RECOVERING THE PRIMORDIAL IMPACT HISTORY OF CHONDRITES IN UNPRECEDENTED DETAIL USING MASSIVE EBSD DATASETS

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Introduction: Chondrites are routinely classified in terms of shock level based on principles outlined by and modified from shock calibration studies of Stöffler *et al.* (1991). These studies characterise shock assuming parent bodies had material properties similar to extant meteorites [1], but primordial parent bodies accreted with significantly more porosity. Recent modelling has sought to understand the effects of shock and compaction of porous targets during early planetary evolution [2, 3]. Unique textures at the meso- and micro-scale are predicted, which predate the traditionally-characterised 'shock level' features described in meteorites. In this study we investigate compaction in the Allende CV3 chondrite using Electron Backscatter Diffraction (EBSD) mapping at unparalleled scale and resolution.

Methods & Materials: An 11.51 mm^2 area of Allende was mapped using EBSD with a step-size of 0.5 μm resulting in 46 million data points. The scale of this map enables the use of a novel approach– subdividing the map into 150 x 150 μm grid squares, we analysed fabrics in each area individually, allowing visualisation of shock wave interaction with the primordial aggregate. Here we consider a 0.972 mm^2 region of interest (5,426,808 data points) where fine-grained matrix encompasses a chondrule. The crystallographic preferred orientation of poles to <100>, <010> and <001> in matrix olivines were visualised for each grid square using equal-area, lower-hemisphere plots.

Results: A strong point maxima alignment of <001> (the shortest axis) normal to the chondrule margin is seen to the right of the chondrule. This is due to a grain 'flattening' with elongate grains aligning in the shortest dimension against the chondrule, and no preferential alignment of <100> and <010>, generating a moderate fabric. To the left, this fabric is absent.

Discussion & Conclusions: Allende is assigned shock level S1 due to the absence of 'traditional' shock features [4]. However, the asymmetric pattern of flattened matrix grains is consistent with model predictions of mechanical strain during earlier impact events, which cause compaction of the parent body from a bimodal mixture of initially highly-porous matrix and zero porosity chondrules. Furthermore, modelling shows that the asymmetric development of the fabric can be used as a 'way up' indicator with respect to the impact: the impact direction was oblique to the sample plane, and the shock wave propagated from the lower-right of the chondrule [2, 3]. The absence of a fabric to the left is due to chondrule 'shielding'. This approach should allow us to recover the early impact histories of chondrites in great detail, by using extant fabrics to model the response of primordial aggregates to the earliest compressive impacts.

References: [1] Stöffler D. *et al.* 1991. *Geochimica et Cosmochimica Acta*, 55(12):3845–3867 [2] Davison T. M. *et al.* 2010. *Icarus*, 208(1):468–481 [3] Bland P. A. *et al*. 2014. *Nature Communications*, 5:5451 [4] Scott. E. R. D. *et al*. 1992. *Geochimica et Cosmochimica Acta*, 56(12):4281–4293.