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What do variations in magnetic fabrics across the breadth of sills tell us about emplacement history?

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Understanding the factors that influence magma transport and emplacement within the crust is vital for understanding the behaviour of volcanic systems. Studying extinct volcanoes where erosion has exposed their plumbing systems provides insights into a range of stages of magma movement, however unravelling which parts of the transport history are preserved is challenging. This study aims to understand how magma flow varies over small distances across the breadth solidified intrusions by using a high-density sampling regime to investigate smaller scale variations in flow fabrics.

Fieldwork was conducted on well exposed sills near Inver Tote, Isle of Skye, Scotland. Here 6 to >15 m thick olivine dolerite sills from the Little Minch Sill Complex (c.60 Ma) have intruded Jurassic sediments. Sampling was undertaken on the 6 m sill at 50 cm intervals for anisotropy of magnetic susceptibility (AMS) and anisotropy of anhysteretic remanent magnetisation (AARM) studies and at 1 m intervals for petrological analyses. When these results are combined, insights into magma transport and emplacement can be determined.

Results suggest that AMS tensors have a K1 axis (long axis) parallel to the sill length, originating from ferromagnetic grains with hysteresis properties suggestive of multi- to pseudo-single domain low-Ti titanomagnetite. The orientations of the K1 axis rotate around the vertical axis (K3, shortest axis) from a N-S orientation to NE-SW orientation with increased distance from the sill margins, remaining parallel to sill length. At the lower contact AARM K1 axes are parallel to AMS K1 suggesting normal fabric and magma flow in a N-S orientation which indicates the Cullin Hills complex in southern Skye being the magmatic source. With increased distance from the margin the AMS and AARM tensors become more oblique to each other suggesting anomalous fabrics and the possible reorientation of magma flow direction. This may be due to flow localization and the development of magma conduits with increased distance from the source.

Detailed sampling and analysis indicate that crystalline and magnetic fabrics associated with magma flow within intrusions suggest flow may be highly variable over small distances. Subsequently, understanding the implications these signals have on interpretations of magma flow dynamics may require reconsideration.