Generation of nordmarkitic melts by melting of basement gneisses: the Astrophyllite Bay complex, Kangerdlugssuaq

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Nielsen, T. F. D. and Brooks, C. K.: Generation of nordmarkitic melts by melting of basement gneisses: the Astrophyllite Bay complex, Kangerdlugssuaq. *Bull. geol. Soc. Denmark*, vol. 38, pp. 161–164, Copenhagen, February 18th, 1991. https://doi.org/10.37570/bgsd-1990-38-15

Acid-basic net-veined or pillowed dykes and intrusive bodies are small but important components in the felsic complexes of the Tertiary magmatic province in East Greenland. In Astrophyllite bay in the Snout Series syenite intrusion at the margin of the Kangerdlugssuaq syenite intrusion basic trachyandesite melts invade and melt the host of Archaean granitic gneisses. Pillows of trachyandesite are chilled to the surrounding felsic anatectic melt. The felsic melt is not granitic but syenitic in composition. Element distributions between the chilled basic and felsic melts suggest that the anatectic melt was transformed to a syenitic composition by diffusion between the two contacting melts.

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In the East Greenland sector of the Tertiary North Atlantic igneous province, magmatism has traditionally been thought of as occurring in an early period of basic activity separated from a later period of largely felsic and increasingly alkaline activity separated by the continental break-up event. While this is broadly true, Nielsen (1978), Brooks & Nielsen (1982) and Nielsen (1987) have documented the occurrence of basic magmas throughout the entire period of activity. This is manifested as dyke swarms, minor plutons and net-veined complexes in which basic pillow structures are a prominent feature. Such net-veined complexes occur in association with sev-

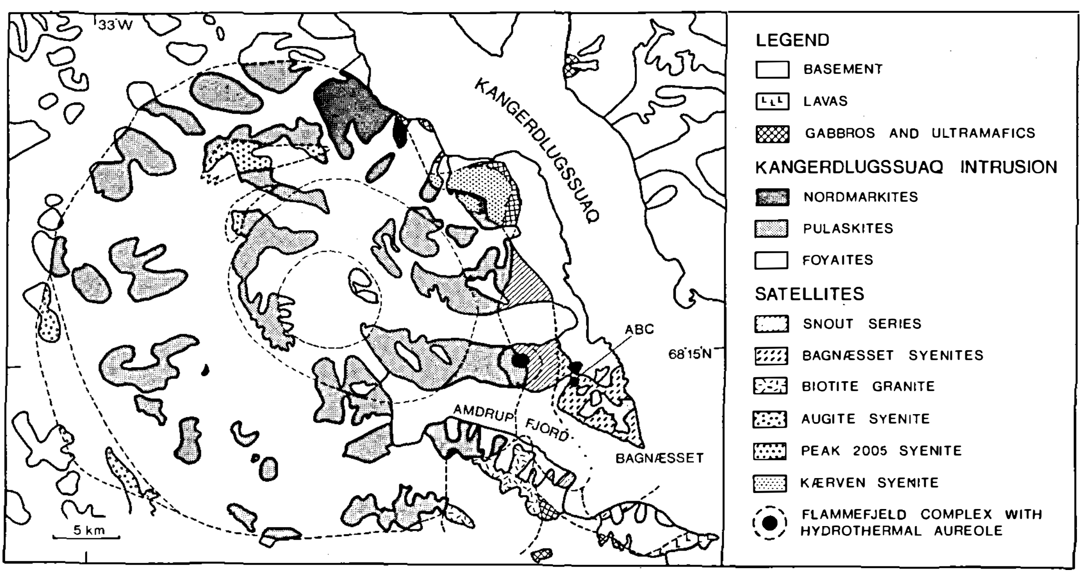

Fig. 1. Location of the Astrophyllite Bay Complex (ABC) at the margin of the Kangerdlugssuaq Intrusion (after Nielsen, 1987). The mafic plug mentioned in the text is indicated.

Table 1.

	coexisting						
	27109B pillow, a	27109A rim, qn	81-83A rim, qn	EG2626B S.S., qn	27110 rim, n	27111 basmt.	27112 hybrid
SiO_2 w%	55.30	65.72	63.32	63.94	65.14	72.41	60.27
TiO_2	2.13	0.36	1.00	0.52	0.38	0.09	1.34
Al_2O_3	14.22	16.38	15.28	17.61	17.09	14.51	15.88
Fe_2O_3	13.18	2.15	3.23	2.14	2.58	0.64	2.39
FeO	6.17	1.48	3.13	2.32	0.81	0.53	4.31
MnO	0.20	0.11	0.17	0.12	0.06	0.04	0.21
MgO	2.86	0.46	0.44	0.80	0.23	0.35	1.56
CaO	5.41	1.19	1.92	3.12	0.83	0.91	3.23
Na_2O	5.43	5.52	5.29	5.13	6.02	4.66	5.63
K_2O	2.50	5.31	4.55	4.16	5.79	4.63	3.36
P_2O_5	0.99	0.99	0.15	0.18	0.05	0.03	0.43
H_2O	0.66	0.21	0.37	0.22	0.16	0.26	0.56
SUM	98.97	98.98	99.21	100.60	99.14	99.06	99.14
qz. norm.	0.00	8.49	7.70	9.79	4.40	24.78	4.17
hy. norm.	8.35	5.50	8.08	4.07	4.25	2.50	9.78
Rb ppm	21	75	54	–	80	69	40
Ba	852	795	1260	–	579	1050	992
Sr	560	165	442	–	57	199	417
La	65	170	217	–	291	40	120
Ce	139	265	357	–	479	53	194
Y	33	30	35	–	36	8.6	36
Pb	6	11	13	–	15	10	5
Cu	10	< 2	< 2	–	3	5	4
Zn	122	72	145	–	89	42	106
Sr_0	0.7076	0.7438	0.7107	(0.71)*	0.7300	0.7516	0.7113

All samples prefixed GM (Geologisk Museum, Copenhagen) except column 3 (C. K. Brooks) and column 4 from Deer & Kempe (1976).
*Other Snout Series samples (Pankurst et al., 1976)
qn: qz-nordmarkite; n: nordmarkite
S.S.: Snout Series
a: andesite

eral of the nordmarkitic syenites, such as Kap Boswell and Kap Deichman (for these localities, see map in Brooks & Nielsen, 1982) and are a very prominent feature of the Kialineq district about 150 km to the south (Brooks, 1977; Brown & Becker, 1986). However, they also occur independently of the syenite intrusion, as on Amdrup Pynt (Brooks & Nielsen, 1982).

The Astropyllite Bay complex (fig. 1) is a typical example of such acid-basic, so-called "net-veined" complexes, in which well-chilled basic pillows are immersed in a felsic matrix, although true net-veining, i.e. brittle fracture, is in this case limited. Relations are best seen in a c. 200 m diameter area at the margin of the Snout Series syenites, itself a heterogeneous body of oversaturated syenites adjacent to the 33 km in diameter Kangerdlugssuaq intrusion (Brooks & Nielsen, 1982; Nielsen, 1987). Here, as described by Brooks & Nielsen (1982), relations are particularly well displayed. The basic melts in the form of rounded pillows, up to several metres in diameter are surrounded by homogeneous felsic material, which can be traced outwards (i.e. away from the pillows) to heterogeneous felsic material with ghost foliation into gneiss. It is clear from this exposure that the gneiss has undergone melting to produce the felsic material, possibly as a result of the intrusion of basic magma into the already heated basement. As such it is a key area for understanding how some felsic magmas have been generated in the province.

This study is based on samples of the unaffected gneiss, the basic pillows, the felsic melts and dyke-like bodies of hybrid composition from the complex. Major and trace elements, rare earths and Sr isotopic compositions are reported (Table 1).

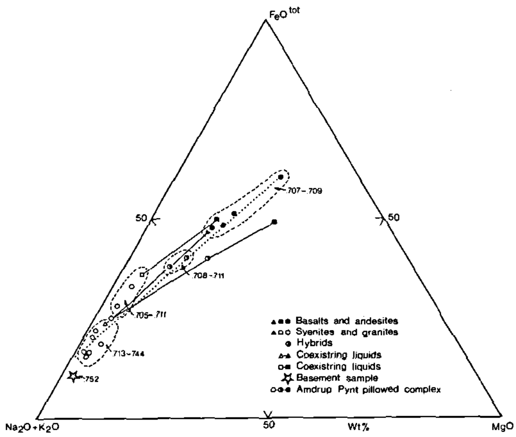

Fig. 2. AFM diagram showing the considerable geochemical variation in the Astrophyllite Bay Complex. Initial strontium isotipe ratios are given for groups of samples. Even though large variations are observed there is a regular increase in the initial strontium isotope ratios towards the alkali corner of the diagram and the basement composition. The coexisting pillow and rim compositions illustrated in figure 3 are shown by triangles.

Fig. 2 shows that the "basic" melts form a rather homogeneous group. they are in fact andesites, comparatively potassic and close to silica saturation. They might be termed trachyandesites while the most silica saturated examples are close to latites. It is clear that these melts are relatively evolved, having previously suffered contamination or crystal fractionation (the former is more likely, judging from the Sr isotopes – see below). Similar compositions form the basic component at Amdrup Pynt and at Kialineq. Nevertheless, truely gabbroic compositions (Table 1) are found in a nearby plug whose special association suggests it is geneticaly related to the rocks discussed here. The basement is a granitic gneiss with around 25% normative quartz, while the felsic melts form a more varied group of nordmarkitic composition with less than 10% normative quartz. It is clear that these felsic melts cannot be simple minimum melts from the basement as might have been expected. On the other hand, hybrid rocks are represented and these can readily be explained as simple mixing products of the granitic to nordmarkitic melts and the andesites.

The melts and the parent basement form a spectrum of compositions in the AFM diagram (fig. 2) lying parallel to the alkalies-iron join. There is a general fall in initial Sr isotopic ratio (i.e. $^{87}Sr/^{86}Sr$ at 50 Ma ago) in the direction of the iron (F) corner, going from 0.752 in the basement sample to approach the values of 0.707–0.709 in the andesites. The felsic (nordmarkitic) melts also have higher absolute contents of Na_2O and K_2O than either the basement gneiss or the andesites, which is expressed in the lower normative quartz and higher normative alkali feldspar components.

Such relationships might be brought by diffusion between the basic and felsic melts as discussed by Watson (1976) and Lesher (1986). Although diffusion in silicate melts is a very slow process, it might operate in an environment such as the one here, where nearby large intrusions would lead to the maintenance of high temperature over a prolonged period.

Fig. 3 shows the results of plotting felsic and basic parts of a 3 kg specimen, where the two components are separated by a sharp chill, in the enrichment factor diagram proposed by Lesher (1986) and Rosing et al. (1989). Although it is not posssible to correct the distribution coefficients according to the degree of polymerization of the parential andesitic and nordmarkitic/granitic liquids prior to equilibration, there is a general accordance between the data plotted here and the experimental results of Watson (1976) as shown by the stippled curve. This is a strong confirmation of the hypothesis that the present compositions of such syenites has been controlled

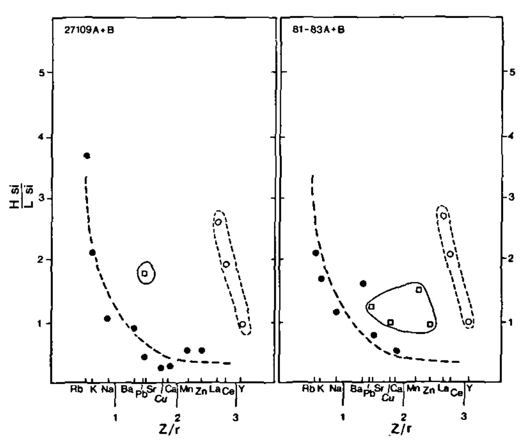

Fig. 3. Distribution of elements between basic pillow (L_{Si}) and syenitic rim (H_{Si}) in samples GM 27109 and CKB 81–83. The salic liquid is clearly developed by partial remobilisation of the adjacent basement. Diagram after Lesher (1986) and experimentally determined distribution of elements by diffusion (stippled curve) after Watson (1976). Anomalous Pb and REE are discussed in the text.

by diffusive processes with basic melts, which themselves have undergone considerable modification in the process.

Exceptions to the systematic relations shown in fig. 3 occur in the case of rare earths and Pb. The former may be related to the presence of chevkinite and allanite, which, on crystallising early acts as a sinks for the rare earths, thereby isolating them from the exchange reactions. Pb is enriched in the nordmarkitic melt and, in other cases examined similar behaviour may be shown by Cu, Mn and Zn. The reason for this is unknown but may be related to the ocurrence of mineralized fractures and veins in the neighbourhood (Geyti & Thomassen, 1984), suggesting that chalcophile elements may have been mobilized by a different mechanism.

Although all the syenitic rocks of the area may not have been formed by the process outlined here, the strong similarities between the nordmarkite described here and the neighbouring Snout Series (Table 1) it seems likely that these nordmarkites have arisen by melting of basement under the influence of basic melts, with which they have then exchanged components. Indeed, basic bodies are common within the Snout syenites.

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Dansk sammendrag

Astrophyllite Bay Complex (ABC) er en del af Snout Series intrusionen der er en satelit til den store tertiære Kangerdlugssuaq syenit intrusion i den tertiære Østgrønlandske magmaprovins ved Kangerdlugssuaq fjorden (68°N) i Østgrønland. I det ekstremt velblottede ABC ses trachyandesitiske smelter at være intruderet i det arkæiske grundfjelds granitiske gnejser. Dette har medført opsmeltning af gnejserne. De basiske smelter danner smeltepuder med lynafkølede rande til den homogene finkornede felsiske anatektiske smelte fra gnejserne. Det skulle forventes at de anatektiske smelter med en oprindelse i et granitisk grundfjeld skulle have en granitisk sammensætning. Dette er ikke tilfældet. Analyser viser at den felsiske smelte er syenitisk i sammensætning og at den ikke kan være en umodificeret anatektiske smelte. De felsiske bjergarter udviser ikke sekundær omdannelse eller omdannelse som følge af senere metasomatose og modificationen til en syenitisk sammensætning må være sket før den felsiske smelte størknede.

Fordelingen af en lang række grundstoffer mellem den basiske trachyandesit og den felsiske smelte viser med få forklarlige undtagelser i sjældne jordarter og overgangsmetaller stor overenstemmelse med elementfordelinger mellem felsiske og basiske smelter ved diffusion som beskrevet af Watson (1976) og Lesher (1986). Den syenitiske sammensætning foreslås således opstået ved opsmeltning af en anatektisk granitisk minimumssmelte efterfulgt af udveksling af grundstoffer ved diffusion med den mere alkaline basiske smelte. Ud fra den store lighed der er mellem bjergartstyperne i ABC og i Snout Series og andre syenitintrusioner i Østgrønland foreslås at diffusionsreekvilibrerede anatektiske smelter kan udgøre dele af de syenitiske bjergarter i andre tertiære syenitiske komplekser i Østgrønland.

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