

## New Mineral Names\*

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### IN THIS ISSUE

This New Mineral Names has entries from four different journals. Five from *American Mineralogist*: adolfpateraite, chromschiefelinite, magnesiohögbomite-2N4S, mejillonesite, and menchettiite and three from *Zapiski Rossiiskogo Mineralogicheskogo Obshchestva*: eurekaumpite, fivegite, and manganoeudialyte. Then there are two recent entries in *Canadian Mineralogist*: ellingsenite and fluornatromicrolite and one from *Acta Crystallographica Section B*, sarrabusite.

#### ADOLFPATERAITE\*

J. Plášil, J. Hloušek, F. Veselovský, K. Fejfarová, M. Dušek, R. Škoda, M. Novák, J. Čejka, J. Sejkora, and P. Ondruš (2012) Adolfpateraite,  $K(UO_2)(SO_4)(OH)(H_2O)$ , a new uranyl sulphate mineral from Jáchymov, Czech Republic. *Am. Mineral.*, 97, 447–454.

Adolfpateraite (2011-042) forms hemispherical crystalline aggregates, up to 3 mm in size in an old gallery on the Geschieber vein, at the fifth level of the Svornost (Einigkeit) shaft, Jáchymov (Sankt Joachimsthal) ore district, western Bohemia, Czech Republic (50°22' 21.136"N, 12°54' 46.150"E). Gypsum, schoepite, čejkaite, and another new, not yet approved mineral—a hydrated potassium uranyl sulfate hydroxy-vanadate—have been observed in close association.

Sulfur yellow to greenish yellow crystals are transparent to translucent with a vitreous luster. The streak is pale yellow. Crystals are brittle, without obvious cleavage and have uneven fracture. Morphological observations are difficult due to the nature of adolfpateraite aggregates. The Mohs hardness is ca. 2. The direct determination of density of adolfpateraite could not be done because of the small size of aggregates. A density of 4.24 g/cm<sup>3</sup> was calculated based on the unit-cell dimensions from single-crystal X-ray data and electron microprobe results. Adolfpateraite exhibits green fluorescence in long-wave ultraviolet radiation. Adolfpateraite is pleochroic, with  $\alpha$  = colorless and  $\gamma$  = yellow ( $\beta$  could not be examined). It is biaxial, with  $\alpha = 1.597(2)$ ,  $\gamma = 1.659(2)$  ( $\beta$  could not be measured), birefringence 0.062. The empirical chemical formula (mean of 4 electron microprobe point analyses) was calculated based on 8 O apfu and is  $K_{0.94}(UO_2)_{1.00}(SO_4)_{1.02}(OH)_{0.90}(H_2O)_{1.00}$  (water content calculated). The simplified formula is  $K(UO_2)(SO_4)(OH)(H_2O)$ , requiring  $K_2O$  10.70,  $UO_3$

64.97,  $SO_3$  18.19,  $H_2O$  6.14, total 100.00 wt%. Adolfpateraite is monoclinic, space group  $P2_1/c$ ,  $a = 8.0462(1)$ ,  $b = 7.9256(1)$ ,  $c = 11.3206(2)$  Å,  $\beta = 107.726(2)^\circ$ ,  $V = 687.65(2)$  Å<sup>3</sup>,  $Z = 4$ , and  $D_{calc} = 4.24$  g/cm<sup>3</sup>. The five strongest reflections in the X-ray powder diffraction pattern are [ $d_{obs}$  in Å ( $I_{obs}\%$ ,  $hkl$ )]: 7.658(76,100), 5.386(100,002), 5.218(85,102), 3.718(46,021), 3.700(37,202).

The mineral is named in honor of Adolf Patera (1819–1894), Czech chemist, mineralogist, and metallurgist, who invented the technology for processing uranium ores from Jáchymov for production of uranium colors. The type specimen is deposited in the collections of the Department of Mineralogy and Petrology of the National Museum in Prague, Václavské náměstí 68, Praha 1 (Czech Republic), catalog number: PIP 3/2011. **K.T.T.**

#### CHROMSCHIEFFELINITE\*

A.R. Kampf, S.J. Mills, R.M. Housley, M.S. Rumsey, and J. Spratt (2012) Lead-tellurium oxysalts from Otto Mountain near Baker, California: VII. Chromschiefelinite,  $Pb_{10}Te_6O_{20}(OH)_{14}(CrO_4)(H_2O)_5$ , the chromate analog of schiefelinite. *Am. Mineral.*, 97, 212–219.

Chromschiefelinite (IMA 2011-003) was discovered at the Bird Nest drift (35°16.606'N, 116° 05.956'W) on the southwest flank of Otto Mountain, 0.4 miles northwest of the Aga mine. The only material available is from a single 1 mm diameter vug in a quartz vein. Other species identified on the holotype specimen are: chalcopyrite, chrysocolla, galena, goethite, hematite, khinite, pyrite, and wulfenite. Chromschiefelinite crystals are blocky to tabular on {010} with striations parallel to [001] and are up to 0.2 mm in maximum dimension. The color and streak are pale yellow and the luster is adamantine. The Mohs hardness is estimated at 2. The new mineral is brittle with irregular fracture and one perfect cleavage on {010}. The density could not be measured because it is greater than those of available high-density liquids and there is insufficient material for physical measurement. The calculated density based on the ideal formula is 5.892 g/cm<sup>3</sup>. Crystals of

\*All minerals marked with an asterisk have been approved by the IMA CNMMC.

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chromschieffelinite are biaxial (–) with the indices of refraction:  $\alpha = 1.930(5)$ ,  $\beta = 1.960(5)$ , and  $\gamma = 1.975(5)$ , measured in white light. The  $2V$ , measured directly on a spindle stage, is  $68(2)^\circ$ , while the calculated  $2V$  is  $69.6^\circ$ . The dispersion is  $r < v$ , strong, orientation is  $X = \mathbf{b}$ ,  $Y = \mathbf{c}$ ,  $Z = \mathbf{a}$ . No pleochroism was observed. Electron microprobe analysis provided: PbO 59.42, TeO<sub>3</sub> 29.08, CrO<sub>3</sub> 1.86, H<sub>2</sub>O 6.63 (structure), total 96.99 wt%; the empirical formula (based on 6 Te) is  $\text{Pb}_{9.65}\text{Te}_6\text{O}_{19.96}(\text{OH})_{14.04}(\text{CrO}_4)_{0.67}(\text{H}_2\text{O})_{6.32}$ . The strongest powder X-ray diffraction lines are  $d_{\text{obs}}$  in  $\text{\AA}$  [ $I_{\text{obs}}\%$ ,  $hkl$ ]: 9.814(100,020), 3.575(41,042,202), 3.347(44,222), 3.262(53,241,060,113), 3.052(45,311), 2.9455(55,152,133), 2.0396(33,115,353), and 1.6500 (multiple) 33. One holotype specimen (consisting of two pieces) is deposited in the Natural History Museum of Los Angeles County, catalog number 63511. **K.T.T.**

### ELLINGSENITE\*

V.N. Yakovenchuk, G.Yu. Ivanyuk, Y.A. Pakhomovsky, E.A. Selivanova, and J.A. Mikhailova (2011) Ellingsenite,  $\text{Na}_5\text{Ca}_6\text{Si}_{18}\text{O}_{38}(\text{OH})_{13}\cdot 6\text{H}_2\text{O}$ , a new martinite-related mineral species from phonolite of the Aris alkaline complex, Namibia. *Can. Mineral.*, 49, 1165–1173.

Ellingsenite is structurally related to the reyerite-gyrolite group of CSH “cement” sheet silicates, but has major interstitial Na between the polyhedral layers. It is pointed out that synthetic Al-substituted analogues of this mineral could have potential as an effective cation-exchanger for K and Cs, and for removing heavy metals from groundwaters. The mineral occurs in hydrothermally altered phonolite of the Aris alkaline complex in Namibia, SW Africa. The crystals occur as radiating sheaves in white spherular aggregates (up to 3 mm) of rhomb-like crystals that are flattened on {001} and elongated along [100]. It has a perfect (001) cleavage. Individual crystals are colorless and have a vitreous luster, whereas crystal aggregates are white and have a silky luster. The mineral is biaxially negative with  $\alpha = 1.520$ ,  $\beta = 1.534$ ,  $\gamma = 1.536$ ,  $2V = 5^\circ$ .

Electron-microprobe analysis (WDS) and H<sub>2</sub>O analysis by the Penfield method gave an empirical composition (wt%): Na<sub>2</sub>O 9.26, SiO<sub>2</sub> 60.35, K<sub>2</sub>O 0.23, CaO 17.35, H<sub>2</sub>O 12.5, S 99.69. Structure solution and refinement was carried out using a Bruker APEX CCD diffractometer (MoK $\alpha$ ). The crystals were problematic and showed poor diffraction characteristics (multi-crystal “powder” components to diffraction spots indicative of significant orientation variation). The best crystal ( $0.12 \times 0.12 \times 0.01 \text{ mm}^3$ ) was used to collect reflection data for structure determination. The structure was solved and refined in triclinic space group *P* $\bar{1}$ . Unit-cell parameters obtained from the single-crystal XRD study are:  $a = 9.576(11)$ ,  $b = 5.577(11)$ ,  $c = 16.438(19) \text{ \AA}$ ,  $\alpha = 85.85(2)^\circ$ ,  $\beta = 75.23(2)^\circ$ ,  $\gamma = 60.142(14)^\circ$ ,  $V = 1262(3) \text{ \AA}^3$  ( $Z = 1$ ). Isotropic structure refinement gave final agreement indices of  $R_1 = 0.247$ ,  $wR_2 = 0.526$  and goodness-of-fit 1.089. The high  $R$  values result from poor crystal quality. An attempt to refine in space group *P*1 did not lead to any improvement in refinement quality. Nonetheless, the essential structure topology of ellingsenite was identified and a crystal-chemically realistic approximate structure obtained. The mineral is clearly related to the reyerite-gyrolite structures but has essential interlayer Na. Only one interlayer Na atom was located, perhaps reflecting the limitations of the diffraction data. The T<sub>2</sub>OT<sub>2</sub> polyhedral sheets comprise an O layer of edge-sharing

octahedrally coordinated Ca and Na atoms (one Na at a center of symmetry and three non-equivalent Ca atoms at general positions). One Ca site has a significant Na content, refined within error as 50% Ca + 50% Na. <sup>16</sup>Na-O bonds range 2.39–2.64 Å (with two further possible long bonds at 2.96 Å giving 8-coordination), and <sup>16</sup>Ca-O range 2.27–2.63 Å. The Na-Ca O layer is sandwiched between two identical T<sub>2</sub> layers of corner-linked SiO<sub>4</sub> tetrahedra related by a center of symmetry at the Na1 site. The T<sub>2</sub> layer consist of isolated hexagonal rings of corner-linked tetrahedra bonded to the O layer by an apical oxygen atom. The hexagonal rings are connected to each other via single SiO<sub>4</sub> tetrahedra that are pointing away from the O layer towards the interlayer where their apical oxygen atoms form putative silanol groups, evidence for which is found in the infrared spectrum (see below). Two oxygen atoms were identified as belonging to H<sub>2</sub>O groups and their refined site occupancies were 0.25(5) and 0.73(5). The interlayer Na2 site lies above the center of the underlying hexagonal ring of tetrahedra, and its site occupancy was refined as 0.86(4). The T<sub>2</sub>OT<sub>2</sub> layer of ellingsenite has the composition  $\{\text{Na}_{1.9}\text{Ca}_{5.1}[\text{Si}_8\text{O}_{20}]_X\}$  where  $X = \text{O, OH}$ . The interlayer space in ellingsenite is  $\sim 2.3 \text{ \AA}$ .

Based upon the chemical analysis and structure determination, the empirical crystal-chemical formula of ellingsenite ( $\text{O} = 57$ ) is  $(\text{Na}_{4.95}\text{K}_{0.09})_{\Sigma=5.04}(\text{Ca}_{5.57}\text{Na}_{0.43})_{\Sigma=6.00}\text{Si}_{18.10}\text{O}_{38}(\text{OH})_{13}\cdot 6\text{H}_2\text{O}$ , and the corresponding ideal formula is  $\text{Na}_5\text{Ca}_6\text{Si}_{18}\text{O}_{38}(\text{OH})_{13}\cdot 6\text{H}_2\text{O}$  ( $Z = 1$ ). Unit-cell parameters obtained from X-ray powder diffraction (Debye-Scherrer camera, 114.7 mm, FeK $\alpha$ ) are:  $a = 9.55(3)$ ,  $b = 9.395(8)$ ,  $c = 16.329(3) \text{ \AA}$ ,  $\alpha = 100.2(1)^\circ$ ,  $\beta = 94.9(2)^\circ$ ,  $\gamma = 117.8(2)^\circ$ ,  $V = 1251(8) \text{ \AA}^3$  ( $Z = 1$ ). The strongest lines in the X-ray powder diffraction pattern are [ $d_{\text{obs}}$  in  $\text{\AA}$  ( $I_{\text{obs}}\%$ ,  $hkl$ )]: 15.50(100,001), 3.023(33,3 $\bar{2}$ 1), 3.159(30,005), 1.827(27,5 $\bar{1}$ 1), 2.791(24,2 $\bar{1}$ 4), 4.22(16,2 $\bar{0}$ 1), 4.98(14,012), 4.89(14,1 $\bar{1}$ 1). An infrared absorption spectrum for ellingsenite powder is reported in which wide bands at 1630 and 3460 cm<sup>-1</sup> are assigned to interlayer H<sub>2</sub>O; medium-strength bands at 1360 and 3260 cm<sup>-1</sup> are assigned to vibrations of silanol groups, Si-(OH). Bands at 780 and 3600 cm<sup>-1</sup> are assigned to libration and stretching modes, respectively, of OH groups. Overall, the infrared spectrum of ellingsenite is similar to that of gyrolite.

Finally, the authors note that the close structural relationship of ellingsenite to the reyerite-gyrolite group implies that its formula should be rewritten on the basis of the [Si<sub>8</sub>O<sub>20</sub>] radical that it shares with these minerals. They propose a corrected empirical structural formula  $(\text{Na}_{1.84}\text{K}_{0.04})_{\Sigma=1.88}(\text{Ca}_{2.46}\text{Na}_{0.54})_{\Sigma=3.00}\text{Si}_8\text{O}_{19.34}(\text{OH})_{0.66}\cdot 5.34\text{H}_2\text{O}$  ( $Z = 2$ ), and the corresponding ideal formula is  $\text{Na}_2(\text{Na,Ca})_3[\text{Si}_8\text{O}_{19}(\text{O,OH})]\cdot 5\text{H}_2\text{O}$  ( $Z = 2$ ). **M.W.**

### EUREKADUMPITE\*

I.V. Pekov, N.V. Chukanov, A.E. Zadov, A.C. Roberts, M.C. Jensen, N.V. Zubkova, and A.J. Nikischer (2010) Eurekadumpite  $(\text{Cu,Zn})_6(\text{TeO}_3)_2(\text{AsO}_4)_3\text{Cl}(\text{OH})_{18}\cdot 7\text{H}_2\text{O}$ —a new hypergene mineral. *Zap. Ross. Mineral. Obshch.*, 139(4), 26–35 (in Russian, English abstract). *Geol. Ore Deposits*, 53(7), 575–582 (2011; in English).

A new mineral eurekadumpite was discovered at the old dumps of Centennial Eureka mine, Tintic district, Juab Co., Utah, U.S.A. It was found in 1992 in the oxidation zone of quartz-sulfide ores containing tellurides (mostly hessite) and is one of the most

common hypogene Te mineral at this mine. Eurekaumpite occurs in small cavities and in fractures in quartz with malpincite, malachite, Zn-bearing olivenite, goethite, and Mn oxides. Other tellurates and tellurites found at the mine are: jensinite, leisingite, frankhawthorneite, juabite, utahite, quetzalcoatlite, and xocomecatlite. The mineral forms spherulites and rosettes up to 1 mm, its clusters and crusts up to  $1.5 \times 1.5$  cm. The individual crystals are extremely thin (less than 1  $\mu\text{m}$ ) splitted leaflets round or with hexagonal outlines up to 0.5 mm in plane. Eurekaumpite is deep blue-green or turquoise-colored, silky in aggregates and pearly on individual flakes with a blue-green streak. Flakes are flexible, but not elastic. Cleavage is mica-like perfect on  $\{010\}$ . Mohs hardness of 2.5–3.  $D_{\text{meas}} = 3.76(2)$ ,  $D_{\text{calc}} = 3.826$  g/cm<sup>3</sup>. The mineral is optically biaxial negative (–),  $\alpha = 1.69(1)$ ,  $\beta = \gamma = 1.775(5)$ ,  $2V_{\text{meas}} = 10(5)^\circ$ .  $X = b$ . Pleochroism is strong:  $Y = Z =$  deep blue-green,  $X =$  light turquoise-colored,  $Y = Z > X$ . IR absorption bands (cm<sup>–1</sup>, strongest lines italic, w = weak) are: *3400, 2990, 1980w, 1628, 1373w, 1077, 1010, 860, 825, 803, 721w, 668, 622, 528, 461*. The IR spectrum shows the presence of the  $(\text{Te}^{4+}\text{O}_3)^{2-}$  and  $(\text{As}^{5+}\text{O}_4)^{3-}$  anionic groups, H<sub>2</sub>O, and OH<sup>–</sup> groups coordinating cations Cu and Zn. The chemical composition of eurekaumpite was determined by WDS on a Camebax SX 50 microprobe. H<sub>2</sub>O was determined by Alimarin method. The absence of C-, N-, and B-containing groups is confirmed by IR data. The average (range) of 14 analyses gave: FeO 0.04 (0.00–0.1), CuO 36.07 (35.3–38.5), ZnO 20.92 (20.0–21.6), TeO<sub>2</sub> 14.02 (13.1–15.0), As<sub>2</sub>O<sub>5</sub> 14.97 (13.2–15.9), Cl 1.45 (1.3–1.7), H<sub>2</sub>O 13.1, –O=Cl<sub>2</sub> 0.33, sum 100.24 wt%. The empirical formula based on 2 atoms of Te is:  $(\text{Cu}_{10.32}\text{Zn}_{5.85}\text{Fe}_{0.01})_{\Sigma 16.18}(\text{TeO}_3)_2(\text{AsO}_4)_{2.97}[\text{Cl}_{0.93}(\text{OH})_{0.07}](\text{OH})_{18.45} \cdot 7.29\text{H}_2\text{O}$ . The idealized formula is:  $(\text{Cu}, \text{Zn})_{16}(\text{TeO}_3)_2(\text{AsO}_4)_3\text{Cl}(\text{OH})_{18} \cdot 7\text{H}_2\text{O}$ . Powder X-ray diffraction data were obtained using a STOE IPDS II single-crystal diffractometer with IP detector (filtered MoK $\alpha$  radiation). The strongest lines on the diffraction pattern [ $d_{\text{obs}}$  (Å)]( $I_{\text{obs}}\%$ ,  $hkl$ ) are: 18.92(100,010), 9.45(19,020), 4.111(13,201), 3.777(24,050,221,041), 2.692(15,311,151,302), 2.524(41,170,252,171), 1.558(22,482,3.10.1,024). The mineral is monoclinic (pseudohexagonal). The monoclinic unit-cell parameters refined from powder X-ray data are:  $a = 8.28(3)$ ,  $b = 18.97(2)$ ,  $c = 7.38(2)$  Å,  $\beta = 121.3(6)^\circ$ ,  $V = 990(6)$  Å<sup>3</sup>,  $Z = 1$ . Possible space groups are:  $P2_1/m$ ,  $P2_1$ , or  $Pm$ . All attempts of single-crystal study including synchrotron radiation failed due to thin splitting of individual crystals. The axes  $b$  of monoclinic cell is perpendicular to the cleavage plane (010). Possible crystal structure motifs and relationship with other Te minerals are discussed. The name of the mineral reflects the fact that it was found on the *dumps* of the Centennial *Eureka* mine. The mineral name is also related to the Greek word *eureka*—“*I have found it*”—it means *found in dump*—an allusion to great role the old mines dumps played in the discovery of new minerals. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2009-072). Type specimens are deposited in the Fersman Mineralogical Museum Russian Academy of Sciences, Moscow, Russia, in the Smithsonian National Museum of Natural History, Washington, D.C., and in the American Museum of Natural History, New York, U.S.A. **D.B**

#### FIVEGITE\*

I.V. Pekov, N.V. Zubkova, N.V. Chukanov, A.E. Zadov, and D. Yu. Pushcharovsky (2010) Fivegite,  $\text{K}_4\text{Ca}_2[\text{AlSi}_7\text{O}_{17}(\text{O}_{2-x}\text{OH}_x)]$

$[(\text{H}_2\text{O})_{2-x}\text{OH}_x]\text{Cl}$ —a new mineral from the Khibiny alkaline massif (Kola Peninsula, Russia). Zap. Ross. Mineral. Obshch., 139(4), 47–63 (in Russian, English abstract). Geol. Ore Deposits, 53(7), 591–603 (2011; in English).

Fivegite is a new mineral found in the active apatite mine Tsentralniy (Central) at Rasvumchorr Mt., Khibiny massif, Kola Peninsula, Russia, in high-potassium peralkaline pegmatite about 10 m long and up to 1 m thick. The pegmatite was (currently mined out) situated in urtite rocks near its contact with nepheline-apatite ore. The mineral associations of this pegmatite belong to three main stages. The earlier one produced nepheline, potassic feldspar, sodalite, aegirine-salite, alkaline amphibole, eudialyte, lamprophyllite, ilmenite, and fluorapatite. The minerals of the next (peralkaline) association are: aegirine, magnesium astrophyllite, lomonosovite, shcherbakovite, barytolamprophyllite, villiaumite, fenaksite, delhayelite, phosinaite-(Ce), clinophosinaite, natisite (after ilmenite), zirsinalite (after eudialyte), kazakovite, pectolite, nacaphite (after fluorapatite), sidorenkite, djerfisherite, rasvumite, sphalerite, and molybdenite. In the later hydrothermal association fivegite occurs only as a product of delhayelite alteration forming homoaxial pseudomorphs after its crystals up to  $2 \times 3 \times 10$  cm. Products of fivegite alteration are hydrodelhayelite, pectolite, and kalborsite. Other associated minerals of this stage are: lovozerite, tisinialite, shafanovskite, ershovite, megacyclite, revdite, grumanite, recently discovered shlykovite, cryptophyllite, and unidentified yet highly hydrated silicates with Na, K, Fe, Mn, Al, Ti. In most cases fivegite is altered completely, rarely it forms up to 70% of the pseudomorph volume. Areas of pure, unaltered fivegite are up to 2 mm. The mineral is transparent, colorless, vitreous to pearly with a white streak. Cleavage is perfect on  $\{100\}$  and distinct on  $\{010\}$ . Mohs hardness is 4.  $D_{\text{meas}} = 2.42(2)$ ,  $D_{\text{calc}} = 2.449$  g/cm<sup>3</sup>. Fivegite fluoresces pink in long-wave UV ( $\lambda = 330$  nm) and light purple in short-wave UV light ( $\lambda = 245$  nm). Some varieties do not fluoresce. The mineral is optically biaxial positive (+),  $\alpha = 1.540(2)$ ,  $\beta = 1.542(2)$ ,  $\gamma = 1.544(2)$ ,  $2V_{\text{meas}} = 60(10)^\circ$ ;  $X = a$ ,  $Y = c$ ,  $Z = b$ . IR spectrum is given in comparison with IR spectra of delhayelite and hydrodelhayelite. Chemical composition of fivegite was determined by EDS on a CamScan MV2300 electron microscope. H<sub>2</sub>O was determined by the Alimarin method. The absence of Li, Be, B, C, and N was confirmed by structure and IR data. The average (range) of 10 analyses gave Na<sub>2</sub>O 1.44 (0.9–1.9), K<sub>2</sub>O 19.56 (18.3–21.2), CaO 14.01 (13.4–14.7), SrO 0.13 (0.0–0.3), MnO 0.03 (0.00–0.10), Fe<sub>2</sub>O<sub>3</sub> 0.14 (0.0–0.5), Al<sub>2</sub>O<sub>3</sub> 6.12 (5.6–6.5), SiO<sub>2</sub> 50.68 (49.2–52.6), SO<sub>3</sub> 0.15 (0.0–0.4), F 0.14 (0.0–0.7), Cl 3.52 (3.2–3.7), H<sub>2</sub>O 4.59, –O=(Cl,F)<sub>2</sub> 0.85; sum 99.66 wt%. The empirical formula based on  $(\text{Si} + \text{Al} + \text{Fe}) = 8$  is:  $\text{H}_{4.22}\text{K}_{3.44}\text{Na}_{0.39}\text{Ca}_{2.07}\text{Sr}_{0.01}\text{Fe}_{0.01}\text{Al}_{1.00}\text{Si}_{6.99}\text{O}_{21.15}\text{F}_{0.06}\text{Cl}_{0.82}(\text{SO}_4)_{0.02}$ . The simplified formula is:  $\text{K}_4\text{Ca}_2[\text{AlSi}_7\text{O}_{17}(\text{O}_{2-x}\text{OH}_x)][(\text{H}_2\text{O})_{2-x}\text{OH}_x]\text{Cl}$  ( $x = 0-2$ ). Powder X-ray diffraction data were obtained using a STOE STADI MP powder diffractometer (filtered CuK $\alpha_1$  radiation). The strongest lines on the diffraction pattern [ $d_{\text{obs}}$  in Å] ( $I_{\text{obs}}\%$ ,  $hkl$ ) include: 6.536(24,001), 6.072(22,400), 3.517(38,020), 3.239(28,102), 3.072(100,121,701), 3.040(46,420,800,302), 2.943(47,112), 2.893(53,321), 2.880(24,212,402), 1.759(30,040,12.2.0). Orthorhombic unit-cell parameters from the powder-diffraction data are:  $a = 24.32(1)$ ,  $b = 7.034(4)$ ,  $c = 6.539(3)$  Å,  $V = 1119(2)$  Å<sup>3</sup>.  $Z = 2$ . Single-crystal X-ray structure data were collected using an



Xcalibur S diffractometer with a CCD detector (MoK $\alpha$  radiation). A total of 15458 reflections were observed, with 3452 unique reflections. The structure was refined in space group  $Pm2_1n$  to  $R1 = 0.0585$ ,  $wR2 = 0.1483$  with cell parameters:  $a = 24.335(2)$ ,  $b = 7.0375(5)$ ,  $c = 6.5400(6)$  Å,  $V = 1120.02(17)$  Å<sup>3</sup>. The crystal structure of fivegite is close to the delhayelite structure. Two-layer tetrahedral blocks [(Al,Si)<sub>2</sub>Si<sub>6</sub>O<sub>17</sub>(O<sub>2-x</sub>OH<sub>x</sub>)] with K and Cl in zeolite-like channels between the layers connected by Ca octahedral chains. H<sub>2</sub>O and OH are located between the tetrahedral blocks. The crystallochemical mechanism of transformations delhayelite – fivegite – hydrodelhayelite with preservation of the stable Ca,Al,Si,O-fragment in structure is discussed and suggested as: (1)  $K_4Na_2Ca_2[AlSi_7O_{19}]F_2Cl + 2H_2O > K_4Ca_2[AlSi_7O_{17}(O_{2-x}OH_x)] [(H_2O)_{2-x}OH_x]Cl + 2Na^+ + 2F^-$  and (2)  $K_4Ca_2[AlSi_7O_{17}(O_{2-x}OH_x)] [(H_2O)_{2-x}OH_x]Cl + (5-x)H_2O > KCa_2[AlSi_7O_{17}(OH)_2](H_2O)_{6-x} + 3K^+ + Cl^-$ . The mineral is named in memory of Russian geologist and mining engineer Mikhail Pavlovich Fiveg (1899–1986), the pioneer prospector of the Khibiny apatite deposits. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2009-067). The type specimen is deposited in the Fersman Mineralogical Museum Russian Academy of Sciences, Moscow, Russia. **D.B.**

#### FLUORNATOMICROLITE\*

T. Witzke, M. Steins, T. Doering, W. Schuckmann, R. Wegner, and H. Pöllmann (2011) Fluornatromicrolite, (Na,Ca,Bi)<sub>2</sub>Ta<sub>2</sub>O<sub>6</sub>F, a new mineral species from Quixaba, Paraíba, Brazil. *Can. Mineral.*, 49, 1105–1110.

Electron microprobe analysis gave, as average composition, Na<sub>2</sub>O 6.39, CaO 9.96, Bi<sub>2</sub>O<sub>3</sub> 6.71, Ta<sub>2</sub>O<sub>5</sub> 76.81, F 3.63, sum 98.97 wt%, corresponding to (Na<sub>1.10</sub>Ca<sub>0.64</sub>Bi<sub>0.15</sub>)Ta<sub>2.00</sub>O<sub>5.91</sub>F<sub>1.02</sub> (Ta fixed to 2 apfu). The mineral occurs as regular to flattened octahedral crystals up to 6 mm in size. The color of the mineral is green, and the streak is white. Adamantine luster, brittle, and with a conchoidal fracture. Cleavage not discernible.  $H = 5$ ,  $D_{\text{meas}} = 6.49(6)$  g/cm<sup>3</sup>,  $D_{\text{calc}} = 6.568$  g/cm<sup>3</sup> ( $Z = 8$ ). Optically isotropic, refractive index 2.11(2) (ellipsometric determination, 633 nm). Single-crystal X-ray structure study ( $R = 0.034$ ) indicated cubic symmetry, space group  $Fd3m$ ,  $a = 10.4451(2)$  Å. Strongest lines of the X-ray powder pattern (Philips Norelco diffractometer, CuK $\alpha$  radiation) are 6.023(31,111), 3.148(33,311), 3.015(100,222), 2.610(27,400), 1.846(59,440), and 1.574(47,622).

The mineral is associated with perthitic microcline, albite, amblygonite, muscovite, quartz, elbaite, tantalite-(Fe), tantalite-(Mn), and green beryl in the Alto Quixaba granitic pegmatite, Frei Martinho municipality, Paraíba State, northeastern Brazil. The name, which alludes to the composition, conforms to the approved nomenclature scheme for pyrochlore group minerals. Type specimens of fluornatromicrolite are deposited in the Mineralogical Collection of the Bergakademie Freiberg, Germany (no. 77975), and in the Mineralogical Collection of the Martin-Luther Universität Halle, Institut für Geologische Wissenschaften (no. 010356). **G.D.G and F.C.**

#### MAGNESIOHÖGBOMITE-2N4S\*

T. Shimura, J. Akai, B. Lazic, T. Armbruster, M. Shimizu, A. Kamei, K. Tsukada, M. Owada, and M. Yuhara (2012)

Magnesiohögbomite-2N4S: A new polysome from the central Sør Rondane Mountains, East Antarctica. *Am. Mineral.*, 97, 268–280.

The new polysome magnesiohögbomite-2N4S (IMA 2010-084) was found in the Sør Rondane Mountains, East Antarctica. It occurs in Mg-Al-rich, Si-poor skarns, characterized by a corundum-spinel-phlogopite-clinocllore assemblage.

Magnesiohögbomite-2N4S appears macroscopically orange red, the streak is light orange colored. Euhedral crystals are hexagonal plates or prisms with cleavage planes on {001}. The mineral is optically uniaxial (–) and pleochroic with  $O =$  reddish brown and  $E =$  pale brown. The mean refractive index calculated from reflectance data in air at 589 nm is 1.85(3). The calculated density is 3.702(2) g/cm<sup>3</sup>. The Mohs hardness is 6.5–7, and VHN300 = 1020–1051, mean 1032 kg/mm<sup>2</sup>. The mean chemical composition (wt%) is SiO<sub>2</sub> 0.05, TiO<sub>2</sub> 7.08, SnO<sub>2</sub> 0.15, Al<sub>2</sub>O<sub>3</sub> 66.03, Cr<sub>2</sub>O<sub>3</sub> 0.02, Fe<sub>2</sub>O<sub>3</sub> 0.50, FeO 4.87, MnO 0.06, MgO 18.71, CaO 0.01, ZnO 0.96, NiO 0.01, CoO 0.02, F 0.06, Cl 0.01, H<sub>2</sub>O 1.00, sum 99.51. The simplified formula is (Mg<sub>8.2</sub>Fe<sub>1.2</sub>Zn<sub>0.2</sub>)<sup>2+</sup>(Al<sub>22.7</sub>Fe<sub>0.1</sub>)<sup>3+</sup>Ti<sub>1.6</sub>O<sub>46</sub>(OH)<sub>2</sub> and ideal formula is Mg<sub>10</sub>Al<sub>22</sub>Ti<sub>2</sub>O<sub>46</sub>(OH)<sub>2</sub>. This mineral is a solid solution between the two ideal end-members, (Mg,Fe,Zn)<sub>10</sub>(Al,Fe)<sub>22</sub>Ti<sub>2</sub>O<sub>46</sub>(OH)<sub>2</sub> and (Mg,Fe,Zn)<sub>8</sub>(Al,Fe)<sub>26</sub>O<sub>46</sub>(OH)<sub>2</sub>. The mineral is hexagonal, space group  $P6_3mc$  (no. 186),  $a = 5.71050(10)$ ,  $c = 27.6760(4)$  Å,  $Z = 1$ ,  $V = 781.60(2)$  Å<sup>3</sup>. The strongest lines in the powder XRD pattern [ $d_{\text{obs}}$  in Å ( $I_{\text{obs}}\%$ ,  $hkl$ )] are: 2.8561(4,37,110), 2.6120(3,39,109), 2.42818(16,100,116), 2.4160(4,39,1010), 2.01181(13,50,208), 1.54892(16,35,2110), 1.42785(6,57,220).

The type material is deposited at the National Museum of Nature and Science, Tokyo, Japan, under the registration number NSM-MF15438. Parts of the holotype are deposited at the following places; (1) Polar Science Museum, Tokyo, Japan (no. NIPR-0073), (2) Science Museum of Niigata University, Niigata, Japan (no. NUMIN-NM02), and (3) Museum of Natural History Bern, Switzerland (no. NMBE 41105). **K.T.T.**

#### MANGANOEUODIALYTE\*

S.F. Nomura, D. Atencio, N.V. Chukanov, R.K. Rastsvetaeva, J.M.V. Coutino, and T.K. Karipidis (2010) Manganoeudialyte—a new mineral from Poços de Caldas, Minas Gerais, Brazil. *Zap. Ross. Mineral. Obshch.*, 139(4), 35–47 (in English, Russian abstract).

Manganoeudialyte is a new member of eudialyte group found in nepheline syenites (khibinites) at the northern edge (“Anel Norte”) of the alkaline Poços de Caldas massif, Minas Gerais, Brazil. It occurs in aggregates up to 1 cm in size interstitial to the rock-forming minerals and associated with eudialyte, K-feldspar, nepheline, aegirine, analcime, sodalite, rinkite, lamprophyllite, astrophyllite, titanite, fluorite, and cancrinite. The mineral grains are pink to purple, vitreous, translucent to transparent with a white streak. It has Mohs hardness of 5–6 and is brittle. Cleavage or parting were not observed. It does not fluoresce under UV light.  $D_{\text{meas}} = 2.89$ ,  $D_{\text{calc}} = 2.935$  g/cm<sup>3</sup>. The mineral is uniaxial positive (+),  $\omega = 1.603(2)$ ,  $\epsilon = 1.608(2)$ , nonpleochroic. Main absorption bands of the IR spectrum are: (cm<sup>-1</sup>; s = strong, w = weak, sh = shoulder): 3440 (O-H stretch-

ing vibrations of H-bonded groups), 1677w, 1620w (HOH bending vibrations of H<sub>2</sub>O), 1135sh, 1052sh, 1017s, 978s (Si-O stretching vibrations of tetrahedral rings), 933s (Si-O stretching vibrations of M3 and M4 tetrahedra), 740, 696, 661, 580w (mixed Si-O stretching and OSiO bending vibrations), 529 (stretching vibrations of FeO<sub>5</sub> polyhedra), 477s, 450s, 415sh (SiOSi bending vibrations combined with different stretching vibrations cation-oxygen). The chemical composition of manganoeudialyte was determined by microprobe (WDS). H<sub>2</sub>O content was obtained by the modified Penfield method. The absence of CO<sub>3</sub> groups confirmed by IR data. The average of 12 analyses (range) gave Na<sub>2</sub>O 12.01 (11.39–12.43), K<sub>2</sub>O 0.59 (0.57–0.64), CaO 10.70 (9.73–11.06), MnO 3.51 (3.04–3.88), SrO 3.00 (2.68–3.64), FeO 2.72 (2.45–2.92), Al<sub>2</sub>O<sub>3</sub> 0.41 (0.07–2.79), La<sub>2</sub>O<sub>3</sub> 0.15 (0.03–0.26), Ce<sub>2</sub>O<sub>3</sub> 0.12 (0.03–0.19), Nd<sub>2</sub>O<sub>3</sub> 0.00 (0.00–0.03), SiO<sub>2</sub> 48.70 (48.24–49.14), TiO<sub>2</sub> 0.47 (0.33–0.59), ZrO<sub>2</sub> 12.08 (11.24–12.50), Nb<sub>2</sub>O<sub>5</sub> 1.21 (0.93–1.72), HfO<sub>2</sub> 0.25 (0.15–0.35), F 0.08 (0.00–0.23), Cl 0.99 (0.91–1.06), H<sub>2</sub>O 3.5, –O=(Cl,F) –0.26; sum 100.23 wt%. The empirical formula based on (Si + Al + Zr + Ti + Hf + Nb) = 29 is: H<sub>12.08</sub>Na<sub>12.05</sub>Sr<sub>0.90</sub>K<sub>0.39</sub>La<sub>0.03</sub>Ce<sub>0.02</sub>Ca<sub>3.93</sub>(Mn<sub>1.54</sub>Fe<sub>1.18</sub>)Zr<sub>3.03</sub>Nb<sub>0.28</sub>Al<sub>0.25</sub>Hf<sub>0.04</sub>Ti<sub>0.18</sub>Si<sub>25.20</sub>O<sub>79.40</sub>Cl<sub>0.87</sub>F<sub>0.13</sub>. The simplified end-member formula given as: Na<sub>14</sub>Ca<sub>6</sub>Mn<sub>3</sub>Zr<sub>3</sub>[Si<sub>26</sub>O<sub>72</sub>(OH)<sub>2</sub>]Cl<sub>2</sub>·4H<sub>2</sub>O. Powder X-ray diffraction data for manganoeudialyte were obtained using a Siemens D5000 diffractometer with a position sensitive detector (filtered CuK $\alpha$  radiation). The strongest lines of the X-ray powder diffraction pattern [*d*, Å(*I*%,*hkl*)] are: 11.537(10,101), 6.421(37,104), 4.329(30,205), 3.526(46,027), 3.218(100,208), 3.023(25,042), 1.609(77,4.1.15), 1.605(41,4.0.16) with refined unit-cell parameters: *a* = 14.253(1), *c* = 30.079(4) Å, *V* = 5292(1) Å<sup>3</sup>, space group *R3m*; *Z* = 3. Single-crystal X-ray data were collected using an Xcalibur S diffractometer with a CCD detector (MoK $\alpha$  radiation). Crystal structure has been refined to *R* = 0.033 for 3129 independent reflections with *F* > 3 $\sigma$ (*F*); total 100 940 reflections. Unit cell parameters: *a* = 14.2418(1), *c* = 30.1143(3) Å, *V* = 5289.7(1) Å<sup>3</sup>. The crystal-chemical formula, derived from and consistent with the results of the single-crystal X-ray structure analysis is [Na<sub>11.93</sub>Sr<sub>0.81</sub>(H<sub>3</sub>O)<sub>0.70</sub>K<sub>0.39</sub>Ce<sub>0.07</sub>]<sub>Σ13.90</sub>[Ca<sub>6</sub>]<sub>Σ1.00</sub>[<sup>VI</sup>Mn<sub>1.56</sub><sup>VI</sup>Fe<sub>1.20</sub><sup>VI</sup>Na<sub>0.24</sub>]<sub>Σ3.00</sub>[Zr<sub>3</sub>]<sub>Σ1.00</sub>[<sup>IV</sup>(Si<sub>0.38</sub>Al<sub>0.25</sub>)<sup>VI</sup>(Nb<sub>0.29</sub>Zr<sub>0.08</sub>)]<sub>Σ1.00</sub>[<sup>IV</sup>Si<sub>0.81</sub><sup>VI</sup>Ti<sub>0.19</sub>]<sub>Σ1.00</sub>[Si<sub>24</sub>O<sub>72</sub>][(OH)<sub>2</sub>][(H<sub>2</sub>O)<sub>3.55</sub>Cl<sub>0.88</sub>(OH)<sub>0.84</sub>O<sub>0.40</sub>F<sub>0.13</sub>]<sub>Σ5.80</sub>. Manganoeudialyte is named following the nomenclature of eudialyte group. Mn is prevalent in the group of sites M2 of the group general formula N<sub>1</sub>N<sub>2</sub>N<sub>3</sub>N<sub>4</sub>N<sub>5</sub>M<sub>1</sub>M<sub>2</sub>M<sub>3</sub>M<sub>4</sub>Z<sub>3</sub>[Si<sub>24</sub>O<sub>72</sub>]O<sub>4–6</sub>X<sub>2</sub> (by Johnsen et al., 2003). It has distorted octahedral coordination [MnO<sub>4</sub>(H<sub>2</sub>O)<sub>2</sub>]. Thus manganoeudialyte contains more H<sub>2</sub>O pfu than eudialyte. The main distinction of manganoeudialyte from another non-centrosymmetric Mn-dominant mineral kentbrooksites is the prevalence of Si in M3 and M4 sites. Both the mineral and its name have been approved by the IMA CNMNC (IMA 2009-039). Type material is deposited in the Museum of Geosciences, Institute of Geosciences, University of São Paulo, São Paulo, Brazil. **D.B.**

#### MEJILLONESITE\*

D. Atencio, N.V. Chukanov, F. Nestola, T. Witzke, J.M.V. Coutinho, A.E. Zadov, R.R. Contreira Filho, and G. Färber (2012) Mejillonesite, a new acid sodium, magnesium phosphate mineral, from Mejillones, Antofagasta, Chile. *Am. Mineral.*, 97, 19–25.

Mejillonesite (IMA 2010-068) occurs very sparsely as isolated crystal aggregates in thin zones on the north slope of Cerro Mejillones (23°05′ 44.56″S 70°30′ 53.78″W), Mejillones Peninsula, Mejillones, Antofagasta, II Region, Chile. Associated minerals are bobierite, opal, clinoptilolite-Na, clinoptilolite-K, and gypsum. Mejillonesite occurs as orthorhombic prismatic and elongated thick tabular crystals up to 6 mm long, usually intergrown in radiating aggregates. The dominant form is the pinacoid {100}. Prisms {*hk0*}, {*h0l*}, and {*0kl*} are also observed. Twinning was not observed. The crystals are colorless, their streak is white, and the luster is vitreous. The mineral is transparent. It is non-fluorescent under both long- and short-wave ultraviolet light. The Mohs hardness is 4, tenacity is brittle. The cleavage is perfect on {100}, good on {010} and {001}, parting was not observed and fracture is stepped. The measured density is 2.36(1) g/cm<sup>3</sup> by flotation in heavy liquids; the calculated density is 2.367 g/cm<sup>3</sup> based on the empirical formula and unit-cell parameters derived from the single-crystal structure study. In transmitted light, mejillonesite is biaxial (–) and has  $\alpha = 1.507(2)$ ,  $\beta = 1.531(2)$ ,  $\gamma = 1.531(2)$ ,  $2V(\text{meas}) = 15(10)^\circ$ ,  $2V(\text{calc}) = 0^\circ$  (589 nm). The optical orientation is *X* = **a**, *Z* = elongation direction. The mineral is non-pleochroic. Dispersion is *r* > *v*, medium. The chemical composition is (by EDS, H<sub>2</sub>O by the Alimarin method, wt%): Na<sub>2</sub>O 9.19, MgO 26.82, P<sub>2</sub>O<sub>5</sub> 46.87, H<sub>2</sub>O 19, total 101.88. The empirical formula, based on 11 oxygen atoms, is Na<sub>0.93</sub>Mg<sub>2.08</sub>(PO<sub>3</sub>OH)<sub>1.00</sub>(PO<sub>4</sub>)<sub>1.06</sub>(OH)<sub>0.86</sub>·0.95H<sub>3</sub>O<sub>2</sub>. The strongest eight X-ray powder-diffraction lines [*d*<sub>obs</sub> in Å(*I*<sub>obs</sub>%,*hkl*)] are: 8.095(100,200), 6.846(9,210), 6.470(8,111), 3.317(5,302), 2.959(5,132), 2.706(12,113), 2.157(19,333), and 2.153(9,622). The crystal structure was solved on a single crystal (*R* = 0.055) and gave the following data: orthorhombic, *Pbca*, *a* = 16.295(1), *b* = 13.009(2), *c* = 8.434(1) Å, *V* = 1787.9(4) Å<sup>3</sup>, *Z* = 8.

Type material is deposited in the Museu de Geociências, Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, 05508-080 São Paulo, SP, Brazil, catalog number DR712, and in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia, registration number 4043/1 (fragment of holotype). **K.T.T.**

#### MENCHETTIITE\*

L. Bindi, F.N. Keutsch, and P. Bonazzi (2012) Menchettiite, AgPb<sub>2.40</sub>Mn<sub>1.60</sub>Sb<sub>3</sub>As<sub>2</sub>S<sub>12</sub>, a new sulfosalt belonging to the lillianite series from the Uchucchacua polymetallic deposit, Lima Department, Peru. *Am. Mineral.*, 97, 440–446.

Menchettiite (IMA 2011-009), ideally AgPb<sub>2.40</sub>Mn<sub>1.60</sub>Sb<sub>3</sub>As<sub>2</sub>S<sub>12</sub>, is a new mineral from the Uchucchacua polymetallic deposit, Oyon district, Catajumbo, Lima Department, Peru. It occurs as black, anhedral to subhedral grains up to 200 μm across, closely associated with orpiment, tennantite/tetrahedrite, other unnamed minerals of the system Pb–Ag–Sb–Mn–As–S, and calcite. Menchettiite is opaque with a metallic luster and possesses a black streak. It is brittle, with uneven fracture; the Vickers microhardness (VHN100) is 128 kg/mm<sup>2</sup> (range 119–136) (corresponding to a Mohs hardness of 2½–3). The calculated density is 5.146 g/cm<sup>3</sup> (on the basis of the empirical formula). In plane-polarized incident light, menchettiite is weakly to moderately birefractant and weakly pleochroic from dark gray to a dark green. Internal reflections are absent. Between crossed polarizers, the mineral is anisotropic, without characteristic

rotation tints. Reflectance percentages ( $R_{\min}$  and  $R_{\max}$ ) for the four standard COM wavelengths are 33.1, 39.8 (471.1 nm), 31.8, 38.0 (548.3 nm), 30.9, 37.3 (586.6 nm), and 29.0, 35.8 (652.3 nm), respectively. Menchettiite is monoclinic, space group  $P2_1/n$ , with unit-cell parameters:  $a = 19.233(2)$ ,  $b = 12.633(3)$ ,  $c = 8.476(2)$  Å,  $\beta = 90.08(2)^\circ$ ,  $V = 2059.4(8)$  Å<sup>3</sup>,  $a:b:c$  1.522:1:0.671,  $Z = 2$ , and it is twinned on  $\{100\}$ . The crystal structure was refined to  $R = 0.0903$  for 2365 reflections with  $F_o > 4\sigma(F_o)$  making it topologically identical to those of ramdohrite, uchucchacuaite, and fizélyite. The six strongest X-ray powder-diffraction lines [ $d_{\text{obs}}$  in Å( $I_{\text{obs}}\%$ ,  $hkl$ )] are: 3.4066(39,  $\bar{3}12$ ), 3.4025(39,  $312$ ), 3.2853(100,  $520$ ), 2.8535(50,  $\bar{2}32$ ), 2.8519(47,  $232$ ), and 2.1190(33,  $004$ ). Electron-microprobe analyses gave the chemical formula  $\text{Ag}_{1.95}\text{Cu}_{0.01}\text{Pb}_{4.81}\text{Mn}_{3.20}\text{Fe}_{0.02}\text{Zn}_{0.01}\text{Sb}_{6.09}\text{As}_{3.94}\text{Bi}_{0.01}\text{S}_{23.95}\text{Se}_{0.01}$ , on the basis of 44 atoms and according to the structure refinement results.

The mineral was named menchettiite after Silvio Menchetti (b. 1937), Professor of Mineralogy and Crystallography at the University of Florence, in recognition of his recent contribution to systematics of sulfosalts. Holotype material is deposited in the collections of the Museo di Storia Naturale, Sezione di Mineralogia e Litologia, Università di Firenze, via La Pira 4, I-50121, Firenze, Italy, catalog number 3109/I. **K.T.T.**

#### SARRABUSITE\*

M. Gemmi, I. Campostrini, F. Demartin, T. Gorelik, and C.M. Gramaccioli (2012) Structure of the new mineral sarrabusite,  $\text{Pb}_5\text{CuCl}_4(\text{SeO}_3)_4$ , solved by manual electron-diffraction tomography. *Acta Cryst.*, B68, 15–23.

The new mineral sarrabusite is the first to have its structure determined by the novel method of electron tomography, specifically precession electron diffraction (PED), a modification of transmission electron microscopy in which the sample is precessed about the beam in a known orientation. Precession at a sufficiently large angle from a zone axis reduces dynamical scattering effects considerably and allows meaningful intensities to be scaled for structure solution and refinement. This technique has already been applied successfully to several organic and inorganic compounds and has great potential for the characterization of very small crystals (<10 nm) for which conventional single-crystal X-ray methods fail. Sarrabusite was found in a hydrothermal ore body hosted by Palaeozoic black shales at the Bacchu Locci Pb-As mine, near Villaputzu, Sardinia. It occurs as lemon-colored spherical aggregates (<100 mm diameter) of tiny tabular crystals (<10 nm). The mineral has a white streak and a vitreous luster. It is translucent and non-fluorescent. The Bacchu Locci mine is well-known for selenite minerals, such as orlandiite,  $\text{Pb}_3\text{Cl}_4(\text{SeO}_3) \cdot \text{H}_2\text{O}$ , and francisite,  $\text{Cu}_3\text{Bi}(\text{SeO}_3)_2\text{O}_2\text{Cl}$ . Other minerals occurring with sarrabusite are chalcomenite  $\text{Cu}(\text{SeO}_3) \cdot 2\text{H}_2\text{O}$ , anglesite, and pseudoboleite  $\text{Pb}_{31}\text{Cu}_{24}\text{Cl}_{62}(\text{OH})_{48}$ . The extremely small dimensions

of sarrabusite crystals precluded study by single-crystal XRD.

The empirical composition of sarrabusite determined by electron microprobe analysis (WDS) is (wt%): Cl 8.41, PbO 61.26,  $\text{SO}_2$  0.14, CdO 1.44, CuO 4.29,  $\text{SeO}_2$  24.84. The structure was determined on an anhedral crystal flake <1 mm long by two alternative approaches based upon electron tomography, one using an “automated diffraction tomography” (ADT) coupled with PED, and the other “manual” electron tomography in which the user has direct control of beam conditioning and sample orientation, and selected-area electron diffraction patterns (SAEDPs) are collected. Both APD/PED and the manual approach are suitable for ab initio structure solution. The structure determinations using both approaches gave comparable results. Diffraction patterns are consistent with monoclinic space groups  $C2/c$  and  $Cc$ . The structure was solved and refined isotropically in space group  $C2/c$  to final agreement indices of 0.333 (AED) and 0.313 (manual). An attempt to solve in  $Cc$  did not result in any improvement. Such high agreement indices are typical of structures determined from electron-diffraction data. However, the structure topology derived is crystal-chemically sound. Unit-cell parameters were refined from X-ray powder diffraction data (Rigaku DMAX-II,  $\text{CuK}\alpha$ ):  $a = 24.917(3)$ ,  $b = 5.506(1)$ ,  $c = 14.242(2)$  Å,  $\beta = 101.77(1)^\circ$ ,  $V = 1912.7(3)$  Å<sup>3</sup>. The strongest lines in the X-ray powder diffraction pattern are [ $d_{\text{obs}}$  in Å( $I_{\text{obs}}\%$ ,  $hkl$ )]: 3.034(100,  $802$ ), 3.685(60,  $\bar{5}11$ ), 2.728(38,  $\bar{5}14$ ), 2.043(28,  $\bar{8}22$ ), 3.314(20,  $\bar{4}04$ ), 2.079(18,  $714$ ), 2.106(15,  $116$ ), 2.418(12,  $604$ ), 2.440(10,  $\bar{9}12$ ). Based upon the chemical composition and structure determination the empirical crystal-chemical formula based on 16 anions pfu is  $(\text{Pb}_{4.83}\text{Cd}_{0.20})_{\Sigma=5.03}\text{Cu}_{0.95}(\text{Se}_{3.94}\text{S}_{0.04})_{\Sigma=3.98}\text{O}_{11.83}\text{Cl}_{4.17}$ , and the corresponding ideal structural formula is  $\text{Pb}_5\text{CuCl}_4(\text{SeO}_3)_4$ , and there are 4 formula units in the unit-cell.

There are three Pb, one Cu, two Se, two Cl, and six O sites in the asymmetric unit. The three Pb polyhedra have coordinations of  $\text{PbO}_4\text{Cl}_4$ ,  $\text{PbO}_6\text{Cl}_2$ , and  $\text{PbO}_8$ , all having square-pyramidal configurations. Copper occupies a Jahn-Teller distorted  $\text{CuO}_4\text{Cl}_2$  octahedron, with two long Cu-Cl bonds (2.48 and 2.94 Å). The two Se atoms form  $\text{SeO}_3$  flattened trigonal pyramids. The structure topology of sarrabusite consists of (010) layers consisting of two distinct alternating components: (1) a straight (“S”) chain of edge-sharing  $\text{PbO}_8$  and  $\text{CuO}_4\text{Cl}_2$  polyhedra extending  $\parallel c$ ; (2) a zigzag (“Z”) chain of corner-sharing  $\text{PbO}_4\text{Cl}_4$  and  $\text{PbO}_6\text{Cl}_2$  polyhedra.  $\text{SeO}_3$  groups link two Z chains to form a ribbon extending  $\parallel c$ . Linkages between S and Z chains involve shared corners and another  $\text{SeO}_3$  group. Finally, connections between (010) polyhedral layers are achieved by superimposing (1) Z chains of different layers with face-sharing of their polyhedra, and (2) S chains upon the rows of  $\text{SeO}_3$  groups bridging Z chains. The structure determination of sarrabusite is a good example of how a correct new structure topology can be identified and meaningfully quantified for very difficult materials that are intractable using conventional methods. **M.W.**