

## HYDROUS URANIUM MOLYBDATE IN MARYSVALE ORE\*

by  
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## ABSTRACT

A mineral believed to be a hydrous uranium molybdate not previously described has been found in the Freedom No. 2 mine at Marysvale. The mineral is hexagonal in crystallization with  $a_0 = 8.597 \text{ \AA}$  and  $c_0 = 14.453 \text{ \AA}$  although it loses water easily with a variation in  $c_0$  of as much as  $2 \text{ \AA}$ . The theoretical percentage composition is  $\text{UO}_3 - 56.99$ ;  $\text{MoO}_3 - 28.68$  and  $\text{H}_2\text{O} - 14.33$ .

The mineral occurs in small flat black flakes with triangular markings, in veinlets, and in disseminated grains. It is believed to be a primary mineral although the distribution through the workings is only partially known. Because of the chemical composition which involves the elements uranium (U), molybdenum (Mo), hydrogen (H), and oxygen (O), the name umohoite is suggested.

## INTRODUCTION

An unusual primary uranium mineral was collected in the Freedom No. 2 mine during the summer of 1952 while studying alteration features connected with the uranium mineralization near Marysvale, Utah. The mineral is black and is found in thin veinlets or disseminated specks along the uranium-bearing vein. It occurs within an alteration zone of clay minerals where it may be found alone, associated with fluorite, pyrite, quartz and uraninite, or accompanying the molybdenum minerals ilsemannite or jordisite.

Sufficient laboratory work has been completed to suggest that the mineral is a new species, a hydrous uranium molybdate of hexagonal crystallization not believed to have been previously recognized. The mineral contains a substantial amount of uranium and gives a high count with a geiger counter. In the finely disseminated condition in which it occurs it has probably been

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\*A preliminary report.

mined along with uraninite and may be responsible for the unusual molybdenum content of Marysvale ore in a number of instances.

Since ore control in mining is largely based upon radioactivity as detected by counters, it is unlikely that failure to recognize the mineral has resulted in any noticeable uranium loss. The genetic significance of the mineral is of interest because of its bearing on the distribution of uranium deposits in the area and at other localities where the mineral may possibly be found.

The mineral has been found chiefly on the 3rd level of the Freedom No. 2 mine, just below the oxidized zone, and appears to be restricted to the lower levels and primary ores. The vein along which the mineral is found follows a nearly vertical fracture in quartz monzonite where the host rock has been altered to clay minerals for a width of 4-6 ft. with uranium mineralization concentrated in an irregular manner along the central portion.

### PROPERTIES

The mineral is black to bluish black with a bright sub-metallic luster and is foliated or platy. It somewhat resembles biotite but lacks the cleavage of the mica and is opaque. The hardness is about 2 and the specific gravity as determined approximately on small fragments with a Berman balance is 4.55 to 4.66. Specific gravity determinations were repeated a number of times, but were hampered in each case by the minute size of the largest grains available.

Polished surfaces are strongly anisotropic and yield the following microchemical etch tests:

HNO<sub>3</sub> 1:1 - effervesces, then turns yellow and yellow-brown;  
HCl 1:1 - negative; KOH 40% - negative; HgCl<sub>2</sub> 5% - negative;  
H<sub>2</sub>O<sub>2</sub> - negative; HCl Dil. 10% U. S. P. - negative;  
FeCl<sub>2</sub> 20% - etches mineral strongly;  
Aqua Regia - quickly and strongly etched.

A sample of about 1.5 grams was separated and submitted to Mr. Silve Kallman of Ledoux and Co. for chemical analysis. The mineral is reported to contain UO<sub>3</sub> - 57.65%; MoO<sub>3</sub> - 28.23%, and H<sub>2</sub>O - 14% + 1% with about 1% of As<sub>2</sub>O<sub>3</sub>. It appears to be essentially a hydrated uranyl molybdate,

$\text{UO}_2 \cdot \text{MoO}_4 \cdot 4\text{H}_2\text{O}$  with a possible theoretical composition of  $\text{UO}_3$  - 56.99%;  $\text{MoO}_3$  - 28.68% and  $\text{H}_2\text{O}$  - 14.33%.

The mineral from the Freedom mine has been examined with the X-ray spectrograph (X-ray fluorescence). Two instruments were used, an early model with moderate sensitivity in the Mineralogical Laboratory, Columbia University, with a fluorite crystal, and a recently improved high sensitivity instrument made available through the courtesy of Mr. Frederick Behr, engineer of the North American Philips Mount Vernon plant, with a lithium fluoride crystal. Strong reflections are given for uranium (13 lines) and molybdenum (2 lines) with moderate peaks for arsenic and iron. Traces of Ru or Pd, La, Ba, Mn and Sb are recorded. Iron may be due to traces of pyrite but the source of the arsenic and the trace elements is uncertain. A small amount of arsenopyrite could be associated with the pyrite.

#### X-RAY MEASUREMENTS

Specimens collected in the field have failed to yield crystals capable of goniometric measurement. Numerous flat plates about 1 mm. in diameter and 0.2 mm. thick have been separated, but all lack angular crystal boundaries. A few have been observed with triangular markings on the flat plates and similar plates yield ray patterns in a Laue camera, the rays showing a hexagonal pattern with a few partly developed spots.

X-ray powder patterns show unusual variability due to the effects of X-ray bombardment. Successive patterns exposed from the same sample mount show a shift in line positions. The total shift in the basal reflection varies as much as  $2\text{\AA}$  under strong X-ray bombardment. In order to secure stability the X-ray spectrometer powder reflections recorded in Table 4 were obtained from a sample previously subjected to approximately 2 days of direct X-ray exposure.

More satisfactory measurements were secured from a series of basal plates mounted on a flat surface, later bombarded and then scanned with a Philips X-ray diffractometer (formerly spectrometer). Ten orders of basal reflections were secured in this way (Table 5) the lines yielding consistent measurements upon repeated scanning, although the low angle lines lack the reproducibility of the high angle lines. Computation of the interplanar spacings approximates values yielded by hexagonal indices within the limitations of the measurements thus far available. The method of Ito (1950) was utilized in establishing indices. The most satisfactory measurements based upon higher angle reflections appear to yield the

TABLE 4

X-ray Spectrometer Reflections on  
Powdered Sample\*

<u>Line Index</u>	<u>Intensity</u>	<u>2 <math>\theta</math></u>	<u>d**</u>
(00.1)	52	6.18	14.29
(10.0)	23	10.31	8.57
(00.2)	264	12.30	7.19
(00.3)	176	18.46	4.80
(20.0)	3	20.64	4.30
(20.2)	2	23.90	3.72
(00.4)	62	24.68	3.60
(20.3)	10	27.67	3.22
(11.4)	7	29.16	3.06
(00.5)	17	30.91	2.891
(00.6)	1	37.41	2.402
(40.0)	2	42.01	2.149
(00.7)	45	43.89	2.061
(00.8)	8	50.48	1.807
(00.9)	3	57.31	1.606
(00.10)	4	64.52	1.443

\*Basal reflections corrected in spacing but not intensity on the basis of crystal reflections.

\*\*  $\lambda = \text{CuK} \alpha_1 = 1.54050 \text{ \AA}$ .

TABLE 5

X-ray Spectrometer Reflections  
on (00.1), n = 1 to 10.

<u>Line</u> <u>Index</u>	<u>Intensity</u>	<u>2θ</u>	<u>d**</u>	<u>d*</u> <u>Corr.</u>
(00.1)	52	6.179	14.29	14.45
(00.2)	264	12.295	7.19	7.23
(00.3)	176	18.462	4.802	4.818
(00.4)	62	24.684	3.604	3.613
(00.5)	17	30.905	2.891	2.891
(00.6)	1	37.407	2.402	2.409
(00.7)	45	43.889	2.061	2.065
(00.8)	8	50.475	1.807	1.807
(00.9)	3	57.309	1.606	1.606
(00.10)	4	64.515	1.443	1.445

\*Recalculated on the basis of (00.5) and (00.8).

\*\*  $\lambda = \text{CuK} \alpha_1 = 1.54050 \text{ \AA}$ .

lattice constants  $a_0(10.0) = 8.597 \text{ \AA}$  and  $c_0(00.1) = 14.453 \text{ \AA}$ .

Variations in line measurement appear largely limited to the (00. 1) planes as shown by computation of (00. 1), (10. 0) and (00. 2) for seven diffraction patterns A to G as follows:

	A	B	C	D	E	F	G
(00. 1)	16.51	16.35	16.05	14.58	14.46	14.38	14.36
(10. 0)	8.52	8.58	8.52	8.55	8.63	8.58	8.57
(00. 2)	7.20	7.27	7.25	7.20	7.23	7.24	7.20

While these measurements lack the accuracy of spectrometer readings, the wide and possibly systematic variation in (00. 1) is unmatched by the unsystematic variations of either (10. 0) or (00. 2).

### NOMENCLATURE

While more precise data are desired the various studies to date indicate that the mineral is homogeneous, hexagonal, and a hydrous uranium molybdate. Such a mineral does not appear to have been previously recognized.\*

In view of the chemical composition the name umohoite is suggested for the mineral. The combination of letters selected follows a precedent set by such names as thucolite (from the chemical symbols ThUCO-lite) and nahcolite (from the chemical symbols NaHCO-lite) in which the symbols of the chemical elements of which the mineral is composed are combined to form a word. Thus U, Mo, H and O are combined with the customary mineral suffix to form the word umohoite.

### ORIGIN

The association of uranium and molybdenum has previously been observed in connection with the vitrophyre dikes that cut the quartz monzonites of the Marysvale uranium area. Thus veinlets of fluorite and uraninite cut the glass which makes up the mass of the dikes, while the partially altered vitrophyre yields molybdenum on the order of 0.5%. Ilsemanite, the

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\*The nearest approach is molybdänuran (Boldyrev, 1926-35) as reported by Hey (1950, 27. 2. 6) to be an anhydrous molybdate of uranium.

molybdenum sulphide and its oxidation product jordisite may be observed in several of the Marysvale veins.

The occurrence of uranium and molybdenum in a single primary mineral is unique. The high water content and apparent tendency to dehydrate even under the comparatively low temperatures of X-ray bombardment is likewise of interest. The association of fluorite and pyrite is another significant item. These features taken together may be assumed indicative of fumarolic activity in which steam and hydrofluoric acid played a prominent role.

The rocks overlying the erosion surface of the quartz monzonite are Mount Belknap volcanics, chiefly rhyolite and volcanic glass. They represent an epoch of volcanism which apparently followed the erosional interval. Glass in dikes within the quartz monzonite and on the erosional surface is indicative of high temperature conditions then prevailing. The uranium-molybdenum mineralization is in places associated as a later phase with these dikes and may well be an aftermath of the volcanic activity.

#### REFERENCES

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