SEAMANITE, A NEW MANGANESE PHOSPHO-BORATE FROM IRON COUNTY, MICHIGAN

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During the summer of 1917 while the senior author was visiting the copper district of Northern Michigan, Professor Arthur E. Seaman of the Michigan College of Mining and Technology called his attenton to what was thought to be a new mineral, which he had recently discovered at the Chicagon mine. Professor Seaman's statement was based upon a qualitative determination of the chemical composition made by Mr. F. B. Wilson, then a member of the chemical department of the College. Several well crystallized specimens were entrusted to the senior author who determined the crystallographic and optical data. On account of the World War further investigation of the mineral was discontinued until a year ago, when the data on the crystallography and on the physical and optical properties were checked and extended in the Mineralogical Laboratory of the University of Michigan by Dr. C. B. Slawson. Professor Seaman also very kindly placed further specimens at the disposal of Dr. Slawson who used them for the chemical analyses given in this paper.

The chemical analyses by Dr. Slawson show conclusively that the mineral is a new hydrated manganese phospho-borate. Accordingly, in recognition of Professor Seaman's long and influential service as Professor of Geology and Mineralogy at the Michigan College of Mining and Technology, and his valuable contributions to the geology and mineralogy of the Upper Peninsula of Michigan, the authors propose the name of seamanite for this new mineral.

Seamanite has been found only in the Chicagon mine, five miles east and one mile north of Iron River, Michigan, in the NE 1/4 of Sec. 26, T43N, R34W, Iron County. It occurs as small acicular crystals in the crevices of a badly fractured and highly ferruginous siliceous rock. In many of the specimens of seamanite minute cube-like crystals of calcite were found which consisted of a positive rhombohedron whose edges were truncated by a small negative rhombohedron. Some of the oxides of manganese are present, usually as a thin coating.

Associated with seamanite there is also a fibrous asbestos-like mineral the identity of which has not been fully determined. From an optical study it is thought that this fibrous mineral also represents a new species. More material is, however, necessary for a chemical study. A report will be made upon this second mineral as soon as the chemical composition can be accurately determined.

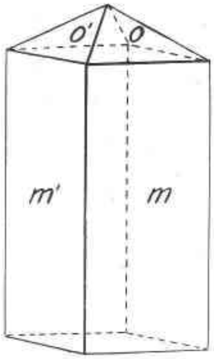

FIG. 1.

The crystals of seamanite are exceptionally slender and small. They are clear and transparent, pale yellow in color when small, but of a distinct wine yellow when larger. The largest crystals measured 10×2×1 millimeters. The observed combination consists of the unit prism, *m*, and the unit bipyramid, *o*. The crystals are commonly terminated at one end by the bipyramidal planes, *o*, while at the other end, due to a distinct basal cleavage, they frequently appear to be terminated by a face of that form (Fig. 1). The faces of the prism are generally rough and rounded and do not give very reliable readings. They are also striated vertically. W. A. Seaman reports having observed the prism (120). Since indistinct images are obtained in positions which would approximate the proper location of faces of this form, the striations may be due to an alternation between the unit and modified prisms. The faces of the bipyramid are very small, but in some instances yielded good images. Although the crystals are not terminated at both ends by bipyramidal faces they are assumed to belong to the bipyramidal class of the orthorhombic system.

The crystallographic data may be summarized as follows:

System = Orthorhombic.
Class = Bipyramidal.
$a:b:c = 0.5195:1:0.4508$.

	OBSERVED	CALCULATED
$m(110):m(1\bar{1}0)=$	*54°35′	......
$o(111):o(1\bar{1}1)=$	*37 30	......
$m(110):o(111)=$	45 52	45°29′

Seamanite has a hardness of 4 and a specific gravity of 3.128. The crystals are soluble in cold dilute acids. Before the blowpipe seamanite fuses readily, after losing its water of crystallization, to a dark slag. Seamanite is optically positive with the following indices of refraction: $\alpha=1.640$, $\beta=1.663$, and $\gamma=1.665$, (all ± 0.003). $X=a$, $Y=b$, $Z=c$, $2V$ approximates 40°, and $r<v$.

TABLE I.

	1	2	3	4
MnO	56.28	55.65	56.22	58.73
MgO CaO			1.61	1.04
FeO			.13	.10
B_2O_3			9.95	9.92
P_2O_5	16.29	15.84	16.65	14.95
H_2O	14.65	14.31	14.57	14.76
			99.13	99.50

TABLE II.

	Average	Factor			
MnO	56.42	.8000			
MgO CaO	1.33	.0277	.8292	3.259	3×1.086
FeO	.11	.0015			
B_2O_3	9.94	.1420			
P_2O_5	15.94	.1122	.2544	1.000	1×1.000
H_2O	14.57	.8090	.8090	3.180	3×1.060

Analyses 1 and 2, Table 1, are the preliminary analyses made with samples of approximately one quarter of a gram each. Carefully hand-picked samples, weighing 0.5933 grams and 0.5365 grams respectively, were used for analyses 3 and 4. The material for analysis 3 consisted of a large number of small crystals while that for analysis 4 was made up of crystals of over one-half centimeter in length. In many instances the larger crystals were coated with a fine powder which was assumed to be manganese oxide. An attempt was made to remove all of this coating but the high percentage of MnO and the low content of P_2O_5 in analysis 4 seem to indicate that some of the coating had been left on the crystals.

Water was determined in an atmosphere of carbon dioxide to prevent the oxidation of the manganese. The sample was then dissolved in hydrochloric acid and boiled with barium hydroxide to precipitate everything with the exception of the B_2O_3 which remained in solution as barium borate. B_2O_3 was determined by titrating the filtrate in the presence of mannitol. The precipitate obtained with barium hydroxide was dissolved in acid and the excess barium removed as the sulphate. From this filtrate manganese was precipitated as MnO_2 by boiling with concentrated nitric acid and sodium chlorate and determined as the pyrophosphate. The filtrate from the manganese separation was then made alkaline which precipitated the magnesium, calcium, and iron as phosphates. Ferrous oxide was determined by titration and the combined content of magnesium and calcium oxides calculated by difference. P_2O_5 was determined as magnesium pyrophosphate to which the phosphate content of the magnesium, calcium, and iron precipitation referred to above was added.*

Since B_2O_3 and P_2O_5 are not present in equal molecular proportions, the factor for the former being the larger, Table 2, it appears that the formula of seamanite should be written as $3MnO.(B_2O_5, P_2O_5) \cdot 3H_2O$. As already indicated, seamanite was partially investigated chemically by Wilson in 1917. He, too, reported that B_2O_3 predominates over P_2O_5. Wilson's results are, however, not available.

Likewise, the ratios derived from the available chemical data of lüneburgite,[1] a hydrated boro-phosphate of magnesium, do not permit of the assumption that B_2O_3 and P_2O_5 are present in the mineral in definite proportions.

LÜNEBURGITE

	Analysis	Factor	
MgO	25.3	.6275	3.000
P_2O_5	29.8	.2098	1.003
B_2O_3	12.7	.1824	.872
H_2O	32.2	1.7889	8.553
	100.0		

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* Calculated as calcium phosphate.

[1] Nöllner, *Ber. Al. München*, 291, 1870.

Furthermore, it should be pointed out that chemically seamanite is closely related to reddingite, $3MnO \cdot P_2O_5 \cdot 3H_2O$. Crystallographically the two minerals are very similar. Both are orthorhombic, and by interchanging the axes of reddingite[2] and taking one-half of the new *a* and *c* axes as the unit lengths, the axial ratios of both minerals are strikingly alike. Moreover, this similarity of values extends to the physical and optical data as the following tabulation shows.

	Reddingite	Seamanite
Composition	$3MnO \cdot P_2O_5 \cdot 3H_2O$	$3MnO \cdot (B_2O_3 \cdot P_2O_5) \cdot 3H_2O$
System	Orthorhombic	Orthorhombic
Axial ratio	0.5271:1:0.4574	0.5195:1:0.4508
Indices of refraction	$\alpha=1.651$	1.640
	$\beta=1.656$	1.663
	$\gamma=1.683$	1.665
Hardness	3–3.5	4
Specific Gravity	3.102	3.128

The analyses given above and the relationship to lüneburgite and reddingite would seem to warrant the assumption that seamanite is a hydrated manganese borate, in which some of the B_2O_3 has been replaced by P_2O_5. The evidence of the chemical analyses seems to support this interpretation.

On the other hand, however, another possible interpretation of the chemical composition of seamanite should be referred to, for it is a well known fact that the accurate separation of and consequently the determination of B_2O_3 and P_2O_5 upon one small sample are extremely difficult. It is, hence, quite probable that some error has been made in these determinations. Accordingly, a somewhat lower value for B_2O_3 and a correspondingly higher value for P_2O_5 would permit of the assumption that the two acid radicals are present in equal molecular proportions. This interpretation seems to find support in the fact that in the recently described cahnite,[3] which is a hydrated boro-arsenate of calcium, the acid radicals are present in equal proportions. The mineral has the composition $4CaO \cdot B_2O_3 \cdot As_2O_5 \cdot 4H_2O$ and may be consid-

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[2] G. J. Brush and E. S. Dana, On a new and remarkable mineral locality in Fairfield Co., Conn.; with a description of several new species occurring there: *Am. J. Sc.*, 1878, **16**, 120; Larsen, The Microscopic Determination of the Non-Opague Minerals, *U. S. Geol. Surv., Bull.* **679**, p. 126.

[3] C. Palache and L. H. Bauer, Cahnite, A New Boro-arsenate of Calcium from Franklin, New Jersey: *Am. Mineral.*, 1927, **12**, 149–153.

ered as a double salt of $2CaO \cdot B_2O_3 \cdot 2H_2O$ and $2CaO \cdot As_2O_5 \cdot 2H_2O$, in the ratio of 1:1.

Consequently, according to this second interpretation of the chemical composition of seamanite the mineral may be regarded as a double salt of $3MnO \cdot B_2O_3 \cdot 3H_2O$ and $3MnO \cdot P_2O_5 \cdot 3H_2O$, in equal proportions. Considering the possibility of a plausible explanation of the composition from the structural standpoint the interpretation as a double salt has much in its favor.

To determine which of these two views is correct it is obvious that further chemical study is necessary. It has, however, been definitely established that seamanite is a new hydrated phosphoborate of manganese.