nism. The presence of minerals such as portlandite and ettringite indicates an extremely high alkalinity, in excess of pH = 11, which also remains unexplained. Water of such high alkalinity is most unusual, but has been observed, although not explained, in at least one case: the spring of Aqua de Ney, California. (Feth *et al.* 1961).

The data presented here are the result of a preliminary study of this interesting rock sequence. Further unusual mineral assemblages are under investigation.

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THE PROBABLE CHEMICAL FORMULA OF AKSAITE, A NEW HYDRATED MAGNESIUM BORATE[1]

JOAN R. CLARK AND RICHARD C. ERD, *U. S. Geological Survey, Washington 25, D. C. and Menlo Park, California.*

Aksaite, a new hydrated magnesium borate, has recently been described by Blazko *et al.* (1962). Crystallographic, optical and chemical data were given, but these authors stated that the chemical composition of aksaite remains in doubt. The two chemical formulas suggested by them as most probable are: $2MgO \cdot 5B_2O_3 \cdot 8H_2O$ and $3MgO \cdot 7B_2O_3 \cdot 10H_2O$.

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

Lehmann and Papenfuss (1959) described the synthesis of $MgO \cdot 3B_2O_3 \cdot 5H_2O$ and gave *x*-ray powder data for that compound. Crystals were kindly supplied to us for examination through the courtesy of Prof. Dr. H.-A. Lehmann, Institut für anorganische Chemie der TH für Chemie, Leuna-Merseburg, to whom we are indebted. The crystallographic and optical data obtained by us for the synthetic magnesium

TABLE 1. CRYSTALLOGRAPHIC AND OPTICAL DATA COMPARED FOR $MgO \cdot 3B_2O_3 \cdot 5H_2O$ AND FOR AKSAITE

	$MgO \cdot 3B_2O_3 \cdot 5H_2O$ Present Study[1]	Aksaite Blazko *et al.* (1962)[2]	
		(1)	(2)
Symmetry	Orthorhombic	Orthorhombic	Orthorhombic
a	12.54±0.04 Å	12.54±0.01 kX	12.52±0.01 kX
b	24.35±0.08	24.28±0.02	24.27±0.03
c	7.484±0.025	7.49±0.01	7.47±0.01
Cell Volume	2285 Å[3]	2280.49 kX[3]	[2270 kX[3]][3]
Space Group	*Pbca*	*Pbca*	*Pbca*
Cell Contents	$8[MgO \cdot 3B_2O_3 \cdot 5H_2O]$	$5[2MgO \cdot 5B_2O_3 \cdot 8H_2O]$	$4[3MgO \cdot 7B_2O_3 \cdot 10H_2O]$
Specific Gravity			
(calc.)	1.972	2.072	2.293
(obs.)	1.99±0.01	2.066	2.367
Optical Classification	Biaxial negative	Biaxial negative	
α	1.472±0.002	1.473±0.001, X=*a*	
β	1.503±0.002, Y=*c*	1.508±0.001, Y=*c*	
γ	1.526±0.002	1.528±0.001, Z=*b*	
2V (calc.)	80°	88° [73°][3]	

[1] Synthetic crystals (Lehmann and Papenfuss, 1959). Precession camera, Zr-filtered Mo radiation, λ (MoKα) = 0.7107 Å; film measurements corrected for shrinkage.

[2] Sample (1) collected by Blazko *et al.*, locality not given; sample (2) collected by V. V. Lobanova, locality not given. The samples are said to be identical in morphology and in optical properties. Single-crystal data obtained from Laue, rotation, oscillation and Weissenberg photographs using Ni-filtered Cu radiation, λ(CuKα) = 1.539 kX.

[3] Calculated by present authors from data given by Blazko *et al.* (1962).

borate crystals are compared in Table 1 with the data given by Blazko *et al.* (1962) for aksaite. The *x*-ray powder data, calculated by us from the cell constants found from single-crystal examination, are given in Table 2 together with the observed lines measured by us and by Lehmann and Papenfuss (1959) for the synthetic crystals. The measured lines for aksaite reported by Blazko *et al.* (1962) are also given in Table 2 for comparison.

The evidence of the two tables is sufficient to show that the mineral crystals of aksaite are the same compound as the synthetic crystals of $MgO \cdot 3B_2O_3 \cdot 5H_2O$, thus confirming the suggestion made by M. E. Mrose, quoted by Fleischer (1963). The chemical analyses and specific gravity determinations for aksaite were apparently made from impure samples, a possibility suggested by Blazko *et al.* (1962).

TABLE 2. *X*-RAY POWDER DATA COMPARED FOR $MgO \cdot 3B_2O_3 \cdot 5H_2O$ AND AKSAITE

Calculated[1]		Observed						
		Synthetic $MgO \cdot 3B_2O_3 \cdot 5H_2O$					Aksaite	
		Present Study[2]		Lehmann and Papenfuss (1959)[3]			Blazko *et al.* (1962)[4]	
hkl	d_{hkl} (Å)	d_{hkl} (Å)	I	$\theta/2$	d_{hkl} (Å)	I	d_{hkl} (kX)	I
020	12.18	12.2	10					
		7.2[5]	2					
021	6.38	6.4	100	—				
200	6.27	6.3	35	7.0	6.3	st	6.36	10
111	6.21							
040	6.09	6.1	50				6.00	8
210	6.07			7.6	5.8	ss		
121	5.68	5.7	2				5.63	3
220	5.57							
131	5.04	5.03	10	8.8	5.04	s		
230	4.96	4.98	10	—			4.98	6
201	4.81							
041, 211	4.72	4.72	50	9.4	4.72	m	4.68	9
221	4.47	4.48	2					
141	4.42	4.37	25	10.1	4.40	s	4.33	6
240	4.37							
231	4.14	4.15	5	10.8	4.11	ss	4.10	r 3
060	4.06							
151	3.88	3.86	2					
250	3.85							
241	3.77	3.74	20	11.6	3.83	ss	3.70	4
002	3.74							
311	3.61							
102	3.59							
022	3.58	3.59	35	12.3	3.62	m	3.54	9
061	3.57							
112	3.55							
321	3.50							
122	3.44							
161	3.43	3.44	10	—			3.43	3
251	3.42							
260	3.41							
331	3.33	3.34	10	13.2	3.38	ss	3.31	4
132	3.28	3.28	2	—				
202	3.21							
212, 042	3.19	3.19	50	14.0	3.19	st	3.19	9
400	3.14							
341	3.13							
222, 410	3.11	3.11	50	14.2	3.14	m	3.09	7
261	3.10							
142	3.09							

[1] Interplanar spacings (d_{hkl}) calculated from single-crystal data given in Table 1 for synthetic $MgO \cdot 3B_2O_3 \cdot 5H_2O$. All possible lines are listed for $d \geq 2.200$ Å.

[2] Film no. 17198; camera diameter 114.59 mm; Ni-filtered Cu radiation, $\lambda(CuK\alpha) = 1.5418$ Å; film measurements corrected for shrinkage; b = broad. Lower limit of 2θ measurable, approximately 7° (13 Å).

[3] Camera diameter 57.4 mm; Ni-filtered Cu radiation; $\theta/2$ corresponds to Bragg θ; d_{hkl} obtained from $\theta/2$ value by present authors; significance of intensity notations apparently as follows: st = very strong, m = strong, s = medium strong, and ss = medium.

[4] Camera diameter 57.29 mm; Mn-filtered Fe radiation; NaCl used as an internal standard. Sample may have contained anhydrite (strongest line 3.50 Å); r = diffuse.

[5] $CuK\beta$ line of 021.

TABLE 2—(*continued*)

Calculated[1]		Observed						
		Synthetic $MgO \cdot 3B_2O_3 \cdot 5H_2O$					Aksaite	
		Present Study[2]		Lehmann and Papenfuss (1959)[3]			Blazko *et al.* (1962)[4]	
hkl	d_{hkl} (Å)	d_{hkl} (Å)	I	$\theta/2$	d_{hkl} (Å)	I	d_{hkl} (kX)	I
171	3.06	3.05	5b	—			3.02	r 1
270, 080, 420	3.04							
232	2.988							
430	2.924	2.92	5					
351	2.920							
152	2.887	2.88	10	15.3	2.92	ss	2.90	r 2
411	2.871							
242	2.842							
081	2.819	2.82	20	15.9	2.81	st		
271	2.818							
421	2.813							
302	2.788	2.79	20	16.2	2.76	ss	2.78	8
440	2.787							
312	2.770							
181, 062	2.751	2.74	2					
280	2.738							
431	2.724							
322	2.718	2.72	2					
361	2.714							
162	2.687	2.69	2	—			2.69	r 3
252	2.682							
332	2.637							
450	2.636							
441	2.612							
281	2.571							
342	2.535							
262	2.519	2.52	2					
371	2.518							
172	2.497							
191	2.494							
451	2.486	2.48	10	17.9	2.51	s	2.470	5
290	2.484							
460	2.481							
023	2.444	2.44	2					
0, 10, 0	2.435							
113	2.434							
352	2.420							
402	2.403	2.40	5	—			2.393	1
123	2.399							
412	2.391							
511	2.367	2.36	15	18.9	2.38	m	2.348	6
082	2.361							
272	2.360							
291, 422	2.358							
461	2.355							
133	2.343							
381	2.337							
521	2.334							
470	2.329							

TABLE 2—(*continued*)

Calculated[1]		Observed						
		Synthetic $MgO \cdot 3B_2O_3 \cdot 5H_2O$					Aksaite	
		Present Study[2]		Lehmann and Papenfuss (1959)[3]			Blazko *et al.* (1962)[4]	
hkl	d*hkl* (Å)	d*hkl* (Å)	I	$\theta/2$	d*hkl* (Å)	I	d*hkl* (kX)	I
182	2.320							
540	2.319							
0, 10, 1	2.316	2.31	10	19.5	2.31	m	2.300	5
213, 043	2.308							
432	2.304							
362	2.298							
531	2.282							
223; 1, 10, 1	2.277	2.27	10				2.259	4
2, 10, 0; 143	2.270							
442	2.235							
233	2.229	2.23	2	20.5	2.20	ss	2.215	1
471	2.224							
541	2.215							
28	2.210							
		2.18	5b				2.162	3
		2.13	10	21.4	2.11	s		
		2.11	5	—			2.115	
		2.09_3	10	22.2	2.04	s	2.074	5
		2.07_6	2					
		2.04_2	2					
		2.02_4	5	—			2.013	6
		1.977	10	22.9	1.98	m	1.970	7
		Plus additional lines, all with I≤5		Plus additional lines, all with I≤ss			Plus additional lines, all with I≤6	

Other considerations provide additional evidence that the formulas given by Blazko *et al.* are implausible. First, the space group *Pbca* contains only fourfold and eightfold positions, so that the total number per cell for each atomic species may be expected to be an integral multiple of four or eight. Five formula units of $2MgO \cdot 3B_2O_3 \cdot 8H_2O$ per cell requires that 10 Mg, 125 O and 50 B be assigned positions, yet none of these numbers is an integral multiple of four or eight. On these grounds, the first formula is unlikely. The second formula, $3MgO \cdot 7B_2O_3 \cdot 10H_2O$, violates the second rule governing hydrated borates (Christ, 1960), *i.e.* a borate polynuclear anion of low to medium negative charge is expected. On the other hand, the formula for the synthetic $MgO \cdot 3B_2O_3 \cdot 5H_2O$ is analogous to that of the mineral gowerite, $CaO \cdot 3B_2O_3 \cdot 5H_2O$ (Erd *et al.* 1959). The structural possibilities associated with this $1 \cdot 3 \cdot x$ formula have been discussed by Christ (1960) and, with particular reference to

gowerite, by Christ and Clark (1960). A similar discussion may be expected to be valid for the 1·3·5 Mg compound by analogy to the relationship between the $2CaO \cdot 3B_2O_3 \cdot xH_2O$ series and the $2MgO \cdot 3B_2O_3 \cdot xH_2O$ series. The prediction by Christ (1960) that the mineral inderite, $2MgO \cdot 3B_2O_3 \cdot 15H_2O$ (=lesserite; Schaller and Mrose, 1960) would have the structural formula, $Mg[B_3O_3(OH)_5] \cdot 5H_2O$, has recently been confirmed by a crystal structure analysis (Ashirov *et al.*, 1962). All evidence therefore points to the chemical formula $MgO \cdot 3B_2O_3 \cdot 5H_2O$, and a probable structural formula $Mg[B_3O_3(OH)_4]_2 \cdot H_2O$ for the mineral aksaite.

We wish to thank four of our colleagues for their contributions to this study. Daniel E. Appleman calculated the d-spacings on a digital computer using a program written by him; Mary E. Mrose took *x*-ray powder patterns of the synthetic crystals, and she and M. Fleischer translated the Russian article on aksaite into English; C. L. Christ gave valuable discussion on the structural principles.

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X-RAY DATA FOR HYDROTUNGSTITE

Richard S. Mitchell, *University of Virginia, Charlottesville, Virginia.*

In the original description of hydrotungstite by Kerr and Young (1944) *x*-ray powder data were given for the more intense reflections, but the values were not indexed and the unit cell constants were lacking. Recently the writer noticed a similarity between the *x*-ray patterns for hydrotungstite (tungstic acid, $H_2WO_4 \cdot H_2O$) and molybdic acid ($H_2MoO_4 \cdot H_2O$). This similarity is quite reasonable since the ionic radii