DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2014/63

Field investigations of carbonatitic - alkaline - silicic intrusive rocks near Qorlortoq, Qassiarsuk area, South Greenland

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Contents

Abstract

The Mesoproterozoic Gardar Igneous Province in South Greenland developed in a continental rift-related environment. Several alkaline intrusions and associated dyke swarms were emplaced in the Archaean and Palaeoproterozoic Ketilidian basement rocks in the time interval between 1300 and 1140 Ma ago. Close to the settlement of Qorlortoq in the Qassiarsuk area, numerous basaltic to trachytic dykes as well as several small alkaline-ultramafic intrusions affected to various extents by syn- or post-carbonatisation processes were emplaced in the Ketilidian basement rocks. In the course of the present study, at least four different sub-types of alkaline-ultramafic intrusions could be identified and their specific field characteristics are presented here. In addition, detailed descriptions and preliminary geochemical investigations of individual dykes, which are interpreted to be syn- and post-magmatic to the emplacement of the carbonatised intrusions, are presented.

Introduction

The small settlement of Qorlortoq is located about 6 km north of Qassiarsuk at the west coast of the upper reaches of the Tunulliarfik fjord in South Greenland (Fig. 1). Several intrusive sheets, dykes and pipe-like structures, influenced by various degrees of carbonatisation, penetrate the basement rocks and were first described by Wegmann (1938). A more detailed investigation of these occurrences was carried out by Stewart (1970) as part of a geological mapping programme, initiated by the Geological Survey of Greenland. The sub-volcanic rocks around Qorlortoq are most likely part of the Qassiarsuk complex described in detail by Stewart (1970) and Andersen (1997, 2008), which crops out within a roughly east–west trending graben structure crossing the Narsaq peninsular around 6 km south of Qorlortoq. The magmatic activity has been interpreted to be part of the Gardar Igneous Period, which formed between 1300 and 1140 Ma ago in response to crustal extension. Several alkaline intrusions, associated dyke swarms and a contemporaneously formed alternating sequence of sandstones and lava flows, called the Eriksfjord Formation (Poulsen, 1964), were emplaced within this period (Fig. 1a). The aim of the field investigations conducted in 2013 was to reassess the field geology in the area around Qorlortoq by collecting a representative sample set of the different rock types present, and to make detailed follow-up petrological and geochemical studies of selected sub-sample sets.

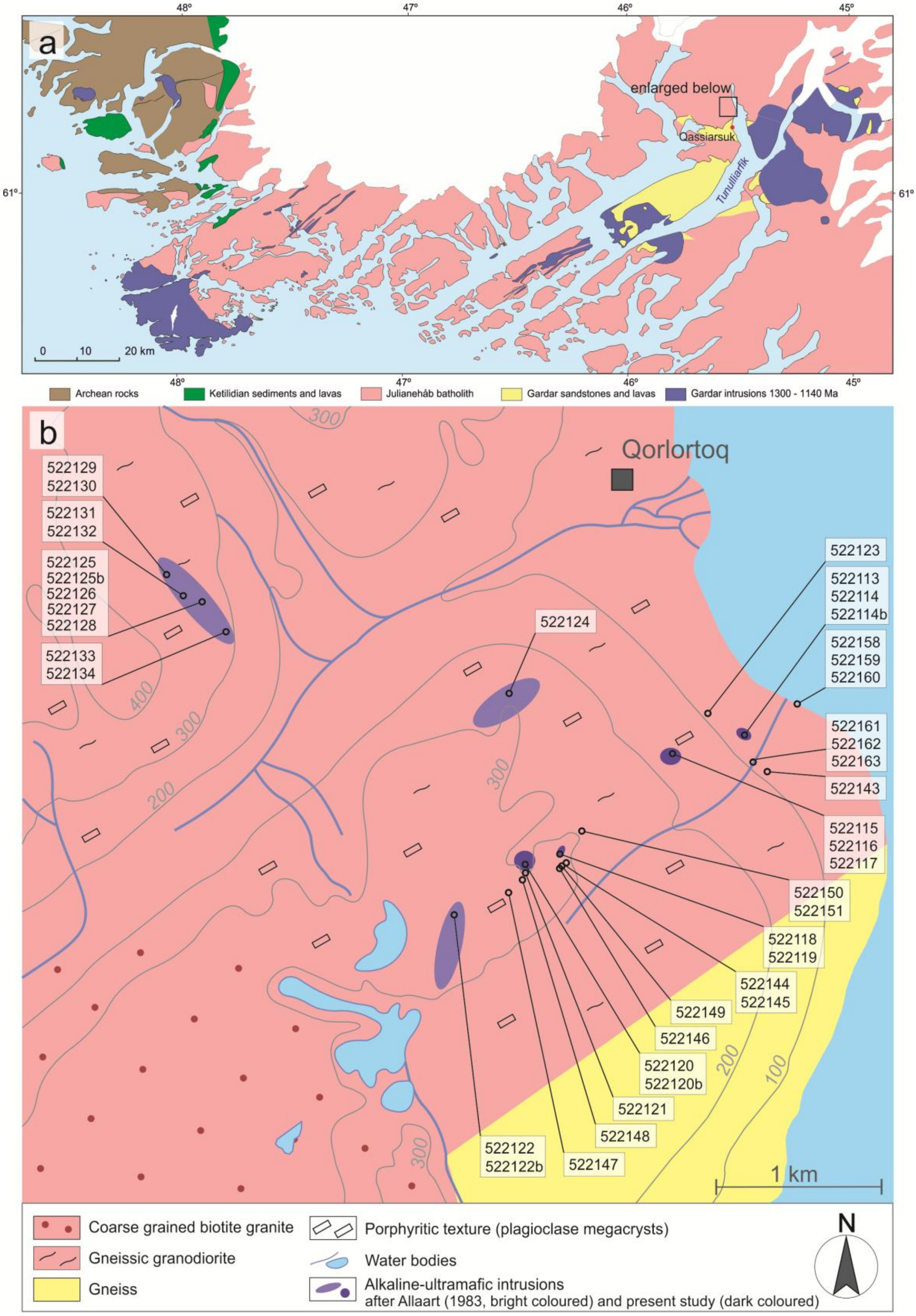

Figure 1. *(a) Simplified geological map showing the Gardar Igneous Province, South Greenland; (b) An enlarged map of the area around Qorlortoq (modified after Allaart, 1983) with sample localities indicated by their sample numbers.*

Geological setting

The basement rocks in the area around Qorlortoq are dominated by coarse-grained biotite granite, gneissic granodiorite and monzonitic to syenitic granite (Fig. 1b; Allaart, 1983) that were formed during the Palaeoproterozoic Ketilidian Orogeny at *c.* 1800 Ma ago (Garde et al., 2002). Pre-Ketilidian gneisses occur in the south, close to the village of Qassiarsuk (Stewart, 1970; Allaart, 1983). At Qorlortoq, the basement is penetrated by a number of minor intrusions, at the scale of tens of metres, assumed to be co-magmatic with the effusive rocks of the Qassiarsuk complex which has been dated at *c.* 1200 Ma by Pb-Pb and Rb-Sr isochrons on whole rock samples (Andersen, 1997). The intrusions occur in the form of sheets, dykes and pipe-like bodies of alkaline-ultramafic rock types which have been carbonatised to various extents. Non-clastic ultramafic intrusions as well as intrusive volcanic breccias have been described in the area (Stewart, 1970). The typical occurrence of the intrusions in the landscape constitutes small hummocky hills (Fig. 2) with a characteristic brick-red colouration of the adjacent granitic basement rock (Fig. 5c). Additionally, several basaltic to trachytic dykes with a general NE–SW to E–W trend penetrate the basement. Based on cross-cutting relationships they are interpreted to be syn- and post-magmatic to the emplacement of the alkaline-ultramafic carbonatised intrusions.

Figure 2. *The landscape at Qorlortoq with a characteristic gentle hummocky hill topography and lush grassy vegetation (excellent for sheep farming) due to the existence of small carbonatised alkaline-ultramafic intrusions and a high density of NE–SW and E–W trending basaltic to trachytic dykes. The blue hut was used as a base for the field work.*

Field work and sampling

The field work was conducted in August 2013 by the authors over a five day period. A rented hut situated in Qorlortoq provided an excellent base for the work. Preliminary sample localities were identified based on the work of Scharbert (1962) and Stewart (1970). During the field work, several additional smaller intrusive bodies of alkaline ultramafic rocks were identified and sampled. In total, thirty-one samples of intrusive breccias, dykes and sheets influenced by different extent of carbonatisation as well as ten dyke and six basement samples were collected during the course of this investigation (Fig. 1b). Coordinates for sample localities as well as detailed sample descriptions are given in the appendix.

Results

The following rock descriptions are based on field observations, hence terms and rock names may not agree with classification based on geochemical and detailed petrographic investigations. The term carbonatised alkaline-ultramafic intrusions is adopted from Stewart (1970). Similar rocks and their extrusive equivalents in the Qassiarsuk complex are termed alkaline silicate to silicocarbonatite rocks in the investigations carried out by Andersen (1997, 2008).

Basement rocks

The investigated basement rocks that make up the area are typically mesocratic, medium- to coarse-grained granites to granodiorites and diorites. These rocks are characterised by foliated, feldspar porphyritic textures (Fig. 3a) with a typical mineral assemblage of plagioclase, amphibole and biotite with varying amounts of quartz and alkali feldspar. Small quartz veins, with or without sulphides (chalcopyrite and pyrite), are commonly seen to pervade the rocks. Locally, tectonised gneisses occur, including both mesocratic and leucocratic varieties, ranging from diorite, to porphyritic granodiorite, to granite (Fig. 3b). Sporadically, rocks of extrusive lavas and sandstones occur as loose blocks or in the form of xenoliths within the investigated intrusions described below, indicating that the Eriksfjord Formation once covered the area. However, they might also be erratic.

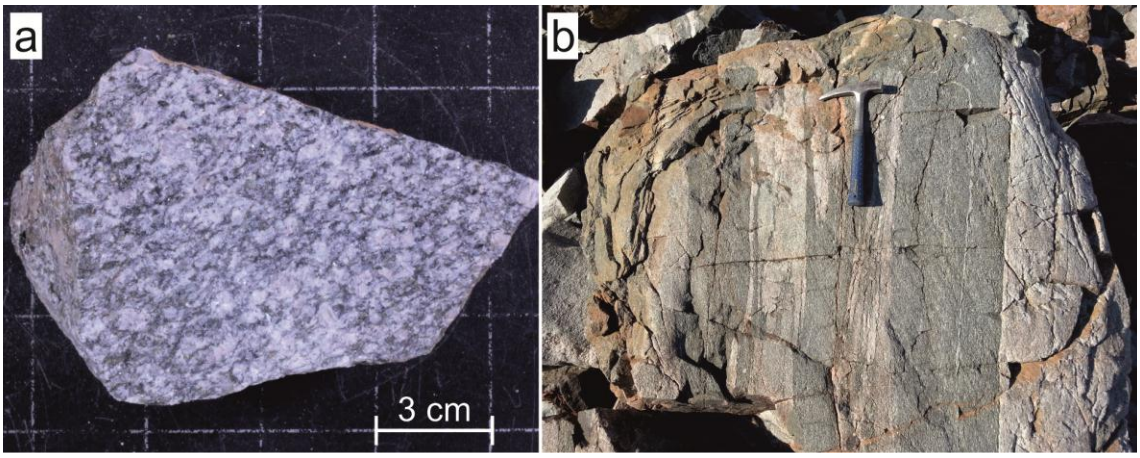

Figure 3. *Basement rocks: (a) Typical leuco- to mesocratic basement rock with a plagioclase porphyritic texture; (b) tectonised mesocratic and leucocratic basement rock.*

Carbonatised alkaline-ultramafic intrusions

Intrusive breccias

Typical field occurrences of intrusive breccias of the Qorlortoq area are illustrated in figure 4a and 4b. The following description of an ultramafic carbonatised breccia is characteristic for a number of outcrops that were investigated during the field work.

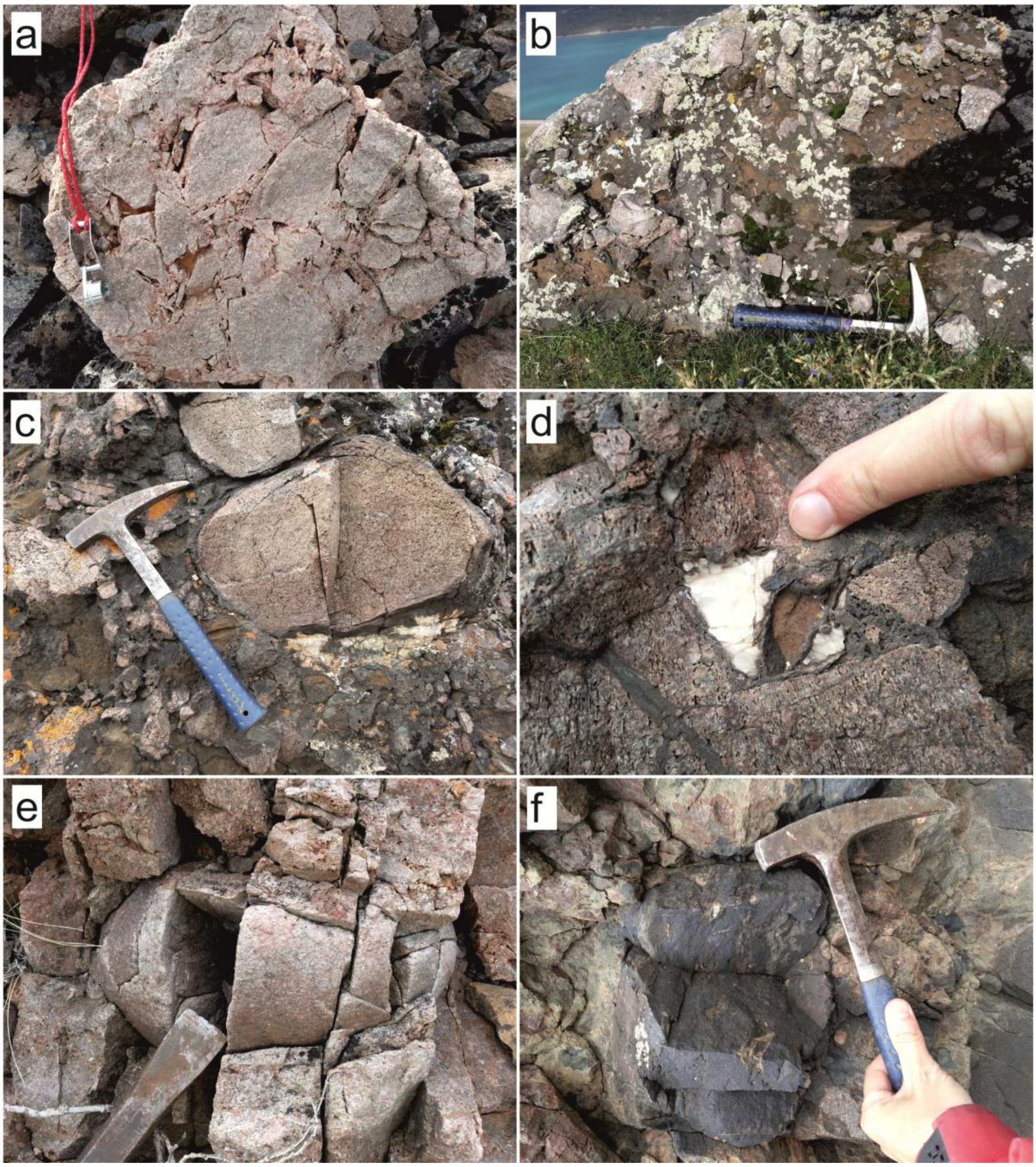

Figure 4. *Intrusive breccias: (a) Brownish matrix with highly brecciated granitic material; (b) angular to rounded clasts within a typical brownish matrix; (c) dark matrix material draped around a rounded granitic clast; (d) vesicular clasts with matrix (black); brownish part of the matrix and secondary calcite fillings of holes and vesicles indicate syn- or post-intrusive carbonatisation; (e) rounded granitic clast within volcanic breccia; (f) rounded mafic clast.*

The matrix of the breccias typically shows flow-like foliation bending around the clasts (Fig. 4c), and commonly contains elongated flow-orientated vesicles that likely represent primary gas vesicles, consistent with a surface-near or subvolcanic environment. Some vesicles could arguably represent voids after dissolution of carbonate minerals. Calcite crystals growing into voids and vesicles are evidence for a syn- or post-carbonatisation of the rock (Fig. 4d). The up to 30 cm large clasts making up the brecciated rocks, vary between angular to rounded shapes and constitute at least three types: (1) variably foliated and feldspar porphyritic granites of the Ketilidian basement, (2) quartzites that are comparable to the sandstones that dominate the sequences of the Eriksfjord Formation and (3) mafic vesicular clasts that possibly represent the basaltic lavas of the Eriksfjord Formation (Fig. 4e, f). The origin of the rounded clasts in the breccia is not clearly understood, but could perhaps reflect a phenomenon of either mechanical abrasion during intrusion, or a reaction with aggressive chemical components of the alkaline intrusive melts or fluids, or a combination of the two. Typically, the granitic clasts show a brick-red alteration colour, possibly reflecting preceeding feldspathisation (see below). Some of the angular holes could reflect dissolution of minerals initially present during alteration or brecciation, others could reflect voids after gas that later escaped. The proportion of matrix material and clasts can vary significantly and some breccias consist of up to 90 % clastic material (Fig. 4a).

Besides the described breccia rocks, three additional textural varieties of carbonatised alkaline-ultramafic rocks were observed within elongated sub-cylindrical intrusions varying in size between a few up to 400 m long or in the form of inclined intrusive sheets and irregular dykes often forming a complex network: (1) massive types, (2) globular types and (3) laminated types. The former two are volumetrically dominant, whereas the laminated type generally seems to form thinner bands within inclined sheets. In some of the larger occurrences, massive, up to 10 m thick layered sequences can be observed, consisting of the variable textured carbonatised rocks (Fig. 5a, b). The granitic basement hosting the intrusions typically shows a strong brick-red colouration (Fig. 5c) suggesting a metasomatic alteration and reaction of the wall rock lithologies with volatile-rich alkaline fluids related to the carbonatitic melts.

Figure 5. *Field occurrence of carbonatised ultramafic intrusions: (a) An about 8 m thick layered sequence of variably textured carbonatised rocks, exposed along a N–S orientated valley cliff; (b) same sequence as in (a) with the globular type at the top and the massive type below; (c) typical outcrop of a carbonatised ultramafic intrusion with a strong brick-red colouration of the adjacent basement granites.*

Massive type

This type builds up massive sheets, locally up to 3 m thick, often interbedded within other textural types. This rock type has typically a fine-grained matrix with centimetre-size feldspar xenocrysts. Calcite mineralisation is observed on layer surfaces and along veins (Fig. 6a). Occasionally, disseminated pyrite or chalcopyrite mineralisation can be observed. In several places mica phenocrysts could be identified indicating lamprophyric affinities of this type. A lamprophyric sub-type was defined based on the abundance of mica. In the investigated occurrences this type commonly consists of 30–40 cm thick sheets of mica-bearing medium- to fine-grained rocks (Fig. 6b). Foliation and the occurrence of veins are commonly observed features in this type.

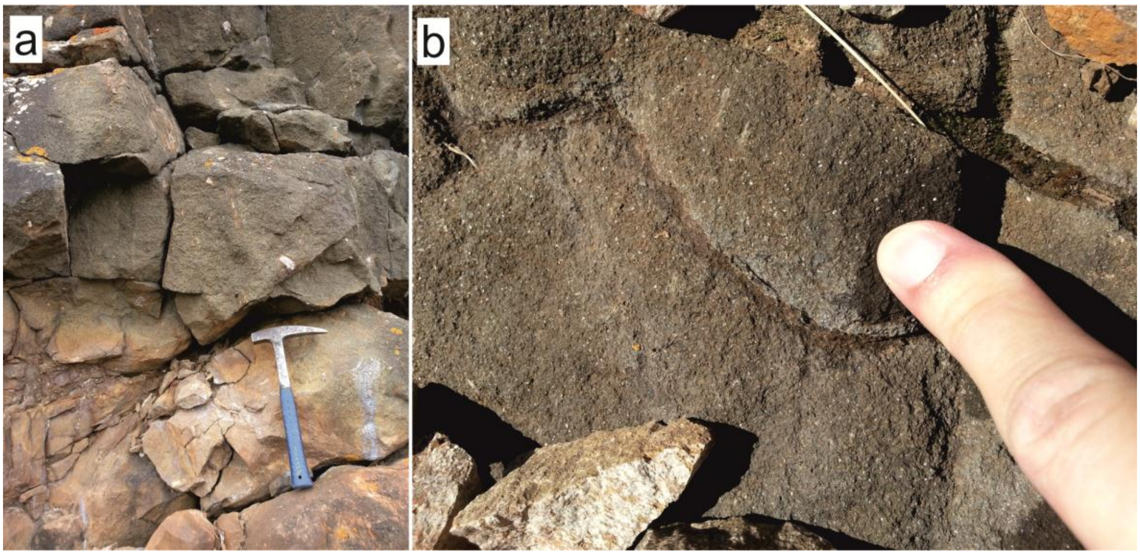

Figure 6. *Massive type of alkaline ultramafic intrusions: (a) Calcite mineralisation; (b) mica-bearing lamprophyric sheet intrusion.*

Globular type

Sills and sheets of this type are widely distributed throughout the investigated area. It is characterised by the occurrence of spherulitic to ellipsoidal bodies which can easily be identified on weathered surfaces (Fig. 7c). The globules rarely exceed 1.5 cm in diameter. Their excellent rounding indicates a syn-magmatic origin and might indicate their development by liquid immiscibility of coexisting carbonatitic and silicic melts as described by Peterson (1989), Kjarsgaard & Peterson (1991), Chazot et al. (2003) and Andersen (2008). The matrix commonly consists of fine-grained brownish material which is often extensively weathered. Several different varieties of the globular type can be identified in the area, mainly indicated by different colouration varying from pale to dark grey (Fig. 7a, b). The colour variation in these supposedly fresh rock types is taken as preliminary evidence for compositional variability, rather than effects of weathering processes.

The field relationships among the variously textured carbonatised rock types indicate a later intrusion of the globular type in the already consolidated massive variety (Fig. 7d). In other cases, dark, more globular-rich varieties are injected or are intercalated with varieties less rich in globules (Fig. 7e), indicating several consecutive pulses of magma. The injection of globule-rich material into the surrounding granitic basement furthermore indicates a very low viscosity of the melt during emplacement (Fig. 7f).

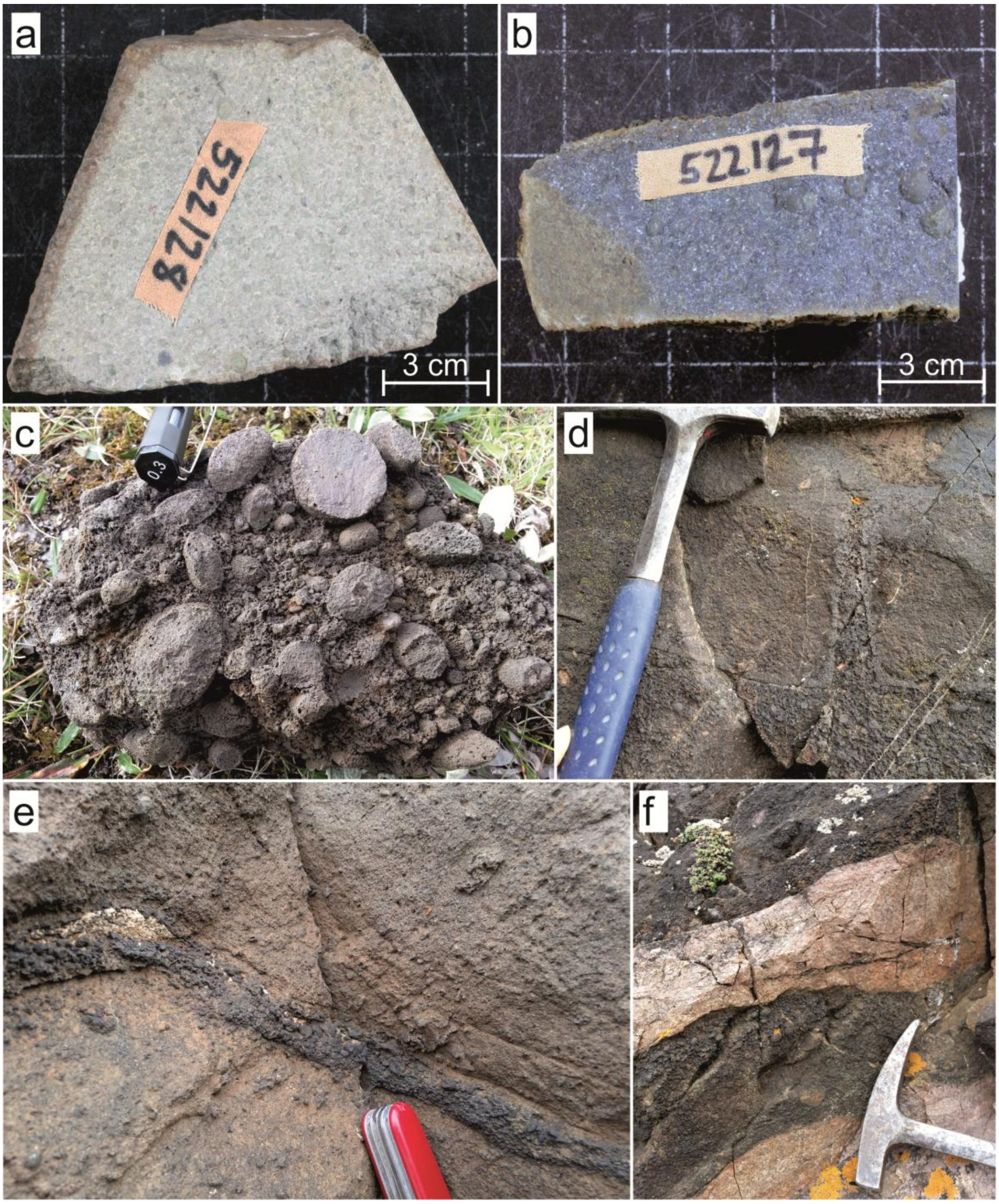

Figure 7. *Globular type of alkaline ultramafic intrusions: Pale grey (a) and dark grey (b) variety; (c) weathered sample with up to 1.5 cm large globules; (d) bands of globular type intercalated in massive type, (e) bands highly enriched in globules penetrating less globule-rich rock; (f) globular type injecting the basement granite.*

Laminated type

Sill- and sheet-like bodies of this type, about a few tens of centimetres in size, consist of fine-grained, typically brownish weathered rock material.

Figure 8. *Laminated variety of alkaline ultramafic intrusions penetrating brecciated material (a) and tectonised basement rocks (b).*

They often occur in association with the other types or within breccias (Fig. 8a) but could also build up complex networks penetrating the granitic basement rocks (Fig. 8b). Flow structures are common features indicating a very low viscosity of the melt during emplacement. As in the massive type, sulphide mineralisation within and along veins is a common feature.

The process of feldspathisation

The process of feldspathisation in the vicinity of the volcanic vents is described by Stewart (1970) and related to the emplacement of carbonatitic rocks and subsequent metasomatisation of the basement rocks. The extensive infiltration of K_2O and Al_2O_3 leads to the development of $KAlSi_3O_8$ at expense of other minerals and ultimately forms an almost mono-mineralic potash-feldspar rock. A set of four samples was collected to represent the increasing degree of feldspathisation of the granitic basement in the vicinity of carbonatitic intrusions (Fig. 9a–d). The alteration is characterised by an increased red colouration and mono-mineralic character of the granite. These rocks also contain several holes, most likely caused by dissolution of silica during alteration.

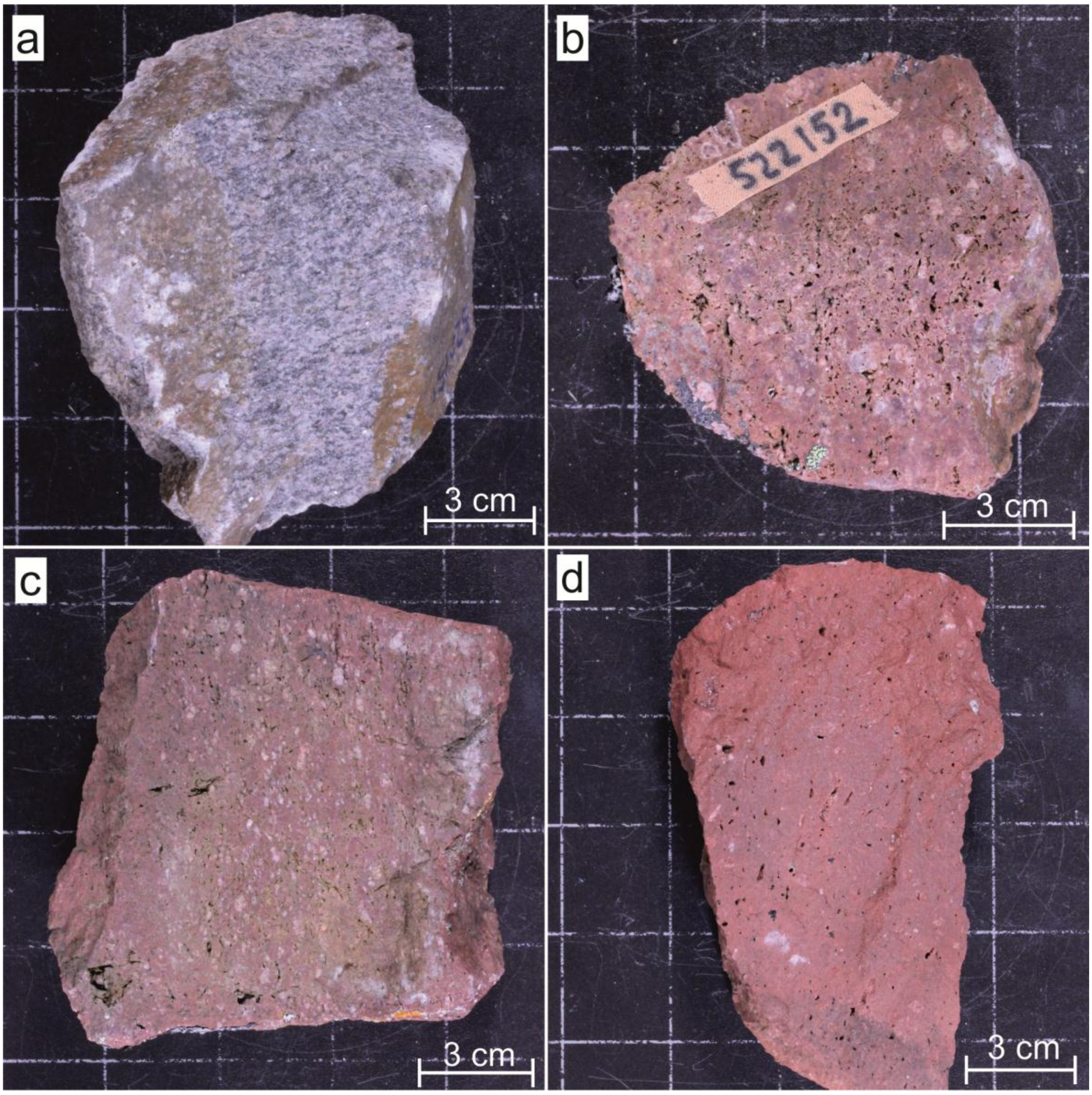

Figure 9. *A set of granitic rocks (samples GGU 522151-522154), representing the increasing degree of alteration or feldspathisation caused by the intrusion of carbonatitic or ultramafic melts and fluids.*

Associated mafic dykes

The Gardar Main Swarm

Several E–W to ENE–WSW (58°–83°) trending dykes of basaltic to trachytic (most abundant) composition cross-cut the area and generally post-date the carbonatised ultramafic intrusion. They are most likely expressions of the Main Dyke Swarm of the younger Gardar rift described in detail by Upton (2013). The dykes are vertical and are typically 1–6 m wide, rarely exceeding 20 m. They are usually fine-grained with distinct chilled margins and increasing grain-size towards the dyke centre, and display aphyric to porphyritic textures with centimentre-size feldspar phenocrysts or xenocrysts.

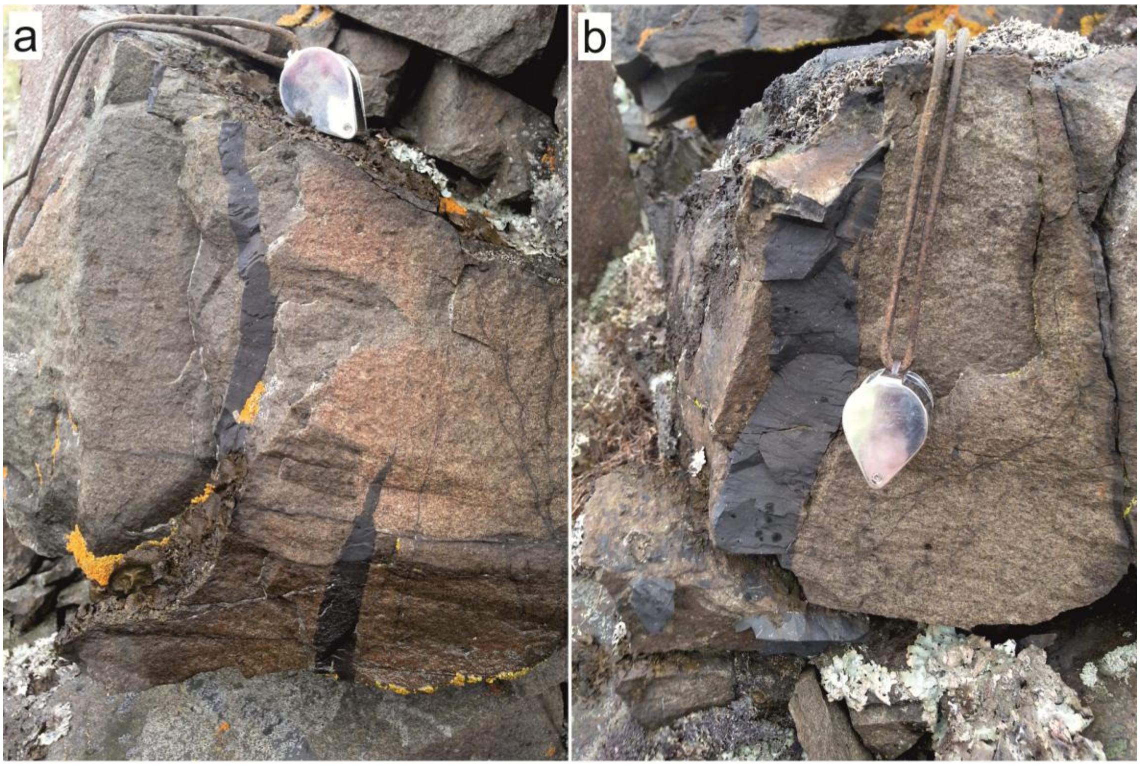

Figure 10. *Glassy veins of mafic material injecting a 6 m wide mafic dyke.*

One dyke contains veins of black glassy material with small needle-shaped phenocrysts indicating a secondary injection of mafic material (Fig. 10). In a few outcrops, the trachytic dykes also show evidence of being affected by hydrothermal alteration (red colouration), possibly related to syn- or post-carbonatisation of adjacent intrusions. This suggested relationship was, however, not firmly established in the field.

Exceptions

Three exceptions to the strike direction of the main swarm could be identified during field investigation; typically those striking between 144° and 190°. These dykes are 1–3 m wide with reddish to brown colour and an inclination of *c.* 80° towards 234°–280°. They are aphyric, fine-grained and commonly display flow banding and chilled margins at the contact to the basement rocks. One of the dykes had a globular or ocelli texture in the centre.

The ‘leopard’-textured dyke

Because of its particular textural features, one dyke was investigated in more detail. This dyke could be followed for some 350 m, striking 43° at its western and 83° at its eastern end, making a local small ridge in the landscape (Fig. 11a). The dyke is astonishingly regular in width, generally between 30 and 40 cm wide, and progressively thins out and disappears in a western direction. In parts, the dyke shows internal shearing as well as displacements and deformation in response to shearing. The dyke has a 3–5 cm chill zone at each side and displays strike-parallel banding as defined by aligned brownish globules set in a greenish grey matrix, clearly visible on weathered surfaces (Fig. 11c).

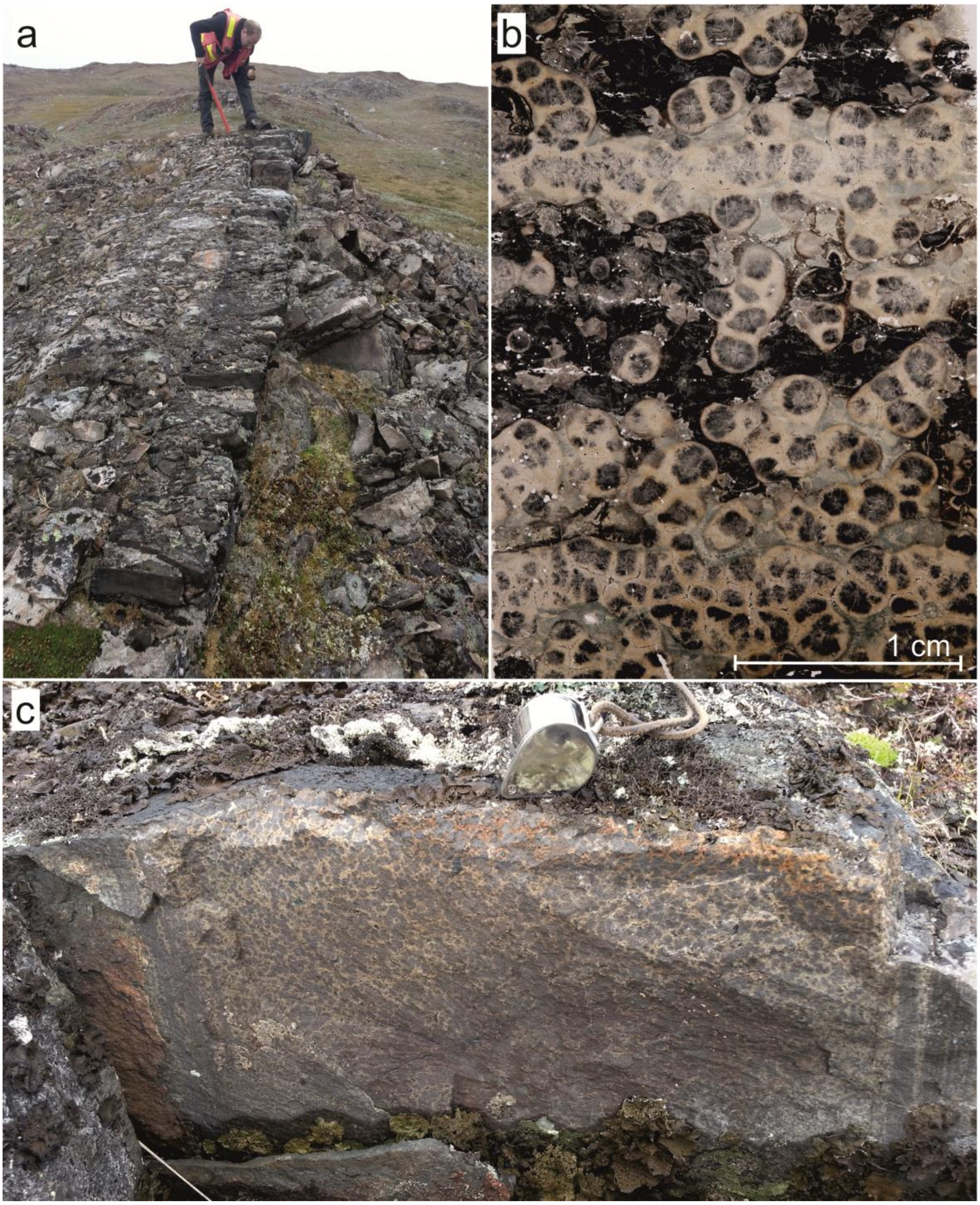

Figure 11. *The 'leopard'-textured dyke: (a) Field occurrence of the 'leopard'-textured dyke; (b) typical globular texture of the central parts of the dyke (sample GGU 522148b); (c) parallel banding at the margin and a globular texture in the centre.*

Where the dyke thins out, this texture is not observable in hand sample, but instead the dyke appears homogenously black. Profiles of the dyke were sampled at three different places with the intension of carrying out detailed petrographic and mineral chemical studies.

A complete thin section profile has been prepared by the Vancouver GeoTech Labs in British Columbia, Canada (sample GGU 522148a–e). Preliminary textural investigations show bands of pale grey globules sitting in a fine-grained grey to blackish matrix. The matrix material is partly recrystallised, forming radial, needle-shaped crystals. The pale grey globules show a sharp boundary towards the matrix material and contain dark grey to black spherulites, often enclosing a needle-shaped small crystal in the centre (Fig. 11b). The results of a preliminary geochemical investigation on whole rock material from the homogeneous part of the dyke are given in the appendix (Table 1). Based on the total silica vs. alkalis discrimination diagram after Le Maitre et al. (1989) the dyke has a trachy-andesitic to trachytic composition. Incompatible and rare earth elements are generally enriched when compared to primitive mantle and chondritic values, respectively, with relative depletion of Ba, Sr, P, Ti and Eu when compared to their neighbouring elements (Fig. 12a, b).

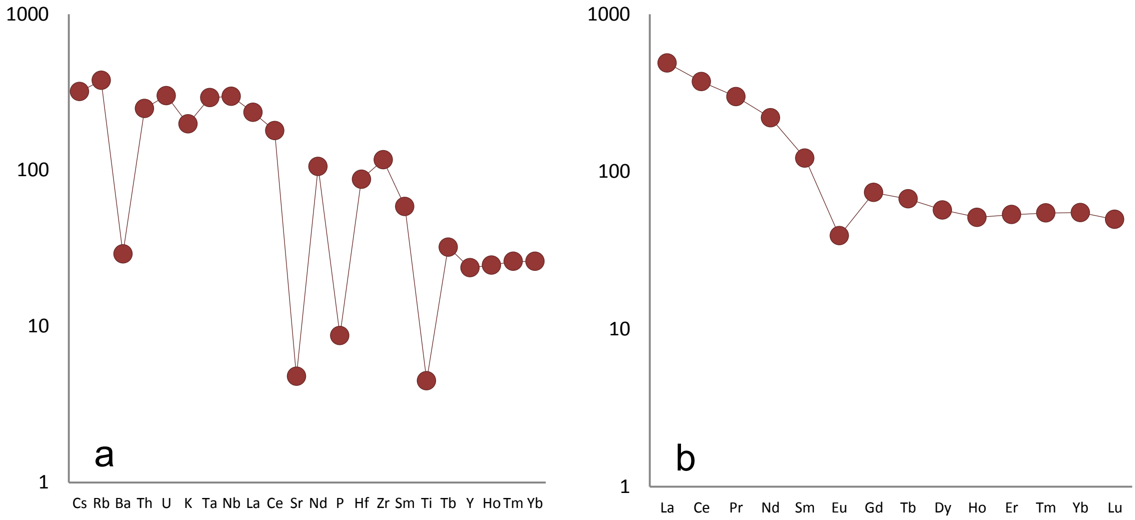

Figure 12. *(a) Multi-element plot of incompatible trace elements for whole rock samples of the investigated dykes normalised to primitive mantle values from McDonough & Sun (1995); (b) Rare earth element plot for whole rock samples of the investigated dykes normalised to chondrite values from Boynton (1984).*

Based on the available data it is not certain, whether the textural features observed are related to devitrification of a primary glassy material, the results of liquid immiscibility or both.

Conclusions and Recommendations

In the course of the present field investigation a representative sample-set was collected representing the various rock types in the area around Qorlortoq. Field observations confirm the carbonatitic – alkaline silicic character of the investigated intrusions as described by Stewart (1970). However, a detailed geochemical investigation of these specific types of magmatism are lacking and would be an important asset to understanding the relationship to the Qassiarsuk complex and its role in the complex evolution of the Gardar Igneous Province. Based on careful observations and preliminary interpretations the following possible work topics are suggested: (1) the role of possible liquid immiscibility or devitrification in the evolution of the 'leopard'-textured dyke; (2) the possible role of liquid immiscibility in the formation of the globular type of carbonatised ultramafic rocks; (3) the characterisation of possible mantle sources involved in the generation of magmatism and its relation to the Qassiarsuk complex and (4) the role of the Qassiarsuk-Qorlortoq carbonatitic-ultramafic magmatism in the evolution of the Gardar Igneous Province.

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Appendix

Samples (as described in the field diary)

522113 61.193991° -45.505038°
3 m wide dyke; dip 82° to 234°; fine grained, reddish to brown colour; contains granitic clast; flow banding near the contact with the granitic host rock.

522114 61.193991° -45.505038°
Representative sample of the granitic volcanic breccia, described above; vesicular reddish matrix with different, up to 20 cm long clasts (granites, quartzites); most of the clasts are angular with sharp edges but also rounded varieties occur; flow structures are observable in the matrix material.

522114b 61.193991° -45.505038°
One of the rounded clasts.

522115 61.193124° -45.512522°
Ultramafic, carbonate-rich breccia with different clast types; very heterogeneous; flow structures indicate low viscosity of matrix material, clasts are partly rounded and show weathering; sample was taken without clasts.

522116 61.193124° -45.512522°
Mafic clast; vesicles indicate near surface conditions; could be basalt from the Eriksfjord Formation.

522117 61.193124° -45.512522°
Mafic clast; highly veined (calcite?).

522118 61.188542° -45.523939°
50–100 cm wide, carbonatitic sheet intrusions in red foliated granite; flow structures are abundant.

522119 61.188542° -45.523939°
522118 turns into a dyke-like structure towards the west (striking 80°), indicating a network-like intrusion of the carbonatitic melts. Sample taken from this dyke structure; slightly coarser grained than 522118.

522120 61.187992° -45.527143° (from Google Earth)
Carbonatitic intrusion; *c.* 40 m in diameter.

522120b 61.187992° -45.527143° (from Google Earth)
Sample from the vicinity of 522120; contains small inclusions of unidentified material.

522121 61.187513° -45.527068° (from Google Earth)
Mafic rock; loose block with immiscibility(?) structures; *c.* 50 m south of 522120.

522122 61.185783° -45.533718° (from Google Earth)
Intrusive carbonatised breccia; contains numerous clasts, mainly of granitic composition; sample from homogeneous matrix material.

522122b 61.185783° -45.533718° (from Google Earth)
Same intrusive breccia as 522122; sample contains mainly granitic clasts.

522123 61.195144° -45.508610°
Mafic dyke; strike 263° E–W; fine grained, dark grey colour; porphyritic with feldspar phenocrysts.

522124 61.195881° -45.528493°
Carbonatitic sheets up to 30 cm wide; locally with high content of granitic clasts; strong red colouration of the surrounding granite; the total outcrop measured *c.* 50 m in diameter; sample taken from a massive part of one of the sheets without clasts.

522125 61.199816° -45.557053°
Massive type of carbonatised ultramafic rock; locally 3 m wide; fine grained matrix with feldspar phenocrysts; calcite crystallisation on weathered surfaces and along veins; mica identified indicating lamprophyric affinities.

522125b 61.199816° -45.557053°
Same as 522125 with large up to 2 cm feldspar phenocrysts.

522126 61.199816° -45.557053°
Layered type of carbonatised ultramafic rock; 5–10 cm wide sheet with internal layering; close to locality where sample 522125 was taken.

522127 61.199816° -45.557053°
Globular type of carbonatised ultramafic rock; grey matrix with dark globules.

522128 61.199816° -45.557053°
Globular type; bright grey matrix with grey globules; obviously different varieties of the globular type occur in the area mainly identified by different colouration; might also be caused by different degrees of weathering of the same rock type.

522129 61.201004° -45.560032°
Globular type of carbonatised ultramafic rock; forms a dyke-like structure here.

522130 Loose block in the area
Globular type of carbonatised ultramafic rock; show piece; highly weathered.

522131 61.200133° -45.558716°
Separate of globules from a globular type of carbonatised ultramafic rock of a layered sequence of variably textured carbonatitic rocks; intercalated with bands highly enriched in globules.

522132 61.200133° -45.558716°
Globular type of carbonatised ultramafic rock; same outcrop as 522131; sample (522132) taken from globule-rich layer, 1 m below the layer from which the separate was sampled.

522133 61.198678° -45.555065°
Globular type of carbonatised ultramafic rock; small calcite(?) veins cross-cutting the sample; feldspar veins might represent back-veining of basement material.

522134 61.198678° -45.555065°
Globular type of carbonatised ultramafic rock; layers (centimetre size) intercalated with granite.

522143 61.192524° -45.502895° (from Google Earth)
Granite to granodiorite; medium- to coarse-grained, slightly porphyritic with feldspar phenocrysts, black and white colouration.

522144 61.188068° -45.523374°
Veins of black glassy material with small needle-shaped phenocrysts intruding a mafic dyke; sample represents a separate of glassy material.

522145 61.188068° -45.523374°
6 m wide mafic dyke, strike 76°; homogeneous, fine-grained; injected by 522144.

522146 61.187960° -45.523830°
1 m wide mafic dyke, strike 58°; homogeneous, fine-grained.

522147 61.186890° -45.528450°
'Leopard'-textured dyke; W-end; 13 cm wide; strike 43°; weathered; homogeneous fine grained; probably chilled from both sides; should represent a geochemical average composition.

522148 61.187332° -45.527288°
'Leopard'-textured; center; 20 cm wide; *c.* 3 cm chill zone with internal layering; complete cross section of the dyke was sampled (Fig.23c).

522149 61.188050° -45.523580°
'Leopard'-textured; E-end; 40 cm wide; strike 85°; the dyke ends in a highly sheared area and was not observed further to the ESE.

522150 61.189590° -45.521730°
Carbonatitic intrusion; massive type; surrounded by brick red altered granite.

522151 61.189590° -45.521730°
Granitic basement close to the carbonatitic intrusion (522150), highly altered; sample taken 4-5 m from the carbonatitic rocks; sample represents a 'fresh' core of a loose block.

522152 Granite, least altered (feldspatisation).

522153 Granite, intermediate altereation (feldspatisation).

522154 Granite, most altered (feldspatisation).

522155 Granite, rounded clasts often found in volcanic breccias of the area.

522156 Carbonatitic melt intruding granitic host rock (ankerite?); secondary quartz mineralisation.

522157 Carbonatitic melt intruding granitic host rock (ankerite?); secondary quartz mineralisation filled a cavity which was most likely previously filled with calcite.

522158 61.195587° -45.499457°
Layered type of carbonatised ultramafic rock; fine-grained; typical brownish weathering colour; pyrite mineralisation observed along veins.

522159 61.195587° -45.499457°
Basement rock; dioritic, medium grained; foliated; dominant minerals: plagioclase, amphibole and minor feldspar.

522160 Beach close to 522159
Lamprophyric type of carbonatised ultramafic rock; loose block; medium grained; layered with veins parallel to the layering; mica phenocrysts; chalcopyrite mineralisation.

522161 61.192609° -45.503689°
2 m wide mafic dyke; dip 80° to 280°; sample taken from the 10 cm wide laminated chill zone.

522162 61.192609° -45.503689°
Same as 522161; sample taken from the centre, which shows internal (immiscibility?) textures, comparable to the 'Leopard'-textured.

522163 61.192609° -45.503689°
Lamprophyric type; same as sample 522160 but *in situ* here.

Geochemical data

Table 1. *Major and trace element concentrations of GGU sample no. 522147 ('leopard'-textured dyke)*

	[wt%]		[ppm]		[ppm]		[ppm]		[ppm]
SiO_2	58.16	**Sc**	12	**Zr**	1223	**Tb**	3.18	**Th**	19.8
TiO_2	0.90	**V**	9	**Nb**	196	**Dy**	18.4	**U**	6.1
Al_2O_3	15.39	**Cr**	b.d.	**Ba**	192	**Ho**	3.68	**Sn**	11
Fe_2O_3(t)	11.05	**Co**	2	**Pb**	30	**Er**	11.2	**Ge**	3.3
MnO	0.25	**Ni**	b.d.	**La**	152	**Tm**	1.77	**Mo**	7
MgO	0.47	**Cu**	20	**Ce**	301	**Yb**	11.5	**Sb**	0.3
CaO	2.25	**Zn**	270	**Pr**	36.6	**Lu**	1.6	**W**	2.2
Na_2O	5.29	**Ga**	42	**Nd**	132	**Be**	12	**Tl**	1.21
K_2O	5.72	**Rb**	226	**Sm**	23.8	**Cs**	6.7		
P_2O_5	0.18	**Sr**	95	**Eu**	2.88	**Hf**	24.8		
LOI	1.02	**Y**	102	**Gd**	19.1	**Ta**	10.8		
Total	100.7								

LOI: loss on ignition
b.d.: below detection limit