UNDERSTANDING THE ROLE OF LOW PRESSURE SHOCK WAVES ON THE FIDELITY OF MAGNETIC RECORDING IN ROCKS AND METEORITES.

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Palaeomagnetic recordings by rocks are routinely used to solve problems in the Earth and Planetary Sciences. Many of these rocks and meteorites will have experienced significant pressures due to a wide range of processes, from tectonics through to earthquakes through to impacts. The theory for the effect of stress on palaeomagnetic signals has for much of the last 70 years been based on theories for uniform magnetic (single-domain, Fig. 1a) particles (< 100 nm for magnetite). These theories predict that stress only becomes important for very high pressures, i.e., > 10-100 GPa. Consequently, the effect of stress on palaeomagnetic recording fidelity has largely been ignored.

![Micromagnetic solutions for metallic iron particles:](image)

**Figure 1.** Micromagnetic solutions for metallic iron particles: a) a small grain with a uniform (single domain or ‘flower state’) magnetisation, and b) a slightly larger particle showing a non-uniform vortex structure. From Muxworthy and Williams (2015).

Recent developments in numerical micromagnetic models (Nagy et al., 2019) and nanometric magnetic imaging (Almeida et al 2016) have shown that stable magnetic remanences in most rocks are recorded by grains > 100 nm that contain non-uniform magnetic structures (vortex structures, Fig. 1b), not uniform magnetic structures as previously thought. We do not know the effect of stress on these non-uniform magnetic structures and their palaeomagnetic recording fidelity. There is some early experimental evidence to suggest that non-uniform magnetic structures are affected by low pressures. In a key paper, Nagata (1971) demonstrated magnetic dependency on pressures < 100 MPa in synthetic samples. Given the difficulties in synthesising dispersed uniform single-domain particles, it is very likely that some of his samples contained non-uniform magnetic structures. There have not been any follow up studies to those of Nagata (1971), as subsequent pressure experiments have focussed on high-energy impact events, where although high pressures are generated, impact-induced heating dominate the magnetic response. The key outstanding question is now: what effect does stress have on the palaeomagnetic recordings of grains with non-uniform magnetic structures, when the strain rate is low, i.e., in all geological processes apart from impacts?

As a pilot study for this PhD project we have made the first numerical calculations on the effect of compressional linear stress on the magnetic response of magnetic particles structure. They show a sharp contrast in the response of uniform and non-uniform magnetic structures, and though far from exhaustive, clearly show a pressure dependency at low pressures < 50 MPa for non-uniformly magnetised particles, i.e., similar to the findings of Nagata (1971). Even at these low pressures our models demonstrate that remagnetisation is possible, indicating that that findings have significant implications for many palaeomagnetic studies and requires urgent investigation. These initial models are only the start.

It is proposed that the student will investigate the effect of stress using a state-of-the-art existing finite-element (FEM) numerical micromagnetic model (Nagy et al, 2019). The aim is to fully understand the effect of stress on natural magnetic systems. Knowledge of a computer programming language is essential.

**References**


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