New Mineral Names*

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Chopinite*

E.S. Grew, T. Armbruster, O. Medenbach, M.G. Yates, C.J. Carson (2007) Chopinite, $[(Mg,Fe)_3](PO_4)_2$, a new mineral isostructural with sarcopside, from a fluorapatite segregation in granulite-facies paragneiss, Larsemann Hills, Prydz Bay, East Antarctica. Eur. J. Mineral., 19, 229–245.

A Mg-dominant analog of sarcopside, chopinite, occurs in one of many isolated fluorapatite segregations in a quartz mass roughly 10 cm thick and 3 m long in a granulite-facies paragneiss from Brattnevet, Larsemann Hills, Prydz Bay, East Antarctica. Grains are mostly anhedral and range in size from 0.1×0.3 mm to 0.2×0.6 mm. The chopinite grains are partially altered and their original form obscured; the present grains could have been aggregates of two or three single crystals. Chopinite is colorless and transparent, biaxial (–), α 1.595(2)°, β 1.648(2)°, γ 1.656(2)° (589 nm). A representative electron-microprobe analysis is SiO_2 0.32, P_2O_5 47.32, Al_2O_3 0.05, MgO 30.35, MnO 0.15, FeO 20.99, CaO 0.35, F 0.02, Cl 0.01, Sum 99.54 wt%, which gives $Ca_{0.02}Mg_{2.20}Fe_{0.86}Mn_{0.01}Si_{0.02}P_{1.95}O_8$. Cell parameters $a = 5.9305(7)$ Å, $b = 4.7583(6)$ Å, $c = 10.2566(10)$ Å, $\beta = 90.663(9)°$, space group $P2_1/c$, $D_{calc} = 3.34$ g/cm³, $Z = 2$. The structure was solved and refined using 567 reflections $[I > 2\sigma(I)]$ single-crystal data to $R1 = 0.024$, $wR2 = 0.058$. The strongest lines in the powder pattern $[d$ in Å, (I_{calc}), $(hkl)]$ are 5.92 (42) (100), 3.84(100) (102), 3.48(52) $(11\bar{1}, 012, 111)$, 2.51 (72) (113, 113), 2.44 (73) $(21\bar{1}, 211)$.

Chopinite and sarcopside are of the olivine structure type, but with ordered vacancies and strongly disordered octahedral due to the 5+ valence for P; which results in marked ordering of Mg at M2 and Fe^{2+} at M1. M2 octahedra form unbroken edge-sharing chains parallel to a, whereas M1 octahedra alternate with vacant octahedra; this vacant octahedral (M1') is also present in sarcopside. Holotype materials (sample no. 121401E and thin section 121401E4) is deposited in the Musée de Minéralogie, Ecole des Mines de Paris as catalog number M 73096. **K.T.T.**

Fluorcalciobritholite*

I.V. Pekov, M. Pasero, A.N. Yaskovskaya, N.V. Chukanov, D.Yu. Pushcharovsky, S. Merlino, N.V. Zubkova, N.N. Kononkova, Y.P. Men'shikov, A.E. Zadov (2007) Fluorcalciobritholite, $(Ca,REE)_5[(Si,P)O_4]_3F$, a new mineral: description and crystal chemistry. Eur. J. Mineral., 19, 95–103.

A new mineral in the britholite-group has been found at Mount Kukisvumchorr, Khibiny alkaline complex, Kola Peninsula, Russia. Electron microprobe gave the following empirical formula based on $[Si + P + S] = 3$ apfu: $[Ca_{2.80}(Ce_{0.93}La_{0.54}Nd_{0.26}Y_{0.18}Pr_{0.08}Sm_{0.03}Gd_{0.03}Dy_{0.02}Yb_{0.02}Er_{0.01})_{\Sigma2.12}Th_{0.04}Mn_{0.03}Sr_{0.02}]_{\Sigma4.99}[(Si_{1.94}P_{1.06})_{\Sigma3}O_{12}][F_{0.76}O_{0.22}Cl_{0.01}]_{\Sigma0.99}$ $(Z = 2)$, or ideally $Ca_3Ce_2(SiO_4)_2(PO_4)F$. Fluorcalciobritholite forms long-prismatic hexagonal crystals up to 0.5×10 mm; the main crystal form is the hexagonal prism {10-10}. The mineral is transparent, with a pale pinkish to brown color and a white streak. Optically it is uniaxial (–) with ω 1.735(5), ε 1.730(5), under a polarizing microscope, it is colorless, and non-pleochroic. Mohs' hardness is 5.5 and $D_{obs} = 4.2(1)$ g/cm³, $D_{calc} = 4.3$ g/cm³. The mineral is hexagonal, space group $P6_3/m$, with $a = 9.580(7)$, $c = 6.985(4)$ Å (single-crystal diffractometry). The strongest lines of the X-ray powder pattern $[d$-values (in Å) (I) $(hkl)]$ are: 3.51 (45) (002), 3.15 (70)(102), 2.85 (100)(211, 121), and 2.78 (60)(300). The basic features of the structure of fluorcalciobritholite are common to all minerals of the apatite-britholite family. It is the analog of fluorbritholite-(Ce), $(REE,Ca)_5[(Si,P)O_4]_3F$, with Ca prevailing over ΣREE. It can also be considered as the analog of fluorapatite, $Ca_5(PO_4)_3F$, with Si prevailing over P. Usually these minerals contain significant impurities (thorium, and sometimes also uranium), and therefore tend to be metamict.

The holotype specimen of fluorcalciobritholite from this study has been deposited in the Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (registration no. 3420/1). **K.T.T.**

Gillardite*

M.E. Clissold, P. Leverett, P.A. Williams, D.E. Hibbs, D.E. Nickel, H. Nickel (2007) The structure of gillardite, the Ni-analog of herbertsmithite, From Widgiemooltha, Western Australia. Can. Min., 45, 317–320.

Gillardite is the Ni analog of herbertsmithite $[Cu_3NiCl_2(OH)_6$ and $Cu_3ZnCl_2(OH)_6]$, respectively. This paper reports the results of a crystal structure determination of a sample from the 1232N deposit at Widgiemooltha, Western Australia. The formal description of the new mineral will be published elsewhere. The material used for this study was loaned from the Museum of Western

Australia (Gartrell spec. no 8774).

Electron microprobe analyses of the sample give the following results: CuO, 51.4–58.6 (ave. 55.2); NiO, 13.7–17.5 (ave. 15.3); CoO, 0.1–0.4 (ave. 0.2); Fe, <0.1–0.3 (ave. 0.1); Cl, 16.2–18.8 (ave. 17.46), giving formulas that range from $(Cu_{3.189}Ni_{0.803}Co_{0.002}Fe_{0.006})Cl_2(OH)_6$ to $(Cu_{2.922}Ni_{1.058}Co_{0.020})Cl_2(OH)_6$, with an average result of all analyses of $(Cu_{3.081}Ni_{0.903}Co_{0.012}Fe_{0.004})Cl_2(OH)_6$.

Structure refinement was carried out on a $0.22 \times .21 \times 0.23$ mm crystal using a Bruker SMART CCD diffractometer at 273(2) K with graphite-monochromated MoKα radiation ($\lambda = 0.71073$ Å). Gillardite is rhombohedral with the space group $R\bar{3}m$ and cell dimensions (in angstroms) of $a = 6.8364(1)$, $c = 13.8469$, and $V = 560.41$ Å³. $Z = 3$, $D_{calc} = 3.76$.

The structure of gillardite is equivalent to the $R\bar{3}m$ substructure of paratacamite and isostructural with herbertsmithite. Electron density is incapable of distinguishing between Ni and Cu, but the nature of the cation sites in the structure allow placement of Ni in the non-Jahn-Teller distorted MO_6 octahedral site and Cu in the MO_4Cl site. **G.P.**

MARRUCCIITE*

P. Orlandi, Y. Moelo, I. Campostrini, A. Meerschaut (2007) Lead-antimony sulfosalts from Tuscany (Italy). IX. Marrucciite, $Hg_3Pb_{16}Sb_{18}S_{46}$, a new sulfosalt from Buca della Vena mine, Apuan Alps: Definition and crystal structure. Eur. J. Mineral., 19, 267–279.

Marrucciite is a new sulfosalt discovered in the Fe-Ba deposit of Buca della Vena, Apuan Alps, Italy; which is also the type locality for several other lead-antimony sulfosalts. These sulfosalts form in the latest hydrothermal stage, within small veinlets crosscutting dolomitic lenses interstratified in Ba-Fe ore. Like rouxelite, the other coexisting Hg bearing sulfosalt, marrucciite was formed by hydrothermal process during the Apenninic tectono-metamorphic event. Marrucciite is monoclinic, space group $C2/m$, with $a = 48.32(1)$ Å, $b = 4.117(1)$ Å, $c = 24.056(5)$ Å, $Z = 2$, $D_{calc} = 6.00$ g/cm³ (density could not be directly measured due to the paucity of the same). The structure was solved and refined using 3627 observed [$I \geq 2\sigma(I)$] single-crystal data to $R1 = 9.56\%$. Main lines of the X-ray diffraction powder pattern [d (in Å), I (main hkl)]: 4.02, 33 ($\bar{1}2.0.3$, 802); 3.480, 64 (803, 604); 3.418, 88 ($\bar{6}07$, 10.0.2, $\bar{3}14$); 3.106, 31 ($\bar{9}.1.4$); 2.994, 100 ($\bar{1}1.1.2$); 2.922, 41 (11.1.1); 2.056, 52 (020); 1.764, 41 (627). Electron microprobe analysis gave (mean of four spot analyses): Cu 0.18(12), Hg 7.90(9), Pb 42.41(7), Sb 29.71(7), S 19.47(18), Cl 0.06(2), sum 99.73(14) wt%. The chemical formula [basis: 46 (S + Cl)] is $Cu_{0.21}Hg_{2.98}Pb_{15.46}Sb_{18.44}S_{45.87}Cl_{0.13}$, giving the ideal formula $Hg_3Pb_{16}Sb_{18}S_{46}$. Hardness could not be determined due to the small size and scarcity of the crystals.

The general architecture of marrucciite corresponds to the SnS-type monoclinic derivatives of the primitive hexagonal $Ba_{12}Bi_{24}S_{48}$. The central column has the composition $HgPb_4Sb_2S_4$; it is a distorted derivative of PbS archetype, three-atoms thick and two octahedra large. It is surrounded with a sub-hexagonal crown of 12 S atoms from the six neighboring rods. These six rods belong to three types (A, B, and C), of the general formula $Me_{10}S_{14}$. These rods are four-atoms thick, and three (hemi-) octahedra large, but each has a distinct chemical and geometrical features.

Marrucciite differs essentially:

(1) By the replacement of the central column Bi_6S_6 around the empty hexagonal axis by a Hg-filled pseudo-or-orthorhombic one, $HgPb_4Sb_2S_4$.

(2) By the SnS-type organization of the C rod of marrucciite, due to the (5 + 2) asymmetric coordination of Sb (strong stereo-chemical activity of the lone electron pair), while in stereochemical activity of the lone pair), while in $Ba_{12}Bi_{24}S_{48}$, all Bi atoms present a distorted octahedral coordination. As a result, the two C rods break down the hexagonal periodicity around the central column: the right part of the marrucciite motif is 3D-topologically identical to the right part of $Ba_{12}Bi_{24}S_{48}$ motif, while in the left part all atoms are shifted by $\Delta y = \frac{1}{2}$ against the right part.

The name is in honor of Angelo Marrucci (1956–2003), a mineral collector in recognition for his contributions to the mineralogy of Tuscany. Type material of marrucciite is deposited at Museo di Storia Naturale e del Territorio, University of Pisa (Italy).

Discussion: This mineral had been described in previous manuscripts [Haber and Babcan (1971); Haber (1980); Haber et al. (1999)] as "gelnicite" and "gelnicaite" from the Slovakian locality Gelnica but there had not been an application to the CNMMN for approval as a valid species. **K.T.T.**

PUMPELLYITE-(AL)*

F. Hatert, M. Pasero, N. Perchiazzi, T. Theye (2007) Pumpellyite-(Al), a new mineral from Bertrix, Belgian Ardennes. Eur. J. Mineral., 19, 247–253.

An Al-rich pumpellyite from the quarry "Carrière de la Flèche," 3 km northwest of the Bertix village, Ardennes Mountains, Belgium has been described. Occurrences of Al-rich pumpellyite were previously reported in the literature, and the crystal structures of several Al-rich pumpellyite samples were published elsewhere (Galli and Alberti 1969; Yoshiasa and Matsumoto 1985; Artioli and Geiger 1994; Artioli et al. 1996), but no formal proposal had been submitted to the CNMMN until this study. The mineral occurs in late-formed veins associated with calcite, K-feldspar, and chlorite in aggregates, up to 5 mm in diameter. Electron-microprobe analyses gave SiO_2 37.52, Al_2O_3 25.63, MgO 1.99, FeO 4.97, MnO 0.11, CaO 23.21, BaO 0.01, Na_2O 0.03, K_2O 0.02, H_2O_{calc} 6.71, total 100.20 wt%. The resulting empirical formula, calculated on the basis of eight cations, is $(Ca_{1.99}Na_{0.01})_{\Sigma2.00}(Al_{0.42}Fe^{2+}_{0.33}Mg_{0.24}Mn_{0.01})_{\Sigma1.00}Al_{2.00}(SiO_4)(Si_2O_7)(OH)_{2.42} \cdot 0.58$ H_2O or ideally $Ca_2(Al,Fe^{2+},Mg)Al_2(SiO_4)(Si_2O_7)(OH,O)_2 \cdot H_2O$. Unit-cell parameters are $a = 8.819(2)$, $b = 5.898(2)$, $c = 19.126(6)$ Å, $\beta = 97.26(3)°$, space group $A2/m$. The eight strongest lines in the powder pattern [d-values (in Å)(I)(hkl)] are 4.371(65)(200), 3.787(80)(202), 3.040(70)(204), 2.912(95)(300), 2.895(100)(30$\bar{2}$), 2.731(40)(20$\bar{6}$), 2.630(35)(31$\bar{1}$), and 2.191(45)(40$\bar{2}$). Pumpellyite-(Al) is biaxial (+), $\alpha = 1.678(2)$, $\beta = 1.680(2)$, $\gamma = 1.691(1)°$ ($\lambda = 590$ nm), colorless in thin-section. The mineral is transparent to translucent, with a vitreous luster and has a colorless streak. The estimated Mohs hardness is 5.5. The density could not be directly measured due to the fibrous habit of the mineral; the D_{calc} is 3.24 g/cm³.

The basic features of the crystal structure of pumpellyite-(Al) are identical to those of the other members of the pumpellyite group. The structure is built up by columns of edge-sharing MO_6

(M = Al^{3+}, Fe^{2+}, Mg^{2+}) octahedra running along [010], which are linked via ortho- and disilicate groups, and by Ca^{2+} cations located on the 7-coordinated sites. The M1 and M2 sites in pumpellyite-(Al) contain Al as the predominant cation. The type material is stored in the collection of the Laboratory of Mineralogy, University of Liege, Belgium (no. 20327). **K.T.T.**

Si-deficient, OH-substituted, boron-bearing vesuvianite

E.V. Galuskin, I.O. Galuskina, K. Stadnicka, T. Armbruster, M. Kozanecki (2007) The crystal structure of Si-deficient, OH-substituted, boron-bearing vesuvianite from the Wiluy river, Sakha-Yakutia, Russia. Can. Mineral., 45, 239–248.

The Si-deficient, OH-substituted, boron-bearing vesuvianite occurs as light cream somewhat well-formed subindividual crystals. Silicon deficient vesuvianite forms in association with an epitactic layer of hibschite covering grossular. The crystals have a spongy heterogeneous nature. The average of eight electron microprobe analyses gave SiO_2 33.53, SO_3 0.07, TiO_2 0.06, B_2O_3 0.98, Al_2O_3 16.18, MgO 4.52, CaO 37.11, MnO 0.40, Fe_2O_3 1.6, H_2O 4.69, F 0.24, Cl 0.12, O = F + Cl 0.12, sum 99.38%. The simplified ideal formula is $Ca_{19}(Al,Mg,Fe,Mn)_{13}B_{<2.5}[(SiO_4)_{10-x}(OH)_{4x}](Si_2O_7)_4(OH,O,F,Cl)_{10}$ where x < 3.

The structure was solved by single-crystal X-ray diffraction on a prismatic crystal (0.18 × 0.18 × 0.11 mm) with the help of a Bruker SMART CCD single-crystal X-ray diffractometer with graphite-monochromated $MoK\alpha$ radiation source. Si-deficient vesuvianite is tetragonal, $P4/nnc$, a = 15678(1), c = 11.828(1) Å, V = 2907.3(3) $Å^3$ with a refined unit-cell to R = 0.037 for 1175 reflections with $F > 4\sigma(F)$. The studied crystals differ from regular vesuvianite by its low silicon content of 16 pfu compared to 18. Bond-length comparisons proved to be consistent with hydrogarnet-type defects, where SiO_4 is replaced by H_4O_4. This defect increases the a-axis with increasing proportion of vacancies at the Si site, which increase the size of the tetrahedra. This effect is cancelled on the c-axis by the compression of adjacent Ca-bearing dodecahedra. The Raman spectra show a more isotropic polarization of the OH-stretching area at 3650 cm^{-1}, which is attributed to OH groups being involved in hydrogranet-type defect.

Si-deficient vesuvianite was found on the bank of the Wiluy River, Sakha-Yakutia, Russia, in rodingite-like rocks. In these rocks it occurs in three different assemblages; within tetrahedal pseudomorphs of hibschite after a wadalite-like mineral, included in a polymineralic pseudomorph after boron-enriched gehlenite and in thin zones on crystalline wiluite. **R.R.**

Synthetic Np^{6+} phosphates analogs of autunite group minerals

T.Z. Forbes, P.C. Burns (2007) The crystal structures of $X(NpO_2)$ $(PO_4)(H_2O)_3$ (X = K^+, Na^+, Rb^+, NH_4^+) and their relationship to the autunite group. Can. Mineral., 45, 471–477.

Four Np^{6+} phosphates were synthesized using hydrothermal methods. Their compositions were $X(NpO_2)(PO_4)(H_2O)_3$ where

X = K^+, Na^+, Rb^+, NH_4^+ ($KP1$, $NaP1$, $RbP1$, NH_4P1). The reagents used were KCl, NaCl, RbCl, NH_4Cl for cations, apatite $Ca_5(PO_4)_3F$ for phosphate groups and a solution of Np^{5+} in a 1 M HCl solution for neptunium groups. Red platy crystals up to 800 μm in size were synthesized.

Single-crystal work using a Bruker three-circle X-ray diffractometer equipped with a CCD detector was performed on each synthetic. All four compositions are tetragonal and crystallize in space group $P4/nnc$. Their unit cells are respectively; $KP1$ a = 6.9564(8), c = 17.826(4) Å, V = 862.6(2) $Å^3$, Z = 4 refined to a R_1 = 0.042 for 831 unique reflections; $NaP1$ a = 7.005(1), c = 16.986(4) Å, V = 833.6(3) $Å^3$, Z = 4 refined to a R_1 = 0.051 for 856 unique reflections; $RbP1$ a = 7.031(4), c = 17.87(2) Å, V = 884(1) $Å^3$, Z = 4 refined to a R_1 = 0.066 for 798 unique reflections; NH_4P1 a = 6.9843(6), c = 18.023(3) Å, V = 879.2(2) $Å^3$, Z = 4 refined to a R_1 = 0.023 for 857 unique reflections. These different structures are made of $[(NpO_2)(PO_4)]$-sheets, which are identical to uranyl phosphate sheets found in autunite group minerals. The monovalent cations and H_2O groups serve as linkage between the sheets.

^{237}Np is a significant source of radiation found in geological repository system and, due to the high solubility of Np^{5+}, it could be dissolved into the groundwater. The formation of neptunyl phosphates could potentially reduce the lost of ^{237}Np from the repository as observed with uranium. **R.R.**

Vihorlatite*

R. Skála, P. Ondruš, F. Veselovský, Z. Táborský, R. ĎuĎa (2007) Vihorlatite, $Bi_{24}Se_{17}Te_4$, a new mineral of the tetradyamite group from Vihorlat Mts., Slovakia. Eur. J. Mineral., 19, 255–265.

The new mineral vihorlatite is found in the region of volcanic Vihorlat Mountains in eastern Slovakia. It occurs in quartz-opal veinlets or secondary quartzites as anhedral grains or lamellar crystals 1–2 mm (up to 8 mm) flattened parallel to (0001). Vihorlatite has a perfect cleavage parallel to (0001) and crystals are frequently bent and display deformation lamellae in polished section. Average chemical composition Bi 71.5, Se 21.4, Te 8.1, S 0.8, Au 0.01, Ag 0.01, Sb 0.04, total 101.86 wt%, results in an empirical formula $Bi_{21.9}Se_{17.4}Te_{4.1}S_{1.6}$. The mineral is trigonal, with space group $P\bar{3}m_1$. The unit-cell dimensions refined from powder data are a = 4.2797(9) Å and c = 87.01(2) Å. For Z = 1, D_{calc} = 7.850(3) g/cm³, D_{meas} = 8.0(2) g/cm³. The five strongest diffraction lines are [d (Å), I/I_0, (hkl)]: 4.55, 55.4, (0.0.19); 3.116, 100, (1.0.15); 2.282, 75.5, (0.1.30); 1.934, 42.8, (1.1.19) (0.0.45); 1.767, 31.5, (0.2.15).

Vihorlatite is a new member of the tetradymite group, which includes minerals of layered trigonal bismuth (±Ag, Pb)-chalcogenides. The crystal structure of vihorlatite is derived from that of Bi_8Se_7 archetype though this model requires a substantial Se ↔ Bi substitution. A general crystallochemical formula, reflecting individual planar atomic layers stacked perpendicular to the c-axis is $(Bi_2)_p(Bi_2X_3)_q$, where p, q, = <1,2,3…> and X = Se, Te, S. The type material is deposited in the mineral collection of the National Museum in Prague, Czech Republic under the catalog number P1N 84444 and the acquisition number P1p 5/89. **K.T.T.**

NEW DATA

2REEPO$_4$-CATH(PO$_4$)$_2$-2THSIO$_4$ SYSTEM*

K. Linthout (2007) Tripartite division of the system 2REEPO$_4$-CaTh(PO$_4$)$_2$-2ThSiO$_4$, discreditation of brabantite, and recognition of cheralite as the name for members dominated by CaTh(PO$_4$)$_2$. Can. Mineral., 45, 503–508.

The revised nomenclature for the system 2REEPO$_4$-CaTh(PO$_4$)$_2$-2ThSiO$_4$, was proposed and approved by the CNMMN under reference number IMA 2005/F. The former system by Bowie and Horne (1953, Min. Mag., 30, 93–99,) includes a sixfold division that comprises three end-members and three intermediate composition areas. End-members were 2REEPO$_4$ = monazite, CaTh(PO$_4$)$_2$ = brabantite, 2ThSiO$_4$ = huttonite, cheralite as intermediate composition between monazite and brabantite, and two undescribed intermediate compositional areas. This classification does not conform to the CNMMN rules that a solid solution series be named based on the dominant end-members in their respective compositions and that ternary solid-solution series should include no more than three mineral names. The new tripartite system is now defined as 2REEPO$_4$ = monazite, CaTh(PO$_4$)$_2$ = cheralite, 2ThSiO$_4$ = huttonite without intermediate species.

The name cheralite was assigned to the CaTh(PO$_4$)$_2$ dominant composition since the type cheralite composition is now within that range and it has chronological priority over brabantite, which is therefore discredited. **R.R.**

BI-PB TELLUROSULFIDES

N.J. Cook, C.L. Ciobanu, C.J. Stanley, W.H. Paar, K. Sundblad, (2007) Compositional data for Bi-Pb tellurosulfides, Can. Mineral., 45, 417–435.

This paper presents new compositional data for Bi-Pb tellurides and complex sulphosalt intergrowths from St. David's mine, Clogau, Wales, Iilijärvi (part of the Ojivari orefield), Finland and Fragant, Carinthia province, Austria. The material from Clogau exhibits an almost complete range of compositions from alexite (PbBi$_2$Te$_2$S$_2$) to tetradymite (Bi$_2$Te$_2$S). Sulphosalt intergrowths from Iilijärvi have a compositional range from Pb$_5$Bi$_4$Te$_4$S$_7$–Pb$_7$Bi$_4$Te$_4$S$_9$ and are associated with aleksite in a matrix of giessenite, galena and cosalite. Samples from the Fragant deposit contain several Bi-Pb tellurosulphides, aleksite being the most common, followed by unnamed phases with compositions close to Pb$_3$Bi$_4$Te$_4$S$_5$, Pb$_5$Bi$_4$Te$_4$S$_7$, and Pb$_6$Bi$_4$Te$_4$S$_8$. They occur as inclusions in galena and are associated with lillianite, cosalite, felbertalite, and aikinite.

The authors use the compositional data from the three occurrences to suggest two scenarios. In the first they posit the existence of an incremental chemical series with the general formula Pb$_N$Bi$_4$Te$_4$S$_{N+2}$. Alternatively the data represent compositions over a continuous compositional series. If the first scenario were correct, the first four members of the series (N = 0–4) would correspond to tetradymite, unnamed PbBi$_4$Te$_4$S$_3$, aleksite, unnamed Pb$_3$Bi$_4$Te$_4$S$_5$, and saddlebackite, (Pb$_2$Bi$_2$Te$_2$S$_3$, found only at the type locale, Boddington Au deposit western Australia). Unnamed

phases from Clogau and Iilijärvi may represent higher members of the same series. Cited as indirect evidence for this scenario are the recognition of synthetic materials prepared at 500° corresponding to N = 1–4. The authors speculate that the variations in compositions are the product of an accretional homologous series where "random sequences of stacking of discrete members of the series at the lattice scale are considered to apply, causing chemical variation." **G.P.**

DEUTERATED MELANTERITE

J.L. Anderson, R.C. Peterson, I.P. Swain (2007) The atomic structure and hydrogen bonding of deuterated melanterite, FeSO$_4$·7D$_2$O. Can. Mineral., 45, 457–469.

Using neutron diffraction data collected at wavelengths of 2.3731 and 1.3308 Å the authors refined the atomic structure of deuterated melanterite. Results of the refinement were a 14.0774(9), b 6.5039(4), c 11.0506(7) Å, β 105.604(1)°, space group $P2_1/c$, Z = 4. The study confirms the previous scheme for hydrogen bonding in melanterite. The study also indicates that the hydrogen bonding to the oxygen atoms of Fe octahedra are responsible for small variations in Fe-O bond lengths (i.e., distorted octahedra). The authors discuss the differing abilities of orthorhombic and monoclinic heptahydrate structures to accommodate metal substitutions, suggesting that the second M site in monoclinic structures (M2) creates a structural flexibility that is more amenable to the incorporation of different metals. **G.P.**

KUDRIAVITE*

T. Balić-Žunić, T. Makovicky, E. Makovicky (2007) The crystal structure of kudriavite, (Cd,Pb)Bi$_2$S$_4$. Can. Mineral., 45, 437–443.

Kudriavite [ideally (Cd,Pb)Bi$_2$S$_4$] is a sulphosalt found in fumaroles of the Kudriavy volcano in the Kurili Archipelago. Chemical analysis of the type material (initially described by Chaplygin et al. 2005 in Can. Mineral., 43, 695–701) gives a formula composition of (Cd$_{0.51}$Pb$_{0.44}$Fe$_{0.02}$Mn$_{0.03}$)$_{\Sigma1.00}$(Bi$_{1.83}$In$_{0.17}$)$_{\Sigma2.00}$ (S$_{3.81}$Se$_{0.19}$)$_{\Sigma4.00}$.

The structure was determined from a single crystal (0.01 × 0.09 × 0.24 mm) using a Bruker-AXS four circle diffractometer equipped with a 1000 K detector, flat graphite monochromator and Mo$K\alpha$ radiation. Lattice parameters are a 13.095(1), b 4.0032(3), c 14.711(1) Å, β 115.59(1)°, V 695.6(1) Å^3 with space group $C2/m$, Z = 4 and calculated densities from microprobe and XRD of 6.571 and 6.750, respectively.

The structure is described as columns of PbS-like slabs combined by "unit-cell twinning" in a quasi-mirror-glide succession. Although the slabs have identical topology, two types are defined on the basis of the coordination state of bordering cations. In type-I slabs, central columns of octahedra are bordered by square pyramidal coordinations completed to split-octahedral by the addition of two S atoms from adjacent slabs. The type-II slabs the central columns of octahedra are flanked by octahedral coordinations involving an S atom from the adjacent slab.

Crystal chemical analysis of the structure indicated that chemical substitutions (Cd ↔ Pb, Bi ↔ In) are limited to Bi-containing sites, which are distributed predominantly in the boundary

coordinations of type-I slabs and in the central octahedral of the type-II slabs. Lead is preferentially concentrated in type-I slabs and indium in the type-II slabs. Crystal chemical analysis suggests that the Pb:Cd ratio of 1:1 found in the type material represents an upper limit of substitution of Pb into the structure. Present data does not allow an estimate of an upper limit for In substitution, but it is likely less than In:Bi = 1:3. **G.P.**

LENINGRADITE*

O.I. Sidra, S.V. Krivovichev, T. Armbruster, S.K. Filatov, I.V. Pekov (2007) The crystal structure of leningradite, $PbCu_3(VO_4)_2Cl_2$. Can. Mineral, 45, 445–449.

Leningradite, initially described in 1990, is a lead, copper vanadate found in fumaroles of the Great fissure Tolbachik eruption, Kamchatka Peninsula. Sidra et al. report a crystal structure refinement of a $0.1 \times 0.06 \times 0.01$ mm crystal. The refinement was carried out using a Bruker three-circle CCD-based X-ray diffractometer operated at 50 kV and 40 mA using Mo$K\alpha$ radiation. The refinement shows that leningradite is orthorhombic, space group *Ibam*, $a = 9.005(7)$, $b = 11.046(9)$, $c = 9.349(7)$ Å, $V = 929.9(13)$ Å^3, $Z = 4$.

The structure is described as a three dimensional framework of copper vanadate chains with large elliptical channels containing one symmetrically unique Pb^{2+} coordinated by four Cl and four O atoms. Copper occurs in two symmetrically independent sites in distorted [4O + 2Cl] coordination. Vanadium is tetrahedrally coordinated by four oxygen. The chains are of two types, both parallel to the c axis; one is formed by corner-sharing $Cu(1)O_4$ squares and VO_4 tetrahedra and the other is formed by corner-sharing $Cu(2)O_4$ squares and VO_4 tetrahedra. **G.P.**