Using rock magnetics to resolve composite magmatic state fabrics: a case study from the Younger Giant Dyke Complex, South Greenland

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Introduction
Understanding the geometry of magma chambers plays a critical role in determining the igneous petrographic processes that occur as intrusions cool. Quantitative fabric analysis methods, such as anisotropy of magnetic susceptibility (AMS), are routinely used to measure magma flow dynamics and determine the mechanism of magma transport and emplacement [1]. However, magma mushes typically experience multiple flow events, e.g., emplacement, convection and interstitial melt percolation [2]. There is thus a need to develop a more sophisticated approach to unravelling complex rock fabrics that record more than one magmatic state process.

This study uses the 1163 Ma Younger Giant Dyke Complex (YGDC) of South Greenland [3] as a case study. The YGDC is a series of giant gabbro-troctolite vertical sheet intrusions (locally up to 800 m wide) emplaced during a major rifting event 1163 Mya as part of the Gardar Igneous Province. Here we assess the magmatic history of modally layered podes of the YGDC using novel rock magnetic data sets.

Rock magnetic techniques, such as in-phase AMS (ipAMS) and out-of-phase AMS (opAMS) are defined by distinct mineralogy and crystal populations [4]. Thus using several analyses in conjunction have the potential of recording separate data sets within the same rock.

Methods
- 156 orientated block samples were collected for rock magnetic analyses. T-X experiments were conducted on representative samples to constrain magnetic mineralogy.
- AMS and T-X were conducted on an AGICO KLY-SA Kappa Bridge at the M3Ore Lab.
- Magnetic remanence characterization experiments were conducted using an AGICO LDA-5 and JRBA at the M3Ore Lab.

Petrographic Observations
- At the dyke margins, 50 m of unfoliated gabbro (Fig. 3d) transitions across 2 m to a foliated troctolite. Foliation is defined by the alignment of plagioclase, parallel to the (010) faces. Layers dip concentrically inward to a central point and are sub horizontal at the center of the dyke (Fig 2; 3e).
- Imbricate structures and ripple textures are observed in the plagioclase framework, and indicate a top-towards-centre of basin shear.
- Melt segregate lenses occur within the micro-gabbro as sheets perpendicular to host-rock contacts.
- No magmatic lineation is identified in the field.

AMS Results
ipAMS
- 80% of ipAMS foliations within the foliated troctolite are oblate (Fig 4), and parallel to the orientation of plagioclase crystals. ipAMS is carried by cumulus Ti-magnetite (Fig 3c, i).
- 85% of ipAMS lineages plunge towards the centre of the basin, with deviations to N-S & E-W present in others (Fig 2).

opAMS
- opAMS preserves dominantly triaxial-prolate fabrics (Fig 4).
- Samples cross-cutting melt segregations within the marginal gabbro exhibit differing in IP and OP AMS (e.g. 042, Fig 2).
- 75% of opAMS lineages plunge towards the centre of the basin, and steepen as ipAMS foliation shallow.

Interpretations
- Imbricate and ripple structures invoke a dynamic flow origin of the foliation. This is supported by consistent ipAMS lineations towards the centre of the pod.
- There is a component of compaction observed in ipAMS (Fig. 4).
- opAMS may record single-domain magnetite clusters which occur along clinopyroxene (a purely interstitial) cleavage planes. (Fig 4)
- We propose AMS is recording fabrics from two distinct flow events: 1) convection above the foliated pods, leading to viscous deposition in the boundary layer, 2) trapped interstitial melt then migrates around the framework due to post-depositional compaction.

References