New Mineral Names*,†

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BUBNOVAITE*

L.A. Gorelova, L.P. Vergasova, S.V. Krivovichev, E.Yu. Avdontseva, S.V. Moskaleva, G.A. Karpov, and S.K. Filatov (2016) Bubnovaite, $K_2Na_8Ca(SO_4)_6$, a new mineral species with modular structure from the Tolbachik volcano, Kamchatka peninsula, Russia. European Journal of Mineralogy, 28(3), 677–686.

Bubnovaite, (IMA 2014-108), ideally $K_2Na_8Ca(SO_4)_6$, is a new mineral found in fumaroles of the 2012–2013 Tolbachik fissure eruption, Kamchatka peninsula, on the new cinder Naboko cone. The samples of bubnovaite were found in a cavity on the NNE flank of the cone at the depth of 30 cm. The temperature of gases at the sampling location was more than 500 °C. The mineral forms fine-grained, light blue, dendritic aggregates, consisting of colorless, transparent, tabular crystals of maximum dimension 0.14 mm, that were recovered with the aid of a long stick and metallic cap to grab samples from the fumarole vent. Bubnovaite is associated with aphthitalite, $(K,Na)_3Na(SO_4)_2$, and thénardite, Na_2SO_4. Crystals of bubnovaite are brittle with a white streak and a vitreous luster. Hardness and density were not measured due to the lack of suitable material. The expected Mohs hardness is 2–3; D_{calc} = 2.656 g/cm³. The mineral is unstable in air and becomes white and non-transparent after several days. The mineral is non-pleochroic, colorless. It is optically uniaxial (–), ω = 1.492(2), ε = 1.489(2) (light source not reported). The average of 7 electron probe WDS analyses [wt% (range)] is: Na_2O 26.99 (25.65–27.94), K_2O 10.99 (10.50–11.45), CaO 4.27 (3.29–5.08), MgO 0.51 (0.38–0.65), CuO 1.21 (0.70–1.71), ZnO 0.81 (0.55–1.24), PbO 1.58 (0.86–2.28), SO_3 54.93 (54.24–55.44), total 101.30. The empirical formula based on 24 O atoms, is $K_{2.05}Na_{7.65}(Ca_{0.67}Mg_{0.11}Cu_{0.13}Zn_{0.09}Pb_{0.06})_{\Sigma1.06}S_{6.03}O_{24}$. IR data was not obtained. The strongest lines in the X-ray powder diffraction pattern are [d Å (I; hkl)]: 3.943 (80; 023), 2.894 (35; 026), 2.868 (62; 033), 2.718 (91; 034), 2.707 (100; 220), 2.647(10; 018), 2.231 (6; 135), 1.970 (21; 046). The unit-cell parameters refined from the powder data are: a = 10.802(4) Å, c = 22.02(1) Å, V = 2226 Å³. Bubnovaite is trigonal, space group P31c. The single crystal unit-cell parameters are: a = 10.804(3), c = 22.011(6) Å, V = 2225.0 Å³, and Z = 4. The crystal structure was refined to R_1 = 0.078 for 1729 observed $[F_o > 4\sigma F_o]$ reflections. It can be described as based upon an **ABACABACABAC** 12-layer superstructure of K, Na, and Ca cations with partially disordered SO_4 tetrahedra. Bubnovaite is closely related to α-K_2SO_4; "metathénardite," Na_2SO_4; aphthitalite, $K_3Na(SO_4)_2$; and hanksite, $Na_{22}K(SO_4)_9(CO_3)_2Cl$.

The mineral is named in honor of Rimma Sergeevna Bubnova, Institute of Silicate Chemistry, Russian Academy of Sciences, Saint-Petersburg State University, St. Petersburg, Russia, for her important contributions to the crystal chemistry of vanadates, silicates, borates, borosilicates and other inorganic oxysalts. Type material is deposited in the Mineralogical Museum, St. Petersburg State University, St. Petersburg, Russia, under the catalogue number 1/19635. **F.C.**

CAIRNCROSSITE*

G. Giester, C.L. Lengauer, H. Pristacz, B. Rieck, D. Topa, and K.-L. Von Bezing (2016) Cairncrossite, a new Ca-Sr (-Na) phyllosilicate from the Wessels Mine, Kalahari Manganese Field, South Africa. European Journal of Mineralogy, 28(2), 495–505.

Cairncrossite (IMA 2013-012), $Sr_2Ca_{7-x}Na_{2x}(Si_4O_{10})_4(OH)_2(H_2O)_{15-x}$, is a new phyllosilicate species found in manganese ore on dumps of the Wessels Mine, Kalahari Manganese Field, South Africa. It was found lining the central cavity of a vug in manganese ore that came from Block 17 of the Wessels Mine. Associated minerals include blue manganoan richterite, minor manganoan sugilite, minor gray to orange lizardite and fibrous pectolite. Cairncrossite crystals form densely packed, radiating platy micaceous aggregates up to 1 cm in size, closely resembling brucite $Mg(OH)_2$. It is the last mineral to have formed during metasomatic alteration of a primary carbonate-rich manganese ore. Cairncrossite is colorless, appearing white, and the crystals are translucent to transparent with a white streak. The luster is vitreous to pearly. Cairncrossite is sectile before brittle fracture, with a Mohs hardness of 3. Cleavage is perfect parallel to (001). D_{meas} = 2.50(3) g/cm³; D_{calc} = 2.489 g/cm³. Cairncrossite is non-pleochroic, optically biaxial (+) with α = 1.518(2), β = 1.522(2), γ = 1.546(2) (λ = 589.3 nm), $2V_{meas}$ = 33.9(6)°, $2V_{calc}$ = 45°; r < v weak; the acute bisectrix Z is about 10° from perpendicular to {001} (**c***). Intense light-blue fluorescence is emitted under short-wave UV light. The Raman spectrum of cairncrossite is similar to that of gyrolite and is characterized by two sharp peaks at 610 (Si–O bending vibration) and 1060 cm⁻¹ (Si–O stretching vibration). The bands observed at 3650 and 3670 cm⁻¹ are assigned to the stretching vibrations of the OH groups, the broad band centered around 3550 cm⁻¹ to stretching vibrations of the H_2O molecules. The average of 14 electron probe WDS analysis [wt% (ranges)] is: Na_2O 3.06 (2.48–3.15), K_2O 0.11 (0.09–0.12), CaO 18.61 (18.17–19.24), SiO_2 54.91 (53.20–55.85), SrO 11.75 (11.25–12.11), total 88.44 (86.32–89.97). The empirical formula based on the 16 Si apfu and H_2O content deduced from observed TGA loss (~15 wt%), is: $Sr_{1.99}K_{0.02}Ca_{5.81}Na_{1.73}Si_{16}O_{55.84}H_{30.33}$. The strongest lines of the Gandolfi X-ray powder diffraction pattern [d Å (I%; hkl)] are: 15.230 (100; 001), 8.290 (15; 1\bar{1}0), 5.080 (25;003), 3.807 (30; 004), 3.045 (20; 005). The refined triclinic unit-cell parameters from these powder data are a =

9.626(1), $b = 9.639(1)$, $c = 15.651(2)$ Å, $\alpha = 100.88(1)$, $\beta = 91.28(1)$, $\gamma = 119.72(2)°$, and $V = 1227.0$ Å^3. The single-crystal unit-cell parameters are: $a = 9.6265(5)$, $b = 9.6391(5)$, $c = 15.6534(10)$ Å, $\alpha = 100.89(1)$, $\beta = 91.27(1)$, $\gamma = 119.73(1)°$ and $V = 1227.08(13)$ Å^3, $Z = 1$, space group $P\bar{1}$. The structure was refined to $R_1 = 0.047$ for 9231 unique, observed $[F_o > 4\sigma F_o]$ reflections. Cairncrossite belongs to the gyrolite and reyerite mineral groups, it is characterized by sheets consisting of edge-sharing CaO$_6$ octahedra, which are corner-linked on both sides to silicate layers built by six-membered rings of silicate tetrahedra. These units are intercalated by layers formed by SrO$_8$ polyhedra, which are arranged in pairs via a common edge, and further bound to disordered NaO$_6$ polyhedra. A complex system of hydrogen bonds strengthens the linkage to adjacent silicate layers. The mineral is named in honor of Bruce Cairncross, Professor and Head of the Department of Geology, University of Johannesburg. He is author of several books and numerous articles on the mineralogy of the Southern African Region with special interest in the Kalahari Manganese Field. He has contributed significantly towards awareness of diversity of the mineralogy in Southern Africa. Holotype material has been deposited in the collections of the Institute for Mineralogy and Crystallography at the University of Vienna (inventory number 13079) and the collection of the Museum of Natural History of Vienna (inventory number N 9858). **F.C.**

FERRAIOLOITE*

S.J. Mills, I.E. Grey, A.R. Kampf, C.M. Macrae, J.B. Smith, C.J. Davidson, and A.M. Glenn (2016) Ferraioloite, MgMn$_4^{2+}$(Fe$_{0.5}^{2+}$Al$_{0.5}^{3+}$)$_4$Zn$_4$ (PO$_4$)$_8$(OH)$_4$(H$_2$O)$_{20}$, a new secondary phosphate mineral from the Foote mine, USA. European Journal of Mineralogy, 28(3), 655–661.

Ferraioloite (IMA 2015-066), ideally MgMn$_4^{2+}$(Fe$_{0.5}^{2+}$Al$_{0.5}^{3+}$)$_4$Zn$_4$(PO$_4$)$_8$ (OH)$_4$(H$_2$O)$_{20}$, is a new secondary phosphate mineral from the Foote Lithium Company mine, Kings Mountain district, Cleveland County, North Carolina, U.S.A. (35°12′40″N, 81°21′20″W), which is the type locality for 12 other minerals (7 of which are also secondary phosphates). It occurs in very small vugs contained in a thin seam of very fine-grained, sugary pegmatite ($\sim$30 × 10 × 20 cm) part of a large, zinc-bearing boulder found on the East dump. Common accessory minerals in the boulder are Mn-bearing fluorapatite, sphalerite, muscovite, and pyrite. Associated secondary minerals in order of abundance are: vivianite, fairfieldite/messelite, phosphophyllite, scholzite/parascholzite, rittmannite, mangangordonite, kingsmountite, kastningite, and metaswitzerite. Ferraioloite crystals occur as very thin greenish gray to lemon yellow plates or blades up to about 0.2 mm in length, but no more than a few micrometers thick. Main observed faces are {010}, {100}, and {011}. Plates often form books or rosettes up to about 0.4 mm across. Crystals are transparent with a vitreous luster, flexible with an irregular fracture, and have perfect cleavage on {100}. Estimated Mohs' hardness is ~2. D_{calc} = 2.59 g/cm^3. Ferraioloite is optically biaxial (–) with $\alpha = 1.575$(calc), $\beta = 1.583(5)$, $\gamma = 1.584$ (white light), $2V_{meas} = 40(5)°$, $2V_{calc} = 40°$; the acute bisectrix Z is about 10° from perpendicular to {001} (**c***). The dispersion is weak ($r > v$). $X \approx \mathbf{a}$, $Y = \mathbf{b}$, $Z \approx \mathbf{c}$ and pleochroism is X, Z = colorless, Y = blue gray; $Y >> X \approx Z$. The average of 10 electron probe WDS analysis [wt% (range)] is: CaO 0.65 (0.51–0.75), MgO 1.09 (0.92–1.23), MnO 16.05 (14.2–19.51), ZnO 18.90 (16.76–20.15), FeO 8.02 (5.71–9.47), Al$_2$O$_3$ 5.58 (5.23–5.99), P$_2$O$_5$ 30.90 (29.52–32.17), H$_2$O (calculated from structure) 21.30, total 102.49. The empirical formula based on 8 P and 56 O apfu is: Ca$_{0.21}$Mg$_{0.50}$Mn$_{4.16}^{2+}$Fe$_{2.05}^{2+}$Al$_{2.01}^{3+}$Zn$_{4.27}$P$_{8.00}$H$_{43.59}$O$_{56}$. The strongest lines of the Gandolfi-like motion powder X-ray diffraction pattern [d Å (I%; hkl)] are: 12.6648 (100; 200), 4.78 (4; $\bar{5}$01), 4.22 (4; 600), 3.580 (4; 204), 3.499 (5; $\bar{5}$12), 3.245 (7; $\bar{4}$04), 2.924 (8; $\bar{7}$03), 2.869 (5; $\bar{3}$05), 2.664 (4; $\bar{1}$23). The parameters of the monoclinic unit cell refined from the powder data are $a = 25.320(6)$, $b = 6.345(6)$, $c = 15.267(6)$ Å, $\beta = 91.031(5)°$, $V = 2452.4$ Å^3. The unit-cell parameters obtained from a single crystal (20 μm × 10 μm × 2 μm) are $a = 25.333(3)$, $b = 6.299(1)$, $c = 15.161(3)$ Å, $\beta = 90.93(3)°$, $V = 2419.0$ Å^3, $Z = 2$, space group $I2/m$. The crystal structure solved and refined to $R_1 = 0.065$ based on 565 unique $I > 3\sigma(I)$ reflections. Ferraioloite has a heteropolyhedral layer structure with layers parallel to (100) and with isolated Mg(H$_2$O)$_6$ octahedra and water molecules packing between the layers. The heteropolyhedral slabs have the same topology as those in the mineral falsterite, Ca$_2$MgMn$_2^{2+}$ (Fe$_{0.5}^{2+}$Fe$_{0.5}^{3+}$)$_4$Zn$_4$(PO$_4$)$_8$(OH)$_4$(H$_2$O)$_{14}$. The H atoms were not located in the structure refinement, but the assignment of OH$^-$ and H$_2$O were inferred from bond-valence calculations. The species is named in honor of the late James (Jim) Anthony Ferraiolo (1947–2014), who worked as scientific assistant at the American Museum of Natural History (AMNH) (1978–1982) and also as transaction coordinator at the Smithsonian Institution's Museum of Natural History (1982–1985). He was best known for his publication A Systematic Classification of Nonsilicate Minerals (Bulletin 172 of the AMNH, 1982). He was also a member of the IMA CNMNC subcommittee for mineral group nomenclature and the subcommittee on unnamed minerals. Two cotype specimens are housed in the collections of Museum Victoria, specimen M53492 and M53493, and two cotype specimens are deposited in the collections of the Natural History Museum of Los Angeles County, catalogue numbers 65593 and 65594. **F.C.**

FONTARNAUITE*

J. Garcia-Veígas, L. Rosell, X. Alcobé, I. Subias, F. Ortí, İ. Gündoğan, and C. Helvaci (2010) Fontarnauite, a new sulphate-borate mineral from the Emet Borate District (Turkey). Revista de la sociedad espanola de mineralogia, Macla, 13, 97–98.

M.A. Cooper, F.C. Hawthorne, J. Garcia-Veígas, X. Alcobé, C. Helvaci, E.S. Grew, and N.A. Ball (2015) Fontarnauite, (Na,K)$_2$(Sr,Ca)(SO$_4$) [B$_5$O$_8$(OH)](H$_2$O)$_2$, a new sulfate-borate mineral from Doganlar (Emet), Kütahya province, Western Anatolia, Turkey. Canadian Mineralogist, 53(5), 803–820.

Fontarnauite (IMA 2009-64a), ideally Na$_2$Sr(SO$_4$)[B$_5$O$_8$(OH)](H$_2$O)$_2$, was discovered in 2009 in drill cores recovered from the borate-bearing Miocene Emet basin in Western Anatolia, Turkey. It occurs in association with probertite, glauberite, and celestine. It was also reported to occur with halite, kaliborite replacing probertite, and kalistronite, replacing fontarnauite in pseudomorphs after glauberite. Among other associated minerals are colemanite, ulexite, dolomite, arsenopyrite, realgar, and orpiment. Fontarnauite forms isolated prismatic crystals, clusters of crystals less than 5 mm long, or less commonly branching aggregates of crystals. The new mineral is colorless to light brown with a white streak and a pearly luster. Fontarnauite is brittle, with a perfect {010} cleavage, a splintery fracture and no parting. It is translucent to transparent. Fontarnauite has a Mohs hardness of 2½–3. Density measured by pycnometry is 2.37 g/cm^3, less than D_{calc} = 2.533 g/cm^3, probably because of inclusions of probertite with the density of 2.15 g/cm^3. No fluorescence was observed. Fontarnauite is optically biaxial (–), $\alpha = 1.517(2)$, $\beta = 1.539(2)$, and $\gamma = 1.543(2)$ (λ 589 nm); $2V_{meas} = 46(1)°$; $2V_{calc} = 46°$. $r > v$ medium to weak. $X \wedge \mathbf{a} = 95.0$ (β obtuse), $Y \parallel \mathbf{b}$, $Z \wedge \mathbf{c} = 81.9°$ (β acute). The Fourier-transform IR spectroscopy identified the following bands in the spectrum of fontarnauite at 25 °C: the broad band with four or more overlapping peaks at 3587, 3531, 3404, and 3208 cm^{-1} corresponding to O–H stretching modes; the peak at 1656 cm^{-1} [δ(H–O–H) bending]; strong peak at 1315–1365 cm^{-1} [asymmetric stretching for triangularly coordinated boron, ν_{as}(^{III}B–O)]; 1136 cm^{-1} [asymmetric stretching in tetrahedrally coordinated boron, ν_{as}(^{IV}B–O); the very strong peak at 989 cm^{-1} (symmetric stretching of the SO$_4^{2-}$ group); the weak peak at 879 cm^{-1} [symmetric stretching for triangularly coordinated boron, ν_s(^{III}B–O)], and the very weak peaks at 862 and 756 cm^{-1} [symmetric stretching for tetrahedrally coordinated boron, ν_s(^{IV}B–O)]. The B–O

frequencies are consistent with the presence of a complex polyanion containing both trigonal planar BO_3 units and BO_4 tetrahedra. Raman spectroscopy identified some features corresponding to the fundamental symmetric stretching vibration of the SO_4^{2-} group; and the two very weak peaks and a low-intensity band (with two peaks) have been identified at 129, 160, and 430–470 cm^{-1}, respectively, corresponding to ^{IV}B–O bending, but the peaks for symmetric stretching of ^{IV}B–O and ^{III}B–O between 740 and 960 cm^{-1} appear to be obscured by intense fluorescence. Thermogravimetric and differential thermal analyses of small cleavage fragments of fontarnauite riddled with probertite and glauberite inclusions gave three endothermic peaks: between 25 and 350, between 450 and 620, and between 720 and 810 °C. The total weight loss at 1000 °C is 14.39%. All H_2O is lost after heating at 650 °C. The total loss in weight attributed to H_2O is 12.1%. The average of 43 electron probe WDS analyses is (wt%, range): B_2O_3 30.77 (29.72–31.59) (B_2O_3 calculated from structure with B = 5 apfu, 38.66 wt%), Na_2O 12.65 (12.16–13.24), K_2O 1.70 (0.87–2.20), CaO 2.26 (1.41–3.69), SrO 18.98 (16.47–20.94), SO_3 17.75 (17.00–18.20), H_2O 10.01 (calculated from structure with OH = 1 and H_2O = 2 apfu), total 102.01. The empirical formula calculated on the basis of 15 O apfu is: $(Na_{1.84}K_{0.16})_{\Sigma2.00}(Sr_{0.82}Ca_{0.18})_{\Sigma1.00}S_{1.00}B_5H_5O_{15}$. The strongest lines of the X-ray powder pattern [d Å (I%; hkl)] are: 11.150 (100; 020), 3.395 (8; 061), 3.339 (20; 042), 3.199 (10; 160,$\bar{1}$42), 3.046 (10; 052), 3.025 (7; 220), 2.750 (10; $\bar{2}$22,142), 2.400 (8; 260), 2.228 (7; 0.10.0,222), 1.924 (7; 311,$\bar{2}$24). Fontarnauite is monoclinic, space group $P2_1/c$, a = 6.458(2), b = 22.299(7), c = 8.571(2) Å, β = 103.047(13)°, V = 1202.5(10) Å^3, Z = 4. The crystal structure of fontarnauite was solved by direct methods and refined to R_1 = 2.9%. Fontarnauite is the eighth borate-sulfate mineral to date. It its crystal structure, two BO_4 tetrahedra and three BO_3 triangles share vertices to form $B_5O_{10}(OH)$ units that link to other $B_5O_{10}(OH)$ units along [100] and [001] to form a $[B_5O_8(OH)]$ sheet that runs parallel to (010). There are H_2O groups, SO_4 tetrahedra, and Na(1) sites within the central cavities of opposing sheets, and the Sr and Na(2) sites occupy the interstices of a given sheet. The region of the structure where opposing cusps of neighboring sheets approach each other is dominated by weaker H-bonding associated with the OH and H_2O groups. The mineral was named after Ramon Fontarnau i Griera, in recognition of his efforts to promote the development of scientific facilities focused on mineral characterization. The holotype specimen is deposited in the Royal Ontario Museum, Toronto, Canada. **Yu.U.**

GRUNDMANNITE*

H.-J. Förster, L. Bindi, and C.J. Stanley (2016) Grundmannite, $CuBiSe_2$, the Se-analog of emplectite, a new mineral from the El Dragón mine, Potosí, Bolivia. European Journal of Mineralogy, 28(2), 467–477.

Grundmannite (IMA 2015-038), ideally $CuBiSe_2$, was discovered in the El Dragón selenide occurrence of the Cordillera Oriental in southwestern Bolivia. Grundmannite is commonly intergrown with watkinsonite and clausthalite. Occasionally it is being in grain-boundary contact with quartz, dolomite, native gold, eldragónite, eskebornite, umangite, klockmannite, Co-rich penroseite, and three unnamed phases of the Cu-Hg-Pb-Bi-Se system. Grundmannite forms sub- to anhedral grains up to 150 μm in size, as well as aggregates of irregularly shaped grains of several hundreds of micrometers across. The new mineral is black, opaque, metallic with a black streak. It is brittle, with irregular fracture, no obvious parting and perfect {001} cleavage. The Mohs hardness is ~2–2½. Density was not measured due to the small crystal size; D_{calc} = 6.582 g/cm^3. In plane-polarized light, grundmannite is weakly bireflectant and weakly pleochroic from cream to light gray. It does not show any internal reflections. In cross-polarized light, grundmannite is distinctly anisotropic, with light-brown to brown rotation tints. The interpolated reflectance values (in air) for grundmannite [R_{min}, R_{max} (nm)] are: 40.7, 42.3 (400); 40.7, 42.6 (420); 40.8, 42.8 (440); 40.9, 43.1 (460); 41.0,

43.6 (480); 41.2, 44.1 (500); 41.5, 44.6 (520); 41.8, 45.0 (540); 41.9, 45.6 (560); 42.0, 45.5 (580); 42.2, 45.8 (600); 42.3, 46.0 (620); 42.5, 46.1 (640); 42.5, 46.3 (660); 42.5, 46.5 (680); 42.5, 46.6 (700). The averaged 19 point WDS electron probe analyses is [wt%, (range)]: Cu 14.88 (14.69–15.05), Hg 0.07 (0.00–0.30), Pb 1.23 (0.99–1.38), Ni 0.05 (0.00–0.22), Bi 44.9 (44.62–45.53), Se 38.92 (38.44–39.33), total 100.05. The empirical formula of grundmannite is $Cu_{0.99}(Bi_{0.91}Pb_{0.02})_{\Sigma0.93}Se_{2.08}$ based on total of 4 apfu The strongest lines of the X-ray powder diffraction pattern are [d Å (I%; hkl)]: 3.4901 (50; 111), 3.3180 (70; 200), 3.2746 (100; 013), 2.4923 (45; 015), and 2.3307 (50; 213). The crystal structure of grundmannite was refined based on the atomic coordinates of the crystal structure of emplectite to R = 2.50%. The new mineral is orthorhombic, $Pnma$, a = 6.6362(5), b = 4.2581(3), c = 15.3691(9) Å, V = 434.29 Å^3, and Z = 4. Grundmannite has a structure topologically identical to that of emplectite, with S positions in emplectite occupied by Se in grundmannite. The structure is based on $BiSe_3$ trigonal pyramids and nearly regular $CuSe_4$ tetrahedra. The mineral was named in the honor of Günter Grundmann (b. 1947), in recognition of his pioneering work on the El Dragón mine. The holotype specimen, which is the section from which the grain used for crystal-structure determination was obtained, is deposited in the collections of the Natural History Museum, London. Cotype material, consisting of a grundmannite-bearing section, is housed within the Mineralogische Staatssammlung München, Museum "Reich der Kristalle," Munich, Germany. **Yu.U.**

KAYROBERTSONITE*

S.J. Mills, I.E. Grey, A.R. Kampf, W.D. Birch, C.M. Macrae, J.B. Smith, and E. Keck (2016) Kayrobertsonite, $MnAl_2(PO_4)_2(OH)_2\cdot6H_2O$, a new phosphate mineral related to nordgauite. European Journal of Mineralogy, 28(3), 649–654.

Kayrobertsonite (IMA 2015-029), ideally orthorhombic $MnAl_2(PO_4)_2(OH)_2\cdot6H_2O$, is a new secondary phosphate mineral from the Hagendorf Süd pegmatite, Hagendorf, Oberpfalz, Bavaria, Germany (49°39′1″N, 12°27′35″E), and the Foote Lithium Company mine, Kings Mountain district, Cleveland County, North Carolina, U.S.A. (35°12′40″N, 81°21′20″W). At Hagendorf, the new mineral was collected by E.K. in 1975–76, between the 60 and 67 m levels of the mine. The specimens consist of fragments of etched, pinkish brown zwieselite–triplite containing irregular cavities up to a few centimeters across. Kayrobertsonite occurs within the cavities along with fluorapatite, nordgauite, whiteite-CaMnMn, members of the jahnsite group, morinite, fluellite, Al-bearing strunzite, and an analog kingsmountite. At the Foote mine, kayrobertsonite was found in a very large spodumene-bearing pegmatite boulder. The mineral occurred in small vugs (< 1 cm^3) in, or adjacent to, highly altered spodumene laths in the pegmatite body, where it was found associated with (in order of decreasing abundance): mangangordonite, variscite, eosphorite, kastningite, paravauxite, beraunite, strengite, strunzite, and cacoxenite. At both localities, kayrobertsonite crystals occur as intergrown masses of snow-white, soft, finely fibrous needles, less than 5 mm in diameter and no more than 100 μm in length, elongated along [001] and flat on {100}. Crystals are translucent with a silky luster, and are somewhat flexible with a splintery fracture. No cleavage was observed. Mohs hardness is estimated to be ~2. D_{meas} = 2.29(3) g/cm^3 (by flotation in sodium polytungstate), D_{calc} = 2.41 g/cm^3. Kayrobertsonite is non-pleochroic, optically biaxial (–), with α = 1.530, β = 1.554, and γ = 1.566 (white light), $2V_{meas}$ = 70.3(5)°, $2V_{calc}$ = 69.6°; $Z \approx$ **c** (length slow). The dispersion of optical axes was not observed. The average of 8 electron probe WDS analyses on the samples from both localities [wt% Foote Mine/*Hagendorff Süd* (ranges not reported)] are: CaO 0.41/*0.74*, MnO 16.11/*15.20*, FeO 0.27/*0.30*, Al_2O_3 22.43/*22.17*, P_2O_5 33.36/*33.11*, F 0.13/*1.88*, O=F –0.05/–*0.79*, H_2O_{calc} [on the basis of $6H_2O+2(OH,H_2O)$ pfu] 29.30/*29.30*, total

101.96/*101.91*. The empirical formulae, with OH adjusted for charge balance are: $Mn_{0.97}Ca_{0.03}Fe_{0.02}Al_{1.87}(PO_4)_2(OH)_{1.62}F_{0.03}(H_2O)_{0.38}\cdot6H_2O$ (Foote mine), $Mn_{0.92}Ca_{0.06}Fe_{0.02}Al_{1.87}(PO_4)_2(OH)_{1.19}F_{0.42}(H_2O)_{0.39}\cdot6H_2O$ (Hagendorf Süd). The strongest lines in the X-ray powder-diffraction pattern (Foote Mine/*Hagendorff Süd*) [*d* (Å) (*I*%; *hkl*)] are: 10.149/*10.047* (100/*100*; 010), 7.700/*7.629* (36/*44*; $\overline{1}10$), 5.011/*5.029* (21/*12*; 011), 3.036/*3.023* (18/*12*; 130), 2.992/*2.952* (23/*10*; $\overline{3}20$), 2.901/*2.891* (25/6; $\overline{1}12$), 2.811/*2.793* (20/5; $\overline{2}02$), 1.987/*1.982* (17/6; 500). The unit-cell parameters refined from powder-diffraction data are $a = 10.060(3)$, $b = 10.167(2)$, $c = 6.108(1)$ Å, $\alpha = 91.79(3)$, $\beta = 99.99(3)$, $\gamma = 98.48(2)°$, $V = 607.5$ Å^3, $Z = 2$. Single-crystal X-ray diffraction data collected on a crystal from Foote Mine of size $15 \times 2 \times 2$ µm refined to $R_1 = 0.071$ for 1639 unique $I \geq 3\sigma(I)$ reflections shows that kayrobertsonite is triclinic, $P\overline{1}$, $a = 10.049(2)$, $b = 10.205(2)$, $c = 6.083(1)$ Å, $\alpha = 91.79(3)$, $\beta = 99.70(3)$, $\gamma = 98.02(3)°$, $V = 607.9$ Å^3, $Z = 2$. The polyhedral framework in kayrobertsonite has the same topology as that in nordgauite, but with replacement of F by OH at the bridging anion sites. The main crystal chemical change from nordgauite to kayrobertsonite is a doubling of the number of water molecules in the [001] channels. The name honors German-American mineral collector Gabriella Kay Robertson (b. 1920) of Los Angeles, California, U.S.A. Since the mid-1950s, Kay has been an ardent and sophisticated mineral collector, specializing in German minerals. Two cotype specimens from the Foote mine and one from Hagendorf are housed in the collections of Museum Victoria, registered numbers M53379, M53380, and M48795, respectively. Two cotype specimens from the Foote mine are housed in the collections of the Natural History Museum of Los Angeles County, registration numbers 65561 and 65562. Specimen M48795 is also one of the cotype specimens of nordgauite. **F.C.**

MAGNESIO-FERRI-FLUORO-HORNBLENDE*

R. Oberti, M. Boiocchi, F.C. Hawthorne, N.A. Ball, and L. Chiappino (2016) Magnesio-ferri-fluoro-hornblende from Portoscuso, Sardinia, Italy: description of a newly approved member of the amphibole supergroup. Mineralogical Magazine, 80(2), 269–275.

Magnesio-ferri-fluoro-hornblende (IMA 2014-091), ideally $^A\square^BCa_2^C(Mg_4Fe^{3+})^T(Si_7Al)O_{22}^WF_2$, is a new member of the amphibole supergroup found along the coast road ~5.5 km northeast of Portoscuso, Cagliari, Sardinia, Italy. It occurs in vugs of volcanic rocks (Seruciignimbrites) in association with tridymite, todorokite, magnetite, and hematite. Magnesio-ferri-fluoro-hornblende forms prismatic crystals up to 3 mm in length with a striations parallel to the elongation common on prism faces. The crystals are dark brown, transparent, with a vitreous luster. The mineral is brittle and shows perfect cleavage on {110}. The density was not measured; $D_{calc} = 3.315$ g/cm^3. No fluorescence was observed. In transmitted light, magnesio-ferri-fluoro-hornblende is pleochroic; Y = dark gray > Z = pale brownish gray > X = pale gray. The mineral is optically biaxial (–), $\alpha = 1.669(2)$, $\beta = 1.676(2)$, $\gamma = 1.678(2)$ ($\lambda = 589.9$ nm); $2V_{meas} = 74(1)°$ and $2V_{calc} = 56°$ (the difference is due to imprecise measurements of β and γ values which are very close); $X \wedge a = 47.6°$ (β obtuse), $Y \parallel b$, $Z \wedge c = 33.4$ (β acute). Electron probe analyses gives [wt% (range)]: SiO$_2$ 45.34 (44.71–46.54), Al$_2$O$_3$ 6.18 (5.99–6.48), TiO$_2$ 1.22 (1.14–1.29), FeO$_{total}$ 20.88 (20.36–22.02), FeO 15.24, Fe$_2$O$_3$ 6.27, MgO 9.71 (9.31–10.15), MnO 0.78 (0.72–0.85), ZnO 0.06 (0.00–0.14), CaO 10.18 (99.43–10.50), Na$_2$O 1.35 (0.71–1.94), K$_2$O 1.15 (1.04–1.19), F 3.22 (2.80-3.61), Cl 0.30 (0.26–0.35), H$_2$O [calc. on the basis of 24 (O,OH,F,Cl) with (OH+F+Cl) = 2 apfu] 0.37, total 99.95. The FeO/Fe$_2$O$_3$ ratio was calculated from single-crystal structure-refinement results. This gives the empirical formula $(Na_{0.15}K_{0.22})_{\Sigma0.37}(Na_{0.25}Ca_{1.66}Mn_{0.09})_{\Sigma2.00}(Mg_{2.20}Fe^{2+}_{1.94}Mn_{0.01}Zn_{0.01}Fe^{3+}_{0.72}Ti_{0.13})_{\Sigma5.01}(Al_{1.11}Si_{6.89})_{\Sigma8.00}O_{22}[F_{1.55}(OH)_{0.37}Cl_{0.08})_{\Sigma2.00}$ based on 24 anions and W(OH+F+Cl) = 2 apfu. The strongest lines in the X-ray powder-diffraction pattern [*d* Å (*I*%; *hkl*)] are: 2.711 (100; 151), 8.412 (89; 110), 3.121 (64; 310), 2.553 (61; $\overline{2}02$), 3.389 (55; 131), 2.599

(45; 061), 2.164 (36; 261), 2.738 (34; $\overline{3}31$). Single-crystal X-ray diffraction data collected on a crystal of size $0.30 \times 0.15 \times 0.55$ mm refined to $R_1 = 0.023$ for 1013 unique $I \geq 3\sigma(I)$ reflections shows magnesio-ferri-fluoro-hornblende is monoclinic, space group $C2/m$, $a = 9.839(5)$, $b = 18.078(9)$, $c = 5.319(3)$ Å, $\beta = 104.99(3)°$, $V = 913.9$ Å^3, $Z = 2$. The new mineral was named according to the new rules for amphibole classification and nomenclature (Hawthorne et al. 2012). The holotype sample has been deposited at the Mineralogical Museum of the Department of Earth and Environmental Sciences of the University of Pavia, Italy. **O.C.G.**

Reference cited

Hawthorne, F.C., Oberti, R., Harlow, G.E., Maresch,W.V., Martin, R.F., Schumacher, J.C., and Welch, M.D. (2012) Nomenclature of the amphibole supergroup. American Mineralogist, 97, 2031–2048.

MELANARSITE*

I.V. Pekov, N.V. Zubkova, V.O. Yapaskurt, Y.S. Polekhovskiy, M.F. Vigasina, D.I. Belakovskiy, S.N. Britvin, E.G. Sidorov, and D.Y. Pushcharovsky (2016) New arsenate minerals from the Arsenatnaya fumarole, Tolbachik volcano, Kamchatka, Russia. VI. Melanarsite, $K_3Cu_7Fe^{3+}O_4(AsO_4)_4$. Mineralogical Magazine, 80(5), 855–867.

Melanarsite (IMA 2014-048), ideally $K_3Cu_7Fe^{3+}O_4(AsO_4)_4$, was discovered in the Arsenatnaya fumarole at the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, the Tolbachik Volcano, Kamchatka, Russia. Melanarsite occurs in association with dmisokolovite, shchurovskite, bradaczekite, hematite, As-bearing orthoclase, johillerite, arsmirandite, aphthitalite, tenorite, langbeinite, anhydrite, tilasite, and fluorophlogopite. Occasionally, melanarsite occurs with haterite or pharmazincite. The new mineral forms well-shaped, coarse crystals up to 0.2 mm, rarely up to 0.4 mm in size. These crystals occur either individually or are combined in dense or open-work clusters up to 1 mm across, rarely forming incrustations up to 1×1 cm in area and up to 0.2 mm thick covering the basalt scoria. The crystals are tabular to prismatic, and usually have a skeletal or blocky character. Melanarsite has black color, a strong vitreous luster and a dark green streak. The mineral is megascopically opaque, in very thin sections it is translucent and dark green, and is brittle. No cleavage or parting was observed; the fracture is uneven. Mohs hardness is ~4. Density was not measured due to the small size of crystals; $D_{calc} = 4.386$ g/cm^3. Melanarsite is optically biaxial (+), $\alpha = 1.80(1)$, β was not measured, and $\gamma = 1.91(1)$ (589 nm); $2V$ was not measured. Dispersion of the optical axes was not observed. Pleochroism, where observed in very thin particles, is strong: Z (very dark grayish-green) > X (green to pale green). Raman spectrum of melanarsite shows strong bands in the range 770 to 870 cm^{-1} (As^{5+}–O stretching vibrations of AsO$_4^{3-}$ anions), bands with frequencies lower than 650 cm^{-1} (bending vibrations in AsO$_4$ tetrahedra, Cu^{2+}–O stretching vibrations and lattice modes), a band at 632 cm^{-1} (assigned as a Cu–O stretching mode), and a strong band at 352 cm^{-1} (an O–As–O bending mode). The absence of bands with frequencies higher than 1000 cm^{-1} indicates the absence of groups with O–H, C–H, C–O, N–H, N–O, and B–O bonds in the mineral. The averaged 7 point WDS electron probe analyses is [wt%, (range)]: K$_2$O 10.70 (10.40–10.91), CaO 0.03 (0.00–0.10), CuO 45.11 (44.51–46.25), ZnO 0.24 (0.00–0.55), Al$_2$O$_3$ 0.32 (0.00–1.36), Fe$_2$O$_3$ 6.11 (5.49–7.07), TiO$_2$ 0.12 (0.00–0.47), P$_2$O$_5$ 0.07 (0.00–0.25), As$_2$O$_5$ 36.86 (35.94–37.77), total 99.56. The empirical formula is $(K_{2.81}Ca_{0.01})_{\Sigma2.82}(Cu_{7.02}Fe^{3+}_{0.95}Al_{0.08}Zn_{0.04}Ti_{0.02})_{\Sigma8.11}(As_{3.97}P_{0.01})_{\Sigma3.98}O_{20}$ based on O = 20 apfu. The strongest lines of the powder X-ray diffraction pattern are [*d* Å (*I*%; *hkl*)]: 9.22 (100; 110), 7.59 (35; $\overline{1}11$), 6.084 (17; 111), 4.595 (26; $\overline{1}31,220,\overline{2}21$), 3.124 (22; $\overline{3}31,\overline{1}51$), 2.763 (20; 400,$\overline{1}52$), 2.570 (23; 043), 2.473 (16; 260,$\overline{2}61,350$). The crystal structure of melanarsite was solved by direct methods and refined to $R = 9.1$%. The new mineral is monoclinic, $C2/c$, $a = 11.4763(9)$, $b = 16.620(2)$, $c = 10.1322(8)$ Å, $\beta = 105.078(9)°$,

V = 1866.0 Å^3, and Z = 4. Melanarsite has a unique crystal structure that is based on heteropolyhedral pseudo-framework built by distorted Cu(1–3)O$_6$ and (Fe,Cu)O$_6$ octahedra and As(1–3)O$_4$ tetrahedra. All Cu-centred octahedra, including (Fe,Cu)-centered ones, are characterized by Jahn-Teller distortion. Potassium cations are located in the tunnels and voids of the pseudo-framework occupying eight- and sevenfold polyhedra. The new mineral (Cyrillic: Меланарсит) was named after its black color (Greek μέλαν, black) and after that fact that it is an arsenate. The type specimen is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

NICKELTSUMCORITE*

I.V. Pekov, N.V. Chukanov, D.A. Varlamov, D.I. Belakovskiy, A.G. Turchkova, P. Voudouris, A. Katerinopoulos, and A. Magganas (2016) Nickeltsumcorite, Pb(Ni,Fe^{3+})$_2$(AsO$_4$)$_2$(H$_2$O,OH)$_2$, a new tsumcorite-group mineral from Lavrion, Greece. Mineralogical Magazine, 80(2), 337–346.

Nickeltsumcorite (IMA 2013-117), Pb(Ni,Fe^{3+})$_2$(AsO$_4$)$_2$(H$_2$O,OH)$_2$, is a new mineral found in dumps from the old Km-3 mine in the Lavrion m ining district, Attikí Prefecture, Greece. The dump material originates from the oxidation zone of a hydrothermal orebody containing gersdorffite and galena in association with annabergite, nickellotharmeyerite, nickelaustinite, gaspéite, calcite, dolomite, aragonite, quartz, goethite, cerussite, arseniosiderite, mimetite, oxyplumboroméite, and Mn oxides/hydroxides. Nickeltsumcorite occurs as open-work aggregates of coarse radial spherulites or dense concentric nodules (up to 0.05 mm, rarely 0.15 mm, in diameter) and interrupted crusts up to 3 mm × 5 mm in area and up to 0.2 mm thick. Bunches or hemispherical clusters of crude individuals and separate imperfect, elongated crystals up to 0.02 mm in length are also observed. The new mineral is yellow, brownish-yellow, light brown or brown with yellow streak, transparent in tiny individuals and translucent in aggregates, has vitreous luster, is brittle, has one direction of distinct cleavage on {001}, uneven fracture and Mohs hardness of ~4. Density was not measured because of the paucity of pure material; D_{calc} = 5.02 g/cm^3. In transmitted light nickeltsumcorite is yellowish-brown, non-pleochroic. It is optically biaxial (–), α = 1.82(2), β = 1.87(1), γ = 1.90(1) (589 nm), $2V_{obs}$ is large, $2V_{calc}$ = 74°. No optical axes dispersion was observed. The main absorption bands of the IR spectrum (cm^{-1}, s = strong, w = weak, sh = shoulder) are: 3610w, 3244, 2800sh (O–H-stretching vibrations), 1944w (O–H-stretching vibrations of acidic OH-groups), 1645 (H–O–H bending vibrations of H$_2$O molecules), 1080w, 1020w (presumably Fe$^{3+}\cdots$O–H bending vibrations), 870 sh, 812 s, 802 s (asymmetric As–O stretching vibrations of AsO$_4^{3-}$ anions), 680sh, 578w, 464s, 425, 400sh [lattice modes possibly involving (Ni,Fe^{3+})$\cdots$O stretching vibrations and librational modes of H$_2$O molecules]. The average of 6 electron probe WDS analyses is [wt% (range)]: CaO 2.79 (2.02–4.54), PbO 28.12 (23.47–30.74), MgO 0.30 (0.00–0.79), CoO 0.15 (0.00–0.37), NiO 17.39 (14.22–20.03), ZnO 0.76 (0.32–1.32), Mn$_2$O$_3$ 0.57 (0.34–1.05), Fe$_2$O$_3$ 6.83 (4.34–9.86), As$_2$O$_5$ 38.17 (37.24–39.19), H$_2$O (by difference) 4.92, total 100.00. This gives the empirical formula (Pb$_{0.76}$Ca$_{0.30}$)$_{\Sigma 1.06}$(Ni$_{1.39}$Fe$^{3+}_{0.51}$Zn$_{0.06}$Mn$^{3+}_{0.04}$Mg$_{0.04}$Co$_{0.01}$)$_{\Sigma 2.05}$As$_{1.99}$O$_{7.97}$[(H$_2$O)$_{1.25}$(OH)$_{0.78}$] based on 10 O apfu. The strongest lines in the X-ray powder-diffraction pattern [d Å (I%;hkl)] are: 4.64 (100; $\bar{1}$11), 4.47 (41; $\bar{2}$01), 3.238 (82; $\bar{1}$12), 3.008 (60; 201), 2.859 (41; 021), 2.545 (79; $\bar{3}$12,112), 2.505 (61; 220,$\bar{2}$03). The unit-cell parameters refined from powder-diffraction data are a = 9.124 (8), b = 6.339(3), c = 7.567(7) Å, β = 115.19(6)°, V = 396.0 Å^3, and Z = 2. No suitable crystal was found to perform a single-crystal study. Nickeltsumcorite belongs to the tsumcorite structure type and forms a solid-solution series with nickellotharmeyerite. It is the Ni-dominant analog of tsumcorite and cobalttsumcorite. The type specimen was deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **O.C.G.**

SANGUITE*

I.V. Pekov, N.V. Zubkova, D. I. Belakovskiy, I.S. Lykova, V.O. Yapaskurt, M.F. Vigasina, E.G. Sidorov, and D.Y. Pushcharovskiy (2015) Sanguite, KCuCl$_3$, a new mineral from the Tolbachik Volcano, Kamchatka, Russia. Canadian Mineralogist, 53(4), 633–641.

Sanguite (IMA 2013-002), ideally KCuCl$_3$, was discovered in the Glavnaya Tenoritovaya ("Major Tenorite") fumarole at the apical part of the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik Volcano, Kamchatka, Russia. Sanguite occurs in association with belloite, avdoninite, eriochalcite, sylvite, halite, carnallite, mitscherlichite, chrysothallite, romanorlovite, mellizinkalite, gypsum, chlorothionite, kainite, sellaite, and earlier hematite, tenorite, and chalcocyanite. Commonly, sanguite occurs in the sulfate-chlorite zone of the Glavnaya Tenoritnaya fumarole, where some areas contain up to 10–15 vol% of the new mineral. Sanguite forms prismatic, short to long elongated by [100] crystals in cavities. The crystals are up to 1 mm long and up to 0.2 mm thick, typically combined in groups, dense clusters or crusts. Some of the basalt scoria cavities are entirely filled by sanguite. Occasionally, the new mineral forms granular aggregates up to 1 mm across in polycomponent chloride incrustations. The major crystal forms are {011}, {100}, and {010}. Sanguite is bright red, with slightly altered samples being dark to brownish red. The new mineral has a reddish orange streak, a vitreous luster, is transparent and very brittle. The Mohs hardness is ~3. The cleavage is perfect on (010), and another distinct one probably on (10$\bar{2}$) observed under the microscope. The fracture is stepped. D_{meas} = 2.86(1) g/cm^3, D_{calc} = 2.88 g/cm^3. Sanguite is optically biaxial (–), α = 1.653(3), β = 1.780(6), and γ = 1.900(8) (λ 589 nm); $2V_{meas}$ = 85(5)°; $2V_{calc}$ = 82°; Y = **b**, Z ^ **a** = 48°. Dispersion of optical axis is very strong, $r > v$. Sanguite is strongly pleochroic: Z (brownish red) > Y (gray to pinkish gray) > X (yellowish gray to colorless). The Raman spectrum shows the band at 547 cm^{-1} (Cu^{2+}–Cl stretching) and several bands with frequencies below 300 cm^{-1} (lattice modes involving K–Cl stretching and Cu^{2+}–Cl bending vibrations). The absence of any bands in the range higher than 600 cm^{-1} is indicative of the absence of groups with O-H, Be-O, Li-O, and C-, N-, and B-bearing groups. The averaged 7 point WDS electron probe analyses is [wt%, (range)]: K 18.57 (17.91–19.02), Cu 29.79 (29.18–30.30), Cl 50.66 (49.87–51.17), total 99.02. The empirical formula of sanguite based on the 5 apfu is K$_{1.00}$Cu$_{0.99}$Cl$_{3.01}$. The strongest lines of the X-ray powder diffraction pattern of sanguite are [d Å (I%; hkl)]: 7.36 (78; 011), 6.92 (100; 020), 3.684 (69; 11$\bar{1}$), 3.146 (64; 032,1 0$\bar{2}$), 3.068 (63; 11$\bar{2}$), 2.857 (73; 12$\bar{2}$), 2.709 (82; 112,042), 2.574 (56; 122). The crystal structure of sanguite was solved by direct methods and refined to R = 5.45%. The new mineral is monoclinic, $P2_1/c$, a = 4.0281(2), b = 13.7906(6), c = 8.7335(4) Å, β = 97.137(4)°, V = 481.38 Å^3, and Z = 4. The crystal structure of sanguite contains almost planar, discrete dimers [Cu$_2^{2+}$Cl$_6$]. The KCl$_9$ polyhedra are connected via common faces to form interrupted layers. Neighboring layers are linked to each other by the common edges of the K-centered polyhedra. The new mineral (Cyrillic: Сангвит) was named from Latin *sanguis* (blood), referring to its bright red blood-like color. The type specimens are deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia. **Yu.U.**

SILICOCARNOTITE*

E.V. Galuskin, I.O. Galuskina, F. Gfeller, B. Krüger, J. Kusz, Y. Vapnik, M. Dulski, and P. Dzierżanowski (2016) Silicocarnotite, Ca$_5$[(SiO$_4$)(PO$_4$)](PO$_4$), a new "old" mineral from the Negev Desert, Israel, and the ternesite–silicocarnotite solid solution: indicators of high-temperature alteration of pyrometamorphic rocks of the Hatrurim Complex, Southern Levant. European Journal of Mineralogy, 28(1), 105–123.

The new mineral silicocarnotite (IMA 2013-139), ideally $Ca_5[(SiO_4)(PO_4)](PO_4)$ has been discovered in semi-manufactured stone artifacts made out of pyrometamorphic gehlenite-bearing rocks found at Paleolithic stone-tool workshops on the eastern slope of the Har Parsa Mt. (31°12′31″N; 35°17′09″E) and near Tsomet Hatrurim (31°12′58″; N 35°15′48″E). These localities are situated in the Hatrurim Complex between city of Arad and the Dead Sea, Negev Desert, Israel. The formation of pyrometamorphic rocks is still under discussion and supposed to be a result of combustion of bitumen contained in primary sedimentary rocks. The name chosen since the new mineral is a natural analog of the well-known orthorhombic synthetic phase $Ca_5(PO_4)_2(SiO_4)$ for which the name "silicocarnotite" has been used for the for more than 100 years. The name is unfortune since the monoclinic mineral carnotite, $K_2(UO_2)_2(VO_4)_2·3H_2O$ bears no relation to silicocarnotite. Silicocarnotite occurs (sometimes being a rock-forming mineral) in gehlenite-bearing rock with andradite, fluorapatite and rankinite with minor pseudowollastonite, kalsilite, magnesioferrite-jacobsite, and lamellae intergrowths of larnite and flamite. Silicocarnotite has been also found forming solid solution with ternesite $Ca_5(SiO_4)_2SO_4$ in larnite- and gehlenite-bearing pyrometamorphic rocks of the Hatrurim Complex, distributed in the Dead Sea rift area on the territories of Israel, Palestine and Jordan. Large ternesite porphyroblasts (metacrysts) in fine-grained larnite–ye'elimite matrix are the most striking evidence for high-temperature alterations of an early "clinker minerals." Silicocarnotite–ternesite grains grew as a result of reactions between primary pyrometamorphic minerals (larnite, flamite, fluorellestadite–fluorapatite) with sulfate-bearing melts, which are side-products of the combustion processes during the pyrometamorphism. New data on morphology, composition, structure, mineral associations, mechanisms, and conditions of growth of the ternesite–silicocarnotite solid-solution series are presented. Silicocarnotite forms grains 0.05–0.15 mm, which occasionally overgrown by a rim of rankinite–silicocarnotite microsymplectites. It also found as spherulitic aggregates on the walls of small cavities filled with katoite and Ca-hydrosilicates. The mineral is colorless transparent with a white streak and a vitreous luster. Cleavage and parting are not observed. It is brittle with an uneven fracture. The indentation hardness is $VHN_{50} = 537$ (523–552) kg/mm^2 corresponding to ~5 of the Mohs scale. The density was not measured due to the lack of pure material; $D_{calc} = 3.06$ g/cm^3. The mineral does not fluoresce under UV rays or the electron beam. In transmitted light silicocarnotite is colorless and non-pleochroic. It is optically biaxial (+), α = 1.618(2), β =1.621(2), γ = 1.628(2) (589 nm), $2V_{meas} = 75(5)°$, $2V_{calc} = 67°$; dispersion of optical axis is medium, $r > v$; $X \parallel \mathbf{b}$, $Y \parallel \mathbf{a}$, $Z \parallel \mathbf{c}$. The Raman spectra of silicocarnotite show the following bands (cm^{-1}): 1085, 1056, 1014 [$v_3(PO_4) + v_3(SiO_4)$], 1004 [$v_1(SO_4)$], 957 [$v_1(PO_4)$], 850 [$v_1(SiO_4)$], 640 [$v_4(PO_4)$], 584 [$v_4(PO_4) + (SiO_4)$], 557 [$v_4(SiO_4)$], 474 [$v_2(PO_4)$], 397 [$v_2(SiO_4)$], 302, 234 [$v(Ca-O)$]. The Raman spectra for P-rich and P-poor ternesite have been also obtained. The ratio of the v_1 band vibration intensities (SO$_4$):(PO$_4$):(SiO$_4$) is a good diagnostic property for minerals of the ternesite–silicocarnotite solid solution series. The averages of 6 electron probe EDS analyses of holotype specimen from Har Parsa and 18 analyses of cotype from Tsomet Hatrurim [wt% (range) holotype/cotype] are: SO$_3$ 1.85 (1.62–2.05)/0.33 (0.13–0.74), V$_2$O$_5$ <0.08/0.50 (0.38–0.76), P$_2$O$_5$ 25.81 (25.45–26.53)/27.82 (26.47–28.56), SiO$_2$ 13.62 (13.47–13.75)/12.74 (12.47–13.13), SrO 0.13 (0.12–0.15)/0.17 (0.13–0.20), CaO 57.61 (57.16–58.06)/57.21 (56.66–57.59), Na$_2$O <0.02/<0.02; total 99.02/98.77. The empirical formulas of holotype and cotype based on 12 O apfu are: $Ca_{5.01}Sr_{0.01}P_{1.77}Si_{1.11}S^{6+}_{0.11}O_{12}$ and $Ca_{4.99}Sr_{0.01}P_{1.92}V_{0.03}Si_{1.04}S^{6+}_{0.02}O_{12}$. The strongest diffraction lines in the pseudo-Gandolfi X-ray powder diffraction pattern are [d Å, (I%; hkl)]: 8.56 (7; 011), 3.900 (17; 112,040), 2.949 (61; 113,221), 2.810 (100; 033,230), 2.588 (55; 133,060), 2.030 (30; 312), 1.865 (30; 303), 1.809 (29; 135,mult.), 1.742 (67; 263,182). The structure was solved on a crystal of 0.028 × 0.018 × 0.015 mm and refined to $R_1 = 0.0147$ for 1516 observed $I > 2σ(I)$ reflections. The mineral is orthorhombic, $Pnma$ with

$a = 6.72230(1)$, $b = 15.4481(2)$, $c = 10.0847(2)$ Å; $V =1047.37$ Å^3, $Z = 4$. Silicocarnotite is isostructural with ternesite and with their synthetic analogs. Their structures are closely related to apatite and exhibit two types of isolated tetrahedra (T1O$_4$ and T2O$_4$) connected via three different sevenfold-coordinated Ca polyhedra. In silicocarnotite T1 occupied exclusevely by P. The charge balance require occupancy of 50% P and 50% Si in T2 tetrahedra. In a pure ternesite T1 tetrahedron is fully occupied by S^{6+} atoms. The type material of silicocarnotite is deposited in the Museum of Natural History in Bern. **D.B.**

Vanadium*

M. Ostrooumov and Y. Taran (2016) Vanadium, V—a new native element mineral from the Colima volcano, State of Colima, Mexico, and implications for fumarole gas composition. Mineralogical Magazine, 80(2), 371–382.

Vanadium (IMA 2012-021a), V, is a new mineral found in sublimates of high-temperature fumaroles of the Colima volcano, Mexico. The mineral precipitates over a narrow temperature range of 550–680 °C, and occurs in association with colimaite and shcherbinaite. Native vanadium was found in natural incrustations and on the inner wall of a silica tube inserted into vents and subsequently in the adjacent rock of the "Z3 fumarole." Native vanadium occurred in patchy films about half a millimeter in diameter and only micrometers thick. It forms smooth, irregular to flattened crystals, 5–20 μm in diameter with smaller irregular crystals observed in silica tubes. Due to the small crystal size, the physical properties of vanadium were not determined. Vanadium has a steel gray color and is opaque and is non-pleochroic. $D_{calc} = 6.033$ g/cm^3. The average of 4 electron probe WDS analyses is [wt% (range)]: V 87.03 (86.52–87.63), Fe 10.24 (9.17–11.25), Al 2.21 (1.25–3.17), Ti 0.49 (0.25–0.73), total 99.97. The empirical formula is $V_{0.86}Fe_{0.09}Al_{0.04}Ti_{0.01}$ based on 1 apfu. The unit-cell parameters derived from the Gandolfi and glancing-angle X-ray diffraction data are: $a = 3.022(3)$ Å, $V = 27.60$ Å^3, $Z = 2$; space group $Im\overline{3}m$. The strongest lines in the calculated X-ray powder-diffraction pattern [d Å (I%; hkl)] are: 2.141 (100; 110), 1.513 (12; 200), 1.230 (19; 211), 0.957 (8; 310), 8.809 (11; 321). Holotype material was deposited in the collections of the Geological Museum of the National Mexican University. **O.C.G.**

Wernerkrauseite*

E.V. Galuskin, B. Krüger, H Krüger, G. Blass, R. Widmer, and I.O. Galuskina (2016) Wernerkrauseite, CaFe$^{3+}_2$Mn^{4+}O$_6$: the first non-stoichiometric post-spinel mineral, from Bellerberg volcano, Eifel, Germany. European Journal of Mineralogy, 28(2), 485–493.

The new mineral wernerkrauseite (IMA 2014-008), ideally CaFe$^{3+}_2$Mn^{4+}O$_6$ was discovered in strongly altered xenoliths within alkaline basalts of the Bellerberg volcano (Caspar quarry), Ettringen near Mayen, Eifel, Rhineland-Palatinate, Germany (50°35′N; 7°23′E). The xenoliths are represented by a light matrix of low-temperature minerals: ettringite–thaumasite, hydrocalumite, jennite, katoite, portlandite, etc., with relict grains of a high-temperature mineral association: Cl-bearing fluorellestadite, wadalite, gehlenite, andradite–schorlomite, perovskite, magnesioferrite, cuspidine, and, rarely, reinhardbraunsite, kerimasite, lakargiite, gehlenite, rankinite, pavlovskyite, and rusinovite. Crystallization of wernerkrauseite took place at temperatures below 850–900 °C under high oxygen fugacity. Wernerkrauseite forms black, elongated, prismatic, acicular crystals up to 0.5 mm with a black streak and strong submetallic luster. The crystals forms are {210}, {110}, {010}, {011}, and {111}. No twinning is observed, whereas parallel crystal intergrowths are typical. Crystals are striated parallel to elongation and have rhombic cross-sections. Wernerkrauseite also occurs in aggregates with magnesioferrite and perovskite. The cleavage is not observed, the fracture is uneven. The micro-indentation hardness $VHN_{25} = 154(5)$ kg/mm^2 cor-

responding to ~3 of the Mohs scale. The density was not measured; D_{calc} = 4.66 g/cm³. In reflected light the mineral is gray, very weakly pleochroic, with a weak bireflectance and anisotropy and with no internal reflections. The reflectance data obtained between 400 and 700 nm with a 20 nm interval vary from ~31% (400 nm) to ~19% (700 nm). The values for the COM wavelengths [R_{max}/R_{min} (nm)] are: 28.1/19.8 (470), 25.7/19.0 (546), 25.0/19.1 (589), 24.3/19.0 (650). Raman bands of wernerkrauseite are (cm⁻¹): ~1300 and 1239 [combination first-order phonons Ag (622) ×2]; 670, 622, 558 (Ag); 495 ($B2g/Ag$); 408, 332 ($Ag/B1g/B3g$); 294 (Ag); 169 ($Ag/B2g$); 117 (Ag). Raman spectra of wernerkrauseite were measured and analyzed in comparison to those of harmunite and marokite and are significantly distinct of those by the occurrence of strong broad band centered at about 620 cm⁻¹. The average of 9 electron probe analyses of the holotype is [wt% (range)]: Al_2O_3 0.27 (0.15–0.43), Fe_2O_3 27.97 (25.98–31.35), MnO_2 29.52 (29.18–29.91), Mn_2O_3 22.97 (19.78–24.76) (Mn⁴⁺/Mn³⁺ calculated by charge balance), MgO 0.40 (0.26–0.53), CaO 18.48 (18.09–18.67), total 99.61. The corresponding empirical formula based on 6 O pfu is $Ca_{0.99}(Fe^{3+}_{1.06}Mn^{4+}_{1.03}Mn^{3+}_{0.88}Mg_{0.03}Al_{0.02})_{\Sigma3.01}O_6$. The powder diffraction pattern was not obtained. The strongest diffraction lines of the calculated powder diffraction pattern are [d Å (I%; hkl)]: 4.698 (44; 102), 4.527 (54; 200), 2.748 (62; 004), 2.646 (100; 302), 2.450 (77; 112), 2.425 (37; 210), 1.818 (43; 214), 1.778 (30; 410), 1.493 (28;

414). The crystal structure solved using single-crystal X-ray diffraction was refined to R_1 = 0.0233 for 800 observed $I > 2\sigma(I)$ reflections. Wernerkrauseite is orthorhombic, $Pnma$, a = 9.0548(2), b = 2.8718(1), c = 10.9908(2) Å, V = 285.80 Å³, Z = 8. The structure is built from rutile-type chains of two types of edge-sharing Fe and/or MnO_6 octahedra. The tunnels between these chains host the Ca sites. The diffraction pattern shows evidence of short-range ordering of Ca-vacancies. Only ⅓ of 8 Ca sites are occupied. Wernerkrauseite is a Ca-deficient structural analog of harmunite, $CaFe_2O_4$, and thus is one of the four known minerals with post-spinel structures. The end-member chemical formula can be given on the basis of spinel stoichiometry: $Ca_{2/3}[Fe^{3+}_{4/3}Mn^{4+}_{2/3}]O_4$, which better reflects its non-stoichiometry. The empirical formula based on 4 O apfu is $Ca_{0.66}(Fe^{3+}_{0.71}Mn^{4+}_{0.68}Mn^{3+}_{0.59}Mg_{0.02}Al_{0.01})_{\Sigma2.01}O_4$ The non-stoichiometric Mn⁴⁺-bearing harmunite $Ca_{0.86}(Fe^{3+}_{1.72}Mn^{4+}_{0.27}Ti^{4+}_{0.01}Mg_{0.01})_{\Sigma2.01}O_4$ was found at the same locality, which suggests the existence of a continuous solid solution between wernerkrauseite, harmunite, and $Ca_{2/3}Mn^{3+}_{4/3}Mn^{4+}_{2/3}O_4$, described by the formula $Ca_{1-x/2}(Fe^{3+},Mn^{3+})_{2-x}Mn^{4+}_xO_4$, with x = 0–⅔. The new mineral is named in honor of Werner Krause (b. 1949), a chemist and researcher in the chemical industry with a special interest to the crystal chemistry and morphology of secondary minerals. He has discovered and described a considerable number of new minerals. Holotype material is deposited in the Museum of Natural History, Bern, Switzerland. **D.B.**