Zhanghuifenite, Na₃Mn²⁺Mg₂Al(PO₄)₆, a new mineral isomorphous with bobfergusonite, from the Santa Ana mine, San Luis province, Argentina

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Abstract

A new mineral species, zhanghuifenite, ideally Na₃Mn²⁺Mg₂Al(PO₄)₆, has been found in the Santa Ana mine, San Luis province, Argentina. It occurs in irregular veinlets or patches, 5 mm thick, in a nodule of beusite interlaminated with lithiophilite. Broken pieces of zhanghuifenite are blocky or tabular. Single crystals are up to 0.8 × 0.5 × 0.5 mm. No twinning or parting is observed macroscopically. The mineral is deep green, transparent with pale green streak and vitreous luster. It is brittle and has a Mohs hardness of ~5 with good cleavage on {010}. The measured and calculated densities are 3.63(2) and 3.62 g/cm³, respectively. Optically, zhanghuifenite is biaxial (+), with α = 1.675(2), β = 1.680(2), γ = 1.690(2) (white light), 2V(meas) = 74(2)°, and 2V(calc) = 71°. The calculated compatibility index based on the empirical formula is 0.020 (excellent). An electron microprobe analysis yields an empirical formula (based on 24 O apfu) (Na₂.80Ca₀.11)Σ₂.91(Mn²⁺₀.69Mg₀.36Fe³⁺₀.₆₉)Σ₃.₉₂(Al₀.₆₁Fe³⁺₀.₄₉)(PO₄)₆. Zhanghuifenite is isomorphous with bobfergusonite, a member of the alluaudite supergroup. It is monoclinic, with space group P2₁/n, Z = 4, and unit-cell parameters a = 12.8926(3), b = 12.4658(3), c = 10.9178(2) Å, β = 97.9200(10)°, and V = 1737.93(7) Å³. The crystal structure of zhanghuifenite contains six octahedral M (= Mn, Fe, Mg, Al) sites and five X (= Na, Mn, Ca) sites with coordination numbers between 6 and 8. The six M octahedra share edges to form two types of kinked chains extending along [011], with one consisting of M₁-M₄-M₅ and the other M₂-M₃-M₆. These chains are joined by PO₄ tetrahedra to form sheets parallel to (010), which are linked together through corner-sharing between PO₄ tetrahedra and MO₆ octahedra in the adjacent sheets, leaving open channels parallel to a, where the large X cations are situated. Zhanghuifenite differs from bobfergusonite in two major aspects. One is that the M₄ and M₅ sites in the former are mainly occupied by Mg, but by Fe²⁺ and Fe³⁺, respectively, in the latter. The other is that the M₁-X₂-X₅ sites in zhanghuifenite are all nearly or fully filled with Na, resulting in 3 Na apfu in the ideal formula, but X₄ and X₅ are mostly half-occupied in bobfergusonite, giving rise to 2 Na apfu.

Keywords: Zhanghuifenite, wyllieite, alluaudite, crystal structure, X-ray diffraction, Raman spectra

Introduction

A new mineral species, zhanghuifenite, ideally Na₃Mn²⁺Mg₂Al(PO₄)₆, has been found in the Santa Ana mine, San Luis province, Argentina. It is named in honor of the late Chinese mineralogist, Prof. Huifen Zhang (1934–2012). Zhang received her undergraduate and graduate educations in China and the former USSR, respectively. She became a professor at the Institute of Geochemistry (in both Guiyang and Guangzhou), the Chinese Academy of Sciences, where she was the director of the division for mineral physics and materials research from 1980 to 1994. Prof. Zhang established the first Raman spectroscopy laboratory for mineralogical research in China and served as a member of the IMA Commission on Mineral Physics from 1990 to 1994. Her major research interests were particularly focused on synthetic quartz, rutile, pyrophyllite, and turquoise. The new mineral and its name have been approved by the Commission on New Minerals, Nomenclature and Classification (CNMNC) of the International Mineralogical Association (IMA 2016-074). The co-type samples have been deposited at the University of Arizona Mineral Museum (catalog no. 21321) and the RRUFF Project (deposition no. R160030) (http://rruff.info).

Zhanghuifenite, isotypic with bobfergusonite, is closely related to minerals of the wyllieite and alluaudite groups. However, it differs from all known members of these groups in both chemical composition and structure. Moore and Molin-Case (1974) showed that the crystal structure of wyllieite is a superstructure derivative of the alluaudite structure. Moore and Ito (1979) introduced a nomenclature for the minerals of the alluaudite and wyllieite groups. Recently, a new nomenclature of the alluaudite supergroup, which