Rowleyite, [Na(NH₄,K)₇Cl₄][(P₂As₂O₁₃)₉·nH₂O·Na₂(NH₄)₄K,C], a new mineral with a microporous framework structure

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ABSTRACT

Rowleyite, [Na(NH₄,K)₇Cl₄][(P₂As₂O₁₃)₉·nH₂O·Na₂(NH₄)₄K,C], is a new mineral species from the Rowley mine, Maricopa County, Arizona, U.S.A. It was found in an unusual low-temperature, apparently post-mining suite of phases that include various vanadates, phosphates, oxalates, and chlorides, some containing NH₄. Other secondary minerals found in association with rowleyite are antipinite, fluorite, mimetite, mottramite, quartz, salammoniac, struvite, vanadinite, willemite, wulfenite, and several other potentially new minerals. Analyzed δ¹³C values for the antipinite in association with rowleyite are consistent with a bat guano source. Crystals of rowleyite are very dark brownish green (appearing black) truncated octahedra up to about 50 μm in diameter. The streak is brownish green, the luster is vitreous, very thin fragments are transparent. The Mohs hardness is about 2, the tenacity is brittle, fracture is irregular, there is no cleavage, and the measured density is 2.23(2) g/cm³. Rowleyite is optically isotropic with n = 1.715(5). Electron microprobe analyses yielded the empirical formula [(NH₄)₉Na₂K₂Cl₂·14.93H₂O·Na₂(NH₄)₄K,C]. Raman and infrared spectroscopy confirmed the presence of NH₄ and H₂O. Rowleyite is cubic, Fd̅3m, with a = 31.704(14) Å, V = 31867(42) Å³, and Z = 16. The crystal structure of rowleyite (R₁ = 0.040 for 1218 F₀ > 4σF₀ reflections) contains [V₄O₁₀]₂⁺ polyoxovanadate units that link to one another via shared vertices with [(P₂As₂O₁₃)₉⁺ tetrahedra to form a 3D framework possessing large interconnected channels. The channels contain a 3D ordered [Na(NH₄,K)₇Cl₄]⁺ salt net, which apparently served as a template for the formation of the framework. In that respect, rowleyite can be considered a salt-inclusion solid (SIS). The rowleyite framework is among the most porous known.

Keywords: Rowleyite, new mineral species, polyoxovanadate, microporous framework, salt-inclusion solid, crystal structure, Rowley mine, Arizona

INTRODUCTION

The Rowley mine, about 100 km southwest of Phoenix, Arizona, U.S.A., is an old Cu-Pb-Au-V-baryte-fluorspar mine, which has not been worked for ore since 1923. Mineral collectors first took notice of the mine as a source of fine wulfenite crystals around 1945. In early 1933, one of the authors (J.J.T.) found ammineite, CuCl₂(NH₃)₂, in the vicinity of bat guano at the end of the tunnel on the 125-foot level. A short time later, another of the authors (J.M.) discovered unusual mineralization 10 to 15 m up the tunnel from the ammineite occurrence. His attention was initially drawn to bluish-green specks that proved to be antipinite, KNa₂Cu₃(C₂O₄)₆. Both ammineite and antipinite are recently described species from the sea-bird guano deposit at Pabellón de Pica, Chile (Bojar et al. 2010; Chukanov et al. 2015). The suite of phases associated with the antipinite in the Rowley mine includes a remarkable assortment of vanadates, phosphates, oxalates, and chlorides, some of which contain NH₄, and many of which are new. Herein, we describe the first of these new phases, rowleyite, which is named for the locality, the Rowley mine. The polyoxometalate framework structure of rowleyite is noteworthy for being among the most porous known.

The new mineral and name were approved by the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association (IMA 2016-037). Five co-type specimens of rowleyite are deposited in the collections of the Natural History Museum of Los Angeles County, Los Angeles, California, U.S.A., catalog numbers 66268, 66269, 66270, 66271, and 66272.

OCCURRENCE

The Rowley mine is located near Theba in the Painted Rock district, Maricopa County, Arizona, U.S.A. (33°2′57″N