Hingganite-(Y) from a syenite pegmatite at Virikkollen, Sandefjord, Vestfold, Norway

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Introduction

Gadolinite group minerals have the general formula $A_2X_xZ_2T_2O_8[O_{2-x}(OH)_{2-2x}]$ where 0 ≤ x ≥ 1, and *A* = Y, REE, Ca; *X* = Fe^{2+} or vacancy; *Z* = Be, B; and *T* = Si. Several gadolinite group minerals have been found in the Larvik Plutonic Complex: gadolinite-(Ce), gadolinite-(Y), hingganite-(Ce), hingganite-(Y), homilite, and datolite (Larsen 2010). Investigation of pegmatite material collected at the locality Virikkollen near Sandefjord, recently described by Larsen & Kolitsch (2012), revealed a mineral that occurs as pale beige spherulites. Preliminary analyses showed this mineral to be Ca-rich hingganite-(Y), ideally $Y_2\square Be_2Si_2O_8(OH)_2$ or $YBeSiO_4(OH)$, which can be expressed as the Fe-free analogue of gadolinite-(Y). The new find initiated a study of this rare mineral.

The occurrence

In April 2010, one of the authors (KEL) observed that expansion of the root system of a small rowan tree combined with repeated frost cracking had exposed a cavity about half a metre across in a pegmatite dike in a road cut of Haneholmveien (Haneholm road) on the eastern side of a small hill called Virikkollen, located 1 km SW of the centre of Sandefjord town. The pegmatite dike appears to have a sheet-like shape and is situated about 4-5 m above the street level. Thorough investigation on the locality showed that the primary pegmatite minerals include microcline, black amphiboles, aegirine, magnetite and minor amounts of fluorapatite, zircon, pyrochlore, biotite and albite. The cavity was lined by large aegirine and microcline crystals and hosted a unique assemblage of late stage, hydrothermal minerals (Larsen & Kolitsch 2012), among them zektzerite and an aspedamite-like mineral (UK-17). Other hydrothermal minerals included second generation aegirine, bastnäsite-(Ce), bertrandite, chalcedony, epididymite, ilmenite, pale mica, milarite, monazite-(Ce), hingganite-(Y), opal, second generation of pyrochlore, quartz, second generation of zircon, plus black manganese oxide crusts and unspecified clay material.

The mineral description

Hingganite-(Y) from the Virikkollen locality occurs as pale beige, radiating spherulites up to 1 mm across, often as intergrown aggregates. The spherulites are abundantly dispersed in the grundmass, mainly quartz and aegirine. The streak is white. No fluorescence is observed under short- and long-wavelength UV light. A back-scatter image of a split and polished spherulite (Fig. 1) show that the composition is rather complex with intergrown silicates, and probably a fine alteration along the hingganite needles. In addition, the spherulite is rimmed by a late-stage hingganite with slightly different chemical composition.

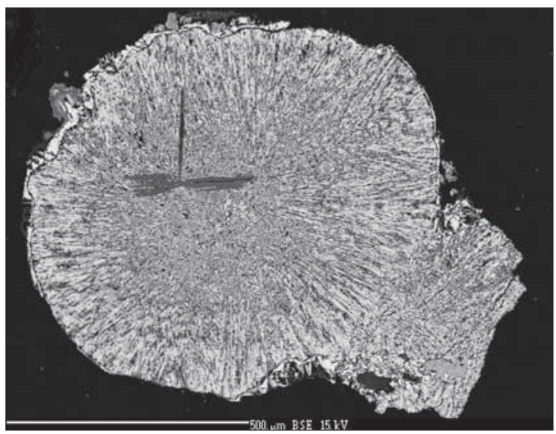

Fig. 1. Cross section of a spherulite of hingganite-(Y) from Virikkollen, Sandefjord. SEM micrograph (BSE mode), R. Škoda.

The chemical composition

Quantitative analyses were carried out using an electron microprobe. The average of 9 spot analyses on the main part of the mineral is shown in Table 1. Ba, Sr, P, Sc, K, Mg, Na and Al were sought, but not detected. The quadrant diagram of the main species in the gadolinite group (Fig. 2) shows the distribution of the *apfu* of (Fe+Mn) *vs.* (Y+REE), clearly indicating that the Virikkollen mineral as a hingganite, and

Table 1. Chemical composition determined by LA-ICP-MS and EMP (average of 9 analyses), and number of atoms calculated on the basis of Si = 2.

	LA-ICP-MS (wt.%)	EMP (*n*=9) (wt.%)	No. of atoms
SiO_2		27.13 (26.81-27.29)	2.000
ThO_2		0.13 (0.09-0.14)	0.002
UO_2		0.02 (0.00-0.06)	0.000
Y_2O_3	31.22	30.60 (29.33-31.58)	1.200
La_2O_3	0.13	0.14 (0.09-0.24)	0.004
Ce_2O_3	1.27	1.37 (1.24-1.51)	0.037
Pr_2O_3	0.29	0.40 (0.33-0.45)	0.011
Nd_2O_3	2.33	2.60 (1.91-2.83)	0.068
Sm_2O_3	1.90	1.40 (1.15-1.67)	0.036
Eu_2O_3	0.24	0.19 (0.15-0.24)	0.005
Gd_2O_3	3.70	3.49 (3.30-3.67)	0.085
Tb_2O_3	0.71	0.65 (0.58-0.76)	0.016
Dy_2O_3	4.55	4.07 (3.80-4.31)	0.097
Ho_2O_3	0.94	0.85 (0.83-0.96)	0.020
Er_2O_3	2.40	2.13 (2.03-2.27)	0.049
Tm_2O_3	0.25	0.21 (0.16-0.26)	0.005
Yb_2O_3	1.27	0.82 (0.70-0.95)	0.019
Lu_2O_3	0.10	0.06 (0.03-0.08)	0.001
CaO		4.27 (3.77-4.69)	0.338
MnO		0.10 (0.04-0.14)	0.006
FeO		2.60 (2.46-2.82)	0.161
BeO	8.79	9.33 (9.12-9.51)*	1.652*
B_2O_3	3.78	2.65 (2.34-2.91)*	0.338*
H_2O		3.47 (2.94-3.75)**	1.706**
Total		98.69	

* Be and B were calculated on the basis of gadolinite-hingganite and datolite end member composition, respectively.

** OH was calculated to keep the formula electro-neutral.

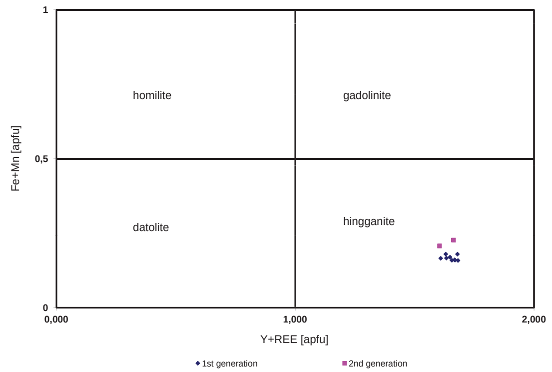

Fig. 2. Quadrant diagram on the apfu of (Fe+Mn) vs. (Y+REE) of the main species in the gadolinite group showing the position of the spot EMP analyses, all within the hingganite region.

with Y as the dominating rare earth element the mineral is hingganite-(Y). The empirical formula for hingganite-(Y) from Virikkollen on the basis of Si = 2 is

$(Y_{1.20}Ca_{0.34}Dy_{0.10}Gd_{0.09}Nd_{0.07}Er_{0.05}Sm_{0.04}Ce_{0.04}Ho_{0.02}Yb_{0.02}Tb_{0.02}Pr_{0.01})_{\Sigma 1.99}(\square_{0.84}Fe_{0.16})_{\Sigma 2.00}(Be_{1.65}B_{0.34})_{\Sigma 1.99}Si_{2.00}O_{10.00}(OH)_{1.68}$.

Two spot analyses on the outer zone of late stage hingganite-(Y) show that this phase is slightly enriched in Fe (average 0.22 *apfu*) (Fig 2).

The contents of Be and B were calculated on the basis of gadolinite-hingganite and datolite end member composition, respectively. In addition, REE, Be and B were determined using a laser ablation inductively coupled plasma mass spectrometry instrument (LA-ICP-MS). The results are shown in Table 1. Most of the analytical results for the REE by this technique are within the variations of the EMP analyses. Interestingly, the calculated Be and B contents differ only slightly from that measured by LA-ICP-MS.

X-ray crystallography

X-ray powder diffraction data on the hingganite-(Y) were obtained using a Panalytical X'pert Pro diffractometer equipped with automatic divergence slits (Cu$K\alpha_1$ radiation, λ = 1.54056 Å). Finely ground mineral was dispersed on a zero-background silicon plate. Data were collected from 5º to 70º 2θ. Lanthanum hexaboride (LaB_6, NIST

SRM 660a) was used as internal standard. The X-ray powder diffraction pattern was indexed using the monoclinic space group $P2_1/a$, and least-squares refinement was done by the program CELREF (Laugier & Bochu 1999). The unit-cell dimensions found are a = 9.8654(17), b = 7.6033(12), c = 4.7561(7) Å, β = 90.11(3)º, V = 356.75(10) Å^3.

Conclusion

The diversity of minerals in the pegmatites in the Larvik Plutonic Complex (LPC) became famous through the monograph by Brøgger (1890). Among all the alkaline complexes worldwide, the pegmatites of the LPC show the largest diversity in beryllium minerals with 26 species, among them 11 type species (Raade 2008; Larsen 2010). Hingganite-(Y) has previously been identified from the LPC: as tiny, beige crystals in the Tuften quarry, Tvedalen, and as groups of radiating, pale rose coloured crystals at Bratthagen, Lågendalen. The present paper is yet another description of the rare beryllium mineral hingganite-(Y) from the LPC.

References

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Detail of the Virikkollen sample showing white spherulites of hingganite-(Y) associated with quartz, aegirine and Fe-hydroxides. Field of view 20 mm. Photo by A. O. Larsen.