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Understanding magnetic remanence acquisition through combined synthetic sediment deposition experiments and numerical simulations

Dario Bilardello (1), Josef Jezek (2), and Stuart Gilder (1)

(1) Department of Earth and Environmental Sciences, Ludwig-Maximilians University, Germany (bilardello@geophysik.uni-muenchen.de), (2) Department of Applied Mathematics and Computer Sciences, Charles University, Czech Republic

Laboratory redeposition experiments have been carried out for decades to understand how sedimentary rocks acquire their remanent magnetizations. These experiments have used natural sediments (often prepared from disaggregated rocks) or synthetic sediments where magnetic minerals (often synthetic) were dispersed in natural quartz-sand, mud or an artificial mixture. Laboratory experiments of vertically falling particles have shown that the net effect of a depositional remanent magnetization is to shallow the remanent inclination with negligible misalignment in declination . Experiments have also revealed a field dependence of the magnetization, which is orders of magnitude lower than the saturation remanence.

Experiments performed to date have yielded extremely heterogeneous results because of the heterogeneous nature (size, shape, magnetic properties, surface charge, etc.) of the particles. Such experiments therefore are limited in answering basic questions that concern the fundamental processeses involved in depositional remanence magnetization (DRM) acquisition. Here, we report redeposition experiments conducted using spherical glass beads of well-constrained size distribution and composition, and well-characterized magnetic properties given by magnetite and other iron impurities within the glass. Experiments are carried out in glass tubes of different diameters placed in controlled magnetic fields.

Our results confirm the field dependence on the magnetization and the fact that the DRM acquired experimentally is lower than saturation. The field dependence of the inclination error is also confirmed. A completely new result of our experiments is a tube-size dependence of the inclination error that is related to the sediment concentration within the tubes. This, in turn, indicates a dependance of the inclination error on the sediment load/burial depth or the sedimentation rate. Other new outcome of our experiments is the certainty that inclination shallowing can be caused by spherical particles only, which up to now was only postulated.

Numerical simulations indicate that for our experiments DRM should be $\sim$10 times lower than the saturation remanence and predict that for spherical particles, rolling of the smaller grains as they settle on the larger grains can produce a substantial shallowing of the inclination and lowering of the remanence. Particle interactions during settling also contributes to significant misalignment relative to the ambient magnetic field. Both 2D and 3D models of the effect of particle rolling and interactions on remanence intensity and inclination are presented. Model results indicate that rolling of the particles may lower the remanent intensity by up to 50% while particle interactions by a further 0.3, bringing the simulations in close agreement to the experimental results.