# NEW DATA ON ROEBLINGITE[1]

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## INTRODUCTION

The mineral roeblingite has been reported from two localities: Franklin Furnace, New Jersey, and Langban, Sweden. The Franklin material was first described by Penfield and Foote (1897) as dense, white, compact masses of minute prismatic crystals associated with axinite, willemite, datolite, barite, arsenopyrite, sphalerite, titanite, rhodonite and rhodochrosite, in or near the limestone-granite contact.

During an extensive mineralogical investigation of the Langban minerals initiated in the late 1920's by G. Aminoff of the Natural History Museum, Stockholm, Sweden, a mineral similar in composition to roeblingite was discovered. A complete investigation of this new discovery demanded more reliable chemical data than was offered by Penfield and Foote. Therefore, R. Blix (1931) performed several chemical analyses on the Franklin roeblingite in an effort to remedy the difficulty encountered by Penfield and Foote in assigning a chemical formula. The chemical analyses from both sources are tabulated in Table I. Strunz (1957) reports the Langban roeblingite as possibly being orthorhombic with $a = 8.3$, $b = 13.1$, and $c = 12.65$ Å. However, some difficulty is encountered in obtaining a reasonable formula from the application of these parameters to the available chemical analyses.

## X-RAY ANALYSIS

A specimen from each of the localities was investigated by both powder diffraction and single crystal methods. This investigation confirmed that roeblingite found at Langban is structurally identical to the Franklin material. A list of indexed d-values for roeblingite is presented in Table II.

The space group as determined from precession and Weissenberg photographs is $Cc$ or $C2/c$, corresponding to the diffraction symmetry $2/mC-/c$. The unit cell has the parameters $a = 13.27 \pm 0.03$, $b = 8.38 \pm 0.02$, $c = 13.09 \pm 0.03$ Å, and $\beta = 103.86 \pm 0.1°$. These are the results of measurements made from Weissenberg and precession photographs of

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material from both localities. The parameters obtained for roeblingite from each locality were identical within the error of measurement. The parameters of Strunz ($a = 8.3$, $b = 13.1$, and $c = 12.65$ Å) apparently reflect the inaccuracy produced by assuming orthogonal geometry.

The lattice shows a pseudo-mirror plane approximately perpendicular to the $a$-axis. Consequently, an F-centered cell, closely related in dimensions to the C-centered cell, can be chosen with $a = 13.27 \pm 0.03$, $b = 8.38$

TABLE I. CHEMICAL ANALYSES AND CELL CONTENTS OF ROEBLINGITE
FROM FRANKLIN FURNACE, NEW JERSEY

Cell Volume $= 1,413$ Å³

| Oxide | Penfield & Foote (1897) | | | Blix (1931) | | |
|---|---|---|---|---|---|---|
| | Wt. % | Cations/ cell | Oxygen Atoms/ cell | Wt. % | Cations/ cell | Oxygen Atoms/ cell |
| $SiO_2$ | 23.58 | 11.47 | 22.94 | 23.57 | 11.47 | 22.94 |
| CaO | 25.95 | 13.52 | 13.52 | 23.12 | 12.04 | 12.04 |
| SrO | 1.40 | 0.39 | 0.39 | 2.79 | 0.79 | 0.79 |
| MnO | 2.48 | 1.02 | 1.02 | 2.49 | 1.03 | 1.03 |
| $Na_2O$ | 0.40 | 0.36 | 0.18 | — | — | — |
| $K_2O$ | 0.13 | 0.08 | 0.04 | — | — | — |
| $H_2O$ | 6.35 | 20.62 | 10.31 | 6.15(+105 ° C.) 0.45(−105° C.) | 18.96 | 9.98 |
| PbO | 31.03 | 4.06 | 4.06 | 30.04 | 3.93 | 3.93 |
| $SO_2$ | 9.00 | 4.11 | 8.22 | $10.81(SO_3)$ | 3.95 | 11.85 |
| $CO_2$ | — | — | — | 0.61 | 0.41 | 0.82 |
| | 100.32 | | 60.68 | 100.03 | | 63.38 |

S.G. $= 3.433$

$\pm 0.02$, $c = 2 \times 13.13 \pm 0.03$ Å, and $\beta = 104.56 \pm 0.1°$. The choice of axes for the C-centered cell defines the perfect cleavage as {001} and the imperfect cleavage as {100}.

## CHEMISTRY

$X$-ray fluorescence analyses were performed on samples of both Langban and Franklin roeblingite. The results indicated that the samples were chemically similar and contained all of the major elements listed in the analyses (Table I).

The number of cations and oxygen atoms per unit cell calculated from the analyses of Penfield and Foote (1897) and Blix (1931) is listed in

## MINERALOGICAL NOTES

TABLE II. X-RAY POWDER DIFFRACTION DATA OF ROEBLINGITE FROM
LANGBAN, SWEDEN AND FRANKLIN FURNACE, NEW JERSEY

$a = 13.27$ Å  Fe K$\alpha$
$b = 8.38$ Å  Mn filter
$c = 13.09$ Å  Intensity: visual estimate
$\beta = 103.86°$  $d_{cal}$ and indices: IBM 7090
  Camera diameter: 114.59 mm

| $d_{obs}$ (Å) | $d_{calc}$ (Å) | Relative Intensity | Indices | $d_{obs}$ (Å) | $d_{calc}$ (Å) | Relative Intensity | Indices |
|---|---|---|---|---|---|---|---|
| 7.2 | 6.996 | 20 | 011 | 2.44 | 2.432 | 40 | 015 |
| 6.4 | 6.441 | 50 | 200 | 2.38 | 2.389 | 60 | $\bar{3}24$ |
| | | | | | 2.379 | | $\bar{5}13$ |
| 6.2 | 6.332 | 40 | $\bar{1}02$ | 2.20 | 2.205 | 70 | $\bar{4}24$ |
| 5.1 | 5.187 | 30 | $\bar{2}02$ | | 2.200 | | $\bar{6}02$ |
| | | | | | 2.198 | | $\bar{4}15$ |
| 4.2 | 4.190 | 40 | 020 | | 2.194 | | 520 |
| 4.1 | 4.063 | 30 | 202 | 2.11 | 2.118 | 70 | 006 |
| | | | | | 2.110 | | $\bar{3}06$ |
| 4.0 | 3.984 | 20 | 120 | | 2.105 | | 233 |
| 3.9 | 3.896 | 20 | $\bar{3}11$ | 2.09 | 2.095 | 30 | 040 |
| 3.8 | 3.780 | 5 | 013 | 2.06 | 2.067 | 40 | 140 |
| | | | | | 2.066 | | $\bar{6}13$ |
| 3.6 | 3.615 | 10 | $\bar{2}13$ | 1.94 | 1.944 | 40 | 142 |
| 3.5 | 3.462 | 10 | 311 | | 1.942 | | $\bar{2}42$ |
| | | | | | 1.934 | | 315 |
| 3.4 | 3.434 | 40 | 113 | | 1.930 | | $\bar{1}26$ |
| 3.2 | 3.198 | 70 | $\bar{4}02$ | 1.90 | 1.910 | 40 | 620 |
| | 3.196 | | $\bar{3}13$ | | 1.909 | | $\bar{1}35$ |
| 3.1 | 3.166 | 80 | $\bar{2}04$ | | 1.900 | | 602 |
| | | | | | 1.897 | | $\bar{2}35$ |
| 3.0 | 2.999 | 90 | 320 | 1.84 | 1.846 | 30 | $\bar{3}35$ |
| | 2.993 | | 213 | | 1.841 | | $\bar{7}11$ |
| 2.94 | 2.926 | 100 | 104 | | 1.840 | | $\bar{7}00$ |
| 2.92 | 2.917 | 50 | 222 | 1.81 | 1.817 | 30 | $\bar{6}24$ |
| 2.88 | 2.909 | 70 | $\bar{3}04$ | | 1.816 | | $\bar{1}17$ |
| | 2.906 | | $\bar{3}22$ | | 1.815 | | 126 |
| 2.71 | 2.728 | 5 | 031 | | 1.815 | | 135 |
| | | | | | 1.814 | | $\bar{7}13$ |
| 2.68 | 2.697 | 5 | $\bar{1}31$ | | 1.807 | | $\bar{4}26$ |
| 2.53 | 2.542 | 70 | $\bar{4}22$ | 1.797 | 1.801 | 30 | 504 |
| | 2.531 | | 024 | | 1.794 | | $\bar{3}17$ |
| | 2.528 | | $\bar{5}11$ | | 1.789 | | $\bar{7}04$ |
| | 2.526 | | $\bar{2}24$ | 1.640 | 1.645 | 30 | $\bar{7}24$ |
| 2.49 | 2.496 | 5 | $\bar{1}15$ | | 1.641 | | 151 |
| | | | | | 1.638 | | 442 |
| | | | | | 1.636 | | $\bar{2}08$ |

Table I. The density used in these calculations was that of Penfield and Foote (1897). The space groups $Cc$ and $C2/c$ have equipoints of ranks 4 and 8. Both analyses, although yielding different numbers of oxygen atoms per unit cell, satisfy the requirements of the equipoint ranks. However, the data of Penfield and Foote are more complete and conform more closely to the cation requirements of the equipoint ranks than do the data of Blix and are therefore preferred. Blix claims to have analysed for the alkali metals but fails to report their percentages. This omission accounts for much of the non-conformity of his analysis.

In an effort to determine the structural role of the hydrogen atoms, a sample of roeblingite was analysed for loss of volatiles in a Bendix Time of Flight mass spectrometer. In this instrument, samples are heated at a uniform rate (6° C./min.) while being subjected to an ultra-high vacuum ($P_{H_2O} = 5 \times 10^{-6}$ mm Hg). Volatile reaction products are ionized, separated into groups of ions of the same mass by a fixed potential, and displayed by the instrument in the form of a "spectrum" of atomic masses. Thus, the operator is provided with the temperature of the reaction, the characteristics of the reaction, and the composition of the volatilized products.

The loss of water vapor from roeblingite began at 40° C. and continued to 300° C., in what appeared to be one continuous reaction. This indicates that all of the hydrogen ions may be of the same type. However, the temperature at which roeblingite begins to lose water is characteristic of the loss of water from both minerals with water of hydration and minerals with loosely bound hydroxyl ions. Consequently, only a tentative formula, $(Pb_4S_4O_{16})R_{16}Si_{12}O_{44}H_{20}$, where $R =$ Ca, Mn, Sr, Na, and K, based on the analysis of Penfield and Foote (1897), can be assigned to roeblingite. The determination of the role of the hydrogen ions must await structure analysis.

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## HOLLOW CHRYSOTILE FIBERS

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### INTRODUCTION

The "hollow tube" theory for chrysotile was established when Turke-
vich and Hiller (1949) published electron micrographs indicating that
single fibers were hollow tubes. This theory was further substantiated by
the work of Noll *et al.* (1958), Huggins (1962), Zussman and Brindley
(1957), Bates *et al.* (1950), Maser *et al.* (1960), and others. Conversely,
Pundsack (1956, 1961), and Kalousek and Muttart (1957), concluded
that the density of chrysotile blocks was incompatible with either tubular
or solid cylinders. More recently, Whittaker (1963) and Bates (1958)
have hypothesized that chrysotile fibers are filled with amorphous or
partially oriented material and that this accounts for the lack of voids in
the fibers. The recent publication by Huggins and Shell (1965) on density
of bulk chrysotile and massive serpentine shows that the density of
Arizona and African chrysotile is compatible with tubular structure, and
that Canadian chrysotile, which has a higher density, has at least 50 per
cent unfilled tubes.