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Magnetic Interactions: Love thy neighbour?

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The last decade has seen a huge increase in the use of naturally occurring magnetic minerals to help us discover the evolution of the Earth and its changing environment. In particular, the ability of natural systems to record geologically stable and meaningful magnetization vectors in the Earth's weak magnetic field is of fundamental importance. Without this ability we would know very little, for example, about the evolution of the geodynamo and the movement of tectonic plates, and would be unaware that the geomagnetic field reverses. In addition, by magnetically examining recent and historical environmental systems it is possible to determine how the climate of the Earth has behaved in the past; such studies make an important contribution to the understanding of how humans now affect the Earth. In fact, the study of natural magnetic systems has been found to be a powerful tool in many other branches of Earth sciences, e.g., accurately dating sedimentary sequences, identifying fragments of continental crust transported very large distances along continental margins, contributing to the understanding of processes of deformation in mountain building events and differentiating between modes of eruption of violent volcanoes.

Yet our interpretation of palaeomagnetic and environmental observations rely on an incomplete understanding of the magnetic signals of rocks and sediments, which generates uncertainty in the interpretation of magnetic proxies and the measured paleomagnetic directions and intensities for all samples except those that contain small, ideal magnetic particles. Ideal recording particles are small and have magnetically homogeneous isolated structures, and are termed single-domain (SD) grains. However, in reality, most rocks and environmental systems are magnetically non-ideal being dominated by larger magnetically non-uniform particles that are commonly affected by magneto-static inter-grain interactions. The magnetic behaviour of such systems is highly non-linear and poorly understood. Over the past decade, I have examined a variety of methods and approaches that attempt to resolve these issues. Primarily, looking at the physics behind inter- and intra-magnetostatic interactions in real magnetic systems and their effect on recording fidelity, and the ability to develop protocols for experimentally identifying such non-ideal behaviour, including verification on natural systems.