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The campsite dykes: A window into the early post-solidification history of the Skaergaard Intrusion, East Greenland ☆

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ABSTRACT

The Skaergaard Intrusion of East Greenland is cut by several generations of dykes, the earliest of which is thought to have intruded shortly after solidification of the Skaergaard. Two ~6 m wide doleritic dykes from the earliest generation are exposed in the campsite area near Homestead Bay of the Skaergaard Peninsula. One of the dykes (the Campsite Dyke) locally contains abundant xenoliths of troctolitic cumulate. The other (the Plagioclase-phyric Dyke) contains abundant large plagioclase phenocrysts. Cross-cutting relationships between the two dykes are not exposed. The median clinopyroxene–plagioclase–plagioclase dihedral angle, Θ_{cpp}, in the Campsite Dyke is 88–89.5°, whereas that of the Plagioclase-phyric Dyke is 79°. Using an empirical relationship between Θ_{cpp} and the duration of crystallisation derived from dolerite sills, the observed Θ_{cpp} suggests that the Campsite Dyke is the older of the two, intruding the Skaergaard when it had cooled to 920–970 °C. The Plagioclase-phyric Dyke intruded later, once the Skaergaard had cooled below 670 °C. The troctolitic xenoliths divide into two separate groups. Type A xenoliths have microstructures similar to those of the Skaergaard Layered Series although mineral compositions are generally more primitive than those of the exposed cumulates — this type of xenolith is likely to have been derived from either deeper levels in the Skaergaard Intrusion or from a closely-related underlying magma chamber. One Type A xenolith has mineral compositions and Θ_{cpp} consistent with an origin in LZb of the Layered Series — this xenolith contains partially inverted pigeonite, suggesting that inversion of low-Ca pyroxene in the lower part of the Layered Series took place after the intrusion had completely solidified. Type B xenoliths are characterized by plagioclase containing large and abundant melt inclusions. Comparison with the microstructures of glassy crystalline nodules from Iceland points to a multi-stage cooling history for Type B xenoliths, consistent with step-wise entrainment of partially crystallised material from a deep chamber. Type B xenoliths are very unlikely to have been derived from deeper levels in the Skaergaard chamber.

1. Introduction

The Skaergaard Intrusion of East Greenland formed during the Tertiary opening of the North Atlantic Ocean. Since the seminal work of Wager and Deer (1939) it has become one of the most important natural laboratories for understanding the progressive fractionation of basaltic magma. A suite of cumulate xenoliths in a large dyke that cuts the intrusion has the potential to provide information about the geology underlying the exposed parts of the Skaergaard chamber (Jakobsen et al., 2010). The xenoliths and their enclosing dyke present not only an opportunity to discover more about the deeper parts of the Layered Series and the associated magmatic plumbing system but, if the timing of intrusion can be established, microstructures in the xenoliths can be used to create a snapshot of the thermal profile through the Skaergaard Intrusion at the moment of entrainment and dyke injection.

In this contribution we demonstrate how it is possible to constrain the timing of dyke intrusion relative to the age of the host Skaergaard Intrusion from the geometry of three-grain junctions in the dyke groundmass. A microstructural analysis of a selection of xenoliths is then used to identify those most likely to have been derived from lower levels of the Skaergaard Intrusion, enabling us to place preliminary qualitative constraints on the cooling history of the Skaergaard.

2. Geological setting of the dykes

The Tertiary Skaergaard Intrusion of East Greenland coast comprises approximately 280 km^3 of basaltic magma intruded at the shallow crustal unconformity between Precambrian gneisses and overlying Tertiary flood basalts into a fault-bounded magma chamber (Nielsen, 2004) formed at the extending continental margin (Fig. 1). The magma crystallised as a closed system, forming three sequences of layered cumulates: the volumetrically dominant Layered Series which

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crystallised from the floor of the intrusion upwards; the Marginal Border Series which crystallised from the sides of the chamber; and the Upper Border Series which crystallised downwards from the roof (Wager and Deer, 1939). The Upper Border Series and the Layered Series meet at the Sandwich Horizon. Within each series, mineral composition varies systematically from primitive to more evolved, consistent with uninterrupted fractional crystallisation. Boundaries between mineral assemblages divide the Layered Series into the Lower Zone (LZ), Middle Zone (MZ) and Upper Zone (UZ), with equivalent subdivisions for the Marginal Border Series (Hoover, 1989) and Upper Border Series (Salmonsen and Tegner, 2013). The unexposed lower part of the intrusion is known as the Hidden Zone (HZ), and has been sampled by a 350 m drill core (the Cambridge 1966 drill core) that is thought to intersect the lower contact of the intrusion (Holness et al., 2007a; Maaløe, 1976).

The Skaergaard Intrusion is cut by two generations of steeply dipping Tertiary dykes that form part of the coastal dyke swarm of East Greenland (Brooks and Nielsen, 1978; Nielsen, 1978). The earlier of the two generations cutting the Skaergaard comprises predominantly north–south trending basaltic and doleritic dykes (Fig. 2) of the group designated THOL-2 by Nielsen (1978). The later generation is camptonitic with an approximately east–west trend (Fig. 2; Vincent, 1953) and has been designated ALK-2 by Nielsen (1978). The spatial relationships between these two generations are clearly exposed just

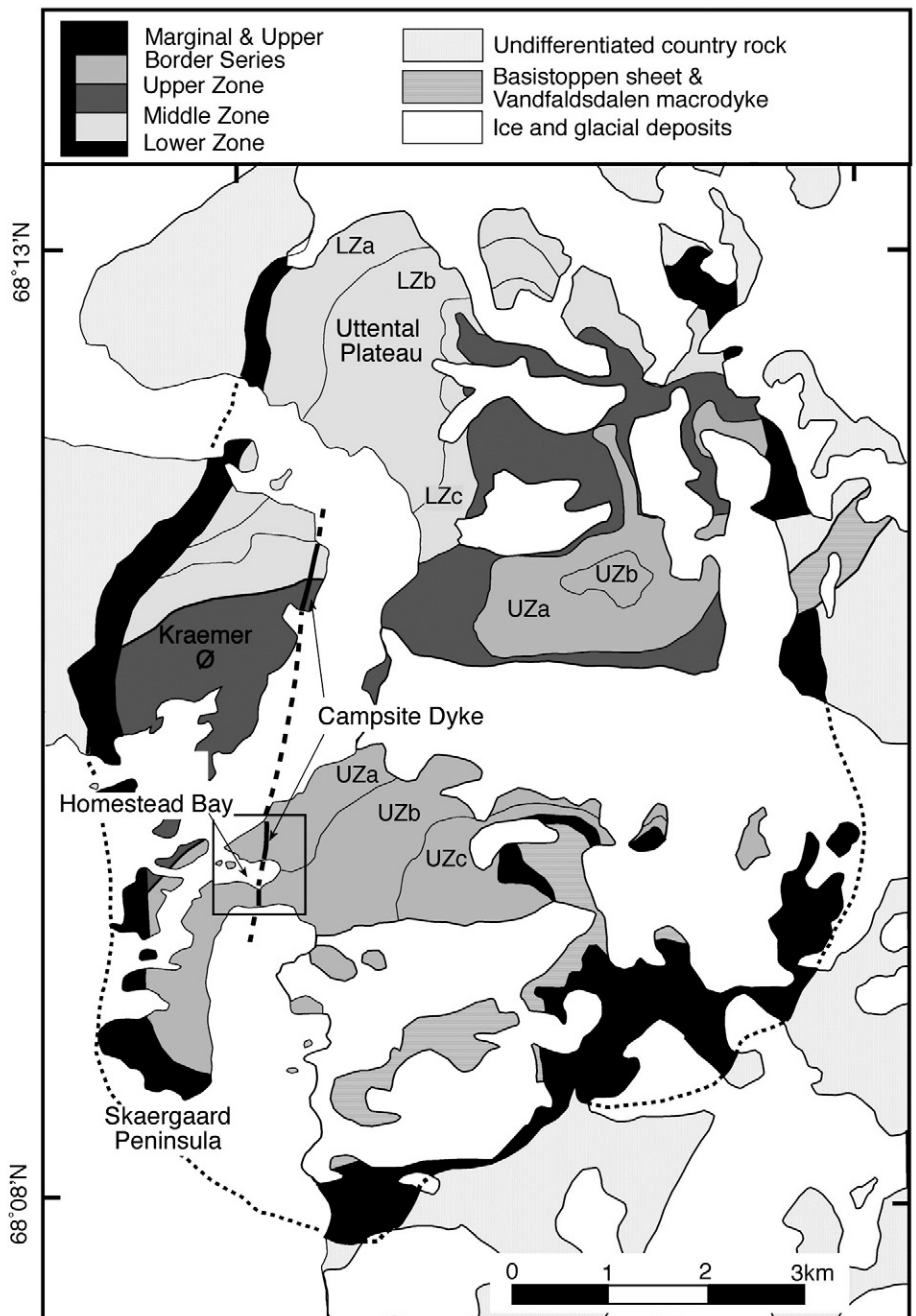

Fig. 1. Sketch map of the Skaergaard Intrusion. The square shows the area covered in Fig. 2. The Campsite Dyke is marked, including the suggested continuation on Kraemer Island. For clarity the Plagioclase-phyric Dyke is not marked.