

BYSTROMITE, MAGNESIUM ANTIMONATE, A NEW MINERAL

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ABSTRACT

Antimony ores from El Antimonio, Sonora, Mexico, contain a new mineral corresponding in chemical composition and structure with magnesium antimonate, MgSb_2O_6 , although in the mineral the lattice is deficient in magnesium and some of the oxygen is replaced by hydroxyl groups. The mineral is massive, color blue-gray, streak light gray, hardness about 7, density 5.7. The mean index of refraction varies from 1.86 to 1.91, the birefringence is approximately 0.01. The mineral occurs in quartz veins associated with stibiconite. X-ray investigation shows that it is tetragonal (ditetragonal dipyramidal), $a=4.68 \text{ \AA}$, $c=9.21 \text{ \AA}$, $c/a=1.968$, space group $P4/mnm$; the structure is of the trirutile type, and the mineral is isomorphous with tapiolite and with many artificial antimonates and tantalates. The name bystromite is proposed after Anders Byström, Swedish crystal chemist, who worked out the structure of synthetic magnesium antimonate in 1941.

During an investigation of antimony ores we received a number of specimens from Dr. D. E. White, of the U. S. Geological Survey, who had collected them from various deposits in Mexico. X-ray powder photographs showed that the common mineral was stibiconite. One specimen, however, gave a different powder photograph, the strong lines of which practically coincided with those recorded for cassiterite. Spectrographic analysis showed magnesium and antimony, with only traces of other elements. A synthetic magnesium antimonate with formula MgSb_2O_6 and structure and lattice dimensions similar to those of cassiterite was described in 1941 (1). The synthesis of magnesium antimonate was repeated and its identity with the new mineral confirmed. This is the first magnesium antimonate recorded as a mineral, and we propose for it the name bystromite,* after Dr. Anders Byström, the senior author of the paper describing the structure of synthetic MgSb_2O_6 .

Bystromite occurs in the antimony deposits of El Antimonio district in the province of Sonora in Mexico. The geology and mines of this district have recently been described by White and Guiza (2). The specimens provided by Dr. White came from La Fortuna and San Jose mines, the type material being that from La Fortuna. In August 1950 one of us visited El Antimonio, without however finding any more of this new mineral, perhaps because at that time little mining was in progress and many of the claims were not being worked.

* The spelling bystromite without the dieresis follows the convention established in the Seventh Edition of Dana's System of Mineralogy. See, for example, lindstromite (Vol. 1).

The ore of antimony in El Antimonio district is stibiconite, and the bystromite is always associated with it. The two minerals are so intimately admixed that the purest specimens of bystromite always contain some stibiconite. This is borne out by the powder photographs, which always show some stibiconite lines, even though this mineral can seldom be detected optically. All the bystromite we have seen has a blue-gray color in hand specimen, and it was thought for a while that this might be characteristic, until similar material proved to be pure or practically pure stibiconite. We have concluded that the only certain identification of bystromite is by means of powder photographs, combined with positive tests for magnesium and antimony.

As mentioned above, the color is blue-gray. The streak is pale gray. The hardness is about 7, but often appears to be much less, due to the porous nature of the specimens. The density measured with the Berman balance on selected grains from the analyzed material was found to be 5.5 ± 0.1 . The chemical analysis indicates admixture of about 8% stibiconite, and when allowance is made for this (assuming a density of 3.9, found for pure stibiconite from El Antimonio) the density of the pure bystromite becomes 5.7. The density calculated from the analysis and the dimensions of the unit cell is 5.80. The agreement is reasonable in view of the assumptions behind the calculations and of the porous and impure nature of the material.

The mineral is massive and non-crystalline and optical examination shows that even the smallest grains consist of aggregates of submicroscopic particles. Mr. T. B. Rhinehammer of the Department of Chemistry of this university kindly examined samples in the electron microscope and reports that even at the highest magnification most of the material appeared as structureless aggregates; a few grains with roughly square or rectangular cross-sections were occasionally seen. The powder photographs confirm its fine-grained nature; the lines on the photographs of the mineral are not as sharp as those on photographs of synthetic MgSb_2O_6 , and the back reflections are not clearly separated into α_1 and α_2 lines.

The measurements of x -ray powder photographs of bystromite, taken with $\text{Cu-K}\alpha$ radiation in a camera of 114.6 mm. diameter, are reproduced in Table 1. Apart from the weak lines of admixed stibiconite, it can be completely indexed in terms of a tetragonal unit cell, with $a = 4.68 \text{ \AA}$, $c = 9.21 \text{ \AA}$, $c/a = 1.968$. A powder photograph of synthetic MgSb_2O_6 , made by heating a mixture of MgO and Sb_2O_3 in the correct proportions in air at 1000°C . for 18 hours, showed complete agreement with that of bystromite. Byström, Hök and Mason (1) showed that for synthetic MgSb_2O_6 $a = 4.63\text{kX}$, $c = 9.21\text{kX}$, space group $P4/mnm$, with two formula groups in the unit cell.

TABLE 1. X-RAY POWDER DIFFRACTION DATA FOR BYSTROMITE
(ANALYZED SPECIMEN), Cu-K α RADIATION

Intensities estimated by visual inspection: 100=strongest line; 90=very strong; 80=strong; 50-70=medium; 30-40=weak; 20=faint; 10=very faint; *=stibiconite line.

<i>I</i>	<i>d</i>	<i>hkl</i>	<i>I</i>	<i>d</i>	<i>hkl</i>
30	5.93	*	40	1.39	{116
40	4.63	100			{303
70	4.19	101	10	1.28	206
100	3.32	110	30	1.19	323
30	3.09	*	20	1.13	226
40	2.96	*	10	1.10	330
30	2.69	112	30	1.06	{316
90	2.57	103			{413
50	2.34	200	10	1.04	420
20	2.25	113	10	1.00	109
30	2.08	{210	20	.919	{219
		{202			{510
30	2.04	211			{336
20	1.81	*	30	.894	{503
90	1.73	213	10	.864	426
40	1.65	220	10	.856	309
10	1.55	*	20	.832	523
20	1.54	006	10	.804	329
40	1.48	310	20	.786	516

Five specimens of bystromite from El Antimonio were selected for the determination of optical properties, thus permitting a measure of the variability. In general, all material examined was divisible into two types; a clear colorless material appearing as an aggregate of tiny crystals under crossed nicols, and turbid grains, also possessing aggregate structure.

In view of the fine-grained structure, the determination of optical characters was limited to birefringence and indices of refraction. The indices of refraction were determined by the immersion method, using a set of newly prepared high-index liquids, whose values were determined by the method of minimum deviation.

The birefringence of the clear material varied from 0.005 to 0.009. The higher value was determined in sample Z61, the analyzed specimen, in which both fractions were found. In this specimen the indices of refraction had a somewhat wider range in the clear fraction than the turbid material. Two specimens (Z90 and Z91) consisted entirely of clear colorless material and had identical indices of refraction—1.855 for the low value and 1.860 for the high value. The colorless fraction of Z61 had a slightly higher index range: 1.862 and 1.871.

The birefringence and indices of refraction are shown in Table 2. In the turbid fraction, the minimum and maximum indices of refraction

TABLE 2. INDICES OF REFRACTION AND BIREFRINGENCE OF DIFFERENT SPECIMENS OF BYSTROMITE

	Turbid Fraction		Biref.	Clear Fraction		
Z61	1.908	1.915	0.007	1.862	1.871	0.009
Z87	1.904	1.908	0.004			
Z89	1.908	1.915	0.007			
Z90				1.855	1.860	0.005
Z91				1.855	1.860	0.005

are 1.904 and 1.915. For two of the specimens, Z61 and Z89, the indices were almost identical, while for a third, Z87, the lower index was 1.904 and the higher one 1.908. In specimens Z87 and Z89 turbid material made up the entire specimen. The only impurity observed in these specimens, which were carefully selected, was an occasional grain of quartz.

The variation in refractive indices from one specimen to another and within the same specimen may be due to variation in composition or to the disturbing effect of intimately admixed stibiconite.

A specimen from La Fortuna mine, only slightly contaminated with stibiconite, was selected for analysis. The admixed stibiconite could not be removed in any way. The only other contaminant was quartz, which was largely eliminated by careful picking. The chemical analysis (Table 3) was made by Mr. M. E. Coller, to whom we express our thanks. The material was found to dissolve completely (with the exception of the quartz) in concentrated HCl containing KI as a reducing agent. Antimony was precipitated with H₂S, the precipitate dissolved by digestion with H₂SO₄ and Na₂SO₄, the resulting solution reduced with Na₂SO₃, and the antimony determined by titration with standard KMnO₄ solution at 5° C. A separate sample was used for the determination of SiO₂, Al₂O₃, Fe₂O₃, CaO, and MgO. It was dissolved in the same way, and the insoluble quartz filtered off and weighed after ignition. The antimony was removed from the filtrate by precipitation with H₂S. Iron and alumina were precipitated with NH₄OH, calcium determined as oxalate, and magnesium as the phosphate. The H₂O(+) was determined by the Penfield method. Oxygen was found by ignition of a weighed sample in a stream of purified hydrogen at 850° C. and weighing of the water thereby produced; this weight was corrected for the water in the mineral, and the remainder reported as reducible oxygen. The result obtained (21.9%) agrees, within the limits of accuracy of the method, with the theoretical value if all antimony is in the quinivalent state (22.05%).

The analysis must first be corrected for the presence of admixed stibiconite. Using the figures for an analyzed stibiconite from El Antimonio and assuming that all the calcium is present in that mineral, the corrected analysis is obtained (Table 3, col. 3). The correction corresponds to 8.3%

TABLE 3. THE CHEMICAL COMPOSITION OF BYSTROMITE

	1	2	3	Molecular Proportions		
Insol. ^a	0.25					
Al ₂ O ₃	0.08					
Fe ₂ O ₃	0.03					
CaO	1.44	1.44				
MgO	6.65		6.65	Mg	165	0.65
Sb	67.15	6.25	60.90	Sb	500	1.97
O ^b	21.9	1.9	20.0	O	1306	5.14
H ₂ O—	0.17					} 6.00
H ₂ O+	2.60	0.63	1.97	OH	218	
	100.27					

1. Bystromite, La Fortuna Mine, El Antimonio, Sonora, Mexico, M. E. Coller, analyst.

2. Correction for admixed stibiconite.

3. Bystromite, corrected composition.

^a Quartz.

^b Theoretical for Sb₂O₅ = 22.05.

stibiconite, which agrees with the amount suggested by the powder photographs. The corrected analysis shows that magnesium is considerably deficient for the composition corresponding to the formula MgSb₂O₆. This deficiency is evidently balanced by a replacement of part of the oxygen by hydroxyl groups. The correctness of this supposition is indicated by the low density of bystromite compared to the calculated value for MgSb₂O₆, which is 6.08.

Little can be said regarding the mode of origin of bystromite. The deposits in which it is found consist of quartz veins containing irregular masses of stibiconite. White and Guiza believe that the stibiconite is secondary after stibnite, as is usual in most deposits of this kind. In the specimens which we have examined bystromite is intimately intermingled with stibiconite. It may have formed contemporaneously with the stibiconite or alternatively it can have been produced from stibiconite by metasomatic action of magnesium-bearing solutions. The latter theory is perhaps supported by the comparatively local distribution of bystromite at El Antimonio, where it apparently occurs in a few of the veins only. Further research in the field is however necessary to provide the evidence required for solving this question.

REFERENCES

1. BYSTRÖM, A., HÖK, B., AND MASON, B., The crystal structure of zinc metantimonate and similar compounds: *Arkiv. Kemi, Mineral., Geol.*, **15B**, no. 4 (1941).
2. WHITE, D., AND GUIZA, R., Antimony deposits of El Antimonio district, Sonora, Mexico: *U. S. Geol. Survey, Bull.* **962-B** (1949).

Manuscript received June 9, 1951.