Fluorthalénite-(Y) from Hundholmen, Tysfjord, north Norway

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Introduction

The yttrium silicate thalénite was described as a new mineral from a granitic pegmatite at Österby, Dalarne, Sweden. The first report (Benedicks 1898) is in fact an extended abstract of a lecture, followed shortly by a formal description (Benedicks 1899). A second find, from the Åskagen granitic pegmatite, Värmland, Sweden, was announced by Sjögren (1906).

The first mention of thalénite from Norway is restricted to a lecture title by Vogt (1913): "Om Thalénit" (foredraget vil bli trykt) ["On thalénite" (the lecture will be published)]. It was not until nine years later that a description of thalénite from the granitic pegmatite at Hundholmen, Tysfjord, was published by Vogt (1922).

For a long time considered to have the chemical formula $Y_2Si_2O_7$, a crystal structure determination of thalénite from "the northwestern rare-earth belt of the USSR" by Kornev et al. (1972) established the correct formula to be $Y_3Si_3O_{10}(OH)$. The structure contains isolated 'triortho' Si_3O_{10} groups consisting of three corner-sharing SiO_4 tetrahedra. Seven- and eight-coordinated Y polyhedra sharing edges and corners are connected into a framework by the Si_3O_{10} groups.

The chemical composition of two thalénites from amazonite pegmatites of the Kola Peninsula was published by Voloshin et al. (1985), revealing 3.39 and 3.76 wt.% F. The analytical data correspond closely to the idealized formula $Y_3Si_3O_{10}F$. Yakubovich et al. (1988) solved the structure of thalénite from the Kola Peninsula and found that F occupies an independent anion site. Consequently, the Kola mineral is the fluorine analogue of thalénite, a distinct new species (Miyawaki & Nakai 1989, Puziewicz 1990). Fluorthalénite-(Y) was subsequently described as a new mineral by Voloshin & Pakhomovskii (1997), from Ploskaya Mountain, Kola Peninsula. The use of suffixes in thalénite-(Y) and fluorthalénite-(Y) is dictated by the Levinson nomenclature for REE-bearing minerals, and this convention is followed in the text below.

Alleged thalénite-(Y) from Hundholmen

Vogt's (1922) description of thalénite-(Y) from Hundholmen is focused on optical data and crystal morphology. Unfortunately, only an incomplete analysis of the mineral, performed on material slightly contaminated with allanite, was presented: SiO_2 29.76, Y_2O_3 etc. 64.34, H_2O 0.75, sum 94.85 wt.%. Vogt emphasizes that the determination of H_2O was made on selected pure and fresh material. He forecasts a complete analysis by the chemist Mr. Rødland, the result of which (if performed) was never published. The distribution of the REEs was estimated from the intensities of an X-ray spectrogram by Schetelig (1931).

Electron-microprobe (EMP) analyses of thalénite-(Y) from Hundholmen, performed by A.V. Voloshin, were published by Kristiansen (1993). Three analyses were performed on a zoned crystal (core, intermediate part and rim; sample RK 4/89) and one analysis on sample RK 8/89. Regrettably, F was not analysed, the content of H_2O is unknown and two of the analyses have unreasonably low totals (92.86 and 96.13 wt.%). The two analyses with acceptable totals are included in Table 1.

Thalénite-(Y) from Hundholmen is always associated with yttrian fluorite ('yttrofluorite'), and it is therefore reasonable to assume that it might be enriched in fluorine. Reconnaissance studies by SEM-EDS (Kristiansen, October 2007) and by EMP (Raade, March 2008) indicated considerable amounts of F, and it was decided to perform a complete EMP analysis.

Electron-microprobe analysis

Wavelength-dispersive (WDS) analyses were performed with a Cameca SX100 electron probe at 20 kV operating voltage and 15 nA probe current, with 10 s counting time on both peak and background and a beam diameter of 5 μm. The probe standards and measured peaks were: wollastonite (Ca *Kα* and Si *Kα*), $REEPO_4$ (*Lα* lines for Y, Tb and Yb; *Lβ* lines for Gd, Dy, Ho, Er, Tm and Lu) and fluorite (F *Kα*). The following elements were sought but found to be below the detection limit: Sc, Ce, Nd, Sm, Eu, Pb and U. The preliminary and standardless SEM-EDS analysis, referred to above, indicated minor amounts of S, Sc and U. Interference between S and Pb is known to occur in an energy-dispersive spectrum. Also the WDS study at first seemed to indicate the presence of minor Pb but the peak is actually due to Y. This shows that EDS analytical data must be interpreted with caution.

The analytical results are shown in Table 1. The core of the crystal has a fairly uniform composition as indicated by the standard deviations. A backscatter electron image revealed three thin zones rimming the crystal, with lighter contrast compared to the core, implying a higher mean atomic number. Since only three analyses were performed on the rim zones, the standard deviations have little significance and are not shown in the table. The content of H_2O was calculated to give (F+OH) = 1. The empirical formulae, on the basis of (O+F+OH) = 11, are:

(for the core) $(Y_{2.41}REE_{0.59}Ca_{0.01})_{\Sigma 3.01}Si_{3.00}O_{10}(F_{0.88}OH_{0.12})_{\Sigma 1.00}$
(for the rim) $(Y_{2.34}REE_{0.67}Ca_{0.01})_{\Sigma 3.02}Si_{2.99}O_{10}(F_{0.90}OH_{0.10})_{\Sigma 1.00}$

The rim is enriched in heavy REEs and depleted in Y compared to the core. The same result, but even more pronounced, was found in the analytical data supplied by A.V. Voloshin (Table 1, columns 3 and 4). The analytical data of type fluorthalénite-(Y) is included in the table for comparison, and show that the Ploskaya mineral is even closer to the Y and F end member.

Discussion

Our EMP data show that the Hundholmen mineral is **fluorthalénite-(Y)** with only a small amount of calculated OH, as could be expected from its close association with yttrian fluorite. Our calculated H_2O values are significantly lower than the H_2O value of 0.75 wt.% published by Vogt (1922). If this difference is real or the Vogt value may be inaccurate is impossible to decide. The mean value of H_2O in type thalénite from Österby is 2.08 wt.% (F was not analysed; Benedicks 1898,1899). The theoretical composition of $Y_3Si_3O_{10}(OH)$ is: Y_2O_3 64.15, SiO_2 34.14, H_2O 1.71, total 100.00 wt.%.

Husdal (2008) has reported thalénite-(Y) from three additional pegmatites within the Tysfjord granite, always in association with yttrian fluorite: Stetind, Lagmannsvik and Øvre Lapplægret. His SEM-EDS analyses of material from Stetind and Lagmannsvik indicate appreciable amounts of F. It is likely that the mineral is fluorthalénite-(Y) also in these cases but quantitative analyses are required to prove it.

Acknowledgements

Muriel Erambert gave invaluable assistance with the EMP analysis. The cost of using the electron microprobe was paid for by the Norwegian Mining Museum. Alf Olav Larsen skilfully prepared the probe section.

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* not seen by the authors

Table 1. Electron-microprobe analyses of fluorthalénite (wt.%).

	1	1	2	3	4	5
	Core (n = 9)	SD	Rim (n = 3)	Core	Rim	(n = 16)
CaO	0.12	0.01	0.09	0.13	0.14	0.33
Y_2O_3	46.01	0.28	44.64	44.18	35.49	55.06
Ce_2O_3	n.d.		n.d.	0.47	0.44	–
Eu_2O_3	n.d.		n.d.	0.41	0.83	–
Gd_2O_3	1.84	0.10	1.59	1.47	1.86	0.24
Tb_2O_3	0.43	0.13	0.51	0.56	0.76	–
Dy_2O_3	4.95	0.07	4.89	4.61	6.32	1.77
Ho_2O_3	1.30	0.08	1.36	1.32	2.11	0.22
Er_2O_3	4.49	0.15	4.97	4.83	6.99	2.91
Tm_2O_3	0.73	0.09	0.79	0.88	1.27	0.26
Yb_2O_3	4.31	0.10	6.31	6.39	10.28	2.40
Lu_2O_3	0.83	0.04	1.14	0.78	1.39	0.19
SiO_2	30.51	0.16	30.37	32.49	30.62	34.55
F	2.84	0.28	2.88	n.a.	n.a.	3.76
H_2O*	0.18		0.15	n.a.	n.a.	–
Sum	98.54		99.69	98.52	98.50	101.69
$-O \equiv F_2$	1.20		1.21			1.58
Total	97.34		98.48			100.11

1 and 2: Hundholmen (this work).
3 and 4: Hundholmen, sample RK 4/89 (analysed by A.V. Voloshin; in Kristiansen 1993).
5: Ploskaya Mountain, Kola Peninsula, Russia (type locality) (Voloshin & Pakhomovskii 1997).

n – number of single analyses; SD – standard deviation;
n.d. – not detected; n.a. – not analysed.
* calculated to give (F+OH) = 1, on the basis of (O+F+OH) = 11.