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RABBITTITE, A NEW URANYL CARBONATE FROM UTAH*

By

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RABBITTITE, A NEW URANYL CARBONATE FROM UTAH

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Mary E. Thompson, Alice D. Weeks, and Alexander M. Sherwood

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 percent, MgO 9.2, UO_3 37.4, CO_2 17.8, H_2O 24.5, acid insoluble 0.5, total 100 percent, and indicates the formula $Ca_3Mg_3(UO_2)_2(CO_3)_6(OH)_4 \cdot 18H_2O$. An X-ray rotation photograph of a small bundle of fibers shows the unit cell length $c_0 = 9.45 \pm 0.05$ A. From the indexing of $hk0$ reflections a_0 is thought to be 32.6 ± 0.1 A and $b_0 = 23.8 \pm 0.1$ A, 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 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 rabbittite. Swartzite is, however, definitely distinct from rabbittite 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 rabbittite.

Rabbittite 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

Rabbittite 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 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

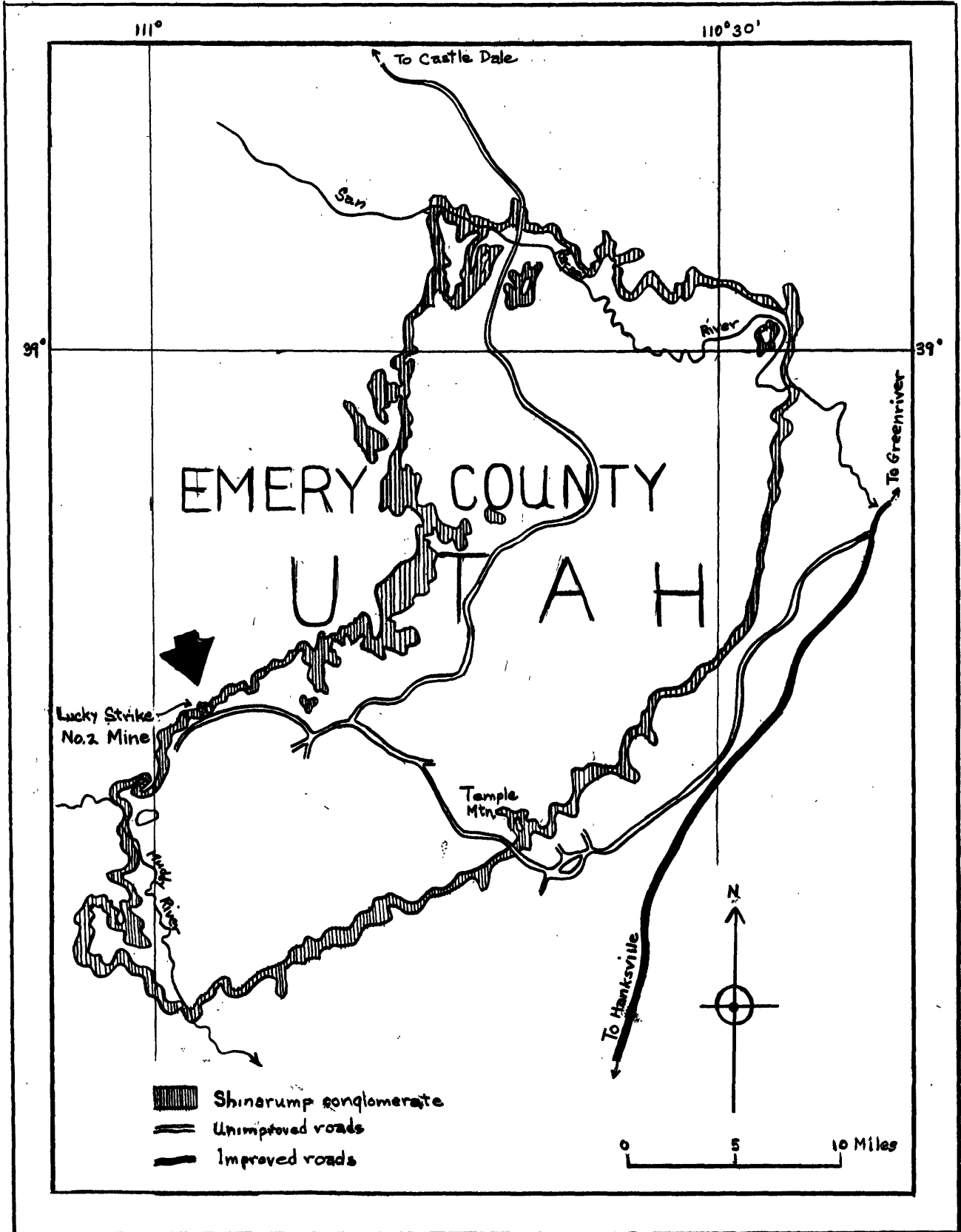


Figure 1.--Index map of locality of rabbitite (geology after Orkild, 1952).

near the portal was high grade, containing pitchblende with a little pyrite and galena and many yellow and orange secondary uranium minerals, including fourmarierite,^{1/} rabbittite, 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 rabbittite occurred.

PHYSICAL AND OPTICAL PROPERTIES

Rabbittite 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.

The hardness of rabbittite 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 2.57.

Rabbittite is considered to be monoclinic on the basis of its optical properties. The small acicular crystals are elongated parallel

^{1/} Specimen courtesy of J. W. Gruner.

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 rabbittite 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 rabbittite are distinctly different from those of swartzite, as shown below:

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

CHEMICAL COMPOSITION

With the aid of a binocular microscope, slightly less than 0.1 g of rabbittite was handpicked for analysis. The mineral was concentrated by picking the largest aggregates of rabbittite from the friable sandstone. The aggregates were crushed, examined under the binocular, and further purified. A semiquantitative spectrographic analysis made by C. S. Ansell on a 10 mg sample showed more than 10 percent U, 1 to 10 percent Mg and Ca, 0.1 to 1 percent 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 rabbittite the sample was first dissolved in 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 NH_4OH , 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 C was determined and the percent CO_2 subtracted from it to calculate the total H_2O .

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 \underline{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 \underline{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 \underline{c} -axis, c_0 was found to be 9.45 ± 0.05 A

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 et al. (1951) by Grimaldi
CaO	10.6	11.32	7.32
MgO	9.2	8.09	5.47
UO ₃	37.4	38.54	38.85
CO ₂	17.8	17.79	17.92
H ₂ O	24.5	24.26	29.69
Acid insoluble	0.5	—	0.75 (rem.)
Total	100.0	100.00	100.00

(personal communication, H. T. Evans, 1953). The zero-layer reflections were indexed graphically, using a modified version of Bjurstrom's chart (Bunn, 1946, p. 380) and the $hk0$ 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 $a_0 = 32.6 \pm 0.1$ A and $b_0 = 23.8 \pm 0.1$ A. The number of formula units in the unit cell is probably 8; by calculation from the approximate figures for a_0 , b_0 , c_0 , from the specific gravity, and with no allowance made for β angle differing from 90° , the number of formula units is 7.8. The mineral is considered monoclinic because of its optical properties. The β angle cannot be accurately determined on the present material, but it is probably close to 90° .

Table 2.--X-ray diffraction powder patterns of rabbittite and swartzite.

(d-spacings of rabbittite measured on X-ray spectrometer pattern, $1/4^\circ$ per minute, Cu/Ni radiation.)

Rabbittite		Swartzite <u>1/</u>	
<u>I</u>	<u>d</u>	<u>I</u>	<u>d</u>
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

1/ Axelrod et al. (1951).

Table 3.--Tentative indexing of hk0 reflections of rhabdophane
 (X-ray rotation photograph around c-axis; Cr/V radiation)

<u>I</u>	<u>d (meas.)</u>	<u>d (calc.)</u>	<u>hk0</u>
	$a_0 = 32.62$	$b_0 = 23.77$	
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

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