

Quarrying operations now in progress in the vicinity of this vein of calcite may uncover other interesting crystals for study.

Grateful acknowledgment is hereby made to Mr. Herbert P. Whitlock, whose experience with the forms of calcite enabled the writer to start correctly with the solution of this crystallographic problem.

#### ADAMITE FROM CHLORIDE CLIFF, CALIFORNIA

JOSEPH MURDOCH, *University of California at Los Angeles.*

Specimens of an undetermined mineral collected at Chloride Cliff, Inyo County, California, were submitted to the writer for identification and proved to be the rather rare zinc arsenate, adamite. This mineral was originally discovered at Chañarcillo, Chile in 1886, and first found in the United States in 1916, in the Tintic district, Utah,<sup>1</sup> later at Cedar Mountain, Mineral County, Nevada,<sup>2</sup> and more recently at Gold Hill, Tooele County, Utah.<sup>3</sup>

At Chloride Cliff the mineral occurs as small crystals, scattered or closely packed, on the surface of fragments of crystalline limestone, in the oxidized zone of workings in this locality. It is the latest mineral to be formed here, overlying crusts of associated limonitic material, crumbly, secondary calcite, and a green mineral which was not identified, but which appears from chemical tests to be one of the hydrous arsenates of copper. This green mineral is quite closely associated with the adamite, and even in some cases causes the latter to appear green on casual inspection. The adamite, however, is perfectly colorless, and where it appears green, closer examination shows it to be superimposed on cores of the other mineral, which show through, and seem to color the whole. There is no transition between the two, and the line of demarcation is perfectly sharp. Much of the adamite is entirely free from the green substance and it is material of this type which was used in the tests.

The blowpipe, physical and optical properties of the mineral identify it as adamite, and the crystal measurements confirm the identification. Owing to the small amount of pure material available it was unfortunately not possible to make a quantitative analysis, but qualitative tests, made for the writer by Professor W. R. Crowell of the Chemistry Department of the University of California at Los Angeles, indicated the absence of all bases except zinc. This, with the lack of coloration in the mineral, renders it reasonable to assume that it approaches closely to the theoretical formula for this species:  $4 \text{ZnO} \cdot \text{As}_2\text{O}_5 \cdot \text{H}_2\text{O}$ . The spe-

<sup>1</sup> Means, A. H., *Am. Jour. Sci.*, (4) vol. 41, p. 125, 1916.

<sup>2</sup> Knopf, A., *U. S. Geol. Surv.*, Bull. 725, p. 372, 1921.

<sup>3</sup> Staples, L. W., *Am. Mineral.*, vol. 20, p. 371, 1935.

cific gravity of a colorless crystal was determined with Clerici solution to be just below 4.3. Optical tests, using white light, gave the following results:

Biaxial positive;  $n=1.720$ ,  $\beta=1.740$   $\gamma=1.745+$ .  $2V=90^\circ \pm$

#### CRYSTALLOGRAPHY

Most of the crystals were too imperfect to measure, but three or four were found which were reasonably complete, and the forms present were determined on the two circle goniometer. Similar faces were noted on many of the imperfect crystals, so that the measured forms seem to be characteristic for the occurrence. The axial ratio used,  $a:b:c=0.996:1:0.718$ , was that determined by Laspeyres<sup>4</sup> for colorless material from Laurium, Greece, on the assumption that this ratio would apply to equally pure material.

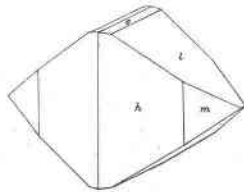


Fig. 1

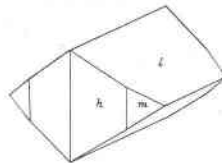


Fig. 2

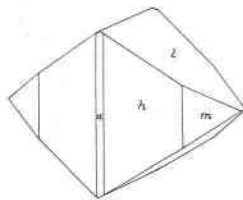


Fig. 3

Measurement showed that the Chloride Cliff crystals were relatively simple, showing three common forms on all the individuals, with two other forms less well developed, on one or two of them. The common forms were the prisms  $m$   $\{110\}$ , and  $h$   $\{210\}$ , and the brachydome  $l$   $\{011\}$ . One crystal showed a narrow development of the brachydome  $e$   $\{013\}$  (an unusual form), and another a very narrow and poorly developed pinacoid  $a$   $\{100\}$ . Hintze<sup>5</sup> lists 32 forms, of which the usual ones

<sup>4</sup> Laspeyres, H., *Zeit. Krist.*, vol. 2, p. 147, 1878.

<sup>5</sup> Hintze, *Handbuch der Mineralogie*, vol. 1, Sect. 4 part 1, p. 643.

are the prisms  $\{110\}$ ,  $\{120\}$ ,  $\{210\}$ ; the brachydome  $\{011\}$ ; and the macrodome  $\{101\}$ . The Chloride Cliff crystals show two types of habits: (1) nearly equidimensional crystals with the prisms and brachydome about equally developed (Figs. 1 and 3) which is the more common type; (2) the same faces are present, but elongated parallel to the  $a$  axis (Fig. 2). In distinction from the Gold Hill occurrence, the macrodome is entirely absent. Colorless crystals from Laurium also show two habits: type 1, prismatic parallel to  $b$ ; and type 2, prismatic parallel to  $c$ . The Chloride Cliff mineral thus affords a new occurrence, and also a new habit for the species.

### BOOK REVIEWS

INTERPRETATIVE PETROLOGY OF THE IGNEOUS ROCKS by HAROLD LATTIMORE ALLING. Octavo xv+353 pages, 48 figs., 11 plates. McGraw-Hill, New York, 1936. Price \$4.00.

This book has as its expressed aim the interpretation of the igneous rocks rather than their description and for the most part the plan is adhered to throughout.

The author begins, appropriately, by discussing the principles upon which interpretation must be based, the principles of chemical equilibrium. The treatment is necessarily brief, in some instances perhaps all too brief. In the discussion of the application of the phase rule (p. 13) only one condition, that of invariancy (in a condensed system), is described. It is doubtful whether the student will readily apprehend how the equation applies to the less simple univariant or divariant system, in other words to a system in which the degrees of freedom are greater than zero. It is unfortunate, too, that the author should make the statement "The phase rule enables the petrologist to predict the composition of igneous rocks in terms of components and hence the composition of minerals can be approximated when equilibria are complete." The plain fact is that the phase rule is only a mathematical equation, though a very useful one, and enables only the prediction of the *number* of phases that can coexist at equilibrium under given sets of conditions. The nature and composition of the phases can be determined only by the laborious process of experimental investigation of the equilibrium diagram.

In treating the change of composition of crystalline compounds during crystallization, from the point of view of reaction between liquid and crystals, the author has failed to grasp (p. 46) the reason why the reaction taking place at an incongruent melting point (peritectic point of the author) has been referred to as a discontinuous reaction. The term discontinuous was used by the reviewer to emphasize the discontinuous change of composition of the crystalline phase (phases) as contrasted with the continuous change of composition in a solid solution series. No question of the incongruent melting taking place at a definite temperature was involved for it is well known and has been observed in many systems that if the number of components and therefore the number of degrees of freedom are great enough, the incongruent melting takes place through a range of temperature. The characteristic feature, discontinuous change of *composition*, persists however.

The discussion of the various groups of rock-forming minerals giving range of chemical composition, the corresponding variation of physical properties and the determined diagrams of phase equilibrium occupies some 80 pages. This section will no doubt prove the most useful part of the book.

The chapter on the crystallization of magmas discusses the various views that have been expressed on this subject and makes some use of the equilibrium diagrams of investigated