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A comparative study between magmatic and magnetic fabrics with flow indicators to infer magma flow in sills

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Structures that form in relation to the process of magma intrusion were studied in 14 Karoo dolerite sills along the KwaZulu-Natal North Coast, South Africa, as these structures may be used to infer a sense of magma flow. Predicting magma flow within small tabular intrusions through field observations is a useful technique however the reliability of these magma flow indicators as predictors of magma flow is not well explored in sills. The magma flow indicators studied encompass bridge structures, intrusive steps, magma lobes, ropy-flow structures and elongated vesicles. The magma flow directions (or orientations) implied by the structures observed in the field were compared to the magmatic and magnetic fabrics obtained from Shape Preferred Orientation (SPO) and Anisotropy of Magnetic Susceptibility (AMS) analyses respectively. The fabrics were determined as being accurate representations of the magmatic fabrics and were used as a proxy for magma flow. For numerous intrusions the SPO and AMS fabrics orientations were comparable to the magma flow directions/orientations implied by the magma flow indicators. However the AMS results more commonly coincided with the magma flow indicator orientations than with the SPO results.

The relationships between the fabrics and the structures observed in the field were used to elucidate a hierarchy of structures, which could be used in future studies to accurately predict a sense of magma flow in sills. Structures that were formed by the intrusion of initially individual sill segments, which then became merged into one intrusion, may not have adequately preserved the sense of magma flow in the coalesced intrusions. This was evidenced here by merged magma lobes and merged sill segments where bridge structures were preserved. For both examples the fabrics inferred a magma flow sense perpendicular to these structures. This scenario could be possible if numerous overlapping segments became merged and the already intruded magma was able to flow between these sill segments. These fabrics have thus preserved a late stage fabric not representative of the initial magma propagation direction. The magma flow sense within a sill that is used to infer the magma source should thus primarily be determined from the structures that formed in response to the initial propagation of the sill segments. Ropy-flow features near the upper contact of sills were defined as accurate indicators of magma flow but could be representative of localised zones of magma movement. Bridge structures that were isolated across the intrusion, suggesting minimal sill segment linkage, were interpreted as the most accurate indicators of magma flow, which was inferred as parallel to the long axis of the structure.