

KVANEFJELDITE, A NEW MINERAL SPECIES FROM THE ILÍMAUSSAQ ALKALINE COMPLEX, SOUTHWEST GREENLAND*

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ABSTRACT

Kvanefjeldite is a new mineral species from the Ilímaussaq alkaline intrusive complex (Greenland). It forms veinlets, streaks and patches up to 3 cm long in arfvedsonite nepheline syenite on the Kvanefjeld plateau. Associated minerals include villiaumite and analcime. Microprobe analyses gave: SiO₂ 65.0, CaO 8.49, Na₂O 22.06, MnO 1.59, FeO 0.05, Y₂O₃ 0.40, total 97.59. TGA gave a weight loss of about 4% at approximately 600°C. No traces of C, S, F and Cl were detected. The empirical formula calculated on the basis of O = 15 in the anhydrous part is: Na_{3.96}(Ca_{0.84}Mn_{0.12}Y_{0.02})Σ_{0.98}Si_{6.01}O₁₄(OH)₂ after addition of (OH). The ideal formula is Na₄(Ca,Mn)(Si₃O₇OH)₂, Ca > Mn. The mineral is orthorhombic, *Pcab*, with cell dimensions *a* 10.213(2), *b* 15.878(4) and *c* 9.058(1) Å, *Z* = 4. It is pink with a violet hue, vitreous lustre, almost pearly on {010}. It forms aggregates of crystals, which are platy on {010}. Cleavage is good on {010}, imperfect on {101}. Hardness (Mohs) 5½-6, density 2.55 (measured), 2.53 g/cm³ (calculated). It is optically biaxial, positive, 2*V_γ* varies from 0 to 9° in white light. Indices of refraction are: α 1.522(1), β 1.522(1), γ 1.543(1). The optical orientation is: α = *a*, β = *c*, γ = *b*. The type material is deposited in the Geological Museum, Copenhagen.

Keywords: kvanefjeldite, Ilímaussaq, Greenland, new mineral species, sodium calcium hydroxyl silicate.

SOMMAIRE

Le kvanefjeldite est une nouvelle espèce minérale du complexe intrusif alcalin d'Ilímaussaq (Groënland). Il se présente en veinules, longues de 3 cm au maximum, traînées et taches dans la syénite néphélinique à arfvedsonite du plateau de Kvanefjeld. Les minéraux satellites comprennent villiaumite et analcime. Les analyses à la sonde ont donné: SiO₂ 65.0, CaO 8.49, Na₂O 22.06, MnO 1.59, FeO 0.05, Y₂O₃ 0.40, total 97.59. L'analyse thermogravimétrique accuse une perte de poids d'environ 4% vers 600°C. On n'a décelé aucune trace de C, S, F et Cl. La formule chimique est calculée en admettant 15 atomes d'oxygène dans la partie anhydre, ce qui donne Na_{3.96}(Ca_{0.84}Mn_{0.12}Y_{0.02})Σ_{0.98}Si_{6.01}O₁₄(OH)₂, après addition des groupes OH. Idéalisée, cette formule s'écrit Na₄(Ca,Mn)(Si₃O₇OH)₂, Ca >

Mn. Le minéral est orthorhombique, *Pcab*, avec maille de dimensions *a* 10.213(2), *b* 15.878(4), *c* 9.058(1) Å, *Z* = 4. Il est de couleur rose violacé, d'éclat vitreux, presque nacré sur {010}. Le clivage est bon sur {010}, imparfait sur {101}. Dureté (Mohs) de 5½ à 6, densité mesurée 2.55, densité calculée 2.53. Optiquement, ce minéral est biaxe positif, d'indices 1.522(1), 1.522(1), 1.543(1), orientés comme suit: α = *a*, β = *c*, γ = *b*. L'angle des axes optiques 2*V_γ* varie de 0 à 9° en lumière blanche. Le matériau type a été déposé au Musée géologique de Copenhague.

(Traduit par la Rédaction)

Mots-clés: kvanefjeldite, Ilímaussaq, Groënland, nouvelle espèce minérale, silicate hydroxylé de sodium et de calcium.

INTRODUCTION

Kvanefjeldite, Na₄(Ca, Mn)(Si₃O₇OH)₂, is a new mineral species from the Ilímaussaq alkaline intrusive complex, one of the latest and most differentiated syenite intrusions from the Gardar period, 1330-1140 Ma.

The crystal structure of kvanefjeldite is solved and published elsewhere (Johnsen *et al.* 1983). The structure is built up of corrugated ²_∞[Si₃O₇OH] layers containing rings of eight tetrahedra. The layers are connected by Ca or Mn in octahedral co-ordination, one Na in a trigonal prism and the other Na in a more irregular 7-co-ordination polyhedron. No similar structure is known.

The mineral is named after the type locality, Kvanefjeld, which is a Danish word meaning the mountain where the plant *angelica* grows. The mineral and the mineral name were approved by the Commission on New Minerals and Mineral Names, I.M.A., in December 1982. The type material is preserved in the collections of the Geological Museum, University of Copenhagen, Denmark.

OCCURRENCE

Kvanefjeldite has only been found at one locality, the Kvanefjeld area in the northwesternmost part of the intrusive complex, where it occurs in streaks

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and veinlets of hydrothermal origin. Uranium prospecting has been carried out in that area since 1955; at the beginning of 1979 an exploration drift was started which, at the end of August of the same year, when one of the authors (OVP) visited the adit, had reached a length of a little more than 200 m. Here a very large number of specimens (~ 1000), with a total weight of ~ 500 kg, carrying villiaumite and epistolite, were collected (GGU no. 47887) from the transitional zone between the two nepheline syenites, named M-C lujavrite (M-C for medium- to coarse-grained) and arfvedsonite lujavrite, and well within the arfvedsonite lujavrite. Kvanefjeldite has been recognized in very few specimens of arfvedsonite lujavrite. The entire material consists of no more than a dozen hand-specimens in which the kvanefjeldite forms patches, streaks and veinlets up to 3 cm in length. Associated minerals include primarily villiaumite but also analcime; the kvanefjeldite is one of the latest minerals to form in the assemblage.

CHEMISTRY

The chemical composition of kvanefjeldite was established by means of the electron-microprobe technique, TGA and emission spectrography. The microprobe analysis was performed on a JEOL 733/superprobe, using an acceleration potential of 15 kV. For the major elements, jadeite (Na), wollastonite (Ca, Si) and Mn metal were used as standards. The ZAF correction was performed by using the JEOL software PACX. The composition (Table 1) represents the mean value of 16 determinations from two grains showing no zoning. Besides the elements listed, emission-spectrography and electron-microprobe analyses revealed only traces of Li, Be, B, F, S and Cl. A LECO test for C was negative. TGA gave about 4% weight loss at ~ 600°C, which

TABLE 1. ELECTRON MICROPROBE DATA FOR KVANEFJELDITE

	s	
SiO ₂	65.0	0.30
Al ₂ O ₃	< 0.02	
TiO ₂	< 0.02	
FeO	0.05	0.03
MnO	1.59	0.15
MgO	< 0.02	
CaO	8.49	0.23
Na ₂ O	22.06	0.28
K ₂ O	< 0.02	
Y ₂ O ₃	0.40	0.10
Total	97.59	

Note: average of 16 analyses. s is standard deviation. Specimens acc. no. 1983.136, GGU no. 47887.

is assigned to OH groups on the basis of the above-mentioned negative tests.

The empirical formula, calculated on the basis

TABLE 2. X-RAY POWDER-DIFFRACTION DATA ON KVANEFJELDITE

h	k	l	d(calc)	d(obs)	I/I ₀ obs
0	2	0	7.939	7.928	1
1	2	0	6.268		
1	1	1	6.233	6.251	3
2	0	0	5.107	5.109	2
0	0	2	4.529	4.529	2
2	0	1	4.448	4.447	6
0	1	2	4.355	4.355	7
2	2	0	4.295		
2	1	1	4.283	4.288	2
1	3	1	4.171	4.175	2
0	4	0	3.9694	3.965	2
0	2	2	3.9339	3.931	2
2	2	1	3.8806	3.880	7
1	4	0	3.6998	3.701	2
1	2	2	3.6710	3.671	4
1	4	1	3.4251	3.426	2
2	0	2	3.3883	3.388	6
2	1	2	3.3137	3.313	5
2	2	2	3.1164	3.1174	10
2	4	1	2.9617		
3	2	1	2.9573	2.9579	2
1	5	1	2.8755	2.8753	3
1	4	2	2.8653	2.8639	4
2	3	2	2.8536		
1	1	3	2.8485	2.8529	3
1	2	3	2.7202	2.7226	2
3	1	2	2.6822	2.6834	1
2	4	2	2.5771	2.5757	5
3	2	2	2.5742		
2	1	3	2.5649		
1	6	0	2.5617	2.5647	4
3	4	1	2.4850	2.4852	1
4	0	1	2.4575	2.4573	2 *
4	1	1	2.4286	2.4257	2
3	5	1	2.2494	2.2488	2
3	1	3	2.2364	2.2383	1 *
1	6	2	2.2297	2.2285	1
4	3	1	2.2289		
4	1	2	2.2026	2.2028	2
1	1	4	2.1897	2.1898	3
4	2	2	2.1417	2.1415	3
1	5	3	2.1396		
4	4	1	2.0895		
3	6	0	2.0893	2.0876	1
2	6	2	2.0856		
2	0	4	2.0701	2.0716	1
2	1	4	2.0527	2.0508	3
4	3	2	2.0505		
3	4	3	1.9633	1.9640	2
4	0	3	1.9496	1.9494	3
1	8	0	1.9483		
4	1	3	1.9351		
5	2	1	1.9326	1.9328	1
1	4	4	1.9314		
5	3	1	1.8648	1.8644	1
2	4	4	1.8355		
3	2	4	1.8344	1.8346	1
3	3	4	1.7761	1.7758	2 B
2	1	5	1.6976		
1	6	4	1.6966	1.6960	1
4	0	4	1.6942		
3	8	1	1.6847		
4	1	4	1.6846	1.6838	1
5	1	3	1.6823		
4	5	3	1.6615		
4	2	4	1.6569	1.6593	1 *
2	6	4	1.6305	1.6314	1
5	3	3	1.6115	1.6111	1
5	6	1	1.5918	1.5913	2
3	1	5	1.5912		
4	6	3	1.5896		
1	10	0	1.5689		
2	4	5	1.5684	1.5687	1
3	2	5	1.5678		
4	8	0	1.5670		
5	4	3	1.5564		
1	5	5	1.5552	1.5551	1

The lines are generally a little diffuse. Lines marked with an asterisk overlap with quartz peaks. B broad line.

of 15 oxygen atoms in the anhydrous part, is: $\text{Na}_{3.96}(\text{Ca}_{0.84}\text{Mn}_{0.12}\text{Y}_{0.02})_{\Sigma 0.98}\text{Si}_{6.01}\text{O}_{14}(\text{OH})_2$ after addition of (OH), corresponding to H_2O 3.21% (total 100.80%). The ideal formula is $\text{Na}_4(\text{Ca},\text{Mn})(\text{Si}_3\text{O}_7\text{OH})_2$ with $\text{Ca} > \text{Mn}$.

X-RAY DIFFRACTION

X-ray powder-diffraction and Weissenberg single-crystal studies show kvanefjeldite to be orthorhombic, with cell dimensions: a 10.213(2), b 15.878(4), c 9.058(1) Å, cell volume 1468.86 Å³. These values were found by least-squares refinement using 32 unambiguously indexed powder lines and the program REFBASE written by ESL. D_{calc} 2.53 g/cm³, $Z = 4$. The following extinctions were observed: hkl : no restrictions, $0kl$: $l = 2n$, $h0l$: $h = 2n$, $hk0$: $k = 2n$, leading uniquely to space group $Pcab$.

The powder data (Table 2) were obtained with a Guinier-Hägg camera, quartz as internal standard and $\text{CuK}\alpha_1$ radiation (λ 1.54051 Å). Quartz lines overlap with some kvanefjeldite lines. These lines, marked with asterisks, are not included in the least-squares refinement. The powder pattern is generally slightly diffuse; one line, marked B, is rather broad.

PHYSICAL PROPERTIES

Kvanefjeldite forms crystalline aggregates up to 15 mm across; the crystals, which show no crystal forms, are platy on {010}. They show good cleavage parallel to the platy development. Two additional cleavage planes, of very poor quality, forming an angle of 83° with each other, correspond to {101}. The mineral is pink with a distinct violet hue; a rare weak yellowish coloring is probably due to alteration; the lustre is vitreous, becoming almost pearly on the {010} cleavage. The pink color with violet hue and the almost pearly lustre on the {010} cleavage are the most striking diagnostic features. The hardness is

5½–6; the specific gravity, determined by suspending the material in heavy liquid, is 2.55; the density, calculated for the normalized empirical formula, is 2.53 g/cm³.

OPTICAL PROPERTIES

Kvanefjeldite is transparent; the principal indices of refraction, determined by means of the λ -T variation method with optical glass as internal standard (Micheelsen 1957), are: n_α 1.522, n_β 1.522 and n_γ 1.543 (all ± 0.001). The mineral is biaxial positive, and its $2V_\gamma$ varies from near 0 to 9° in white light. The orientation of the indicatrix, determined on oscillation photographs taken with α , β and γ as oscillation axes, is $\alpha = a$, $\beta = c$ and $\gamma = b$.

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REFERENCES

- JOHNSEN, O., LEONARDBSEN, E.S., FALTH, L. & ANNEHED, H. (1983): Crystal structure of kvanefjeldite: the introduction of $\frac{2}{\infty}[\text{Si}_3\text{O}_7\text{OH}]$ layers with eight-membered rings. *Neues Jahrb. Mineral, Monatsh.* 505-512.
- MICHEELSEN, H. (1957): An immersion method for exact determinations of refractive indices. The glass method. *Medd. Dansk Geol. Foren.* 13, 177-191.
- Received May 16, 1983, revised manuscript accepted August 30, 1983.