THERMOREMANENT MAGNETISATION RECORDED DURING IMPACT-INDUCED COMPACTION EXPERIMENTS ON SYNTHETIC CHONDRITIC METEORITES

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Introduction: Carbonaceous chondrites (CCs) are among the most primitive Solar System objects on Earth. These meteorites are understood to have originated from undifferentiated planetesimals, meaning their unmelted and relatively unaltered nature since accretion has allowed them to retain a record of the earliest processes in the formation of the Solar System.

Some CCs have been found to host an ancient natural remanent magnetization (NRM) that forms a planar magnetic fabric, suggesting the remanence was recorded during an impact-induced event [1]. Numerical modelling of impact compaction of chondritic meteorites has shown that low-intensity (<2 GPa) impacts into highly porous chondritic precursor material [2] can generate final states with crystallographic matrix fabric and porosities consistent with recovered chondrites [3]. Moreover, in such impacts, there is a strong thermal dichotomy, where the temperatures in the compacted porous matrix are far greater than the temperatures experienced by chondrules. This means that magnetic carriers present in the matrix could reach high enough temperatures and record a 'snapshot' of an ambient magnetic background field, such as the one that existed throughout the planet-forming regions of the Solar Nebula [1, 4].

Experiments: To determine whether the remanence hosted in chondrite matrix material can be recorded during an impact event, we developed shock recovery experiments with synthetic chondrites under controlled magnetic conditions. The light-gas gun experiments imparted a planar shockwave with a peak pressure around 1 GPa through synthetic analog chondritic precursor material in the presence of a magnetic field which we varied the strength of between 0-150 µT, in line with estimates of the strength of the Solar Nebula field [4]. The analog samples were a silica-magnetite-hematite powder mixture with a bulk porosity ~70%, consistent with chondrite precursor material [3].

Modeling: We used the iSALE-2D shock physics code [5, 6] to better understand the PT conditions experienced by the sample and capsule during our impact experiments. Compaction of matrix porosity was calculated using the $\varepsilon - \alpha$ porous-compaction model [6, 7]. Our iSALE simulations were also used to optimize the experimental parameters, predicting average peak temperatures of 390°C and an average peak pressure around 1.35 GPa, consistent with inferred impact compaction of carbonaceous chondrite Allende.

Results: Our magnetic results were measured using an ORION sample magnetometer [8]. We have identified a strong NRM in our recovered samples. The thermal demagnetization profile (Fig. 1), reveals the remanence is a TRM with a broad peak, centered just below 400°C, consistent with the peak temperature predicted by the iSALE simulation of the experiment. We have also found a strong planar fabric, confirming the shock-induced origin of the NRM imparted onto the sample.

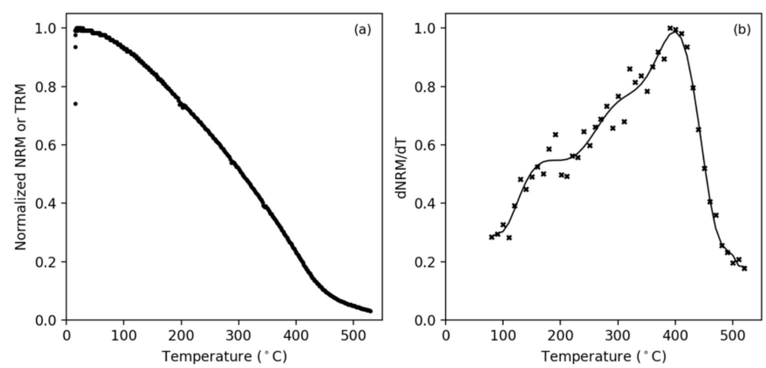

Figure 1: Thermal demagnetization profiles for a synthetic chondrite produced during a ~1 GPa impact experiment in a 150 µT magnetic field. Measurements were taken at 10°C intervals and the y-axis has been normalized by the peak paleointensity. The normalized demagnetization profile (a) shows a steady decline until almost all the remanence is erased by 500°C. The differential profile (b) shows an increase until 400°C where the sample steeply demagnetized, diagnostic of a TRM present that is unstable beyond this temperature.

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