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The role of microstructures in magnetite on magnetic anomalies, a case-study from the Stardalur volcano, Iceland

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A positive magnetic anomaly (27000nT above background, (Kristjansson, 2013)), is centered over the Stardalur Volcano in Iceland. Q values on average are > 22, which indicates the anomaly is dominated by remanence. The rocks are unusual in that the average NRM is 61 A/m, 15 times stronger than average Icelandic basalts (Kristjansson, 2013). To explore why these rocks carry such a large magnetization an extensive sample set from a drill core traversing 138 m of the Stardalur lava flows has been analyzed by optical and scanning electron microscopy (SEM) combined with detailed rock magnetic properties measurements. High and low-temperature magnetic measurements suggest that magnetite is the main magnetic carrier. These rocks contain magnetite with extensive oxidation-exsolution of ilmenite with lamellae from the micron to nm scale

To characterize fully the geometry of the lamellae a slice-and-view procedure on a dual beam focused ion beam SEM is used. The particle size and oxidation-exsolution structures are then used to create a three-dimensional finite-element mesh of the grain. These are loaded into the MERRILL micromagnetics software to calculate realistic magnetization structures.
Domain states of the magnetite with different morphologies are investigated. Magnetite with μm to nm size lamellae are modeled to evaluate if the paramagnetic ilmenite lamellae are thick enough to subdivide the large magnetite grains into smaller areas which would result in single domain to pseudo-single domain behavior.

Using the true geometry of the grains and exsolution micro-structures allows for a full evaluation of the effect of the shape, size, and spacing on the magnetic properties of the particles and interactions. Understanding the nature and geological conditions of formation for the microstructures is an important key to further our knowledge on remanence dominated anomalies.