Čejkaite, a new mineral from Jáchymov, NW Bohemia, Czech Republic

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ABSTRACT

Čejkaite, a new mineral from Jáchymov, NW Bohemia, Czech Republic, forms a thin earthy efflorescence over a calcite vein associated with disintegrated uraninite. The color is pale yellow to beige, the streak is light yellow, and the luster is vitreous. The broad secondary mineral association includes andersonite and schröckingerite. Chemical analysis (by ICP-MS and TG) gave (in wt%): Na2O = 21.39, MgO = 0.15, FeO = 0.53, UO2 = 53.93, and CO2 = 24.00 (calculated by difference). The simplified chemical formula is Na4(UO2)(CO3)3. The mineral is triclinic, space group P1 or P1, a = 9.291(2), b = 9.292(2), c = 12.895(2) Å, α = 90.73(2), β = 90.82(2), γ = 120.00(1)°, V = 963.7(4) Å3, Z = 4, Dm = 3.67(1) g/cm3, and Dab = 3.766(5) g/cm3. The strongest seven lines in the X-ray powder-diffraction pattern [d in Å(I)(hkl)] are: 8.022(92)(110, 010, 100), 5.080(57)(102, 012), 5.024(60)(112, 1T), 4.967(68)(102, 012), 4.639(100)(120, 210, 110), 3.221(63)(004), 2.681(60)(310, 114, 030, 300). Optical data could not be measured due to the extremely small grain size, but the calculated mean refractive index is 1.5825. Crystal size varies from 0.2 to 0.6 μm and shows an indistinct hexagonal outline. Thermal decomposition of synthetic čejkaite proceeds in three main steps. DTA endotherm at 430 °C corresponds to the decomposition of the uranyl tricarbonate groups. IR spectrum of čejkaite confirms the presence of crystallographically nonequivalent (CO3)2– groups and the absence of water. The average U-O bond length in (UO2)2+, calculated from νd = 848 cm–1, is R(U-O) ~ 1.81 Å. A model based on the crystal structure of trigonal Na₄(UO₂)(CO₃)₃ was adopted and applied to solve the čejkaite crystal structure by the Rietveld method (7238 unique reflections, Rp = 0.076, Rwp = 0.104). Uranium is eight-coordinated, and forms a [UO₂O₆] skeleton with almost linear O-U-O that is roughly perpendicular to an irregular cycle formed by six O atoms that, in turn, belong to three more-or-less regular and planar CO₃ groups. Atoms Na1, Na1a, and Na2 are octahedrally coordinated, whereas Na3 is pentagonally coordinated. The mineral name honors Jiří Čejka for his notable contributions to the crystal chemistry of U minerals.

INTRODUCTION

In the course of work on the project Study of secondary minerals in the Jáchymov ore district (Ondruš et al. 1997b, 1997c), thirty new naturally forming inorganic phases were recognized and studied. This paper describes one of these, čejkaite, which is triclinic Na₄(UO₂)(CO₃)₃, in detail. Because čejkaite was observed at Jáchymov as an extremely rare species, we prepared a synthetic analog of this new mineral in our laboratory, which allowed us to study this phase in more detail. Triclinic Na₄UO₂(CO₃)₃ was synthesized according to the following method: a solution containing 2 · 10⁻³ M uranyl nitrate was added slowly with constant stirring to a solution of 6·10⁻³ M sodium carbonate. A yellow precipitate formed and was decanted three times using distilled water.

To compare the physical and chemical properties and crystal structure parameters of čejkaite to its trigonal polymorph, we also prepared synthetic trigonal Na₄(UO₂)(CO₃)₃. The latter was synthesized from synthetic triclinic Na₄(UO₂)(CO₃)₃ pow- der by recrystallization in sealed silica glass tubes under hydrothermal conditions at a pressure of about 20 MPa and a temperature of 135 °C for 3 days (Císařová et al. 2001).

Under hydrothermal conditions at about 200 °C, čejkaite recrystallizes to trigonal Na₄UO₂(CO₃)₃, whose crystal structure has been characterized by Douglass (1956), Čejka (1999), Císařová et al. (2001), and Li et al. (2001a). Koglin et al. (1979) summarized the basic structural motif of the UO₅(CO₃)₃ complex. Burns (1999) listed twenty-three uranyl phases that have known crystal structures based on a finite cluster of polyhedra of higher bond valence (Burns et al. 1996), but only six of these are recognized as minerals. One may expect that this finite cluster should also occur in uranyl-carbonate minerals in which the crystal structure has not yet been solved (rabbittite, widenmannite, znucalite, and many others).

The holotype material of čejkaite is deposited in the mineralogical collection of the National Museum, Prague, Czech Republic.