The Canadian Mineralogist
Vol. 36, pp. 1077-1081 (1998)

BLATONITE, $UO_2CO_3 \cdot H_2O$, A NEW URANYL CARBONATE MONOHYDRATE FROM SAN JUAN COUNTY, UTAH

RENAUD VOCHTEN[1]

Laboratorium voor chemische en fysische mineralogie, Departement Scheikunde, Universiteit Antwerpen, Middelheimlaan 1, B-2020 Antwerpen, Belgium

MICHEL DELIENS

Institut royal des Sciences naturelles de Belgique, section de Minéralogie, Rue Vautier, 29, B-1000 Brussels, Belgium

Abstract

Blatonite, ideally $UO_2CO_3 \cdot H_2O$, is a new uranyl carbonate mineral found in the Jomac mine, Brown's Rim, San Juan County, Utah. It occurs in seams of gypsum located between some bedding planes of a layer of siltstones within the Triassic Shinarump conglomerate. Associated U^{6+} minerals are boltwoodite, coconinoite, metazeunerite, and rutherfordine, together with the Cu^{2+} minerals azurite, brochantite, carbonate-cyanotrichite and malachite. Blatonite occurs as acicular crystals that are canary yellow and translucent with a silky luster and colorless streak. It strongly fluoresces in UV. H_{Mohs} = 2–3. $D_{meas.}$ = 4.05(2), $D_{calc.}$ = 4.02 g/cm^3 (idealized formula). Optically uniaxial (+), ω 1.588(2), ϵ 1.612(2). The crystals are nonpleochroic. Blatonite is hexagonal or trigonal (space group unknown): *a* 15.79(1), *c* 23.93(3) Å, *V* 5167(9) Å^3 and *Z* = 36. The strongest reflections of the X-ray powder pattern [*d*(in Å)(I)*hkl*] are: 7.86(47)110, 6.91(55)103, 6.56(77)201, 4.76(40)114, 4.34(36)213 and 3.06(100)207. Electron microprobe and thermogravimetric analyses gave UO_3 81.98, CO_2 12.82, H_2O 5.38, total 100.18 wt %. The empirical formula is 0.988 $UO_2 \cdot$1.004 $CO_2 \cdot$1.029 H_2O. The name honors the Belgian crystallographer Norbert Blaton, University of Leuven, Belgium. Holotype material is deposited in the mineralogical collection of the Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

Keywords: blatonite, new mineral species, uranyl carbonate monohydrate, Jomac mine, San Juan County, Utah.

Sommaire

La blatonite, de formule idéale $UO_2CO_3 \cdot H_2O$, est un nouveau carbonate d'uranyle découvert dans la mine Jomac, Brown's Rim, comté de San Juan, Utah. Le minéral se rencontre dans du gypse présent dans certains plans de stratification d'une couche d'argilite, au sein du conglomérat triassique de Shinarump. L'association comprend des minéraux uranifères tels que la boltwoodite, la coconinoïte, la métazeunérite et la rutherfordine, et des minéraux cuprifères tels que l'azurite, la carbonate-cyanotrichite, la brochantite et la malachite. Les cristaux aciculaires sont jaune canari et translucides avec un éclat soyeux. Le trait est incolore. Le minéral est fortement fluorescent aux UV. $H_{(Mohs)}$ = 2 – 3. $D_{(mesurée)}$ = 4.05(2), $D_{(calculée)}$ (d'après la formule idéale) = 4.02 g/cm^3. Optiquement uniaxe (+) avec ω = 1,588(2) et ϵ = 1,612(2). Les cristaux ne présentent aucun pléochroïsme. La blatonite est hexagonale ou trigonale, groupe spatial non établi, avec *a* 15,79(1), *c* 23,93(3) Å, *V* 5167(9) Å^3 et *Z* = 36. Les raies les plus intenses du spectre de diffraction X [*d*(en Å)(I)*hkl*] sont: 7,86(47)110, 6,91(55)103, 6,56(77)201, 4,76(40)114, 4,34(36)213 et 3,06(100)207. L'analyse chimique à la microsonde électronique et par thermogravimétrie donne: UO_3 81,98, CO_2 12,82, H_2O 5,38, total 100,18%. La formule empirique correspond à 0,988 $UO_2 \cdot$1,004 $CO_2 \cdot$1,029 H_2O. Le nom est en l'honneur du cristallographe belge Norbert Blaton de l'Université de Leuven, Belgique. Le matériel holotype est enregistré dans la collection de l'Institut royal des Sciences naturelles de Belgique à Bruxelles.

Mots-clés: blatonite, nouvelle espèce minérale, carbonate monohydraté d'uranium, mine Jomac, comté de San Juan, Utah.

[1] *E-mail address*: revo@nets.ruca.ua.ac.be

Introduction

Until now, two uranyl carbonates devoid of other cations in their structures have been described as minerals: rutherfordine, UO_2CO_3 (Marckwald 1906), and joliotite, $UO_2CO_3 \cdot 2H_2O$ (Walenta 1976). Blatonite, ideally $UO_2CO_3 \cdot H_2O$, was discovered in the Jomac uranium mine, Brown's Rim, San Juan County, Utah, by Patrick Haynes, an American geologist and mineral collector. He provided us with material in order to more fully characterize the mineral. After haynesite (Deliens & Piret 1991), a uranyl selenite named after him, blatonite is the second species originating from his collection.

The Jomac mine was successively owned by Alliance Nuclear Inc. of Spokane, Washington, from 1950 to 1979, and by Birco Development of Moab, Utah, between 1983 and 1985. The mines of the district are now closed and are part of the Glen Canyon National Recreation Area.

Blatonite was approved by the Commission of New Minerals and Mineral Names of the IMA in September 1997 (97–18). The holotype specimen is preserved in the mineralogical collection of the Royal Belgian Institute of Natural History, Brussels, with catalogue number R.C. 4788. The name honors Norbert Blaton (b. 1945), crystallographer at the University of Leuven, Belgium, specialist of the crystal structure of uranium minerals.

Occurrence

The host rock is the Triassic Shinarump conglomerate, rich in organic material such as black coally smears and logs of partially petrified wood. The most common U^{6+} mineral in the mine is coconinoite, which is scattered throughout the conglomerate, locally replacing organic debris. Blatonite occurs in seams of gypsum located along bedding planes of a layer of siltstone within the conglomerate. Associated U^{6+} minerals are boltwoodite, coconinoite, metazeunerite and rutherfordine, together with the copper minerals azurite, brochantite, carbonate-cyanotrichite and malachite. Pink manganoan smithsonite and tiny patches of sulfides, as well as some unknown material, complete the association.

Morphology and Physical Properties

Blatonite mostly appears as very thin asbestiform aggregates; the bundles of needle-shaped subparallel fibers are up to 0.1 mm in width and 1 mm in length. Some crystals are fan-like and terminated. A SEM photomicrograph of crystals of blatonite (Fig. 1A) shows aggregates of parallel slender fibers. The mineral is canary yellow and is translucent, with a silky luster and white streak. The Mohs hardness is 2–3, and the parting is along the fibers. The crystals are flexible, and their fracture is uneven. The density, measured at 25°C in Clerici solution, is 4.05(2) g/cm^3. The calculated density, based on the idealized formula, is 4.02 g/cm^3. Blatonite is soluble with effervescence in dilute mineral acids and in dilute organic acids such as acetic acid.

Optical Characteristics

Blatonite is uniaxial positive. The indices of refraction ω and ϵ, determined at 589–599 nm, are 1.588(2) and 1.612(2). The crystals are length-fast and nonpleochroic. Blatonite fluoresces strongly greenish yellow at 360 nm; in this way, it contrasts with joliotite, which fluoresces weakly, and rutherfordine, which does not fluoresce at all.

X-Ray Crystallography

As can be seen from Figure 1B, on a scale of 5 μm, the fibrous crystals are narrow and distorted. Because of this habit, we could not determine the crystal structure, nor unit cell and space group, by single-crystal X-ray diffraction. X-ray powder-diffraction data were recorded with a Guinier–Hägg camera using monochromatic Cu$K\alpha_1$ radiation (λ 1.5406 Å). Silicon powder (SRM–460) was used as an internal standard. Relative intensities of the diffraction lines were measured with a line scanner LS–20 (Key Instruments, Täby, Sweden). Peak positions were determined using the computer program SCANPI (Johansson *et al.* 1980). The X-ray-diffraction spectrum shows only 14 lines, in part because of the fibrous habit of the crystals; it was indexed with the program TREOR (Werner *et al.* 1985). Blatonite belongs to the hexagonal or trigonal system, but the space group could not be deduced. The unit-cell parameters, refined by the least-squares program PIRUM (Werner 1969), are: a 15.79 (1), c 23.93(3) Å, $c:a$ 1.516, $V = 5167(9)$ Å^3, $Z = 36$. The figure-of-merit values are F(14) = 6(0.030309,92). A fully indexed powder-diffraction pattern is given in Table 1.

Chemical Composition

The crystals of blatonite were chemically analyzed with a Cameca SX–50 electron microprobe of the "Centre d'analyse par microsonde pour les sciences de la terre" of the University of Louvain (J. Wautier, analyst), using a beam size of 2 μm, an operating voltage of 15 kV, and a beam current of 20 nA. Synthetic UO_2 was used as the standard. The analysis done for 14 points revealed the presence of uranium as the only cation detected. The mean content of UO_3 is 81.98 wt.% (range 78.5–83.2%). The proportion of H_2O and CO_2 was determined with a thermogravimetric analyzer (TGA 2950, TA Instruments). The heating rate applied was 5°/min with a constant flow of N_2 at 50 mL/min. The loss of H_2O and CO_2 is complete at 500°C and corresponds to 5.38 wt.% H_2O and 12.82 wt.% CO_2. The formula, calculated on the basis of six oxygen atoms, is

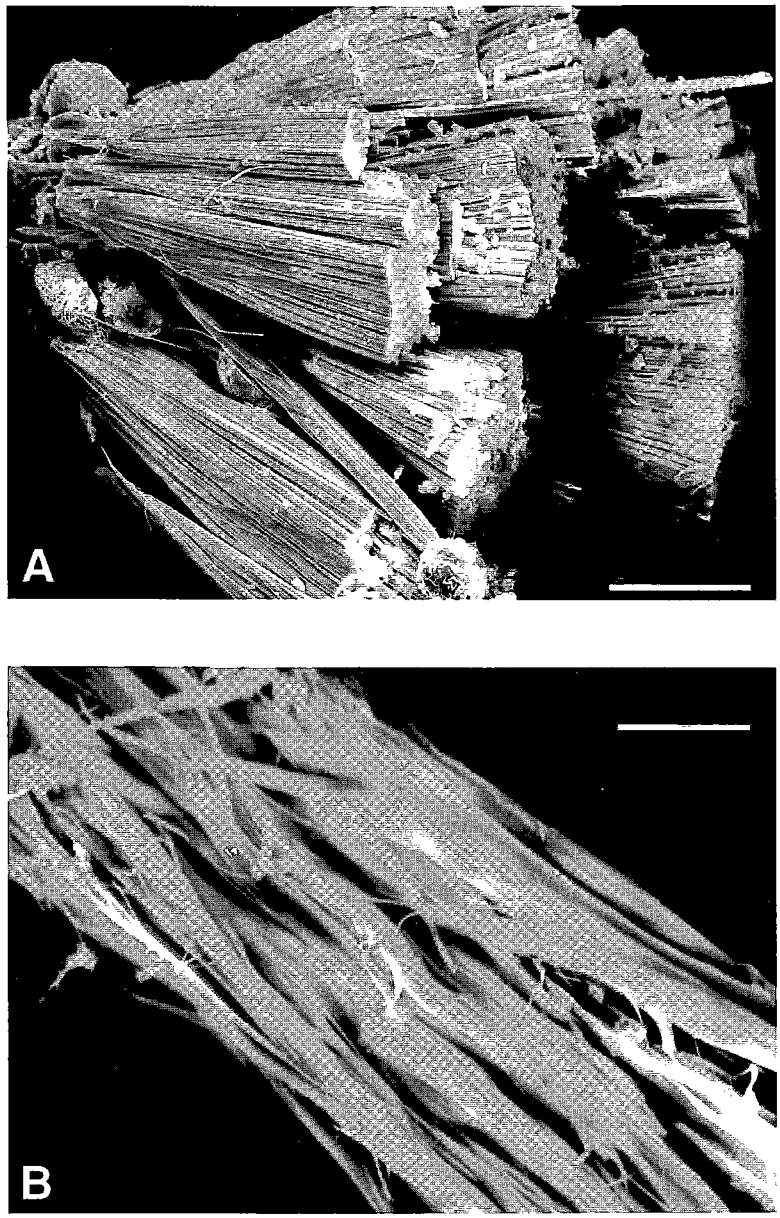

FIG. 1. Crystals of blatonite, as photographed with a scanning electron microscope. Scale bar: 100 μm (A), 10 μm (B).

$(UO_2)_{0.988}(CO_3)_{1.004}$•1.029 H_2O. The ideal formula is UO_2CO_3•H_2O. Calculation of the Gladstone–Dale relationship using the constants of Mandarino (1981) yielded a compatibility index of 0.036, indicative of excellent agreement between physical and chemical data.

INFRARED SPECTROSCOPY

The infrared spectrum was recorded using the KBr dispersion technique (1 mg in 300 mg KBr) with an Ati-Mattson Genesis Fourier-transform infrared spectrometer over the range 400–4000 cm^{-1}. The infrared

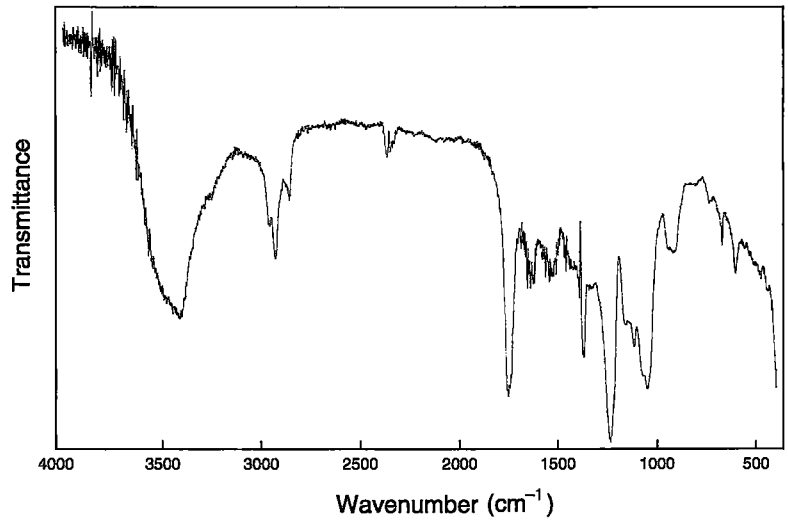

FIG. 2. Fourier transform infrared spectrum of blatonite.

spectrum is shown in Figure 2. The assignments of absorption bands are summarized in Table 2.

RELATIONSHIP TO OTHER SPECIES

Blatonite is chemically related to rutherfordine, UO_2CO_3, and joliotite, $UO_2CO_3 \cdot 2H_2O$, differing only in the H_2O content. By heating joliotite for two hours at 100°C, Walenta (1976) found that the indices of refraction increased and that the X-ray-diffraction lines became more diffuse. A small peak appeared at $d = 10.25$ Å, but the spectra of heated joliotite and of joliotite still are distinct from that of blatonite. After loss of H_2O, joliotite thus is not transformed into blatonite, and blatonite cannot be considered as a *meta* form of joliotite. We conclude that three structurally distinct simple uranyl carbonates exist, one anhydrous, UO_2CO_3, rutherfordine, and two hydrated: $UO_2CO_3 \cdot H_2O$, blatonite, and $UO_2CO_3 \cdot 2H_2O$, joliotite.

TABLE 1. X-RAY POWDER-DIFFRACTION DATA FOR BLATONITE

hkl	d_{obs} (Å)	d_{calc} (Å)	*I*
100	13.76	13.676	20
102	8.97	9.005	28
110	7.86	7.896	47
103	6.91	6.891	55
201	6.56	6.575	77
211	5.07	5.052	31
114	4.76	4.769	40
213	4.34	4.338	36
221	3.89	3.895	20
215	3.52B	3.512	31
401	3.39	3.384	33
207	3.056	3.058	100
412	2.893	2.896	22
503	2.587B	2.587	18

Guinier-Hägg camera, diameter 100 mm, Cu$K\alpha_1$ radiation, exposure time 45 minutes, intensities measured using an LS-20 line scanner (Key Instruments, Sweden).

TABLE 2. INFRARED ABSORPTION BANDS FOR BLATONITE

wavenumber (cm^{-1})	Vibrational mode	Ref.
3426 (*bs*)	ν (OH) stretching	(1)
2935 (vw)	ν (OH) stretching	(3)
2914 (m)	ν (OH) antisymmetric stretching	(1)
1750 (vs)	δ (H-OH) bending	(3)
1630(w)	δ(H-OH) bending	(3)
1367 (m)	$\nu_3(CO_3^{2-})$ antisymmetric stretching	(2)
1235 (s)	δ(U-OH) bending	(4)
1110 (vw)	$\nu_1(CO_3^{2-})$ symmetric stretching	(2)
1051 (m)	δ(U-OH) bending	(1)
950(w)	ν_3(O-U-O) antisymmetric stretching	(1)
914 (w)	$\nu_2(CO_3^{2-})$ out of plane bending	(5)
727 (vw)	$\nu_4(CO_3^{2-})$ in plane bending	(5)
670 (w)	OH libration (?)	

Intensity: v: very strong, s: strong, m: medium, w: weak. Band shape: *b*: broad. References cited: (1) Čejka *et al.* (1996), (2) Botto *et al.* (1989), (3) Farmer (1974), (4) Čejka & Urbanec (1990), (5) Nakamoto (1963).

Acknowledgements

We thank the Fund for Scientific Research Vlaanderen (FWO–Vl) for financial support awarded to one of us (RV). We are indebted to Ing. J. Jansens of the Laboratory of Inorganic Chemistry, University of Antwerp for recording the TGA curve. We thank Mr. J. Eysermans and F. Schalenbergs of the Research Group "Electron Microscopy for Material Research" for making the SEM micrographs, and Mrs. D. Dielen for typing the manuscript. We are also indebted to some anonymous members of the Commission on New Minerals and Mineral Names, IMA, to editor Dr. Robert F. Martin, to associate editor Dr. Peter C. Burns and to referee Dr. Frances Hill for their valuable comments.

References

Botto, I.L, Garcia, A.C. & Deliens, M. (1989): Thermal and IR spectroscopic characterization of kamotoite. *Collect. Czech. Chem. Commun.* **54**, 1263-1268.

Čejka, J., Sejkora, J., Mrázek, Z., Urbanec, Z. & Jarchovsky, T. (1996): Jáchymovite $(UO_2)_8(SO_4)(OH)_{14}•13H_2O$, a new uranyl mineral from Jáchymov, the Krusné Hory Mts., Czech Republic, and its comparison with uranopilite. *Neues Jahrb. Mineral., Abh.* **170**, 155-170.

_____ & Urbanec, Z. (1990): *Secondary Uranium Minerals.* Rozpravy Ceskoslovenské Akademie Ved, Praha, Czech Republic.

Deliens, M. & Piret, P. (1991): La haynesite, sélénite hydraté d'uranyle, nouvelle espèce minérale de la mine Repete, comté de San Juan, Utah. *Can. Mineral.* **29**, 561-564.

Farmer, V.C. (1974) : *The Infrared Spectra of Minerals.* Mineralogical Society, London, U.K.

Johansson, K.E., Palm, T. & Werner, P.-E. (1980): An automatic microdensitometer for X-ray powder diffraction photographs. *J. Phys. E: Sci. Instrum.* **13**, 1289-1291.

Mandarino, J.A. (1981): The Gladstone – Dale relationship. IV. The compatibility concept and its application. *Can. Mineral.* **19**, 441-450.

Marckwald, W. (1906): Über Uranerze aus Deutsch-Ostafrika. *Zentralbl. Mineral.*, 761-763.

Nakamoto, K. (1963): *Infrared Spectra of Inorganic and Coordination Compounds.* John Wiley and Sons, New York, N.Y.

Walenta, K. (1976): Widenmannit und Joliotit, zwei neue Uranylkarbonatmineralien aus den Schwarzwald. *Schweiz. Mineral. Petrogr. Mitt.* **56**, 167-185.

Werner, P.-E. (1969): A Fortran program for least-squares refinement of crystal-structure cell dimensions. *Arkiv Kemi* **31**, 513-516.

_____, Eriksson, L. & Westdahl, M. (1985): TREOR, a semi-exhaustive trial-error powder indexing program for all symmetries. *J. Appl. Crystallogr.* **18**, 367-370.

Received January 28, 1998, revised manuscript accepted May 21, 1998.