

New Mineral Names: Alteration Products

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In this series of New Mineral Names, the theme is alteration products ranging from supergene mineralization to ambient pressure and temperature bat guano–rock interactions. The minerals highlighted here are: arrheniusite-(Ce), erssonite, krupičkaite, priscillagrewite-(Y), seaborgite, thalliomelane, thebaite, and uranoclite.

URANOCLITE

Uranoclite (Kampf et al. 2021c), ideally $(\text{UO}_2)_2(\text{OH})_2\text{Cl}_2(\text{H}_2\text{O})_4$, is named after its chemical composition, as it is a uranyl chloride mineral. A synthetic phase of this mineral was first reported by Huys et al. (2010), which was an accidental synthesis of an attempted reaction between uranium(VI) oxide dehydrate, and hydrogen bis(trifluoromethylsulfonyl)amide, possibly for use as a uranium ionic liquid for remediation, or for electrochemical deposition and concentration.

The Blue Lizard underground mine (a former uranium-copper source) is a mineralogically diverse hot spot, which is remarkable given that the ore body size is only about $\approx 1600 \text{ m}^3$ (Mason and Arndt 1996). Twenty-two new minerals have been described coming from this remineralized siltstone and sandstone rock in the Chinle Fm. Uranoclite is the first new mineral from the Blue Lizard mine that is not a sulfate and does not contain sodium (16 of the other 22 newly discovered minerals are sodium sulfates).

Uranoclite crystallizes in space group $P2_1/n$ with $a = 10.763(8) \text{ \AA}$, $b = 6.156(8) \text{ \AA}$, $c = 17.798(8) \text{ \AA}$, $\beta = 95.656(15)^\circ$, and a calculated density of 4.038 g/cm^3 . The mineral was approved in 2020 by the Commission on New Minerals, Nomenclature and Classification (IMA 2020-074). The two cotype specimens are deposited in the collections of the Natural History Museum of Los Angeles County, Los Angeles, CA, U.S.A. (catalog numbers: 75101 and 75102).

PRISCILLAGREWITE-(Y)

Priscillagrewite-(Y) (Dudley 1969), ideally $(\text{Ca}_2\text{Y})\text{Zr}_2\text{Al}_3\text{O}_{12}$, is named in honor of the accomplished Emeritus Professor Priscilla Crosswell Perkins Grew where she taught in the Department of Earth and Atmospheric Sciences at the University of Nebraska–Lincoln and is the Director Emerita of the State Museum of Natural History at the University of Nebraska. She also is a fellow of the Mineralogical Society of America and the first person to publish an electron beam scanning photograph of oscillatory zoning in an eclogite garnet (Dudley 1969). Dr. Grew was responsible for coordinating federal repatriation of

human remains and archeological artifacts from the University of Nebraska–Lincoln to Native American Tribes.

Priscillagrewite-(Y) is a garnet group mineral, described by electron backscattered diffraction. It was discovered in central Jordan in the upper part of the Muwaqqar formation consisting of apatite layered marble from protoliths of bituminous marls, and limestone intercalated with phosphorite. The authors argue that the source material for priscillagrewite-(Y) is not from REE-containing phosphatic minerals such as fluorapatite, but likely from detrital zircon as the source of both the zircon and yttrium.

Electron backscattering diffraction was used to compare EBSD data to known structural models, and from this, the unit-cell parameters and space group were determined. Coupling this information along with Raman and electron microprobe data, the new mineral species was able to be sufficiently described. Priscillagrewite-(Y) belongs to the bitikleite group of garnets (bitikleite, usturite, dzhuluite, and elbrusite).

Priscillagrewite-(Y) crystallizes in space group $Ia\bar{3}d$ with $a = 12.50 \text{ \AA}$, and a calculated density of 4.48 g/cm^3 . The mineral was approved in 2020 (IMA 2020-002) and the holotype material has been deposited in the mineralogical collection of Fersman Mineralogical Museum, Moscow, Russia (catalog number: M58208).

ARRHENIUSITE-(Ce)

Arrheniusite-(Ce) (Holtstam et al. 2021), ideally $\text{CaMg}[(\text{Ce}_7\text{Y}_3)\text{Ca}_5](\text{SiO}_4)_3(\text{Si}_3\text{B}_3\text{O}_{18})(\text{AsO}_4)(\text{BO}_3)\text{F}_{11}$, is named in honor of Carl Axel Arrhenius, a lieutenant-colonel who in 1787 discovered the rare earth element mineral gadolinite-(Y), from the Ytterby pegmatite quarry in Stockholm County, Sweden. In 1817, Arrhenius was elected to the Royal Swedish Academy of Sciences (not to be confused with the namesake of the Arrhenius equation, who was Svante Arrhenius).

Arrheniusite-(Ce) was discovered in a hand specimen of unreported origin from the Östanmossa mine, Västmanland County, Sweden. Östanmossa is an iron ore mine that occurs in synform skarns with remnant calcite and dolomite marbles. A large concentration of REE was found at the Grodorten drift, which is presumed to be the likely source of arrheniusite-(Ce). Arrheniusite-(Ce) belongs to the vulcanite group of minerals, but unlike the other group members, it is non-magmatic

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

in origin. Instead, the formation of arrheniusite-(Ce) is from hydrothermal fluids in dolomitic rocks.

Arrheniusite-(Ce) crystallizes in space group $R3m$ with $a = 10.8082(3)$ Å, $c = 27.5196(9)$ Å, and a calculated density of $4.78(1)$ g/cm³. The mineral was approved in 2019 (IMA 2019-086) and the holotype is deposited in the type mineral collection of the Department of Geosciences, Swedish Museum of Natural History, Stockholm, Sweden (catalog number GEO-NRM 1954015).

ERSSONITE

Erssonite (Zhitova et al. 2021), ideally $\text{CaMg}_7\text{Fe}_2(\text{OH})_{18}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$, and is named in honor of the chemist and mineralogist, Dr. Anders Ersson, who was the Senior Engineer at the Materials Technology section and who collected the type material. Erssonite is found on the dumps of the Långban mine in Sweden, and it likely formed from hydrothermal alteration. The Långban mine has been described as the most mineralogically diverse area on the planet, with over 300 different minerals, of which there are over 60 type minerals, as being described from this mine. Interestingly, only dolomite is being extracted for economic purposes.

Layered double hydroxides (LDH) constitute a large family of minerals and synthetic compounds featuring crystal structures consisting of alternating positively charged brucite layers, typically having octahedral coordination and negatively charged interlayers. These materials are an active area of current research for applications in heavy metal polluted wastewater, acid mine drainage remediation, anion removal from waters, or lithium capture from brine solutions. Notably, the wermlandite group minerals are cation exchanges, whereas the other LDH minerals, such as hydrotalcite, are anion exchangers.

Erssonite crystallizes in space group $P3c1$ with $a = 9.3550(6)$ Å, $c = 22.5462(14)$ Å, and a calculated density of 2.02 g/cm³. The mineral was approved by the CNMNC in 2021 (IMA 2021-016) and the type material is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, Russia (catalog number: 5669/1), and at the Swedish Museum of Natural History, Stockholm, Sweden (catalog number: GEO-NRM 20210001).

THEBAITE

Thebaite-(NH₄) (Kampf et al. 2021a), ideally $(\text{NH}_4, \text{K})_3\text{Al}(\text{C}_2\text{O}_4)(\text{PO}_3\text{OH})_2(\text{H}_2\text{O})$, is named after the small Arizona settlement near the Rowley mine and is found in an actively forming bat guano assemblage at the 125 ft level. This is the third mineral known to have both oxalate and phosphate groups, with the two others being phoxite and davidbrowneite-(NH₄). The Rowley mine is a former Cu-PbAu-Ag-Mo-V-baryte-fluorspar deposit that are associated with an andesite porphyry dike in Tertiary volcanic rocks. The mine also produces fine wulfenite crystals that are popular among collectors.

Synthetic phases containing both phosphate and oxalate groups are often called oxalatophosphates. In many of these phases, the phosphate and oxalate groups link with octahedrally coordinated cations to form porous frameworks with potential technological applications such as catalysis, adsorption, ion exchange, gas storage, separation, and sensing (Luan et al. 2015).

Thebaite crystallizes in space group $Fm\bar{3}m$ with $a = 9.3933(3)$ Å and a calculated density of 4.843 g/cm³. The mineral name was approved in 2020 (IMA 2020-072), and the holotype specimen of thebaite-(NH₄) is deposited in the collection of the Natural History Museum of Los Angeles County, Los Angeles, California, U.S.A. (catalog number 75082).

THALLIOMELANE

Thalliomelane (Gołębiewska et al. 2021), ideally $\text{TiMn}_{7/5}\text{Cu}_{0.5}\text{O}_{16}$, shows that not all new minerals have a name ending in “-ite”. Thalliomelane is named after its thallium content and its affinity to the dark manganese oxide minerals analogous to the mineral naming scheme of cryptomelane and strontiomelane.

Thalliomelane, a new member of the coronadite group (hollandite supergroup), was discovered at Zalas near Kraków in southern Poland in a fault breccia encrusted with supergene copper minerals. The Zalas quarry consists of Permian volcanics (rhyodacite and andesite) with sandy limestones and hydrothermal mineralization. The overlying rocks consist of Middle and Upper Jurassic sedimentary marine successions contain abundant and diverse assemblages of shallow marine fossils (Borszcz and Zatoń 2009) making it a popular collecting spot.

The hollandite supergroup contains several manganese and titanium oxide 2×2 octahedra tunnel structures, with the coronadite group dominated by manganese oxide octahedra, and the priderite group dominated by titanium oxide octahedra. These minerals have been extensively studied for lithium ion conduction aimed to either sequester lithium or act as cathode material in batteries.

Thalliomelane crystallizes in space group $I4/m$ with $a = 9.8664(12)$ Å, $c = 2.8721(4)$ Å, and a calculated density is 5.370 g/cm³. The mineral was approved by the CNMNC in 2019 (IMA 2019-055) and the holotype material is deposited in the collection of the Mineralogical Museum of the University of Wrocław, Institute of Geological Sciences, Mineralogical Museum, Poland (catalog number MMWr IV8025).

KRUPIČKAITE

Krupičkaite (Steciuk et al. 2021), ideal $\text{Cu}_6[\text{AsO}_3(\text{OH})]_6 \cdot 8\text{H}_2\text{O}$, is named after Prof. Jirí Krupička who was a geologist, linguist, and astronomer in Prague. Prof. Krupička was a labor camp survivor and was imprisoned for writing a manuscript denouncing the nuclear arms race. He was not imprisoned until he was caught trying to smuggle the manuscript across the border in 1949. During his 10 years as a political prisoner for treason, he was forced to mine uranium for the Soviet nuclear program in grueling 12-hour shifts. He later rejoined his family and moved to Canada in 1968 where he was a professor at the University of Alberta until 1998.

Krupičkaite was found in an old ore-stope from near surface mining work at the Rovnost I mine. The Rovnost I mine was worked for uranium and radium for glass staining and for the Soviet nuclear weapons program. The structure was solved from transmission electron diffraction because the crystals are powdery and have indistinct morphology when maximum crystals sizes around $1 \mu\text{m}$, using the precession electron diffraction tomography technique. The structure of krupičkaite is closely related to geminite, $\text{Cu}(\text{AsO}_3\text{OH}) \cdot \text{H}_2\text{O}$, and both are

indistinguishable in the field. The structural differences between the two are that krupičkaite has a different layer stacking pattern with sheets having a wavy topology. Another related mineral to krupičkaite is slavkovite, which is a highly hydrated mineral with highly mixed CuO_5 and CuO_6 chains in the layers, and this is different than krupičkaite because krupičkaite possesses alternating layers of $\text{CuO}_6/\text{CuO}_5$ and CuO_6 chains.

Krupičkaite crystallizes in the space group $P2_1/n$ with $a = 15.25 \text{ \AA}$, $b = 17.59 \text{ \AA}$, $c = 10.27 \text{ \AA}$, $\beta = 103.42^\circ$. The calculated density from single-crystal diffraction data 1.242 g/cm^3 closely matches the measured density of 3.123 g/cm^3 . The mineral was approved by the CNMNC in 2020 (IMA 2020-032), and the type specimen is located in the collections of the Department of Mineralogy and Petrology, National Museum in Prague, Czechia (catalog number: P1P 18/2020).

SEABORGITE

Seaborgite (Kampf et al. 2021b), ideally $\text{LiNa}_6\text{K}_2(\text{UO}_2)(\text{SO}_4)_3(\text{SO}_3\text{OH})(\text{H}_2\text{O})$, is named after Glenn T. Seaborg who was an American chemist involved in the synthesis, discovery, and investigation of 10 transuranium elements. Seaborgium (element 106) was named after Glenn Seaborg and he earned a Nobel Prize in chemistry in 1951. He and his colleagues were the first ones to concentrate a weighable amount of plutonium in 1942.

Seaborgite was found in the Blue Lizard mine, San Juan County, Utah, U.S.A., in a post-mining oxidation zone in the sandstone beds. These beds are rich in bitumen with uraninite and sulfide minerals. Seaborgite likely formed from evaporation during dry periods in the usually damp mine. Interestingly, this is the first uranium-bearing mineral that contains structurally essential lithium. The authors postulate that the lithium could have migrated from lithium-bearing clays within, or nearby, the deposit by way of hydrothermal fluid circulation.

Seaborgite crystallizes in space group $P\bar{1}$ with $a = 5.4511(4) \text{ \AA}$, $b = 14.4870(12) \text{ \AA}$, $c = 15.8735(15) \text{ \AA}$, $\alpha =$

$76.295(5)^\circ$, $\beta = 100.238(11)^\circ$, $\gamma = 85.511(6)^\circ$, and a calculated density of $2.97(2) \text{ g/cm}^3$. The mineral was approved by the CNMNC in 2019 (IMA 2019-087), and the type specimen is located in the Natural History Museum of Los Angeles County, Los Angeles, CA, U.S.A. (catalog number: 74163).

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