.33/0.31,  $\text{Nd}_2\text{O}_3$  0.49/1.12,  $\text{Nb}_2\text{O}_5$  14.11/14.64,  $\text{Ta}_2\text{O}_5$  15.25/16.34,  $\text{TiO}_2$  2.20/0.95,  $\text{SiO}_2$  2.14/3.55,  $\text{Fe}_2\text{O}_3$  1.08/0.89,  $\text{Al}_2\text{O}_3$  0.73/0.71,  $\text{H}_2\text{O}$  (calc) 11.49/14.99, total 104.41/97.43. Thus, these samples have very different U contents. The narrow fibrous character of the crystals precluded direct determination of water contents. Infrared spectroscopy indicates the presence of OH and  $\text{H}_2\text{O}$  groups.

The fibrous crystals are frequently bent and this feature, together with their thinness, presents a considerable challenge to structure determination by XRD. The structure of a very small crystal ( $0.002 \times 0.007 \times 0.05 \text{ mm}^3$ ) was determined from single-crystal XRD data using a Bruker D8 3-circle CCD-based diffractometer fitted with a rotating anode and multi-layer optics—a combination that afforded a much more intense X-ray beam than is normally used, thereby enhancing the diffraction signal from this tiny crystal. The structure was solved and refined in orthorhombic space group *Cmcm* to final agreement indices of  $R_1 = 0.037$ ,  $wR_2 = 0.094$ . Unit-cell parameters obtained from the single-crystal XRD study are:  $a = 14.150(6)$ ,  $b = 10.395(4)$ ,  $c = 7.529(3) \text{ \AA}$ ,  $V = 1107(1) \text{ \AA}^3$  ( $Z = 4$ ). The strongest lines in the X-ray powder diffraction pattern are [ $d_{\text{obs}}$  in  $\text{Å}$ , ( $I_{\text{obs}}$  %,  $hkl$ ): 8.405 (80, 110), 7.081 (100, 200), 4.201 (90, 220), 3.333 (60, 202), 3.053 (80, 022), 2.931 (70, 420), 2.803 (60, 222), 2.589 (50, 040/402)]. Calculated densities for sample 1 and sample 2 are 4.713 and 4.172  $\text{g/cm}^3$ , respectively.

The asymmetric unit of carlosbarbosaite contains one U site, one Nb site, one Ca site, and six O atoms of which one is OH and another  $\text{H}_2\text{O}$ . U is 7-coordinate in a pentagonal bipyramid configuration with two U–O bonds at  $\sim 1.8 \text{ \AA}$  that are characteristic of the uranyl  $\text{UO}_2^{2+}$  ion and  $\text{U}^{6+}$ . The five equatorial bonds have a  $\langle \text{U–O} \rangle$  of 2.357  $\text{Å}$ . Nb is octahedrally coordinated by four O atoms and two OH groups, with a  $\langle \text{Nb–O} \rangle$  of 1.974  $\text{Å}$ . Ca is coordinated by four O atoms from uranyl groups and four  $\text{H}_2\text{O}$

groups. The structure topology of carlosbarbosaite comprises two polyhedral elements: (1) a  $\text{Nb}_2\text{O}_8$  double chain of edge- and corner-sharing octahedra, and (2) a  $\text{UO}_5$  chain in which two of the five equatorial O–O edges of the  $\text{UO}_7$  pentagonal bipyramid are shared with an adjacent  $\text{Nb}_2\text{O}_8$  chain and two with adjacent  $\text{UO}_7$  polyhedra. The two types of chain extend parallel to  $c$  to form a circuit of eight alternating chains (four of each type) that produces a tunnel extending along  $c$ . Each tunnel is partially occupied by Ca atoms, each of which is coordinated by two  $\text{H}_2\text{O}$  groups and four uranyl O atoms. The uranyl groups are directed toward the channel Ca sites. In the samples and crystal studied, the Ca content is  $\sim 0.3$  apfu and Ca is not considered as part of the defining stoichiometry of carlosbarbosaite. Further connectivity within the tunnel and among  $\text{CaO}_8$  polyhedra and adjacent  $\text{Nb}_2\text{O}_8$  chains is provided by hydrogen bonds from tunnel  $\text{H}_2\text{O}$  and chain OH groups.

Structure refinement (site-scattering values) indicated that the U site has a significantly reduced occupancy of 80%. Taken together with the microprobe analyses of the two samples, two distinct end-members were proposed that reflect the variable occupancy of the U site:  $(\text{UO}_2)_2\text{Nb}_2\text{O}_6(\text{OH})_2(\text{H}_2\text{O})_2$  and  $(\text{H}_2\text{O})_4\text{Nb}_2[\text{O}_2(\text{OH})_4](\text{OH})_2(\text{H}_2\text{O})_2$ . In the latter end-member the U sites are vacant. Considering these two end-members, the corresponding  $(\text{UO}_2)_2\text{Nb}_2\text{O}_6(\text{OH})_2(\text{H}_2\text{O})_2$  end-member contents of sample 1 and sample 2 analyses are 70% and 51%, respectively. **M.W.**

**CRYPTOPHYLLITE\***

I.V. Pekov, N.V. Zubkova, Ya.E. Filinchuk, N.V. Chukanov, A.E. Zadov, D.Yu. Pushcharovsky, and E.R. Gobecheva (2010) Shlykovite  $\text{KCa}[\text{Si}_4\text{O}_9(\text{OH})] \cdot 3\text{H}_2\text{O}$  and Cryptophyllite  $\text{K}_2\text{Ca}[\text{Si}_4\text{O}_{10}] \cdot 5\text{H}_2\text{O}$ —new minerals from Khibiny alkaline massif (Kola Peninsula, Russia). *Zap. Ross. Mineral. Obshch.*, 139(1), 37–50 (in Russian, English abstract)

N.V. Zubkova, Ya.E. Filinchuk, I.V. Pekov, D.Yu. Pushcharovsky, and E.R. Gobecheva (2010) Crystal structures of shlykovite and cryptophyllite: comparative crystal chemistry of phyllosilicate minerals of the mountainite family. *Eur. J. Mineral.*, 22, 547–555.

The new mineral cryptophyllite have been found in close association with another new hydrous K–Ca phyllosilicate shlykovite in the active open pit apatite mine Tsentralniy (Central), Rasvumchorr Mt., Khibiny massif, Kola Peninsula, Russia, in the high-potassium peralkaline pegmatite about 10 m long and up to 1 m thick. The pegmatite was (currently mined out) situated in urtite rocks near its contact with nepheline-apatite ore. The mineral associations of that pegmatite belong to three main stages. The earlier one produced nepheline, potassic feldspar, sodalite, aegirine-salite, alkaline amphibole, eudialyte, lamprophyllite, ilmenite, and fluorapatite. The minerals of the next (peralkaline) association are: aegirine, magnesium astrophyllite, lomonosovite, shcherbakovite, barytolamprophyllite, villiamite, fenaksite, delhayelite, phosinaite-(Ce), clinophosinaite, natisite (after ilmenite), zirsinalite (after eudialyte), kazakovite, pectolite, nacaphite (after fluorapatite), sidorenkite, djerfisherite, rasvumite, sphalerite, and molybdenite. The later low-temperature

(under 200–250 °C) hydrothermal association is characterized by hydration of earlier minerals: zirsinalite replaced by lovozerite, kazakovite by tisinallite, and delhayelite replaced by aggregates of hydrodelhayelite, pectolite, and kalborsite. Other products of that association found in fractures and small cavities are: shafranovskite, ershovite, megacyclite, revdite, grumantite, shlykovite, cryptophyllite, unidentified K-Na zeolite, and poorly crystallized hydrous Na, K, Fe, Mn, and Ti silicates. Cryptophyllite forms platelets up to  $0.02 \times 0.1 \times 0.2$  mm in size usually distorted and/or splitted. It found only intergrown with shlykovite. Their aggregates usually form thin crusts up to 0.2 mm thick and up to  $15 \times 15$  mm in plane and consist of bundles of parallel leaflets of cryptophyllite and shlykovite where both minerals are oriented along  $\{001\}$  or are in random orientations. Cryptophyllite usually is a minor part of those intergrowths (10–40% of its volume). Rarely it is dominant (up to 60%). Rosette-like intergrowths of these minerals up to 1 mm were also found. Cryptophyllite is transparent, colorless, and vitreous in separate individual plates, while aggregates could be white, beige, light brown or yellowish-gray, dull, pearly, or silky. The streak is white. Cleavage is perfect on  $\{001\}$ . Hardness, density, and IR spectrum could not be obtained due to lack of material.  $D_{\text{calc}} = 2.185$  g/cm<sup>3</sup>. Cryptophyllite does not fluoresce under UV light. In transmitted light it is colorless and nonpleochroic. The mineral is optically biaxial positive with  $\alpha = 1.520(2)$ ,  $\beta = 1.523(2)$ ,  $\gamma = 1.527(2)$ ,  $2V_{\text{meas}} > 70^\circ$ ,  $2V_{\text{calc}} = 82$ ;  $X = c$ . Dispersion of the optical axes was not observed. Chemical composition of cryptophyllite was determined by EDS on a CamScan MV2300 electron microscope. The beam was rastered over an area  $16 \times 16$   $\mu\text{m}$ . The average (range) of 4 analyses gave: Na<sub>2</sub>O 1.12 (0.8–1.3), K<sub>2</sub>O 17.73 (17.5–18.2), CaO 11.59 (11.3–11.9), Al<sub>2</sub>O<sub>3</sub> 0.08 (0.00–0.15), SiO<sub>2</sub> 50.24 (49.0–51.1), H<sub>2</sub>O (by difference) 19.24, total 100.00 wt%. Other elements heavier than Be were below detection limits. The absence of Li and Be was confirmed by structural analysis. The empirical formula based on (Si,Al)<sub>4</sub>(O,OH)<sub>10</sub> by analogy with shlykovite (OH/H<sub>2</sub>O ratio calculated by charge balance) is: (K<sub>1.80</sub>Na<sub>0.17</sub>)<sub>Σ1.97</sub>Ca<sub>0.99</sub>Al<sub>0.01</sub>Si<sub>3.99</sub>O<sub>9.94</sub>(OH)<sub>0.06</sub>·5H<sub>2</sub>O. The idealized formula is K<sub>2</sub>Ca[Si<sub>4</sub>O<sub>10</sub>]·5H<sub>2</sub>O. Powder X-ray diffraction data were obtained using a STOE IPDS II monocystal diffractometer with IP detector (filtered MoK $\alpha$  radiation). The strongest lines on the diffraction pattern [ $d_{\text{obs}}$  in Å ( $I_{\text{obs}}\%$ ,  $hkl$ )] include: 16.01 (100, 002), 7.98 (24, 004), 6.24 (48, 101), 3.228 (22,  $\bar{1}09$ ), 3.197 (27, 0.0.10), 2.995 (47, 122), 2.903 (84, 123, 204,  $\bar{1}24$ , 211), 2.623 (20, 028,  $\bar{2}08$ , 126), with refined cell parameters:  $a = 6.486$  (5),  $b = 6.997$  (4),  $c = 32.11(2)$ ,  $\beta = 94.91(6)^\circ$ ,  $V = 1452$  (3) Å<sup>3</sup>,  $Z = 4$ . A single crystal was studied using synchrotron radiation at the Swiss-Norwegian Beam Lines (SNBL) at the European Synchrotron Radiation Facility (ESRF), Grenoble, France. Diffraction data were collected at temperature 296 K by the MAR345 IP detector at a wavelength 0.70000 Å. Cryptophyllite appeared to be monoclinic,  $P2_1/n$ ,  $a = 6.4934(14)$ ,  $b = 6.9919(5)$ ,  $c = 32.087$  (3) Å,  $\beta = 94.680$  (12)°,  $V = 1451.9$  (4) Å<sup>3</sup>,  $Z = 4$ . The structure refined to R(F) = 0.0856 for 1667 unique reflections with  $I > 2\sigma(I)$ . Cryptophyllite and shlykovite were studied at the same intergrown crystal are representatives of two new, closely related structure types. The structure based on blocks of two identical mountainite type layers of Si-tetrahedra (T) sandwiched with edge-sharing Ca-octahedra

columns [CaO<sub>3</sub>(H<sub>2</sub>O)]<sup>∞</sup> (O). T-layers [Si<sub>4</sub>O<sub>10</sub>]<sup>∞</sup> consist of 4- and 8-membered rings of Si-tetrahedra. In shlykovite structure one of not shared oxygen atoms in T-layer replaced with (OH) group so T-layer composition is [Si<sub>4</sub>O<sub>9</sub>(OH)]<sup>∞</sup>. Cations of K are located in the voids of the T layers in both cryptophyllite and shlykovite. The structure of those minerals differs by the content of the interlayer space. Shlykovite has only H<sub>2</sub>O molecules between TOT blocks while cryptophyllite has H<sub>2</sub>O and K atoms. The similarity in the main structure unit (TOT blocks) configuration for mountainite, cryptophyllite, and shlykovite define the mountainite structural family. This type of structure related to the structures of the rhodesite mero-pleisotype series members. T-layers of shlykovite can be considered as a half of a double layer [Si<sub>16</sub>O<sub>34</sub>(O,OH)<sub>4</sub>]<sup>∞</sup> described in the structures of rhodesite, macdonaldite, monteregianite-(Y), some synthetic compounds and also in related alumosilicates delhayelite and hydrodelhayelite where the layer composition is [(Al,Si)<sub>2</sub>Si<sub>14</sub>O<sub>34</sub>(O,OH)<sub>4</sub>]<sup>∞</sup>. The name cryptophyllite is derived from Greek words “κρυπτος”—crypto and “φυλλον”—leaf as an allusion to its occurrence in intimate intergrowths with visually indistinguishable shlykovite and to its layered structure. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2008-061). The type specimen is deposited in the Fersman Mineralogical Museum Russian Academy of Sciences, Moscow, Russia. **D.B.**

#### CUPROKALININITE\*

L.Z. Reznitsky, E.V. Sklyarov, Z.F. Ushapovskaya, L.F. Suvo-rova, Yu.S. Polekhovskiy, P. Dzerzanovsky, and I.G. Barash (2010) Cuprokalininite CuCr<sub>2</sub>S<sub>4</sub>—the new sulphospinel from metamorphic rocks of Slyudyanka complex (South Baikal region). Zap. Ross. Mineral. Obshch., 139(6), 39–49 (in Russian, English abstract). Geol. Ore Deposits, 53(8), 758–766 (2011; in English).

Cuprokalininite, a new mineral of the thiospinel group, has been discovered among other accessory minerals as scattered inclusions in light greenish-gray quartz lenses or bands alternating with light-greenish sugary diopside bands in Cr-V-bearing quartz-diopside metamorphic rocks of Sludyanka complex at South Baikal region of Russia. Those rocks considered to be siliceous-carbonate sediments metamorphosed at high-temperature stage (~800 °C) of granulite facies. Other associated minerals are: Cr-V-tremolite and mica, calcite, Cr-V spinels, V-titanite, pyrite, plagioclase, mineral of isomorphic series natalyite-kosmochlor, goldmanite-uvarovite, dravite-chromdravite, and karelianite-eskolaite. Cuprokalininite forms black (with dark-bronze tint) submetallic octahedral or cuboctahedral crystals 0.05–0.20 mm in size, sometimes with a pseudododecahedral faces  $\{110\}$ . Polysynthetic and simple twinning by  $\{111\}$  is common. By morphology it differs from other sulfospinels kalininite and florensovite, which form only anhedral grains. The streak is black. Cleavage and parting were not observed. The mineral is very brittle with Mohs hardness 4.5–5; VHN<sub>20-30</sub> = 396 (356–458) kg/mm<sup>2</sup>. No data on measured density is given;  $D_{\text{calc}} = 4.16$  g/cm<sup>3</sup>. The mineral is slightly electromagnetic, not soluble in HCl. Cuprokalininite is a pale cream isotropic in reflected light with no internal reflections. Reflectance data were obtained using MSF-21 micro spectrophotometer in air [ $R\%$  (nm)]: 34.30 (400),

34.10 (420), 33.90 (440), 33.70 (460), 33.5 (480), 33.2 (500), 330.0 (520), 32.80 (540), 32.30 (560), 32.20 (580), 31.90 (600), 31.60 (620), 31.20 (640), 30.90 (660), 30.60 (680), 30.40 (700). The chemical composition of cuprokalinitite was determined on a Superprobe JXA 820 and (for one grain) on CAMECA SX-100. The average (range) of 202 analyses for 11 grains gave: Cu 21.03 (19.77–21.99), Fe 0.47 (0.03–1.82), Zn 0.17 (0–0.80), Cr 29.01 (25.97–32.49), V 5.85 (2.65–9.09), As 0.21 (0–1.16), Sb 0.08 (0–0.27), S 43.25 (42.61–44.00), total 100.07 wt%. Other elements detectable by microprobe were below detection limits. Empirical formula (based on 7 atoms) is  $(\text{Cu}_{0.98}\text{Fe}_{0.02}\text{Zn}_{0.01})_{\Sigma 1.01}(\text{Cr}_{1.65}\text{V}_{0.34}\text{As}_{0.01})_{\Sigma 2.00}\text{S}_{3.99}$ . The idealized formula is  $\text{CuCr}_2\text{S}_4$ . Powder X-ray diffraction data were obtained using a Debye-Scherrer camera  $D = 57.3$  mm (filtered  $\text{FeK}\alpha$  radiation). The strongest lines are: [ $d_{\text{obs}}$  in Å ( $I_{\text{obs}}$ %,  $hkl$ )] 3.44 (6, 220), 2.94 (10, 311), 2.44 (6, 400), 1.884 (9, 511, 333), 1.731 (10, 440), 1.133 (6, 751, 555), 1.098 (6, 840), 1.030 (6, 931), 1.002 (10, 844). By analogy with a synthetic  $\text{CuCr}_2\text{S}_4$  the X-ray data were indexed in cubic system, space group  $Fd\bar{3}m$ . The unit-cell parameter  $a = 9.814(2)$  Å,  $V = 945.2(4)$  Å<sup>3</sup>,  $Z = 8$ . The single-crystal X-ray structure data could not be obtained due to the lack of suitable crystal (all available were twinned). Chemical, X-ray, and optical data for cuprokalinitite are given in comparison with a related mineral florensovite  $\text{CuCr}_{1.5}\text{Sb}_{0.5}\text{S}_4$ . The relationships among florensovite, kalinitite, and cuprokalinitite and the valence state of Cu, Cr, and Sb in those minerals are discussed based on data on synthetic and natural compounds. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2010-008). The mineral is named for its composition as the Cu-analogue of kalinitite,  $\text{ZnCr}_2\text{S}_4$ . The holotype and cotype specimens have been deposited at the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow. **D.B.**

#### DAVIDLLOYDITE\*

F.C. Hawthorne, M.A. Cooper, Y.A. Abdu, N.A. Ball, M.E. Back, and K.T. Tait (2012) Davidlloydite, ideally  $\text{Zn}_3(\text{AsO}_4)_2(\text{H}_2\text{O})_4$ , a new arsenate mineral from the Tsumeb mine, Otjikoto (Oshikoto) region, Namibia: description and crystal structure. *Mineral. Mag.*, 76, 45–57.

Davidlloydite IMA 2011-053 is a new hydrated zinc arsenate that occurs in the “3<sup>rd</sup> oxidation zone” (4400-foot level) at the Tsumeb mine, Namibia, in association with stranskiite, adamite-olivine, geminate, and calcioandryobertsite. Davidlloydite crystals occur as aggregates, up to 0.5 mm across, of elongate prisms up to  $0.1 \times 0.02 \times 0.01$  mm<sup>3</sup> or on partially enclosed by fine-grained calcioandryobertsite. Crystals are elongate along [001] and flattened on {010}, colorless with a vitreous luster. The streak is white. Davidlloydite has been characterized by electron microprobe, optical microscopy, Raman spectroscopy, single-crystal and powder XRD. The empirical composition of davidlloydite determined by electron microprobe analysis (WDS) is (wt%):  $\text{As}_2\text{O}_5$  43.03, ZnO 37.95, CuO 5.65. Calculated  $\text{H}_2\text{O}$  content is 13.27 wt%. The mineral is biaxially positive with  $2V = 65^\circ$  and principal refractive indices  $\alpha = 1.671^\circ$ ,  $\beta = 1.687^\circ$ ,  $\gamma = 1.695^\circ$ . It is non-pleochroic and weakly dispersive ( $r < v$ ).

The structure of a small crystal ( $0.02 \times 0.02 \times 0.08$  mm<sup>3</sup>) was determined from single-crystal XRD data, and solved and

refined in triclinic space group  $P\bar{1}$  to final agreement indices of  $R_1 = 0.015$ ,  $wR_2 = 0.041$ . Unit-cell parameters obtained from the single-crystal XRD study are:  $a = 5.9756(4)$ ,  $b = 7.6002(5)$ ,  $c = 5.4471(4)$  Å,  $\alpha = 84.2892(9)^\circ$ ,  $\beta = 90.4920(9)^\circ$ ,  $\gamma = 87.9958(9)^\circ$ ,  $V = 245.99(5)$  Å<sup>3</sup> ( $Z = 1$ ). Calculated density is 3.661 g/cm<sup>3</sup>. The strongest lines in the X-ray powder diffraction pattern are [ $d_{\text{obs}}$  in Å, ( $I_{\text{obs}}$ %,  $hkl$ )]: 4.620 (100, 011/ $\bar{1}10$ ), 7.526 (71, 010), 2.974 (49, 200/ $0\bar{2}1$ ), 3.253 (40, 021/ $\bar{1}20$ ), 2.701 (39,  $\bar{2}10/002/\bar{1}21$ ), 5.409 (37, 001), 2.810 (37, 210). Based upon the chemical composition and structure determination the empirical crystal-chemical formula based on 12 anions pfu with 4 $\text{H}_2\text{O}$  is  $(\text{Zn}_{2.53}\text{Cu}_{0.39})_{\Sigma=2.92}\text{As}_{2.03}\text{O}_8(\text{H}_2\text{O})_4$ , and the corresponding ideal structural formula is  $\text{Zn}_3\text{As}_2\text{O}_8(\text{H}_2\text{O})_4$ .

There are two Zn, one As, six O, and four H sites in the asymmetric unit. Zn occurs in tetrahedral and octahedral coordination as  $\text{ZnO}_4$  and  $\text{ZnO}_2(\text{H}_2\text{O})_4$ , respectively. As is tetrahedral coordinated,  $\text{AsO}_4$  with a  $\langle\text{As-O}\rangle$  of 1.687 Å, being characteristic of  $\text{As}^{5+}$ . O atoms of  $\text{H}_2\text{O}$  groups were identified through bond-valence analysis. In the sample studied, around 40% of the  $^{65}\text{Zn}$  site is occupied by  $\text{Cu}^{2+}$ . The structure consists (010) sheets of corner-lined alternating  $\text{ZnO}_4$  and  $\text{AsO}_4$  tetrahedra. These sheets are stacked along  $b$  and are connected to each other via the two non- $\text{H}_2\text{O}$  oxygen atoms of isolated  $\text{ZnO}_2(\text{H}_2\text{O})_4$  octahedra. Direct connectivity between octahedra is only via hydrogen bonds involving  $\text{H}_2\text{O}$  groups. Some hydrogen bonds connect to the adjacent sheets of tetrahedra. The Raman spectrum of davidlloydite in the OH-stretching region consists of a group of broad peaks in the range 2800–3600 cm<sup>-1</sup>, in which at least six peaks occur, with two prominent ones at  $\sim 3290$  and  $\sim 3360$  cm<sup>-1</sup>. These peaks are assigned to hydrogen-bonded  $\text{H}_2\text{O}$  modes.

There is a strong structural correspondence between davidlloydite and parahopeite  $\text{Zn}_3(\text{PO}_4)_2(\text{H}_2\text{O})_4$ , which shares the same basic layered structure of alternating sheets of  $\text{ZnO}_4$  and  $\text{PO}_4$  tetrahedra and isolated  $\text{ZnO}_2(\text{H}_2\text{O})_4$  octahedra, but differing in the sense of rotation of tetrahedra relative to octahedra. Formally, davidlloydite is a triclinic polytype of arsenohopeite  $\text{Zn}_3(\text{AsO}_4)_2(\text{H}_2\text{O})_4$  (orthorhombic). The authors indicate the likelihood of rich polytypism in these closely related structures. **M.W.**

#### FLORENCITE-(SM)\*

S.A. Repina, V.I. Popova, E.I. Churin, E.V. Belogub, and V.V. Chiller (2010) Florencite-(Sm),  $(\text{Sm},\text{Nd})\text{Al}_3(\text{PO}_4)_2(\text{OH})_6$ —a new mineral of alunite-jarosite group from the Subpolar Urals. *Zap. Ross. Mineral. Obshch.*, 139(4), 16–25 (in Russian, English abstract). *Geol. Ore Deposits*, 53(7), 564–574 (2011; in English).

The new mineral florencite-(Sm) along with florencite-(Ce), florencite-(La), and florencite-(Nd) belongs to the florencite group of the alunite-jarosite supergroup. It was found in quartz veins up to 3 m thick situated in quartz conglomerates near its contacts with Al enriched metasomatites at the site Svodovyi, Maldynyrd Ridge, Subpolar Urals, Russia. The veins consist of the aggregate of gigantic anhedral milky or smoky quartz crystals with blue asbestos-like dravite near the selvages. The intergrowths of pink partly euhedral or anhedral florencite-(Ce) crystals up to 3 cm with xenotime-(Y) were found in the central

part of the veins. Florencite-(Sm) forms multiple zones 0.01–0.1 mm thick in the rhombohedra {101} sectors of grow within poor developed rhombohedral crystals ({102} + {011} with minor {502} faces) of florencite-(Ce). The total thickness of closely located series of Sm-enriched zones is 1–3 mm. Those series are distinctive on pink cleaved planes by its light yellowish tint. Florencite-(Sm) is transparent, colorless to pale-pink or pale-yellow, vitreous to greasy with a white streak. It has perfect cleavage on {001} and parting on {110}. Mohs hardness is 5.5–6.  $D_{\text{meas}} = 3.60(1)$ ,  $D_{\text{calc}} = 3.666$  (for EDS set of analysis), and 3.753 g/cm<sup>3</sup> (for WDS set). The mineral is optically uniaxial positive (+), colorless, nonpleochroic,  $\omega = 1.704(2)$ ,  $\epsilon = 1.713(2)$ . The cathodoluminescence spectrum of florencite-(Sm) shows two sharp lines at 592 (green, Sm<sup>3+</sup>) and 558 nm (yellow, Nd<sup>3+</sup>). IR absorption bands (cm<sup>-1</sup>, strongest lines italic, sh – shoulder) are: 466, 600 sh, 510, 621, 660 sh, 836, 921, 1104, 1036, 1105, 1223, 1787, 1845, 1994, 2319, 2387, 2957, 3374. The chemical composition of florencite-(Sm) was determined by EDS on a JXA-733 Jeol Superprobe and by WDS on a SX-100 Cameca microprobe. The water content was measured by TGA. The average (range) of 5 EDS analyses gave: La<sub>2</sub>O<sub>3</sub> n.d., Ce<sub>2</sub>O<sub>3</sub> 1.92 (0.78–3.04), Pr<sub>2</sub>O<sub>3</sub> 0.16 (0.00–0.80), Nd<sub>2</sub>O<sub>3</sub> 9.35 (7.57–11.11), Sm<sub>2</sub>O<sub>3</sub> 12.96 (11.93–13.47), Eu<sub>2</sub>O<sub>3</sub> n.d., Gd<sub>2</sub>O<sub>3</sub> 2.55 (2.16–3.01), Dy<sub>2</sub>O<sub>3</sub> n.d., SrO 1.91 (0.58–2.74), CaO 0.77 (0.31–1.49), Al<sub>2</sub>O<sub>3</sub> 30.20 (28.33–32.19), P<sub>2</sub>O<sub>5</sub> 27.18 (25.42–28.33), SO<sub>3</sub> 2.13 (1.12–3.37), SiO<sub>2</sub> n.d.; H<sub>2</sub>O 10.74, sum 99.87 wt%. The average (range) of 3 WDS analyses gave: La<sub>2</sub>O<sub>3</sub> 0.62 (0.60–0.73), Ce<sub>2</sub>O<sub>3</sub> 3.29 (3.31–3.61), Pr<sub>2</sub>O<sub>3</sub> 1.05 (0.98–1.11), Nd<sub>2</sub>O<sub>3</sub> 10.31 (10.20–10.42), Sm<sub>2</sub>O<sub>3</sub> 12.62 (12.03–13.32), Eu<sub>2</sub>O<sub>3</sub> 0.41 (0.39–0.43), Gd<sub>2</sub>O<sub>3</sub> 2.30 (2.13–2.47), Dy<sub>2</sub>O<sub>3</sub> 0.13 (0.0–0.40), SrO 0.71 (0.68–0.72), CaO 0.35 (0.31–0.41), Al<sub>2</sub>O<sub>3</sub> 29.89 (29.30–30.44), P<sub>2</sub>O<sub>5</sub> 26.14 (25.80–26.53), SO<sub>3</sub> 0.85 (0.81–0.92), SiO<sub>2</sub> 0.09 (0.06–0.12); H<sub>2</sub>O 10.74, sum 99.50 wt%. The empirical formulas based on 14 O atoms are (respectively): (Sm<sub>0.37</sub>Nd<sub>0.28</sub>Gd<sub>0.07</sub>Ce<sub>0.06</sub>Pr<sub>0.01</sub>Sr<sub>0.09</sub>Ca<sub>0.07</sub>)<sub>Σ0.95</sub>Al<sub>2.97</sub>(P<sub>1.92</sub>S<sub>0.13</sub>)<sub>Σ2.05</sub>O<sub>14</sub>H<sub>5.98</sub> and (Sm<sub>0.37</sub>Nd<sub>0.37</sub>Ce<sub>0.10</sub>Gd<sub>0.07</sub>Pr<sub>0.03</sub>La<sub>0.02</sub>Eu<sub>0.01</sub>Sr<sub>0.04</sub>Ca<sub>0.03</sub>)<sub>Σ0.99</sub>Al<sub>3.02</sub>(P<sub>1.90</sub>S<sub>0.05</sub>Si<sub>0.01</sub>)<sub>Σ1.96</sub>O<sub>14</sub>H<sub>6.15</sub>. The idealized formula is: (Sm,Nd)Al<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>6</sub>. Powder X-ray diffraction data were obtained using a Shimadzu XRD-6000 diffractometer (filtered CuK $\alpha$ , radiation). The strongest lines on the X-ray powder diffraction pattern [ $d_{\text{obs}}$  (Å) ( $I_{\text{obs}}$ %,  $hkl$ )] are: 5.65 (43, 101), 3.479 (37, 110), 2.925 (100, 113), 2.161 (46, 107), 1.881(58, 303). The mineral is trigonal, space group is  $R\bar{3}m$  by analogy with other florencite group members and synthetic SmAl<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>6</sub> and NdAl<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>6</sub>. The unit-cell parameters refined from powder X-ray data are:  $a = 6.972(4)$ ,  $c = 16.182(7)$  Å,  $V = 681.2$  Å<sup>3</sup>.  $Z = 3$ . No single-crystal studies have been performed. The mineral is named as a Sm-dominant member of the group. The mineral and its name have been approved by the IMA CNMNC (IMA 2009-074). Type specimen is deposited in the Natural Science Museum of Ilmen State Reserve, Miass, Russia. **D.B.**

#### NATROTITANITE

A.V. Stepanov, G.K. Bekenova, V.L. Levin, and F.C. Hawthorne (2012) Natrotitanite, ideally (Na<sub>0.5</sub>Y<sub>0.5</sub>)Ti(SiO<sub>4</sub>)O, a new mineral from the Verkhnee Espe deposit, Akjailyautas mountains, Eastern Kazakhstan: description and crystal structure. Mineral. Mag., 76, 37–44.

Natrotitanite IMA 2010-033, ideally (Na<sub>0.5</sub>Y<sub>0.5</sub>)Ti(SiO<sub>4</sub>)O, was found at the Verkhnee Espe REE deposit, hosted by alkaline granites at the northern margin of the Akjailyautas granite massif in Kazakhstan. The mineral does not occur as homogeneous single crystals, but as chemically and optically distinct thin rims on prismatic crystals of (Na,Y,REE)-bearing titanite (up to 1 × 1 × 5 mm<sup>3</sup>). These transparent, milky-white/yellowish-gray composite crystals occur as stellate aggregates replacing narsasukite. They do not fluoresce under UV light. Only refractive indices  $\alpha$  (1.904) and  $\gamma$  (2.030) could be measured. The simplified empirical composition of natrotitanite (energy-dispersive spectrometry) is <sup>Ca</sup>(Na<sub>0.39</sub>Ca<sub>0.32</sub>Y<sub>0.15</sub>REE<sub>0.14</sub>)<sub>Σ=1</sub><sup>Y</sup>(Ti<sub>0.95</sub>Nb<sub>0.02</sub>Sn<sub>0.01</sub>Fe<sub>0.01</sub><sup>3+</sup>Mn<sub>0.01</sub>V<sub>0.01</sub>)Si<sub>1.01</sub>O<sub>4</sub>(O<sub>0.83</sub>F<sub>0.17</sub>).

The structure of a small chemically zoned crystal (0.04 × 0.08 × 0.08 mm<sup>3</sup>) was determined by single-crystal XRD. The structure was solved and refined in space group  $C2/c$  to final agreement indices of  $R_1 = 0.018$ ,  $wR_2 = 0.049$ . Use of space group  $C2/c$ , which is the alternative (and standard) setting of space group  $A2/a$ , which has been used in previous studies of titanite, was chosen by the authors to emphasize the importance of the M $\phi_5$  chain of octahedra that is the principal structural component of titanite and is also shared by many other minerals. Choosing  $C2/c$  correlates the chain with the  $c$  dimension. Unit-cell parameters obtained from the single-crystal XRD study are:  $a = 6.5691(2)$ ,  $b = 8.6869(3)$ ,  $c = 7.0924(2)$  Å,  $\beta = 114.1269(4)^\circ$ ,  $V = 369.4(2)$  Å<sup>3</sup> ( $Z = 4$ ). Calculated density is 3.833 g/cm<sup>3</sup>. The strongest lines in the X-ray powder diffraction pattern are [ $d_{\text{obs}}$  in Å ( $I_{\text{obs}}$  %,  $hkl$ )]: 2.597 (100, 130), 3.248 (80, 11 $\bar{2}$ ), 2.994 (60, 200), 3.253 (40, 021/120), 1.641 (40, 330), 4.941 (30, 110), 1.498 (30, 400), 2.273 (30, 11 $\bar{3}$ ). The primary chemical substitutions are: <sup>Ca</sup>Na + <sup>Ca</sup>(Y, REE) → <sup>Ca</sup>Ca + <sup>Ca</sup>Ca, and <sup>Ca</sup>Na + F → <sup>Ca</sup>Ca + O. **M.W.**

#### SHLYKOVITE\*

I.V. Pekov, N.V. Zubkova, Ya.E. Filinchuk, N.V. Chukanov, A.E. Zadov, D.Yu. Pushcharovsky, and E.R. Gobechia (2010) Shlykovite KCa[Si<sub>4</sub>O<sub>9</sub>(OH)]·3H<sub>2</sub>O and Cryptophyllite K<sub>2</sub>Ca[Si<sub>4</sub>O<sub>10</sub>]·5H<sub>2</sub>O—new minerals from Khibiny alkaline massif (Kola Peninsula, Russia). Zap. Ross. Mineral. Obshch., 139(1), 37–50 (in Russian, English abstract)

N.V. Zubkova, Ya.E. Filinchuk, I.V. Pekov, D.Yu. Pushcharovsky, and E.R. Gobechia (2010) Crystal structures of shlykovite and cryptophyllite: comparative crystal chemistry of phyllosilicate minerals of the mountainite family. Eur. J. Mineral., 22, 547–555.

The new mineral shlykovite along with another new hydrous K-Ca phyllosilicate cryptophyllite have been discovered in the active open pit apatite mine Tsentralniy (Central) at the Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia, in the high-potassium peralkaline pegmatite about 10 m long and up to 1 m thick. The pegmatite was (currently mined out) situated in urtite rocks near its contact with nepheline-apatite ore. The mineral associations of that pegmatite belong to three main stages. The earlier one produced nepheline, potassic feldspar, sodalite, aegirine-salite, alkaline amphibole, eudialyte, lamprophyllite, ilmenite, and fluorapatite. The minerals of the next

(peralkaline) association are: aegirine, magnesium astrophyllite, lomonosovite, shcherbakovite, barytolamprophyllite, villiaumite, fenaksite, delhayelite, phosinaite-(Ce), clinophosinaite, natisite (after ilmenite), zirsinalite (after eudialyte), kazakovite, pectolite, nacaphite (after fluorapatite), sidorenkite, djerfisherite, rasvumite, sphalerite, and molybdenite. The later low-temperature (under 200–250 °C) hydrothermal association is characterized by hydration of earlier minerals: zirsinalite replaced by lovozerite, kazakovite by tisinialite, and delhayelite replaced by aggregates of hydrodelhayelite, pectolite, and kalborsite. Other products of that association found in fractures and small cavities are shafranovskite, ershovite, megacyclite, revdite, grumantite, shlykovite, cryptophyllite, unidentified K-Na zeolite, and poor crystallized hydrous Na, K, Fe, Mn, and Ti silicates. Shlykovite forms distorted lamellae, up to  $0.03 \times 0.3 \times 1$  mm in size flattened along {001}, fibers up to 0.5 mm, their radial or unoriented aggregates up to 3 mm and parallel-fibrous veinlets up to 0.3 mm thick and up to 2 cm long. Rarely the mineral forms pinakoidal crystals up to 0.4 mm. Shlykovite often occurs in close (oriented or unoriented) intergrowths with cryptophyllite forming 60–90% of intergrowths volume. Shlykovite crystals are colorless vitreous while aggregates could be white, beige, light brown or yellowish-gray, dull, pearly or silky. The streak is white. Cleavage is perfect on {001}. The lamellae are pliable. Mohs hardness is 2.5–3. The density could not be measured due to porosity of aggregates.  $D_{\text{calc}} = 2.244 \text{ g/cm}^3$ . Shlykovite does not fluoresce under UV light. In transmitted light it is colorless and nonpleochroic. The mineral is optically biaxial negative.  $\alpha = 1.500(3)$ ,  $\beta = 1.509(2)$ ,  $\gamma = 1.515(2)$ ,  $2V_{\text{meas}} = -60(20)^\circ$ ,  $2V_{\text{calc}} = 78$ ;  $X = c$ . Dispersion of the optical axes is medium,  $r < v$ . IR spectrum of shlykovite is given in comparison with IR spectra of mountainite, rhodesite, and apophyllite-OH. IR absorption bands ( $\text{cm}^{-1}$ , strongest lines italic, sh = shoulder) are: 3585, 3250, 3090sh, (stretching vibrations O-H); 1680, 1660sh, 1585 (deformation vibrations of  $\text{H}_2\text{O}$ ); *1135, 1097, 1024, 999, 962* (stretching vibrations of Si-O); 880sh, 795, 760sh, 690sh, 680, 590 (combined vibrations of tetrahedral layer); 470sh, 455, 432, 420sh (deformation vibrations Si-O-Si). Chemical composition of shlykovite was determined by EDS on a CamScan MV2300 electron microscope. The beam was rastered over an area  $16 \times 16 \mu\text{m}$ . The average (range) of 7 analyses gave:  $\text{Na}_2\text{O}$  0.68 (0.4–0.9),  $\text{K}_2\text{O}$  11.03 (10.6–12.0),  $\text{CaO}$  13.70 (13.6–13.9),  $\text{SiO}_2$  59.86 (59.2–60.8),  $\text{H}_2\text{O}$  (by difference) 14.73, total 100.00 wt%. Other elements heavier than Be were below detection limits. The absence of Li and Be was confirmed by structural analysis. The empirical formula (based on 13 O atoms; OH/ $\text{H}_2\text{O}$  by charge

balance) is:  $(\text{K}_{0.96}\text{Na}_{0.09})_{\Sigma 1.05}\text{Ca}_{1.00}\text{Si}_{4.07}\text{O}_{9.32}(\text{OH})_{0.68} \cdot 3\text{H}_2\text{O}$ . The idealized formula is  $\text{KCa}[\text{Si}_4\text{O}_9(\text{OH})] \cdot 3\text{H}_2\text{O}$ . Powder X-ray diffraction data were obtained using a STOE STADI MP powder diffractometer (filtered  $\text{CuK}\alpha$ , radiation). The strongest lines on the diffraction pattern [ $d_{\text{obs}}$  in Å ( $I_{\text{obs}}\%$ ,  $hkl$ )] include: 13.33 (100, 002), 6.67 (76, 004), 6.47 (55, 100); 4.835 (26,  $\bar{1}04$ ), 4.113 (24, 113), 3.978 (36,  $\bar{1}14$ ), 3.790 (27, 114), 3.529 (37, 106), 3.469 (45, 021), 3.068 (57,  $\bar{1}21$ ,  $\bar{1}08$ ), 3.042 (45, 121,  $\bar{1}22$ ), 2.996 (32, 018,  $\bar{2}04$ ), 2.945 (62,  $\bar{1}23$ ,  $\bar{2}11$ ), with refined unit-cell parameters of  $a = 6.505$  (4),  $b = 6.988$  (5),  $c = 26.72$  (2),  $\beta = 94.64$  (8) Å,  $V = 1211(3)$  Å<sup>3</sup>. A single crystal was studied using synchrotron radiation at the Swiss-Norwegian Beam Lines (SNBL) at the European Synchrotron Radiation Facility (ESRF), Grenoble, France. Diffraction data were collected at temperature 296 K by the MAR345 IP detector at a wavelength of 0.70000 Å. Shlykovite appeared to be monoclinic,  $P2_1/c$ ,  $a = 6.4897(4)$ ,  $b = 6.9969(5)$ ,  $c = 26.714(2)$  Å,  $\beta = 94.597(8)^\circ$ ,  $V = 1209.12(15)$  Å<sup>3</sup>,  $Z = 4$ . The structure solved refined to  $R(F) = 0.0960$  for 1147 unique reflections with  $I > 2\sigma(I)$ . Shlykovite and cryptophyllite were studied on the same intergrown crystal and are representatives of two new, closely related structure types. The structure based on blocks of two identical mountainite type layers of Si-tetrahedra (T) sandwiched with edge-sharing Ca-octahedra columns  $[\text{CaO}_5(\text{H}_2\text{O})]^\infty$  (O). For shlykovite T-layers  $[\text{Si}_4\text{O}_9(\text{OH})]^\infty$  consist of 4- and 8-membered rings of Si-tetrahedra where one of not shared oxygen atoms replaced with (OH) group. That replacement does not exist in cryptophyllite for which T-layer formula is  $[\text{Si}_4\text{O}_{10}]^\infty$ . K cations are located in the voids of the T layers in both shlykovite and cryptophyllite. The structure of those minerals differs by the content of the interlayer space. Shlykovite has only  $\text{H}_2\text{O}$  molecules between TOT blocks, while cryptophyllite has  $\text{H}_2\text{O}$  and K atoms. The similarity in the main structure unit (TOT blocks) configuration for mountainite, shlykovite, and cryptophyllite allow the authors to define the mountainite structural family. This type of structure related to the structures of the rhodesite mero-pleisotype series members. T-layers of shlykovite can be considered as a half of a double layer  $[\text{Si}_{16}\text{O}_{34}(\text{O},\text{OH})_4]^\infty$  described in the structures of rhodesite, macdonaldite, monteregianite-(Y), some synthetic compounds and also in related alumosilicates delhayelite and hydrodelhayelite where the layer composition is  $[(\text{Al},\text{Si})_2\text{Si}_{14}\text{O}_{34}(\text{O},\text{OH})_4]^\infty$ . Shlykovite is named in memory of Russian geologist at Moscow State University Valeriy Georgievich Shlykov (1941–2007). Both the mineral and its name have been approved by the IMA CNMNC (IMA 2008-062). The type specimen is deposited in the Fersman Mineralogical Museum Russian Academy of Sciences, Moscow, Russia. **D.B.**