

Roebblingite: new chemical data

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ABSTRACT. New chemical analyses of roebblingite from Franklin, New Jersey, and Långban, Sweden, are presented. The average composition of Franklin roebblingite is SiO_2 24.9, CaO 23.8, SrO 2.4, MnO 2.4, PbO 30.2, SO_3 10.4, H_2O 6.13%, Sum = 100.23%. The data support space group $C2/m$ and suggest the formula is $(\text{Ca,Sr})_{12}(\text{Mn,Ca})_2\text{Pb}_4(\text{SO}_4)_4\text{Si}_{12}\text{O}_{28}(\text{OH})_{20}$, if there is ordering on the site of rank 2.

ROEBBLINGITE was first described from Franklin, New Jersey, by Penfield and Foote (1897). It was among the first of the lead silicate minerals found at Franklin, many of which are known only from there and from Långban, Varmland, Sweden.

The chemical composition of roebblingite has long been the subject of some confusion. The original analysis of Penfield and Foote (1897) reported the presence of sulphite in roebblingite, but a later analysis by Blix (1931) demonstrated that the S in roebblingite is present as sulphate. His procedures are well detailed and the reader is referred to his paper for details. The original formula proposed by Penfield and Foote was $\text{H}_{10}\text{Ca}_7\text{Pb}_2\text{Si}_5\text{S}_2\text{O}_{28}$; Blix (1931) proposed $2\text{PbSO}_4\text{R}_7\text{H}_{10}\text{Si}_6\text{O}_{24}$ where R = Ca, Sr, and Mn. Subsequent study by Foit (1966) established the unit cell parameters for roebblingite and presented a tentative formula of $(\text{Pb}_4\text{S}_2\text{O}_{16})\text{R}_{16}\text{Si}_{12}\text{O}_{44}\text{H}_{20}$ with R = Ca, Mn, Sr, Na, and K. Our results, given here, indicate eighteen divalent cations instead of the twenty proposed by Foit (1966), and confirm the data of Blix (1931).

Optical properties. The Franklin roebblingite occurs as nodular masses, usually not exceeding 10 cm in diameter, and composed of very fine-grained aggregates of lath-like crystals. Unlike this massive Franklin material, Långban roebblingite occurs as colourless prismatic crystals in parallel growth and suitable for the measurement of optical

properties. Crystals from analysed sample no. B17051 are biaxial (+) with refractive indices $\alpha = 1.654(1)$, $\beta = 1.660(1)$, and $\gamma = 1.678(1)$. The optic axial angle was measured directly using a spindle stage and is $2V_\gamma = 61(2)^\circ$, in good agreement with the calculated value of 61° . The plane of the cleavage contains α and β . Dispersion of the optic axes is slight with $r < v$. There is no pleochroism. Calculation of specific refractive energy for roebblingite using the constants of Mandarino (1976) yield $K_C = 0.189$ and $K_P = 0.190$, providing excellent compatibility of the data using the compatibility index of Mandarino (1979).

Chemistry. All samples studied herein are from the Smithsonian collection and were chemically analysed using an ARL-SEM electron microprobe with an operating voltage of 15 kV and a beam current of 0.15 μA . The standards used for analysis were PbO for Pb, manganite for Mn, hornblende for Ca and Si, and celestine for Sr and S. The data were corrected using a modified version of the MAGIC-4 computer program. Total water was determined using the Penfield method; H_2O^- was determined as loss at 110°C . Additional water analyses of otherwise unanalysed samples yielded 6.01 H_2O^+ , 0.44 H_2O^- %, and 5.96 H_2O^+ , 0.37 H_2O^- %, confirming the given water content of sample R18452 in Table I.

The analysis by Blix (1931) agrees closely with those of this study. The Franklin roebblingites are slightly enriched in strontium, but Sr is much lower in the Långban sample. Penfield and Foote (1897) reported the presence of sodium and potassium, but these were not found by Blix (1931) and are not present in the samples we studied. Ba, P, and Zn were sought but not found.

Discussion. Calculation of unit cell contents for Långban roebblingite (analysis 5) using the unit cell

TABLE I. Chemical analyses of roeblingite

	SiO ₂	CaO	SrO	MnO	PbO	SO ₃	H ₂ O ⁺	H ₂ O ⁻	Total	NMNH no.	Locality
A.	23.58	25.95	1.40	2.48	31.03	9.00*	6.35	—	100.32**		Franklin, NJ
B.	23.57	23.12	2.79	2.49	30.04	10.81	6.15	0.45	100.03***		Franklin, NJ
1.	25.2	23.7	2.3	2.8	30.2	10.5	6.04†	0.18	100.92	R124-1	Franklin, NJ
2.	24.7	24.5	2.6	1.5	30.7	10.5	6.13††	—	100.63	C6402	Franklin, NJ
3.	24.6	22.9	2.4	3.4	30.4	10.4	6.13††	—	100.23	R3996	Franklin, NJ
4.	25.0	24.2	2.2	2.0	29.6	10.2	6.13††	—	99.33	R18452	Franklin, NJ
5.	24.6	22.6	0.7	4.4	30.7	10.6	6.13††	—	99.73	B17051	Långban, Sweden
	24.9	23.8	2.4	2.4	30.2	10.4	6.13††	—	100.23	Average of analyses 1-4	
	24.63	22.98	—	4.84	30.48	10.94	6.13	—	100.00	Theory†††	

* Originally given as SO₂. ** Included 0.40% Na₂O, 0.13% K₂O. *** Included 0.61% CO₂. † Water determined by Penfield method. †† Water taken from theoretical composition. ††† Theory for Mn₂Ca₁₂Pb₄(SO₄)₄Si₁₂O₂₈(OH)₂₀. A—analysis from Penfield and Foote (1897). B—analysis from Blix (1931). Accuracy of data: ± 3% of the amount present.

parameters of Foit (1966) ($a = 13.27$, $b = 8.38$, $c = 13.09 \text{ \AA}$, $\beta = 103.86(10)^\circ$) and a newly determined density of 3.50 g/cm³ yields: (Ca_{12.00}Sr_{0.20}Mn_{1.84}Pb_{4.09})_{218.13}(SO₄)_{3.94}Si_{12.19}O_{28.57}(OH)₂₀. The sum of divalent cations approximates eighteen which, although inconsistent with the space groups *Cc* or *C2/c* (Foit, 1966), which require equipoint ranks of four and eight, is consistent with the space group *C2/m* reported by Welin (1968) from an unpublished study by Moore (1967). The near constancy of Pb in all analyses suggests little or no solid solution of other ions with Pb. Mn is present in all roeblingite analyses and approximates two atoms in Långban material, which suggests that Mn may be essential to roeblingite and ordered in the site of rank 2. Comparison of the average of the Franklin analyses with the Långban analysis (Table I) shows inverse variation of Mn and Sr, but the substitution of these two is unlikely because of the substantial difference in their atomic radii. Based on these considerations, we suggest that roeblingite has the formula (Ca,Sr)₁₂(Mn,Ca)₂Pb₄(SO₄)₄Si₁₂O₂₈(OH)₂₀ with space group *C2/m*,

and $Z = 1$, but this can be proven only by a complete crystal structure determination. In addition, it is noteworthy that both Franklin and Långban have barysilite among the lead silicates, indicating that conditions were conducive to the formation of compound silicates of Pb and Mn.

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