Meyrowitzite, Ca(UO\(_2\))(CO\(_3\))\(_2\)·5H\(_2\)O, a new mineral with a novel uranyl-carbonate sheet

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**ABSTRACT**

Meyrowitzite, Ca(UO\(_2\))(CO\(_3\))\(_2\)·5H\(_2\)O, is a new mineral species from the Markey mine, Red Canyon, San Juan County, Utah, U.S.A. It is a secondary phase found on calcite-veined asphaltum in association with gypsum, markeyite, and rozenite. Meyrowitzite occurs as blades up to about 0.2 mm in length, elongate on [010], flattened on [100], and exhibiting the forms [100], [001], [101], [110], and [011]. The mineral is yellow and transparent with vitreous lustre and very pale yellow streak. Fluorescence under a 405 nm laser is from weak greenish yellow to moderate greenish blue. The Mohs hardness is ca. 2, tenacity is brittle, fracture is irregular, and there is one perfect cleavage, {010}. The measured density is 2.70(2) g/cm\(^3\). The mineral is optically biaxial (+) with \(\alpha = 1.520(2), \beta = 1.528(2),\) and \(\gamma = 1.561(2)\) (white light). The 2\(V(\text{meas}) = 53.0(6)^\circ\); weak dispersion, \(r > v\); optical orientation: \(Z = b, Y^* a = 19^\circ\) in obtuse \(\beta\); pleochroism pale yellow, \(X < Y < Z\). Electron microprobe analyses provided the empirical formula Ca\(_{1.94}\)(U\(_{1.00}\)O\(_2\))(CO\(_3\))\(_2\), with cationic formula \(\text{UO}_2\cdot 5\text{H}_2\text{O}\) on the basis of \(\text{U} = 1\) and \(\text{O} = 13\) apfu, as indicated by the crystal structure determination. Meyrowitzite is monoclinic, \(P_2_1/n, a = 12.376(3), b = 16.0867(14), c = 20.1340(17)\) Å, \(\beta = 107.679(13)^\circ\), \(V = 3819.3(12)\) Å\(^3\), and \(Z = 12\). The structure \((R_s = 0.055\) for 3559 \(I > 2\sigma(I)\)) contains both \(\text{UO}_2\) pentagonal bipyramids and \(\text{UO}_6\) hexagonal bipyramids, the latter participating in uranyl tricarbonate clusters (UTC). The two kinds of bipyramids and the carbonate groups link to form a novel corrugated heteropolyhedral sheet. This is the first structural characterization of a uranyl-carbonate mineral with a U:C ratio of 1:2. Meyrowitzite is apparently dimorphous with zellerite.

**Keywords:** Meyrowitzite, new mineral species, uranyl tricarbonate, crystal structure, zellerite, Markey mine, Red Canyon, Utah

**INTRODUCTION**

Carbonate minerals containing U\(^{VI}\) are usually relatively soluble in aqueous solutions. Aqueous uranyl-carbonate complexes are generally quite stable and are responsible for uranium migration in the environment on a large scale (Langmuir 1978; Clark et al. 1995). The most abundant complexes are uranyl monocarbonate, ([UO\(_2\)(CO\(_3\))]\(^-\)), uranyl dicarbonate, ([UO\(_2\)(CO\(_3\))]\(^{2-}\)) and uranyl tricarbonate, ([UO\(_2\)(CO\(_3\))]\(^{3-}\)), with \(pK_a\) values of 5.5, 7, and 9, respectively (Langmuir 1978). The most abundant uranyl carbonate minerals are those with a U:C ratio of 1:3, which crystallize from solutions of relatively high pH, from neutral to alkaline. However, very little data are available for minerals with a U:C ratio of 1:2; for example, the mineral zellerite, Ca[U\(_2\)(CO\(_3\))]\(_5\)H\(_2\)O (Coleman et al. 1966), which occurs commonly within the carbonate-rich alteration associations of supergene U minerals, has so far eluded crystallographic characterization. Here, we present the description of the new uranyl-carbonate mineral, meyrowitzite, Ca(UO\(_2\))(CO\(_3\))\(_2\)·5H\(_2\)O, a dimorph of zellerite, and the first structural characterization of a uranyl-carbonate mineral with a U:C ratio of 1:2.

Meyrowitzite is named in honor of American analytical chemist Robert Meyrowitz (1916–2013). Meyrowitz received his bachelor’s degree in chemistry from the City College of New York in 1936, after which he conducted research in microchemical analysis at Brooklyn College (New York). During World War II, he served in the U.S. Army and, because of his skills as a chemist, he was assigned to work on the Manhattan Project. After the war, he joined the U.S. Geological Survey (USGS), from which he retired in 1973. In his years at the USGS, he was especially known for his knack for developing innovative new methods for analyzing small and difficult to study mineralogical samples and is also well known for his formulation of the high-index immersion liquids (1.74 to 2.00) that are still in use for optical determinations (Meyrowitz and Larsen 1951). He published prolifically, often collaborating on the descriptions of new minerals (e.g., brockite, duttonite, goldmanite, hendersontite, metazellerite, ningyoite, sahamalite, sherwoodite, simplotite, weeksite, and zellerite). Many of the new minerals species that he worked on were from the uranium deposits of the western...