

New Mineral Names: Arsenic and Lead

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IN THIS ISSUE

This issue of New Mineral Names provides a summary of new species that contain arsenic and lead. As of November 2022, there are 1219 minerals that contain constituent arsenic or lead, which is roughly 20% of all known mineral species. These two elements are an important component in many of the newly described minerals that typically form from hydrothermal or other diagenetic processes. Here we look at nitroplumbite, thorasphite, tennantite-(Cd), paradimorphite, tombstoneite, aldomarinoite, lomardoite, dobšínáite, panskyite, yugensonite, and kufahrte.

NITROPLUMBITE

Nitroplumbite (Kampf et al. 2022a), ideally $[\text{Pb}_4(\text{OH})_4](\text{NO}_3)_4$, is named after its composition. Plumbite is not a mineral but is the IUPAC name for PbO_2^- oxyanion and PbO_3^- is the plumbate oxyanion. Nitroplumbite was found in the Burro Mine, in San Miguel County, Colorado, U.S.A., located approximately 20 miles SSW of the abandoned town of Uravan. This mine is in the Uravan mineral belt, an extensive region known for high-grade uranium and vanadium ores. The Uravan area is rich and diverse in minerals, and in the last 20 years, 40 new minerals have been described from here. Nitroplumbite was found in the Salt Wash Member (sandstone) in the Morrison Formation and was located in an area of accumulated plant material.

The town Uravan was named after mining started in the area in the 1930s. In the 1940s through the 1960s, uranium was mined to support weapons development and commercial nuclear power plants in the U.S.A. The secrecy of the mining operations, however, led to the exploitation of Native American miners and their lands (Lewis et al. 2017), as well as significant environmental impacts for the people in the region (Moore-Nall 2015).

Nitroplumbite crystallizes in space group *Ia* with $a = 18.3471(7) \text{ \AA}$, $b = 17.3057(4) \text{ \AA}$, $c = 18.6698(8) \text{ \AA}$, $\beta = 91.872(3)^\circ$, $V = 5924.7(4) \text{ \AA}^3$ and has a calculated density of 5.297 g/cm^3 . The mineral and its name have been approved by the Commission on New Minerals Nomenclature and Classification (CNMNC) of the International Mineralogical Association (IMA 2021-045a). One holotype and one cotype specimen, both micromounts, are deposited in the collections of the Natural History Museum of Los Angeles County, California, U.S.A., catalog numbers 76147 (holotype) and 76148 (cotype).

THORASPHITE

Thorasphite (Elliott 2022), ideally $\text{Th}_2\text{H}(\text{AsO}_4)_2(\text{PO}_4) \cdot 6\text{H}_2\text{O}$, is named after its composition, **thorium - arsenate** or **As - phosphate**. It was discovered on the dumps at the Elsmore tin deposit in New South Wales, Australia. Thorasphite was found in a heavily weathered sandstone with only jarosite as an accessory mineral in the assemblage, indicating weathering took place under acidic conditions. The authors postulated that the Th may have come from weathered monazite crystals that were in nearby cavities.

The structure of thorasphite is a mix polyhedral microporous framework with PO_4 and AsO_4 groups bound to $\text{ThO}_7(\text{H}_2\text{O})_2$ polyhedra. The

8-member ring channel only contains extra-framework H_2O groups, which are bound to OH groups on the framework. However, the H positions were not determined. It is possible that thorasphite represents an As sink that can crystallize in acidic solutions at low temperatures and near surface conditions, though more work is needed to determine the crystallization mechanism.

Thorasphite crystallizes in space group *Pbcn* with $a = 13.673(3) \text{ \AA}$, $b = 9.925(2) \text{ \AA}$, $c = 10.222(2) \text{ \AA}$, $V = 1387.2(5) \text{ \AA}^3$, and has a calculated density of 4.185 g/cm^3 . The mineral and name have been approved by the IMA Commission on New Minerals, Nomenclature and Classification (IMA 2017-085). The holotype specimen is stored in the collections of the South Australian Museum, Adelaide, South Australia, catalog number G34702.

TENNANTITE-(CD)

Tennantite-(Cd) (Biagioni et al. 2022), ideally $\text{Cu}_{10}\text{Cd}_2\text{As}_4\text{S}_{13}$, is a new tetrahedrite group mineral and is the seventh member of the tennantite subgroup. It was found in an “old German collection” of undisclosed ownership or preservation condition. The rock from which tennantite-(Cd) was described was reported to be from the Berenguela mining district of La Paz, Bolivia.

Although extensive geological context of this mineral was not reported because it was found out of context, its presence emphasizes the importance of mineral collection preservation. In addition, tennantite-(Cd) does provide some geological formation constraints on this unique tetrahedrite mineral, and therefore increases our understanding of this important class of thermoelectric compounds that are based on the tetrahedrite structure and chemistry (Weller and Morelli 2022). Continued research on the provenance and precise geological formation conditions would be interesting to know in the future.

Tennantite-(Cd) crystallizes in space group $\bar{I}43m$ with $a = 10.3088(2) \text{ \AA}$, $V = 1095.53(6) \text{ \AA}^3$ with a calculated density of 4.724 g/cm^3 . The new mineral and its name have been approved by the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association (IMA 2021-083). The holotype specimen is deposited in the collections of the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia, catalog number 97773. The cotype material is kept in the collections of the Department of Mineralogy and Petrology, National Museum in Prague, Czech Republic, catalog number PIP 47/2021.

PARADIMORPHITE

Paradimorphite (Camprostrini et al. 2022), ideally As_4S_3 , is named after its relationship with dimorphite. In 1850, Arcangelo Scacchi found

* All minerals have been approved by the IMA CNMNC. For a complete listing of all IMA-validated unnamed minerals and their codes, see <http://cnmnc.miam.jp/> (click on “IMA list of minerals”).

two arsenic sulfide minerals in the fumaroles of the Campi Flegrei, located near Napoli, Italy. These two arsenic sulfides were classified at the time as having two distinctly different crystal morphologies corresponding to $a:b:c$ length ratios of 1:1.287:1.153 (Form I) and 1:1.658:1.508 (Form II) as measured on a goniometer. Despite the difference crystal morphologies and statistically significant measurements, Scacchi was not convinced that these two species were distinctly different minerals, and thus the mineral was named dimorphite to reflect this apparent variation in crystal shape.

Multiple studies and conflicting nomenclature regarding this arsenic sulfide have appeared in the 172 years since the initial discovery by Scacchi, but Campostrini et al. (2022) has now demonstrated that these two materials are indeed different. Dimorphite is officially acknowledged by the CNMNC as belonging to Scacchi's Form II description as the low-temperature polymorph of As_2S_3 , and Form I is the high-temperature polymorph, now known as paradimorphite.

Two specimens were used in the study: a modern sample from the Solfatara di Pozzuoli fumarole and an old sample found as a sublimate in an active fumarole that was collected after the 1906 eruption of Vesuvius belonging to the former collection of the Istituto Geomineralogico Italiano.

Paradimorphite crystallizes in space group $Pnma$ with $a = 9.1577(7)$ Å, $b = 8.0332(6)$ Å, $c = 10.2005(8)$ Å, $V = 750.41(10)$ Å³, with an observed density and calculated density of 3.510(3) and 3.500 g/cm³, respectively. The mineral and its name have been approved by the CNMNC (IMA 2020-101). The holotype (from Solfatara di Pozzuoli) and cotype (from Vesuvius) specimens of paradimorphite are deposited in the Reference Collection of the Dipartimento di Chimica, Università degli Studi di Milano, Italy, catalogue numbers 2020-03/6121 and 2020-04/4226, respectively.

TOMBSTONEITE

Tombstoneite (Kampf et al. 2022b), ideally $(\text{Ca}_{0.5}\text{Pb}_{0.5})\text{Pb}_3\text{Cu}_2^{2+}\text{Te}_6^{6+}\text{O}_6(\text{Te}^{4+}\text{O}_3)_6(\text{Se}^{4+}\text{O}_3)_2(\text{SO}_4)_2 \cdot 3\text{H}_2\text{O}$, is named after the location it was found. Tombstoneite was reported to be from the Grand Central Mine, Tombstone district, Arizona. It was first identified as tiny crystals in specimen bought from a commercial mineral dealer. With the aid of optical and Raman microscopy, it was determined that the microcrystals on the matrix could be a new mineral species. Subsequent X-ray diffraction and electron microprobe analysis confirmed that it was a new mineral species.

Since 1972, 12 new minerals have been described from Tombstone, Arizona, and nearly all of them have contained significant amounts of Pb and Te. The structure of tombstoneite is quite unique in that it contains $\text{Te}^{6+}\text{O}_3(\text{Te}^{4+}\text{O}_3)_3$ cluster with pinwheel-like geometry. According to the authors, this is significant as no other natural, or synthetic, material has a finite $\text{Te}^{6+}/\text{Te}^{4+}$ coordination complex.

Tombstoneite crystallizes in space group $P321$ with $a = 9.1377(9)$ Å, $c = 12.2797(9)$ Å, $V = 887.96(18)$ Å³ and has a calculated density of 5.680 g/cm³. The new mineral and name were approved by the CNMNC (IMA 2021-053). The holotype specimen deposited in the collections of the Natural History Museum of Los Angeles County, California, U.S.A., catalogue number 76195.

LOMBARDOITE AND ALDOMARINOITE

Lombardoite and aldomarinoite (Cámara 2022) were both collected on the dumps of an old mine found close to the Valletta Pass in the Valletta Valley, Piedmont, Italy. The name lombardoite honors Dr. Bruno Lombardo (1944–2014), a geologist and petrologist who had extensively contributed to the study of the evolution of orogenic belts around the world. The name aldomarinoite honors Mr. Aldo Marino, a prolific collector and founding member of the Italian Micromineralogical Association.

The geology of the Valletta mine is not well constrained, but pre-

dominantly consists of diagenetically altered marine sequences with intermittent volcanic rocks. The rocks found at the mine dumps are often fractured with quartz and calcite veins with heavy metal mineral phases (As, Ba, Sr, V). The authors postulate that these metals follow oxidized hydrothermal fluids along faults where lombardoite and aldomarinoite could have formed.

Lombardoite, ideally $\text{Ba}_2\text{Mn}^{3+}(\text{AsO}_4)_2(\text{OH})$, crystallizes in space group $P2_1/m$ with $a = 7.8636(1)$ Å, $b = 6.13418(1)$ Å, $c = 9.1197(1)$ Å, $\beta = 112.660(2)^\circ$, $V = 405.94(1)$ Å³, and has a calculated density of 4.679 g/cm³. Aldomarinoite, ideally $\text{Sr}_2\text{Mn}^{3+}(\text{AsO}_4)_2(\text{OH})$, crystallizes in space group $P2_1/m$ with $a = 7.5577(4)$ Å, $b = 5.9978(3)$ Å, $c = 8.7387(4)$ Å, $\beta = 111.938(6)^\circ$, $V = 367.43(3)$ Å³, and has a calculated density of 4.679 g/cm³. The new minerals and their name were approved by the CNMNC (IMA 2016-058, lombardoite and IMA 2021-054, aldomarinoite). A fragment of the holotype material for lombardoite is deposited in the mineralogical collections of the Museo Regionale di Scienze Naturali di Torino, Italy, catalog number M/U 17111. The holotype material of aldomarinoite is deposited in the mineral collections of the Museo delle Collezioni di Mineralogia, Gemmologia, Petrologia e Giacimentologia, Milano, Italy, catalog number MCMGPG-H2021-001.

DOBŠINÁITE

Dobšináite (Sejkora et al. 2021), ideally $\text{Ca}_2\text{Ca}(\text{AsO}_4)_2 \cdot 2\text{H}_2\text{O}$, is named after its locality, Dobšiná, Slovak Republic. Dobšináite was found in an abandoned small mine at the Dionýz mining field northeast of the town of Dobšiná, Slovak Republic, in the Carpathian Mountains.

The ore geology of the area consists of a network of carbonate-quartz veins (Zembert-Terézia vein system) that hosts Co-Ni-Fe-Cu-Ag mineralization in veins about 1.0(±0.5) m in width. Mining in the area dates back to the Bronze Age, and since the 10th century, extensive iron and copper ore was extracted (Romhányi et al. 2020). Later, in 1780, cobalt-nickel ore was discovered in the Dobšiná area (Kúšik 2015) likely from experienced Saxony miners migrating into these areas. In the 19th century, the extraction of cobalt-nickel ore from Dobšiná was exported to England, German States, and Belgium. The area is still considered a rich Ni-Co deposit (and the dumps) with European mining companies investing in the area.

Dobšináite crystallizes in space group $P2_1/c$ with $a = 5.990(2)$ Å, $b = 13.013(4)$ Å, $c = 5.726(2)$ Å, $\beta = 108.47(3)^\circ$, $V = 423.3(3)$ Å³, and has a calculated density of 3.395 g/cm³. The new mineral and its name have been approved by the CNMNC (IMA 2020-81). The holotype sample of dobšináite is deposited in the collections of the Moravian Museum, Brno, Czech Republic, catalog number B12257.

PANSKYITE

Panskyite (Vymazalová et al. 2021), ideally $\text{Pd}_0\text{Ag}_2\text{Pb}_2\text{S}_4$, is named after its locality, the Pansky Massif of the Fedorova–Pana layered intrusion in the Kola Peninsula, Russia, and is the Pb analog of thalhammerite ($\text{Pd}_0\text{Ag}_2\text{Bi}_2\text{S}_4$). Panskyite inclusions were embedded in chalcopyrite or intergrown with other platinum group minerals (sizes ranged from 0.5–10 μm). The small size and inaccessibility of the inclusion prevented their extraction in amounts required for detailed crystallographic investigations. Therefore, crystal structure investigations were performed on synthetic $\text{Pd}_0\text{Ag}_2\text{Pb}_2\text{S}_4$ prepared by the authors during a 7-month reaction at 400 °C. The synthetic and natural samples were then compared on a scanning electron microscope with backscatter electron diffraction to show that they were the same material.

Panskyite crystallizes in space group $I4/mmm$ with $a = 7.973(3)$ Å, $c = 9.139(3)$ Å, $V = 581.0(4)$ Å³, and has a calculated density of 9.81 g/cm³. Both the mineral and its name were approved by the CNMNC (IMA 2020-039). The holotype (polished section), along with its synthetic analog, is deposited at the Department of Earth Sciences of the Natural History Museum, London, U.K., catalogue number BM 2020,2.

YURGENSONITE

Yurgensonite (Pekov et al. 2021), ideally $K_2SnTiO_2(AsO_4)_2$, was found in the fumaroles around the Tolbachik volcano in Russia. This amazingly diverse mineralogical hotspot continues to produce new and interesting minerals. Here, the new arsenate mineral yurgensonite was found at the Arsenatnaya fumarole.

Specimens with yurgensonite and a Sn-rich variety of katiarsite (isomorphous with yurgensonite) were collected by the authors in 2018 from the northern part of the fumarole. Temperatures measured in pockets with these minerals at the time of collecting were 360–400 °C. Crystals of the yurgensonite were deposited directly from the gas phase as volcanic sublimates, or formed as a result of the interaction between fumarolic gas, a carrier metal (e.g. As, Sn, K), with the basaltic scoria, which could have been the source of Ti.

Yurgensonite crystallizes in space group $Pna2_1$ with $a = 13.2681(6)$ Å, $b = 6.6209(3)$ Å, $c = 10.8113(5)$ Å, $V = 949.74(7)$ Å³, and has a calculated density of 3.877 g/cm³. Both the new mineral and its name have been approved by the CNMNC (IMA 2019-059). The type specimens are deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia, catalog numbers 96702 and 96703.

KUFAHRITE

Kufahrte (Sidorov et al. 2021), ideally PtPb, is named in honor of Fahr Shakirovitch Kutjev (1943–1993), a geologist from the Institute of Volcanology of the former USSR Academy of Sciences who played an important role in the discovery of the Korean-Kamchatka platinum belt, including the placer deposit where kufahrte was found.

Kufahrte was found in a heavy metal concentrate during panning at the Ledyanoy Creek placer deposit. This deposit is related to the Galmoenan Ural–Alaskan type ultramafic complex at the Koryak Highlands, which is one of the largest platinum-group mineral placers in the world.

The Sb counterpart of kufahrte is stumpflite, and Pd–Pb alloys all are the result of post-magmatic processes that likely formed from hydrothermal fluids. As with many of these microscopic minerals that form in limited quantities, there was not enough material for routine crystal structure analysis. The authors were able to collect limited powder X-ray diffraction data and compare that to the known synthetic PtPb material, which has the NiAs nickeline-group structure type, and was a good fit.

Kufahrte crystallizes in space group $P6_3/mmc$ with $a = 4.2492(6)$ Å, $c = 5.486(6)$ Å, $V = 85.78$ Å³, and has a calculated density of 14.80 g/cm³. The mineral and its name have been approved by the CNMNC (IMA 2020-045). The holotype material (polished section) is deposited in the Fersman Mineralogical Museum, Moscow, Russia, catalog number 5576/1.

REFERENCES CITED

- Biagioli, C., Kasatkin, A., Sejkora, J., Nestola, F., and Škoda, R. (2022) Tennantite-(Cd), $Cu_4(Cu,Cd)_4As_4S_{13}$, from the Berenguela mining district, Bolivia: The first Cd-member of the tetrahedrite group. *Mineralogical Magazine*, 86(5), 834–840.
- Cámara, F., Baratelli, L., Ciriotti, M.E., Nestola, F., Piccoli, G.C., Bosi, F., Bitarello, E., Hälenius, U., and Balestra, C. (2022) As-bearing new mineral species from Valletta mine, Maira Valley, Piedmont, Italy: IV. Lombardoite, $Ba_2Mn^{3+}(AsO_4)_2(OH)$ and aldomarinoite, $Sr_2Mn^{3+}(AsO_4)_2(OH)$, description and crystal structure. *Mineralogical Magazine*, 86(3), 447–458.
- Campostrini, I., Castellano, C., Demartin, F., Rocchetti, I., Russo, M., and Vignola, P. (2022) Paradimorphite, β - As_4S_3 , a vintage new mineral from Solfatara di Pozzuoli and Vesuvius, Napoli, Italy. *Mineralogical Magazine*, 86(3), 500–506.
- Elliott, P. (2022) Thorasphite, $Th_2H(AsO_4)_2(PO_4) \cdot 6H_2O$, a new mineral from Elsmore, New South Wales, Australia. *Canadian Mineralogist*, 60(4), 719–727.
- Kampf, A.R., Hughes, J.M., Nash, B.P., and Marty, J. (2022a) Nitroplumbite, $[Pb_4(OH)_4](NO_3)_4$, a new mineral with cubane-like $[Pb_4(OH)_4]^{4+}$ clusters from the Burro Mine, San Miguel County, Colorado, USA. *Canadian Mineralogist*, 60(5), 787–795.
- Kampf, A.R., Mills, S.J., Housley, R.M., Ma, C., and Thorne, B. (2022b) Tombstoneite, a new mineral from Tombstone, Arizona, USA, with a pinwheel-like $Te^6+O_3(Te^6+O_3)_3$ cluster. *Mineralogical Magazine*, 1–8.
- Kúšik, D. (2015) History of mining at the territory of Slovakia. *Slovak Geological Magazine*, 15(2), 5–20.
- Lewis, J., Hoover, J., and MacKenzie, D. (2017) Mining and environmental health disparities in Native American communities. *Current Environmental Health Reports*, 4(2), 130–141.
- Moore-Nall, A. (2015) The legacy of uranium development on or near Indian Reservations and health implications rekindling public awareness. *Geosciences*, 5(1), 15–29.
- Pekov, I.V., Zubkova, N.V., Agakhanov, A.A., Yapaskurt, V.O., Belakovskiy, D.I., Viganina, M.F., Britvin, S.N., Turchkova, A.G., Sidorov, E.G., and Pushcharovskiy, D.Y. (2021) New arsenate minerals from the Arsenatnaya fumarole, Tolbachik volcano, Kamchatka, Russia. XVI. Yurgensonite, $K_2SnTiO_2(AsO_4)_2$, the first natural tin arsenate, and the katiarsite–yurgensonite isomorphous series. *Mineralogical Magazine*, 85(5), 698–707.
- Romhányi, B.F., Pinke, Z., and Laszlovszky, J. (2020) Environmental impacts of medieval uses of natural resources in the Carpathian Basin. *The Hungarian Historical Review*, 9(2), 241–283.
- Sejkora, J., Števkó, M., Škoda, R., Višková, E., Toman, J., Hreus, S., Plášil, J., and Dolníček, Z. (2021) Dobšináite, $Ca_2Ca(AsO_4)_2 \cdot 2H_2O$, a new member of the roselite group from Dobšiná (Slovak Republic). *Journal of Geosciences*, 66(2), 127–135.
- Sidorov, E.G., Kutjev, A.V., Zhitova, E.S., Agakhanov, A.A., Sandimirova, E.I., Vymazalova, A., Chubarov, V.M., and Zolotarev, A.A. (2021) Kufahrte, PtPb, a new mineral from Ledyanoy Creek placer, Galmoenan ultramafic complex, Koryak Highlands, Russia. *Mineralogical Magazine*, 85(2), 254–261.
- Vymazalová, A., Subbotin, V.V., Laufek, F., Savchenko, Y.E., Stanley, C.J., Gabov, D.A., and Plášil, J. (2021) Panskyite, $Pd_4Ag_2Pb_2S_4$, a new platinum group mineral from the Southern Kievev ore occurrence of the Fedorova–Pana layered intrusion, Kola Peninsula, Russia. *Mineralogical Magazine*, 85(2), 161–171.
- Weller, D.P. and Morelli, D.T. (2022) Tetrahedrite Thermoelectrics: From Fundamental Science to Facile Synthesis. *Frontiers in Electronic Materials*, 14. <https://doi.org/10.3389/femat.2022.913280>