

New Mineral Names

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ABSTRACT

In this issue of New Mineral Names, a thematic approach is used to help provide context for advances and discoveries in mineralogy. Changes in nomenclature and the definition of minerals have led to new mineral descriptions. Here we look into minerals, which might not have been classified as such 50 years ago, and their associated new classification schemes that open the door to new mineral descriptions: goldhillite, radvaniceite, zvěstovite-(Zn), oberwolfachite, cesiokenopyrochlore, orishchinite, kahlenbergite, zoisite-(Pb), and dendoraite-(NH₄).

GOLDHILLITE

Goldhillite (Ismagilova et al. 2022), ideally Cu₂Zn(AsO₄)₂(OH)₆·H₂O, was named after its type locality, the Gold Hill mine, Tooele County, Utah. It was found in the Fersman Mineralogical Museum collection as a sample labeled as philipsburgite.

There are currently more than 150 known copper arsenate and copper phosphate minerals combined, but there are only three that are copper arsenate-phosphate minerals; epifanovite NaCaCu₅(PO₄)₄[AsO₂(OH)₂]·7H₂O, milkovoite Cu₄O(PO₄)(AsO₄), and philipsburgite Cu₃Zn(AsO₄)(PO₄)(OH)₆·H₂O. However, the original publication (Peacor et al. 1985) of philipsburgite defined it as being a disordered phosphate-arsenate with end-member phosphate being kipushite, (Cu,Zn)₅Zn(PO₄)₂(OH)₆·H₂O and the arsenate end-member was not known at the time.

This new study redefines the structure and chemical composition of philipsburgite to show that philipsburgite has ordered phosphate-arsenate sites, Cu₅Zn(AsO₄)(PO₄)(OH)₆·H₂O, and defines the arsenate end-member to be goldhillite.

Goldhillite crystallizes in space group *P2*₁/*c* with *a* = 12.3573(5) Å, *b* = 9.2325(3) Å, *c* = 10.7163(4) Å, β = 97.346(4)°, *V* = 1212.59(8) Å³, and has a calculated density of 4.199 g/cm³. The mineral and its name were approved in 2021 by the International Mineralogical Association Commission on New Minerals, Nomenclature and Classification (CNMNC) (IMA 2021-034). The holotype is in the collection of the Fersman Mineralogical Museum in Moscow, Russia (catalog number 88338). The cotype is in the collection of the Natural History Museum of Los Angeles County, California, U.S.A. (catalog number 76142).

RADVANCEITE

Radvaniceite (Sejkora et al. 2022), GeS₂, was named after its locality, Radvanice village in the eastern Czech Republic.

The radvaniceite specimens were collected in an abandoned

Kateřina coal mine dump near Radvanice between 1995 and 1998. At that time, specimens that formed from combustion were not considered to be minerals by the IMA Commission on New Minerals and Mineral Names. Recent changes by the IMA to the definition of a mineral now allow products of combustion to be considered minerals as long as the fire was started naturally and that no anthropogenic materials were deposited in the mine. In the case of radvaniceite, the coal fire likely started from the oxidation of pyrite around 1967. The fire is now under control, and remediation of the mine dump was successfully completed in 2005.

Radvaniceite crystallizes in space group *Pc* with *a* = 6.8831(12) Å, *b* = 22.501(3) Å, *c* = 6.8081(11) Å, β = 120.365(9)°, *V* = 909.8(4) Å³, and the calculated density is 3.05 and 2.99 g/cm³ for the empirical and ideal formula, respectively. The mineral and its name were approved by the IMA CNMNC in 2021 (IMA 2021-052). The holotype specimen of radvaniceite is in the collections of the Department of Mineralogy and Petrology of the National Museum in Prague, Czech Republic (catalog number PIP 9/2021).

ZVĚSTOVITE-(Zn)

Zvěstovite-(Zn) (Sejkora et al. 2021), ideally Ag₆(Ag,Zn₂)As₄S₁₃, was discovered during a systematic study of tetrahedrite group minerals in the Czech Republic. One hand specimen containing zvěstovite-(Zn) was collected at a mine dump in the southern part of the abandoned deposit of Zvěstov. Upon chemical analysis, that specimen was determined to have unusually high Ag content, which led to further investigation. There are no known written records of mining at this locality, but Velebil et al. (2016) found a ceramic fragment that dates to around the 15th or 16th century. The hydrothermal deposit was likely mined for Pb-Ag-Zn given the abundance of galena, sphalerite, chalcopyrite, pyrite, and arsenopyrite at the site.

Zvěstovite-(Zn) crystallizes in space group *I4* $\bar{3}$ *m* with *a* = 10.850(2) Å, *V* = 1277.3(8) Å³, and the calculated density is 5.16 g/cm³. The new mineral and its name were approved by the IMA CNMNC in 2020 (IMA 2020-061). The holotype material (polished section) is deposited in the mineralogical

* 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.main.jp/> (click on "IMA list of minerals").

collection of the Department of Mineralogy and Petrology of the National Museum in Prague, Czech Republic (catalog number PIP 50/2020). The crystal used for the single-crystal X-ray diffraction study is stored in the mineralogical collection of the Museo di Storia Naturale of the Università di Pisa, Italy (catalog number 19921).

OBERWOLFACHITE

Oberwolfachite (Chukanov et al. 2021), $\text{SrFe}_3^{3+}(\text{AsO}_4)(\text{SO}_4)(\text{OH})_6$, is named after the Oberwolfach baryte mining area where the holotype specimen was found, and belongs to the alunite supergroup of minerals. Oberwolfachite is isostructural with beudantite, $\text{PbFe}_3^{3+}(\text{AsO}_4)(\text{SO}_4)(\text{OH})_6$, and likely crystallized from supergene or low-temperature hydrothermal conditions.

Oberwolfachite was collected at dumps of the Clara mine, Oberwolfach baryte mining area, in the Black Forest next to Baden-Württemberg, Germany. The Clara mine is famous for its mineral diversity. To date, 463 minerals are known to occur there, with 15 type specimens described from the Clara mine. A co-type of oberwolfachite was also found in the Monterniers mines, Auvergne-Rhône-Alpes, France.

The alunite supergroup (Bayliss et al. 2010) includes trigonal minerals with the general formula $\text{DG}_3(\text{TX}_4)_2\text{X}'_6$ where $\text{D} = \mathbf{K}^+$, \mathbf{Na}^+ , $\mathbf{H}_3\text{O}^+$, \mathbf{NH}_4^+ , \mathbf{Tl}^+ , \mathbf{Ag}^+ , \mathbf{Rb}^+ , \mathbf{Ca}^{2+} , \mathbf{Sr}^{2+} , \mathbf{Ba}^{2+} , \mathbf{Ca}^{2+} , \mathbf{Pb}^{2+} , \mathbf{Hg}^{2+} , \mathbf{Ln}^{3+} ($\mathbf{Ln} = \mathbf{La}, \mathbf{Ce}, \mathbf{Nd}, \mathbf{Sm}$), \mathbf{Bi}^{3+} , \mathbf{Th}^{4+} , and vacancy (\square); $\text{G} = \mathbf{Zn}^{2+}$, \mathbf{Cu}^{2+} , \mathbf{Mg}^{2+} , \mathbf{Al}^{3+} , \mathbf{Fe}^{3+} , \mathbf{V}^{3+} , \mathbf{Ga}^{3+} , \mathbf{Cr}^{3+} , and \mathbf{Sn}^{4+} ; and $\text{T} = \mathbf{Si}^{4+}$, \mathbf{P}^{5+} , \mathbf{As}^{5+} , \mathbf{S}^{6+} , and \mathbf{Cr}^{6+} ; $\text{X} = \mathbf{O}$ and \mathbf{OH} ; $\text{X}' = \mathbf{H}_2\text{O}$, \mathbf{OH} , and \mathbf{F} (species-defining components are in **bold**).

Oberwolfachite crystallizes in space group $R\bar{3}m$ with $a = 7.3270(3) \text{ \AA}$, $c = 17.0931(9) \text{ \AA}$, $V = 794.70(8) \text{ \AA}^3$, and has a calculated density of 3.874 g/cm^3 . The new mineral and its name were approved by the IMA CNMNC in 2021 (IMA 2021-010). The holotype specimen is deposited in the collection of the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia (catalog number 5674/1). A part of the cotype from Monterniers mines is stored in the collection of the Natural History Museum, University of Oslo, Norway (catalog number KNR 44331).

CESIOKENOPYROCHLORE

Cesiokenopyrochlore (Agakhanov et al. 2021), ideally $\square_2(\text{Nb}, \text{W}, \text{Ta})_{22}\text{O}_6\text{Cs}$, is named for its composition and nomenclature. The pyrochlore supergroup has the general formula $\text{A}_{2-m}\text{B}_2\text{X}_{6-w}\text{Y}_{1-n}$. For cesiokenopyrochlore, the Y site has Cs (prefix *cesio*-), and the A site has the vacancy (prefix *keno*-). Combining the B site (which is Nb dominant) and X site gives the formula $\text{Nb}_2(\text{O}, \text{OH})_6$, which is the backbone of the pyrochlore mineral subgroup (within the pyrochlore supergroup).

The new mineral was found in a purchased specimen at the Munich Show in 2010. The specimen was originally purchased as a pegmatite sample with béhierite. Upon close examination of the béhierite, the authors found tiny crystals (approximately 0.05 mm) overgrowing the béhierite. The overgrowth was determined to be a pyrochlore mineral with anonymously high Cs content.

Cesiokenopyrochlore likely formed during late-stage mineralization in a granitic pegmatite. Cesium could have also been enriched in the mineral as a result of natural cation exchange

with a hydrothermal solution in late-stage pegmatite evolution.

Cesiokenopyrochlore crystallizes in space group $Fd\bar{3}m$ with $a = 10.444(1) \text{ \AA}$, $V = 1139.5(2) \text{ \AA}^3$, and has a calculated density of 5.984 g/cm^3 . The new mineral and its name were approved by the IMA CNMNC in 2016 (IMA 2016-104). The type specimen is deposited in the collection of the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia (catalog number 95895).

ORISHCHINITE

Orishchinite (Britvin et al. 2022), ideally Ni_2P , is named in honor of Stepan Vasil'ovich Orishchin who was a Soviet and Ukrainian crystal chemist who made extensive contributions to the chemistry of phosphides, arsenides, and silicides.

Orishchinite was found in a paralava, which in this case was formed from the melting of marble and phosphorites in the Jizah District of Jordan. The host rock is part of the Hartrurim Formation and is one of the largest complexes of the sedimentary strata known to have experienced combustion metamorphism. The melting likely occurred during the natural combustion of bituminous shales or natural gases that are common in the area. There are possible high-pressure mineral phases in the Hartrurim Fm., which have led to hypotheses that an impact event could have sparked the combustion process. To date, there is no scientific consensus as to the cause of the fire. The Hartrurim Fm. is bound unconformably with sediment layers above and below, so the age of the formation is difficult to determine, but Ar-Ar ages estimate that there could have been multiple combustion events ranging from 2 Mya to 16 Mya (Gur et al. 1995).

Orishchinite crystallizes in space group $Pnma$ with $a = 5.8020(7) \text{ \AA}$, $b = 3.5933(4) \text{ \AA}$, $c = 6.7558(8) \text{ \AA}$, $V = 140.85(3) \text{ \AA}^3$, and with a calculated density of 7.695 g/cm^3 . Both the mineral and its name have been approved by the IMA CNMNC in 2019 (IMA 2019-039). The holotype specimen of orishchinite is deposited at the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia (catalog number 5408/1).

KAHLENBERGITE

Kahlenbergite (Krüger et al. 2021), ideally $\text{KAl}_{11}\text{O}_{17}$, is named in honor of Volker Kahlenberg, a professor at the University of Innsbruck, Austria, where he has made significant contributions to the fields of mineralogy, crystallography, and crystal chemistry. Kahlenbergite was found within 300 m of the top of Mt. Parsa, and in pyrometamorphic rocks of the Negev Desert. The new mineral occurs with hematite enclaves in a wollastonite-gehlenite hornfels rock.

The structure of kahlenbergite has been known synthetically as potassium β -alumina since 1976 (Dernier and Remeika 1976). Notably, the cations in the kahlenbergite structure are more ordered (position and occupancy) than the synthetic material.

Kahlenbergite crystallizes in space group $P6_3/mmc$ with $a = 5.6486(1) \text{ \AA}$, $b = 22.8970(3) \text{ \AA}$, $V = 632.69(2) \text{ \AA}^3$, with a calculated density of 3.40 g/cm^3 . Both the mineral and its name have been approved by the IMA CNMNC in 2018 (IMA 2018-158). The type material was deposited in the mineralogical collection of the Fersman Mineralogical Museum, Moscow, Russia (catalog number 96587).

ZOISITE-(Pb)

Zoisite-(Pb) (Perchiazzi et al. 2021), $\text{CaPbAl}_3[\text{Si}_2\text{O}_7][\text{SiO}_4]\text{O}(\text{OH})$ is isostructural to zoisite $\text{Ca}_2\text{Al}_3[\text{Si}_2\text{O}_7][\text{SiO}_4]\text{O}(\text{OH})$, but with more Pb. It was found in the dumps of the Jakobsberg manganese-iron oxide deposit in the Filipstad district, Sweden. Zoisite-(Pb) has similar chemistry to hancockite $(\text{CaPb})(\text{Al}_2\text{Fe})[\text{Si}_2\text{O}_7][\text{SiO}_4]\text{O}(\text{OH})$ and is distinguished by different Al/(Al+Fe) atomic ratios, 0.966 and 0.768, respectively.

Before 2005, both zoisite and zoisite-(Pb) would have been classified as belonging to the epidote group of minerals. A new nomenclature scheme was proposed in 2006 to make epidote group mineral naming more consistent, requiring all group minerals to be monoclinic. The new nomenclature removed zoisite from the epidote group because it is orthorhombic (Armbruster et al. 2006). According to the new epidote nomenclature, hancockite was renamed epidote-(Pb), but was later changed back to hancockite (Revheim and King 2016) because of a 2015 approved IMA guideline that allowed the reinstatement of historical names (Hatert et al. 2013).

The authors have posited that there may be many other minerals that have yet to be described that could fall into a zoisite-based nomenclature, and they may submit a proposal to add a new group for all zoisite-related minerals (currently, there is no zoisite group).

Zoisite-(Pb) crystallizes in space group $Pnma$ with $a = 16.3978(6)$ Å, $b = 5.5953(2)$ Å, $c = 10.1953(3)$ Å, $V = 936.43(1)$ Å³, and a calculated density of 4.13 g/cm³. The new mineral and name were approved by the IMA CNMNC in 2021 (IMA 2021-025). The holotype specimen of zoisite-(Pb) is deposited in the mineralogical collection of the Museo di Storia Naturale, Università di Pisa, Pisa, Italy (catalog number 19927).

DENDORAITE-(NH₄)

Dendorait-(NH₄) (Kampf et al. 2021), $(\text{NH}_4)_2\text{NaAl}(\text{C}_2\text{O}_4)(\text{PO}_3\text{OH})_2(\text{H}_2\text{O})_2$, was named after the Dendora Valley, Arizona, the location of the Rowley Mine from which the specimen was recovered. Dendorait-(NH₄) has strong evidence of biologically aided precipitation as it was discovered in a hot and humid area of the mine associated with bat guano.

It is one of five known minerals that contain both oxalate and phosphate. The other four are davidbrowneite-(NH₄), phoxite, relianceite-(K), and thebaite-(NH₄); all of which can be found in the Rowley Mine. The activity of bat guano and solubility of minerals in the mine are responsible for this array of new and interesting minerals.

Prior to the mid-1990s, it is unlikely that biologically aided crystallization would allow for those products to have been considered minerals. However, it is clear that biological processes and mineralogy cannot be easily separated. These interrelationships were formally recognized as far back as 1995 (Nickel 1995) and 1998 (Nickel and Grice 1998).

Dendorait-(NH₄) crystallizes in space group $P2_1/n$ with $a = 10.695(6)$ Å, $b = 6.285(4)$ Å, $c = 19.227(12)$ Å, $\beta = 90.933(10)^\circ$, $V = 1292(2)$ Å³, and has a calculated density of 2.122 g/cm³. The

new mineral and name were approved by the IMA CNMNC in 2020 (IMA 2020-103). The holotype specimen of dendorait-(NH₄) is deposited in the collections of the Natural History Museum of Los Angeles County, California, United States (catalog number 75275).

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