TRACING THE SHOCK HISTORY OF CARBONACEOUS CHONDRITES USING CALCITE TWINS

P. Lindgren and M. R. Lee. School of Geographical and Earth Sciences, University of Glasgow, Glasgow G12 8QQ, U.K. E-mail: paula.lindgren@glasgow.ac.uk.

Introduction: Mechanical twinning in calcite forms instantly via shear stress along the crystallographic planes: e = {-1018}, f = {-1012} and r = {10-14} [1]. The shear stress can be static, as during uniaxial compaction, or essentially instantaneous as during impacts. Calcite twins in carbonaceous chondrites are most likely formed via impact "gardening" [2, 3] and form at relatively low shock pressures, i.e. in the region of ~100 MPa [4]. The e-twins are the most easily activated, followed by f- and r-twins at higher pressure [5]. We are carrying out a survey of calcite twinning in a suite of CM2 carbonaceous chondrites including LON 94101, Murray, Murchison and MET 01072, to assess whether calcite twin morphology (e.g. complexity, density, thickness, spacing etc) can provide new insights on their shock magnitude and history.

Methods: The calcite grains were imaged and analyzed using a FEI Quanta 200F field emission environmental scanning electron microscope (SEM) that is equipped with an EDAX-TSL electron backscatter diffraction (EBSD) system running TSL OIM 5.2 software. The Hikari high speed EBSD camera was used to capture Kikuchi patterns so that the crystallographic orientations of calcite grains and their twins could be determined. For more detailed examination of calcite twins, foils were cut from grain surfaces using a FEI DualBeam focused ion beam (FIB) instrument and then studied using a FEI T20 transmission electron microscope (TEM).

Results and Discussion: Preliminary results show that calcite grains in all of the samples studied are twinned, and that the twins occur on the {-1018} planes and are therefore e-twins. The e-twins may form on one, two or all three of the {-1018} planes [6]. The calcite grains in LON 94101 and Murray are twinned in only one orientation. Murchison on the other hand, contains some calcite grains with twins present in two different orientations, where one twin-set cross cuts and displaces an earlier twin-set, indicating a more complex deformation history. Current work is focusing on MET 01072, which has a foliated texture and flattened chondrules [7] indicative of being exposed to a higher pressure than the previously analyzed CM2s. Twin microstructures in this meteorite will provide an important benchmark for calibrating the pressures experienced by the other less highly shocked CM2s.

Acknowledgements: We are grateful to NASA-JSC for loan of thin sections, Peter Chung and William Smith at Glasgow University for skilled technical support and to STFC for funding.

References: [1] De Bresser J. H. P. & Spiers C. J. 1997. *Tectonophysics* 272:1–23. [2] Lindgren P. et al. 2011. *Earth and Planetary Science Letters* 306:289-298. [3] Brearley A.J. et al. 1999. Abstract#1301. 30th Lunar and Planetary Science Conference. [4] Lindgren P. et al. 2012. Abstract#1934. 43rd Lunar and Planetary Science Conference. [5] Langenhorst et al. 2003. *In:* Davison et al. (editors). High-pressure compression of solids V: Shock chemistry with applications to meteorite impacts. [6] Prior D.J. et al. 1999. *American Mineralogist* 84:1741-1759. [7] Antarctic Meteorite Newsletter 25(2). 2002. JSC. Houston.