THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 7 JUNE, 1922 NO. 6

# BUSTAMITE FROM FRANKLIN FURNACE, NEW JERSEY[1]

ESPER S. LARSEN, *U. S. Geological Survey*,

AND

EARL V. SHANNON, *U. S. National Museum*

Recently a lot of some ten specimens of a material of unusual character from Franklin Furnace, N. J., was submitted to the National Museum for study by Ward's Natural Science Establishment of Rochester. This material contains several rare or new minerals but owing to their intimate intermixture it is being found exceedingly difficult to secure pure materials for analysis. The present paper is the first of several which will, in all probability be published on the basis of this material as the study of the minerals progresses.

The main bulk of the specimens consists of a pure white feldspar-like mineral which is probably albite although, owing to certain anomalous characters, it is but tentatively identified pending analysis. Scattered through this albite are resinous masses of brown garnet, coppery scales of biotite, and prismatic grains of the bustamite described below. In certain areas the feldspar is largely replaced by a fine granular aggregate which varies from white to bright blue in color and consists, as shown by optical study, of an intergrowth of several minerals at least one of which is an undescribed silicate containing lead. The bluest of this material was labeled cyprine but such preliminary examinations as have been made indicate that the blue and the white materials are identical.

The bustamite, which is moderately abundant in the specimens, is delicate pale pink in color but fades somewhat on exposure to light. It forms prismatic grains and masses reaching 1.5 cm.

[1] Published by permission of the Director of the U. S. Geological Survey and the Secretary of the Smithsonian Institution.

in maximum length although the average is very much less than this. Occasionally it contains included or intergrown garnet, biotite, and "cyprine." The luster is beautifully silky, like that of many specimens of wollastonite, which the mineral greatly resembles, and, owing to the perfection of the cleavages the mineral has a fibrous appearance.

Before the blowpipe the bustamite fuses at a moderately high temperature to a black glass. It is only partly decomposed by boiling with acids. A sample of material estimated by microscopic examination to be 99% pure was analyzed yielding the following results and ratios:

ANALYSIS AND RATIOS OF BUSTAMITE

| CONSTITUENT | PER CENT | RATIOS | | |
|---|---|---|---|---|
| $SiO_2$ | 48.44 | .8038 | 80.38 | 1.00×1 |
| FeO | .27 | .0017 | | |
| CaO | 25.20 | .4493 | | |
| MnO | 25.20 | .3553 | 82.89 | 1.03×1 |
| MgO | .65 | .0161 | | |
| ZnO | .53 | .0065 | | |
| Ignition | .34 | | | |
| Total | 100.63 | | | |

These ratios indicate that the mineral is essentially an anhydrous metasilicate of manganese and lime, these oxides, coincidentally, being in exactly equal percentages, although, owing to its lower atomic weight, lime is, molecularly, somewhat in excess of manganese, the ratio $CaSiO_3$:$MnSiO_3$ being approximately 4:3. On chemical grounds this may be regarded either as a calcium rhodonite or a manganese wollastonite. The mineral does not form euhedral crystals but the cleavages are sufficiently perfect that the cleavage fragments yield good signals and concordant measurements on the goniometer. There are cleavages in four directions in one zone corresponding to the planes *b*(010), *m*(110), M($1\bar{1}0$), and *a*(100) of rhodonite. In the following table are given the measurements obtained on four cleavage fragments. The average angles are compared with the theoretical angles for the same faces for rhodonite and with the angles given for pyroxmangite by Ford.[2] The best cleavage is that taken as *b*(010) to bring the angles

[2] Ford, Wm. E., *Am. Jour. Sci.*, 36, 169, 1913.

into the closest possible agreement with rhodonite. The luster on this cleavage is decidedly pearly. The cleavages *m*(110) and M(1$\bar{1}$0) are only slightly less perfect and also have pearly luster on the cleavage surfaces. The least perfect cleavage is that taken as *a*(100) which has vitreous luster.

CLEAVAGE MEASUREMENTS ON BUSTAMITE FROM FRANKLIN

| | rho=90° | phi= | | |
|---|---|---|---|---|
| | *b*(010) | *m*(110) | M(1$\bar{1}$0) | *a*(100) |
| Cleavage 1. | 0°05′ | 93°53′ | 45°06′ | 139°43′ |
| | 0 05 | 95 12 | 45 00 | 139 59 |
| Cleavage 2. | 0 00 | 94 51 | 44 45 | 139 45 |
| | .... | 94 53 | ...... | 140 21 |
| Cleavage 3. | 0 30 | 93 52 | 44 50 | 140 17 |
| | 0 31 | 94 41 | 44 56 | 139 14 |
| Cleavage 4. | 1 17 | 93 53 | 45 06 | 139 43 |
| | 0 00 | 95 12 | 45 00 | 139 59 |
| Average | 0 00 | 94 33 | 44 58 | 139 53 |
| Rhodonite | 0 00 | 94 26 | 45 53 | 138 21½ |
| Pyroxmangite | 0 00 | ..... | 45 14 | 137 14 |

Rhodonite is described as having cleavages parallel to *m*(110) and M(1$\bar{1}$0), with a less perfect cleavage parallel to *c*(001). No cleavages parallel to the pinacoids *b*(010) and *a*(100) have been reported. Several cleavage fragments from fowlerite crystals from Franklin were examined and found to show only the three cleavages reported for thodonite, no trace of the additional cleavages found in the bustamite being seen. The basal (001) cleavage was marked in the fowlerite while no trace of it could be found in the bustamite. A sample of bustamite from Schio-Vicentin, Italy, was not satisfactory for goniometric measurement of the cleavages as it was composed of slightly divergent prismatic fibers deformed by mutual interference and too small to yield good cleavage fragments. No trace of the basal cleavage could be detected in this or in fragments of pyroxmangite.

Although, as shown below, the bustamite is triclinic and not referable to wollastonite, which is monoclinic, very interesting results are obtained upon comparing the angles of the two. Thus when the bustamite is oriented so as to make the most perfect cleavage *c*(001), the least perfect cleavage remaining *a*(100), the other two perfect cleavages fall at the positions of *v*(101) and *t*($\bar{1}$01). Wollastonite is described as having cleavages parallel to *a*(100), *c*(001), and *t*($\bar{1}$01). No cleavage parallel to *v*(101) has been reported but measurement of a cleavage fragment of wollastonite from Natural Bridge, N. Y. (Cat. 48314), showed that cleavages *v*(101) and *t*($\bar{1}$01) were both equally developed. The angles are compared below:

Comparison of Angles of Bustamite and Wollastonite

| | phi = 90° Bustamite cleavage measured | rho = Wollastonite theory | Wollastonite cleavage measured |
|---|---|---|---|
| *c*(001) | 5°09′ | 5°30′ | 4°49′ |
| *a*(100) | 90 00 | 90 00 | 90 00 |
| *v*(101) | 45 09 | 45 33 | 44 40 |
| *t*($\bar{1}$01) | 39 49 | 39 35 | 40 18 |

Optical Properties: The mineral powders into fibers resembling those of wollastonite, and the microscope and goniometer show that there are several cleavages. Fragments lying on the best cleavage (110) show another cleavage, nearly as good, at about 90°, give extinction (Z) at about 12° to the trace of the second cleavage, and show the emergence of the acute bisectrix out of the field of the microscope across the length. Such fragments turned on the other cleavage at about 90° (1$\bar{1}$0), which is nearly as perfect as the first, give positive elongation and nearly parallel extinction and also show the emergence of the acute bisectrix out of the field across the length. Sections lying on a third less perfect cleavage (010) that bevels the edges of the other two show the emergence of the acute bisectrix just out of center and give no sharp extinction in white light, with extinction for yellow light (Z) to length 36°. Fragments lying on a fourth imperfect cleavage (100) in the same zone give nearly parallel extinction and positive elongation and show the emergence of Y near the center of the field.

The mineral is optically−, $2V = 44° \pm 3°$, dispersion $\rho < \nu$ slight, crossed dispersion considerable.

$\alpha = 1.662$; $\beta = 1.674$; $\gamma = 1.676$; all $\pm 0.003$.

Bustamite from Schio-Vicentin, Italy, kindly furnished the authors by Colonel Roebling, is in coarse fibers or columns associated with calcite. The fibers show two perfect but unequally developed cleavages parallel to the length of the fibers. Fragments lying on the most perfect cleavage give nearly parallel extinction, and most fragments show the emergence of an optic axis near the center of the field of the microscope. The plane of the optic axes is parallel to the length, and the acute bisectrix is just out of the field of the microscope. The axial angle is moderate. A few sections show inclined extinction and a small optic angle with the acute bisectrix just out of the field. Turned on the other cleavage, which is at about 90°, the fibers show strong birefringence, and X to the length is 39°. These sections commonly show polysynthetic twinning with symmetrical extinction and the composition plane about normal to the fragments and parallel to the elongation, probably in the plane of the more perfect cleavage. This mineral is optically+, 2V is variable and in most pieces is medium to medium large, $\rho<\nu$ is perceptible. The indices of refraction vary about 0.01, and the average values are:

$$\alpha=1.721 \qquad \beta=1.725 \qquad \gamma=1.736$$

These properties indicate only a moderate content of lime.

The properties of bustamite from Franklin Furnace are very different from those of fowlerite from Franklin Furnace, of rhodonite from Broken Hill[3] and of rhodonite, labelled bustamite, from Schio-Vicentin, Italy, as shown in the accompanying table.

OPTICAL PROPERTIES OF BUSTAMITE, RHODONITE, AND FOWLERITE

| | Bustamite Franklin Furnace | Rhodonite Schio-Vicentin, Italy | Rhodonite Broken Hill N. S. W. | Fowlerite Franklin Furnace |
|---|---|---|---|---|
| $\alpha$ | 1.662 | 1.721 | 1.733 | 1.726 |
| $\beta$ | 1.674 | 1.725 | 1.740 | 1.730 |
| $\gamma$ | 1.676 | 1.736 | 1.744 | 1.737 |
| $\gamma-\alpha$ | .014 | .015 | .011 | .011 |
| Opt. char. | — | + | — | + |
| 2V | 44° | med. large | medium | large |
| Dispersion | $\rho<\nu$ slight Crossed strong | $\rho<\nu$ perc. | $\rho<\nu$ weak | |
| Optical orientation | Z $\wedge$ zone of cleavage 36°. X nearly ⊥ imperfect cleavage | Y nearly ⊥ to second cleavage X $\wedge$ elong. about 39°. | | |

[3] Larsen, E. S., The Microscopic Determination of the Non-opaque Minerals, *U. S. Geol. Survey Bull.* **679**, 126-7, 1921.

A large cleavage piece of pale pink bustamite from Franklin Furnace kindly presented to the U. S. National Museum by Mr. R. B. Gage of Trenton, N. J., has the following optical properties:

Optically−, 2V medium. $\alpha=1.667$, $\beta=1.678$, $\gamma=1.680$.

Fragments lying on the most perfect cleavage show the emergence of X out of the field and give variable but small extinction angles. Several specimens from Franklin Furnace that superficially resembled the bustamite were examined microscopically and proved to have optical properties much like those of the fowlerite variety of rhodonite, though with somewhat lower indices of refraction.

CONCLUSION: The bustamite from Franklin Furnace is a triclinic pyroxene, related to rhodonite. Chemically it contains nearly equal molecular proportions of CaO and MnO with CaO in slight excess. In optical properties it differs considerably from rhodonite. Out of ten specimens of bustamite and rhodonite, mostly from Franklin Furnace, that have been examined optically, two had properties very near those of the analyzed bustamite, six had properties near those of fowlerite, a variety of rhodonite, while one had properties about midway between the rhodonite and bustamite. It, therefore, seems probable that bustamite is a subspecies of rhodonite with the approximate composition $CaO.MnO.2SiO_2$. Further work to finally determine this is desirable, and the authors would like to obtain samples of calciferous rhodonite and bustamite for optical study to determine to what extent replacement of MnO by CaO takes place in rhodonite.

## ALTERATION OF SILICATES BY SONSTADT'S SOLUTION

T. L. WALKER, *University of Toronto*

In the preparation of samples for analyses while engaged in an investigation of the zeolites of Nova Scotia, the writer learned that Sonstadt's mercuric potassic iodide solution may not be used either for separations or for specific gravity determinations in the case of some of the zeolites, owing to the readiness with which the minerals are changed by the substitution of potash for soda and lime, accompanied by a large loss of water and an increase in density.

The classic experiments of Lemberg[1] showed that alterations of this type are common when zeolites rich in lime or soda are

[1] Lemberg, *Zeit. deutsch. geol. Gesell.*, 28, 546.