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

Lot Koopmans and William McCarthy
University of St Andrews, School of Earth and Environmental Sciences, United Kingdom of Great Britain – England, Scotland, Wales (lk55@st-andrews.ac.uk)

Understanding the geometry of magma chambers plays a critical role in determining the igneous petrogenic 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. However, magma mushes typically experience multiple flow events; e.g. emplacement, convection, and interstitial melt percolation. There is thus a need to develop a more a sophisticated approach to unravelling complex rock fabrics that record more than one magmatic state process. This study uses novel rock magnetic datasets to untangle the evolution of the 1163 Ma Younger Giant Dyke Complex (YGDC) of SW Greenland, a multi-sheeted troctolite dyke system that attains widths up to 800 m and encloses several evolved and/or modally layered ovoid pods.

Field results identify that ovoid pods occur in the thickest dyke segments. Several pods are defined by gently inward dipping modal layers and/or a parallel mineral foliations, and in-phase AMS magnetic foliations lie parallel to the observed field fabrics. Critically, imbricated plagioclase crystals record a magma transport direction toward the center of each pod, and this observation is substantiated by in-phase AMS lineations that plunge down dip of the foliation and shallow toward the center of each pod. These observations are interpreted to show gravitational settling under a convective flow regime.

In addition, 66% of out-of-phase AMS fabrics are non-parallel with in-phase AMS results. Out-of-phase AMS is a relatively new technique and is thought to reflect anisotropy controlled by a restrictive group of ferromagnetic minerals such as single domain magnetite and pyrrhotite. Out-of-phase lineations in layered pods are relatively steeply inclined and do not shallow towards the center, we therefore hypothesize that these lineations record a late stage filter-pressing process within the crystal mush. To test this hypothesis, anisotropy of anhysteretic remanent magnetism (AARM) data were collected from 15 samples. Results show that the AARM and out-of-phase AMS tensor axes are parallel, indicating that the sub-fabric detected by out-of-phase AMS is normal and most likely controlled by single domain magnetite.

Our results show that the application of rock magnetic techniques is effective in unravelling magma convection fabrics from later melt migration fabrics in mushy magmas.