

## Rowlandite from the Barringer Hill rare-earth pegmatite district, Llano and Burnet Counties, Texas

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### Abstract

Rowlandite, a rare metamict yttrium silicate, occurs commonly in nine of the twelve pegmatites in the Barringer Hill rare-earth pegmatite district as irregular masses (0.5–1 cm) with gadolinite and yttrialite. The rowlandite is either glassy, translucent, and bottle-green ( $n = 1.725 \pm 0.003$ ), or a vitreous scarlet color ( $n = 1.675 \pm 0.003$ ).  $G = 4.41$ – $4.52$ .

Heating at  $900^\circ\text{C}$  for 1 hour in air results in the crystallization of a phase assemblage similar to that of yttrialite heated under the same conditions, low-temperature  $\gamma$ -yttrialite being the most prominent phase. The calculated formula based on  $\text{RE}_3(\text{SiO}_4)_2(\text{F},\text{OH})$  is  $(\text{Y}_{1.328}\text{RE}_{0.895}\text{Fe}_{0.281}\text{Mn}_{0.105}\text{Mg}_{0.015}\text{Ca}_{0.040}\text{Na}_{0.028}\text{K}_{0.008}\text{Th}_{0.026})(\text{Si}_{2.215}\text{Al}_{0.007}\text{O}_{7.788})(\text{F}_{0.673}\text{Cl}_{0.007}\text{OH}_{0.317})$ .

### Introduction

Rowlandite was first described from the Barringer Hill pegmatite, Llano County, Texas (Hidden, 1891; Hidden and Hillebrand, 1893). Frondel (1961) published an X-ray study and a partial chemical analysis of a Barringer Hill rowlandite. Although once unique to the Barringer Hill locality, rowlandite has been found as a common mineral in nine of the district's twelve pegmatites (Crook, 1977). No positive identification of rowlandite has been reported from outside the Barringer Hill district, although Krivokoneva *et al.* (1974) reported metamict and crystalline forms of a chemically similar rare-earth fluorosilicate.

Material from this study has been deposited in the collections of the Department of Geology and Mineralogy, The University of Michigan.

### Physical properties

Rowlandite occurs in irregular masses (0.5–1 cm) with gadolinite and yttrialite. Where fresh, rowlandite has a distinctive glassy translucent bottle-green color; however, its most typical occurrence is as a translucent to vitreous scarlet glass. Many fragments contain numerous inclusions and brown cloudy patches that microprobe analysis shows to be ilmenite. For fresh unaltered green fragments,  $n = 1.725 \pm 0.003$ ; for red altered fragments,  $n = 1.675 \pm 0.003$ . Rowlandite is completely devoid of crystal form, has a well-developed conchoidal fracture, a hardness of approximately 6 (less with alteration), and a specific gravity (meas) from 4.41 to 4.52.

### Annealing and X-ray diffraction analysis

X-ray data on annealed specimens (Table 1) were determined for four rowlandites from Barringer Hill (NMNH #C3096, R3784, 95368, 83324) and two rowlandites from Clear Creek, Burnet County. The

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annealing treatment of the completely metamict rowlandite was a standard one-hour heating at 900°C in a vertical tube furnace in air. Temperature was measured continuously by a thermocouple placed immediately above the sample in a platinum crucible.

Rowlandite did not anneal readily and single-crystal analysis was not attempted on any of the material. The X-ray powder diffraction data reflect the presence of a combination of recrystallized phases, the  $\gamma$ -phase yttrialite (Ito and Johnson, 1968; Lima-de-Faria, 1964) being the most prominent. Variations in composition as well as the temperature of recrystallization can have significant effects on the X-ray diffraction pattern (Krivokoneva *et al.*, 1974). The similarity between the X-ray diffraction patterns of rowlandite and yttrialite heated under identical conditions suggests only that the phase assemblages that result from recrystallization are similar, not that the rowlandite and yttrialite structures are similar. Vlasov (1966, p. 243–246) lists rowlandite as monoclinic and as a variety of thalenite. The annealing study does not confirm the proposed monoclinic structure.

Differential thermal analysis of rowlandite (NMMNH #R3784 and 95368) revealed broad endothermic peaks between 200° and 300°C due to variable water of hydration, and an exothermic peak at 870°.

### Chemical analysis

Electron microprobe analyses (Table 2) of rowlandite were conducted with 150 nA specimen current and 15 kV excitation voltage (10 kV for fluorine and chlorine). Analyzed specimens of gadolinite and yttrialite (Rode Ranch pegmatite, Texas) and synthetic rare-earth salts were used as electron microprobe standards. To allow for the fewest possible interferences, specific  $L_{\alpha 1}$ ,  $L_{\beta 1}$ , and  $K_{\alpha 1}$  lines were used following the method of Siivola (1975). Iron is assumed to be present as  $Fe^{3+}$ . Water was measured by weight loss on ignition minus the analyzed fluorine content. Corrections for microprobe data were calculated using Rucklidge's EMPADR VII program (J. Rucklidge and E. L. Gasparrini, Department of Geology, University of Toronto, written communication, 1969). Analyses of rowlandite, either the green or red material, yield a calculated formula of  $(Y_{1.329}RE_{0.895}Fe_{0.281}Mg_{0.015}Mn_{0.105}Ca_{0.040}Na_{0.026}K_{0.008}Th_{0.026})(Si_{2.215}Al_{0.007}O_{7.788})(F_{0.673}Cl_{0.007}OH_{0.317})$  based on 8 oxygens and one fluorine. The ideal formula for rowlandite is thus  $(Y,RE,Fe,Mn)_3(SiO_4)_2(F,OH)$ . These analyses agree with previous reported values for Barringer Hill rowlandite and confirm rowlandite

Table 1. X-ray data for annealed rowlandite

1		2	
d(obs)	I	d(obs)	I
4.93	10	4.85	70
*4.67	20	--	--
*4.04	20	--	--
3.62	10	3.64	10
*3.48	20	3.52	60
--	--	3.24	5
*3.19	10	--	--
*3.06	100	3.05	100
* --	--	2.99	20
2.90	5	2.90	30
*2.78	20	2.78	20
*2.70	10	--	--
2.64	20	2.631	40
2.44	5	2.440	30
*2.39	20	--	--
*2.06	20	2.071	10
*2.02	20	--	--
1.92	5	1.923	5
*1.83	5	1.800	5
*1.75	5	1.738	20
*1.60	5	--	--
*1.54	10	--	--

1: Rowlandite, Barringer Hill (USNM #3096, 3784, 9538, 83324)  
2: Rowlandite, Clear Creek

\* $Y-Y_2Si_2O_7$  (Ito and Johnson, 1968)

Samples were heated at 900°C for 1 hour in air; CuK-alpha radiation; intensities visually estimated; diffraction data collected with diffractometer and Debye-Scherrer camera (114.6 mm).

to be a rare-earth fluor-orthosilicate. This is not consistent with the formulae proposed by Krivokoneva *et al.* (1974).

### Occurrence

The definition of rowlandite as a primary species remains problematic. Hidden (1891), in the original description, primarily discussed the bottle-green variety and its relationship to both gadolinite and yttrialite. The material used in defining the species was sorted from previously-mined material, and the paragenetic relationship was lost. Rowlandite found by one of the authors (WWC) is apparently secondary after gadolinite and yttrialite and is not a primary phase. When green and red rowlandite occur together, the reddish material is clearly an alteration of the green, although they are chemically indistinguishable. No secondary minerals other than

Table 2. Chemical analyses of rowlandite

	1	2		1	2
CaO	0.44	0.33	Y <sub>2</sub> O <sub>3</sub>	29.44	26.18
MnO	0.83	0.76	La <sub>2</sub> O <sub>3</sub>	0.33	0.21
MgO	0.21	0.36	Ce <sub>2</sub> O <sub>3</sub>	3.17	3.24
Na <sub>2</sub> O	0.16	0.11	Pr <sub>2</sub> O <sub>3</sub>	0.39	0.36
K <sub>2</sub> O	0.08	0.10	Nd <sub>2</sub> O <sub>3</sub>	1.65	1.44
Fe <sub>2</sub> O <sub>3</sub>	3.96	4.12	Sm <sub>2</sub> O <sub>3</sub>	2.62	2.09
Al <sub>2</sub> O <sub>3</sub>	0.07	0.39	Gd <sub>2</sub> O <sub>3</sub>	4.51	4.69
SiO <sub>2</sub>	26.12	25.79	Tb <sub>2</sub> O <sub>3</sub>	1.32	1.35
PbO	trace	-	Ho <sub>2</sub> O <sub>3</sub>	0.86	0.93
U <sub>3</sub> O <sub>8</sub>	trace	trace	Er <sub>2</sub> O <sub>3</sub>	6.16	6.24
ThO <sub>2</sub>	1.34	2.69	Tm <sub>2</sub> O <sub>3</sub>	0.48	0.66
MoO <sub>3</sub>	trace	-	Yb <sub>2</sub> O <sub>3</sub>	5.87	6.01
RE <sub>2</sub> O <sub>3</sub>	62.61	60.32	Lu <sub>2</sub> O <sub>3</sub>	0.73	1.14
F	4.62	4.78	Dy <sub>2</sub> O <sub>3</sub>	5.08	5.78
Cl	0.07	0.19			
H <sub>2</sub> O	0.56	0.63			
TOTAL	101.07	100.57			
less O for F and Cl	1.96	2.06			
	99.11	98.51			

1: Rowlandite (green), Barringer Hill (USNM 83324)

2: Rowlandite (red), Clear Creek

\*H<sub>2</sub>O measured by loss on ignition.

rowlandite were found on any of the primary minerals below a depth of 1.5 meters at the Rode Ranch pegmatite. Observations at other pegmatites in the district also showed that extensive alteration (super-gene mineralization) was restricted to the surface horizon. Thus rowlandite appears to be a first-stage alteration product of the rare-earth minerals gadolinite and yttrilite which when exposed to surface weathering forms tenerite, behoite, and hematite.

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