

# RABBITTITE, A NEW URANYL CARBONATE FROM UTAH\*

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## ABSTRACT

Rabbitite is a new hydrated calcium magnesium uranyl carbonate found in the Lucky Strike No. 2 mine, San Rafael district, Emery County, Utah, in July 1952. It is pale green, finely acicular to fibrous, silky, and occurs as an efflorescence on the mine wall. It is optically biaxial, probably positive, with indices of refraction  $\alpha=1.502\pm 0.005$ ,  $\beta=1.508\pm 0.005$  and  $\gamma=1.525\pm 0.003$ . The specific gravity is about 2.6. The chemical analysis shows CaO 10.6 per cent, MgO 9.2, UO<sub>3</sub> 37.4, CO<sub>2</sub> 17.8, H<sub>2</sub>O 24.5, acid insoluble 0.5; total 100 per cent, and indicates the formula Ca<sub>2</sub>Mg<sub>3</sub>(UO<sub>2</sub>)<sub>2</sub>(CO<sub>3</sub>)<sub>6</sub>(OH)<sub>4</sub>·18H<sub>2</sub>O. An *x*-ray rotation photograph of a small bundle of fibers shows the unit cell length  $c_0=9.45\pm 0.05$  Å. From the indexing of *h**k*0 reflections  $a_0$  is thought to be  $32.6\pm 0.1$  Å and  $b_0$   $23.8\pm 0.1$  Å, with  $Z=8$ .

## INTRODUCTION AND ACKNOWLEDGMENTS

Rabbitite was collected from the Lucky Strike No. 2 mine, Emery County, Utah, in July 1952 by M. E. Thompson and A. D. Weeks when they visited the mine with other U. S. Geological Survey geologists. The mineral was determined as a new one because its *x*-ray diffraction powder pattern and its physical and optical properties differ from those of other known uranium carbonates.

Of the uranyl carbonates in the literature, only swartzite might be confused with rabbitite. Swartzite is, however, definitely distinct from rabbitite, and to make the differences clear the optical properties, chemical analysis, and *d*-spacings of the *x*-ray powder pattern of swartzite are included for comparison with those of rabbitite.

Rabbitite is named in honor of John C. Rabbitt, who was chief of the U. S. Geological Survey Trace Elements Section from 1947 to 1953—in recognition of the leadership and inspiration he gave to the members of the laboratory.

Thanks are gratefully extended to J. W. Gruner, University of Minnesota, for loan of an ore sample from the Lucky Strike No. 2 mine.

This work was part of a project on mineralogy of uranium in sandstone-type deposits that is being conducted by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

## OCCURRENCE

Rabbitite occurs as an efflorescence on a pillar of high-grade ore near the portal of the Lucky Strike No. 2 mine, Emery County, Utah. The

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mine is in a uranium deposit in the Shinarump conglomerate (Triassic), between the San Rafael River and the Muddy River on the west flank of the San Rafael Swell. Figure 1 is an index map showing the location of the mine. The ore contains pitchblende and is only partly oxidized because the deposit is protected by the overlying Chinle formation and Wingate sandstone, which rise in a high cliff above the mine. The ore near the portal was high grade, containing pitchblende with a little

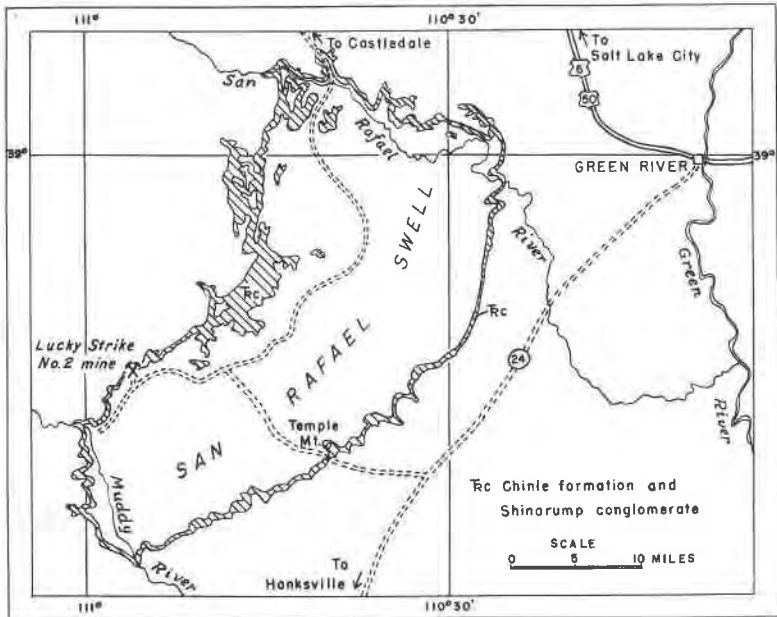


FIG. 1. Index map of locality of rabbitite.

pyrite and galena, and many yellow and orange secondary uranium minerals, including fourmarierite,<sup>1</sup> rabbitite, zippeite, another uranium sulfate that is related to zippeite, and another new uranium mineral, possibly magnesium uranyl sulfate, whose description is not yet completed. Gypsum and at least two pink cobalt efflorescences, Bieberite and sphaerocobaltite, were collected from the same pillar on which the rabbitite occurred.

#### PHYSICAL AND OPTICAL PROPERTIES

Rabbitite occurs as bundles of pale-green extremely small acicular crystals with a silky luster. The bundles of fibers resemble talc, in that some of them are bent and twisted.

<sup>1</sup> Specimen courtesy of J. W. Gruner.

The hardness of rabbitite was determined approximately by rubbing it against gypsum and calcite while viewing the test through the binocular microscope. The mineral seems to be slightly harder than gypsum. If it is crushed too roughly when being prepared as a spindle for an *x*-ray powder photograph, the resulting picture shows broadened reflections. The mineral effervesces in dilute HCl and is slowly soluble in cold water. The specific gravity was measured by suspending grains of the mineral in a mixture of bromoform and acetone. The mineral floats just under the surface of a liquid with specific gravity of 2.57.

Rabbitite is considered to be monoclinic on the basis of its optical properties. The small acicular crystals are elongated parallel to the *c*-axis. Under the microscope the crystals show a cleavage across the fibers, which is probably parallel to {001}, and two easy and perfect prismatic cleavages.

Even with the aid of an oil-immersion lens, individual crystals of rabbitite are too small to give an interference figure. The fibers in some of the bundles seem to lie in parallel orientation, and measurements of the optical constants were made on several such bundles. Some of the bundles seem to be flattened on {100} and give an optical figure thought to be an obtuse bisectrix figure.

The optical properties of rabbitite are distinctly different from those of swartzite, as shown below:

Orientation	<i>Rabbitite</i>	<i>Swartzite</i>
	<i>n</i>	<i>n</i>
X	1.502 ± 0.005	1.465
Y = <i>b</i>	1.508 ± 0.005	1.51
Z ∠ <i>c</i> ~ 15°	1.525 ± 0.003	1.540
	Biaxial positive (?)	Biaxial negative

#### CHEMICAL COMPOSITION

With the aid of a binocular microscope, slightly less than 0.1 g. of rabbitite was handpicked for analysis. The mineral was concentrated by picking the largest aggregates of rabbitite from the friable sandstone. The aggregates were crushed, examined under the binocular, and further purified. A semiquantitative spectrographic analysis made by C. S. Annell on a 10-mg. sample showed more than 10 per cent U, 1 to 10 per cent Mg and Ca, 0.1 to 1 per cent Si, and 0.01 to 0.1 Al and Y. About 75 mg. was available for the chemical analysis (Table 1) made by A. M. Sherwood.

In the chemical analysis of rabbitite the sample was first dissolved in

TABLE 1. CHEMICAL ANALYSIS AND THEORETICAL COMPOSITION OF RABBITTITE AND CHEMICAL ANALYSIS OF SWARTZITE

	Rabbittite		Swartzite
	Analysis of 75 mg. by A. M. Sherwood	$\text{Ca}_3\text{Mg}_3(\text{UO}_2)_2(\text{CO}_3)_6(\text{OH})_4 \cdot 18\text{H}_2\text{O}$	Analysis in Axelrod <i>et al.</i> (1951) by F. S. Grimaldi
CaO	10.6	11.32	7.32
MgO	9.2	8.09	5.47
UO <sub>3</sub>	37.4	38.54	38.85
CO <sub>2</sub>	17.8	17.79	17.92
H <sub>2</sub> O	24.5	24.26	29.69
Acid insoluble	0.5		0.75 (rem.)
Total	100.0	100.00	100.00

water, and carbon dioxide was determined by titration with standard HCl. The silica was removed by volatilization with HF. The uranium was then separated with  $\text{NH}_4\text{OH}$ , reduced, and titrated with  $\text{K}_2\text{Cr}_2\text{O}_7$ . Calcium was precipitated with  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  and ignited to CaO; and the magnesium was precipitated with  $(\text{NH}_4)_2\text{HPO}_4$  and ignited to  $\text{Mg}_2\text{P}_2\text{O}_7$ . Total loss on ignition at  $900^\circ\text{C}$ . was determined, and the per cent  $\text{CO}_2$  was subtracted from it to calculate the total  $\text{H}_2\text{O}$ .

The analysis indicates that the formula is probably  $\text{Ca}_3\text{Mg}_3(\text{UO}_2)_2(\text{CO}_3)_6(\text{OH})_4 \cdot 18\text{H}_2\text{O}$  and that it differs from that of the other magnesium and calcium uranyl carbonates—bayleyite  $\text{Mg}_2(\text{UO}_2)(\text{CO}_3)_3 \cdot 18\text{H}_2\text{O}$ , swartzite  $\text{CaMg}(\text{UO}_2)(\text{CO}_3)_3 \cdot 12\text{H}_2\text{O}$  (Axelrod *et al.*, 1951), and liebigite  $\text{Ca}_2(\text{UO}_2)(\text{CO}_3)_3 \cdot 9\text{H}_2\text{O}$  (?). Swartzite contains the same elements as rabbittite but in different proportions. The chemical analysis of swartzite is given in Table 1.

#### X-RAY DIFFRACTION DATA

The *x*-ray powder pattern of rabbittite distinguishes it from the other uranyl carbonates although, in common with the others, its powder pattern contains a number of lines with large *d*-spacings, indicating a large unit cell. The pattern obtained with the *x*-ray spectrometer shows the closely spaced inner lines (Table 2) with much better resolution than the ordinary powder pattern. The *d*-spacings of swartzite, as given in Axelrod *et al.* (1951), are listed in Table 2 with those of rabbittite. From an *x*-ray rotation photograph of a bundle of fibers of rabbittite around the *c*-axis,  $c_0$  was found to be  $9.45 \pm 0.05 \text{ \AA}$  (personal communication, H. T. Evans, 1953). The zero-layer reflections were indexed graphically, using a modi-

TABLE 2. X-RAY DIFFRACTION POWDER PATTERNS OF RABBITTITE AND SWARTZITE  
 ( $d$ -spacings of rabbitite measured on x-ray spectrometer pattern,  
 $1/4^\circ$  per minute, Cu/Ni radiation)

Rabbitite		Swartzite <sup>1</sup>	
$I$	$d$	$I$	$d$
3	19.4	10	8.76
1	18.6	9	7.31
5	11.28	5	6.37
3	8.63	1	5.83
10	8.24	10	5.50
8	7.79	1	5.13
3	7.15	8	4.82
1	6.81	2	4.62
3	6.47	2	4.46
1	6.35	2	4.37
5, broad	5.83	2	3.85
5	5.72	7	3.66
3	5.22	5	3.53
5	4.81	1	3.39
7	4.71	1	3.31
1	4.51	1	3.25
8	4.37	7	3.19
1	4.28	2	3.11
3	4.05	1	3.04
3	4.03	8	2.91
3	3.84	2	2.82
1, broad	3.71	5	2.61
3	3.60	4	2.28
5	3.33	3	2.23
		2	2.19
		2	2.10
		8	2.06
		5	1.817
		8	1.707
		2	1.375
		2	1.268
		3	1.217
		2	0.9615

<sup>1</sup> Axelrod *et al.* (1951).

fied version of Bjurström's chart (Bunn, 1946, p. 280) and the  $hkl0$  indices thus obtained are listed in Table 3. The  $a$  and  $b$  axes appear to be at right angles to one another, and according to the graphical solution  $a_0 = 32.6 \pm 0.1 \text{ \AA}$  and  $b_0 = 23.8 \pm 0.1 \text{ \AA}$ . The number of formula units in the unit cell, is probably 8; by calculation from the approximate figures for

TABLE 3.—TENTATIVE INDEXING OF  $hk0$  REFLECTIONS OF RABBITTITE  
(X-ray rotation photograph around  $c$ -axis; Cr/V radiation;  
 $a_0=32.62$ ,  $b_0=23.77$ )

	$a_0=32.62$	$b_0=23.77$	
$I$	$d$ (meas.)	$d$ (calc.)	$hk0$
5	19.0	19.21	110
3	16.2	16.3	200
4	13.5	13.45	210
3, broad	12.0	11.88	020
7	11.24	11.17	120
3	9.89	9.89	310
3	9.60	9.60	220
3	8.96	—	—
10	8.13	8.15	400
		8.02	320
		7.92	030
3	7.71	7.71	410
		7.70	130
3	7.13	7.13	230
1	5.95	5.94	040
3	5.82	5.85	140
3	5.70	5.72	520
		5.68	430
1	5.21	5.21	340
5	4.80	4.80	440
		4.75	050
5	4.70	4.71	150
5	4.40	4.39	540
5	4.34	4.36	350
1	4.10	4.11	450
3	4.03	4.01	640
5	3.84	3.85	260
		3.84	550

$a_0$ ,  $b_0$ ,  $c_0$ , from the specific gravity, and with no allowance made for  $\beta$  angle differing from  $90^\circ$ , the number of formula units is 7.8. The mineral is considered monoclinic because of its optical properties. The  $\beta$  angle cannot be accurately determined on the present material, but it is probably close to  $90^\circ$ .

## REFERENCES

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