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3D modeling of high-resolution magnetic microscopy data of a serpentine-magnesite sample from Modum, southern Norway

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Scanning magnetic microscopy is a high-resolution technique for mapping the vertical component of the magnetic field over a planar surface of a rock sample. The technique offers a spatial resolution down to tens of micrometers, which can be used to investigate discrete magnetic mineral grains, or magnetic textures and structures. We present thin section magnetic scans of a serpentine-magnesite sample from Modum, in southern Norway. Across the selected thin section is a 2 to 6 millimeters wide magnetite grain surrounded by serpentine and carbonate.
The instrument used here is equipped with a room-temperature magnetic tunnel junction sensor and has Helmholtz coils surrounding the sample space enabling scanning in near field-free conditions, or alternatively in a controlled magnetic field. The ability to conduct measurements in the presence of a known field allows direct observation of behavior of samples in fields similar to that at the surface of the Earth. Based on its size and purity, the magnetite in the Modum sample is predicted to exhibit multidomain behavior and contribute to induced anomalies in the Earth's crust.
Scans were acquired in field-free conditions to characterize the magnetic remanence field, as well as in fields of 40μT applied in the plane of the sample, parallel to the trend of the magnetite grains. Additional magnetic scans were acquired after sample demagnetization in inducing fields of varying intensity and orientation. We applied a forward modeling approach on the magnetic data acquired over the thin section. Modeling consists of uniformly magnetized 3D polygonal bodies whose geometry is constrained by the thickness of the thin section, and by the shape of the magnetite grains. We used the induced field anomalies to characterize the extent of the individual polygons inside the magnetite, and then we modeled the natural remanent magnetization (NRM) direction in each polygon to fit the magnetic remanence field.
3D magnetic modeling is used to determine the NRM directions and intensities of discrete magnetic sources within the magnetite. Modeling suggests there are homogeneously magnetized areas within the magnetite grains with variable NRM directions.