New Mineral Names*†

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ALMEIDAITE*


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 dacitic 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 Brazilian orogenic event (600–450 Ma), generating quartz–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 e-axis. Almeidaite is black with a brown streak, is opaque with fluorescent in long UV light. It is optically uniaxial (+) with high birefringence. 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), FeO 22.83 (Mössbauer; 21.99–23.62), Y$_2$O$_3$ 2.81 (2.09–3.55), La$_2$O$_3$ 0.25 (0–0.48), TiO$_2$ 56.10 (55.33–56.80), H$_2$O 0.4 (gas chromatography of products of ignition at 1200 °C), total 99.23 wt%. This gives the empirical formula (Pb$_{0.59}$Sr$_{0.04}$Ca$_{0.03}$La$_{0.03}$)$_{0.47}$(Fe$_{13.02}$Ti$^{3+}$)$_{0.43}$(Ti$_{13.02}$Fe$_{18}$O$_{38}$)$_{2.78}$, based on 38 O apfu. The strongest lines in the X-ray powder-diffraction pattern [d$_{ab}$ Å (I$_{ab}$%); hkl]] are: 2.907 (100; 116,115,124,214,107), 2.492 (55; 131,311,215), 3.074 (50; 205,300,165,115,311), 3.023 (50; 300,165,311,107), 2.781 (44; 033,303). The unit-cell parameters refined from powder-diffraction data are: a = 10.462(5), c = 21.092(2), V = 2000 Å$^3$; 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 ≥ 3σ(I) shows almeidaite is trigonal, space group R$\overline{3}$, with the unit-cell parameters a = 10.4359(2), c = 21.0471(4), $V' = 1985.10(7)$ Å$^3$, 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 the 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*


Barlowite (IMA 2010–020), ideally Cu$_4$FBr(OH)$_9$, 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 0{01}, 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 0{01} and as brittle. $D_{\text{max}} > 3.8 \text{ g/cm}^3$ (sinks in the heaviest liquid available); $D_{\text{calc}} = 4.21 \text{ g/cm}^3$. Crystals are readily soluble in cold dilute HCl. Barlowite is optically uniaxial (−), non-pleochroic, with accessory Y-bearing pectolite, britholite, and steenstrupine.

Barrydawsonite-(Y) typically forms single grains which are either subhedral prismatic up to 0.2 × 0.1 × 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 $2V_{\text{max}} = 63(1)^\circ$, $2V_{\text{calc}} = 64(1)^\circ$, with optic orientation $Z = \text{br}$, $X^V = 15^\circ$ 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)]: Na$_{0.54}$Ca$_{0.74}$Mn$_{0.15}$Fe$_{0.07}$Y$_{0.38}$Nd$_{0.01}$Pr$_{0.05}$Nd$_{0.38}$O$_{0.35}$Si$_{3.00}$O$_{9}$H$_{3.05}$ based on 9 anions per formula unit. The strongest lines in the X-ray powder-diffraction pattern [d$_{\text{obs}}$ Å (I$_{\text{obs}}$/% hkl)]: $5.790$ (100; 020), $2.707$ (55; 112), $2.889$ (40; 020), $2.452$ (40; 022), $1.668$ (30; 200,033), $1.778$ (20; 032,015). The unit-cell parameters refined from powder-diffraction data are: $a = 6.681(1)$ Å, $c = 9.274(1)$ Å, $V = 358.43$ Å$^3$. Single-crystal X-ray diffraction data collected on a crystal of size $80 \times 60 \times 10$ mm refined to $R = 0.0145$ for 231 unique reflections with $I \geq 4\sigma(I)$ shows barlowite is hexagonal, space group $P6_3/mmc$, $a = 6.6786(2)$ Å, $c = 9.2744(3)$ Å, $V = 358.251$ Å$^3$, 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)p6 (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)**


Barrydawsonite-(Y) (IMA 2014-042), ideally Na$_{1.5}$Ca$_{0.5}$Y$_{0.5}$Si$_3$O$_{9}$H$_3$, is a new mineral found at the Merlot Claim, North Red Wine Pluton, Labrador, Canada. The mineral was found in metamorphosed euclidean nepheline syenite associated with potassic arfvedsonite, aegirine, albitie, and potassium feldspar with accessory Y-bearing pectolite, britholite, and steenstrupine.

**BLUEBELLITE* AND MOJAVEITE**


Bluebellite (IMA 2012-120), ideally Cu$_4$[Fe$_2$O$_7$(OH)$_2$](OH)$_2$Cl, and mojaveite (IMA 2012-121), ideally Cu$_4$[Te$_4$O$_9$(OH)$_2$](OH)$_2$Cl, 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 murochite, calcite,
fluorite, and hemimorphite. Mojaveite was discovered at the Aga mine where it occurs with cerussite, chrysocolla, khinite, perite, and quartz; 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, burkhardite, galena, goethite, khinite, mcalpineite, thorite, timroseite, paratimroseite, quartz, and wulfenite. Bluebellite forms bright bluish-green flattened plates or flakes up to \(20 \times 20 \times 5\) \(\mu\text{m}\) 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\}, \{002\}, \{100\}, \{110\}, and \{110\}. 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 \(\text{mm}\) 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 \(\sim 1\). The densities could not be measured; \(D_{\text{calc}} = 4.746\) for bluebellite and 4.886 \(g/cm^3\) for mojaveite. Optically both minerals are uniaxial (−), with \(\omega\) and \(\varepsilon \gg 1.8\). Refractive indices could not be measured directly but are estimated to be \(n_e = 1.96\) 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)]: \(\text{CuO} 48.62 (47.81–50.47), \text{Al}_2\text{O}_3 0.12 (0–0.23), \text{SiO}_2 0.75 (0.71–0.83), \text{I}_2\text{O}_5 17.26 (16.90–17.78), \text{Cl} 4.06 (3.99–4.14), \text{O}=\text{Cl} 0.92, \text{H}_2\text{O}_{\text{calc}} = 9.27, \text{total} 79.16.\) For mojaveite \(\text{CuO} 56.74 (56.21–57.49), \text{PbO} 2.14 (1.46–2.45), \text{Bi}_2\text{O}_3 0.33 (0–0.50), \text{TeO}_3 21.12 (20.86–21.57), \text{Cl} 4.51 (4.38–4.60), \text{O}=\text{Cl} 1.02, \text{H}_2\text{O}_{\text{calc}} = 9.71, \text{total} 93.53.\) Low totals are due to \(\text{CuS}\) and \(\text{Bi}_2\text{Te}_3\) being present.

Bonazziite (IMA 2013-141), the natural analog of the \(\beta\)-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 Khaiderdakan 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 \(\beta\)-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 alcaránite. However having greater unit-cell volume, alcaránite also has a chemical composition As\(_4\)S\(_4\) and crystallized in monoclinic space group \(P2/c\) while the synthetic \(\beta\)-As\(_4\)S\(_4\) crystallizes in the \(C2/c\) space group. Later the natural \(\beta\)-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-Étienne, Loire, Rhône-Alpes, France, but was never submitted to IMA due to confusion with alcaránite or due to semi-technological origin. In the museum specimen from Khaiderdakan bonazziite occurs as rare reddish-orange crystals up to 100 \(\mu\text{m}\) with realgar, sulfur, wakabayashilite, alcaránite, 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\(_{15}\) is \(70 (60–76)\) kg/mm\(^2\) corresponding to Mohs hardness of \(\sim 2\). 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 [\(R_{\text{max}}\), \(R_{\text{min}}\), % (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–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)]: Na2O 4.06 (3.72–4.22), CaO 0.05 (0.03–0.06), MnO 41.76 (40.94–42.46), Mn3O4 3.07 (2.55–3.87; calc. based on 2 (OH) groups pfu and V distribution), MgO 0.96 (0.90–1.01), Al2O3 0.04 (0.01–0.12), CuO 0.02 (0.01–0.04), SiO2 39.73 (38.70–40.21), As2O5 6.87 (6.10–7.79), V2O5 1.43 (1.35–1.61); tetrahedral V5+ is calculated as 6– (Si + As) and excess V is assigned to the octahedral sites as V3+), SO3 0.01 (0.01–0.02) and F 0.04 (0–0.19), –O–F 0.02 (0–0.08), H2O 2.20 (calc. on the basis of 2 OH groups pfu). This gives the empirical formula Na4.09(Mn2+4.06Mn4+1.73Mg0.16Al0.06Ca0.01)Σ4.99[(Si1.36As0.48V0.13)Σ2.09O7.01(OH))(OH)0.65F0.02] based on 19 O apfu. The strongest lines in the X-ray powder-diffraction pattern [d obs Å (I(%) hkl)] are: 3.055 (69; 221), 3.042 (43; 102), 3.012 (65; 32T), 2.985 (55; 23T), 2.825 (100; 213), 2.708 (92; 220), 2.627 (43; 232), 2.381 (58; 4TT), 2.226 (25; 214) and 1.680 (36; 433). 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 R1 = 0.0347 for 4389 unique reflections with I > 4σ(I) shows braccoite is triclinic, space group P T, with a = 9.7354(5), b = 9.9572(3), c = 9.6057(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 hydroxyproenoid sanerite, and is topologically identical to it. The structure consists of a five-repeat single isolated chain of SiO4 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 (111). 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*

on \{100\} and \{010\}. It is brittle, with a Mohs hardness of 2; $D_{\text{meas}} = 1.48(2)$, $D_{\text{calc}} = 1.464$ g/cm$^3$. No fluorescence under UV light or electron beam was observed. In transmitted light, the mineral is strongly pleochroic Z – Y (deep blue) >> X (pale gray-blue). It is optically biaxial (-), $\alpha = 1.561(2)$, $\beta = 1.615(3)$, $\gamma = 1.620(2)$, $2\mu_{\text{obs}} = 25(10)^{\circ}$, $2\mu_{\text{calc}} = 33^\circ$. $X = c$; optical axes dispersion is moderate, $r > v$. The IR spectrum shows (cm$^{-1}$) intensive broad bands in the range 3200–3500 (deformation of N–H and O–H bonds); narrow bands at 3100–3200 (C–H stretching of ligands and H$_2$O bending); strong bands 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 29.5(9), C 12.2(5), O 3.4(5) by gas chromatography; total 98.1. The empirical formula based on Cu$^+$/Fe = 2 apfu is Cu$_{1.92}$Fe$_{0.08}$[Na$_{1.84}$Cu$_{0.16}$Cl$_{3.4}$]$_{3}$$(\text{SeO}_2)_3$(OH)·4H$_2$O. The strongest lines of the X-ray powder diffraction pattern are $d_{\text{obs}}$ Å ($I_{\text{rel}}$%); $hkl$: 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 $a = 19.484(3)$, $b = 7.2136(10)$, $c = 11.9994(4)$ Å, $V = 1686.5$ Å$^3$; 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 $R_{\text{f}} = 0.1627$ for 949 independent reflections with $I > 2\sigma(I)$ suggested that chains of the corner-sharing Cu(I)-centered octahedra and single Cu(2)-centered octahedra are connected via 1,2,4-triazolate anions C$_3$N$_3$H$_7$. NH$_3$ and Cl$^-$ are additional ligands coordinating Cu$^{2+}$. This structural motif is close to that of the associated phase Na$_{2}$Cu$_2$Cl$_3$(N$_3$C$_2$H$_2$)$_2$(NH$_3$)$_2$·4H$_2$O (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

**Favreauite**


Favreauite (IMA 2014-013), ideally PbBiCu$_4$O$_4$(SeO$_4$)$_4$(OH)·H$_2$O, 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, chalcocite, malachite, molybdenite, 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 \{010\} and combined in subparallel and divergent groups. The mineral has perfect cleavage on \{010\}, an irregular fracture. The Mohs hardness is estimated as ~3. The density could not be measured; $D_{\text{calc}} = 4.851$ g/cm$^3$. 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$_4$ stretching). Other SeO$_4$ bands are at (cm$^{-1}$): 764 and 795 ($v_3$ antisymmetric stretching), 493 and 542 ($v_4$ bending modes), 320 and 392 ($v_5$ bending modes). 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$_2$O$_3$ 13.95 (13.71–14.22), SeO$_3$ 30.16 (29.35–31.29), H$_2$O (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$_{0.95}$Cu$_{1.7}$Bi$_{0.9}$Ca$_{0.17}$O$_{0.91}$Se$_{4.10}$O$_{16}$(OH)·H$_2$O. The strongest lines of the X-ray powder diffraction pattern are $d_{\text{obs}}$ Å ($I_{\text{rel}}$%); $hkl$: 5.67 (100; 111), 3.470 (76; 220,202), 3.390 (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: $a = 9.860(4)$ Å, $c = 9.700(5)$ Å, $V = 943.0$ Å$^3$, space group $P4/n$; $Z = 2$. The crystal structure was refined to $R_{\text{f}} = 0.0329$ for 1354 observed reflections [10 F$_{\text{o}}$ > 4σ(F$_{\text{o}}$)]. It consists of a corrugated layer of CuO$_4$ squares, decorated by SeO$_4$ 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$_2$O 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 $T_4$ 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$_4$Te$_4$O$_{12}$(SO$_4$)$_2$Cl and atlasovite KCu$_4$Fe$_4$O$_{12}$(SO$_4$)$_2$Cl. Those structures could be derived from the framework structure of mudrochite, Pb$_2$Cu$_2$O$_4$(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*  

Fermiite (IMA 2014-068), ideally Na₄(UO₂)(SO₄)₃·3H₂O and oppenheimerite (IMA 2014-073), ideally Na₄(UO₂)(SO₄)₃·3H₂O 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, chalcantite, epsomite, gypsum, hexahydrite, kröhnkeite, managanoblödite, sideronatrite, tamarugite, and wetherillite. The general assemblage also include aluminocoquimbite, catamakite, belakovskite, bobcookite, brochantite, calcite, cobaltoblödite, copiapite, coquimbite, cyanotrichite, d’ansite-(Mn), dickite, dietrichite, ferrinatrite, gerhardtite, gourdite, galite, kieserite, lishizenite, meisserite, metavoltine, natrozippeite, plašilite, pseujobonnanite, rhomboclase, romerite, and other new minerals currently under investigation. Both new species are slightly deliquescent and easily soluble in H₂O 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. D₉₉ = 3.23(2) and D₉₈ = 3.313 g/cm³. Fermiite is optically biaxial (+), α = 1.527, β = 1.534, γ = 1.567 (white light); 2Vₒ = 51(1)°, 2Vₐ = 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)]: Na₂O 17.10 (15.65–18.05), UO₃ 50.77 (48.74–54.52), SO₃ 29.75 (27.88–31.54), H₂O (by stoichiometry) 9.85; total 101.31. The empirical formula based on 13 O pfu is Na₄.₉₈(U₀.₅₅O₂)(S₁.₉₉O₄)₃(H₂O)₃. The strongest lines of the X-ray powder diffraction pattern are [d_obs Å (I₀₀₈ %; 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; 113,020), 2.669 (33; T72,2T1,032), 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), α = 66.116(9), β = 70.342(8), γ = 84.510(6), V = 548.6 Å³. The parameters obtained by single-crystal X-ray study are: a = 7.9756(6), b = 8.1952(6), c = 9.8051(7), α = 65.967(5), β = 70.28(1), γ = 84.516(6), V = 549.10 Å³. Oppenheimerite is triclinic, space group Pm₃n, Z = 2.

The Raman spectra of both new species are very similar and show bands (fermite wavenumbers followed by those of oppenheimerite in parentheses, in italics) at (cm⁻¹): 3540, 3465, 3285; (3526, 3400, 3218); O–H stretching; weak 1606; (–) (H₂O bending); weak 1215, 1156, 1060; ν₁(SO₄)²⁻ antisymmetric stretching; strong 1013, 996; (1013, 1002, 986, 970); ν₂(SO₄)²⁻ symmetric stretching; weak 922; (–) ν₂(UO₂)²⁻ antisymmetric stretching; very strong 830 with shoulders at 860 and 813; (841 with shoulder at 823) ν₁(UO₂)²⁺ symmetric stretching; weak 638, 616, 583; (635, 603) ν₁(δ) (SO₄)²⁻ bending; 506, 443, 384; (459, 378) ν₂(δ) (SO₄)²⁻ bending and 239, 256; (207) ν₃(δ)(UO₂)²⁺. Remaining bands below 200 are assigned to lattice vibrations. The crystal structure of fermiite was refined to R = 2.21% for 15073 I₀ > 3σI and that of oppenheimerite was refined R = 3.07% for 23277 I₀ > 3σI. Both structures have typical for uranyl sulfates coordination of U(VI), 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 SO₄ groups forming infinite chains. The [(UO₂)(SO₄)₃]⁺ chain in fermiite is parallel to [100] and the ([UO₂)(SO₄)₃(H₂O)]⁺ chain in oppenheimerite is parallel to [111]. 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 new species were deposited in the Natural History Museum of Los Angeles County, California, U.S.A., and one cototype specimen for each of new minerals were deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Parawulffite** and **Wulffite**  

Wulfite (IMA 2013-035), ideally K₃Na₃Cu₂O₂(SO₄)₈, and parawulfite (IMA 2013-036), ideally K₃Na₃Cu₂O₂(SO₄)₈, are two new minerals from the fumarole sublimates at the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. Wulfite was named in honor of an outstanding Russian crystallographer G.V. Wulff (1863–1925), and the name parawulfite reflects that the new mineral is very similar to wulffite. Wulfite occurs in the Arsenatnya fumarole as incrustations on the surface of basalt scoria or on tenorite or aphthitalite crusts in association with euchlorine, fedotovite, hematite, johlliterite, fluoborite, langbeinite, calciolangbeinite, arcanite, krasheninnikovite, lammerite, lammerite-β, bradazekite, urusovite, gahnite (Cu-bearing variety), orthoclase (As-bearing variety), and fluorophlogopite. Wulfite forms coarse prismatic crystals up to 2 × 1.2 mm, elongated along [010]. Parawulfite 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, alamoklyuchevskite, langbeinite, calciolangbeinite, chalcocyanite, steklite, orthoclase (As-bearing variety), rutile (Fe- and Sb-bearing variety), pseudobrookite, lysomite, and lamerite. Parawulfite forms imperfect, prismatic, usually elongated along [010], commonly curved crystals that are dark green, sometimes deep emerald green or deep green with a bluish hue (wulfite), transparent with vitreous luster, and have a light green streak. They are both brittle with Mohs hardness of ~2½. Wulfite has two perfect cleavages parallel to elongation and the third one coplanar to (010). Parawulfite has two perfect cleavages, one is parallel to elongation and the second is coplanar to (010). Wulfite has a stepped and parawulfite has a laminated fracture. D_\text{meas} = 3.23(2), D_\text{calc} = 3.19 g/cm³ for wulfite; D_\text{meas} = 3.35(2), D_\text{calc} = 3.32 g/cm³ for parawulfite. Wulfite is optically biaxial (+), α = 1.582(3), β = 1.610(3), and γ = 1.715(3) (589 nm); 2V_\text{calc} = 58°; Z = b. It is strongly pleochroic: Z (emerald-green) > Y (green, with medium saturation color) > X (pale green). Parawulfite is biaxial (+), α = 1.585(3), γ = 1.717(4) (589 nm); 2V_\text{calc} = 58°; Z = b, and has a very strong pleochroism: Z (deep emerald-green) > X (very pale green, almost colorless). Both minerals slowly dissolve in H₂O at room temperature. The average of 6 electron probe WDS analyses on wulfite is [wt%, (range)]: Na₂O 4.11 (3.76–4.29), K₂O 16.46 (15.82–17.22), Rb₂O 0.95 (0.64–1.16), Cs₂O 0.65 (0–1.05), CuO 38.88 (37.96–40.02), ZnO 0.15 (0–0.39), SO₃ 39.11 (38.44–40.15), total 100.31. The formula calculated on the basis of 18 O atoms pfu is: Na₁₁₀.₄₅K₂₂.₈₄Rb₁₀.₃₃Cs₁₀.₄₄S₁₁.₉₈Zn₀₂.₈₄O₁₃.₈₄. PAR 26-1561. The average of 4 electron probe WDS analyses on parawulfite is [wt%, (range)]: Na₂O 5.61 (5.14–6.03), K₂O 13.74 (12.91–14.36), Rb₂O 1.42 (1.20–1.71), Cs₂O 1.21 (0.96–1.42), CuO 38.79 (37.97–39.76), ZnO 0.18 (0–0.36), SO₃ 39.26 (38.44–39.81), total 100.21. The empirical formula calculated on the basis of 36 O atoms pfu is: Na₂₀.₈₄K₁₇.₇₇Rb₁₂.₅₂Cs₁₄.₃₅Zn₁₂.₄₁Cu₁₄.₂₁SO₄₈. IR absorption spectroscopy identified the following bands [wulfite // parawulfite] (cm⁻¹, s = strong bands, sh = shoulder): ~1223, 1198, 1153s, 1118s // 1212s, 1202s, 1149s, 1116s [asymmetric stretching vibrations of SO₄²⁻ anions], 1026s, 989s // 1036s, 1006s, 981s [symmetric stretching vibrations of SO₄²⁻ anions], 671, 645sh, 635, 612 // 690, 665, 642, 618, 572, 550 [bending vibrations of SO₄²⁻], 535sh, 511 // 503, 450 [lattice modes involving stretching vibrations of shorter bonds in Cu-centered polyhedral with (4+1) Cu²⁺ coordination and possibly the bending mode of SO₄²⁻]. The strongest lines of the X-ray powder diffraction pattern of wulfite [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 parawulfite [d_{obs}, Å (I_{obs}; hkl)] are: 9.06 (100; T02;102), 7.00 (23; 200), 3.096 (31; 313,215), 2.736 (33; T17,117), 2.492 (24; 020), 2.321 (26; 019,513). Wulfite is orthorhombic, space group Pn2₁/a, a = 14.810(3), b = 4.9478(2), c = 24.1127(11) Å, V = 1703.79 Å³, Z = 4. Parawulfite is monoclinic, space group P2₁/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 R₁ = 7.21% (for wulfite) and R₁ = 9.85% (for parawulfite). Wulfite and parawulfite are closely related structurally. Their structures contain a heteropolyhedral quasi-framework formed by Cu–O–S chains and chains of NaO₆ octahedra [Na₁1O₆ in parawulfite]. In both minerals, the heteropolyhedral Cu–O–S chains run along [010] and are built of Cu-centered polyhedra with (4+1) Cu²⁺ coordination (square pyramids) and SO₄ tetrahedra. Wulfite and parawulfite 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.

SAAMITE*
F. Cámara, E. Sokolova, Y.A. Abdu and F.C. Hawthorne (2014) Saamite, BaTiNbNa₃Ti(Si₂O₇)₂O₂(OH)₂(H₂O)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 Ba₁₀TiNbNa₃Ti(Si₂O₇)₂O₂(OH)₂(H₂O)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, 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), gahnite-(Cu-bearing variety), hydroxylapatite, belovite-(Ce), and gahnite-(La). 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_\text{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_\text{obs} = 69(2)°.
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$2V_{\text{calc}} = 65^\circ$; dispersion $r > \nu$, medium; non-pleochroic. Transmission Fourier-transform IR spectroscopy identified a few bands at $\sim 1605, 1645, \sim 1747$, and $\sim 3420$ cm$^{-1}$. The average of 22 electron probe WDS analyses is [wt% (range)]: Nb$_2$O$_5$ 12.24 (10.6–13.8), TiO$_2$ 20.37 (18.04–20.37), SiO$_2$ 29.07 (28.22–30.28), Al$_2$O$_3$ 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$_2$O 0.77 (0.68–0.90), Na$_2$O 8.39 (5.52–8.39), H$_2$O (by stoichiometry) 5.77, F 1.71 (1.31–1.89), –O=F 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$_{0.13}$O$_{0.06}$)$_{\Sigma 1}$ (Ca$_{0.74}$Ca$_{0.26}$)$_{\Sigma 1}$ (Na$_{2.22}$Mn$_{0.55}$Fe$_{2+}$$_{0.04}$O$_{0.19}$)$_{\Sigma 3}$Si$_{3.97}$O$_{19.26}$H$_{5.26}$F$_{0.74}$. The strongest lines of the X-ray powder diffraction patterns [d$_{\text{obs}}$ Å (I$_{\text{obs}}$%; 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; 122), 1.785 (9; 1T4), 2.887 (9; T22,0T7,115) and 1.785 (9; 0T4, 137,040,228,230,231). All crystals of saamite were found to be twinned. The crystal structure of saamite was solved by direct methods and refined to $R_I = 9.92\%$. The mineral is triclinic, $P\overline{T}$, $a = 5.437(2)$, $b = 7.141(3)$, $c = 21.69(1)$ Å, $\alpha = 92.97(1)$, $\beta = 96.07(1)$, $\gamma = 90.01(1)^\circ$, $V = 836.3$ 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$_3$Ti apfu. The TS block has two different H sheets where Si$_2$O$_7$ groups link to [5]-coordinated Ti and [6]-coordinated Nb polyhedra, respectively. There are two peripheral sites, [10]-coordinated A$^\alpha$(1) and [8]-coordinated A$^\alpha$(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$_2$O–H$_2$O groups and H$_2$O–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.

References cited