Notes on leucophanite from the Ilímaussaq alkaline complex, South Greenland

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Leucophanite from the Ilímaussaq alkaline complex was first described in 1905. For nearly 60 years it was believed to be rare and of very limited distribution in Ilímaussaq, but it has lately proved to be of relatively widespread occurrence. Detailed descriptions of the various occurrences are given. The crystals show the forms {001}, {110}, {101}, {102}, {111} and {113}; all the crystals are twinned either along (110) or (010). Optically the Ilímaussaq leucophanite is biaxial with $2V_{\alpha}$ (measured) = 40°; α = 1.575, $\beta = \gamma$ = 1.597. The empirical formula, calculated on the basis of Si + Al = 4, is:
$(Ca_{1.97}Mg_{0.05}REE_{0.06})_{\Sigma 2.08}(Na_{2.13}K_{0.01})_{\Sigma 2.14}Be_{1.92}(Si_{3.88}Al_{0.12})_{\Sigma 4.00}O_{12.01}(F_{1.87}OH_{0.19})_{\Sigma 2.06}$.
Unit cell parameters determined on the newly found material are a = 7.38–7.40, b = 7.40–7.41, c = 9.96–9.95, all ± 0.01 Å (Kangerluarsuk) and a = 7.43, b = 7.43, c = 9.90, all ± 0.01 Å (Nakkaalaaq). Thus, a full set of data for the Ilímaussaq leucophanite is now available.

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Leucophanite ($NaCaBeSi_2O_6F$) from the Kangerluarsuk area of the Ilímaussaq alkaline complex, was first collected by K.J.V. Steenstrup in 1899 and described by Bøggild (1905).

For nearly 60 years leucophanite was believed to be a rare mineral of very limited distribution in Ilímaussaq, but it has lately proved to be of more widespread occurrence. In the early 1960s leucophanite was found in albitite veins, which also contain eudidymite and epididymite, in the naujaite on the Taseq slope of the complex, and was briefly mentioned by Semenov & Sørensen (1966). Leucophanite from Kvanefjeld in the northern part of the complex was noticed by Semenov (1969). See Sørensen (2001, this volume) for a map of the localities mentioned in the text and a brief description of the complex.

In the early 1970s leucophanite was re-located in the Kangerluarsuk area and described in detail by Semenov *et al.* (1987). This leucophanite was found in pegmatites in white kakortokite in the upper part of the first major tributary upstream from the estuary of the Lakseelv. According to Semenov *et al.* (1987) these pegmatites are rich in microcline, carry some arfvedsonite and eudialyte, and in the central part are enriched in aegirine, helvite, astrophyllite, rinkite and leucophanite; others carry natrolite both as violet masses and colourless crystals.

During the 1997 field season, leucophanite was found at two additional localities, one in the Kangerluarsuk area and another at the diagonally opposite end of the complex, on the summit of Nakkaalaaq in the northern part of the complex.

In the Kangerluarsuk area leucophanite was found in a pegmatite in augite syenite, near the contact of the complex on the southern side of the fjord, at an altitude of about 100 m. The up to 50 cm wide pegmatite consists of albite, natrolite, fluorite, a profusion of orange, platy crystals of monazite, and leucophanite. The order of crystallisation is: albite → natrolite → fluorite → monazite → leucophanite. The leucophanite is of an unusual appearance; it forms 0.2 mm crusts of pearly white aggregates of bladed crystals on colourless fluorite and corroded albite crystals, as well as millimetre-large aggregates of white to

mauve, bladed crystals with pearly lustre, between the albite and fluorite crystals.

On the summit of Nakkaalaaq the augite syenite, which constitutes the roof of the Ilímaussaq alkaline complex, is cut by a set of parallel veins, a major one several metres wide and several others down to a width of about half a metre. Though the entire Nakkaalaaq summit is covered by scree, the veins are traceable over several hundred metres. The veins consist mainly of massive or coarsely crystalline flesh-coloured, pinkish or whitish microcline, and are locally rich in druses lined with well-developed crystals of microcline. Leucophanite has been found both in the major vein and in one of the smaller veins; in the former it occurs as millimetre-large aggregates of snow-white bladed crystals with pearly lustre, interstitial to the microcline crystals; in the smaller vein it occurs as very small, transparent, colourless, apparently tetragonal crystals partly lining the walls of a few cavities. Associated minerals, nearly all well-developed crystals in the numerous cavities, include aegirine, calcite, galena, hematite, hemimorphite, and a profusion of Be minerals including bavenite, bertrandite, epididymite, genthelvite and helvite. Fersmite, recently described by Petersen *et al.* (1998), is a rare member of this highly interesting paragenesis. Microcline followed by aegirine were the first minerals, leucophanite among the last of the Be minerals, and calcite probably the very last mineral to crystallise.

Table 1. Microprobe analyses of zoned crystals of steenstrupine from the Ilímaussaq alkaline complex

Sample No.	50-149.7 centre (5)	50-149.7 rim (6)	50-150.6 centre (2)	50-150.6 rim (1)	199104 centre (4)	199104 rim (1)
SiO_2	26.94	27.75	27.54	25.98	27.40	27.06
TiO_2	0.16	0.07	0.28	0.18	0.25	0.20
ZrO_2	n.a.	n.a.	n.a.	n.a.	1.41	2.33
ThO_2	3.95	0.42	4.13	1.40	5.04	1.83
Al_2O_3	n.a.	n.a.	n.a.	n.a.	0.28	0.04
La_2O_3	8.78	12.85	8.94	14.22	11.49	11.79
Ce_2O_3	14.57	15.53	13.80	13.76	15.74	16.49
Pr_2O_3	1.29	1.04	1.28	1.54	2.39	2.08
Nd_2O_3	3.72	2.80	3.50	2.78	4.01	4.22
Sm_2O_3	0.31	0.19	0.19	0.15	n.a.	n.a.
Y_2O_3	1.47	1.05	1.56	0.31	1.05	0.10
FeO	4.34	2.50	3.96	1.85	3.87	3.42
MnO	3.61	6.22	3.42	5.69	4.42	5.00
CaO	2.18	1.58	2.00	1.65	1.88	1.95
SrO	0.10	0.14	0.07	0.11	n.a.	n.a.
Na_2O	8.41	12.98	7.88	13.65	2.75	6.59
K_2O	0.05	0.02	0.20	0.31	n.a.	n.a.
P_2O_5	9.36	11.26	8.50	9.35	11.31	12.30
Nb_2O_5	0.10	0.24	0.13	0.67	n.a.	n.a.
U_3O_8	n.a.	n.a.	n.a.	n.a.	0.70	0.35
	89.34	96.64	87.38	93.60	93.89	95.75
ΣRE_2O_3	28.67	32.41	27.71	32.45	33.63	34.58
La_2O_3/Nd_2O_3	2.36	4.59	2.55	5.12	2.86	2.79

Analyses in oxide wt%. H_2O and F have not been analysed which explains the low totals.
Figures in brackets: number of analyses.
n.a. = not analysed.
Samples 50-149.7 and 50-150.6 are from drill core 50 at 149.7 and 150.6 m, respectively. Analyst: G.N. Nechelyustov.
199104 is a GGU sample from Makovicky & Karup-Møller (1981), recalculated from element wt% to oxide wt%.

Morphology

The surviving material from Bøggild's investigations consists of less than 10 small crystals (1–5 mm), picked out of sodalite syenite. The crystals show the forms {001}, {110}, {101}–({201}), {102}–({101}), {111}–({221}) and {113}–({223}); the indices given are derived from the presently accepted unit cell parameters (The MINERAL Database 1997); indices in parentheses are those of Bøggild (1905) and are only given when different. All the crystals are twinned either along (110) or (010). The former can only be observed in thin sections, the optic axial planes being orientated at right angles to each other in the two individuals; the latter, on the other hand, are visible by means of their re-entrant angles. The properties of this leucophanite are in all essentials like those of the leucophanite from the type locality at Låven, Langesundsfjorden, Norway (e.g., Brøgger 1890).

Optical properties

According to Semenov *et al.* (1987) the yellowish green leucophanite forms pseudotetragonal prisms up to 1.5 cm. Optically this leucophanite is biaxial, $2V_\alpha$ (measured) = 40°; the refractive indices are: $\alpha = 1.575$ and $\beta = \gamma = 1.597$, in good agreement with those of leucophanite from elsewhere.

Chemical composition

The only complete chemical analysis of the Ilímaussaq leucophanite is of the material from the locality in the Kangerluarsuk area visited by Semenov in the early 1980s, and is reproduced in Table 1. The REE spectrum (in per cent) is given as:

$La_{11.0}Ce_{33.2}Pr_{5.6}Nd_{24.6}Sm_{5.5}Gd_{6.2}Tb_{2.0}Dy_{2.7}Er_{0.3}Yb_{0.2}Y_{9.0}$.

The SEM energy dispersive (X-ray) spectra of the leucophanite from the two new localities in the Ilímaussaq alkaline complex are both in perfect agreement with that of the leucophanite from Kangerluarsuk for which complete quantitative chemical data are available (Semenov *et al.* 1987).

Unit cell parameters

Leucophanite crystallises orthorhombic (The MINERAL Database 1997), pseudotetragonal. The unit cell

parameters refined from Gandolfi-type powder patterns, Cu$K\alpha$ radiation, λ = 1.54178 Å, were found to be: a = 7.38–7.40, b = 7.40–7.41, c = 9.96–9.95 all ± 0.01 Å and a = 7.43, b = 7.43, c = 9.90, all ± 0.01 Å, from the new localities in Kangerluarsuk and on Nakkaalaaq, respectively. The unit cell parameters of the Ilímaussaq leucophanite are thus in good agreement with those obtained from a Guinier-Hägg type powder pattern, Cu$K\alpha$ radiation with quartz as internal standard, of the leucophanite of Semenov *et al.* (1987) but never published: a = 7.39, b = 7.41 and c = 9.98 Å, and with those given in the literature: a = 7.401, b = 7.412, c = 9.990 Å (The MINERAL Database 1997).

Conclusion

The successive finds of leucophanite in Ilímaussaq have led to more and more detailed knowledge of its properties, and with the determination of the unit cell parameters of the material from the two latest finds a full set of data for the leucophanite from Ilímaussaq is available for the first time.

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