

New Mineral Names*†

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This New Mineral Names has entries for 11 new minerals, including cesiodymite, cryptochalcite, feodosiyite, fluoro-tremolite, itelmenite, ozerovaitite, ramazzoite, redcanyonite, selivanovite, vanderheydenite, and wrightite.

CRYPTOCHALCITE* AND CESIODYMIT*^{*}

I.V. Pekov, N.V. Zubkova, A.A. Agakhanov, D.Y. Pushcharovsky, V.O. Yapaskurt, D.I. Belakovskiy, M.F. Vigasina, E.G. Sidorov and S.N. Britvin (2018) Cryptochalcite, $K_2Cu_5O(SO_4)_5$, and cesiodymite, $CsKCu_5O(SO_4)_5$, two new isotypic minerals and the K-Cs isomorphism in this solid-solution series. European Journal of Mineralogy, 30(3), 593–607.

Cryptochalcite (IMA 2014-106), ideally $K_2Cu_5O(SO_4)_5$, and cesiodymite (IMA 2016-002), ideally $CsKCu_5O(SO_4)_5$, both triclinic, were discovered in the fumarole sublimates of the Second scoria cone, Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. Cryptochalcite was found in the Arsenatnaya (holotype) and Yadovitaya fumaroles, and cesiodymite was found only in the Arsenatnaya fumarole. The name cryptochalcite (Cyrillic: криптохальцит) is derived from the Greek κρυπτός, which means “concealed”, and χαλκός, which means “copper”. Cryptochalcite is a green copper mineral and occurs in intimate association with other green copper oxysulfates and is visually very similar to them, hence the name cryptochalcite means “concealed among other copper minerals.” The name cesiodymite (Cyrillic: цезиодимит) is derived from cesium and Greek δίδυμος, which means “a twin brother”: the mineral contains species-defining cesium and is a Cs-K-ordered analog of cryptochalcite. In the Arsenatnaya fumarole, cryptochalcite and cesiodymite belong to the same mineral assemblage and are found in association with eu-chlorine, chalcocyanite, dolerophanite, alumoklyuchevskite, anglesite, fedotovite, wulfite, langbeinite, apthitalite, piypite, klyuchevskite, eleomelanite, anhydrite, dravertite, krashennikovite, calciolangbeinite, steklite, hematite, tenorite, pseudobrookite, As-bearing orthoclase, sylvite, halite, lammerite, lammerite-β, urusovite, and gold. In the Yadovitaya fumarole cryptochalcite was found in association with eu-chlorine, alumoklyuchevskite, langbeinite, steklite, fedotovite, hematite, and lyonsite. Cryptochalcite in Arsenatnaya occurs as poorly formed prismatic crystals or irregular grains up to $0.1 \times 0.1 \times 0.3$ mm in size and their open-work aggregates up to 1.2 mm across. Cesiodymite forms crude prismatic or thick tabular crystals up to 0.05×0.1 mm \times 0.15 mm or grains up to 0.3 mm in size and their clusters, crusts or open-work aggregates up to 0.5 mm across. Both cryptochalcite and cesiodymite overgrow encrustations of eu-chlorine, sometimes anglesite, chalcocyanite, dolerophanite, alumoklyuchevskite or apthitalite, which cover the basalt scoria altered by fumarole gases. In Yadovitaya, cryptochalcite occurs as

crude, roundish, usually blocky, prismatic crystals up to 0.08×0.2 mm in size and forming discontinuous crusts up to 1.5×2 cm in area and up to 0.2 mm in thickness, also covering the basalt scoria. The two new minerals are visually not distinguishable from one another. They are both transparent, and in aggregates sometimes translucent, light green to green in color, occasionally with a yellow hue. They both have a pale green streak, vitreous luster, and are brittle with an uneven fracture, and do not display any cleavage or parting. Their Mohs hardness is 3. Density was not measured due to the small size of the crystals and the porous nature of aggregates. $D_{calc} = 3.411$ g/cm³ for cryptochalcite and $D_{calc} = 3.593$ g/cm³ for cesiodymite. The new minerals are optically biaxial (–); with $\alpha = 1.610(3)$, $\beta = 1.632(4)$, $\gamma = 1.643(4)$, $2V_{meas} = 65(5)^\circ$, $2V_{calc} = 70^\circ$ ($\lambda = 589$ nm) for cryptochalcite; and $\alpha = 1.61(1)$, $\beta = 1.627(4)$, $\gamma = 1.635(4)$, $2V_{meas} = 70(10)^\circ$, $2V_{calc} = 68^\circ$ ($\lambda = 589$ nm) for cesiodymite. No dispersion of optical axis observed for both. Cryptochalcite and cesiodymite readily become dull and bluish for several minutes and slowly dissolve in H₂O at room temperature. The Raman spectra of cryptochalcite and cesiodymite are generally similar but demonstrate some difference in wavenumbers and intensities of bands (cm⁻¹): 1200–1050 [$F2(\nu_3)$ -type stretching vibrations of SO_4^{2-}], 1030–950 [$A1(\nu_1)$ symmetric stretching vibrations of SO_4^{2-}], 670–590 [$F2(\nu_4)$ bending vibrations of SO_4^{2-}], 500–420 [$E(\nu_2)$ bending vibrations of SO_4^{2-}], and 320–100 (lattice modes). The absence of bands with frequencies higher than 1200 cm⁻¹ indicates the absence of groups with O–H, C–H, C–O, N–H, and N–O bonds in both new minerals. The averages of electron probe WDS analyses (4 for cryptochalcite and 5 for cesiodymite) are [wt% (range)]: Na₂O 0.30 (0.22–0.38), K₂O 9.55 (9.27–9.84), Rb₂O 0.89 (0.80–1.02), Cs₂O 0.90 (0.72–1.08), MgO 0.83 (0.68–1.05), CuO 33.95 (32.95–34.80), ZnO 9.14 (8.83–9.48), SO₃ 44.06 (43.17–44.60), total 99.62 for cryptochalcite; and K₂O 5.47 (4.78–5.77), Rb₂O 1.55 (1.39–1.67), Cs₂O 10.48 (9.98–11.13), CuO 29.91 (29.08–30.62), ZnO 11.05 (10.45–11.67), SO₃ 40.74 (39.71–41.17), total 99.20 for cesiodymite. The empirical formulae based on O=21 pfu are: $(K_{1.83}Na_{0.09}Rb_{0.06}Cs_{0.06})_{\Sigma 2.07}(Cu_{3.86}Zn_{1.02}Mg_{0.19})_{\Sigma 5.07}S_{4.97}O_{21}$ for cryptochalcite and $(K_{1.14}Rb_{0.16}Cs_{0.73})_{\Sigma 2.03}(Cu_{3.69}Zn_{1.33}S_{5.02}S_{4.99}O_{21})$ for cesiodymite. The strongest lines in the powder X-ray diffraction pattern are [d Å, (I %)]: 13.9 (30), 6.95 (100), 6.22 (45), 3.93 (65), 3.76 (30), 3.39 (30), 3.19 (35), 2.500 (4) for cryptochalcite; and 6.95 (54), 3.946 (100), 3.765 (37), 3.404 (39), 3.188 (50), 3.149 (27), 3.104 (28), 2.681 (31) for cesiodymite. The crystal structures of both new minerals were solved by direct methods and refined to $R_1 = 5.03\%$ and $R_1 = 8.98\%$ for cryptochalcite and cesiodymite, respectively. The new minerals are both triclinic, $P1$, $Z = 4$; cryptochalcite has: $a = 10.0045(3)$, $b = 12.6663(4)$, $c = 14.4397(5)$ Å, $\alpha = 102.194(3)$, $\beta = 101.372(3)$, $\gamma = 90.008(3)^\circ$, $V = 1751.7$ Å³ while cesiodymite: $a = 10.0682(4)$, $b = 12.7860(7)$, $c = 14.5486(8)$ Å, $\alpha = 102.038(5)$, $\beta = 100.847(4)$, $\gamma = 89.956(4)^\circ$, $V = 1797.5$ Å³. Cryptochalcite and cesiodymite are isostructural and share a novel structure type. Their crystal structures

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

are based on the heteropolyhedral $\{Cu_5O(SO_4)_3\}^{2-}$ framework composed by two types of alternating Cu^{2+} -S-O polyhedral layers: $\{Cu_2(SO_4)_2\}^0$ and $\{Cu_3O(SO_4)\}^{2+}$, which are connected via $[SO_4]$ tetrahedra. Cu-centered polyhedra are differently distorted octahedra, tetragonal pyramids and trigonal bipyramids. K and Cs cations occupy sites in the tunnels of the framework. Cryptochalcite and cesiodymite differ from one another only in the ratio and distribution of K and Cs between the *A* sites and in the coordination of *A* cations. The holotype specimens for both minerals are deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

FEODOSIYITE*

I.V. Pekov, N.V. Zubkova, V.O. Yapaskurt, D.I. Belakovskiy, I.S. Lykova, M.F. Viganina, D.A. Ksenofontov, S.N. Britvin, E.G. Sidorov, D.A. Khanin and D.Yu. Pushcharovsky (2018) Feodosiyite, $Cu_{11}Mg_2Cl_{18}(OH)_8 \cdot H_2O$, a new mineral from the Tolbachik volcano, Kamchatka, Russia. *Mineralogical Magazine*, 82(5), 1079–1088. *Neues Jahrbuch für Mineralogie, Abhandlungen*, 195/1, 27–39.

Feodosiyite (2015-063), ideally $Cu_{11}Mg_2Cl_{18}(OH)_8 \cdot H_2O$, was discovered in the Glavnaya Tenoritovaya (“Major Tenorite”) fumarole, Second scoria cone, Northern Breakthrough (North Breach), Great Fissure eruption, Tolbachik volcano, Kamchatka, Russia. The new mineral was found in the moderately hot sulfate-chloride zone that occurs as a lenticular body ~1.5 m long and up to 0.2 m thick, on the northern flank of the fumarole. The gas temperature in this zone during collecting was about 100 °C. Feodosiyite is closely associated with belloite, avdoninite, sylvite, carnallite, chlorothionite, and dioskouriite. Other associated minerals are eriochalcite, halite, mitscherlichite, sanguite, chrysothallite, romanorlovite, mellizinkalite, flinteite, kainite, gypsum, sellaitite, and incompletely studied K-Pb-Cu chloride; hematite, tenorite, and chalcocyanite are earlier, sublimate minerals. Feodosiyite occurs as well-formed or crude, tabular or prismatic crystals up to $0.015 \times 0.04 \times 0.05$ mm, rarely up to $0.02 \times 0.1 \times 0.1$ mm. Some crystals display thin polysynthetic twinning. Crystals form groups or crusts up to 1 mm. Interrupted incrustations up to $0.5 \text{ cm} \times 1 \text{ cm} \times 0.1 \text{ mm}$ overgrow basalt scoria. The new mineral is bright green and transparent. It has a light green streak and vitreous luster. It is brittle, has uneven fracture and one direction of imperfect cleavage, and Mohs hardness is ~3; $D_{\text{meas}} = 2.57 \text{ g/cm}^3$, $D_{\text{calc}} = 2.563 \text{ g/cm}^3$. Feodosiyite slowly dissolves in H_2O at room temperature. In humid air the new mineral is unstable and alters to a bluish friable aggregate of hydrous Cu and Mg chlorides after several months. The mineral is optically biaxial (–) with $\alpha = 1.660(3)$, $\beta = 1.690(5)$, $\gamma = 1.718(5)$ ($\lambda = 589 \text{ nm}$), $2V_{\text{meas}} = 90(5)^\circ$, $2V_{\text{calc}} = 86.5^\circ$. Dispersion of an optical axis is very strong, $r > v$. Pleochroism is distinct: *Z* (grass green) > *Y* (light yellowish-green) > *X* (pale green with grayish hue). The Raman spectra of feodosiyite show bands (cm^{-1}): 3500 to 3250 (O-H stretching), the strong narrow band at 3386 with the shoulder at 3461 (hydroxyl groups vibrations), the broad band at 3310 (vibrations of H_2O); the relatively weak band at 1615 (H-O-H bending vibrations of H_2O molecules); 898, 857, and 807 [O-H libration ($Cu^{2+} \cdots O-H$ bending) modes]; 485 (Cu^{2+} -O stretchings); 396 and 325 (Cu^{2+} -O and Mg-O stretching modes); and the bands frequencies below 300 cm^{-1} probably correspond to lattice modes involving, in particular, Cu^{2+} -Cl vibrations. The averaged 5-point WDS electron probe analyses [wt% (range)] is: MgO 5.39 (4.84–5.91), Cu 46.98 (45.46–49.29), Cl 35.42 (34.23–37.28), H_2O_{calc} 20.21, $-O=Cl_2$ 8.00, total 100.00 wt%. The empirical formula is $Cu_{10.58}Mg_{2.40}Cl_{17.90}(OH)_{8.06} \cdot 16.04H_2O$ based on 42 O+Cl pfu. The strongest lines of the powder X-ray diffraction pattern are [$d \text{ \AA}$ (*I*%; *hkl*)]: 11.87 (100; 100), 6.585 (15; 021), 5.969 (25; $\bar{1}0\bar{2}$), 5.905 (16; 200), 5.231 (13; 121), 3.135 (8; 222, $\bar{4}1\bar{2}$, $\bar{1}51$), 2.924 (11; $\bar{3}\bar{3}\bar{3}$, $\bar{2}51$). The crystal structure of feodosiyite was solved by direct methods and refined to $R_1 = 8.67\%$. The new mineral is monoclinic, $P2_1/c$, $a = 12.9010(6)$, $b = 16.4193(5)$, $c = 11.9614(5)$ Å,

$\beta = 113.691(6)^\circ$, $V = 2320.20 \text{ \AA}^3$, and $Z = 2$. Feodosiyite has a unique crystal structure. It is based on layers of Cu^{2+} -centred polyhedra. Cu^{2+} cations occupy six crystallographically non-equivalent sites that are placed in: distorted octahedra $Cu(1,3,5)(OH)_2Cl_4$, $Cu(2)(OH)_3Cl_3$, and $Cu(6)(OH)_2(H_2O)Cl_3$, and distorted tetragonal pyramids $Cu(4)(OH)_2Cl_3$. Almost regular $Mg(H_2O)_6$ octahedra are isolated and linked with the layers of Cu-centred polyhedra only by H-bonds. These octahedra and separate H_2O molecules occur in the interlayer space. The new mineral name honors Feodosiy Nikolaevich Chernyshev (1856–1914) an outstanding Russian geologist, Academician of the Russian Academy of Sciences and Director of Russian Geological Committee in 1903–1914. The type specimen was sealed in a glass vial and is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

FLUORO-TREMOLITE*

R. Oberti, F. Cámara, F. Bellatreccia, F. Radica, A. Gianfagna and M. Boiocchi (2018) Fluoro-tremolite from the Limecrest-Southdown quarry, Sparta, New Jersey, USA: crystal chemistry of a newly approved end-member of the amphibole supergroup. *Mineralogical Magazine*, 82(1), 145–157.

Fluoro-tremolite, ideally $A^{\square}B^{\square}Ca_2^{\square}Mg_5^{\square}Si_8O_{22}^{\square}F_2$, monoclinic, is the fluorine-analog of tremolite, the composition at the root of amphibole compositional space in all classification schemes used to date. Despite the frequent use of the term “fluorotremolite” (“fluorotremolite”, “fluortremolite”) in the mineralogical literature, this was remained a named amphibole (Burke and Leake 2004) and lacked a complete mineralogical description. The structural data for fluorine-rich tremolite to date was provided by Hawthorne and Grundy (1976) for a sample with $F = 0.66 \text{ apfu}$. The structure of synthetic fluoro-tremolite was first reported by Cameron and Gibbs (1973). During systematic characterization of amphiboles that still lack a complete mineral description, fluoro-tremolite was identified in a specimen G409 provided by Franklin Mineral Museum from the skarns at the Limecrest-Southdown quarry, Sparta, New Jersey, U.S.A. This specimen is now considered as holotype and has number 7710 at the same museum. Fluoro-tremolite as new mineral species was approved by CNMNC (IMA 2016-018). Coexisting phases in the holotype are calcite, chondrodite and pyrrhotite. Fluoro-tremolite occurs as prismatic light-greenish to colorless crystals forming gray to whitish green aggregates (the data on grain or crystal sizes, presence of inclusions, twinning are not provided). It has a gray streak and vitreous luster; the crystals are transparent and do not fluoresce under ultraviolet illumination. Density was not measured; $D_{\text{calc}} = 3.044 \text{ g/cm}^3$. The mineral is biaxial (+), $\alpha = 1.5987(5)$, $\beta = 1.6102(5)$, $\gamma = 1.6257(5)$ (589 nm), $2V_{\text{meas}} = 85(1)^\circ$, and $2V_{\text{calc}} = 82^\circ$ (the data on optical orientation is not provided). The FTIR spectrum of fluoro-tremolite is quite similar to that of synthetic fluoro-tremolite with 1.9 F^- apfu (Ishida et al. 2008). The bands (cm^{-1} ; sh – shoulder) are: 3672, 3658, 3643 (OH-stretching vibrations); 1132, 1104, 1059, 1039, 1017sh, 994, 954, 918 (Si–O-stretching vibrations), 880sh (^{14}Al -O lattice vibrations), 755 (Si–O-Si deformations), 720, 712 (Si–O- ^{14}Al deformations), 687 (O–H libration), 663 (O–Si–O deformation), 544sh, 509 (M–O deformation). The detail analysis of peak positions in comparison with tremolite and synthetic fluoro-tremolite is given based on their crystal structures peculiarities. The average of three electron probe WDS analyses [wt% (range)] is: SiO_2 55.52 (55.40–55.66), TiO_2 0.14 (0.07–0.21), Al_2O_3 1.95 (1.86–2.09), Cr_2O_3 0.02 (0–0.05), FeO_{tot} 2.44 (2.37–2.51), MnO 0.03 (0–0.08), MgO 22.74 (22.54–22.88), ZnO 0.10 (0–0.29), CaO 13.41 (13.34–13.51), Na_2O 1.10 (1.06–1.16), K_2O 0.11 (0.11–0.13), H_2O_{calc} 0.91, F 2.65 (2.52–2.76), Cl 0.03 (0.02–0.04); $-O=F_2$ 3.07, $-O=Cl_2$ 0.01, total 100.03. The amount of H_2O was calculated based on single-crystal structure refinement and with the constraints of non-negative Fe^{2+} values and $(OH + F + Cl) = 2$ atoms pfu. The empirical formula is $A^{(Na_{0.85}K_{0.02})_{20.30}}B^{(Ca_{1.99}Na_{0.01})_{22.00}}C^{(Mg_{4.70}$

$\text{Fe}_{0.28}\text{Zn}_{0.01}\text{Ti}_{0.16}\text{Mg}_{2.55}\text{O}_{22}(\text{Si}_{7.68}\text{Al}_{0.32})_{\Sigma 8.00}\text{O}_{22}(\text{F}_{1.16}\text{OH}_{0.84})_{\Sigma 2.00}$ based on 24 (O+F) apfu. The strongest lines in the calculated powder X-ray diffraction pattern are [d_{calc} Å ($I\%$; hkl): 2.706 (100; 151), 6.98 (20; 004), 4.655 (37; 006), 3.555 (88; 020,311), 2.827 (100; 026,315,317), 2.055 (58; 331,602), 3.126 (67; 310), 2.531 (59; 202), 3.381 (57; 131), 2.940 (43; 151,221), 3.276 (37; 240), 2.337 (36; 351), 2.592 (35; 061), 2.731 (34; 331), 2.163 (34; 261)]. The crystal structure was refined to $R_{\text{all}} = 1.7\%$. Fluoro-tremolite is monoclinic, $C2/m$, $a = 9.846(2)$, $b = 18.050(3)$, $c = 5.2769(14)$ Å, $\beta = 104.80(2)^\circ$, $V = 906.7$ Å³, $Z = 2$. The refined and analyzed crystal was assigned code 1082 in the amphibole database of the CNR-IGG in Pavia, Italy. The new structure and crystal-chemical data provided for synthetic fluoro-tremolite and tremolite from the type locality of Val Tremola (codes 751 and 361, respectively, in the same database). In the structure F^- is located in O(3) site, which is coordinated by the cations at the M(1) and M(3) sites. Cameron and Gibbs (1973) showed that the (OH)–F substitution significantly reduces the size of octahedra strip and hence the a and b cell parameters. The higher thermal stability of fluoro-tremolite was explained both by the higher bond-strength of the Mg–F bonds compare to Fe–F bonds. In fluoro-tremolite 1082 the significant contraction observed for the M(1)–O(2) and M(3)–O(1) bond distances although the O(1) and O(2) sites are not involved in the $^{O(3)}(\text{OH})^{-O(3)}\text{F}$ exchange. This shortening must be related to a general contraction of the O-layer due to the presence of F^- at the O(3) site. The A cations preferentially order at the $A(m)$ subsite. **D.B.**

Comments: Fluor-tremolite is most likely more common mineral than it thought to be since in a number of an older analysis of tremolite fluorine was not measured. “Fluortremolite” with F 3.84 wt% (1.64 apfu) described by Petersen et al. (1982) from Adirondack marbles (near Balmat, New York, U.S.A.). But no complete description was submitted to CNMNC IMA. The distribution of fluoro-tremolite in nature deserves an additional study. The presented paper provided a big set of a new structural data and a detail analysis of FTIR data based on the structure details. However, three analytical points of microprobe analysis seems a bit low when new mineral species (mostly differ by F content) is defined. Directly measured water content would also help to confirm fluorine dominance.

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ITELMENITE*

E.V. Nazarchuk, O.I. Siidra, A.A. Agakhanov, E.A. Lukina, E.Y. Avdontseva and G.A. Karpov (2018) Itelmenite, $\text{Na}_2\text{CuMg}_2(\text{SO}_4)_4$, a new anhydrous sulfate mineral from the Tolbachik volcano. *Mineralogical Magazine*, 82(6), 1233–1241.

Itelmenite (IMA 2015-047), ideally $\text{Na}_2\text{CuMg}_2(\text{SO}_4)_4$, orthorhombic, was discovered in 2014 in Saranchinaïtovaya fumarole on the Naboko scoria cone (N55°46'06", E160°18'59", altitude 1650 m) of the Tolbachik volcano Fissure Eruption (2012–2013), Kamchatka Peninsula, Russia. The temperature of gases at the sampling location was ~600–620 °C. Itelmenite could be deposited directly from the gas or might form as a result of the interaction between gas and basalt scoria. Itelmenite occurs as irregularly shaped grains or microcrystalline masses associating with anhydrite, saranchinaïte, hermannjahnite, euchlorine, thénardite, aphthalite, and hematite. Itelmenite is light grayish-blue with a white streak

and a vitreous luster. It is brittle with uneven fracture and no cleavage. Hardness and density were not measured due to the lack of suitable material; $D_{\text{calc}} = 3.10$ g/cm³. The estimated Mohs hardness is 2–3. The mineral is unstable in air, is soluble in H₂O at room temperature and slowly transforms into a hydrate in humid air. In transmitted plane-polarized light itelmenite is colorless, nonpleochroic. It is optically biaxial (+), $\alpha = 1.535(2)$, $\beta = 1.555(2)$, $\gamma = 1.585(2)$ (589 nm), $2V_{\text{calc}} = 79.8^\circ$. The average of 10 spots electron-probe EDS analysis (using defocused 5 µm beam) is [wt% (range)]: Na₂O 10.77 (9.97–11.23), K₂O 0.20 (0–0.31), MgO 11.10 (9.10–11.75), CuO 15.38 (14.78–15.71), ZnO 5.61 (4.15–6.05), SO₃ 56.42 (55.20–57.02), total 99.48. No other elements with $Z > 9$ were detected. The empirical formula based on O = 32 pfu is $(\text{Na}_{3.93}\text{K}_{0.05})_{\Sigma 3.98}\text{Mg}_{3.12}(\text{Cu}_{2.19}\text{Zn}_{0.78})_{\Sigma 2.97}\text{S}_{7.97}\text{O}_{32}$. The strongest lines of the powder X-ray diffraction pattern are [d Å ($I\%$; hkl): 7.961 (41; 102), 7.180 (32;004), 5.912 (64; 112), 3.846 (87; 122), 3.629 (52; 214), 3.393 (62; 215), 3.000 (44; 027), 2.939 (100; 312), 2.498 (56; 230)]. Unit-cell parameters refined from the powder data are $a = 9.575(5)$, $b = 8.786(4)$, $c = 28.78(1)$ Å, $V = 2416$ Å³. Single-crystal X-ray data obtained from the crystal $0.15 \times 0.15 \times 0.15$ mm shows itelmenite is orthorhombic, space group $Pbca$, $a = 9.568(2)$, $b = 8.790(2)$, $c = 28.715(8)$ Å, $V = 2415.0$ Å³, $Z = 4$. The crystal structure was solved by direct methods and refined to $R_1 = 0.034$ for 1855 unique observed $|F_o| \geq 4\sigma F$ reflections. There are four S fourfold-coordinated sites, two symmetrically independent Na sites Na1O₁₀ and Na2O₈ (Na1 site partly substituted by K), and three M sites. The M1 and M2 sites are in MO₃ distorted tetragonal pyramidal coordination, whereas M3 site is in octahedral coordination (MO₆). The M1 site is mostly occupied by Cu, the M2 site by Mg and Cu, and the M3 site mostly by Mg. The structure of itelmenite is based on unique $[\text{A}_3^{2+}(\text{SO}_4)_4]^{2-}$ (A = Mg, Cu and Zn) heteropolyhedral framework with voids filled by Na⁺ cations. In this framework sulfate tetrahedra are packed into pseudo-layered arrangements perpendicular to the a axis. Na1O₁₀ and Na2O₈ polyhedra are also arranged in pseudo-layers, but perpendicular to the c axis. Each MO₃ or MO₆ polyhedron shares all common corners with sulfate tetrahedra. The framework can be split into A and B layers. The A layers are formed by M2O₃ polyhedra and sulfate tetrahedra, whereas B layers consist of M3O₆ octahedra and sulfate tetrahedra. Chains based on M1O₃ polyhedra occur in the channels between the layers. The mineral is named for the Itelmen, an ethnic group who are the original inhabitants of the area around Tolbachik volcano and at Kamchatka Peninsula. Type material is deposited at the Mineralogical Museum, St. Petersburg State University, St. Petersburg, Russia. **D.B.**

OZEROVAITE*

A.P. Shablinskii, S.K. Filatov, L.P. Vergasova, E.Yu. Avdontseva, S.V. Moskaleva and A.V. Povolotskiy (2019) Ozerovaite, $\text{Na}_2\text{KAl}_3(\text{AsO}_4)_4$, new mineral species from Tolbachik volcano, Kamchatka peninsula, Russia. *European Journal of Mineralogy*, 31(1), 159–166.

Ozerovaite (IMA 2016-019), ideally $\text{Na}_2\text{KAl}_3(\text{AsO}_4)_4$, orthorhombic, is a new mineral discovered in the fumaroles on the eastern side of the micrograben of the second cinder cone of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka Peninsula, Russia. The temperature of the volcanic gases in the fumarole at time of sampling (1983) was about 410–420 °C. The vent of fumarole was encrusted with ponomarevite, while piypite prevailed at a depth of 0.5 m. The bottom of the visible part of the fumarole was encrusted with sylvite associating with dolerophanite, euchlorine, lammerite, johillerite, urusovite, bradaczekite, filatovite, hatertite, hematite, ozerovaite, wrightite, and tenorite. Based on association, the formation temperature of the arsenate minerals is estimated as 500–600 °C. Ozerovaite forms tabular crystals of $0.04 \times 0.02 \times 0.004$ mm average size in aggregates of 0.02–0.3 mm. Crystals are colorless to pale yellow, transparent, with white streak, vitreous luster, and good cleavage on {010}. The mineral is brittle. Hardness and density

were not determined, due to the small crystal size; $D_{\text{calc}} = 3.439 \text{ g/cm}^3$. The mineral is insoluble in water. It is colorless in transmitted plane-polarized light. Ozerovaita is optically biaxial (-), $\alpha_{\text{calc}} = 1.645$, $\beta = 1.667(2)$, $\gamma = 1.674(2)$ (589 nm), $2V_{\text{meas}} = 58(10)^\circ$. The average of four electron probe EDS analyses is [wt% (range)]: Na₂O 7.71 (7.54–7.96), K₂O 6.91 (6.59–7.34), As₂O₃ 61.8 (60.68–62.59), P₂O₅ 0.70 (0.66–0.75), CuO 1.18 (1.02–1.42), Al₂O₃ 18.23 (17.88–18.67), Fe₂O₃ 3.48 (3.24–4.05), ZnO 0.37 (0.31–0.42), total 100.04. No other elements were detected. The empirical formula based on 16 O pfu is (Na_{1.82}K_{1.08})_{2.90}(Al_{2.62}Fe_{0.32}Cu_{0.12}Zn_{0.02})_{3.08}(As_{3.95}P_{0.07})_{24.02}O₁₆. The strongest lines of the X-ray powder diffraction pattern are [$d \text{ \AA}$ ($I\%$; hkl): 10.37 (44; 020), 5.47 (47; 200), 4.84 (47; 220), 3.76 (17; 240), 3.07 (26; 061), 2.922 (83; 260), 2.824 (100; 202), 2.735 (71; 400)]. The unit-cell parameters refined from the powder data are $a = 10.588(14)$, $b = 20.94(2)$, $c = 6.384(8) \text{ \AA}$, $V = 1415 \text{ \AA}^3$. Single-crystal X-ray data shows ozerovaita is orthorhombic: $Cmca$, $a = 10.615(2)$, $b = 20.937(3)$, $c = 6.393(1) \text{ \AA}$, $V = 1420.9 \text{ \AA}^3$, $Z = 4$. The crystal structure refined to $R_1 = 0.031$ based on 946 unique observed reflections. It is constructed of AlO₆ octahedra and strongly distorted AsO₄ tetrahedra, linked by the corners and edges. Adjacent layers, parallel to (010), are held together by KO₆, NaO₆, and NaO₄ polyhedra. There are two AsO₄ tetrahedra and two AlO₆ octahedra in one asymmetric unit. Each Al(1)O₆ octahedron is connected by the corners with four Al(2)O₆ octahedra and six AsO₄ tetrahedra, whereas an Al(2)O₆ octahedron shares a common edge with an As(2)O₄ tetrahedron, and shares corners with four other AsO₄ tetrahedra and two Al(1)O₆ octahedra. The crystal structure of ozerovaita is related to that of the $A_3B_3(XO_4)_4$ family, ($A = \text{Na, K, Sr; } B = \text{Al, Cr, Fe; } X = \text{As, P}$) and is similar to synthetic Na₃KAl₃(AsO₄)₂. The mineral name honors Nina Aleksandrovna Ozerova (1930–2012), for her contributions to geochemistry, geology, metallogeny, ecology and the eco-geochemistry of mercury. The type material is deposited at the Mineralogical Museum, St. Petersburg State University, St. Petersburg, Russia. **D.B.**

RAMAZZOITE*

A.R. Kampf, G.R. Rossman, C. Ma, D. Belmonte, C. Biagioni, F. Castellaro and L. Chiappino (2018) Ramazzoite, [Mg₈Cu₁₂(PO₄)(CO₃)₄(OH)₂₄(H₂O)₂₀][(H_{0.33}SO₄)₃(H₂O)₃₆], the first mineral with a polyoxometalate cation. *European Journal of Mineralogy*, 30(4), 827–834.

Ramazzoite (IMA 2017-090), [Mg₈Cu₁₂(PO₄)(CO₃)₄(OH)₂₄(H₂O)₂₀][(H_{0.33}SO₄)₃(H₂O)₃₆], cubic, is a new polyoxometalate (POM) mineral from the Monte Ramazzo mine (44°28'5"N, 8°51'33"E), near Genova, Liguria, Italy. The mine was operating at least as early as 1465, mainly for copper, and later for iron sulfate and magnesium sulfate. The ore is hosted in ultramafic rocks (serpentinites) in contact with mafic rocks (basalt dikes and pillow lavas) of the Figogna Unit in the Ligurian Alps. Ramazzoite is a late-stage, secondary mineral that crystallized from low-temperature, aqueous solution. Ramazzoite is found on magnetite-rich matrix; associated minerals include chlorartinite, chrysotile, dypingite, goethite, lepidocrocite, nesquehonite, and an unidentified Mg sulfate-carbonate. Ramazzoite occurs as simple cubes up to about 0.15 mm on edge. Crystals are blue to greenish blue and transparent with a vitreous to oily luster and pale blue streak. Twins by merohedry were observed during structure determination. Crystals are very brittle with a conchoidal fracture. Perfect cleavage was observed on {100}. Mohs hardness is 2½ (scratch test). The mineral is non-fluorescent. $D_{\text{obs}} = 1.98 \text{ g/cm}^3$ (by floatation in methylene iodide-toluene) and $D_{\text{calc}} = 1.962 \text{ g/cm}^3$. It is isotropic with $n = 1.491(1)$ (white light). The mineral is soluble with mild effervescence in dilute HCl at room temperature. The Raman spectra (532 nm laser) show bands (cm⁻¹; s – strong, w – weak, sh – shoulder) at: 3565s, 3455sh, 3259sh, 2936s [O–H stretching vibrations of H₂O molecules and OH⁻ groups], 1469w, 1432w 1362w [ν_2 double degenerate antisymmetric stretching vibrations of CO₃²⁻ groups], 1086 [ν_1 symmetric stretching vibrations of the CO₃²⁻ groups or to the triply degenerate ν_3 antisymmetric stretching vibrations of the

PO₄³⁻ and/or SO₄²⁻ groups], 984s [ν_1 symmetric stretching vibrations of the SO₄²⁻ groups], 940w [ν_1 symmetric stretching vibrations of the PO₄³⁻ groups], 674w, 615w, 590w [triple degenerate bending vibrations of the PO₄³⁻ and/or SO₄²⁻ groups or to the bending modes of the CO₃²⁻ group], 500s, 451sh [ν_2 (δ) doubly degenerate bending vibrations of the PO₄³⁻ and/or SO₄²⁻ groups], <300 [probably connected with the Cu–O and Mg–O stretching and bending modes and lattice modes]. The average of five electron microprobe WDS analyses (three crystals) is [wt% (range) / normalized to 100%]: MgO 22.61 (20.82–24.05) / 16.73; CuO 30.30 (29.48–31.32) / 22.43; P₂O₅ 3.38 (3.25–3.52) / 2.50; SO₃ 11.51 (11.00–12.23) / 8.52, CO₂ – / 6.21 (based upon the structure), H₂O_{calc} (based upon 36 H₂O in the interstitial unit to approximate the measured density) – / 43.60, total 99.99. The empirical formula calculated on the basis of 1 P apfu is: [(Mg_{8.00}Cu_{8.00}Mg_{3.78})(PO₄)(CO₃)₄(OH)₂₄(H₂O)₂₀][(H_{0.65}S_{1.01}O₄)₃(H₂O)₃₆]. The strongest X-ray powder diffraction lines are [$d \text{ \AA}$ ($I\%$; hkl): 13.37 (100; 100), 9.43 (24; 110), 4.224 (8; 310), 4.043 (11; 311), 3.252 (9; 322), and 2.857 (9; 332)]. Unit-cell parameters refined from the powder data with whole-pattern fitting are $a = 13.393(3) \text{ \AA}$, $V = 2402 \text{ \AA}^3$. Single-crystal X-ray data on a crystal of 0.15 × 0.15 × 0.15 mm ($R_1 = 0.06438$ for 802 $I > 2\sigma I$ reflections; $R_{\text{all}} = 0.0659$ for 848 reflections) shows ramazzoite is cubic, $P43m$, $a = 13.3887(10) \text{ \AA}$, $V = 2400 \text{ \AA}^3$, $Z = 1$. Ramazzoite is a novel POM (polyoxometalate). The POM in ramazzoite has at its center a PO₄³⁻ group, which is surrounded by twelve Cu-centered octahedra in a Keggin α -isomer configuration. The Keggin-like core of the POM is “capped” by eight Mg-centered octahedra, each sharing the three edges of one face with edges of three separate Cu-centered octahedra. On the periphery of the POM there are 12 CO₃²⁻ groups, only ½ occupied, so there are 4 CO₃²⁻ groups pfu. H₂O groups are in the interstitial region to fulfill its valence balance. The POM structural unit has the ideal formula [Mg₈Cu₁₂(PO₄)(CO₃)₄(OH)₂₄(H₂O)₂₀]⁵⁺. The interstitial portion of the structure contains one fully occupied S site at a threefold special position, plus H₂O groups. The interstitial region has the stoichiometry [(H_{0.33}SO₄)₃(H₂O)₃₆]. Ramazzoite is named for the locality, the Monte Ramazzo mine. The description is based upon two cotype specimens deposited in the Natural History Museum of Los Angeles County, Los Angeles, California, U.S.A., catalogue numbers 66691 and 66692. **F.C.**

REDCANYONITE*

T.A. Olds, J. Plášil, A.R. Kampf, P.C. Burns, B.P. Nash, J. Marty, T.P. Rose and S.M. Carlson (2018) Redcanyonite, (NH₄)₂Mn[(UO₂)₄O₄(SO₄)₂](H₂O)₄, a new zippeite-group mineral from the Blue Lizard mine, San Juan County, Utah, USA. *Mineralogical Magazine*, 82(6), 1261–1275.

Redcanyonite (IMA 2016-082), (NH₄)₂Mn[(UO₂)₄O₄(SO₄)₂](H₂O)₄, monoclinic, is a new member of the zippeite group, which occurs underground in the Blue Lizard mine, on the northern edge of the Red Canyon, White Canyon district, San Juan County, Utah, U.S.A. (37°33'26"N, 110°17'44"W). Secondary uranium mineralization in Red Canyon is often localized and most prevalent within organic-rich beds that are laced with uraninite and sulfides. The source of NH₄⁺ is inferred from decomposition of organic material. Redcanyonite occurs intimately with ammoniozippeite in several specimens. Other associated secondary minerals include bobcockite, brochantite, devilline, gypsum, johannite, posnjakite, natrozippeite, pentahydrate, and pickeringite. Redcanyonite occurs as radial aggregates (up to 1 mm in diameter) of needles and blades individually measuring up to 0.2 mm long. Crystals are flattened on {010} and elongated on [100], and exhibit the forms {001}, {010}, {101}, and {10 $\bar{1}$ }. Many crystals are twinned by 180° rotation on [100]. Crystals are translucent with a vitreous luster, pale orange streak, and are non-fluorescent under both long-wave and short-wave ultraviolet illumination. Mohs hardness is ~2. Crystals of redcanyonite are brittle with perfect {010} cleavage and uneven fracture. The density was not measured due to the lack of material; $D_{\text{calc}} = 4.633 \text{ g/cm}^3$ (based on the empirical formula) and 4.688 g/cm³ (for the ideal formula). Optically

is biaxial (+), with $\alpha = 1.725(3)$, $\beta = 1.755(3)$, and $\gamma = 1.850(5)$ (white light); $2V_{\text{meas}} = 60(2)^\circ$, $2V_{\text{calc}} = 61.3^\circ$; $X = \mathbf{b}$, $Y \approx \mathbf{c}^*$, $Z \approx \mathbf{a}$. Dispersion of an optical axes is very strong, $r < v$. The mineral is pleochroic with $X = \text{orange}$, $Y = \text{yellow}$ and $Z = \text{orange}$; $Y \ll X < Z$. Attenuated total reflectance (ATR) Fourier-transform infrared (FTIR) show the following bands (cm^{-1} ; vs – very strong, s – strong, w – weak, sh – shoulder): broad between ~ 3500 and ~ 2800 (ν O–H stretching vibrations of hydrogen-bonded H_2O , overlapped with N–H stretching vibrations from interlayer NH_4^+ molecules), 1615w [ν_2 (δ)-bending vibration of hydrogen-bonded crystalline H_2O], 1408s (N–H bending vibration of NH_4^+ molecules), 1155, 1140, and 1084 [split triply degenerate ν_3 (SO_4) $^{2-}$ antisymmetric stretching vibration], 1100–1000 [ν_1 (SO_4) $^{2-}$ symmetric stretch enveloped by the ν_3 (UO_2) $^{2+}$ antisymmetric stretch], 940vs [ν_3 antisymmetric stretch of (UO_2) $^{2+}$], 836w [ν_1 symmetric stretch of (UO_2) $^{2+}$]. Raman spectroscopy (785 nm laser) show the following bands (cm^{-1} ; vs – very strong, s – strong, w – weak, sh – shoulder): 1263w, 1158w, and 1097w (triply degenerate ν_3 (SO_4) $^{2-}$ antisymmetric stretching vibrations), 1013 [ν_1 (SO_4) $^{2-}$ symmetric stretch], 819, 809sh [ν_1 symmetric stretch of (UO_2) $^{2+}$], 666w and 601w [split, triply degenerate $\nu_4(\delta)$ (SO_4) $^{2-}$ bending vibrations], 506, 464, and 418 [split doubly degenerate $\nu_2(\delta)$ (SO_4) $^{2-}$ bending vibrations], 354 and 329 [ν (U–O_{equatorial}) stretching vibrations], 284 and 261 [$\nu_2(\delta)$ U–O–U bending modes], and 206, 176, 150, and 127 (external lattice vibration modes and UO_2^{2+} translations and rotations). The mineral is easily soluble in room-temperature dilute HCl. The average of five electron microprobe WDS analyses is [wt% (range)]: (NH_4) $_2\text{O}$ 3.41 (2.84–4.20), P_2O_5 0.10 (0.00–0.16), SO_3 10.28 (9.45–10.77), MnO 2.26 (1.72–2.87), CuO 0.46 (0.11–0.71), ZnO 0.34 (0.12–0.49), UO_3 74.27 (73.13–75.13), H_2O 5.10 (from the structure), total 96.22. The empirical formula, calculated on the basis of 4 U and 24 O atoms pfu is $(\text{NH}_4)_{2.02}(\text{Mn}_{0.49}\text{Cu}_{0.09}\text{Zn}_{0.06})_{\Sigma 0.64}\text{H}_{0.72}[(\text{UO}_2)_4\text{O}_4(\text{S}_{0.99}\text{P}_{0.01}\text{O}_4)_2](\text{H}_2\text{O})_4$. The strongest lines in the powder X-ray diffraction pattern are [d Å (%; hkl): 8.55 (21; 001), 7.19 (100; 020), 3.600 (33; 220,131,040), 3.453 (56; 202), 3.112 (72; 221), 2.657 (23; 023), and 2.491 (21; $\bar{2}42$). Unit-cell parameters refined from the powder data are $a = 8.665(2)$, $b = 14.359(2)$, $c = 8.834(2)$ Å, $\beta = 104.190(5)^\circ$, and $V = 1065.5$ Å 3 . The crystal structure was solved by charge-flipping method using single crystal X-ray diffraction on a crystal of $0.030 \times 0.025 \times 0.002$ mm ($R_1 = 0.075$ for 1079 $I > 2\sigma I$ reflections; $R_{\text{int}} = 0.0493$ for 1382 reflections). Redcanyonite is monoclinic, $C2/m$, $a = 8.6572(17)$, $b = 14.155(3)$, $c = 8.8430(19)$ Å, $\beta = 104.117(18)^\circ$, and $V = 1050.9$ Å 3 , $Z = 2$. The crystal of redcanyonite chosen for diffraction was twinned, with twin law $(\bar{1}, 0, \frac{1}{2}, 0, \bar{1}, 0, 0, 1)$. In the redcanyonite structure the uranyl pentagonal bipyramids and sulfate tetrahedra are linked to form the well-known zippeite type, which consists of zigzag chains of uranyl pentagonal bipyramids two-polyhedra wide that extend along [100], where individual chains link to form a sheet by sharing equatorial vertices with sulfate tetrahedra. Each sulfate tetrahedron links four unique bipyramids (two bipyramids of two separate chains) and propagates the zippeite-type sheet along [001]. Individual sheets stack parallel to (010), which corresponds to the excellent cleavage. Sheets are linked through a network of H bonds that emanate from interstitial water and ammonium groups. Redcanyonite is named after Red Canyon in southeast Utah and alludes to the red and orange hues of iron-stained sandstones within the canyon, which are also adopted in the striking color of the new mineral. Red Canyon is the type locality for 22 recently described uranium minerals with several more currently under study. Six co-type specimens are deposited in the collections of the Natural History Museum of Los Angeles County (California, U.S.A.), under the catalogue numbers 66293, 66294, 66295, 66296, 66297, and 66298. **F.C.**

SELIVANOVAITE*

Y.A. Pakhomovsky, T.L. Panikorovskii, V.N. Yakovenchuk, G.Yu. Ivanyuk, J.A. Mikhailova, S.V. Krivovichev, V.N. Bocharov and A.O. Kalashnikov (2018) Selivanovaite, $\text{NaTi}_3(\text{Ti}, \text{Na}, \text{Fe}, \text{Mn})_4[(\text{Si}_2\text{O}_7)_2\text{O}_4(\text{OH}, \text{H}_2\text{O})_4] \cdot n\text{H}_2\text{O}$, a new rock-forming mineral from the eudialyte-

rich malnigite of the Lovozero alkaline massif (Kola Peninsula, Russia). *European Journal of Mineralogy*, 30(3), 525–535.

Selivanovaite (IMA 2015-126), $\text{NaTi}_3(\text{Ti}, \text{Na}, \text{Fe}, \text{Mn})_4[(\text{Si}_2\text{O}_7)_2\text{O}_4(\text{OH}, \text{H}_2\text{O})_4] \cdot n\text{H}_2\text{O}$, triclinic, is a new titanosilicate of the murmanite group (seidozerite supergroup) found in drill cores of medium-grained trachtyoid eudialyte malnigite of Mt. Kedykvypakhk, at the horizon 850–1050 m (50–150 m below day surface (Alluav set of the giant Lovozero loparite–eudialyte Ta-Nb-REE-Zr deposit). The rock consists mainly of euhedral microcline-perthite (up to 1.5 cm), nepheline (up to 1 cm) and manganese eudialyte crystals (up to 0.5 cm) cemented by fine-acicular aegirine with poikilitic laths of minor lamprophyllite and selivanovaite (up to 10%; 3% in average). The mean modal composition of the rock is $\text{Kfs}_{40}\text{Nph}_{30}\text{Aeg}_{20}\text{Eud}_{10}$. Other minor rock-forming minerals include sodalite, natrolite, and magnesioarfvedsonite. Characteristic accessory minerals are murmanite, loparite-(Ce), pyrochlore, thorite, anatase, baryte, rhabdophane-(Ce), pyrrhotite, chalcocopyrite, pyrite, chlorbartonite, djerfisherite, sphalerite, and löllingite. Selivanovaite forms dark-orange vitreous to greasy anhedral platy metacrystals up to 8 mm with numerous poikilitic inclusions of aegirine and magnesioarfvedsonite. It is translucent in thin plates and has a brownish-white streak. The cleavage is perfect on {001} and weak on {110}, the fracture is stepped. The mineral is brittle with Mohs hardness ~ 3 . $D_{\text{meas}} = 3.15(3)$ (Clerici solution); $D_{\text{calc}} = 3.34(3)$ g/cm 3 . Selivanovaite dissolves slowly in 10% cold HCl. In transmitted light, selivanovaite is brown and non-pleochroic. It is biaxial (+), $\alpha = 1.79(1)$, $\beta = 1.81(1)$, $\gamma = 1.87(1)$ (589 nm), $2V_{\text{meas}} = 40(5)^\circ$, $2V_{\text{calc}} = 57.3^\circ$; $Z^{\text{c}} = 5\text{--}10^\circ$; dispersion of optical axes was not observed. The Raman spectrum of selivanovaite (the mineral is very unstable under the laser beam) shows bands (cm^{-1}): 1600 (symmetric bending vibrations of H_2O); in region between 690 and 434 (symmetric and antisymmetric bending vibrations of SiO_3); 780, 930 (Si–O stretching); 610, 281, 180 (symmetric stretching and bending vibrations of the TiO_6 , FeO_6 , and MgO_6 groups); 77, 104, 147 – lattice modes. The average of WDS electron probe analysis (5–6 points on each of 3 crystals with defocused beam moved during the analysis to avoid water loss due to instability the mineral under the beam) [wt% (range)] is: Na_2O 5.45 (4.06–7.17), MgO 0.59 (0.41–0.70), Al_2O_3 0.04 (0–0.11), SiO_2 25.55 (23.38–27.83), K_2O 0.63 (0.17–1.28), CaO 1.68 (1.35–2.34), TiO_2 31.17 (26.77–36.95), MnO 2.64 (2.29–2.89), Fe_2O_3 6.63 (3.10–10.94), ZrO_2 2.31 (2.01–2.71), Nb_2O_5 6.69 (6.04–7.02), H_2O 17.0 (by the Penfield method), total 100.38. The empirical formula calculated on the basis of Si = 4 pfu is: $(\text{Na}_{1.65}\text{Mn}_{0.35}\text{Ca}_{0.28}\text{Zr}_{0.18}\text{Mg}_{0.14}\text{K}_{0.13})_{\Sigma 2.73}(\text{Ti}_{3.67}\text{Fe}_{0.78}\text{Nb}_{0.47}\text{Al}_{0.01})_{\Sigma 4.93}[\text{Si}_4\text{O}_{19.72}] \cdot 8.87\text{H}_2\text{O}$. The structure refinement is giving the H_2O content ~ 1.72 pfu. That implies the presence of a significant amount of nonstructural (adsorbed) water up to 7 H_2O pfu. Similar to murmanite, the non-structural H_2O can be easily eliminated in vacuum or under even mild heating. There are no clear relations between different cation contents, but the mineral enriched with Fe at the expense of Ti and Na compare to coexisting murmanite due to the isomorphic substitutions $2\text{Na}^+ + \text{Ti}^{4+} \leftrightarrow \square + 2\text{Fe}^{3+}$ and/or $\text{Na}^+ + \text{Ti}^{4+} \leftrightarrow \text{Ca}^{2+} + \text{Fe}^{3+}$. The strongest X-ray powder-diffraction lines [d Å ($I_{\text{rel}}\%$; hkl)] are: 11.43 (100; 001), 6.37 (25; $\bar{1}11$), 5.73 (15; 002), 4.208 (16; $\bar{2}11$), 3.108 (35; $\bar{2}\bar{2}1$), 3.043 (20; $\bar{1}04$), 2.596 (17; 014). Unit-cell parameters refined from the powder patterns are: $a = 8.673(5)$, $b = 8.694(1)$, $c = 12.21(1)$ Å, $\alpha = 92.70(5)$, $\beta = 108.52(1)$, $\gamma = 105.42(1)^\circ$, $V = 833$ Å 3 , $Z = 2$. The single-crystal cell parameters are practically identical: $a = 8.673(5)$, $b = 8.694(3)$, $c = 12.21(1)$ Å, $\alpha = 92.70(5)$, $\beta = 108.46(7)$, $\gamma = 105.40(4)^\circ$. The single-crystal X-ray data for a crystal $0.015 \times 0.015 \times 0.002$ mm shows extremely weak diffraction. The structure was refined to $R_1 = 0.193$ ($R_{\text{int}} = 0.165$) for 2881 independent $F_o > 4\sigma(F_o)$ reflections in the space group $P1$; $Z = 2$. The crystal structure of selivanovaite is closely related to those of murmanite-group minerals and consists of the HOH-layers with the composition $[\text{N}_2\text{M}_2\text{Si}_4\text{O}_{18}(\text{OH})_2]$ ($M = \text{Ti}, \text{Nb}, \text{Fe}$ and Mn , $N = \text{Na}, \text{K}, \text{Ca}, \text{Mn}, \text{Mg}$, and Zr) connected by additional N -centered octahedra with H_2O molecules between them. It differs from vigrishinite by geometry and

stereochemistry of the H-sheets. The name honors Ekaterina A. Selivanova (b. 1967), of the Kola Science Centre of the Russian Academy of Sciences, for her contribution to the mineralogy of alkaline complexes. **D.B.**

VANDERHEYDENITE*

P. Elliott and U. Kolitsch (2018) Description and crystal structure of vanderheydenite, $Zn_6(PO_4)_2(SO_4)(OH)_4 \cdot 7H_2O$, a new mineral from Broken Hill, New South Wales, Australia. *European Journal of Mineralogy*, 30(4), 835–840.

Vanderheydenite (IMA 2014-076), ideally $Zn_6(PO_4)_2(SO_4)(OH)_4 \cdot 7H_2O$, monoclinic, is a new mineral from the Block 14 Opencut, Broken Hill, New South Wales, Australia. The Broken Hill ore body consists of massive, recrystallized sphalerite- and galena-rich sulfide hosted within a unit of gneiss known as the Potosi Gneiss. The lower portion of the oxidized zone grades into silver-rich supergene mineralization, comprising coronadite, quartz, kaolinite, and goethite. Between this and the sulfide zone is an irregular zone of cerussite, whose boundary with the sulfide zone is marked by a band of leached sulfides, where vanderheydenite was found in a highly weathered sulfide ore in the Block 14 Opencut. The new mineral formed in cavities as a result of the release of Zn, S, As, and P from the breakdown of sphalerite, galena, and fluorapatite. Associated minerals are colorless to white prisms of pyromorphite, colorless crystals of anglesite, and aggregates of colorless to white crystals of liversidgeite. Vanderheydenite occurs as aggregates of colorless crystals up to 0.5 mm across. Individual crystals are thin blades that are flattened on {100} and are up to 0.4 mm in width and 0.05 mm in thickness. Crystal forms are major {100}, {010}, and {021}, resulting in a pseudohexagonal outline. Vanderheydenite has a white streak and a vitreous luster; it does not fluoresce under ultraviolet light. Mohs hardness is ~3. Cleavage was not observed. Density was not measured; $D_{calc} = 3.12 \text{ g/cm}^3$ (based on the empirical formula) and 3.06 g/cm^3 (for the ideal formula). It is optically biaxial (–), $\alpha = 1.565(4)$, $\beta = 1.580(4)$, $\gamma = 1.582(4)$; (white light); $2V_{calc} = 39.8^\circ$. The FTIR spectra show as main bands (cm^{-1}): a broad band from ~3674 to ~2720 (O–H-stretching vibrations), 1636 (ν_2 H–O–H bending of H_2O groups), 1056 (ν_3 vibration of the SO_4 tetrahedra, overlapping with ν_3 vibration of the PO_4 tetrahedra), 968 (ν_1 vibration of the SO_4 tetrahedra, overlapping with ν_1 vibration of the PO_4 tetrahedra of SO_4^{2-} ions), 885 and 853 [ν_3 vibrations of the AsO_4 tetrahedra]. The average of 13 WDS electron probe analyses is [wt% (range)]: ZnO 55.63 (54.49–56.68), CuO 0.07 (0.00–0.21), FeO 0.11 (0–0.28), MnO 0.06 (0–0.15), P_2O_5 14.18 (13.10–15.29), As_2O_5 4.33 (3.14–5.18), SO_3 8.71 (7.31–9.85), H_2O 18.31 (from the structural formula), total 101.40. The empirical formula was calculated on the basis of 23 oxygen atoms is $(Zn_{5.99}Cu_{0.01}Fe_{0.01}Mn_{0.01})_{26.02}[(PO_4)_{1.75}(AsO_4)_{0.33}]_{22.08}(SO_4)_{0.95}(OH)_{3.91} \cdot 6.96H_2O$. The strongest lines of the powder X-ray diffraction pattern [$d \text{ \AA}$ ($P\%$; hkl)] are: 9.826 (57; 020), 7.296 (20; 011), 6.134 (100; 021), 3.368 (10; 032, 150), 3.069 (9; 210, 042). The unit-cell parameters calculated from the powder data are: $a = 6.209(2)$, $b = 19.637(7)$, $c = 7.822(3) \text{ \AA}$, $\beta = 90.672(2)^\circ$, $V = 953.64 \text{ \AA}^3$. The crystal structure was solved by direct methods using single crystal X-ray diffraction on a crystal of $0.070 \times 0.050 \times 0.005 \text{ mm}$ ($R_1 = 0.0497$ for 939 $F_o > 4\sigma F_o$ reflections; $R_{all} = 0.1228$ for 1920 reflections). Vanderheydenite is monoclinic, $P2_1/n$, $a = 6.2040(12)$, $b = 19.619(4)$, $c = 7.7821(16) \text{ \AA}$, $\beta = 90.67(3)^\circ$, $V = 947.1 \text{ \AA}^3$, $Z = 2$. The crystal structure of vanderheydenite is unique and is comprised of zigzag sheets of $Zn\phi_6$ octahedra, $Zn\phi_5$ trigonal bipyramids and TO_4 tetrahedra. Alternate $Zn1\phi_6$ ($w = O, OH, \text{ or } H_2O$) and $Zn2\phi_6$ octahedra share trans edges to form a $[M\phi_4]$ chain that extends parallel to [100]. The $Zn3\phi_5$ trigonal bipyramids share an edge with both $Zn1\phi_6$ and $Zn2\phi_6$ octahedra and link to a second $[M\phi_4]$ chain by corner sharing, forming zigzag sheets in the (010) plane. Sheets are decorated

by corner-sharing TIO_4 tetrahedra. Sheets link in the [011] direction by $T2O_4$ tetrahedra which share corners with $Zn1\phi_6$ and $Zn2\phi_6$ octahedra. Interstitial channels between the sheets extend parallel to the a -direction and are occupied by H_2O groups, which are strongly to weakly hydrogen bonded. The mineral is named in honor of Arnold van der Heyden who worked as a mine geologist at Broken Hill for the former Minerals Mining and Metallurgy Ltd from December 1985 until June 1991. The holotype specimen [also the holotype specimen for liversidgeite, $Zn_6(PO_4)_4 \cdot 7H_2O$] is deposited in the South Australian Museum, Adelaide, South Australia. **F.C.**

WRIGHTITE*

A.P. Shablinskii, S.K. Filatov, L.P. Vergasova, E.Yu. Avdontseva and S.V. Moskaleva (2018) Wrightite, $K_2Al_2O(AsO_4)_2$, a new oxo-orthoarsenate from the Second scoria cone, Northern Breakthrough, Great Fissure eruption, Tolbachik volcano, Kamchatka peninsula, Russia. *Mineralogical Magazine*, 82(6), 1243–1251.

Wrightite (IMA 2015-120), ideally $K_2Al_2O(AsO_4)_2$, orthorhombic, is a new mineral discovered in 1983 in one of fumarole on the east side of the micrograben at the Second scoria cone, Northern Breakthrough, Great Fissure eruption, Tolbachik volcano, Kamchatka peninsula, Russia. The temperature of the volcanic gases in the fumarole was 410–420 °C and the vent was encrusted with ponomarevite, while piypite prevailed at a depth of 0.5 m. The bottom of the visible part of the fumarole was encrusted with sylvite associating with dolerophanite, euchlorine, lammerite, johillerite, urusovite, bradaczekite, filatovite, haterite, hematite, ozerovaite, and tenorite. Based on association, the formation temperature of the arsenate minerals is estimated as 500–600 °C. Wrightite forms light yellow aggregates of transparent tabular colorless to light yellow crystals, with an average size $0.05 \times 0.03 \times 0.005 \text{ mm}$. Well-formed crystals are very rare. The mineral has vitreous luster and white streak. It is brittle. Cleavage or parting are not reported. Hardness and density were not determined due to the small crystal size; $D_{calc} = 3.50 \text{ g/cm}^3$. Wrightite is optically is biaxial (–), $\alpha = 1.679(2)$, $\beta = 1.685(2)$, γ (calc) = 1.687; $2V = 62(10)^\circ$ ($\lambda = 589 \text{ nm}$). The X and Y directions are in the plane of tabular crystals. Tabular crystals have a positive elongation. No pleochroism is observed. The average of electron probe EDS analyses on 11 grains [wt% (range)] is: Na_2O 2.72 (2.39–3.03), K_2O 18.31 (17.75–18.65), As_2O_5 51.89 (51.19–52.99), Al_2O_3 21.14 (17.06–23.41), Fe_2O_3 4.39 (1.07–9.06), total 98.45. No other elements were detected. The empirical formula based on $O=9$ pfu is $(K_{1.69}Na_{0.38})_{22.07}(Al_{1.80}Fe_{0.24})_{22.04}As_{1.96}O_9$. The strongest lines in the powder X-ray diffraction pattern [$d \text{ \AA}$ ($P\%$; hkl)] are: 8.77 (36; 002), 6.01 (18; 102), 4.458 (17; 111), 4.097 (16; 112), 4.010 (19; 201, 013), 3.875 (19; 104), 3.003 (16; 204); 2.972 (100; 015). The unit-cell parameters, derived from a powder XRD data are $a = 8.230(5)$, $b = 5.555(4)$, $c = 17.584(1) \text{ \AA}$, $V = 803.9 \text{ \AA}^3$. Single-crystal X-ray data shows wrightite is orthorhombic, space group $Pnma$, $a = 8.2377(3)$, $b = 5.5731(6)$, $c = 17.683(1) \text{ \AA}$, $V = 811.8 \text{ \AA}^3$, $Z = 4$. The crystal structure (refined to $R_1 = 0.043$ for the 1924 independent reflections) is similar to that of the synthetic analog $NaKAl_2O(AsO_4)_2$ and consists of $Al_2O(AsO_4)_2$ layers in the (001) plane with clusters of edge-sharing AlO_6 octahedra. Each layer contains two independent isolated AsO_4 tetrahedra and two AlO_6 octahedra. AlO_6 octahedra are linked by edges, forming zigzag chains along the b axis inside the $Al_2O(AsO_4)_2$ layer. Eightfold- and sixfold-coordinated K atoms are located in the interlayer space between $Al_2O(AsO_4)_2$ layers. The mineral name honors Adrian Carl Wright (b. 1944), Emeritus Professor at the University of Reading, U.K., a well-known expert in structural studies of glass-forming systems. The type material is deposited at the Mineralogical Museum, St. Petersburg State University, St. Petersburg, Russia. **D.B.**