Under Pressure: Meteorite paleointensities may be underestimated due to pressure demagnetization

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The study of meteorites can yield valuable information about the physical environment within the early solar system. Paleomagnetic methods can help estimate the strength of magnetic fields present in the solar nebula and during the onset of planetary formation. Such paleointensity measurements require an unaltered natural remanent magnetization. However, most meteorite magnetizations are likely to have been altered by at least one major shock event. Even exposures to low (<5 GPa) shock or static pressures are known to alter magnetic properties and remanence without leaving any petrographic evidence. Consequently, if such pressure-induced changes are unrecognized, then they may contribute to erroneous paleointensity estimations.

This study investigates the influence of hydrostatic and non-hydrostatic stress on magnetizations at pressures < 2 GPa, corresponding to the lowest shock stage classification (S1) in meteorites. Thermal remanences were imparted to natural samples containing titanomagnetite, similar to the magnetic carriers found in achondritic meteorites. Thellier-style paleointensity experiments were conducted under ambient conditions or after pressure cycling. Room temperature hydrostatic or non-hydrostatic pressures of 0.6, 1.2 and 1.8 GPa were applied with the maximum pressure axis parallel or perpendicular to the remanence direction.

Thellier-style experiments on un-pressured samples recovered the laboratory field accurately. Pressure cycling preferentially demagnetized grains with low unblocking temperatures. Hydrostatic pressure demagnetization is directly proportional to a reduction in paleointensity. Non-hydrostatic pressure demagnetization is more efficient, resulting in a substantial underestimation of the paleointensity. Considering that meteorites classified as unshocked may have experienced pressures up to 5 GPa, paleointensity estimates derived from meteorites should be considered as minimum values.