New Mineral Names*·†

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Almeidaite*

L.A.D. Menezes Filho, N.V. Chukanov, R.K. Rastsvetaeva, S.M. Aksenov, I.V. Pekov, M.L.S.C. Chaves, R.P. Richards, D. Atencio, P.R.G. Brandão, R. Scholz, K. Krambrock, R.L. Moreira, F.S. Guimarães, A.W. Romano, A.C. Persiano, L.C.A. De Oliveira and J.D. Ardisson (2015) Almeidaite, $Pb(Mn,Y)Zn_2(Ti,Fe^{3+})_{18}O_{36}(O,OH)_2$, a new crichtonite-group mineral, from Novo Horizonte, Bahia, Brazil. Mineralogical Magazine, 79(2), 269–283.

Almeidaite (IMA 2013-020), $Pb(Mn,Y)Zn_2(Ti,Fe^{3+})_{18}O_{36}(O,OH)_2$, is a new mineral from Novo Horizonte, Bahia, Brazil. The mineral was found in altered dacite, 2 m away from a hydrothermal quartz vein that intercepts the dacite. Associated minerals include rutile, hematite, quartz with rutile inclusions, and xenotime-(Y), although these did not belong to the original dacite but to the hydrothermal quartz veins. Almeidaite likely formed as a product of the reaction of hydrothermal fluids with the dacite host rock, whereby the dacites are part of a package of metavolcanic acid rocks resulting from a peraluminous and alkaline magmatism with an age estimated as 1.75 B.y. The formation was deeply fractured and heated during the Braziliano orogenic event (600–450 Ma), generating a swarm of hydrothermal quartz veins. Almeidaite forms platy crystals up to 30 × 30 × 6 mm, dominated by the basal pinacoid {001} with typically scalloped and imperfect faces and bounded by mostly steep rhombohedra and the hexagonal prism {110}. Most crystals are multiply twinned with non-planar contact surfaces that are approximately parallel to the **c** axis. Almeidaite is black with a brown streak, is opaque with submetallic luster, is brittle, shows no cleavage or parting and has conchoidal fracture. Mohs hardness = 6; D_{meas} = 4.68(5), D_{calc} = 4.616 g/cm³. Almeidaite is non-fluorescent in long-wave or short-wave UV light. It is optically uniaxial (+) with high birefringence. Reflectance values were measured between 400 and 700 nm in 20 nm intervals. The values for COM wavelengths [R_{min}, R_{max} % (nm)] in air are: 12.78, 15.39 (470); 12.86, 15.43 (546); 12.91, 15.55 (589); 13.04, 15.75 (650). The main absorption bands of the IR spectrum (cm⁻¹, s = strong, sh = shoulder, w = weak) are: 3340 (O-H stretching vibrations), 1099w, 1041w, 1012w (overtones and Zn-OH bending vibrations), 695sh, 574s, 534s, 485sh (stretching vibrations in octahedra and tetrahedra). The average of 5 electron probe EDS analyses is [wt% (range)]: CaO 0.12 (0–0.27), SrO 0.69 (0.49–0.88), PbO 7.13 (6.51–7.68), MnO 2.64 (2.25–2.85), ZnO 6.26 (5.93–6.43), Fe_2O_3 22.83 (Mössbauer; 21.99–23.62), Y_2O_3 2.81 (2.09–3.55), La_2O_3 0.25 (0–0.48), TiO_2 56.10 (55.33–56.80), H_2O 0.4 (gas chromatography of products of ignition at 1200 °C), total 99.23 wt%. This gives the empirical formula $(Pb_{0.59}Sr_{0.12}Ca_{0.04}La_{0.03})_{\Sigma0.78}(Mn_{0.54}Y_{0.46})_{\Sigma1.00}Zn_{1.43}(Ti_{13.02}Fe^{3+}_{4.98})_{\Sigma18.00}(Fe^{3+}_{0.32}Mn_{0.15})_{\Sigma0.47}[O_{37.18}(OH)_{0.82}]_{\Sigma38.00}$ based on 38 O apfu. The strongest lines in the X-ray powder-diffraction pattern [d_{obs} Å (I_{obs}%; *hkl*)] are: 2.907 (100; 116,11$\bar{6}$,12$\bar{4}$,214,107), 2.492 (55; 131,31$\bar{1}$), 2.157 (55; 315,13$\bar{5}$,119,11$\bar{9}$), 3.074 (50; 205), 3.023 (50; 300), 1.615 (50; 3 1 $\bar{1}$0), 2.781 (44; 033,303). The unit-cell parameters refined from powder-diffraction data are: *a* = 10.462(5), *c* = 21.09(2) Å, *V* = 2000 Å³; *Z* = 3. Single-crystal X-ray diffraction data collected on a crystal of size 0.2 × 0.25 × 0.45 mm refined to R_1 = 3.91 for 2110 unique reflections with $I \geq 3(I)$ shows almeidaite is trigonal, space group $R\bar{3}$, with the unit-cell parameters *a* = 10.4359(2), *c* = 21.0471(4) Å, *V* = 1985.10(7) Å³, and *Z* = 3. Almeidaite is a member of the crichtonite group with a Pb-dominated 12-coordinated *A* site and Zn-dominated 4-coordinated *T* site. The structure is based on a closed-packed anion framework with a nine layer stacking sequence in which *A* occupies one of the anion sites within the cubic layers. The mineral is named in honor of Fernando Flávio Marques de Almeida (1916–2013) for his work on the geology of Brazil and South America. Type material is deposited in Museu de Geociências, Instituto de Geociências, Universidade de São Paulo, Brazil. **O.C.G.**

Barlowite*

P. Elliott, M.A. Cooper and A. Pring (2015) Barlowite, $Cu_4FBr(OH)_6$, a new mineral isostructural with claringbullite: description and crystal structure. Mineralogical Magazine, 78(7), 1755–1762.

Barlowite (IMA 2010-020), ideally $Cu_4FBr(OH)_6$, is a new mineral found at the Great Australia mine, Cloncurry, Queensland, Australia. An assemblage of secondary copper

minerals was found mostly lining cavities in cuprite-rich rocks, having formed by oxidation of primary Cu mineralization under low-temperature conditions. Barlowite has probably crystallized as a result of a change from acid to more alkaline conditions, being among the last minerals to form. Associated minerals include gerhardtite and brochantite. Barlowite occurs as thin hexagonal blue crystals up to 0.5×0.3 mm, flattened on {001}, and as aggregates of platy transparent to translucent crystals up to 3 mm. Barlowite has sky blue streak, vitreous luster, Mohs hardness of 2–2½, irregular fracture and perfect cleavage on {001} and are brittle. $D_{meas} > 3.8$ g/cm³ (sinks in the heaviest liquid available); $D_{calc} = 4.21$ g/cm³. Crystals are readily soluble in cold dilute HCl. Barlowite is optically uniaxial (–), non-pleochroic, with $\omega = 1.840(4)$–$1.845(4)$ and $\varepsilon = 1.833(4)$–$1.840(4)$. IR spectrum shows a broad band at ~3595 to ~2540 cm⁻¹, centered on 3275 cm⁻¹, due to OH-stretching vibrations. No band attributed to molecular water was observed. The average of 20 electron probe WDS analyses is [wt% (range)]: CuO 70.08 (68.65–70.93), F 4.64 (3.96–5.03), Cl 0.73 (0.59–1.04), Br 16.79 (16.1–17.43), H₂O (calc) 11.59, –O=F₂ 1.95, –O=Cl₂ 0.16, –O=Br₂ 1.68, total 100.04. This gives the empirical formula $Cu_{4.00}F_{1.11}Br_{0.95}Cl_{0.09}(OH)_{5.85}$ based on 18 O atoms and H₂O calculated to achieve 8 anions and charge balance. The strongest lines in the X-ray powder-diffraction pattern [d_{obs} Å (I_{obs}%; hkl)] are: 5.790 (100; 010), 2.707 (55; 112), 2.889 (40; 020), 2.452 (40; 022), 1.668 (30; 220,033), 1.778 (20; 032,015). The unit-cell parameters refined from powder-diffraction data are: $a = 6.681(1)$, $c = 9.274(1)$ Å, $V = 358.43$ Å³. Single-crystal X-ray diffraction data collected on a crystal of size $80 \times 60 \times 10$ µm refined to $R_1 = 0.0145$ for 231 unique reflections with $I \geq 4\sigma(I)$ shows barlowite is hexagonal, space group $P6_3/mmc$, $a = 6.6786(2)$, $c = 9.2744(3)$ Å, $V = 358.251$ Å³, and $Z = 2$. Barlowite is isostructural with claringbullite and is its Br and F analog. The Cu(1) atom is coordinated by four OH groups and two Br atoms in a Jahn-Teller distorted octahedral arrangement. Each Cu(1)φ6 (φ: O, Br) [4+2] octahedron shares four edges with adjacent octahedra to form a sheet in the (001) plane, and adjacent sheets link along [001] by sharing Br anions. The F anion is located in the center of the channels that run along [001]. Barlowite is named in honor of William Barlow (1845–1934), an English amateur geologist and crystallographer who independently enumerated the 230 space groups, as well as having proposed several crystal structures in the 1880s that were later validated by X-ray crystallography. The type specimen of barlowite is deposited in the South Australian Museum, North Terrace, Adelaide, Australia. **O.C.G.**

BARRYDAWSONITE-(Y)*

R.H. Mitchell, M.D. Welch, A.R. Kampf, A.K. Chakhmouradian and J. Spratt (2015) Barrydawsonite-(Y), Na₁.₅CaY₀.₅Si₃O₉H: a new pyroxenoid of the pectolite–serandite group. Mineralogical Magazine, 79(3), 671–686.

Barrydawsonite-(Y) (IMA 2014-042), ideally $Na_{1.5}CaY_{0.5}Si_3O_9H$, is a new mineral found at the Merlot Claim, North Red Wine Pluton, Labrador, Canada. The mineral was found in metamorphosed eudialyte nepheline syenite associated with potassic arfvedsonite, aegirine, albite, and potassium feldspar with accessory Y-bearing pectolite, britholite, and steenstrupine.

Barrydawsonite-(Y) typically forms single grains which are either subhedral prismatic up to $0.2 \times 0.1 \times 0.1$ mm or anhedral crystals up to 0.5 mm in the largest dimension. Crystals are colorless and commonly have discrete thin rims of Y-bearing pectolite. Barrydawsonite-(Y) is optically biaxial (+) with $\alpha = 1.612(1)$, $\beta = 1.617(1)$, $\gamma = 1.630(1)$ and $2V_{meas} = 63(1)°$, $2V_{calc} = 64°$, with optic orientation $Z = $ **b**; $X \wedge$ **c** = 15° in obtuse angle β. The mineral is nonpleochroic and has moderate dispersion $r < v$. The average of 14 electron probe WDS analyses is [wt% (range)]: Na₂O 12.82 (12.43–13.47), CaO 11.14 (10.08–11.52), MnO 2.92 (2.82–3.02), FeO 1.33 (1.24–1.39), SiO₂ 48.46 (47.91–49.45), Y₂O₃ 11.61 (11.35–11.99), La₂O₃ 0.03 (0–0.19), Ce₂O₃ 0.19 (0.15–0.32), Pr₂O₃ 0.05 (0–0.09), Nd₂O₃ 0.35 (0.31–0.41), Sm₂O₃ 0.38 (0.35–0.40), Gd₂O₃ 0.95 (0.92–0.97), Tb₂O₃ 0.24 (0.21–0.26), Dy₂O₃ 1.81 (1.73–1.95), Ho₂O₃ 0.41 (0.38–0.47), Er₂O₃ 1.15 (1.09–1.22), Tm₂O₃ 0.14 (0.11–0.18), Yb₂O₃ 0.76 (0.71–0.81), Lu₂O₃ 0.07 (0.05–0.09), H₂O (by stoichiometry) 2.43 total 97.23. This gives the empirical formula $Na_{1.54}Ca_{0.74}Mn_{0.15}Fe_{0.07}Y_{0.38}Nd_{0.01}Sm_{0.01}Gd_{0.02}Tb_{0.01}Dy_{0.04}Ho_{0.01}Er_{0.02}Yb_{0.01}Si_{3.00}O_9H$ based on 9 anions pfu. The strongest lines in the X-ray powder-diffraction pattern [d_{obs} Å (I_{obs}%; hkl)] are: 2.905 (100; 023), 3.094 (30; 210,$\overline{2}$11,$\overline{1}$21,202), 1.761 (29; 127,323,040), 3.272 (27; $\overline{2}$02,104), 1.702 (27; 140,$\overline{2}$27,$\overline{3}$25). The unit-cell parameters refined from powder-diffraction data are: $a = 15.539(3)$, $b = 7.036(4)$, $c = 6.992(4)$ Å, $\beta = 95.16(1)°$, $V = 761.4$ Å³. Single-crystal X-ray diffraction data collected on a crystal of size $0.37 \times 0.18 \times 0.16$ mm refined to $R_1 = 0.029$ for 4116 unique reflections with $I \geq 2\sigma(I)$ shows barrydawsonite-(Y) is monoclinic, space group $P2_1/a$: $a = 15.5026(2)$, $b = 7.0233(1)$, $c = 6.9769(1)$ Å, $\beta = 95.149(1)°$, $V = 756.58$ Å³; $Z = 4$. Barrydawsonite-(Y) is related to pectolite by the substitution ½ [NaM³⁺Ca₋₂] (M³⁺ = Y, REE). It is the only member of the pectolite group that has the structure of the monoclinic *M2abc* polytype. The mineral has three metal sites: $M(1) = $ Ca, $M(2) = $ Na₀.₅(Y, REE)₀.₅, $M(3) = $ Na. $M(1)$ and $M(2)$ are octahedrally coordinated sites, and $M(3)$ is [8]-coordinated as in pectolite and serandite. The octahedron containing trivalent cations receives a hydrogen bond. The mineral is named in honor of John Barry Dawson (1932–2013), professor and an eminent British petrologist who made ground-breaking studies of silica—undersaturated rocks of the Earth's crust and mantle. The holotype specimen of barrydawsonite-(Y) is deposited in the Natural History Museum, London, U.K., and cotype crystals are in the Natural History Museum of Los Angeles County, California, U.S.A., and in the Robert B. Ferguson Museum of Mineralogy, University of Manitoba, Canada. **O.C.G.**

BLUEBELLITE* AND MOJAVEITE*

S.J. Mills, A.R. Kampf, A.G. Christy, R.M. Housley, G.R. Rossman, R.E. Reynolds and J. Marty (2014) Bluebellite and mojaveite, two new minerals from the central Mojave Desert, California, USA. Mineralogical Magazine, 78(5), 1325–1340.

Bluebellite (IMA 2012-120), ideally $Cu_6[I^{5+}O_3(OH)_3](OH)_7Cl$, and mojaveite (IMA 2012-121), ideally $Cu_6[Te^{6+}O_4(OH)_2](OH)_7Cl$, were discovered in the Mojave Desert, California, and were both named after their type localities: Blue Bell claims in the area, and the Mojave Desert. Bluebellite was discovered in a highly siliceous hornfels in association with murdochite, calcite,

fluorite, and hemimorphite. Mojaveite was discovered at the Aga mine where it occurs with cerussite, chrysocolla, khinite, perite, and quarts; at the Blue Bell claims where it occurs with cerussite, chlorargyrite, chrysocolla, hemimorphite, kettnerite, perite, quartz, and wulfenite, and at the Bird Nest drift, where it is found in association with andradite, chrysocolla, cerussite, burckhardtite, galena, goethite, khinite, mcalpineite, thorneite, timroseite, paratimroseite, quartz, and wulfenite. Bluebellite forms bright bluish-green flattened plates or flakes up to $\sim 20 \times 20 \times 5$ μm in size that are commonly intergrown in irregular aggregates. The only forms observed are {001} and {001}. Bluebellite has a pale bluish-green streak, an adamantine luster, perfect cleavage on {001} and an irregular fracture. Mojaveite forms greenish-blue adamantine, pearly or dull curved plates flattened on {001}, which rarely show a hexagonal outline, and are intergrown in irregular aggregates; the observed morphology is consistent with the forms {001}, {00$\overline{1}$}, {100}, {010}, {110}, and {$\overline{1}$20}. Mojaveite also occurs as compact balls, varying in color from sky blue to medium greenish blue. Both individual plates and compact balls reach 0.5 mm in maximum dimension. Mojaveite has perfect cleavage on {001} and an irregular fracture. Both minerals are sectile, non-fluorescent, with the Mohs hardness estimated as ~1. The densities could not be measured; D_{calc} = 4.746 for bluebellite and 4.886 g/cm^3 for mojaveite. Optically both minerals are uniaxial (–), with ω and ε >> 1.8. Refractive indices could not be measured directly but are estimated to be n_{ave} = 1.96 for bluebellite and 1.95 for mojaveite. The pleochroism of bluebellite is: O (bluish green) >> E (nearly colorless), and for mojaveite is: O (greenish blue) >> E (light greenish blue). The averaged 5 point electron probe WDS analyses of bluebellite is [wt% (range)]: CuO 48.62 (47.81–50.47), Al$_2$O$_3$ 0.12 (0–0.23), SiO$_2$ 0.75 (0.71–0.83), I$_2$O$_5$ 17.26 (16.90–17.78), Cl 4.06 (3.99–4.14), –O=Cl$_2$ 0.92, H$_2$O$_{calc}$ = 9.27, total 79.16. For mojaveite CuO 56.74 (56.21–57.49), PbO 2.14 (1.46–2.45), Bi$_2$O$_3$ 0.33 (0–0.50), TeO$_3$ 21.12 (20.86–21.57), Cl 4.51 (4.38–4.60), –O=Cl$_2$ 1.02, H$_2$O$_{calc}$ = 9.71, total 93.53. Low totals are due to porous nature of aggregates of bluebellite, which take a very poor polish. Both minerals are unstable under the electron beam. The empirical formula of bluebellite is Cu$_{5.82}$I$_{0.99}$Al$_{0.02}$Si$_{0.12}$O$_{3.11}$ (OH)$_{9.80}$Cl$_{1.09}$ and of mojaveite is Cu$_{5.92}$Te$_{1.00}$Pb$_{0.08}$Bi$_{0.01}$O$_4$(OH)$_{8.94}$ Cl$_{1.06}$ based on O+Cl = 14 apfu for both. The Raman spectrum of bluebellite has strong iodate-related bands at 680, 611, and 254 cm^{-1}, whereas the most intense Raman bands in mojaveite occur at 694, 654 (poorly resolved), 624, 611, and 254 cm^{-1}. The strongest lines of the X-ray powder diffraction pattern of bluebellite are [d_{obs} Å (I_{obs}%; hkl)]: 4.427 (99; 003), 2.664 (35; 211), 2.516 (100; 21$\overline{2}$), 2.213 (9; 006), 2.103 (29; 033,214), 1.899 (47; 312,21$\overline{5}$), 1.566 (48; 140,217), 1.479 (29; 045,14$\overline{3}$,324). The strongest lines of the X-ray powder diffraction pattern of mojaveite are [d_{obs} Å (I_{obs}%; hkl)]: 4.403 (91; 003), 2.672 (28; 211), 2.512 (100; 21$\overline{2}$), 2.110 (27; 033,214), 1.889 (34; 312,21$\overline{5}$,22$\overline{3}$), 1.570 (39; 404,140,217), 1.481 (34; 045,14$\overline{3}$,324), 1.338 (14; 422). Single-crystal X-ray studies were not possible due to the poor quality of the crystals for both new minerals. Bluebellite and mojaveite are trigonal, $R3$, a = 8.3017(5), c = 13.259(1) Å, V = 791.4 Å^3, and Z = 3 (bluebellite) and a = 8.316(2), c = 13.202(6) Å, V = 790.7 Å^3, and Z = 3 (mojaveite), with unit-cell parameters refined from the powder data. The crystal structures of bluebellite

and mojaveite are similar based on striking similarities of the powder X-ray diffraction patterns. Crystal structures that satisfy bond-valence requirements for both new minerals were proposed to be based on stacking of brucite-like Cu$_6$$MX_{14}$ layers, where M = (I or Te) and X = (O, OH, and Cl). A number of cotype specimens of bluebellite and mojaveite are deposited in the Natural History Museum of Los Angeles County, California, U.S.A., and in the Museum Victoria, Melbourne, Victoria, Australia. **Yu.U.**

BONAZZIITE*

L. Bindi, G. Pratesi, M. Muniz-Miranda, M. Zoppi, L. Chelazzi, G.O. Lepore and S. Menchetti (2015) From ancient pigments to modern optoelectronic applications of arsenic sulfides: bonazziite, the natural analogue of β-As$_4$S$_4$ from Khaidarkan deposit, Kyrgyzstan. Mineralogical Magazine, 79(1), 121–131.

Bonazziite (IMA 2013-141), the natural analog of the β-As$_4$S$_4$, polymorph of realgar and pararealgar, has been found at the specimen labeled as wakabayashilite from the Mineralogical Collection of the Museo di Storia Naturale, University of Florence, Italy (catalog number 3143/1) originated from Khaidarkan Sb-Hg deposit, south of Fergana Valley, Kyrgyzstan. This specimen is considered to be a holotype. The occurrence of a natural phase with diffraction pattern and other properties quite similar to that of the synthetic β-As$_4$S$_4$ was first reported by Clark (1970) in the Ag-As-Sb vein deposit at Alacrán, Chile. The proposal for a new mineral was not approved and according to the system of codification for unnamed minerals (Smith and Nickel 2007), it was listed as UM1970-19-S:As. Later, the new mineral described at Uzon caldera, Kamchatka, Russia (Popova et al. 1986) was assumed by authors to be identical to that of Clark (1970) and named alacránite. However having greater unit-cell volume, alacránite also has a chemical composition As$_8$S$_9$ and crystallized in monoclinic space group $P2/c$ while the synthetic β-As$_4$S$_4$ crystallizes in the $C2/c$ space group. Later the natural β-As$_4$S$_4$ was reported from seafloor around Lihir Island, Papua New Guinea (Burns and Percival 2001), from the burning dump of Kateřina colliery, Radvanice, Czech Republic (Bonazzi et al. 2003) and from the burning coal dump of La Ricamarie, Saint-Etienne, Loire, Rhône-Alpes, France, but was never submitted to IMA due to confusion with alacránite or due to semi-technogenical origin. In the museum specimen from Khaidarkan bonazziite occurs as rare reddish-orange crystals up to 100 μm with realgar, sulfur, wakabayashilite, alacránite, non-stoichiometric As$_4$S$_{4+x}$ sulfides, and stibnite in a calcite matrix. The mineral is opaque with a resinous luster and a dark-orange streak. It is brittle. The microhardness VHN$_{15}$ = 70 (60–76) kg/mm^2 corresponding to Mohs hardness of ~2. In plane-polarized light, bonazziite is strongly bireflectant and pleochroic from orange to light red with orange–red internal reflections. In crossed polars, it is strongly anisotropic with greyish to light-blue rotation tints. The reflectance values in air for COM wavelengths [R_{min}, R_{max} % (nm)] are 19.9, 22.2 (471.1), 19.1, 21.3 (548.3), 18.8, 19.7 (586.6), 17.8, 18.9 (652.3). In the Raman spectrum of bonazziite most of the bands are due to either As–As/As–S stretching modes (187, 343, 352, and 362 cm^{-1}) or As–S–As/As–As–S/S–As–S/As–As–As bending modes (164 and 217 cm^{-1}). The peak at 275 cm^{-1} indi-

cates the presence of minor amounts of pararealgar appeared due to alteration of bonazziite by laser light. Both polychromatic and monochromatic light are found to alter realgar and the bonazziite to pararealgar. An average of 6 electron probe WDS analyses is [wt% (range)]: As 68.94 (67.88–69.35), S 30.20 (28.61–30.83); total 99.14. The empirical formula is $As_{3.95}S_{4.05}$ based on 8 atoms pfu. The strongest lines of the X-ray powder diffraction pattern are [d_{obs} Å (I_{obs} %; hkl)]: 5.74 (100; $\bar{1}11$), 4.10 (60; 021), 3.92 (50; $\bar{1}12$), 3.12 (60; 022,310), 2.95 (50; 221,202), 2.86 (80; $\bar{2}22,\bar{1}31$). Bonazziite is monoclinic, space group $C2/c$; a = 9.956(1), b = 9.308(1), c = 8.869(1) Å, β = 102.55(2)°; V = 802.3 Å³; Z = 4. The crystal structure [refined to R_1 = 0.0263 for 735 reflections with $F_o > 4σ(F_o)$] is based on the covalently bonded As_4S_4 cage-like molecules, in which each As atom links one As and two S atoms. The molecules are held together by van der Waals forces. The As_4S_4 molecule is identical to that found in the structure of realgar. The mineral was named in honor of Paola Bonazzi (b. 1960), Professor in Mineralogy at the University of Florence, in recognition of her seminal contributions to the study of arsenic sulfides and their alteration by the light. **D.B.**

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BRACCOITE*

F. Cámara, E. Bittarello, M.E. Ciriotti, F. Nestola, F. Radica and M. Marchesini (2015) As-bearing new mineral species from Valletta mine, Maira Valley, Piedmont, Italy: II. Braccoite, $NaMn_5^{2+}[Si_5AsO_{17}(OH)](OH)$, description and crystal structure. Mineralogical Magazine, 79(1), 171–189.

Braccoite (IMA 2013-093), ideally $NaMn_5^{2+}[Si_5AsO_{17}(OH)]$ (OH), is a new mineral found in the Valletta mine dumps, in Maira Valley, Cuneo province, Piedmont, Italy. It is associated with tiragalloite, gamagarite, hematite, manganberzeliite, palenzonaite, quartz, saneroite, tokyoite, unidentified Mn oxides, organic compounds, and Mn arsenates and silicates, and probably originates from the reaction between ore minerals and hydrothermal fluids. Braccoite occurs as subhedral translucent brown-red equant crystals, a few hundred microns across, grouped in thin masses a few centimeters in size. It has pale-yellow streak, vitreous to resinous luster, is brittle with uneven fracture and shows no cleavage or parting. Hardness and density were not measured due to small crystal size and intergrowth with tiragalloite. D_{calc} = 3.56 g/cm³. Braccoite is optically biaxial (+), α = 1.749(1), β = 1.750(1) and γ = 1.760(1) (589 nm), $2V_{meas}$ = 26(2)°, and $2V_{calc}$ = 35°. It is weakly pleochroic with X = brownish yellow, Y = dark yellow, Z = yellow. The mineral is non-fluorescent in long-wave or short-wave UV light. In the micro-Raman spectrum, intense bands at ~829, 907, and 932 cm⁻¹ and weak peaks at 706 and 748 cm⁻¹ confirm the presence of $(SiO_4)^{4-}$ and $(AsO_4)^{3-}$ while a broad envelope

of overlapping bands centered upon 3361 and 3507 cm⁻¹ are characteristic of OH stretching modes. The average of 5 electron probe WDS analyses is [wt% (range)]: Na_2O 4.06 (3.72–4.22), CaO 0.05 (0.03–0.06), MnO 41.76 (40.94–42.46), Mn_2O_3 3.07 (2.55–3.87; calc. based on 2 (OH) groups pfu and V distribution), MgO 0.96 (0.90–1.01), Al_2O_3 0.04 (0.01–0.12), CuO 0.02 (0.01–0.04), SiO_2 39.73 (38.70–40.21), As_2O_5 6.87 (6.10–7.79), V_2O_5 1.43 (1.35–1.61; tetrahedral V^{5+} is calculated as 6 – (Si + As) and excess V is assigned to the octahedral sites as V^{3+}), SO_3 0.01 (0.01–0.02) and F 0.04 (0–0.19), $-O=F_2$ 0.02 (0–0.08), H_2O 2.20 (calc. on the basis of 2 OH groups pfu). This gives the empirical formula $Na_{1.06}(Mn_{4.46}^{2+}Mn_{0.32}^{3+}Mg_{0.19}Al_{0.01}Ca_{0.01})_{Σ4.99}$ $[(Si_{5.36}As_{0.48}V_{0.15})_{Σ5.99}O_{17}(OH)](OH_{0.98}F_{0.02})$ based on 19 O apfu. The strongest lines in the X-ray powder-diffraction pattern [d_{obs} Å (I_{obs}%; hkl)] are: 3.055 (69; $2\bar{2}1$), 3.042 (43; 102), 3.012 (65; $3\bar{2}\bar{1}$), 2.985 (55; $2\bar{3}\bar{1}$), 2.825 (100; $21\bar{3}$), 2.708 (92; 220), 2.627 (43; $2\bar{3}\bar{2}$), 2.381 (58; $4\bar{1}\bar{1}$), 2.226 (25; $21\bar{4}$) and 1.680 (36; $43\bar{3}$). The unit-cell parameters refined from powder-diffraction data are: a = 9.756(6), b = 9.961(7), c = 9.087(7) Å, α = 92.23(5), β = 117.27(5), γ = 105.21(4)°, V = 742.2(9) Å³. Single-crystal X-ray diffraction data collected on a crystal of size 0.20 × 0.15 × 0.17 mm refined to R_1 = 0.0347 for 4389 unique reflections with $I ≥ 4σ(I)$ shows braccoite is triclinic, space group $P\bar{1}$, with a = 9.7354(4), b = 9.9572(3), c = 9.0657(3) Å, α = 92.691(2), β = 117.057(4), γ = 105.323(3)°, V = 740.37(4) Å³, and Z = 2. Braccoite is the As-dominant analog of the hydropyroxenoid saneroite, and is topologically identical to it. The structure consists of a five-repeat single isolated chain of SiO_4 tetrahedra which have a sixth tetrahedron as an appendix and where chains repeat laterally by a center of symmetry forming a layer of tetrahedra parallel to ($1\bar{1}1$). Five octahedral sites occupied by Mn form a band that runs parallel to two single chains of tetrahedra attached above and below, with the band being laterally separated by channels occupied partially by two independent Na sites. The mineral is named after Roberto Bracco (b. 1959), a systematic minerals collector with a special interest in manganese minerals. A fragment of the holotype material has been deposited in the Museo Regionale di Scienze Naturali di Torino, Italy. **O.C.G.**

CHANABAYAITE*

N.V. Chukanov, N.V. Zubkova, G. Möhn, I.V. Pekov, D.Yu. Pushcharovsky and A.E. Zadov (2015) Chanabayaite, $Cu_2(N_3C_2H_2)_2Cl(NH_3,Cl,H_2O,□)_4$, a new mineral containing triazolate anion. Zapiski RMO (Proceedings of the Russian Mineralogical Society), 144(2), 36–37 (in Russian).

Chanabayaite (IMA 2013-065), a new metalorganic mineral containing 1,2,4-triazolate anion with simplified chemical formula $Cu_2(N_3C_2H_2)_2Cl(NH_3,Cl,H_2O,□)_4$, was discovered in a guano deposit on the northern slope of the Pabellón de Pica Mountain, near the village of Chanabaya, Iquique Province, Tarapacá region, Chile (22°55′S; 70°08′W). The mineral was found in guano near the contact with chalcopyrite-bearing gabbro in association with sal ammoniac, halite, joanneumite, and nitratine. Chanabayaite forms deep blue translucent vitreous imperfect prismatic crystals up to 0.05 × 0.1 × 0.5 mm and their radial aggregates up to 1 mm on the gabbro or on the sal ammoniac aggregates. Chanabayaite has a blue streak, perfect cleavage on {001}, and imperfect cleavage

on {100} and {010}. It is brittle, with a Mohs hardness of 2; D_{meas} = 1.48(2), D_{calc} = 1.464 g/cm³. No fluorescence under UV light or electron beam was observed. In transmitted light, the mineral is strongly pleochroic $Z \sim Y$ (deep blue) >> X (pale gray-blue). It is optically biaxial (–), α = 1.561(2), β = 1.615(3), γ = 1.620(2), $2V_{obs}$ = 25(10)°, $2V_{calc}$ = 33°. X = c; optical axes dispersion is moderate, $r > v$. The IR spectrum shows (cm⁻¹) intensive broad bands in the range 3200–3500 (stretching vibrations of N–H and O–H bonds); narrow bands at 3100–3200 (C–H stretching of 1,2,4-triazolate anion); 1550–1650 (deformation modes of NH_3 ligands and H_2O bending); strong bands at 1000–1500 (vibrations of 1,2,4-triazolate cycle and symmetric bending vibrations of NH_3 molecules); weak bands at 1000–1300 (in plane bending vibrations of C–H bonds). Band at 888 cm⁻¹ corresponds to planar bending vibrations of 1,2,4-triazolate ring, and bands with wavenumbers below 700 cm⁻¹ are assigned to out-of-plane vibrations of 1,2,4-triazolate anion and torsional vibrations of NH_3 ligand. The chemical composition of chanabayaite is [wt% (range)]: Cu 32.23 (30.87–32.97), Fe 1.14 (0.81–1.42), Cl 16.13 (15.77–16.85) by electron probe; H 3.1(3), N 29.9(5), C 12.2(5), O 3.4(5) by gas chromatography; total 98.1. The empirical formula, calculated on the basis of Cu+Fe = 2 apfu is $Cu_{1.92}Fe_{0.08}Cl_{1.72}N_{8.09}C_{3.85}H_{11.66}O_{0.81}$. The strongest lines of the X-ray powder diffraction pattern are [d_{obs} Å (I_{obs}%; hkl)]: 10.19 (100; 101), 6.189 (40; 011), 5.729 (23; 301), 5.216 (75; 211, 202), 4.964 (20; 400), 2.830 (20; 602,413,503), 2.611 (24; 123,422,404). The orthorhombic unit-cell parameters refined from the powder data are: a = 19.45(1), b = 7.216(4), c = 11.96(1) Å. The single-crystal unit-cell parameters are a = 19.484(3), b = 7.2136(10), c = 11.999(4) Å, V = 1686.5 Å³; space group $Imma$; Z = 4. A high-quality single-crystal X-ray diffraction data could not be obtained due to a low quality of available crystals. The structural model [refined to R_1 = 0.1627 for 949 independent reflections with $I > 2\sigma(I)$] suggested that chains of the corner-sharing Cu(l)-centered octahedra and single Cu(2)-centered octahedra are connected via 1,2,4-triazolate anions $C_2N_3H_2^-$. NH_3 and Cl⁻ are additional ligands coordinating Cu^{2+}. This structural motif is close to that of the associated phase $Na_2Cu_2Cl_3(N_3C_2H_2)_2(NH_3)_2 \cdot 4H_2O$ (Zubkova et al. 2016). Chanabayaite is probably a transformational mineral formed as a result of leaching Na and one third of Cl and partial dehydration of this protophase. The mineral is named for the locality near the village of Chanabaya. The type specimen is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **D.B.**

References cited

Zubkova, N.V., Chukanov, N.V., Pekov, I.V., Möhn, G., Giester, G., Yapaskurt, V.O., Lykova, I.S., and Pushcharovsky, D.Yu. (2016) The crystal structure of the natural 1,2,4-triazolate compound NaCu₂Cl₃[N₃C₂H₂]₂[NH₃]₂·4H₂O. Zeitschrift für Kristallographie, 231, 47–54.

FAVREAUITE*

S.J. Mills, A.R. Kampf, A.G. Christy, R.M. Housley, B. Thornes, Yu-S. Chen and I.M. Steele (2014) Favreauite, a new selenite mineral from the El Dragón mine, Bolivia. European Journal of Mineralogy, 26(6), 771–781.

Favreauite (IMA 2014-013), ideally $PbBiCu_6O_4(SeO_3)_4(OH) \cdot H_2O$, is a new selenite mineral discovered at the El Dragón mine, Antonio Quijarro Province, Potosí Department, Bolivia. (19°49′15″S, 65°55′0″W). It occurs with ahlfeldite, allophane, calcite, chalcomenite, malachite, molybdomenite, and yet to be published hydrous Al selenite in vugs in a matrix composed of Co- and Cu-rich penroseite, dolomite and goethite. Favreauite is the secondary mineral resulted from the oxidation of the selenide vein hosted by sandstones and shales. It forms green vitreous transparent tiny square tabular crystals up to 0.1 × 0.01 mm, flattened on {001} and combined in subparallel and divergent groups. The mineral has perfect cleavage on {001}, an irregular fracture. The Mohs hardness is estimated as ~3. The density could not be measured; D_{calc} = 4.851 g/cm³. In transmitted light favreauite is slightly pleochroic in green tints, O < E. It is optically uniaxial (–); calculated refractive index 1.854. The most intensive band of the Raman spectrum is at 847 cm⁻¹ (v_1 SeO_3 stretching). Other SeO_3 bands are at (cm⁻¹): 764 and 795 (v_3 antisymmetric stetching), 493 and 542 (v_2 bending modes), 320 and 392 (v_4 bending modes). Broad band at 3525 is assigned to O–H stretching modes. The average of 6 WDS electron probe analyses is [wt% (range)]: CaO 0.64 (0.58–0.72), CuO 30.63 (30.02–31.26), PbO 14.08 (13.58–14.50), Bi_2O_3 13.95 (13.71–14.22), SeO_2 30.16 (29.35–31.29), H_2O (calculated by charge balance) 1.79; total 91.25. The low total is due to high sensitivity to electron beam damage even at 15 kV/5 nA. The empirical formula based on 18 O pfu is $Pb_{0.95}Ca_{0.17}Bi_{0.90}Cu_{5.81}Se_{4.10}O_{16}(OH) \cdot H_2O$. The strongest lines of the X-ray powder diffraction pattern are [d_{obs} Å (I_{obs}%; hkl)]: 5.67 (100; 111), 3.470 (76; 220,202), 3.190 (35; 003), 2.961 (40; 311,113), 2.709 (33; 302,203), 2.632 (34; 231,312), 2.247 (36; 331,133), 1.665 (33; 305,513,531). The tetragonal unit-cell parameters refined from the powder data are in excellent agreement with those obtained by single-crystal study: a = 9.860(4), c = 9.700(5) Å, V = 943.0 Å³, space group $P4/n$; Z = 2. The crystal structure was refined to R_1 = 0.0329 for 1354 observed reflections [$F_o > 4\sigma F_o$]. It consists of a corrugated layer of CuO_4 squares, decorated by SeO_3 triangular pyramids. In the sheet, each O is coordinated to three Cu atoms. Pb, Bi, hydroxide, and water fill voids in the structure, with Cu making two additional long bonds to interlayer OH⁻ and H_2O forming typical Jahn-Teller elongated octahedra. Bi occupies hollows in each Cu–O sheet, and the Pb atoms connect successive sheets. Bi and Pb are both in distorted cubic coordination with four long and four short bonds. The Bi site has point symmetry 4, and all four short Bi–O bonds are on the same side, consistent with the presence of a stereoactive lone pair. In contrast, the Pb site has the non-polar point symmetry $\bar{4}$, and short and long bonds alternate around Pb in a pattern that is inconsistent with lone-pair activity. The structure of favreauite is unique but is closely related to those of nabokoite $KCu_7Te^{4+}O_4(SO_4)_5Cl$ and atlasovite $KCu_6Fe^{3+}BiO_4(SO_4)_5Cl$. Those structures could be derived from the framework structure of murdochite, $Pb^{4+}Cu_6^{2+}O_{8-x}(Cl,Br)_{2x}$ by selective deletion of atoms. The mineral named in honor Georges Favreau, amateur mineralogist and professional engineer, President of the Association Française de Microminéralogie between 1993 and 2007, for his contributions to mineralogy. One cotype specimen is housed at the Museum Victoria, Australia, and three are deposited in the Natural History Museum of Los Angeles County, Los Angeles, U.S.A. **D.B.**

FERMIITE* AND OPPENHEIMERITE*

A.R. Kampf, J. Plašil, A.V. Kasatkin, J. Marty and J. Čejka (2015) Fermiite, $Na_4(UO_2)(SO_4)_3 \cdot 3H_2O$ and oppenheimerite, $Na_2(UO_2)(SO_4)_2 \cdot 3H_2O$, two new uranyl sulfate minerals from the Blue Lizard mine, San Juan County, Utah, USA. Mineralogical Magazine, 79(5), 1123–1142.

Fermiite (IMA 2014-068), ideally $Na_4(UO_2)(SO_4)_3 \cdot 3H_2O$ and oppenheimerite (IMA 2014-073), ideally $Na_2(UO_2)(SO_4)_2 \cdot 3H_2O$ are two new uranyl sulfate minerals discovered in the Blue Lizard underground U mine, Red Canyon, White Canyon district, San Juan County, Utah, U.S.A. Six other uranyl sulfates were discovered at this mine recently. Both minerals formed as a result of the post-mining oxidation of primary uraninite, pyrite, chalcopyrite, bornite, and covellite deposited as replacement of wood and other organic material and as disseminations in the enclosing sandstone. They occur together in direct association with blödite, bluelizardite, chalcanthite, epsomite, gypsum, hexahydrite, kröhnkite, manganoblödite, sideronatrite, tamarugite, and wetherillite. The general assemblage also include alumino-coquimbite, atacamite, belakovskiite, bobcookite, brochantite, calcite, cobaltoblödite, copiapite, coquimbite, cyanotrichite, d'ansite-(Mn), dickite, dietrichite, ferrinatrite, gerhardtite, gordaite, halite, kieserite, lishizhenite, meisserite, metavoltine, natrozippeite, plašilite, pseudojohannite, rhomboclase, romerite, and other new minerals currently under investigation. Both new species are slightly deliquescent and easily soluble in H_2O at room temperature. Both have white streak, Mohs hardness of ~2½ and bright greenish-white fluorescence under UV radiation of any wave. Both are unstable under electron beam.

Fermiite forms pale transparent greenish-yellow vitreous prisms of {101} habit up to ~0.5 mm long and their subparallel or irregular aggregates. Other crystals forms are {011}, {110}, {010}, and {001}. The mineral has conchoidal fracture with no cleavage and is brittle. $D_{meas} = 3.23(2)$ and $D_{calc} = 3.313$ g/cm³. Fermiite is optically biaxial (+), $\alpha = 1.527$, $\beta = 1.534$, $\gamma = 1.567$ (white light); $2V_{meas} = 51(1)°$, $2V_{calc} = 50°$; dispersion of optical axes is distinct $r < v$; $X = b$, $Y = c$, $Z = a$. Pleochroism: $X, Y =$ colorless, $Z =$ pale greenish yellow; $X = Y < Z$. The mean of 6 electron probe EDS analyses is [wt% (range)]: Na_2O 17.10 (15.65–18.05), UO_3 42.77 (40.88–45.35), SO_3 33.85 (32.64–35.49), H_2O (by stoichiometry) 7.70; total 101.42. The empirical formula based on 17 O pfu is $Na_{3.88}(U_{1.05}O_2)(S_{0.99}O_4)_3(H_2O)_3$. The strongest lines of the X-ray powder diffraction pattern are [d_{obs} Å (I_{obs}%; hkl)]: 9.42 (33; 101), 7.71 (43; 002), 7.01 (100; 011), 6.00 (49; 111,200), 4.70 (42; 103,202), 3.476 (85; 213), 3.336 (55; 122,114), 3.131 (57; 303,023). Unit-cell parameters refined from the powder data with whole pattern fitting are $a = 11.8867(6)$, $b = 7.8783(4)$, $c = 15.3856(9)$ Å, $V = 1440.8$ Å³. The parameters obtained by single crystal X-ray study are: $a = 11.8407(12)$, $b = 7.8695(5)$, $c = 15.3255(19)$ Å, $V = 1428.0$ Å³. Fermiite is orthorhombic, space group $Pmn2_1$, $Z = 4$.

Oppenheimerite forms pale transparent; vitreous, greenish-yellow crystals elongated on [111] in subparallel intergrowths up to several millimeters long. Crystals exhibit the forms {100}, {010}, {001}, {101}, {011}, {110}, and {10$\bar{1}$}. Crystals are slightly sectile with irregular fracture and three good cleavages on {$\bar{1}$10}, {011}, and {101}. $D_{meas} > 3.33$ (could not be measured futher due to solubility in Clerici liquid); $D_{calc} = 3.360$ g/cm³. The mineral is optically biaxial (+), $\alpha = 1.537$, $\beta = 1.555$, $\gamma = 1.594$ (white light); $2V_{meas} = 72(2)°$, $2V_{calc} = 70°$; optical axes dispersion is moderate $r > v$, inclined; $X \approx \perp$ {101}, $Z \approx$ [11$\bar{1}$]. Pleochroism: $X, Y =$ pale greenish yellow, $Z =$ greenish yellow; $X < Y < Z$. The mean of 12 electron probe EDS analyses is [wt% (range)]: Na_2O 10.94 (9.12–11.92), UO_3 50.77 (48.74–54.52), SO_3 29.75 (27.88–31.54), H_2O (by stoichiometry) 9.85; total 101.31. The empirical formula based on 13 O pfu is $Na_{1.94}(U_{0.97}O_2)(S_{1.02}O_4)_2(H_2O)_3$. The strongest lines of the X-ray powder diffraction pattern are [d_{obs} Å (I_{obs}%; hkl)]: 7.29 (31; 010,011), 6.85 (73; 101), 5.39 (47; 110), 4.253 (29; 002), 3.700 (43; 200,211), 3.257 (100; 113,$\bar{1}$02), 2.669 (33; $\bar{1}\bar{1}$2,$\bar{2}\bar{1}$1,032), 2.346 (28; 232,214,310). Unit-cell parameters refined from the powder data with whole pattern fitting are $a = 7.962(2)$, $b = 8.178(2)$, $c = 9.796(2)$ Å, $\alpha = 66.116(9)$, $\beta = 70.342(8)$, $\gamma = 84.510(6)°$, $V = 548.6$ Å³. The parameters obtained by single-crystal X-ray study are: $a = 7.9576(6)$, $b = 8.1952(6)$, $c = 9.8051(7)$ Å, $\alpha = 65.967(5)$, $\beta = 70.281(5)$, $\gamma = 84.516(6)°$, $V = 549.10$ Å³. Oppenheimerite is triclinic, space group $P\bar{1}$, $Z = 2$.

The Raman spectra of both new species are very similar and show bands (fermiite wavenumbers followed by those of oppenheimerite in parentheses, in italics) at (cm⁻¹): 3540, 3465, 3285; (*3526, 3400, 3218*) (O–H stretching); weak 1606; (–) (H_2O bending); weak with shoulders 1228, 1180, 1120, 1104, 1080; (*1215, 1156, 1060*) [$\nu_3(SO_4)^{2-}$ antisymmetric stretching]; strong 1013, 996; (*1013, 1002, 986, 970*) [$\nu_1(SO_4)^{2-}$ symmetric stretching]; weak 922; (–) [$\nu_3(UO_2)^{2+}$ antisymmetric stretching]; very strong 830 with shoulders at 860 and 813; (*841 with shoulder at 825*) [$\nu_1(UO_2)^{2+}$ symmetric stretching]; weak 638, 616, 583; (*651, 603*) [$\nu_4(\delta)(SO_4)^{2-}$ bending]; 506, 443, 384; (*459, 378*) [$\nu_2(\delta)(SO_4)^{2-}$ bending] and 239, 256; (*207*) [$\nu_2(\delta)(UO_2)^{2+}$]. Remaining bands below 200 are assigned to lattice vibrations. The crystal structure of fermiite was refined to $R_1 = 2.21\%$ for 1951 $Io > 3\sigma I$ and that of oppenheimerite was refined $R_1 = 3.07\%$ for 2337 $Io > 3\sigma I$. Both structures have typical for uranyl sulfates coordination of U^{6+}, surrounded by 7 O atoms to form square pentagonal bipyramids, where the two short apical bonds of the bipyramid constitute the uranyl group. Adjacent bipyramids are linked to one another via two bridging SO_4 groups forming infinite chains. The $[(UO_2)(SO_4)_3]^{4-}$ chain in fermiite is parallel to [100] and the $[(UO_2)(SO_4)_2(H_2O)]^{2-}$ chain in oppenheimerite is parallel to [11$\bar{1}$]. In both structures, the chains are linked by bonds involving 5 different Na–O polyhedra for fermiite and 2 different Na–O polyhedra for oppenheimerite to form a framework. The new minerals are named in honor the famous theoretical physicists Enrico Fermi (1901–1954) and J. Robert Oppenheimer (1904–1967). Both are well known, particularly for their work for the Manhattan Project during World War II. Three cotype specimens for each species were deposited in the Natural History Museum of Los Angeles County, California, U.S.A., and one cotype specimen for each of new minerals were deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **D.B.**

PARAWULFFITE* AND WULFFITE*

I.V. Pekov, N.V. Zubkova, V.O. Yapaskurt, D.I. Belakovskiy, N.V. Chukanov, I.S. Lykova, D.P. Savelyev, E.G. Sidorov

and D.Yu. Pushcharovsky (2014) Wulffite, $K_3NaCu_4O_2(SO_4)_4$, and parawulffite, $K_5Na_3Cu_8O_4(SO_4)_8$, two new minerals from fumarole sublimates of the Tolbachik Volcano, Kamchatka, Russia. Canadian Mineralogist, 52(4), 699–716.

Wulffite (IMA 2013-035), ideally $K_3NaCu_4O_2(SO_4)_4$, and parawulffite (IMA 2013-036), ideally $K_5Na_3Cu_8O_4(SO_4)_8$, are two new minerals from the fumarolic sublimates at the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. Wulffite was named in honor of an outstanding Russian crystallographer G.V. Wulff (1863–1925), and the name parawulffite reflects that the new mineral is very similar to wulffite. Wulffite occurs in the Arsenatnaya fumarole as incrustations on the surface of basalt scoria or on tenorite or aphthitalite crusts in association with euchlorine, fedotovite, hematite, johillerite, fluoborite, langbeinite, calciolangbeinite, arcanite, krasheninnikovite, lammerite, lammerite-β, bradaczekite, urusovite, gahnite (Cu-bearing variety), orthoclase (As-bearing variety), and fluorophlogopite. Wulffite forms coarse prismatic crystals up to 2×1.2 mm, elongated along [010]. Parawulffite was discovered in the Yadovitaya fumarole as incrustations formed by crude crystals or irregularly shaped grains on basalt scoria and on hematite crusts in association with euchlorine, fedotovite, tenorite, alumoklyuchevskite, langbeinite, calciolangbeinite, chalcocyanite, steklite, orthoclase (As-bearing variety), rutile (Fe- and Sb-bearing variety), pseudobrookite, lyonsite, and lamerite, Parawulffite forms imperfect, prismatic, usually elongated along [010], commonly curved crystals that have a blocky character and are up to 0.4×0.2 mm. Both minerals are dark green, sometimes deep emerald-green or deep green with a bluish hue (wulffite), transparent with vitreous luster, and have a light green streak. They are both brittle with Mohs hardness of ~2½. Wulffite has two perfect cleavages parallel to elongation and the third one coplanar to (010). Parawulffite has two perfect cleavages, one is parallel to elongation and the second is coplanar to (010). Wulffite has a stepped and parawulffite has a laminated fracture. $D_{meas} = 3.23(2)$, $D_{calc} = 3.19$ g/cm³ for wulffite; $D_{meas} = 3.35(2)$, $D_{calc} = 3.32$ g/cm³ for parawulffite. Wulffite is optically biaxial (+), α = 1.582(3), β = 1.610(3), and γ = 1.715(3) (589 nm); $2V_{calc} = 58°$; $Z = b$. It is strongly pleochroic: Z (emerald-green) > Y (green, with medium saturation color) > X (pale green). Parawulffite is biaxial (+), α = 1.585(3), γ = 1.717(4) (589 nm); $Z = b$, and has a very strong pleochroism: Z (deep emerald-green) > X (very pale green, almost colorless). Both minerals slowly dissolve in H_2O at room temperature. The average of 6 electron probe WDS analyses on wulffite is [wt%, (range)]: Na_2O 4.11 (3.76–4.29), K_2O 16.46 (15.82–17.22), Rb_2O 0.95 (0.64–1.16), Cs_2O 0.65 (0–1.05), CuO 38.88 (37.96–40.02), ZnO 0.15 (0–0.39), SO_3 39.11 (38.64–40.15), total 100.31. The formula calculated on the basis of 18 O atoms pfu is: $Na_{1.08}(K_{2.85}Rb_{0.08}Cs_{0.04})_{\Sigma2.97}(Cu_{3.99}Zn_{0.02})_{\Sigma4.01}$ $S_{3.99}O_{18}$. The average of 4 electron probe WDS analyses on parawulffite is [wt%, (range)] Na_2O 5.61 (5.14–6.03), K_2O 13.74 (12.91–14.36), Rb_2O 1.42 (1.20–1.71), Cs_2O 1.21 (0.96–1.42), CuO 38.79 (37.97–39.76), ZnO 0.18 (0–0.36), SO_3 39.26 (38.44–39.81), total 100.21. The empirical formula calculated on the basis of 36 O atoms pfu is: $Na_{2.95}(K_{4.75}Rb_{0.25}Cs_{0.14})_{\Sigma5.14}$ $(Cu_{7.95}Zn_{0.04})_{\Sigma7.99}S_{7.99}O_{36}$. IR absorption spectroscopy identified

the following bands [wulffite // parawulffite] (cm⁻¹, s = strong bands, sh = shoulder): ~1223, 1198, 1153s, 1118s // 1212s, 1202s, 1149s, 1116s [asymmetric stretching vibrations of SO_4^{2-} anions), 1026s, 989s // 1036s, 1006s, 981s [symmetric stretching vibrations of SO_4^{2-} anions], 671, 645sh, 635, 612 // 690, 665, 642, 618, 572, 550 [bending vibrations of SO_4^{2-}], 535sh, 511 // 503, 450 [lattice modes involving stretching vibrations of shorter bonds in Cu-centered polyhedral with (4+1) Cu^{2+} coordination and possibly the bending mode of SO_4^{2-}]. The strongest lines of the X-ray powder diffraction pattern of wulffite [d_{obs} Å (I_{obs}%; hkl)] are: 9.27 (100; 102), 7.16 (22; 200), 3.125 (16; 313,215), 2.882 (16; 411), 2.780 (33; 117), 2.725 (20; 020). The strongest lines of the X-ray powder diffraction pattern of parawulffite [d_{obs} Å (I_{obs}%; hkl)] are: 9.06 (100; $\overline{1}$02,102), 7.00 (23; 200), 3.096 (31; 313,$\overline{2}$15), 2.736 (33; $\overline{1}$17,117), 2.492 (24; 020), 2.321 (26; 019,513). Wulffite is orthorhombic, space group $Pn2_1a$, a = 14.2810(6), b = 4.9478(2), c = 24.1127(11) Å, V = 1703.79 Å³, Z = 4. Parawulffite is monoclinic, space group $P2/c$, a = 13.9043(10), b = 4.9765(3), c = 23.5855(17) Å, β = 90.209(6)°, V = 1631.98 Å³, Z = 2. The crystal structures for both minerals were solved by direct methods and refined to R_1 = 7.21% (for wulffite) and to R_1 = 9.85% (for parawulffite). Wulffite and parawulffite are closely related structurally. Their structures contain a heteropolyhedral quasi-framework formed by Cu–O–S chains and chains of NaO_6 octahedra [$Na(1)O_6$ in parawulffite]. In both minerals, the heteropolyhedral Cu–O–S chains run along [010] and are built of Cu-centered polyhedra with (4+1) Cu^{2+} coordination (square pyramids) and SO_4 tetrahedra. Wulffite and parawulffite differ from one another in ratios of alkali cations and their arrangement in cavities of the quasi-framework and in the configuration of Cu–O–S chains. The type specimens are deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

SAAMITE*

F. Cámara, E. Sokolova, Y.A. Abdu and F.C. Hawthorne (2014) Saamite, $Ba\square TiNbNa_3Ti(Si_2O_7)_2O_2(OH)_2(H_2O)_2$, a group-III Ti-disilicate mineral from the Khibiny alkaline massif, Kola Peninsula, Russia: description and crystal structure. Canadian Mineralogist, 52(4), 745–762.

Saamite (IMA 2013-083), ideally $Ba\square TiNbNa_3Ti(Si_2O_7)_2$ $O_2(OH)_2(H_2O)_2$, is a new mineral discovered at the Kirovskii mine, Mount Kukisvumchorr, Khibiny alkaline massif, Kola Peninsula, Russia. Saamite is named after *Saami*, indigenous people populating parts of the Kola Peninsula in Russia, Norway, Sweden, and Finland. The new mineral occurs in a hydrothermally altered pegmatite body emplaced in nepheline syenites. It associated with natrolite, barytolamprophyllite, kazanskyite, nechelyustovite, hydroxylapatite, belovite-(La), belovite-(Ce), gaidonnayite, nenadkevichite, epididymite, apophyllite-(KF), and sphalerite. Saamite forms transparent, colorless to very pale tan platy crystals and up to 180 μm long and 2–10 μm thick. It has a white streak, vitreous luster, perfect cleavage on {001} and an uneven fracture. Mohs hardness is ~3. The density could not be measured; D_{calc} = 3.243 g/cm³. Fluorescence under 240–400 nm UV radiation was not observed. Saamite is biaxial (+), α = 1.760(5), β = 1.770(5), γ = 1.795(5) (589 nm), $2V_{obs}$ = 69(2)°,

$2V_{calc} = 65°$; dispersion $r > v$, medium; non-pleochroic. Transmission Fourier-transform IR spectroscopy identified a few bands at ~1605, 1645, ~1747, and ~3420 cm^{-1}. The average of 22 electron probe WDS analyses is [wt%, (range)]: Nb_2O_5 12.24 (10.6–13.8), TiO_2 20.37 (18.04–20.37), SiO_2 29.07 (28.22–30.28), Al_2O_3 0.08 (0.06–0.13), FeO 0.32 (0.15–0.32), MnO 5.87 (5.37–6.38), MgO 0.04 (0.01–0.07), BaO 11.31 (9.71–12.07), SrO 2.51 (2.26–3.09), CaO 1.76 (1.62–1.95), K_2O 0.77 (0.68–0.90), Na_2O 8.39 (5.52–8.39), H_2O (by stoichiometry) 5.77, F 1.71 (1.31–1.89), –O=F$_2$ 0.72, total 99.49. For Na, the first point analysis was used since the mineral is unstable under the electron beam and loses Na during analysis. The empirical formula calculated on the basis of 20 (O+F) pfu is: $(Ba_{0.61}Sr_{0.20}K_{0.13}\square_{0.06})_{\Sigma1}$ $(\square_{0.74}Ca_{0.26})_{\Sigma1}(Na_{2.22}Mn_{0.55}Fe^{2+}_{0.04}\square_{0.19})_{\Sigma3}Si_{3.97}O_{19.26}H_{5.26}F_{0.74}$. The strongest lines of the X-ray powder diffraction patterns [d_{obs} Å (I_{obs}%; hkl)] are: 21.539 (100; 001), 2.790 (15; 122), 2.692 (14; 008), 3.077 (130; 007), 7.180 (11; 003), 2.865 (11; 1$\bar{2}$2), 1.785 (9; 1$\bar{1}$4), 2.887 (9; $\bar{1}$22,0$\bar{1}$7,115) and 1.785 (9; 0$\bar{4}$1, 1$\bar{3}$7,040,$\bar{2}\bar{2}$8,230,23$\bar{1}$). All crystals of saamite were found to be twinned. The crystal structure of saamite was solved by direct methods and refined to $R_1 = 9.92\%$. The mineral is triclinic, $P\bar{1}$, $a = 5.437(2)$, $b = 7.141(3)$, $c = 21.69(1)$ Å, $\alpha = 92.97(1)$, $\beta = 96.07(1)$, $\gamma = 90.01(1)°$, $V = 836.3$ Å^3, and $Z = 2$. Saamite is a Group-III TS-block Ti-disilicate mineral following the nomenclature of Sokolova (2006). In the crystal structure of saamite, the main structural unit is the TS block, which consists of HOH sheets (H-heteropolyhedral, O-octahedral). The TS block exhibits linkage and stereochemistry typical for Group III [Ti (+ Nb + Mg) = 3 apfu] of TS-block minerals. The O sheet is composed of Na- and Ti-dominant octahedra and has ideal composition Na_3Ti apfu. The TS block has two different H sheets where Si_2O_7 groups link to [5]-coordinated Ti and [6]-coordinated Nb polyhedra, respectively. There are two peripheral sites, [10]-coordinated A^P(1) and [8]-coordinated A^P(2), occupied mainly by Ba (less Sr and K) at 94% and Ca at 26%, respectively. In the crystal structure of saamite, adjacent TS blocks connect in two different ways: (1) via hydrogen bonds between H_2O–H_2O groups and H_2O–O atoms of adjacent TS blocks; (2) via a layer of Ba atoms that constitute the I block. The holotype of saamite is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

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