THE AMERICAN MINERALOGIST, VOL. 48, NOVEMBER-DECEMBER, 1963

ORIENTED OVERGROWTHS OF THAUMASITE ON ETTRINGITE

A. B. CARPENTER, *Department of Geology, University of Missouri, Columbia, Missouri.*

The occurrence of ettringite in spurrite-merwinite-gehlenite skarn at the 910 level of the Commercial quarry, Crestmore, California, has recently been described by Murdoch and Chalmers (1960). Additional specimens of this mineral were collected by the present author from the same locality during the summer of 1958 and have been studied as part of an investigation of the mineralogy and geochemistry of this deposit.

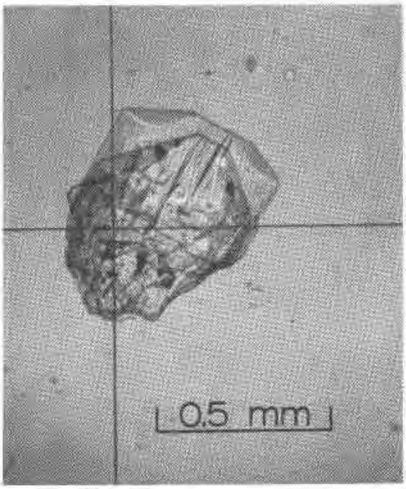

FIG. 1. Oriented overgrowth of thaumasite on ettringite. The mineral grain is immersed in an oil with n = 1.490.

As in the case of the occurrence described by Murdoch and Chalmers the ettringite is present as clear colorless crystals up to 1 mm in length and 0.5 mm in diameter associated with calcite and afwillite in open fractures in the contact rock. An interesting and previously unreported feature of Crestmore ettringite is that many of the crystals are covered by overgrowths of thaumasite (Fig. 1). In a few instances the overgrowths of thaumasite are enclosed by a second generation of ettringite.

The refractive indices of the coexisting ettringite and thaumasite were measured by the immersion method using white light as a source of illumination. The indices of the immersion media, which bracketed the indices to be measured to within ± 0.002, were calibrated with an Abbé

TABLE 1. OPTICAL DATA FOR ETTRINGITE AND THAUMASITE

Mineral	ε	ω	Locality	Remarks
Ettringite	1.458±.002	1.468±.002	Crestmore, Calif.	Enclosed by thaumasite overgrowth
Thaumasite	1.470±.002	1.492±.002	Crestmore, Calif.	Overgrowth on ettringite
"Mineral K"	1.467±.003	1.494±.002	Crestmore, Calif.	Woodford (1943); probably thaumasite associated with ettringite
Thaumasite	1.468±.002	1.507±.002	Crestmore, Calif.	Carpenter (this study); associated with calcite, ettringite absent
Ettringite	1.458±.002	1.464±.002	Synthetic	Lerch *et al.* (1929)
Ettringite	1.4618	1.4655	Scawt Hill	Bannister (1936)
Ettringite	1.455	1.465	Crestmore, Calif.	Murdoch and Chalmers (1958); ("woodfordite")
Thaumasite	1.468	1.507	Sweden	Lévy and Lacroix (1888)
Thaumasite	1.468	1.505	Great Notch, N. J.	Brown (1916)
Thaumasite	1.468	1.506	Ducktown, Tenn.	Schaller (1938)
Thaumasite	1.470	1.504	Co. Down, N. Ireland	Knill (1960)

refractometer immediately after comparison with a mineral fragment. The results of this investigation are presented in Table 1. A compilation of typical values for the refractive indices of ettringite and thausmasite from other localities is included in Table 1 for comparison. These data indicate that the refractive indices of ettringite associated with thaumasite are higher than in those cases where thaumasite is absent. Similarly, the refractive indices of thaumasite associated with ettringite are lower than in specimens in which ettringite is absent. A possible explanation for this phenomenon is presented below.

The orientation of the thausmatie overgrowths with respect to the enclosed ettringite was determined by optical and x-ray methods. During the refractive index determinations it was observed that the thaumasite and ettringite portions of a composite crystal had identical optical extinction positions. This phenomenon indicates that the c axes for the two minerals must be parallel. In addition, single crystal x-ray precession photographs were taken about [0001] and $[10\bar{1}0]$. These photographs confirmed the conclusion that the c axes for the two minerals are parallel and showed that their a axes are also parallel.

McConnell and Murdoch (1962) have already called attention to the similarities in the physical properties and unit cell dimensions of ettringite and thaumasite and concluded that "the structures of ettringite and thaumasite must be closely related in several respects." The presence of oriented overgrowths of thaumasite is additional evidence in favor of their hypothesis. In fact, the anomalous refractive indices of the associated ettringite and thaumasite suggest that there may be a limited solid solution series between these minerals. However, chemical analyses of coexisting ettringite and thaumasite samples whose purity has been checked by optical and *x*-ray methods are necessary before the presence and limits of such a mineral series can definitely be established.

The author wishes to thank the Riverside Cement Company, Riverside, California, and the Society of the Sigma Xi for their financial support of the investigation of the mineralogy and geochemistry of the Crestmore limestone deposit.

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THE AMERICAN MINERALOGIST, VOL. 48, NOVEMBER-DECEMBER, 1963

SYNTHETIC SOLID SOLUTIONS IN THE SYSTEMS $MgCO_3$-$FeCO_3$ AND $MnCO_3$-$FeCO_3$

P. E. Rosenberg, *Department of Geology, Washington State University, Pullman, Washington.*

Introduction

Complete series of solid solutions have long been predicted in the systems $MgCO_3$-$FeCO_3$ and $MnCO_3$-$FeCO_3$ on the basis of mineral analyses (Palache *et al.*, 1951) but experimental studies of these systems have not been reported in the literature. On theoretical grounds, considerable solid solubility might be expected, even at relatively low temperatures, since the ionic radii of divalent Mg, Mn, and Fe do not differ widely (Goldsmith, 1959). Subsolidus relations in the above binary systems were