Seven other minerals are found, either at the Great Hill locality, Cobalt, or at the Old Silver Mine. The list includes the following minerals, making a total of forty-five more or less rare minerals from the region, of which twenty-two have been found at the Strickland quarry.

| | | | |
|---|---|---|---|
| Chloanthite, | Galenite, | Arsenopyrite, | Chalcopyrite. |
| Niccolite, | Marcasite, | Löllingite, | |

## A STUDY OF THE CONSTITUTION OF THAUMASITE

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The empirical formula of thaumasite has been shown by several analyses to be $CaCO_3.CaSO_4.CaSiO_3.15H_2O$. Penfield and Pratt[1] considered the mineral a silicate, but Wherry[2] has shown it to be more probably a sulfate, crystallographically related to connellite and hanksite. He points out that at the West Paterson locality the thaumasite has been formed by the action upon anhydrite of solutions capable of depositing calcite and zeolites. Penfield and Pratt made a study of the rate of dehydration of the mineral, and concluded that it contained thirteen molecules of water and four hydroxyl groups. A later study of the dehydration curve by Merwin[3] indicated fourteen molecules of water and two hydroxyl groups. Wherry's interpretation fits in best with the latter.

This paper is an attempt to decide between these interpretations of the water content, by means of the theory of molecular refractivity, which affirms that the molecular refractivity of a compound is equal to the sum of that of its components.[4] While this theory was developed with especial reference to organic liquids, it also holds well for inorganic solids;[5] and altho the crystallinity and consequent anisotropism may affect its applicability slightly, the deviation is not enough to vitiate the results arrived at in a study such as the present one.

[1] Penfield, S. L., and Pratt, J. H.: *Am. J. Sci.*, (4), 1, 229, 1896.

[2] Wherry, E. T.: *Proc. U. S. Nat. Mus.*, **54**, 373, 1918.

[3] Merwin, H. E.: *J. Wash. Acad. Sci.*, 4, 494, 1914.

[4] The refractivities are preferably calculated by the Lorentz-Lorenz formula: $R=\frac{n^2-1}{n^2+2}\cdot\frac{M}{d}$, where n is the mean index of refraction, M the molecular weight, d the specific gravity, and R the molecular refractivity.

[5] Pope, W. J.: *J. Chem. Soc.*, **69**, 1530, 1896.

The molecular refractivities of $CaCO_3$, $CaSO_4$, $CaSiO_3$ and $H_2O$ were calculated from the observed specific gravity and mean refractive index (for sodium light) of calcite, anhydrite, wollastonite, and water. The calcite value was used in place of the slightly lower aragonite value because of the close association of thaumasite and calcite, which seems to indicate a relation in constitution, as far as the carbonate portion of the thaumasite molecule is concerned. Similarly the value for calcium metasilicate was used, since thaumasite is associated with zeolites, prevailingly metasilicates. For the molecular refractivities of hydroxyl, oxygen, and hydrogen, Eisenlohr's values[6] for sodium light were used. All these values are given in Table I, in which is included the molecular refractivity of thaumasite, as calculated from the mean of all published values for its specific gravity and refractive index.[7]

TABLE I

| Compound | Molecular weight | Specific gravity | Mean refractive index | Molecular refractivity |
|---|---|---|---|---|
| $CaSO_4$ | 136.13 | 2.96 | 1.586 | 15.43 |
| $CaCO_3$ | 100.07 | 2.72 | 1.601 | 12.60 |
| $CaSiO_3$ | 116.37 | 2.91 | 1.630 | 14.23 |
| $H_2O$ | 18.02 | 1.00 | 1.333 | 3.71 |
| Thaumasite | 622.81 | 1.87 | 1.496 | 97.29 |
| OH | according to Eisenlohr, 1912 | | | 2.63 |
| $O''$ | according to Eisenlohr, 1912 | | | 2.21 |
| $H'$ | according to Eisenlohr, 1912 | | | 1.10 |

Two hydroxyl groups replace one atom of oxygen, so that for purposes of calculating molecular refractivities the formulas may be respectively considered as:

$CaCO_3.CaSiO_3.CaSO_4$. less 2 O plus 4 $OH.13H_2O$ and

$CaCO_3.CaSiO_3.CaSO_4$ less 1 O plus 2 $OH.14H_2O$.

The proposed solution of the problem of the relative proportion of hydroxyl and of water rests on the fact that the molecular refractivity of water is 3.71, while the sum of the molecular refractivities of two hydroxyls less one oxygen, which replace the molecule of water in the above formulas, is 3.05, since the value for

[6] Eisenlohr, F.: *Spektrochem. Org. Verb.*, Stuttgart, 1912, p. 48.

[7] Specific gravity: 1.88 (Penfield), 1.877 (Lindström), 1.85 (Schaller); refractive indices: $\omega$ 1.503, $\epsilon$ 1.467 (Bertrand), 1.505 and 1.468 (Brown), 1.507 and 1.468 (Levy and Lacroix), 1.519 and 1.476 (Penfield).

oxygen varies according to its state of combination. Therefore, the values of the molecular refractivity, as given in Table II, for each of these constitutions, differ noticeably; and the calculated value which agrees most closely with the actual value for thaumasite, as given in Table I, represents the most probable constitution. The mean index of refraction, as calculated from these values of the molecular refractivity and the specific gravity of thaumasite by means of the Lorentz-Lorenz formula, are given in the third column, and, for the sake of comparison, corresponding values for a molecule with fifteen waters and no hydroxyl are given.

TABLE II

| Constitution | Calculated molecular refractivity | Calculated refractive index |
|---|---|---|
| $CaCO_3.CaSiO_3.CaSO_4.-2\ O+4\ OH.13H_2O$ | 96.59 | 1.492 |
| $CaCO_3.CaSiO_3.CaSO_4.-1\ O+2\ OH.14H_2O$ | 97.25 | 1.496 |
| $CaCO_3.CaSiO_3.CaSO_4.15H_2O$ | 97.91 | 1.500 |

The value of the refractive index calculated for the constitution with fourteen molecules of water agrees so closely with the observed mean value for thaumasite (1.496) as to strongly confirm Merwin's results, and incidentally also Wherry's interpretation of the mineral as a sulfate.

## BOOK REVIEW

DETERMINATIVE MINERALOGY. CHARLES H. WARREN. 163 pages. McGraw-Hill Book Co., New York, 1921.

The purpose for which this book has been published, as stated in the preface, is a very good one, namely to supply the student with a relatively inexpensive determinative text. Whether the additional requirement of its being a satisfactory one has been met the reviewer is not so certain. The plan of the book is the usual one, comprising a description of the use of the blowpipe, a list of tests for the elements, tabulated lists of special tests and a series of tables in which groups of minerals are eliminated one after another until the one under investigation is located.

The first chapter, on the blowpipe, is thoro and should be helpful to the student. Some may not like the style in places, especially in such arrangements of terms as "Decomposition of insoluble (in acids) minerals" (p. 14); the use of inches on some pages and centimeters on others; the calling of the ame thing interchangeably and without explanation a gypsum, plaster, or plaster of Paris tablet, and so on. The English is not always correct, as for example, "All white oxide sublimates are volatile in the R. F. although some (tin) is difficultly so." (p. 12.)