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REFERENCES

BANERJEE, B. I. (1958), An *X*-Ray View of the Petroleum Industry, talk given at meeting of American Crystallographic Association, June 24, 1958.

BATES, T. F., SAND, L. B., AND MINK, J. F. (1950), Tubular Crystals of Chrysotile Asbestos, *Science* **111,** 512–513.

BRECK, D. W. (1958), Paper given at the Conference on the Structure and Properties of Natural and Synthetic Minerals, Penn. State Univ., July 5–8, 1957, reported in the *Am. Mineral.* **43,** p. 175.

BROWN, J. F., AND WHITE, D. M. (1958), Paper given at the 133rd Amer. Chem. Soc. meeting, April, 1958. Reported in Chem. and Eng. News, April 28, 1958, p. 47, and Scientific American, July, 1958, p. 50. Also as Report No. 58-RL-1875 "Stereospecific Polymerization in Thiourea Canal Complexes" by J. F. Brown, N. R. Young and D. M. White, Research Information Section, General Electric Laboratory,The Knolls, Schenectady, N. Y., January, 1958.

DONNAY, G., AND DONNAY, J. D. H. (1953), The Crystallography of Bastnaesite, Parisite, Roentgenite and Synchisite, *Am. Mineral.* **38,** 932–963.

DOUCETTE, E. I., Bell Telephone Laboratories (1958), Personal Communication.

FARNEY, G. K., Bell Telephone Laboratories (1958), Personal Communication.

KING, A. G. (1957), Pyrite-uraninite Polycrystal, *Am. Mineral.* **42,** 648–656.

KITTEL, C. (1946), Theory of the Structure of Ferromagnetic Domains in Films and Small Particles, *Phys. Rev.* **70,** 965.

LEWIS, W. (1950), *Thin Films and Surfaces*, Chemical Publishing Co., New York.

NOLL, W., AND KIRCHER, H. (1950), Zur Morphologie des Chrysotilasbestes, *Naturwiss.* **37,** 540–541.

PASHLEY, D. W. (1956), The Study of Epitaxy in Thin Surface Films, *Phil. Mag. Suppl.* **5,** no. 18, 173–240.

PUNDSACK, FRED L. (1956), The Properties of Asbestos. II. The Density and Structure of Chrysotile, *Jour. Phys. Chem.* **60,** 361–364.

REED, E. D. (1955), A Tunable, Low-Voltage Reflex Klystron for Operation in the 50 to 60-kmc. Band, *Bell System Technical Journal* **34,** 563–599.

WILLIAMS, H. J., AND SHERWOOD, R. C., Bell Telephone Laboratories (1958), Personal Communication.

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SYNTHESIS OF SABUGALITE[1]

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In his paper on sabugalite, $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$, Frondel (1951) stated that his efforts to synthesize this mineral had been unsuccessful.

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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 ($I4/mmm$), $a_0=6.96$ Å and $c_0=19.22$ Å. 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 $d=4.86$ Å has been resolved on our patterns of both the synthetic and the naturally occurring material, to $d=4.93$ Å and 4.80 Å, which then can be indexed as (110) and (004) respectively.

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

	Synthetic (G. B. Magin, Jr., Analyst)	Natural (Frondel, 1951)	Theoretical
UO_3	64.43	65.22	64.41
Al_2O_3	2.90	2.65	2.87
P_2O_5	15.75	16.08	15.99
H_2O	16.67	15.93	16.73
Total	99.75	99.88	100.00

TABLE 2. *X*-RAY POWDER DATA FOR NATURAL AND SYNTHETIC SABUGALITE: $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$

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

		Synthetic sabugalite (Film No. 9899)		Natural sabugalite (Film No. 8991) Locality: Mina da Quarta Seira, Sabugal, Portugal		Natural sabugalite (Frondel, 1951) Locality: Mina da Quarta Seira, Sabugal, Portugal	
hkl	$d_{calc.}$	$d_{meas.}$	I	$d_{meas.}$	I	$d_{meas.}$	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					6.56	1
		6.37	3	6.37	4		
						5.59	1
				5.44†	3		
		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						
		4.55	25	4.58	13		
112	4.380	4.40	9	4.40	9	4.39	4
		4.17(*vb*)	2	4.19(*b*)	2		
		3.97	2				
				3.63†	4		
200	3.480	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(*b*)	9	3.22(*b*)	9	3.22	½
211	3.073	3.05(*b*)	2	3.08	2	3.06	½
		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(*b*)	4	2.47(*b*)	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*)

		Synthetic sabugalite (Film No. 9899)		Natural sabugalite (Film No. 8991) Locality: Mina da Quarta Seira, Sabugal, Portugal		Natural sabugalite (Frondel, 1951) Locality: Mina da Quarta Seira, Sabugal, Portugal	
hkl	$d_{calc.}$	$d_{meas.}$	I	$d_{meas.}$	I	$d_{meas.}$	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(*b*)	9	2.20(*b*)	13	2.188	6
303	2.182						
118	2.165						
312	2.146						
217	2.058	2.08(*vb*)	3	2.10(*vb*)	4		
109	2.040						
		1.989	2	1.998	1		
		1.918	4	1.926	6		
		1.859	3	1.863	3		
		1.791(*b*)	3	1.794(*vb*)	4	1.792	1
		1.740	4	1.743	9	1.726	1
		1.670	2	1.684	1	1.641	½
		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(*b*)	1	1.423(*b*)	2		
		1.366(*b*)	3	1.370(*vb*)	4	1.364	1

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REFERENCES

FRONDEL, CLIFFORD (1951), Studies of uranium minerals (VIII): Sabugalite, an aluminum-autunite. *Am. Mineral.* **36,** 671–679.

BEINTEMA, J. (1938), On the composition and the crystallography of autunite and the meta-autunites. *Rec. Trav. Chim. Pays-Bas* **57,** 155–175.