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Yttromicrolite, a new mineral, and a redefinition of hjelmite

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Abstract

X-ray diffraction data for non-metamict hjelmite from Falun, Sweden, shows it to be cubic, space group $Fd3m$, $a = 10.179(1)$A, $V = 1054.7$A^3. The mineral is isotropic with a variable index of refraction, $n = 2.26(2)$–$2.34(2)$. The strongest lines in the X-ray diffraction pattern are 5.87(1) (111), 3.070(2) (311), 2.939(10) (222), 2.542(1) (400), 1.534(6) (622), 1.470(5) (444), and 1.167(3) (662). The calculated formula based on $A_{2-m}B_2O_6(O,OH,F)_{1-n}\cdot pH_2O$ is $(Y_{0.431}RE_{0.251}Ca_{0.251}Mn_{0.123}Mg_{0.062}U_{0.052}Pb_{0.021}Th_{0.013})(Ta_{1.036}Nb_{0.661}Fe_{0.141}Sn_{0.131}Ti_{0.028}W_{0.003})O_{6.000}(O_{0.072}OH_{0.934})$. X-ray, optical, and chemical analyses show that hjelmite is the tantalum analogue of yttropyrochlore, and in accordance with the IMA classification scheme for the pyrochlore group it has been renamed yttromicrolite.

Introduction

Hjelmite was first described from Falun, Sweden by Nordenskiöld (1860) who considered it, on the basis of morphological data, to be a dubious species, possibly related to tapiolite or samarskite. Weibull (1887), on rough crystals, determined that the mineral was pseudo-tetragonal, and thus related to tapiolite. Berman (in Palache *et al.*, 1944, p. 780) obtained an X-ray powder photograph of material labeled hjelmite from Stripåsen, Sweden, and found it to be similar to microlite. Mathias (1961) X-rayed supposed hjelmite from Norway and found it to be a mixture of pyrochlore plus tapiolite plus an unknown phase; this interpretation has been accepted in recent reference works. Poor analytical work and conflicting X-ray data on non-type material have left the mineral ill-defined. Additional data on hjelmite have not been obtained due to the scarcity of material and the dubious status attached to it because of inadequate previous research.

Recently I received some samples of hjelmite from the Kårarfvet Mine, near Falun, Sweden. The material was subjected to microprobe and X-ray analysis and found to be the tantalum equivalent of yttropyrochlore. In accordance with the IMA classification of the pyrochlore group (Hogarth, 1977), the mineral has been renamed yttromicrolite, and the name hjelmite dropped. The mineral, the name, and the discrediture have been approved by the Commission on New Minerals and Mineral Names, IMA. Type material has been deposited in the Smithsonian Institution (NMNH #144190).

Occurrence

In October 1977, I obtained several small crystals of hjelmite-labeled material from the type locality, a granite pegmatite near the Kårarfvet Mine, Falun, Sweden. Associated minerals in the pegmatite include allanite, gadolinite, tantalite, albite, muscovite, garnet, microcline, and quartz. Yttromicrolite is found within the replacement unit of the pegmatite intimately associated with albite, muscovite, and quartz. Four crystal fragments were found, megascopically distinguishable from gadolinite and allanite by their crystal shape and their lack of exterior alteration material.

Physical properties

Yttromicrolite occurs as 0.1–1mm dense masses and octahedral single crystals with observed forms {111}, {001}, {010}, and rarely {210}. Fracture is granular to subconchoidal, and there is no observable cleavage. The color is black, but a faint green-black color is observed in thin fragments. The streak is greenish-black. Hardness is 5–5½. Measured density is 5.565(5)–6.412(5), variable due to the degree of metamictization; 6.530 (calc). The octahedral habit is similar to all members of the pyrochlore group.

The mineral is isotropic, but may show a weak anomalous birefringence in non-metamict material.

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Table 1. X-ray powder data for yttromicrolite

d_{obs}	d_{calc}	hkl	I
5.87	5.877	111	10
3.070	3.069	311	20
2.939	2.938	222	100
2.542	2.545	400	10
1.960	1.959	333	5
		511	
1.800	1.799	440	5
1.534	1.534	622	60
1.470	1.469	444	50
1.167	1.168	662	30
1.040	1.039	844	5

Phillips-Norelco diffractometer, CuKα radiation. Intensities visually estimated.

In the birefringent material, amber, pale brown to brown zonal colors are typically present. The index of refraction is extremely variable, decreasing with increasing hydration due to metamictization; n(meas in S–Se melts) = 2.26(2)–2.34(2).

Table 2. Chemical analysis of yttromicrolite

CaO	2.77	RE_2O_3	
MgO	0.49	Y_2O_3	9.46
MnO	1.73	La_2O_3	0.29
PbO	0.88	Ce_2O_3	0.43
ThO_2	0.64	Pr_2O_3	0.13
U_3O_8	4.53	Nd_2O_3	0.67
RE_2O_3	18.42	Sm_2O_3	0.75
Fe_2O_3	2.18	Gd_2O_3	1.98
Ta_2O_5	44.52	Tb_2O_3	0.31
Nb_2O_5	17.10	Dy_2O_3	1.12
SnO_2	3.81	Ho_2O_3	0.45
TiO_2	0.43	Er_2O_3	0.89
WO_3	0.19	Tm_2O_3	0.38
H_2O^*	1.64	Yb_2O_3	0.92
TOTAL	99.33	Lu_2O_3	0.64
		TOTAL	18.42

Specimen from the Kårarfvet Mine, Falun, Sweden. Microprobe standards used: analyzed gadolinite-(Y), analyzed yttrialite, Nb, Ta, and W metals, analyzed ilmenite, and analyzed cassiterite.
*H_2O measured by weight loss on ignition.

X-ray crystallography

Single crystals were studied using oscillating crystal, Weissenberg, and precession methods. The unit-cell parameter from a least-squares refinement is a = 10.179(1)A, V = 1054.7A^3. Extinctions observed were: $\{hkl\}$, $h + k = 2n$, $h + l = 2n$, $k + l = 2n$; $\{0kl\}$, $k + l = 4n$. The space group is $Fd3m$. Powder data from a Philips diffractometer (Table 1) were indexed using the refined lattice parameter from the single-crystal study. Data of heated metamict material (1100°C for 12 hours) are essentially the same.

The space group, $Fd3m$, is consistent with members of the pyrochlore group. The refined cell edge (10.179A) is within the reported range of member species (10.00–10.57A) and is very close to yttropyrochlore (10.17A).

Chemical analysis

An electron microprobe analysis (Table 2) was used in the characterization of yttromicrolite. Analyses were conducted with 150 nA specimen current and 15 kV excitation voltage. Water was measured by weight loss on ignition and confirmed as being present only as $H_2O(+)$ by both DTA and TGA. Tests for fluorine, chlorine, zirconium, and aluminum were negative. Corrections were made using Rucklidge's EMPADR VII program (J. Rucklidge and E. L. Gasparrini, Department of Geology, University of Toronto, written communication, 1969).

The electron microprobe analysis was normalized on the basis of Ta+Nb+Fe^{3+}+Sn+Ti+W = 2, consistent with the pyrochlore group. There is considerable substitution in the analyzed non-metamict material (Table 2), and the calculated empirical formula is $(Y_{0.431}RE_{0.251}Ca_{0.251}Mn_{0.123}Mg_{0.062}U_{0.082}Pb_{0.021}Th_{0.013})(Ta_{1.036}Nb_{0.661}Fe^{3+}_{0.141}Sn_{0.131}Ti_{0.028}W_{0.003})O_{6.000}(O_{0.072}OH_{0.934})$. Thus the formula is ideally $A_{2-m}B_2O_6(O,OH,F)_{1-n}$ with A = Y,RE,Ca,Mn,Mg,U,Pb,Th; B = Ta,Nb,Fe^{3+},Sn,Ti, and W. Analysis of metamict yttromicrolite yields a similar formula unit with slight decreases in total rare earths and ferric iron and increases in calcium and $H_2O(-)$ content.

Discussion

The pyrochlore group comprises a series of cubic multiple oxides having the following characteristics (Hogarth, 1977):

(a) essential amounts of Nb, Ta, and Ti, either individually or in combination;

(b) space group $Fd3m$;

(c) the pyrochlore type structure;

(d) the general formula $A_{2-m}B_2O_6$ $(O,OH,F)_{1-n}$.

pH_2O. Three major subgroups exist, pyrochlore–microlite–betafite, depending on the atomic proportions of the B atoms, Nb, Ta, and Ti. Further subdivisions are then made within each subgroup depending upon the composition of the A site.

The composition of hjelmite falls within the microlite subgroup. Yttrium and the ΣY heavy lanthanides are the dominant atoms in the A site, comprising approximately 50 mole percent of the site. Atoms representing 20 mole percent or more of the A site within the pyrochlore group qualify a mineral for separate-species status; thus hjelmite is the yttrium member of the microlite subgroup. The name yttromicrolite is used in accordance with the chemical nomenclature for the pyrochlore group.

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