

New Mineral Names*†

DMITRIY I. BELAKOVSKIY¹, FERNANDO CÁMARA², OLIVIER C. GAGNE³, AND YULIA UVAROVA⁴

¹Fersman Mineralogical Museum, Russian Academy of Sciences, Leninskiy Prospekt 18 korp. 2, Moscow 119071, Russia

²Dipartimento di Scienze della Terra, Università di degli Studi di Torino, Via Valperga Caluso, 35-10125 Torino, Italy

³Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

⁴CSIRO Mineral Resources, CSIRO, ARRC, 26 Dick Perry Avenue, Kensington, Western Australia 6151, Australia

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This New Mineral Names has entries for 18 new minerals, including aradite, chlorkyuygenite, chubarovite, cryobostryxite, ferriakasaikaite-(La), ferriandrosite-(La), ferro-pedrizite, flamite, flinteite, fluorchegemite, fluorkyuygenite, fluormayenite, fluor-tsilaisite, gatedalite, kononovite, mendigite, nabimusaite, and zadovite.

ARADITE* AND ZADOVITE*

E.V. Galuskin, F. Gfeller, I.O. Galuskina, A. Pakhomova, T. Armbruster, Y. Vapnik, R. Włodyka, P. Dzierzanowski, and M. Murashko (2015) New minerals with a modular structure derived from hatrurite from the pyrometamorphic Hatrurim Complex. Part II. Zadovite, BaCa₆[(SiO₄)(PO₄)](PO₄)₂F and aradite, BaCa₆[(SiO₄)(VO₄)](VO₄)₂F, from paralavas of the Hatrurim Basin, Negev Desert, Israel. Mineralogical Magazine, 79, 1073–1087.

Two new minerals aradite (IMA 2013-047), ideally BaCa₆[(SiO₄)(VO₄)](VO₄)₂F and zadovite (IMA 2013-031), ideally BaCa₆[(SiO₄)(PO₄)](PO₄)₂F, the members of the solid solution BaCa₆[(SiO₄)(PO₄)(VO₄)₄]F, were discovered in a few centimeter thick paralava veins in gehlenite-rich pyrometamorphic rocks of the Hatrurim Complex, Gurim Anticline, Hatrurim Basin (31°12'N 35°14'E), located near the town of Arad in the Negev Desert, Israel. Aradite and zadovite are associated with rock-forming gehlenite, pseudowollastonite, wollastonite, andradite–schorlomite garnet-series, rankinite, magnesioferrite, kalsilite and fluorapatite; with minor P-rich ellestadite, larnite, cuspidine, and hematite. Accessory minerals are dorrite-khesinite, barioferrite, walstromite, barite, gurimite, fresnoite, delafossite, cuprite, vorlanite, perovskite, and hexacelsian. Zadovite and aradite are colorless, transparent with a white streak, have vitreous luster and uneven fracture. Both are uniaxial (–) with ω = 1.784(3), ε = 1.780(3) (aradite) and ω = 1.711(2), ε = 1.708(2) (zadovite) (589 nm). UV fluorescence was not observed. The micro-indentation hardness measured only for zadovite corresponds to a Mohs hardness of ~5–5½. Density was not measured directly due to small grain size; *D*_{calc} = 3.509 (aradite) and 3.503 g/cm³ (zadovite). Raman spectra of both minerals show bands above 800 cm⁻¹ from symmetric (ν₁) and antisymmetric (ν₃) stretching vibrations of (TO₄), bands in the range 300–700 cm⁻¹ attributed to bending vibrations (ν₂ and ν₄) of (TO₄), and bands below 300 cm⁻¹ assigned to stretching vibrations of Ca–O and also the vibration of R(TO₄) and T(TO₄). The Raman spectra reflect the varying PO₄ (e.g. change of band intensity at ~1031 cm⁻¹) and VO₄ contents (e.g. change of band intensity at ~835 cm⁻¹). The presence of SO₄ leads to an additional Raman band at ~997 cm⁻¹. Average of 5 (aradite) and 14 (zadovite) electron probe WDS analyses is [wt% (range)]: Na₂O 2.36 (2.31–2.49), CaO 40.80 (40.53–40.99), SrO 0.32 (0.22–0.42), BaO 18.24 (18.09–18.79), Al₂O₃ 0.03 (0–0.06), Fe₂O₃ 0.10 (0.03–0.18), SiO₂ 7.89 (7.71–9.50), P₂O₅ 5.46 (3.77–7.01), V₂O₅ 22.09 (19.95–24.69), SO₃ 1.58 (0.84–2.22),

F 2.36 (2.31–2.49), –O=F₂ 0.99, total 98.84 for aradite and Na₂O 0.18 (0.16–0.21), CaO 42.26 (41.89–42.57), SrO 0.33 (0.24–0.38), BaO 19.92 (19.58–20.28), SiO₂ 8.43 (8.28–8.57), P₂O₅ 19.29 (17.49–20.57), V₂O₅ 7.51 (6.20–9.07), SO₃ 1.22 (0.98–1.37), F 2.45 (2.21–2.77), –O=F₂ 1.03, total 100.56 for zadovite. The empirical formula calculated on the basis of 17 (O+F) pfu is: BaCa₆[(Si,P)O₄]_{1.53}(VO₄)_{0.47}[(VO₄)_{1.51}(PO₄)_{0.49}]F for aradite, and BaCa₆[(SiO₄)(PO₄)](PO₄)_{1.39}(VO₄)_{0.61}]F for zadovite. The strongest X-ray calculated powder diffraction lines [*d* Å (*I*%; *hkl*)] are: 8.734 (32; 003), 6.010 (33; 101), 3.565 (100; 110), 3.301 (48; 113), 3.201 (40; 107), 3.066 (32; 021), 2.762 (85; 116), 1.783 (32; 220) for aradite and 3.548 (87; 110), 3.279 (41; 113), 3.154 (88; 107), 3.051 (100; 021), 2.859 (63; 009), 2.738 (67; 116), 1.973 (55; 02.10), 1.774 (75; 220) for zadovite. X-ray single-crystal diffraction study [refined to *R*₁ = 0.0304 for 399 unique *I*_{obs} > 2σ(*I*) reflections for aradite and to *R*₁ = 0.0124 for 702 unique *I*_{obs} > 2σ(*I*) reflections for zadovite] on an aradite crystal fragment of 30×20×10 μm and on an zadovite crystal fragment of 150×60×60 μm shows that the minerals are trigonal, space group *R* $\bar{3}m$, *Z* = 3, with cell parameters *a* = 7.1300(1), *c* = 26.2033(9) Å, *V* = 1153.63 Å³ for aradite, and *a* = 7.0966(1), *c* = 25.7284(3) Å, *V* = 1122.13 Å³ for zadovite. The structure of zadovite-series minerals belonging to the nabimusaite group is characterized by a 1:1 alternation of antiperovskite-like {[FCa₃(TO₄)₂}⁴⁺ modules and Ba(TO₄)₂²⁺ modules. The name zadovite honors the Russian mineralogist Aleksandr Efimovich Zadov (1958–2012), author or co-author of more than 90 new mineral species. Aradite is named after the town of Arad near the type locality. Type material is deposited in the Museum of Natural History in Bern, Switzerland, catalog numbers NMBE 42103 (zadovite, the same type specimen is also the holotype for gurimite) and NMBE 42188 (aradite). F.C.

CHLORKYUYGENITE*, FLUORKYUYGENITE*, FLUORMAYENITE*

E.V. Galuskin, F. Gfeller, I.O. Galuskina, T. Armbruster, R. Bailau, and V.V. Sharygin (2015) Mayenite supergroup, part I: Recommended nomenclature. European Journal of Mineralogy, 27, 99–111.
E.V. Galuskin, I.O. Galuskina, J. Kusz, F. Gfeller, T. Armbruster, R. Bailau, M. Dulski, V.M. Gazeev, N.N. Pertsev, A.E. Zadov, and P. Dzierzanowski (2015) Mayenite supergroup, part II: Chlorkyuygenite from Upper Chegem, Northern Caucasus, Kabardino-Balkaria, Russia, a new microporous mineral with “zeolitic” H₂O. European Journal of Mineralogy, 27, 113–122.
E.V. Galuskin, F. Gfeller, T. Armbruster, I.O. Galuskina, Y. Vapnik, M. Dulski, M. Murashko, P. Dzierzanowski, V.V. Sharygin, S.V. Krivovichev, and R. Wirth (2015) Mayenite supergroup, part III: Fluormayenite, Ca₁₂Al₁₄O₃₃[(□₄F₂)] and fluorkyuygenite, Ca₁₂Al₁₄O₃₃[(H₂O)₄F₂], two new minerals from pyrometamorphic rocks of the Hatrurim Complex, South Levant. European Journal of Mineralogy, 27, 123–136.

* 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/>.

Redefinition of the mayenite: The mayenite supergroup recommended nomenclature

The new mayenite supergroup nomenclature accepted by the IMA-CNMNC (proposal 2014/13-C) comprising two groups of minerals isostructural with mayenite (space group $I43d$, $a \approx 12 \text{ \AA}$) with the general formula $X_{12}T_{14}O_{32-x}(OH)_{3x}[W_{6-3x}]$: the mayenite group (oxides) and the wadalite group (silicates), for which the anionic charge over 6 W sites is -2 and -6 , respectively ($X = \text{Ca}$; $T = \text{Al, Mg, Fe, Si, Ti}$; $W = \text{Cl, F, H}_2\text{O}$, or vacant). A detailed re-examination of the type specimens of mayenite, originally described as $\text{Ca}_{12}\text{Al}_{14}\text{O}_{33}$, shows its correct end-member formula as $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[\square_4\text{Cl}_2]$. Consequently, mayenite was redefined as chlormayenite, while the name mayenite is reserved for a potential mineral with the end-member composition $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[\square_3\text{O}]$. As a consequence, the mineral brearleyite, $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[\square_4\text{Cl}_2]$, described in 2011 appeared to be identical with chlormayenite and is therefore discredited. By analogy with chlormayenite the kyuygenite recently approved by the IMA-CNMNC was renamed to chlorkyuygenite. Thus currently the mayenite group includes four species: chlormayenite $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[\square_4\text{Cl}_2]$ and three recently discovered minerals (see below) chlorkyuygenite, $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[(\text{H}_2\text{O})_4\text{Cl}_2]$, fluormayenite $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[\square_4\text{F}_2]$, and fluorkyuygenite, $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[(\text{H}_2\text{O})_4\text{F}_2]$. The wadalite group includes two mineral species wadalite, $\text{Ca}_{12}\text{Al}_{10}\text{Si}_4\text{O}_{32}[\text{Cl}_6]$ and eltyubyuite $\text{Ca}_{12}\text{Fe}_{10}^{3+}\text{Si}_4\text{O}_{32}[\text{Cl}_6]$. Minerals of the mayenite group have a zeolite-like structure with a $\{\text{Al}_{14}\text{O}_{32}\}^{22-}$ tetrahedral framework enclosing six big cages ($\sim 5 \text{ \AA}$) each occupied by two Ca^{2+} , which leads to an excess of two positive charges. At the centre of the cage (W site) anions balance the charge of the framework and Ca.

Chlorkyuygenite (IMA 2012-046), a new mineral with an ideal formula $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[(\text{H}_2\text{O})_4\text{Cl}_2]$, was initially mentioned as "mayenite-Cl" then approved under the name kyuygenite and finally approved by IMA CNMNC (proposal 2014/13-C) as chlorkyuygenite according to mayenite group nomenclature. It was discovered as an accessory mineral in Cahumite zones of calcareous skarn xenoliths in ignimbrites of the Upper Chegem Caldera, Northern Caucasus, Kabardino-Balkaria, Russia. The mineral thought to be crystallized initially as chlormayenite, which later was altered under influence of volcanic gases containing water vapor. Isometric grains and tris-tetrahedral crystals of chlorkyuygenite up to $50 \mu\text{m}$ and its aggregates up to $100\text{--}150 \mu\text{m}$ are enclosed in chegemite-fluorchegemite, reinhardbraunsite or srebrodolskite. Chlorkyuygenite also forms rims around wadalite crystals. Other associated minerals include kumtyubeite, rondorfite, hydroxyllestadite, lakargite, perovskite, kerimasite, elbrusite, ettringite-group minerals, hydrocalumite, bultfonteinite, and the minerals of the katoite-grossular series. Larnite, spurrite and galuskinite are noted as relics in Ca-humites. Chlorkyuygenite is colorless, occasionally with a greenish or yellowish tint, and the white streak. The mineral has a strong vitreous luster. The micro-indentation hardness $\text{VHN}_{50} = 632(37) \text{ kg/mm}^2$ corresponds to $5\text{--}5\frac{1}{2}$ of the Mohs scale; $D_{\text{calc}} = 2.941 \text{ g/cm}^3$. Chlorkyuygenite is transparent, isotropic, $n = 1.672(1)$ (589 nm). The main bands in the Raman spectra (cm^{-1}) are: 202 (O–Ca–O vibrations), 321, 511, 705, 776 and 881 (Al–O). A broad band with two maxima near 3400 and 3200 cm^{-1} is related to H–O stretching vibrations of H_2O . Weak bands in the region of H_2O -bending and OH-stretching vibrations are also noted. The temperature dependent Raman spectra show the molecular water is completely released from the mineral structure at about $550 \text{ }^\circ\text{C}$. A FTIR spectrum shows main bands at 780 and 847 cm^{-1} (Al–O stretching vibrations). An average of 27 electron probe analysis of chlorkyuygenite [wt% (range)] is SiO_2 0.70 (0.53–0.92), TiO_2 0.17 (0.10–0.24), Al_2O_3 43.00 (42.1–44.1), Fe_2O_3 4.27 (3.86–4.81), Y_2O_3 <0.08, MgO <0.03, CaO 43.70 (43.1–44.2), Cl 5.13 (4.88–5.66), H_2O 4.42 (calc. from O+Cl = 6, by stoichiometry), $-\text{O}=\text{Cl}_2$ 1.16, total 100.23, corresponding to the empirical formula $\text{Ca}_{11.99}(\text{Al}_{12.98}\text{Fe}_{0.82}^{3+}\text{Si}_{0.18}\text{Ti}_{0.03})_{\Sigma 14.01}\text{O}_{32}[(\text{H}_2\text{O})_{3.77}\text{Cl}_{2.23}]_{26}$. The most intensive calculated X-ray powder diffraction lines are [d_{calc} \AA ($I_{\text{calc}}\%$; hkl)]: 4.91 (31; 211), 3.215

(15; 321), 3.007 (38; 400), 2.690 (100; 420), 2.455 (46; 422), 2.196 (21; 521), 1.668 (26; 640). The crystal structure was solved by direct methods and refined to $R_1 = 0.0116$ for 300 unique $I > 2\sigma(I)$ reflections in the space group $I43d$; $a = 12.0285(1) \text{ \AA}$, $V = 1740.34 \text{ \AA}^3$, $Z = 2$. The structure differs from the one of chlormayenite by H_2O molecules filling the empty structural cages of W sites. The tetrahedral framework of chlorkyuygenite $\{\text{Al}_{14}\text{O}_{32}\}^{22-}$ encloses six structural cages, each occupied by two Ca^{2+} ions, leading to an excess of positive charges which is balanced by incorporation of Cl^- at two of six W sites. Chlorine is linearly coordinated by two Ca cations. The disordered character of Cl and H_2O within the cages did not allow the determination of the proton positions. The original name of chlorkyuygenite (kyuygenite) is for the Kyuygen-Kaya Mountain in the northern part of the Upper Chegem caldera (type locality). Type material is deposited in the Naturhistorisches Museum of Bern, Switzerland and in the Fersman Mineralogical Museum Russian Academy of Sciences, Moscow, Russia (this specimen is the holotype for both chlorkyuygenite and chegemite).

Two new minerals, **fluormayenite** (IMA 2013-019), ideally $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[\square_4\text{F}_2]$, and **fluorkyuygenite** (IMA 2013-043) ideally $\text{Ca}_{12}\text{Al}_{14}\text{O}_{32}[(\text{H}_2\text{O})_4\text{F}_2]$, were discovered as major constituents of lamite pyrometamorphic rocks of the Hatrurim Complex (Mottled Zone) distributed along the Dead Sea rift on the territory of Israel, Palestinian Autonomy, and Jordan. The holotype specimens of fluormayenite and fluorkyuygenite were collected at the Jabel Harmun, Judean Mts., Palestinian Autonomy and in the Hatrurim Basin, Negev Desert, Israel, respectively. Mineral associations for both minerals are similar and include larnite, shulamite, Cr-containing spinel–magnesian ferrite series, ye'elimite, fluorapatite–fluorellestadite, periclase, brownmillerite, oldhamite as well as the retrograde phases portlandite, hematite, hillbrandite, afwillite, foshagite, ettringite, katoite, and hydrocalumite. Fluorkyuygenite thought to be crystallized initially as fluormayenite which later was altered by the water vapor-enriched gases during a combustion process. Fluormayenite and fluorkyuygenite form crystals, usually $<20 \mu\text{m}$ in size, are colorless, occasionally with greenish or yellowish tint with a white streak and a vitreous luster. The micro-indentation hardness of fluormayenite and fluorkyuygenite is $\text{VHS}_{50} = 771(38)$ and $712(83) \text{ kg/mm}^2$ corresponding to $\sim 5\frac{1}{2}\text{--}6$ and $5\text{--}5\frac{1}{2}$ of the Mohs scale respectively. Both minerals do not show fluorescence in UV light, are transparent, isotropic with $n = 1.612(3)$ and $1.610(3)$ (589 nm), respectively. Raman spectra of fluormayenite and fluorkyuygenite in the spectral region $200\text{--}1000 \text{ cm}^{-1}$ are similar and are characterized by the bands at (cm^{-1}): ~ 320 , 520, 700, 770 (Al–O vibrations). Fluorkyuygenite shows a broad band between $2600\text{--}3500 \text{ cm}^{-1}$ with a weak maxima at 3020 and 3200 ($\nu \text{ H}_2\text{O}$) shifted towards a lower frequencies compare to chlorkyuygenite. Bands at $3560\text{--}3580 \text{ cm}^{-1}$ related to OH groups substituting F. Fluormayenite shows OH bands at $3670\text{--}3680 \text{ cm}^{-1}$. Temperature-dependent Raman spectra show the molecular water is completely released from the fluorkyuygenite structure at about $400 \text{ }^\circ\text{C}$. The averages of electron probe WDS analyses of fluormayenite [wt% (range)] and fluorkyuygenite [wt% (range)], respectively are: SiO_2 0.04 (0.02–0.08), $\{0.89$ (0.44–1.41), Al_2O_3 48.85 (48.2–49.1), $\{45.00$ (44.4–45.4), Fe_2O_3 1.51 (1.32–1.75), $\{2.10$ (1.59–2.68), MgO 0.11 (0.08–0.15), $\{<0.02\}$, CaO 46.96 (47.4–47.8), $\{44.64$ (44.0–45.2), Na_2O 0.08 (0.06–0.10), $\{<0.02\}$, SO_3 0.08 (0.04–0.12), $\{<0.03\}$, P_2O_5 0.03 (0.03–0.06), $\{<0.03\}$, Cl 0.11 (0.09–0.12), $\{<0.02\}$, F 1.83 (1.58–2.11), $\{2.38$ (1.84–2.84), H_2O 1.09, $\{4.72\}$ [calculated as $6 - (\text{F} + \text{Cl} + \text{OH})$], $-\text{O}=(\text{F}+\text{Cl})$ 0.80, $\{1.00\}$, total 99.88, $\{98.72\}$. The corresponding empirical formulae are $(\text{Ca}_{11.95}\text{Na}_{0.04})_{\Sigma 11.99}(\text{Al}_{13.68}\text{Fe}_{0.27}^{3+}\text{Mg}_{0.04}\text{Si}_{0.01}\text{P}_{0.01}\text{S}_{0.01}^{6+})_{\Sigma 14.02}\text{O}_{31.50}(\text{OH})_{1.49}[\square_{4.58}\text{F}_{1.38}\text{Cl}_{0.04}]_{26}$, and $\text{Ca}_{12.03}(\text{Al}_{13.34}\text{Fe}_{0.40}^{3+}\text{Si}_{0.22}\text{Ti}_{0.13}\text{P}_{0.02}\text{S}_{0.02})_{\Sigma 13.97}\text{O}_{32}[(\text{H}_2\text{O})_{3.81}\text{F}_{1.89}(\text{OH})_{0.30}]_{26}$, respectively. The most intense calculated X-ray powder diffraction lines for fluormayenite are [d_{calc} \AA ($I_{\text{calc}}\%$; hkl)]: 4.885 (41; 211), 3.198 (46; 321), 2.992 (61; 400), 2.676 (100; 420), 2.443 (45; 422), 2.185 (32; 521) and those for fluorkyuygenite are: 4.895 (92; 211), 3.204 (26; 321), 2.997 (47; 400), 2.681 (100; 420), 2.447 (43; 422), 2.189

(41; 521). The crystal structures of both minerals were solved by direct methods in the space group $I43d$, $Z = 2$ and refined to $R_1 = 0.0302$ using 686 unique $I > 2\sigma(I)$ reflections for fluormayenite [$a = 11.9894(2)$ Å, $V = 1723.42$ Å³] and to $R_1 = 0.0274$ using 280 unique $I > 2\sigma(I)$ reflections for fluorkyuygenite [$a = 11.966(2)$ Å, $V = 1713.4$ Å³]. In fluormayenite 1/3 of the structural cages of the tetrahedral framework are occupied by fluorine. In fluorkyuygenite, in addition to fluorine and negligible amounts of OH, H₂O molecules occupy about 2/3 of the cages. The new minerals were named as fluorine analogs of chlormayenite and chlorkyuygenite. The holotype of fluormayenite is deposited in the Museum of Natural History in Bern, Switzerland. Fragments of the fluorkyuygenite holotype, which at the same time are fragments of the shulamite holotype, were deposited in the Mineralogical Museum of St. Petersburg University, Russia, in the Central Siberian Geological Museum of the V.S. Sobolev Institute of Geology and Mineralogy, Novosibirsk, Russia and in the Fersman Mineralogical Museum of Russian Academy of Sciences, Moscow, Russia. **D.B.**

CHUBAROVITE*

I.V. Pekov, N.V. Zubkova, L.A. Pautov, V.O. Yapaskurt, N.V. Chukanov, I.S. Lykova, S.N. Britvin, E.G. Sidorov, and D.Yu. Pushcharovsky (2015) Chubarovite, $KZn_2(BO_3)Cl_2$, a new mineral species from the Tolbachik volcano, Kamchatka, Russia. *Canadian Mineralogist*, 53, 273–284.

Chubarovite (IMA 2014-018), ideally $KZn_2(BO_3)Cl_2$, was discovered in the sublimates of active fumaroles at the First and Second scoria cones of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. In the Arsenatnaya fumarole at the Second scoria cone (holotype) chubarovite occurs in association with fluorborite, krashennikovite, sylvite, halite, langbeinite, apthitalite, arcanite, zincite, flinteite, wulfite, johillerite, urusovite, pseudobrookite, vanthoffite, svabite, orthoclase, fluorphlogopite, hematite, and tenorite; while at the First scoria cone, it is found with sellaite, fluorite, anhydrite, halite, cotunnite, chalcocolloite, sofitite, and flinteite. Sometimes chubarovite overgrows chalcocolloite crystals. Chubarovite forms hexagonal or trigonal lamellar to tabular crystals up to 1.5×0.5 mm (typically 0.2×0.8 mm) with pinacoidal and rhombohedral faces. Crystals are well-shaped or crude, sometimes divergent, resembling flowers or an open book. Simple twins of two types are observed: contact twins with the axis [001] and single composition surface {001} and, more rare, X-shaped penetration twins on (103). Commonly crystals are combined in open-work groups, drusy aggregates or compact clusters or crusts up to 1 cm across. Areas covered with chubarovite are up to 20 cm². Chubarovite is transparent, colorless, has a white streak and vitreous luster. It is flexible but not elastic, lamellae can be easily bent. The cleavage is perfect on {001} and the fracture is laminated. Mohs hardness is ~2; $D_{\text{meas}} = 2.68$ and $D_{\text{calc}} = 2.716$ g/cm³. The mineral is non-fluorescent. Optically chubarovite is uniaxial (-), with $\omega = 1.541(2)$, $\epsilon = 1.539(2)$ (589 nm); colorless, non-pleochroic. The main bands at IR spectrum (cm⁻¹, s = strong band, w = weak band, sh = shoulder) are: 1344w sh, 1257s (degenerate stretching mode of the orthoborate group), 747, 695 (combinations of degenerate and nondegenerate modes of BO₃ groups), 496w, 402s (lattice modes involving Zn–O stretching vibrations and both translational and librational vibrations of BO₃ groups). No bands corresponding to H₂O, OH, or covalent C–O bonds were observed. The averaged 4 point WDS electron probe analyses gave [wt%, (range)]: K₂O 16.48 (16.27–16.69), Rb₂O 0.46 (0.44–0.48), ZnO 53.96 (53.63–54.16), B₂O₃ 10.98, Cl 24.48 (24.16–24.79), –O=Cl₂ 5.53, total 100.03. The empirical formula is $(K_{1.05}Rb_{0.01})_{\Sigma 1.06}Zn_{2.00}B_{0.95}O_{2.92}Cl_2$ based on (O+Cl) = 5 apfu. The strongest lines of the X-ray powder diffraction pattern are [d Å ($P\%$; hkl)]: 8.79 (100; 003), 4.394 (43; 006), 4.225 (25; 101), 4.074 (91; 012), 3.590 (90; 104), 3.324 (30; 015), 2.470 (67; 110), 2.245 (25; 1.0.10). The crystal structure of chubarovite was solved by direct methods and refined to $R = 2.01\%$. The new mineral is trigonal, $R32$, $a = 4.9429(4)$, $c = 26.348(2)$ Å, $V = 557.50$ Å³, and $Z = 3$. The crystal structure is of a

novel type and is based on anionic and cationic layers alternating along [001]. The anionic layer $\{Zn_2(BO_3)Cl_2\}^-$, consists of [BO₃] groups sharing all O vertices with bases of [Zn₂OCl] tetrahedra, with each triangle connected to six Zn tetrahedra. Each Cl vertex is shared between one Zn tetrahedron and three edge-connected KCl₆ octahedra that belong to the cationic layer of K⁺ cations. The mineral is named in honor of the Russian mineralogist and physicist Valeriy Mikhailovich Chubarov (b. 1948). The type specimen is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

CRYOBOSTRYXITE*

I.V. Pekov, N.V. Zubkova, S.N. Britvin, V.O. Yapaskurt, N.V. Chukanov, I.S. Lykova, E.G. Sidorov, and D.Yu. Pushcharovsky (2015) New zinc and potassium chlorides from fumaroles of the Tolbachik volcano, Kamchatka, Russia: Mineral data and crystal chemistry. III. Cryobostryxite, $KZnCl_3 \cdot 2H_2O$. *European Journal of Mineralogy*, 27, 805–812.

Cryobostryxite (IMA 2014-058), ideally $KZnCl_3 \cdot 2H_2O$, is a new mineral formed in the upper, moderately hot (30–80 °C) zone of an active fumaroles at the First scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. It is probably formed as a product of the interactions between high-temperature volcanic sublimates and meteoric water. Cryobostryxite occurs on a surface of basalt scoria or in incrustations consisting of sellaite, fluorite, halite and/or anhydrite. Other associated minerals are gypsum, ralstonite and opal. Earlier, primary minerals of the assemblage are sellaite, fluorite, halite, anhydrite, cotunnite, sofitite, flinteite, chubarovite, anglesite, chalcocolloite, zincomenite, saltonseaitite, hollandite, hematite, jakobssonite, leonardsenite, and olscherite. Cryobostryxite forms anthodites up to 2 mm long and 0.5 mm thick, their near-parallel columnar or chaotic open-work aggregates up to 4–5 mm, sugar-like crusts up to 2×2 mm and up to 0.3 mm thick, rarely, coarse prismatic to acicular crystals up to 0.2–1 mm. The mineral is transparent, colorless, with a white streak and a vitreous luster. Cleavage was not observed. It is brittle with Mohs hardness ~2; $D_{\text{meas}} = 2.30(2)$, $D_{\text{calc}} = 2.300$ g/cm³. Cryobostryxite is optically biaxial (+) with $\alpha = 1.522(2)$, $\beta = 1.530(2)$, $\gamma = 1.576(2)$ (589 nm); $2V_{\text{estimated}} = 30(15)$. The strongest bands in the IR spectrum (cm⁻¹) are: 3600–3200 (O–H stretching), 1607 (H–O–H bending), 508 (vibrations of H₂O molecule as a whole). Weak bands in the range 600–1200 correspond to overtones and combination modes. Absorptions corresponding to B–O, C–O, N–O, and N–H bonds are absent. The average of 4 spot electron probe WDS analyses [wt% (range)] is: K 14.85 (14.12–15.58), Ti 4.08 (3.61–4.68), Zn 25.82 (24.83–27.11), Cl 41.70 (41.18–42.24), H₂O (calc. as 2 molecules pfu) 14.19, total 100.64. The empirical formula calculated on the basis of K+Ti+Zn+Cl = 5 apfu is $(K_{0.96}Ti_{0.05})_{\Sigma 1.01}Zn_{1.00}Cl_{2.99} \cdot 2H_2O$. Cryobostryxite belongs to a new chemical family of minerals, which includes flinteite K_2ZnCl_4 and mellizinkalite $K_3Zn_2Cl_7$. The strongest lines of the X-ray powder diffraction pattern are [d Å ($P\%$; hkl)]: 7.62 (30; 011), 5.986 (43; 100), 5.766 (35; 002), 3.907 (33; $\bar{1}21$), 3.466 (20; 121), 3.062 (100; 202,023), 2.996 (24; $\bar{2}11,200$), 2.853 (27; $\bar{1}14$). The crystal structure refined to $R_1 = 0.0654$ for 1259 $I > 2\sigma(I)$ independent reflections. Cryobostryxite is monoclinic, space group $P2_1/c$, $a = 6.2795(3)$, $b = 10.1397(3)$, $c = 12.0829(7)$ Å, $\beta = 107.732(5)^\circ$, $V = 732.79$ Å³, and $Z = 4$. The crystal structure contains isolated Zn-centered tetrahedra $ZnCl_3(H_2O)$, which are connected via eight-coordinated K-centered polyhedra $KCl_3(H_2O)$ to form a pseudo-framework. Both Zn- and K-centered polyhedra involve only O(1) atoms of the H₂O(1) molecules, whereas H₂O(2) molecules are located in holes of the K-Zn-Cl-H₂O(1) polyhedral pseudo-framework and form hydrogen bonds. The mineral name is based on two Greek words, κρύος, cold or ice, and βόστρυξ, curl, reflecting very similar appearance of the anthodites of the mineral to ice curls. Cotype specimen is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **D.B.**

FERRIAKASAKAITE-(La)* AND FERRIANDROSITE-(La)*

M. Nagashima, D. Nishio-Hamane, N. Tomita, T. Minakawa, and S. Inaba (2015) Ferriakasaite-(La) and ferriandrosite-(La): New epidote supergroup minerals from Ise, Mie Prefecture, Japan. *Mineralogical Magazine*, 79, 735–753.

Ferriakasaite-(La) (IMA 2013-126), ideally $A^1Ca^{A2}La^{M1}Fe^{3+M2}Al^{M3}Mn^{2+}(SiO_4)(Si_2O_7)O(OH)$ and ferriandrosite-(La) (IMA 2013-127), ideally $A^1Mn^{2+}A^2La^{M1}Fe^{3+M2}Al^{M3}Mn^{2+}(SiO_4)(Si_2O_7)O(OH)$, are two new minerals discovered in the Shobu area, Ise City, Mie Prefecture, Japan. The minerals were found in tephroite-calcite veinlets cutting the stratiform ferromanganese deposit, in association with rhodochrosite, bementite and allanite-group minerals. Ferriakasaite-(La) and ferriandrosite-(La) are indistinguishable macroscopically or by optical microscopy. The new minerals mostly occur as euhedral to subhedral prismatic crystals elongated by [010], with lengths varying from several micrometers to 150 μm . Crystals are dark brown with a vitreous luster and are brittle with imperfect cleavage on {001}. The data on optical properties and density are not given; $D_{calc} = 4.22$ [ferriakasaite-(La)] and 4.23 g/cm^3 [ferriandrosite-(La)]. The average of 3 WDS electron probe analyses of ferriakasaite-(La) is [wt% (range)]: SiO_2 29.15 (29.11–29.30), TiO_2 0.75 (0.71–0.80), Al_2O_3 9.35 (9.28–9.43), Cr_2O_3 0.06 (0.05–0.08), V_2O_5 4.11 (3.96–4.19), Fe_2O_3 5.96 (5.18–6.77), FeO 5.05 (4.45–5.94), MnO 10.90 (9.98–11.55), NiO 0.03 (0.01–0.05), MgO 0.46 (0.44–0.48), CaO 5.38 (5.07–5.57), SrO 0.01 (0–0.02), BaO 0.02 (0–0.03), K_2O 0.03 (0–0.05), P_2O_5 0.03 (0–0.05), Y_2O_3 0.03 (0–0.07), La_2O_3 12.73 (12.01–13.06), Ce_2O_3 5.25 (5.22–5.31), Pr_2O_3 1.93 (1.80–2.09), Nd_2O_3 4.97 (4.62–5.29), Gd_2O_3 0.51 (0.48–0.56), Er_2O_3 0.09 (0.04–0.16), F 0.05 (0.02–0.08), $-O=F_2$ 0.02, H_2O (by difference) 3.17, total 100.00; and the average of 3 WDS electron probe analyses of ferriandrosite-(La) is: SiO_2 29.25 (29.05–29.54), TiO_2 0.86 (0.62–1.07), Al_2O_3 9.61 (9.58–9.66), Cr_2O_3 0.08 (0.02–0.12), V_2O_5 3.40 (3.31–3.53), Fe_2O_3 5.48 (5.23–5.61), FeO 5.23 (4.88–5.45), MnO 12.05 (11.41–12.85), NiO 0.02 (0–0.05), MgO 0.65 (0.58–0.71), CaO 4.26 (3.77–4.86), SrO 0.04 (0–0.10), Y_2O_3 0.01 (0–0.02), La_2O_3 12.97 (12.34–13.57), Ce_2O_3 5.25 (5.14–5.36), Pr_2O_3 2.05 (1.92–2.11), Nd_2O_3 5.16 (4.72–5.38), Gd_2O_3 0.48 (0.28–0.65), Er_2O_3 0.01 (0–0.04), F 0.28 (0.27–0.30), $-O=F_2$ 0.12, H_2O (by difference) 3.01, total 100.00. The empirical formulae are respectively: $A^1(Ca_{0.54}Mn_{0.46}^{2+})^{A2}[(La_{0.48}Ce_{0.20}Pr_{0.07}Nd_{0.18}Gd_{0.02})_{\Sigma 0.95}Ca_{0.05}]^{M1}(Fe_{0.42}^{3+}V_{0.34}^{5+}Al_{0.18}Ti_{0.06}^{4+})^{M2}(Al_{0.96}Fe_{0.04}^{3+})^{M3}(Mn_{0.50}^{2+}Fe_{0.43}^{2+}Mg_{0.07})(SiO_4)(Si_2O_7)O(OH)$ and $A^1(Mn_{0.56}^{2+}Ca_{0.44})^{A2}[(La_{0.49}Ce_{0.20}Pr_{0.08}Nd_{0.19}Gd_{0.02})_{\Sigma 0.97}Ca_{0.03}]^{M1}(Fe_{0.30}^{3+}V_{0.28}^{5+}Al_{0.20}Fe_{0.05}^{3+}Ti_{0.07}^{4+})^{M2}(Al_{0.97}Fe_{0.03}^{3+})^{M3}(Mn_{0.50}^{2+}Fe_{0.40}^{2+}Mg_{0.10})(SiO_4)(Si_2O_7)O(OH)$ based on 8 cations pfu (combined with the structure refinement). FeO and Fe_2O_3 were calculated based on charge balance where the total positive charge = 25. The strongest lines in the calculated X-ray powder-diffraction pattern of ferriakasaite-(La) [d_{calc} (Å) ($I_{calc}\%$; hkl)] are: 2.899 (100; 11 $\bar{3}$), 2.614 (31 $\bar{1}$), 3.509 (47; 21 $\bar{1}$), 2.871 (40; 020), 2.710 (35; 013), 2.706 (35; 120) and those for ferriandrosite-(La) [d_{calc} (Å) ($I_{calc}\%$; hkl)] are: 2.900 (100; 11 $\bar{3}$), 2.615 (53; 31 $\bar{1}$), 3.510 (46; 21 $\bar{1}$), 2.870 (40; 020), 2.710 (35; 013), 2.706 (35; 120). Single-crystal X-ray diffraction data collected on a crystal of size 0.06×0.04×0.02 mm refined to $R_1 = 0.0313$ for 1500 unique reflections shows ferriakasaite-(La) is monoclinic, space group $P2_1/m$, with $a = 8.8733(2)$, $b = 5.7415(1)$, $c = 10.0805(3)$ Å, $\beta = 113.845(2)^\circ$, $V = 469.73$ Å 3 , and $Z = 2$. For ferriandrosite-(La), single-crystal X-ray diffraction data collected on a crystal of size 0.04×0.04×0.04 mm refined to $R_1 = 0.0293$ for 2733 unique reflections shows the mineral is monoclinic, space group $P2_1/m$, with $a = 8.8779(1)$, $b = 5.73995(1)$, $c = 10.0875(2)$ Å, $\beta = 113.899(1)^\circ$, $V = 469.97$ Å 3 , and $Z = 2$. The new minerals have the epidote structure, with new combinations of dominant cations at A1 and M3 sites, which are the key sites to determine a root name for epidote-supergroup minerals: Ca and Mn^{2+} for ferriakasaite-(La), respectively, and Mn^{2+} and Mn^{3+} for ferriandrosite-(La), which is the M^3Fe^{3+} equivalent of androsite. Ferriakasaite-(La) is named in honor of Masahide Akasaka (b. 1950) for his outstanding contribution to mineralogy. Ferriandrosite-(La) is

based on the “ferriandrosite-(REE)” new root of the allanite group proposed by Armbruster et al. (2006). Type specimens of ferriakasaite-(La) and ferriandrosite-(La) are deposited in the National Museum of Nature and Science, Tokyo, Japan. **O.C.G.**

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FERRO-PEDRIZITE*

S.I. Konovalenko, S.A. Ananyev, N.V. Chukanov, S.M. Aksenov, R.K. Rastsvetayeva, A.I. Bakhtin, A.G. Nikolaev, R.R. Gainov, F.G. Vagizov, A.N. Sapozhnikov, D.I. Belakovskiy, Y.V. Bychkova, G. Klingelhöfer, and M. Blumers (2015) Ferro-pedrize, $NaLi_2(Fe_2^+Al_2Li)Si_8O_{22}(OH)_2$, a new amphibole-supergroup mineral from the Sutlug pegmatite, Tyva Republic, Russia. *European Journal of Mineralogy*, 27, 417–426.

Ferro-pedrize (IMA2014-037), ideally $NaLi_2(Fe_2^+Al_2Li)Si_8O_{22}(OH)_2$, is a new amphibole-supergroup mineral discovered in the Sutlug pegmatite in the Targi River Basin, Tyva Republic, Eastern Siberia, Russia. The associated minerals are quartz, albite, microcline, spodumene, cassiterite, beryl, columbite-(Mn), fergusonite- β -(Y), fluorapatite, schorl, trillithionite and fluorite. Ferro-pedrize forms dark gray-blue to violet-blue acicular and long prismatic crystals up to 2×5×50 mm, with major crystal forms {110} prism and the {100} and {010} pinacoids, in random, radial or subparallel aggregates. Ferro-pedrize is intensely colored, dark gray-blue to violet-blue, with pale gray streak, and vitreous luster. Ferro-pedrize is brittle, has a Mohs hardness of 6 and a splintery fracture. It has a perfect cleavage on {110} and a less perfect one on {001}. $D_{meas} = 3.13(1)$ g/cm^3 (by flotation in heavy liquids) and 3.16(1) g/cm^3 (by hydrostatic weighing), and $D_{calc} = 3.138$ g/cm^3 . No fluorescence under UV light was observed. Ferro-pedrize is biaxial (–), $\alpha = 1.614(3)$, $\beta = 1.638(3)$, $\gamma = 1.653(3)$ (589 nm); $2V_{meas} = 75(5)^\circ$, $2V_{calc} = 76^\circ$. The orientation is: $Y = b$, $Z \wedge c = 3-4^\circ$, $X \wedge a \approx 16^\circ$. Positive elongation is observed for the crystals parallel to the planes {010} and {YZ}. The dispersion of the optical axes is weak, $r < v$. The mineral is weakly pleochroic X (colorless) $< Y \approx Z$ (pale lilac-gray). IR spectrum of ferro-pedrize show bands in the ranges 550–600 (Li–O stretching vibrations), from 650 to 800 cm^{-1} (O–Si–O and M···O–H bending vibration), from 900 to 1150 cm^{-1} (Si–O stretching vibrations), and 3600–3750 cm^{-1} (O–H stretching vibrations). Bands below 600 cm^{-1} correspond to M–O stretching and Si–O–Si bending modes. Average of 5 electron probe EDS analyses is [wt% (range)]: Li_2O 4.67 (by the ICP-MS), Na_2O 2.54 (2.43–2.67), K_2O 0.13 (0–0.23), CaO 0.29 (0.20–0.35), MgO 4.48 (4.27–4.64), MnO 0.59 (0.43–0.65), Fe_{total} 13.20 (13.02–13.37), FeO 9.06 and Fe_2O_3 4.60 (by Mössbauer spectroscopy), Al_2O_3 13.13 (12.80–13.46), SiO_2 57.59 (57.25–57.91), F 1.15(1) (by wet chemical analyses), H_2O 1.50(1) (by gas chromatography), $-O=F_2$ 0.48, total 99.25. The empirical formula calculated on the basis of 24 (O+F) pfu is: $(Na_{0.60}K_{0.02})_{\Sigma 0.62}(Li_{1.89}Na_{0.07}Ca_{0.04})_{\Sigma 2.00}(Fe_{1.03}^{3+}Mg_{0.90}Mn_{0.07}^{2+}Al_{1.88}Fe_{0.47}^{3+}Li_{0.65})_{\Sigma 2.00}[(Si_{7.79}Al_{0.21})_{\Sigma 8.00}O_{22}][O(H)_{1.36}F_{0.49}O_{0.15}]$. The strongest X-ray powder diffraction lines [d Å ($I\%$; hkl)] are: 8.147 (52; 110), 4.420 (22; 040), 3.009 (100; 310), 2.7102 (28; 330), 2.6865 (29; 151), 2.6236 (21; 461). The monoclinic unit-cell parameters refined from the powder data are: $a = 9.376(4)$, $b = 17.663(2)$, $c = 5.277(6)$ Å, $\beta = 102.22(1)^\circ$, $V = 854.1$ Å 3 . X-ray single-crystal diffraction study [refined to $R_1 = 0.0391$ for 4843 unique $I > 2\sigma(I)$ reflections on a twinned crystal fragment of 150×180×200 μm shows that the mineral is monoclinic, space group $C2/m$, $a = 79.3716(4)$, $b = 17.694(1)$, $c = 5.2800(6)$ Å, $\beta = 102.22(1)^\circ$, $V = 853.5$ Å 3 , $Z = 2$. The name follows the classification for amphiboles approved by IMA-CNMNC (Hawthorne et al. 2012). The type specimen is deposited in the Mineralogical Museum of the Tomsk State University, Russia, with the registration number 19116. **F.C.**

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FLAMITE*

E.V. Sokol, Y.V. Seryotkin, S.N. Kokh, Y. Vapnik, E.N. Nigmatulina, S.V. Goryainov, E.V. Belogub, and V.V. Sharygin (2015) Flamite, $(\text{Ca},\text{Na},\text{K})_2(\text{Si},\text{P})\text{O}_4$, a new mineral from ultrahigh-temperature combustion metamorphic rocks, Hatrurim Basin, Negev Desert, Israel. *Mineralogical Magazine*, 79, 583–596.

F. Gfeller, R. Widmer, B. Krüger, E.V. Galuskin, I.O. Galuskina, and T. Armbruster. (2015) The crystal structure of flamite and its relation to Ca_2SiO_4 polymorphs and nagelschmidite. *European Journal of Mineralogy*, 27, 755–769.

The new mineral species flamite (IMA 2013-122), with general formula $(\text{Ca},\text{Na},\text{K})_2(\text{Si},\text{P})\text{O}_4$, a natural analog of the P,Na,K-doped high-temperature $\alpha\text{-Ca}_2\text{SiO}_4$ modification, was discovered as a rock-forming mineral in Ca- and Al-rich paralava, an ultrahigh-temperature combustion metamorphic rock found in the Hatrurim Basin in Negev Desert, Israel. Thin paralava veinlets in gehlenite hornfels, had experienced slight retrograde alteration. The mineral assemblage consists of ~40% Ca_2SiO_4 solid solutions (flamite as a regular lamellar intergrowth with partially hydrated larnite), ~30% gehlenite, 15% rankinite, and 10% Ti-rich andradite. Minor phases (~5 vol%) are Fe-rich perovskite, magnesioferrite, and hematite, which contains tubular inclusions of cloudy flamite. Ettringite and calcium silicate hydrates are minor retrograde phases. Flamite occurs as 100–250 μm anhedral lamellar crystals filling interstitial areas between gehlenite and as intergrowths with rankinite and Ti-rich andradite. The mineral is pale yellow or gray, transparent with a white streak, vitreous luster and no parting or cleavage. The micro-indentation hardness $\text{VHN}_{50} = 706$ (579–753) kg/mm^2 corresponding to 5–5½ of Mohs scale. The density was not measured due to intimate intergrowths with larnite; $D_{\text{calc}} = 3.264$ g/cm^3 . No fluorescence in UV light was observed. Flamite is optically uniaxial (+), with $\omega = 1.634(2)$ and $\epsilon = 1.640(2)$ (589 nm); $Z = \epsilon$. The main bands in the Raman spectrum (cm^{-1}) are: 170, 260, 520, 538, 850, 863, 885, 952, and 1003. Generally, the bands are associated with vibrations of isolated $[\text{SiO}_4]$ groups and Ca^{2+} cations (translational modes). No bands related to the presence $[\text{CO}_3]^{2-}$, OH groups or H_2O were detected. The average of 21 electron probe analyses of the holotype sample [wt% (range)] is: CaO 59.76 (58.27–61.23), SiO_2 28.87 (28.14–30.17), Al_2O_3 0.04 (0–0.08), FeO 0.15 (0–0.48), MgO 0.16 (0.08–0.55), BaO 0.05 (0–0.17), SrO 0.24 (0.17–0.35), V_2O_5 0.10 (0–0.16), P_2O_5 6.01–8.55, Na_2O 1.55 (1.12–1.98), K_2O 1.73 (1.40–2.04), total 100.03. The empirical formula is $[\text{Ca}_{1.82}\text{Na}_{0.09}\text{K}_{0.06}(\text{Mg},\text{Fe},\text{Sr},\text{Ba})_{0.02}\text{Si}_{1.99}(\text{Si}_{0.82}\text{P}_{0.18})_{0.01}\text{O}_4]$. Flamite dissolves in 10% HCl with the formation of a SiO_2 gel. The strongest lines in the calculated powder X-ray diffraction pattern are [d_{calc} , Å ($I_{\text{calc}}\%$; hkl): 2.765 (44; 082), 2.759 (42; $\bar{4}$.14.1), 2.713 (100; $\bar{8}$.16.0), 2.518 (29; $\bar{8}$.16.1), 1.762 (32)]. According to the original single crystal XRD study flamite is hexagonal, space group $P6_3$; $a = 43.3726(18)$, $c = 6.8270(4)$ Å ; $V = 11122.2$ Å^3 , $Z = 128$. The later re-examination of the holotype material revealed that flamite is orthorhombic, crystallizes in the space group $Pnm2_1$, with $a = 9.3845(6)$, $b = 21.7310(14)$, $c = 6.8346(4)$ Å , $V = 1393.81$ Å^3 , $Z = 4$, and better described by the formula $\text{Ca}_{8-x}(\text{Na},\text{K})_x(\text{SiO}_4)_{4-x}(\text{PO}_4)_x$. It is isostructural with the known synthetic P-doped clinker phase $\text{Ca}_{15}\square(\text{SiO}_4)_6(\text{PO}_4)_2$. The flamite structure is a derivative of the hexagonal high-temperature variety of dicalcium-silicate, so-called $\alpha\text{-C}_2\text{S}$, and is characterized by a cyclic triplet of individuals rotated 120° around c , interpreted as symplectite-like transformation “twinning” derived from $\alpha\text{-C}_2\text{S}$. The composition of intergrown flamite lamellae is chemically variable concerning the degree of Na, K, and P substitution. In terms of the structure flamite is closely related to nagelschmidite, $\text{Ca}_7(\text{SiO}_4)_2(\text{PO}_4)_2$, and the high-temperature polymorphs of C_2S . The mineral name is derived from “flame” and refers to the origin of the mineral by ultrahigh-temperature combustion metamorphism triggered by fossil-fuel ignition. The holotype specimen is stored in the collections

of the Central Siberian Geological Museum of the V.S. Sobolev, Institute of Geology and Mineralogy, Novosibirsk, Russia. **D.B.**

FLINTEITE*

I.V. Pekov, N.V. Zubkova, V.O. Yapaskurt, S.N. Britvin, M.F. Viganina, E.G. Sidorov, and D.Yu. Pushcharovsky (2015) New zinc and potassium chlorides from fumaroles of the Tolbachik volcano, Kamchatka, Russia: Mineral data and crystal chemistry. II. Flinteite, K_2ZnCl_4 . *European Journal of Mineralogy*, 27, 581–588.

The new mineral flinteite (IMA 2014-009), ideally K_2ZnCl_4 , was discovered in active fumaroles at two neighbored scoria cones of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. At the First scoria cone (locality of the holotype) flinteite is a common mineral associated with halite, sellaite, fluorite, saltonseaitite, chubarovite, and hollandite. At the Second scoria cone flinteite found in the Arsenatnaya fumarole in areas with the temperature 300–360 $^\circ\text{C}$ (with langbeinite, calciolangbeinite, apthitalite, fluoborite, sylvite, halite, arcanite, tenorite, zincite, chubarovite, krashennikovite, vanthoffite, wulfite, johillerite, and urusovite on the earlier sublimated orthoclase, fluorophlogopite, hematite, and pseudobrookite) and in the sulphate-chloride zone of the Glavnaya Tenoritovaya fumarole at temperature 110 $^\circ\text{C}$ (with belloite, avdoninite, eriochalcite, mellizinkalite, sylvite, halite, carnallite, mitscherlichite, sanguite, chrysothallite, romanorlovite, gypsum, chlorothionite, and kaimite). Flinteite typically forms prismatic crystals up to $0.2 \times 0.3 \times 1.2$ mm, their groups, granular aggregates or crusts up to $0.5 \times 5 \times 5$ mm. The mineral is transparent, light green, light yellow to bright greenish-yellow or colorless with a vitreous luster. Flinteite has a distinct cleavage in one direction, uneven fracture and is brittle. The Mohs hardness is ~2. Density was not measured due to the presence of inclusions of porous volcanic scoria in the flinteite grains; $D_{\text{calc}} = 2.49$ g/cm^3 . The mineral is optically biaxial (+), $\alpha = 1.573(1)$, $\beta = 1.574(1)$, $\gamma = 1.576(1)$ (589 nm), $2V_{\text{estimated}} = 40(25)^\circ$, $2V_{\text{calc}} = 71^\circ$ (the discrepancy is probably due to the low birefringence). It is colorless, non-pleochroic. All bands of the Raman spectrum of flinteite have maxima below 300 cm^{-1} . The intense, narrow band at 294 cm^{-1} corresponds to Zn–Cl stretching vibrations, bands at 192, 140, and 113 cm^{-1} correspond to lattice modes, Zn–Cl bending and K–Cl stretching vibrations. No bands indicating the presence of groups with O–H, C–H, C–O, N–H, N–O, B–O, Be–O, and Li–O bonds were observed. The average of 4 electron probe WDS analyses of the holotype [wt% (range)] is: K 24.97 (23.53–25.94), Ti 5.82 (5.27–6.11), Co 0.07 (0–0.29), Zn 22.23 (21.48–23.00), Cl 46.95 (45.76–47.60), total 100.04. The empirical formula based on the sum of all atoms = 7 pfu is: $(\text{K}_{1.91}\text{Ti}_{0.09})_{22.00}\text{Zn}_{1.04}\text{Cl}_{3.96}$. Compositional variations for all analyzed samples are (wt% range): K (16.34–28.34), Ti (0.31–27.74), Co (0–0.52), Zn (16.70–22.91), Cl (37.20–49.71), Cs (0–2.16), Rb (0–2.44). Flinteite dissolves very easily in H_2O at room temperature and is unstable in a humid atmosphere. The most common product of flinteite alteration is crybostryxite $\text{KZnCl}_3 \cdot 2\text{H}_2\text{O}$. The strongest lines in the powder X-ray diffraction pattern [d Å ($I\%$; hkl)] are: 6.23 (27; 011,020), 5.123 (88; 311,320), 3.629 (98; 611,002), 3.599 (100; 031), 3.133 (35; 022), 3.039 (26; 630), 2.897 (35; 910), 2.688 (46; 911,920). The unit-cell parameters refined from the powder data are: $a = 26.827(6)$, $b = 12.405(3)$, $c = 7.252(1)$ Å , $V = 2413$ Å^3 . The crystal structure was solved by direct methods and refined to $R_1 = 0.0686$ on the basis of 3516 independent $I > 2\sigma(I)$ reflections. Flinteite is orthorhombic, $Pna2_1$, $a = 26.8090(10)$, $b = 12.4085(6)$, $c = 7.2512(3)$ Å , $V = 2412.18$ Å^3 , $Z = 12$. The structure contains three Zn sites centering isolated ZnCl_4 tetrahedra and six independent K sites of different coordination. Flinteite is the natural analog of a synthetic non-intrinsic ferroelectric K_2ZnCl_4 modification with a commensurate structure stable between 145 and 403 K. Flinteite was studied at room temperature and was probably formed as the result of a phase transition when cooling after the extraction of crystals of its

protophase from the hot fumaroles. The mineral is named in honor of the famous Russian crystallographer Evgeniy Evgenievich Flint (1887–1975). The holotype is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **D.B.**

FLUORCHEGEMITE*

I.O. Galuskina, B. Krüger, E.V. Galuskin, T. Armbruster, V.M. Gazeev, R. Włodyka, M. Dulski, and P. Dzierżanowski (2015) Fluorchegemite, $\text{Ca}_7(\text{SiO}_4)_3\text{F}_2$, a new mineral from the edgewise-bearing endoskarn zone of an altered xenolith in ignimbrites from Upper Chegem caldera, Northern Caucasus, Kabardino-Balkaria, Russia: Occurrence, crystal structure, and new data on the mineral assemblages. *Canadian Mineralogist*, 53, 325–344.

Fluorchegemite (IMA 2011-112), ideally $\text{Ca}_7(\text{SiO}_4)_3\text{F}_2$, is a new mineral from an edgewise-bearing zone of endoskarn at the contact of a large altered calciferous xenolith within ignimbrites of the Upper Chegem Caldera, Northern Caucasus, Kabardino-Balkaria, Russia. It is associated with larnite, edgewise, wadalite, eltyubyuite, rondorfite, lakargiite, Th-kerimasite, bultfonteinite, killalaite, hillebrandite, afwillite, trabzonite, and jennite. Fluorchegemite forms either acicular crystals up to 0.1 mm that are irregularly distributed in the host rock and are associated with relatively large edgewise crystals, or larger acicular crystals up to 0.2 mm that form aggregates replacing larnite in lens-shaped assemblages. Occasionally the crystals are twinned. The new mineral is colorless with a white streak, imperfect cleavage on {010} and irregular fracture. It has a Mohs hardness of $\sim 5\frac{1}{2}$ –6. Density was not measured because of inclusions of other minerals, $D_{\text{calc}} = 2.91 \text{ g/cm}^3$. Fluorchegemite is colorless nonpleochroic, is optically biaxial (–), with $\alpha = 1.610(2)$, $\beta = 1.6150(2)$, $\gamma = 1.619(2)$ (589 nm); $2V_{\text{meas}} = 80(8)^\circ$; $2V_{\text{calc}} = 84^\circ$; $X = \mathbf{a}$, $Y = \mathbf{b}$, $Z = \mathbf{c}$ Dispersion of optical axis is weak, $r > v$. The main bands in the Raman spectrum (cm^{-1} , $s = \text{strong}$) are: 258, 297 (vibrations of CaO_6 octahedra); 410s, 422, 560s (bending vibrations of SiO_4 tetrahedra); 817s, 843, 922s (stretching vibrations of SiO_4 tetrahedra); 3539, 3548, 3552 (OH-stretching). Fourier-transform IR spectrum show the bands (cm^{-1} , $s = \text{strong}$): 756, 795, 805, 821s, 844s, 889s, 914s, 934s, 962s, 991s, 1031s, 1102, 3552s. Strong bands correspond to asymmetric vibrations in SiO_4 tetrahedra. The average of 10 electron probe WDS analyses of the holotype sample is [wt% (range)]: TiO_2 0.17 (0.04–0.27), SiO_2 29.91 (29.43–30.13), CaO 65.65 (65.31–66.01), MgO 0.04 (0.03–0.05), F 4.43 (4.07–4.97), H_2O 0.90, $-\text{O}=\text{F}$ 1.88, total 99.22. The formula calculated on the basis of 10 ($\text{O}+\text{OH}+\text{F}$) apfu is: $(\text{Ca}_{7.01}\text{Mg}_{0.01})_{\Sigma 7.02}(\text{Si}_{2.98}\text{Ti}_{0.01})_{\Sigma 2.99}\text{O}_{12}[\text{F}_{1.40}(\text{OH})_{0.60}]_{\Sigma 2.00}$. The strongest lines of the X-ray powder diffraction pattern [d Å (P); hkl] are: 2.531 (100; 200), 1.905 (90; 227), 2.718 (63; 117), 3.013 (57; 131), 2.991 (56; 116), 3.636 (52; 114), 2.832 (51; 133), 2.699 (46; 134). Fluorchegemite is orthorhombic, space group $Pbnm$, $a = 5.0620(1)$, $b = 11.3917(2)$, $c = 23.5180(3)$ Å, $V = 1356.16(4)$ Å³, $Z = 4$. The crystal structure of fluorchegemite was refined on the basis of that of chegemite to $R_1 = 3.98\%$. Crystal structure of fluorchegemite consists of a framework composed of zigzag chains of four $[\text{Ca}(\text{O},\text{F},\text{OH})_6]$ octahedra linked by two types of isolated SiO_4 tetrahedra. The mineral is named as a fluorine analog of chegemite $\text{Ca}_7(\text{SiO}_4)_3(\text{OH})_2$. The holotype is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

FLUOR-TSILAISITE*

F. Bosi, G.B. Andreozzi, G. Agrosi, and E. Scandale (2015) Fluor-tsilaisite, $\text{NaMn}_3\text{Al}_6(\text{Si}_6\text{O}_{18})(\text{BO}_3)_3(\text{OH})_3\text{F}$, a new tourmaline from San Piero in Campo (Elba, Italy) and new data on tsilaisitic tourmaline from the holotype specimen locality. *Mineralogical Magazine*, 79, 89–101.

Fluor-tsilaisite (IMA 2012-044), ideally $\text{NaMn}_3\text{Al}_6(\text{Si}_6\text{O}_{18})(\text{BO}_3)_3(\text{OH})_3\text{F}$, is a new mineral found at Grotta d'oggi, San Piero in Campo, Elba Island, Italy. The mineral occurs in an aplitic dike of a LCT-type pegmatite in association with quartz, K-feldspar, plagioclase,

elbaite, schorl, fluor-elbaite, and tsilaisite. The holotype crystal is a color-zoned tourmaline ~ 9 mm long and 60 mm² in basal section with a morphology that consists of elongated {100} and {110} prisms with striated faces, terminated by a prominent {001} pedion and small, minor {101} pyramidal faces. Fluor-tsilaisite is greenish yellow with white streak and a vitreous luster. It is brittle with an imperfect cleavage on {101} and {110}, {001} parting and sub-conchoidal fracture. The Mohs hardness is ~ 7 . The density was not measured; $D_{\text{calc}} = 3.134 \text{ g/cm}^3$. In transmitted light, fluor-tsilaisite is pleochroic with $O = \text{pale greenish yellow} > E = \text{very pale greenish yellow}$. Fluor-tsilaisite is uniaxial (–) with $\omega = 1.645(5)$, $\epsilon = 1.625(5)$ (white light). The mineral shows no fluorescence in UV light. The average of 10 electron probe WDS analyses is [wt% (St.dev.)]: SiO_2 36.65(14), TiO_2 0.33(8), B_2O_3 10.44 (by stoichiometry), Al_2O_3 35.92(16), MnO 11.63(20), FeO 0.19(6), CaO 0.08(2), Na_2O 1.92(4), K_2O 0.02(1), Li_2O 0.46 (by stoichiometry), F 0.66(9), H_2O 2.97 (by structure refinement), $-\text{O}=\text{F}$ 0.28, total 100.00. This gives the empirical formula $^{3}(\text{Na}_{0.69}\text{Ca}_{0.02})_{\Sigma 1.00}^{+}{}^{2}(\text{Mn}_{1.29}\text{Al}_{1.21}\text{Li}_{0.56}\text{Ti}_{0.03})_{\Sigma 6.00}^{2+}{}^{2}\text{Al}_6^{+}(\text{Si}_{5.98}\text{Al}_{0.03})_{\Sigma 6.01}\text{B}_{2.92}\text{O}_{27}\text{V}(\text{OH})_3^{+}[\text{F}_{0.39}(\text{OH})_{0.25}\text{O}_{0.36}]_{\Sigma 1.00}$. Mn and Fe were considered as divalent cations. Not enough material was available for powder-diffraction measurements, and the calculated spectrum was judged unsuitable for diagnostic identification of the mineral and was therefore not given. Single-crystal X-ray diffraction data collected on a crystal of size 0.20×0.22×0.26 mm refined to $R_1 = 0.036$ for 3496 unique reflections shows fluor-tsilaisite is rhombohedral, space group $R\bar{3}m$, $a = 15.9398(6)$, $c = 7.1363(3)$ Å, $V = 1570.25$ Å³, $Z = 3$. Fluor-tsilaisite is related to tsilaisite through the substitution ${}^{\text{VI}}\text{F} \leftrightarrow {}^{\text{VI}}(\text{OH})$ and with fluor-elbaite through the substitution ${}^{\text{VI}}(\text{Al} + \text{Li}) \leftrightarrow 2{}^{\text{VI}}\text{Mn}^{2+}$. The new mineral appears to be a stepwise intermediate during tourmaline evolution from tsilaisite to fluor-elbaite. The name is derived from the tsilaisite root of the tourmaline supergroup. The holotype of fluor-tsilaisite is deposited in the “Museo di Scienze della Terra, settore Mineralogico Petrografico Carlo Lorenzo Garavelli”, Università di Bari, Bari, Italy. **O.C.G.**

GATEDALITE*

U. Hälenius and F. Bosi (2015) Gatedalite, $\text{Zr}(\text{Mn}^{2+}\text{Mn}_4^{3+})\text{SiO}_{12}$, a new mineral species of the braunite group from Långban, Sweden. *Mineralogical Magazine*, 79, 625–634.

Gatedalite (IMA 2013-091), ideally $\text{Zr}(\text{Mn}^{2+}\text{Mn}_4^{3+})\text{SiO}_{12}$, is a new mineral found at the Långban Mn-Fe oxide deposit, Värmland, central Sweden. It is found in hausmannite-impregnated skarn with jacobsonite, Mn-calcite, tephroite, Mn-phlogopite, långbanite, pinakiolite, and oxyplumboroméite. The mineral occurs as irregularly rounded anhedral grains up to 60 μm . Gatedalite is gray and opaque with submetallic luster, shows no cleavage or parting, and is brittle. The hardness and density could not be determined due to small grain size and extreme scarcity of material; $D_{\text{calc}} = 4.783 \text{ g/cm}^3$. The mineral shows very weak anisotropy and birefractance and no pleochroism. Reflectance values for COM wavelengths [R_{min} , R_{max} % (nm)] are: 20.0, 19.1 (470); 19.1, 18.1 (546); 18.9, 18.0 (589); 18.7, 17.4 (650). The average of 4 electron probe WDS analyses is [wt% (range)]: SiO_2 9.82 (9.53–10.10), ZrO_2 9.97 (9.44–11.10), Al_2O_3 0.05 (0.05–0.06), Mn_2O_3 57.90 (56.31–59.26), Fe_2O_3 7.81 (7.35–8.28), Ce_2O_3 0.28 (0.16–0.37), MgO 3.20 (2.99–3.52), CaO 0.16 (0.14–0.20), MnO 11.34 (10.67–11.90), ZnO 0.13 (0.00–0.19), Na_2O 0.01 (0.00–0.02), total 100.68. This gives the empirical formula $(\text{Zr}_{1.49}\text{Mn}_{0.47}\text{Ca}_{0.02}\text{Zr}_{0.01}\text{Ce}_{0.01})_{\Sigma 1.00}^{4+}(\text{Mn}_{3.44}\text{Fe}_{0.59}\text{Mn}_{0.50}\text{Mg}_{0.48}\text{Al}_{0.01})_{\Sigma 6.02}\text{Si}_6\text{O}_{12}$ based on 12 O apfu. The analyzed Mn content was split into Mn_2O_3 and MnO on the basis of electro neutrality and 12 O apfu. Not enough material was available to measure powder XRD data; the strongest lines in the calculated X-ray powder-diffraction pattern [d_{calc} (Å) ($I_{\text{calc}}\%$); hkl] are: 2.730 (100; 224), 2.367 (12; 040), 1.6735 (12; 440), 1.6707 (29; 048), 1.4267 (16; 264). Single-crystal X-ray diffraction data collected on a crystal of size 0.04×0.04×0.06 mm refined to $R_1 = 0.0509$ for 1339

unique reflections shows gatedralite is tetragonal, space group $I4_1/acd$, with the unit-cell parameters $a = 9.4668(6)$ Å, $c = 18.8701(14)$ Å, $V = 1691.1$ Å³, and $Z = 8$. Gatedralite is a member of the braunite group (general formula AB_6SiO_{12}) and is related to braunite via $(Zr^{4+} + Mn^{2+}) \rightarrow 2Mn^{3+}$ substitution. The mineral is named in honor of amateur mineralogist Kjell Gatedal (b. 1947) from Nora, Örebro, Sweden, for his contributions to the mineralogy of Långban-type deposits. The holotype specimen of gatedralite is deposited in the Swedish Museum of Natural History, Stockholm, Sweden. **O.C.G.**

KONONOVITE*

I.V. Pekov, M.G. Krzhizhanovskaya, V.O. Yapaskurt, D.I. Belakovskiy, N.V. Chukanov, I.S. Lykova, and E.G. Sidorov (2015) Kononovite, $NaMg(SO_4)F$, a new mineral from the Arsenatnaya fumarole, Tolbachik volcano, Kamchatka, Russia. *European Journal of Mineralogy*, 27, 575–580.

Kononovite, (IMA 2013-116), ideally $NaMg(SO_4)F$ is a new sulfate member of the durangite group from the Arsenatnaya fumarole at the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. Kononovite found in a single specimen in close association with langbeinite, hematite, anglesite, and euchlorine. Temperatures measured immediately after uncovering of the fumarole camera containing kononovite vary from 360 to 390 °C. Admixed uklonskovite is a product of the kononovite supergene alteration. The new mineral occurs as prismatic to thick tabular crystals up to $0.04 \times 0.06 \times 0.1$ mm, isolated or, more typically, forming clusters or interrupted crusts up to several square centimeters in area and up to 0.05 mm thick overgrowing basalt scoria. Kononovite is white, transparent in tiny grains and translucent in blocky crystals. It has white streak and vitreous luster. Kononovite is brittle but with signs of weak plasticity. Mohs hardness is ~3. The fracture is uneven. $D_{meas} = 2.91(1)$ g/cm³ (by flotation in heavy liquids), $D_{calc} = 2.945$ g/cm³. The mineral is non-fluorescent under UV light or an electron beam. In plane-polarized light kononovite is colorless, nonpleochroic. It is optically biaxial (+), $\alpha = 1.488(2)$, $\beta = 1.491(2)$, $\gamma = 1.496(2)$ (589 nm), $2V_{meas} = 75(5)^\circ$, and $2V_{calc} = 76^\circ$. The IR spectrum of kononovite shows absorption bands (cm⁻¹, w = weak band, s = strong band, sh = shoulder) at 2132w (combination mode of symmetric and asymmetric vibrations of SO_4^{2-} anions), 1133s [$\nu_3(F_2)$ = asymmetric stretching vibrations of SO_4^{2-} anions], 1010 [$\nu_1(A_1)$ = symmetric stretching vibrations of SO_4^{2-} anions], 635s, 612s [$\nu_2(F_2)$ = bending vibrations of SO_4^{2-} anions], 544, 505w, 461 (lattice modes involving $Mg \cdots O$ and $Mg \cdots F$ stretching vibrations). Bands corresponding to NH_4^+ , CO_3^{2-} and NO_3^- groups (the range 1300–1500 cm⁻¹) were not observed. The average of 4 electron probe WDS analyses is [wt% (range)]: Na₂O 18.68 (17.82–19.18), K₂O 0.14 (0.00–0.31), MgO 24.77 (24.03–25.43), ZnO 0.28 (0.00–0.65), PbO 0.10 (0.00–0.41), SO₃ 48.44 (47.40–49.14), F 11.82 (11.45–12.01), Cl 0.12 (0.00–0.49), $-O=(F,Cl)_2$ 5.00, total 99.35. The empirical formula calculated on the basis of 5 (O+F) pfu is: $Na_{0.99}K_{0.01}Mg_{1.01}Zn_{0.01}S_{0.99}O_{3.97}F_{1.02}Cl_{0.01}$. The strongest X-ray powder diffraction lines [d Å (%; hkl)] are: 4.766 (38; $\bar{1}11$), 3.567 (33; 021), 3.233 (82; $\bar{1}12$), 3.210 (55; 002), 3.041 (100; 200), 2.589 (53; 130), 2.571 (38; 022), 2.269 (33; 131). The monoclinic unit-cell parameters refined from the powder data are: $a = 6.662(2)$, $b = 8.584(3)$, $c = 7.035(2)$ Å, $\beta = 114.06(3)^\circ$, $V = 367.4$ Å³, $Z = 4$. Kononovite is isostructural with fluoro(hydroxyl) phosphates and fluorarsenates of the durangite group: isokite $CaMg(PO_4)F$, lacroixite $NaAl(PO_4)F$, panasqueiraitite $Ca(Mg,Fe)(PO_4)(OH,F)$, durangite $NaAl(AsO_4)F$, maxwellite $NaFe^{3+}(AsO_4)F$, and tilasite $CaMg(AsO_4)F$. The name kononovite (Cyrillic: кононовит) honors the Russian mineralogist Oleg Vasil'evich Kononov (b. 1932), a specialist in general and technological mineralogy, teacher of mineralogy at Lomonosov Moscow State University for more than 50 years. The holotype is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **F.C.**

MENDIGITE*

N.V. Chukanov, S.M. Aksenov, R.K. Rastsvetaeva, K.V. Van, D.I. Belakovskiy, I.V. Pekov, V.V. Gurzhiy, W. Schüller, and B. Ternes (2015) Mendigite, $Mn_2Mn_2MnCa(Si_3O_9)_2$, a new mineral species of the bustamite group from the Eifel Volcanic Region, Germany. *Zapiski Rossiiskogo Mineralogicheskogo Obshchestva*, 144, 48–60 (in Russian, English abstract); *Geology of Ore Deposits*, 57, 721–731 (in English).

Mendigite (IMA 2014-007), ideally $Mn_2Mn_2MnCa(Si_3O_9)_2$, is a new mineral discovered in the In den Dellen near Mendig, Laacher Lake area, Eifel Mountains, Rhineland-Palatinate (Rheinland-Pfalz), Germany. The new mineral was found in sanidinite in the operating pumice quarry in association with sanidine, nosean, rhodonite, tephroite, magnetite, and a pyrochlore-group mineral. Mendigite forms imperfect long-prismatic crystals up to $0.1 \times 0.2 \times 2.5$ mm in size, flattened on {001}; occasionally crystals form polysynthetic twins parallel to (100). The mineral is dark brown, has a brown streak, vitreous luster, perfect cleavage on {001}; $D_{calc} = 3.56$ g/cm³. Mendigite is biaxial (–), with $\beta = 1.782(5)$, $\gamma = 1.796(5)$ (589 nm), $2V_{obs} = 50(10)^\circ$; α was not measured due to a perfect cleavage, but was estimated to be 1.722 based on β , γ , and $2V$ values. Dispersion of optical axis is medium, $r > v$. Mendigite is non-pleochroic, with extinction angle of about 4–5° relative to [100]. The bands in IR spectrum (cm⁻¹, s = strong, sh = shoulder) are: 1088s, 1030s, 945s, 907s (Si-O stretching vibrations); 694, 655, 564 (O-Si-O bending vibrations); 515, 461s, 445, 425sh (lattice modes involving Si-O-Si bending and $M \cdots O$ stretching vibrations, where $M = Mn, Fe, Ca$). The average of 4 electron probe EDS analyses [wt%, (range)] is: SiO₂ 43.80 (43.24–44.54), Al₂O₃ 1.08 (0.87–1.28), Fe₂O₃ 4.42 (4.15–4.70), Mn₂O₃ 2.91, MnO 37.47 (39.37–40.80, for total Mn calculated as MnO), CaO 10.78 (10.11–10.92), MgO 0.36 (0.25–0.49), total 100.82. The amount of Mn₂O₃ was calculated taking into account structural data and charge balance. The formula calculated on the basis of 12 (Mg+Ca+Mn+Al+Fe+Si) cations pfu is: $(Ca_{1.47}Mn_{4.03}Mg_{0.07}Mn_{0.28}Fe_{0.15}Fe_{0.27}Al_{0.16})_{\Sigma 6.00}O_{18}$. The strongest lines of the X-ray powder diffraction pattern [d Å (%; hkl)] are: 3.72 (32; 020), 3.40 (20; 002,021), 3.199 (25; 012), 3.000 (26; $01\bar{2}, 1\bar{2}0$), 2.885 (100; $221, 2\bar{1}1, 1\bar{2}\bar{1}$), 2.691 (21; $222, 2\bar{1}0$), 2.397 (21; $02\bar{2}, 21\bar{1}, 203, 031$), 1.774 (37; 412, $3\bar{2}1$). The crystal structure of mendigite was determined with the “charge flipping” procedure and refined to $R_1 = 5.59\%$. The mineral is triclinic, $P\bar{1}$, $a = 7.0993(4)$, $b = 7.6370(5)$, $c = 7.7037(4)$ Å, $\alpha = 79.58(1)^\circ$, $\beta = 62.62(1)^\circ$, $\gamma = 76.47(1)^\circ$, $V = 359.29(4)$ Å³, $Z = 1$. Mendigite is isostructural with bustamite and ferrobustamite. The crystal structure of mendigite is formed by bands of M polyhedra that are three-polyhedra wide, and wollastonite-type chains of SiO₄ tetrahedra. Each band of M polyhedra is linked to two chains of SiO₄ tetrahedra on both sides of the band. The type specimen is deposited in the Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

NABIMUSAITE*

E.V. Galuskin, F. Gfeller, T. Armbruster, I.O. Galuskina, Y. Vapnik, M. Murashko, R. Włodyka, and P. Dzierzanowski (2015) New minerals with a modular structure derived from hatrurite from the pyrometamorphic Hatrurim Complex. Part I. Nabimusaite, $KCa_{12}(SiO_4)_4(SO_4)_2O_2F$, from larnite rocks of Jabel Harmun, Palestinian Autonomy, Israel. *Mineralogical Magazine*, 79, 1061–1072.

Nabimusaite (IMA 2012-057), ideally $KCa_{12}(SiO_4)_4(SO_4)_2O_2F$, has been discovered in pyrometamorphic rocks of the Hatrurim Complex (“Mottled zone”) on Jabel (Mount) Harmun near the village Nabi Musa, Judea Desert, West Bank, Palestinian Autonomy. Later this mineral was found as a rock-forming component at many locations of larnite pyrometamorphic rocks of the Hatrurim Complex in the Judean Mountains (Ma’ale-Adumim and Nahal Darga localities) and in the Negev Desert (Har Parsa Mountain), Israel. Nabimusaite formation related to a high-temperature syn-pyrometamorphic alteration of primary ye’elimite-larnite rocks during combustion events as a result of the reaction of potassium-enriched, sulfate-bearing melt with larnite

and ellestadite. The new mineral occurs in larnite-ye'elimite nodules locally termed "pseudo-conglomerates." Other associated minerals are brownmillerite, P-fluorellestadite, fluormayenite-fluorkyuygenite, and less commonly gehlenite, ternesite, jasmundite, periclase, oldhamite, covellite, dzierzanowskite, shulamitite, magnesioferrite, and spinel. Nabimusaiate is usually developed after fluorellestadite, but also replaces larnite. Along the rims, nabimusaiate grains are substituted by a mixture of uncharacterized Ca hydrosilicates, minerals of the ettringite group and barite. Nabimusaiate forms xenomorphic, poikilitic crystals generally 0.1–0.2 mm, rarely up to 0.5 mm, filled with inclusions of larnite and ye'elimite. The mineral is colorless, transparent with a white streak and a vitreous luster. No fluorescence in UV light was observed. It is brittle and has pronounced parting and imperfect cleavage on {001}. The micro-indentation hardness $VHN_{50} = 420$ (370–500) kg/mm² corresponds to ~5 of Mohs scale. Density was not measured due to numerous inclusions in the grains; $D_{\text{calc}} = 3.119$ g/cm³. Nabimusaiate is uniaxial (–), $\omega = 1.644(2)$, $\epsilon = 1.640(2)$ (589 nm), nonpleochroic. The main bands in the Raman spectrum (cm⁻¹) are: 129 (Ba–O vibration); 403 (ν_2 SiO₄⁺); 463 (ν_2 SO₄²⁻); 524 and 563 (ν_4 SiO₄⁺); 637 (ν_4 SO₄²⁻); 831, 849, and 885 (ν_1 SiO₄⁺); 930 and 948 (ν_2 SiO₄⁺); 993 (ν_1 SO₄²⁻); 1121 (ν_3 SO₄²⁻). The average of 24 electron probe WDS analysis of the holotype sample [wt% (range)] is: SO₃ 13.85 (12.59–14.70), V₂O₅ <0.07, P₂O₅ 1.80 (1.51–2.21), TiO₂ 0.10 (0.04–0.21), SiO₂ 18.44 (17.93–18.85), Al₂O₃ 0.34 (0.25–0.48), BaO 3.60 (2.01–4.91), SrO 0.21 (0.13–0.29), Fe₂O₃ 0.13 (0–0.28), CaO 57.95 (56.39–59.21), MgO 0.10 (0.06–0.13), ZnO <0.06, K₂O 2.52 (2.05–3.02), Na₂O 0.14 (0.08–0.20), F 1.05 (0.53–1.54), –O=F₂ 0.44, total 99.79. The empirical formula calculated on the basis of (O+F) = 27 apfu is: (K_{0.62}Ba_{0.27}Na_{0.05}Mg_{0.03}Sr_{0.02})_{20.99}Ca_{11.98}(Si_{3.56}P_{0.29}Al_{0.08}Fe_{0.02}Ti_{0.01})_{23.96}

S_{2.01}O_{26.36}F_{0.64}. Nabimusaiate is characterized by a variable chemical composition. Some spots in nabimusaiate grains are enriched with Ba up to composition (Ba_{0.55}K_{0.38}Na_{0.05}Mg_{0.03})_{21.01}Ca_{11.97}(Si_{3.54}P_{0.23}Al_{0.17}Fe_{0.02}Ti_{0.04})₂₄(S_{1.87}P_{0.14})_{22.01}O_{26.52}F_{0.48}, which is a potentially new mineral—Ba analog of nabimusaiate (currently approved by IMA CNMNC as dargaite D.B.). Due to difficulties in the selection of uncontaminated grains the powder X-ray diffraction data have been calculated from the refined crystal structure. The strongest X-ray calculated powder diffraction lines [d_{calc} Å (I_{calc} %; hkl)] are: 3.595 (52; 110), 3.105 (97; 021), 2.829 (71; 119), 2.753 (97; 027), 2.750 (89; 0.0.15), 2.140 (50; 2.0.14), 1.986 (46; 0.2.16), 1.798 (100; 220). The crystal structure has been solved and refined to $R_1 = 0.0416$ for 547 $I > 2\sigma I$ unique reflections. The mineral is trigonal, space group $R\bar{3}m$, $a = 7.1905(4)$, $c = 41.251(3)$ Å, $V = 1847.1$ Å³, $Z = 3$. The nabimusaiate structure is a representative of the intercalated antiperovskite type. It may be derived from the structure of hatrurite, also known as the clinker phase "alite" (Ca₃SiO₅). Both structures are characterized by triplets of face-sharing, antiperovskite type anion-centred [(O,F)Ca₆] octahedra of composition [FO₂Ca₁₂]¹⁹⁺ in nabimusaiate. Compared to hatrurite the antiperovskite modules [FO₂Ca₁₂(SiO₄)₄]³⁺ in nabimusaiate are intercalated with K(SO₄)₂ slices. Tetrahedral tips of SiO₄ tetrahedra between the triplets within the antiperovskite layer in hatrurite all point in the same direction along [001], while in nabimusaiate (as well as in nabimusaiate-group minerals zadovite and aradite) the Si(1) and Si(2) tetrahedra point in opposite directions. The Si(1) sites are fully occupied by Si and P is accumulated at the Si(2) sites. The crystal structure of nabimusaiate corresponds to the synthetic phase KCa₁₂(SiO₄)₄(SO₄)₂O₂F. The mineral is named for its type locality near the village of Nabi Musa. Type material is deposited in the Museum of Natural History of Bern, Switzerland. **D.B.**

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