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WEEKSITE, A NEW URANIUM SILICATE FROM THE THOMAS RANGE, JUAB COUNTY, UTAH[1]

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ABSTRACT

Weeksite, $K_2(UO_2)_2(Si_2O_5)_3 \cdot 4H_2O$, is a new uranyl silicate mineral named for Dr. Alice D. Weeks. It is a soft yellow non-fluorescent mineral with a waxy to silky luster, and it crystallizes chiefly in radiating fibrous clusters. In the Thomas Range, where it was first found, it occurs in opal veinlets in rhyolite and as replacements of pebbles in a tuffaceous conglomerate. Weeksite also has been identified from eight other localities in Pennsylvania, Wyoming, California, New Mexico, Mexico, Arizona, and Texas.

Weeksite is biaxial negative $2V=$about 60°; dispersion $r>v$, strong; $\alpha=1.596$, $\beta=1.603$, $\gamma=1.606$; $X=b$, colorless, $Y=c$, pale yellow green, $Z=a$, yellow green. The measured specific gravity is about 4.1.

A chemical analysis of material from the Thomas Range showed: K_2O 5.5, Na_2O 0.7, BaO 1.4, CaO 1.1, UO_3 51.5, SiO_2 33.6, H_2O 6.6, Al_2O_3 0.6, CO_2 0.3; total 101.3%. A synthetic Na analogue of weeksite showed Na_2O 7.2, UO_3 52.0, SiO_2 33.9, H_2O (in part from wood) 8.1, C (from wood) 0.3; total 101.5%.

Weeksite is orthorhombic, pseudotetragonal; the space group is $Pnnb-D^6_{2h}$;

$$a = 14.26 \pm 0.02 \text{ A}, \; b = 35.88 \pm 0.10 \text{ Å}, \; c = 14.20 \pm 0.02 \text{ A}; \; a:b:c = .3974:1:.3958.$$

Cell contents 16 $[K_2(UO_2)_2(Si_2O_5)_3 \cdot 4H_2O]$. The nine strongest lines of the x-ray powder pattern of weeksite are: 7.11 (10), 5.57 (9), 8.98 (8), 3.55 (7), 3.30 (7), 2.91 (6), 3.20 (5), 2.37 (5), 2.28 (5); and those of the synthetic Na analogue are: 7.11 (10), 5.57 (9), 9.03 (8), 3.56 (7), 3.30 (7), 2.94 (6), 3.19 (5), 2.37 (5), 2.28 (5).

INTRODUCTION AND ACKNOWLEDGMENTS

Weeksite, a potassium uranyl silicate mineral, closely resembles uranophane in physical appearance. It was first noted as an unknown and perhaps new mineral in 1950, when a uranium mineral from the east side of the Thomas Range in western Utah gave an unidentified x-ray powder pattern. Since that time x-ray powder patterns have indicated its presence in nine other localities in Arizona, California, Mexico, New Mexico, Pennsylvania, Texas, Utah, and Wyoming.

Weeksite, in its known occurrences, is rare, very fine grained, and intimately intermixed with other minerals. For these reasons, it was not until 1955 that enough of the material was collected for a complete chemical analysis. This material came from the east side of the Thomas Range. Although it was originally hoped to make a more thorough study of weeksite, correlating the chemical composition of this mineral with its physical and optical properties from a number of localities, the minute

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[1] Publication authorized by the Director, U. S. Geological Survey.

quantities of this mineral found at most localities made such a comparative study impossible.

The optical properties and chemical composition of specimens of weeksite from different localities are somewhat variable. Indices of refraction of weeksite vary among specimens from different localities, as well as between these specimens and a synthetic sodium analogue. Some variation in the alkali metal content is indicated by semiquantitative spectrographic analyses of weeksite from various localities. *X*-ray powder patterns of this mineral from the various localities indicate that the specimens are structurally the same. We have synthesized this mineral and its sodium analogue, and both synthetic minerals gave the same *x*-ray pattern. Thus, the chemical composition and optical properties of this mineral vary somewhat from one locality to the next. In order to have strictly comparable data, the optical properties, chemical composition, and *x*-ray diffraction data all were made on weeksite from the east side of the Thomas Range. These are compared with those of synthesized weeksite and its sodium analogue.

This new mineral is named for Dr. Alice D. Weeks of the U. S. Geological Survey, who has studied and described many new uranium and vanadium minerals. Her report with Mary E. Thompson entitled, "Identification and Occurrence of Uranium and Vanadium Minerals from the Colorado Plateaus," (1954) is a major contribution and provides mineralogists and geologists with reliable data for the recognition of these minerals.

We gratefully acknowledge the assistance of many of our colleagues in the U. S. Geological Survey. These include Samuel Rubenstein and George Ashby, who studied samples of weeksite from Easton, Pennsylvania; Joan Clark and Daphne Ross for *x*-ray studies; Malcolm Ross for electron diffraction studies; Frank Cuttitta for preliminary work on the chemical analysis; and J. C. Chandler for his work in synthesis of the mineral. Thanks are also due Eugene B. Gross of the U. S. Atomic Energy Commission for information on specimens from the Good Will claim, Utah, and from near San Carlos, Mexico; to Russell Honea of the University of Colorado for data on the mineral from the Mammoth mine, Texas; to T. C. McBurney for a specimen and data on the mineral from the Coso Mountains, California; and to Clifford Frondel of Harvard University for advice and encouragement.

This investigation is part of the project of mineralogical investigations conducted by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

OCCURRENCE

Weeksite has been identified from ten widely separated localities.

The type specimen of weeksite comes from the Autunite No. 8 claim, which is in the W ½ sec. 10, T. 13 S., R. 11 W., on the east side of the Thomas Range, in central Juab County, Utah. This claim was originally located in July 1950 by W. W. Sorenson, C. S. Boyle, G. E. Wilson, and C. F. Wilson. The oldest rock in the vicinity of the Autunite No. 8 claim is a porphyritic rhyolite containing numerous phenocrysts of sanidine and quartz, some of plagioclase, and a few of biotite in a brown aphanitic groundmass. This rhyolite is overlain irregularly by a black glass welded tuff consisting of elongate pieces of pumice and crystals of plagioclase and biotite in a black to brown glass matrix. These two volcanic rocks are of probable Miocene age and, following their emplacement, were eroded to a mature topography. A white vitric tuff of probable Pliocene age was deposited on this surface. This tuff contains numerous volcanic rock fragments, mainly pumice, and some tiny crystal fragments of sanidine and quartz in a dense, white ash matrix.

The weeksite occurs in numerous veinlets, from one thirty-second to one-quarter of an inch thick, which fill a series of closely spaced fractures in the porphyritic rhyolite. These fractures have a steep dip and a general north to northwest trend, although a few trend northeast. The area in which these veinlets are exposed is about 100 feet long and has a maximum width of 25 feet. As weeksite is scattered along these veinlets, and as the veinlets are quite thin, the amount of uranium present is small. An 8.0-foot horizontal channel sample across the center of the deposit contained only 0.026 per cent uranium.

The veins are made up chiefly of bluish-white, white, or pale yellowish-green opal, which fluoresces a bright yellowish green and in places is botryoidal. The only uranium mineral observed is weeksite, which occurs in finely fibrous yellow rosettes. These rosettes are 0.2 to 1 mm. across and are found both encrusted and intergrown with the opal (Fig. 1). In a few places weeksite occurs on fracture surfaces free of opal. Other vein minerals are calcite and fluorite. The calcite is common only in parts of some veins and occurs in clear crystals as much as a quarter of an inch across. The fluorite is less common than weeksite and occurs mostly as small colorless to white crystals easily confused with the opal or calcite.

Weeksite has also been found on the Good Will claim in the NW ¼ sec. 36, T. 12 S., R. 12 W., on the west side of the main part of the Thomas Range. This property is 4.5 miles northwest of the Autunite No. 8 claim and was originally located in April 1954 by Bernard L. and Joseph Christensen. The geologic history of this area is briefly the following: 1) an ash fall formed a quartz-sanidine crystal tuff in Middle Miocene time, 2) a wide valley was formed in the tuff, 3) a lake formed in this valley into which in rapid succession were deposited a well-sorted crystal tuff, a tuffaceous sandstone, and a tuffaceous limestone conglomerate,

4) the lake dried up and an ash fall formed a white vitric tuff, 5) the region was tilted gently to the west, and a north-trending fault developed along the east side of the district, and 6) uranium mineralization occurred. Uranium minerals are found in two types of occurrences on the Good Will property: disseminated in the tuffaceous sandstone and as replacement in limestone cobbles in the conglomerate which overlies the sandstone. The only occurrences of economic significance are those in the tuffaceous sandstone. Beta-uranophane, the chief ore mineral, fills numerous pore spaces in the sandstone. The only other uranium mineral noted in this rock was schroeckingerite, which occurred in a few veinlets in one pit.

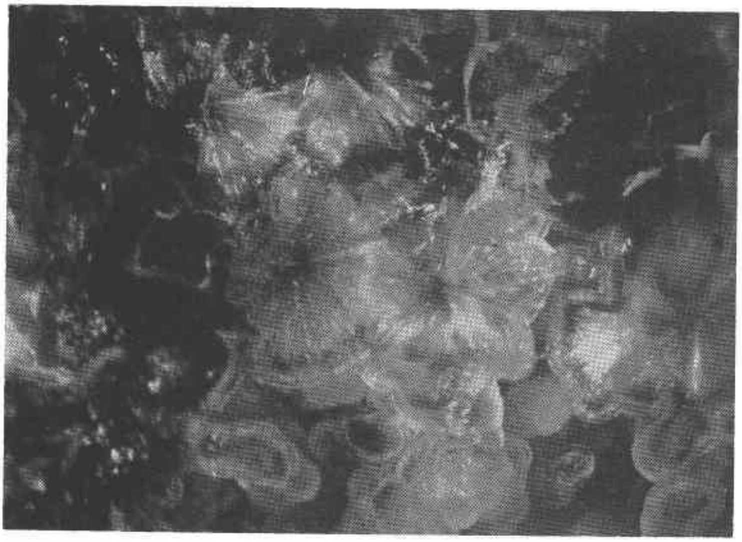

FIG. 1. Rosettes of weeksite enclosed by thin botryoidal bands of opal. East side of Thomas Range. ×38.

Weeksite occurs in the conglomerate, where it irregularly replaces parts of limestone pebbles or cobbles. In pebbles over an inch in diameter weeksite is confined to an irregular outer layer as much as one-quarter of an inch thick, but in smaller pebbles it may also replace part of the center. The pebbles containing weeksite are erratically scattered throughout the conglomerate. Weeksite occurs in extremely fine grains and is the only mineral replacing the limestone pebbles. No weeksite has been found in the uranium deposits in the underlying tuffaceous sandstone, and neither beta-uranophane nor schroeckingerite has been found in the conglomerate.

The uranium mineralization that formed the weeksite at the Autunite

No. 8 and the Good Will claims is believed to have taken place during the last stages of vulcanism (Pliocene) in the Thomas Range. It was during this period after the consolidation of most of the volcanic rocks that uraniferous fluorspar deposits were formed in the western part of the Thomas Range (Staatz and Osterwald, 1956, p. 132).

Weeksite has also been found in eight other localities: 1) from just above the Haiwee Reservoir in the Coso Mountains, California, where we identified it as a coating along fractures in granite associated with uranophane and an unknown yellow uranium mineral on a sample submitted by T. C. McBurney in 1955. This is the same locality from which the new mineral haiweeite was described by McBurney and Murdoch (1959); 2) from the Jackpile mine, Laguna, New Mexico, where it occurs in a sandstone-type deposit; 3) from the Silver Cliff mine, near Lusk, Wyoming, where it occurs in calcareous sandstone with uranophane (A. D. Weeks, 1958, oral communication); 4) from the Williams quarry, Easton, Pennsylvania (Samuel Rubenstein, 1955, written communication), where it is found in fractures in the Precambrian Franklin limestone associated with thorian uraninite, thorogummite, uranophane, carnotite, and boltwoodite (Montgomery, 1957, p. 812–813); 5) from the Red Rock district, Lassen County, California, where it is found in fractures in rhyolite (D. R. Ross, 1958, oral communication); 6) from the dump of an abandoned mercury mine, Chihuahua State, Mexico, 4½ miles southwest of Lajitas, Texas, where it is associated with carnotite (E. B. Gross, 1955, written communication); 7) from the Mammoth mine near Presidio, Texas, where it lines cavities in a welded tuff (Russell Honea, 1958, oral communication); and 8) from the Red Knob claims, Muggins Mountains, Yuma County, Arizona, where it is associated with opal, carnotite, vanadinite, gypsum, calcite, and azurite (W. I. Finch and M. E. Thompson, 1957, oral communication).

Physical and Optical Properties

Weeksite at the Autunite No. 8 claim occurs as small spherulites of yellow radiating crystals. The crystals have a waxy to silky luster and structurally resemble wavellite (Fig. 1). Uranophane and haiweeite have the same habit and appearance, and it is virtually impossible to tell them apart megascopically.

Weeksite is soft. It crushed somewhat more easily than gypsum when a sample was ground for *x*-ray examination. An approximate specific gravity of 4.1 was obtained by centrifuging grains of the mineral in warm concentrated Clerici solution. The specific gravity as calculated from the formula weight and the unit cell size is 4.02 for $16[K_2(UO_2)_2(Si_2O_5)_3 \cdot 4H_2O$ per cell.

The optical properties of weeksite and of uranophane are given in

Table 1. Weeksite is orthorhombic. The small acicular crystals are elongated parallel to the *c* axis and show two good prismatic cleavages. Some crystals are more bladed than acicular and are flattened on the (010) plane. Specimens of this mineral from an abandoned mercury mine in Mexico occur in flat plates. Like uranophane, weeksite is not fluorescent in either long or short wave ultraviolet light. The mean index of refraction of the synthetic sodium analogue is 1.58. The indices of refraction of weeksite are close to those of haiweeite, johannite and meta-autunite. Johannite differs from weeksite, however, in being biaxial positive instead of biaxial negative, light green instead of yellow, and a copper uranyl sulfate instead of a potassium uranyl silicate. Meta-autunite differs from weeksite in being generally crystallized in scaly aggregates instead of in fibrous rosettes, fluorescent instead of nonfluorescent, and a calcium uranyl phosphate instead of a potassium uranyl silicate. Haiweeite differs from weeksite in that it is fluorescent, crystallizes in the monoclinic system, and has a similar but distinctly different *x*-ray pattern. This pattern was a recurrent unknown under investigation in the laboratories of the U. S. Geological Survey.

TABLE 1. A COMPARISON OF THE OPTICAL PROPERTIES OF WEEKSITE AND URANOPHANE

Orientation	Index of refraction	Pleochroism	Remarks
Weeksite[1]			
$X=b$	1.596 ± .003	colorless	biaxial (−)
$Y=c$	1.603 ± .002	pale yellow-green	2 V = 50–60° (observed)
$Z=a$	1.606 ± .003	yellow-green	2 V = 66° (calculated) $r>v$, strong
Uranophane[2]			
$X\wedge a=2.8°$	1.642–1.645	colorless	biaxial negative
$Y\wedge c=10°$	1.665–1.667	pale canary yellow	2 V = 32°
$Z=b$	1.667–1.672	canary yellow	$r<v$, marked to extreme

[1] Autunite No. 8 claim on the east side of the Thomas Range, Utah.
[2] Data from Larsen, E. S., Jr., Hess, F. L., and Schaller, W. T., 1926.

CHEMICAL COMPOSITION

About 100 mg. of weeksite from the east side of the Thomas Range was purified for analysis. The mineral first was concentrated by crushing the rhyolite containing the uraniferous opal veinlets and making a heavy liquid separation of the powder. That portion of the mineral mixture which sank in bromoform was further purified by scrubbing in an ultrasonic generator and by passing it through a Frantz Isodynamic Separator. The nonmagnetic portion from the separator contained predominantly weeksite and some opal and rutile. The impurities were picked out by hand under the binocular microscope. The sample is estimated to have been entirely free of impurities.

The methods employed in the chemical analysis were guided by qualitative spectrographic analyses of the samples (Table 2). Approximately 100 mg. of the naturally occurring mineral and 35 mg. of the synthetic Na analogue of the mineral were available for chemical analysis (Table 3). There was not enough of the synthetic K compound for chemical analysis. One fraction of the sample was used for the CO_2 or C and total H_2O determinations; a second fraction of the sample for the H_2O^-, SiO_2 insoluble in (1+1) HNO_3, SiO_2 soluble in (1+1) HNO_3, UO_3, BaO, Al_2O_3, and Fe_2O_3 determinations; and a third fraction of the sample for the K_2O, Na_2O, and CaO determinations. Micro- and semimicroprocedures were used throughout.

TABLE 2. SPECTROGRAPHIC ANALYSIS OF WEEKSITE FROM AUTUNITE NO. 8 CLAIM AND THE SYNTHETIC Na ANALOGUE

Sample	Over 10%	1 to 5%	0.5 to 1%	0.1 to 0.5%	0.05 to 0.1%
MHS-1-50[1]	U Si	—	Al	Ba Ca	Na
MHS-1-50[2]	—	K (3%)	Na (0.7%)	—	—
G-143[1] (synthetic)	U Si	—	—	Na B Al	—

[1] Based on a 1 mg. portion of the sample using method of Stich (1953); values given are rough approximations. Analyst: Katherine V. Hazel, U. S. Geological Survey.

[2] Semiquantitative analysis for alkalies of a 10 mg. portion of the ignited residue remaining after the CO_2 and H_2O had been determined. Method of Waring and Annell (1953) was used. Analyst: Helen W. Worthing, U. S. Geological Survey. Figures are reported to the nearest number in the series 7, 3, 1.5, 0.7, 0.3, 0.15, and 0.07, in per cent. These numbers represent midpoints of group data on a geometric scale. Comparisons of this type of semiquantitative results with data obtained by quantitative methods, either chemical or spectrographic, show that the assigned group includes the quantitative value about 60 per cent of the time.

The first fraction of the sample was decomposed by ignition at 900° C. in a stream of oxygen. CO_2 or C and total water were determined by use of a modified microcombustion train of the type used for the determination of carbon and hydrogen in organic compounds.

The second fraction of the sample was dried to constant weight at 110° ± 5° C. and then boiled with (1+1) HNO_3 until the insoluble material was completely white. Filter paper was used for the separation of the residue, which, after washing with dilute nitric acid, was ignited to constant weight at 850° C. Qualitative spectrographic analysis of the ignited residue showed that silicon was the only major constituent present. The soluble silica was determined gravimetrically by dehydration in a HNO_3 solution. Aliquots of the filtrate from the soluble silica determination were used for the UO_3, BaO, Al_2O_3, and Fe_2O_3 determinations. UO_3 was determined spectrophotometrically by the ammonium thiocyanate procedure in an acetone-water medium. Barium was separated and determined as the sulfate. Aluminum was determined spectrophotometrically using aluminon. To avoid the interference due to uranium in the aluminon procedure, aluminum was separated from the uranium by use of the ion-exchange resin Dowex 1X10 in a 9 molar HCl medium. Iron was determined spectrophotometrically by the o-phenanthroline procedure.

Table 3. Chemical Analyses of Natural Weeksite and Its Synthetic Na Analogue, and Haiweeite

	1 MHS-1-50	2 G-143	3	4	5
SiO_2 insoluble in 1+1 HNO_3	33.0	32.0	32.79	33.77	33.1
SiO_2 soluble in 1+1 HNO_3	0.6	1.9			
Al_2O_3	0.6				
UO_3	51.5	52.0	52.09	53.66	52.8
CaO	1.1				5.4
Na_2O	0.7	7.2		5.82	
K_2O	5.5		8.56		
BaO	1.4				
C		0.3 (wood)			
CO_2	0.3				
H_2O (total)	6.6	8.1 (some from wood)	6.56	6.75	8.7
H_2O+[a]	5.5	6.2			
H_2O-	1.1	1.9			
Fe_2O_3	<0.1				
Total	101.3	101.5	100.00	100.00	100.0

1. Weeksite from the Autunite No. 8 claim on the east side of the Thomas Range. Robert Meyrowitz, analyst.
2. Synthetic sodium analogue of weeksite. Robert Meyrowitz, analyst.
3. $K_2(UO_2)_2(Si_2O_5)_3 \cdot 4H_2O$.
4. $Na_2(UO)_2(Si_2O_5)_3 \cdot 4H_2O$.
5. Haiweeite, McBurney and Murdoch, 1959.

[a] Calculated by difference between total H_2O and H_2O^-.

In the third fraction of the sample, potassium, sodium, and calcium were determined by flame photometry using aliquots of the filtrate resulting from the removal of the (1+1) HNO_3 insoluble material. The filtrate was compared to standard solutions containing approximately the same concentrations of uranium, potassium, sodium, and calcium as were present in the solution of the sample.

Weeksite is one of those silicates which, when treated with acid, yield a hard skeleton of silica. Murata (1943 and 1946) described this feature for certain common silicates and notes that it is limited to some silicate structures, including SiO_3 chains, SiO_4 double chains, Si_2O_5 sheets with but minor substitution of ferric iron for silicon, and three dimensional frameworks having an aluminum content less than the ratio of two aluminum atoms to three silicon atoms.

The formula calculated from the chemical analyses (Table 3) is $K_2(UO_2)_2(Si_2O_5)_3 \cdot 4H_2O$, but Na, Ca, and Ba and probably other metals can also substitute for K. The newly described mineral haiweeite is the calcium analogue of weeksite, having the formula $Ca(UO_2)_2(Si_2O_5)_3 \cdot 5H_2O$ (McBurney and Murdoch, 1959). In the synthetic sodium analogue (Table 3) sodium has completely substituted for potassium in the mineral, yet its *x*-ray powder pattern is identical to that of the synthetic weeksite. Weeksite is the only uranyl silicate known besides boltwoodite (Frondel and Ito, 1956) that contains an alkali as an essential cation.

Weeksite and the sodium analogue of weeksite were prepared synthetically by Pommer by heating alkaline uranate solutions in sealed pyrex tubes at 150° C. for at least three days. The calculated pressure inside the tubes was approximately 70 lbs./in.^{2}. The conditions of synthesis are summarized in Table 4. It should be noted that the solutions did not contain silica; the glass of the tube, somewhat attacked by alkaline solutions at the temperature of the experiment, was relied upon as a source of silica. The Na analogue of weeksite first appeared as a solid phase during an attempt to reduce a uranium-vanadium solution with wood at a high pH to form a mixture of uraninite and montroseite. The wood failed to act as reducing agent, probably because the pH was too high. More of the compound was prepared by this method in order to test its reproducibility and to furnish a supply of the material for further study. After the chemical composition of weeksite became known, weeksite was synthesized successfully without the addition of vanadium. The use of wood was continued, however, because in other mineral synthesis experiments (Pommer, 1958, unpublished laboratory data) wood appeared to act as a buffer in some solutions and promoted the formation of phases which otherwise did not precipitate. Finally a synthesis of the Na analogue without wood was successful. Part of the work then was repeated to form the K phase. Several of the solutions contained sodium carbonate or potassium carbonate as a buffer. The conditions of formation of boltwoodite and weeksite are similar and boltwoodite co-precipitated in several runs. The components of all the runs were identified by *x*-ray diffraction.

Table 4. Synthesis of Weeksite and Related Compounds

Simple number	pH	Molarity of uranium (added as uranyl nitrate)	Molarity of vanadium (added as vanadyl sulfate)	pH adjusted with	Buffered with carbonate	Wood added	Compound formed[1]
G-33	10.0	0.025	0.05	NaOH	no	yes	a
G-52	10.0	0.025	0.05	NaOH	no	yes	a
G-53	10.0	0.025	0.05	NaOH	no	yes	b
G-55	10.0	0.025	0.05	NaOH	no	yes	c
G-143	11.2	0.05		NaOH	yes	yes	c
G-160	11.2	0.05		NaOH	yes	yes	d
G-163	11.2	0.05		NaOH	yes	yes	e
G-166	11.2	0.05		NaOH	no	no	c
G-167	11.2	0.05		KOH	yes	yes	f
G-170	11.2	0.05		KOH	yes	yes	g
G-174	11.2	0.05		KOH	no	no	g
G-179	11.2	0.05		KOH	yes	yes	f
G-182	11.2	0.05		KOH	yes	yes	g
G-184	11.2	0.05		KOH	yes	yes	g
G-187	11.2	0.05		KOH	no	no	g
G-188	11.2	0.05		KOH	no	no	g

a. Sodium analogue of weeksite but with slightly larger spacing of some lines.
b. Sodium analogue of weeksite mixed with boltwoodite $K_2(UO_2)_2(SiO_3)_2(OH)_2 \cdot 5H_2O$).
c. Sodium analogue of weeksite.
d. Sodium analogue of weeksite plus some other unidentified compound represented by three diffraction lines.
e. Sodium analogue of weeksite, plus some other unidentified compound represented by two weak lines.
f. Boltwoodite the dominant compound with lesser amounts of weeksite.
g. Weeksite.

[1] Compound identified by *x*-ray study by Daphne R. Ross.

X-Ray Diffraction Data

The *x*-ray diffraction powder pattern of weeksite was one of the recurrent unknown patterns in the *x*-ray laboratories of the Geological Survey from 1950 until the recent detailed study. The pattern resembles the patterns of the uranophane group in a general way, but not in detail, and is similar to, but distinctly different from, that of haiweeite. No significant differences could be observed between the powder patterns of natural

TABLE 5. *X*-RAY POWDER DATA FOR NATURAL AND SYNTHETIC WEEKSITE, $K_2(UO_2)_2(Si_2O_5)_3 \cdot 4H_2O$, AND FOR THE SYNTHETIC Na ANALOGUE, COMPARED WITH HAIWEEITE

Weeksite: orthorhombic, $a = 14.26 \pm 0.02$, $b = 35.88 \pm 0.10$, $c = 14.20 \pm 0.02$ Å; space group, $Pnnb - D_{2h}^6$

Calculated		Measured[1]					
		Weeksite			Synthetic Na Analogue	Haiweeite	
		Natural		Synthetic			
hkl	d_{hkl}	I	d_{hkl}	d_{hkl}	d_{hkl}	I	d_{hkl}
040	8.97	8	8.98	8.67	9.03	10	9.14
(β, 200, 002		1	7.87)			2	8.05
200	7.13	10	7.11	7.08	7.11		
002	7.10					4	7.05
(β, 240, 042		1	6.17)				
240	5.58	9	5.57	5.57	5.57	2	5.53
042	5.56					1	5.06
222	4.84	3	4.83	4.84	4.85	½	4.90
071	4.82						
260	4.58						
062, 171	4.57	4	4.58	4.57	4.60	6	4.56
301	4.51						
080, 103	4.49	3	4.48				
322	3.86					6	4.42
262, 223	3.85	4	3.84	3.84	3.84	2	3.82
091	3.84						
280	3.80	½	3.79				
082	3.79						
400	3.57	7	3.55	3.54	3.56	4	3.54
004	3.55						
282, 303	3.35	4b	3.34				
313	3.34						
044, 440, 362	3.30	7	3.30	3.29	3.30	3	3.30
263	3.29						
144	3.22						
2.10.0	3.21	5	3.20	3.19	3.19	5	3.19
0.10.2, 402, 441	3.20						
204, 0.11.1	3.18						
422, 343	3.14						
224, 2.10.1, 372	3.13	1	3.13			5	3.106
1.10.2, 273, 292	3.12						

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[1] Camera diameter, 114.6 mm; radiation, Cu/Ni, λ CuK$\alpha = 1.5418$ Å. Film cut-off, $d \geq 13.0$ Å; b = broad.

TABLE 5 (*continued*)

Calculated		Measured[1]					
		Weeksite			Synthetic Na Analogue	Haiweeite	
		Natural		Synthetic			
hkl	d_{hkl}	I	d_{hkl}	d_{hkl}	d_{hkl}	I	d_{hkl}
432	3.08						
234	3.07	1	3.06				
460	3.06						
093, 064	3.05						
442	3.00						
244, 0.12.0, 391, 461	2.99	4	2.99	2.99	2.99		
164, 193	2.98						
2.10.2, 363	2.92						
452	2.91	6	2.91	2.91	2.94	3	2.905
2.11.1, 1.11.2, 254	2.90						
373, 3.10.1, 392	2.81	3	2.80	2.79	2.81	1	2.81
293, 1.10.3	2.80						
0.11.3, 383	2.69	½	2.69			2	2.62
3.11.2	2.52	3	2.51	2.51	2.51	½	2.51
2.11.3, 404, 414	2.51						
		4	2.41	2.41	2.44		
		5	2.37	2.37	2.37	2	2.39
		5	2.28	2.28	2.28	2	2.28
		4	2.24	2.24	2.24		
		3	2.20	2.20	2.20	1	2.21
		½	2.17				
		4	2.13	2.13	2.14		
		4	2.11	2.10	2.10	1	2.11
		4	1.994				
		3	1.973	1.977	1.973	1	1.979
		3	1.922	1.921	1.916	1	1.923
		4	1.905				
		4	1.899	1.897	1.901	1	1.898
		1	1.872				
		½	1.854			½	1.854
		2b	1.831			1	1.829
		3	1.791				
		4	1.778			1	1.781
		½	1.763				
		3b	1.741				
		1	1.726			1	1.732
		4	1.689			1	1.686
		plus additional lines, all with $I \leq 3$					

weeksite, synthetic weeksite, and the synthesized Na analogue, in spite of the wide difference between the ionic radii of Na and K. Nor were there any differences in the spacing or in the width of the lines between roughly and gently ground specimens of the same sample. Powder patterns of samples ground in acetone did not differ from the pattern of a sample ground only in air.

X-ray diffraction studies by Joan R. Clark and George Ashby lead to the following results: orthorhombic, pseudocell of dimensions $a=7.131 \pm 0.010$, $b=17.94 \pm 0.05$, $c=7.10 \pm 0.010$ Å. In the pseudocell volume of 908.4 Å^3 are contained two $[K_2(UO_2)_2(Si_2O_5)_2 \cdot 4H_2O]$. Later examination of better single crystals by precession *x*-ray techniques shows that the possible space groups for the pseudocell are: $A2mm-C_{2v}^{11}$, $Amm2-C_{2v}^{14}$, or $Ammm-D_{2h}^{19}$ (if centrosymmetric); $A222-D^6_2$ (if noncentrosymmetric). Observation of faint reflections shows that the true cell has dimensions $a=14.26 \pm 0.02$, $b=35.88 \pm 0.10$, $c=14.20 \pm 0.02$ Å, so that the true volume is eight times the volume of the pseudocell and therefore contains 16 formula units of weeksite. The space group of the true cell is $Pnnb-D_{2h}^6$.

Calculated interplanar spacings based on the true cell and space group are given in Table 5, together with observed *d*-spacings for natural and synthetic weeksite, the synthetic Na analogue, and haiweeite.

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(over)

Note added in proof

Since this paper was prepared, Russell Honea (1959) has applied the unit cell parameters determined for weeksite by Joan Clarke by *x*-ray diffraction to material he calls gastunite. Honea's material is undoubtedly identical with weeksite. More recent study of the type gastunite, which was not available to Honea at the time his paper was published, shows that gastunite and haiweeite are probably the same material.

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