

## ACKNOWLEDGMENT

It is a pleasure to acknowledge the kind offices of Alan G. Chynoweth, who critically read an early draft of this note, and recommended its organization in the present form.

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THE AMERICAN MINERALOGIST, VOL. 44, MARCH-APRIL, 1959

SYNTHESIS OF SABUGALITE<sup>1</sup>

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In his paper on sabugalite,  $\text{HAL}(\text{UO}_2)_4(\text{PO}_4)_4 \cdot 16\text{H}_2\text{O}$ , Frondel (1951) stated that his efforts to synthesize this mineral had been unsuccessful.

<sup>1</sup> Publication authorized by the Director, U. S. Geological Survey.

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Two of the authors (Magin and Jansen) were at that time working on the synthesis of uranyl phosphates and successfully synthesized this mineral. The method used was similar to that used by Beintema (1938) in his synthesis of uranocircite. The stoichiometric amount of uranyl acetate dihydrate (200.0 mg) was added to 27.5 mg. of aluminum chloride hexahydrate in a large volume of water (600 ml.). A threefold excess of phosphoric acid (1.4 ml. of a 100 g/liter solution of  $H_3PO_4$ ) was added. A yellow fine-grained precipitate formed slowly and was digested in a covered beaker on the steam bath for 2 days. The chemical analysis of the resulting product is given in Table 1.

Because the synthetic crystals were exceedingly fine grained, they did not yield satisfactory optical data. However, the average index of refraction of the synthetic product indicated a value of about 1.57, which is within the range of indices given by Frondel for natural sabugalite with water content approximately the same as that of the synthetic product.

Both the natural and the synthetic sabugalite were indexed on the basis of the data given by Frondel (1951)—tetragonal ( $I4/mmm$ ),  $a_0=6.96 \text{ \AA}$  and  $c_0=19.22 \text{ \AA}$ . The results obtained with the use of these data are not satisfactory, however, as not all the reflections could be indexed. Good single crystal patterns could not be obtained due to the very thin and warped nature of the crystals. Until better material is discovered, assignment of the space group to which this mineral belongs must be only tentative.

In Table 2 Frondel's powder data of sabugalite are given for comparison with our data. The line at  $d=4.86 \text{ \AA}$  has been resolved on our patterns of both the synthetic and the naturally occurring material, to  $d=4.93 \text{ \AA}$  and  $4.80 \text{ \AA}$ , which then can be indexed as (110) and (004) respectively.

The writers gratefully acknowledge the help of Mrs. Daphne R. Ross

TABLE 1. CHEMICAL ANALYSIS (IN PER CENT) OF SABUGALITE

	Synthetic (G. B. Magin, Jr., Analyst)	Natural (Frondel, 1951)	Theoretical
UO <sub>3</sub>	64.43	65.22	64.41
Al <sub>2</sub> O <sub>3</sub>	2.90	2.65	2.87
P <sub>2</sub> O <sub>5</sub>	15.75	16.08	15.99
H <sub>2</sub> O	16.67	15.93	16.73
Total	99.75	99.88	100.00

TABLE 2. X-RAY POWDER DATA FOR NATURAL AND SYNTHETIC  
SABUGALITE:  $\text{HAl}(\text{UO}_2)_4(\text{PO}_4)_4 \cdot 16\text{H}_2\text{O}$

Indexed on tetragonal unit cell: space group  $I4/mmm$ ;  $a_0 = 6.96 \text{ \AA}$ ,  $c_0 = 19.22 \text{ \AA}$ ;  $\text{CuK}\alpha$  radiation ( $\lambda = 1.5418 \text{ \AA}$ ); nickel filter; camera diameter = 114.59 mm.; cut-off at 11.0  $\text{\AA}$

$hkl$	$d_{\text{calc.}}$	Synthetic sabugalite (Film No. 9899)		Natural sabugalite (Film No. 8991) Locality: Mina da Quarta Seira, Sabu- gal, Portugal		Natural sabugalite (Fron del, 1951) Locality: Mina da Quarta Seira, Sa- bugal, Portugal	
		$d_{\text{meas.}}$	I	$d_{\text{meas.}}$	I	$d_{\text{meas.}}$	I
002	9.605	9.61	100	9.61	100	9.69	10
		9.03*	9	8.93*	9		
		8.43	1	8.43†	9		
		6.71	3	6.76	3		
101	6.544	6.37	3	6.37	4	6.56	1
				5.44†	3	5.59	1
		5.31	4				
110	4.922	4.93	18	4.93	35		
004	4.802	4.80	18	4.80	35	4.86	9
103	4.713						
112	4.380	4.55	25	4.58	13		
		4.40	9	4.40	9	4.39	4
		4.17( <i>vb</i> )	2	4.19( <i>b</i> )	2		
200	3.480	3.97	2	3.63†	4		
		3.48	35	3.48†	50	3.47	8
114	3.437						
105	3.364	3.36	9	3.36	13	3.36	1
006	3.202	3.22( <i>b</i> )	9	3.22( <i>b</i> )	9	3.22	$\frac{1}{2}$
211	3.073	3.05( <i>b</i> )	2	3.08	2	3.06	$\frac{1}{2}$
		2.94	3	2.93	6		
		2.88	3				
204	2.818					2.818	1
213	2.800						
116	2.684						
		2.63	6	2.62	4		
107	2.553						
220	2.461	2.46( <i>b</i> )	4	2.47( <i>b</i> )	4	2.452	2
214	2.418						
008	2.401	2.40	6	2.40	9	2.389	2

*b* = broad. *vb* = very broad.

\* Possibly a lower hydration state of sabugalite.

† Meta-autunite.

TABLE 2 (Continued)

<i>hkl</i>	<i>d</i> <sub>calc.</sub>	Synthetic sabugalite (Film No. 9899)			Natural sabugalite (Film No. 8991) Locality: Mina da Quarta Seira, Sabu- gal, Portugal		Natural sabugalite (Fron del, 1951) Locality: Mina da Quarta Seira, Sa- bugal, Portugal	
		<i>d</i> <sub>meas.</sub>	I	<i>d</i> <sub>meas.</sub>	I	<i>d</i> <sub>meas.</sub>	I	
222	2.384							
206	2.356							
301	2.303	2.29	2	2.30	2			
		2.24	2	2.25	1			
310	2.201							
224	2.190	2.19( <i>b</i> )	9	2.20( <i>b</i> )	13	2.188	6	
303	2.182							
118	2.165							
312	2.146							
217	2.058	2.08( <i>vb</i> )	3	2.10( <i>vb</i> )	4			
109	2.040							
		1.989	2	1.998	1			
		1.918	4	1.926	6			
		1.859	3	1.863	3			
		1.791( <i>b</i> )	3	1.794( <i>vb</i> )	4	1.792	1	
		1.740	4	1.743	9	1.726	1	
		1.670	2	1.684	1	1.641	$\frac{1}{2}$	
		1.603	1	1.605	2			
		1.578	2	1.583	3			
		1.551	2	1.556	2	1.552	1	
		1.523	2	1.528	3			
		1.421( <i>b</i> )	1	1.423( <i>b</i> )	2			
		1.366( <i>b</i> )	3	1.370( <i>vb</i> )	4	1.364	1	

of the U. S. Geological Survey in the *x*-ray studies. This work is part of a program being conducted by the U. S. Geological Survey on behalf of the Division of Research of the U. S. Atomic Energy Commission.

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