

# The minium mineral group

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Compounds with the general formula  $MX_2O_4$  ( $X$  = ion with a lone electron pair;  $As^{3+}$ ,  $Sb^{3+}$ ,  $Bi^{3+}$  or  $Pb^{2+}$ ), with tetragonal crystal symmetry, are intensely studied by material scientists because of potential functional properties, e.g., as ferroelectrics (Bennet & Rabe 2012). The principal space group is  $P4_2/mbc$ , with unit-cell parameters  $a = 8\text{--}9 \text{ \AA}$  and  $c \sim 6 \text{ \AA}$ . In the crystal structure (e.g., Zemmann 1951), the 2 to 4-valent  $M$  atoms are coordinated by 6 O atoms in distorted (axially elongated) octahedra, which connect via trans-edges to form rutile-like ribbons along the  $c$ -axis. The  $X$  atoms form trigonal  $XO_3$  pyramids, which are linked via corners to form zig-zag  $(XO_2)_n$  chains. The lone-pair electrons of the  $X$  atoms protrude into tunnels created by four neighboring parallel chains.

Minerals belonging to this type are trippkeite ( $Cu^{2+}As^{3+}_2O_4$ ) and schafarzikite ( $Fe^{2+}Sb^{3+}_2O_4$ ), that were previously included in the “trippkeite group”. Minium,  $Pb^{4+}Pb^{2+}_2O_4$ , is an isostructural mineral, and since the compound is known from antiquity (mentioned by Pliny the Elder and others), it deserves priority as a group name. The minium group was recently established by an IMA decision (23-C). Kusachiite,  $Cu^{2+}Bi^{3+}_2O_4$ , used to belong to the old “trippkeite group”, but is not strictly isostructural: the  $Cu^{2+}$  ion has 4-fold (square planar) coordination to O, and Bi occurs in  $BiO_4$  polyhedra (Boivin et al. 1976). Apuanite,  $(Fe^{2+}Fe^{3+}_2)(Fe^{3+}_2Sb^{3+}_4)O_{12}S$  and versiliaite,  $(Fe^{2+}_2Fe^{3+}_2)(Fe^{3+}_2Sb^{3+}_6)O_{16}S$  (Mellini & Merlino, 1979) are direct structural derivatives but not counted to the minium group because of mixed anion compositions (introduction of extra S atoms to balance  $Fe^{3+}$  in the octahedral ribbons).

In the course of examining undescribed fissure minerals from the Långban Mn-Fe deposit, in the collections of the Swedish Museum of Natural History, two new members of the group have been discovered: igelströmite ( $Fe^{3+}[Sb^{3+}Pb^{2+}]O_4$ ; IMA2021-035), derived from schafarzikite via the coupled heterovalent substitution  $Fe^{2+} + Sb^{3+} \rightarrow Fe^{3+} + Pb^{2+}$ ; and manganoschafarzikite ( $Mn^{2+}Sb^{3+}_2O_4$ ; IMA2022-129), the Mn analogue of schafarzikite. They occur on open fractures in fine-grained hematite ore, together with calcite, barite, nadorite, serpentine, mimetite, rhodochrosite and other minerals. The late-stage mineral formation postdates brittle deformation of the ore bodies, at relatively low temperatures ( $< 200^\circ C$ ) and close to atmospheric pressure conditions. Chemical, structural and spectroscopic data have been collected for the new minerals and will be presented.

The abundance of synthetic structural equivalents to the group suggests that additional natural members could exist. For new species, it is recommended to adhere to the existing minerals for root names, based on the  $X$  atom content, and add prefixes for elements substituting at  $M$  sites. As an example, isostructural  $CoAs_2O_4$  would be named “cobaltotrippkeite”.

## References

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