3D MICROSTRUCTURE AND CALCITE TWIN STRESS ANALYSES IN THE MURCHISON (CM2) METEORITE

P. Lindgren and M. R. Lee. School of Geographical and Earth Sciences, University of Glasgow, E-mail: E:Mail: paula.lindgren@glasgow.ac.uk

Introduction: The internal microstructure of a meteorite can provide important insights into its regional deformation history and the parent body environment within which it has resided [1, 2]. The CM2 carbonaceous chondrites contain a few volume percent carbonates, mainly calcite, which formed by parent body aqueous alteration [3], and may also be used to explore the deformation. Calcite is widely used in terrestrial structural geology since it deforms to produce twins whose orientations are geometrically related to the c axes of the host calcite and to the principal axes of stress [4]. The samples used in terrestrial studies contain abundant calcite and the twins are formed by low strain rates during tectonism. However, only small samples of carbonaceous chondrites are available for analysis, the calcite is rare, and the twins are likely to be impact induced [1, 5]. To test the applicability of calcite twin stress analyses to carbonaceous chondrites we carried out a 3D microstructural investigation on a fragment of Murchison (CM2). The fragment was embedded in resin and polished in to a block 8 × 7 × 5 mm in size. The orientation of calcite twins and the principal axes of stress were determined via SEM imaging and electron backscatter diffraction (EBSD) analyses on three sides of the block oriented normal to each other.

Results and discussion: SEM imaging of the three sides of the block shows that the internal microfabric, i.e. the alignment of deformed chondrules and the foliation of the matrix components, links up in 3D as expected. EBSD analyses show that aragonite found on one side is oriented with its c axis in the same plane as the microfabric, implying that the aragonite and the microfabric formed under the same uniaxial stress regime. The calcite grains on the three sides have a weak crystallographic preferred orientation, but here the data are limited with a broad scatter. These calcite grains also have $\{\bar{1}018\}$ e-twins and preliminary results from two sides are somewhat scattered, but still suggest that the calcite twin stress analyses are consistent, i.e. the principal axes of stress (compression and extension) are connected in 3D. Results also reveal that multiple phases of twinning are present in at least one of the calcite grains, where one set of twins is offset and cross-cut by a second set of twins, indicating at least two deformation events. Some of the calcite grains exhibit a post-twinning subgrain microstructure with low/high angle boundaries (all <20° misorientation). Other calcite grains are aggregates of individual calcite crystals with high-angle grain boundaries, which grew in different orientations prior to twinning. Twins in these aggregate grains yield clustered principal axes of stress, which confirms that calcite twin stress analyses are a robust method to analyze deformation of carbonaceous chondrites and other calcite-bearing meteorites. Further work on the microstructures is to be complimented with 3D X-ray tomography.

References: [1] Lindgren P. et al. 2011. *Earth and Planetary Science Letters* (in press) [2] Trigo-Rodriguez J.M. 2006. Geochimica et Cosmochimica Acta 70: 1271-1290 [3] Brearley A.J. 2006. *Meteoritics and the Early Solar System II.* The University of Arizona Press, Tuscon [4] Turner F.J. 1953. American Journal of Science 251: 276-298 [5] Brearley A. et al. 1999. *30th LPSC*, Abstract# 1301