

completely crystalline. It is not fibrous with the structure which is commonly called metacolloidal, for example, like chalcedony. No pleochroism could be detected in the fine aggregates nor could any interference figure be obtained from such fine-grained material.

There can remain little doubt that this mineral is not halloysite, the isotropic equivalent of kaolinite but, it is one of the high-water clay group identical with the gouge clays and, as indicated by unpublished work, with the Arkansas bentonite. It now appears that the name leverrierite was inappropriate for this compound but it has not, as yet, been decided just what mineral name should be applied to it. Its occurrence in the present specimens as an alteration product of zeolites is, so far, unique and quite different from its other modes of origin.

### ANTLERITE FROM CHUQUICAMATA, CHILE

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In a lot of unlabelled specimens of copper ore from Chuquicamata, Chile, recently sent by Mr. Juan L. Carrasco, there was found in abundance a dark green mineral occurring in thin veins in a sericitized granitic rock. In one specimen it occurs with gypsum and, for the most part, not associated with other copper minerals. It was supposed that the green material was brochantite, atacamite, or a mixture of the two, since these have been reported<sup>1</sup> as among the principal ore minerals of this locality. However, chemical analyses and determination of optical properties show conclusively that it is antlerite ( $3\text{CuO}\cdot\text{SO}_3\cdot 2\text{H}_2\text{O}$ ) and not brochantite ( $4\text{CuO}\cdot\text{SO}_3\cdot 3\text{H}_2\text{O}$ ).

Crystals of antlerite from the same locality have recently been described and drawn by Ungemach,<sup>2</sup> who found from measurements on very good crystals that they are orthorhombic with an axial ratio of  $a:b:c=0.5038:1:0.6868$ . The material examined by the writers was in part well crystallized but measurements were carried out only far enough to locate the crystallographic  $c$  axis for determination of the optical orientation. The habit of the

<sup>1</sup> Palache and Warren: *Am. J. Sci.*, **26**, 345 (1908).

J. A. Hendricks: *Univ. of Cal. Publications*, **14**, 75-84 (1922).

<sup>2</sup> *Bull. Soc. Min. France*, **47**, 124 (1924).

crystals varies; some are flattened parallel to (010), which is the direction of the highly perfect cleavage; others are about equally developed along the three axes. The greatest thickness of any of the veins in the specimens available is only about 2 or 3 mm.; some of the flat crystals have a thickness about equal to this and a much greater length and width.

The optical properties of the antlerite were determined by J. H. C. Martens as follows: refractive indices,  $a = 1.730 \pm .010$ ,  $\lambda = 1.786 \pm .010$ ; optical character positive,  $2V$  moderate; orientation  $X = b$ ,  $Y = c$ ,  $Z = a$ ; the obtuse bisectrix therefore is perpendicular to the (010) cleavage; pleochroism rather strong,  $X =$  yellowish green,  $Y = Z =$  bluish green. Some parts of the antlerite appear in mass darker and more opaque than others, but microscopic examination of thin fragments shows that there is no variation in the mineral itself but that the lesser degree of transparency is caused by small inclusions of colorless or nearly colorless isotropic material of low refractive index, probably air or water. The hardness of antlerite is about 3, a little less than that of brochantite.

Duplicate analyses made by L. F. Audrieth on carefully selected material containing no impurities except some fragments of the wall rock, which appear in the analysis as insoluble material, and less than one per cent by volume of the small isotropic inclusions mentioned above, gave the following results.

ANALYSES OF ANTLERITE,  $3\text{CuO} \cdot \text{SO}_3 \cdot 2\text{H}_2\text{O}$ 

	I	II	Mean of I and II	Theoretical
CuO	66.48	66.21	66.34	67.28
SO <sub>3</sub>	22.38	22.27	22.32	22.56
H <sub>2</sub> O	10.75	10.29	10.52	10.16
Volatile (H <sub>2</sub> O+SO <sub>3</sub> )	33.07	.....	.....	.....
Insol. in HCl	0.87	0.89	0.88	.....
Cl	none	.....	.....	.....
			100.06	100.00

Water in analysis I was determined by subtracting the average SO<sub>3</sub> content from the total volatile matter. The volatile matter was determined by heating a sample to constant weight in a platinum crucible over a blast lamp. Water in analysis II was determined as loss on ignition, using CaO to retain the SO<sub>3</sub> and taking care to avoid absorption of CO<sub>2</sub> from the air by the CaO.

The loss of weight at 120°C. is negligible, although the mineral decrepitates noticeably at higher temperature indicating that water may be occluded within the crystals.

Spectrographs of the antlerite indicate the presence of small amounts of silicon, aluminum and titanium, probably in the form of oxides and included under the insoluble matter in the above analyses. Traces of calcium, iron and silver are also present in quantities too small to be detected by other analytical methods (less than 0.01 per cent).

In the same collection of specimens from Chuquicamata, chalcantinite and natrochalcite were also found, the latter in distinct crystals of the type recorded by Palache and Warren, and in such abundance that it is probably one of the important ore minerals.

The recent recognition of antlerite as occurring in this deposit, evidently in large amounts, suggests that much of what has been called brochantite may really be antlerite, since the two minerals are similar in general appearance and their qualitative chemical reactions are the same.

## THE FORM OF REPLACEMENT CRYSTALS

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Epidote crystals introduced during the replacement of a rock mass<sup>1</sup> have been found elongated parallel to the *c* axis, a direction along which elongation of epidote is very rare. The sections contain a great many of these epidote crystals which are mostly microscopic in size, but in every case the elongation was found to be parallel to the *c* axis rather than along *b*, the common direction of elongation. The development of such a rare crystal form under replacement conditions warrants an explanation since it may make clear certain features of replacement processes.

The mechanism of replacement<sup>2</sup> and the probable nature of the introduced material will not be discussed here beyond a few brief comments pertinent to the subject of this paper.

The positions occupied by material favorable to the reaction with the introduced substance no doubt determined the positions

<sup>1</sup> Observed in thin sections of rocks from Courtland, Arizona, in the possession of Professor L. C. Graton, Harvard University.

<sup>2</sup> The Mechanism of Replacement and Recrystallization: Ernest E. Fairbanks, *Econ. Geol.*, forthcoming article.