UNDERSTANDING THE DEFORMATION HISTORY OF MURCHISON (CM2): CLUES FROM CALCITE TWIN STRESS ANALYSIS AND HIGH RESOLUTION X-RAY COMPUTED TOMOGRAPHY

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Introduction: The Murchison CM2 carbonaceous chondrite contains a microfabric as revealed by the preferred orientation of matrix phyllosilicates [1] and the foliation of dark inclusions [2]. Olivine microstructures show that Murchison has a shock stage of S2 [3], and so this shock stage may also be responsible for the microfabric. Here we have sought to understand better the mechanisms of deformation and to assess whether there is evidence for multiple deformation events by combining two techniques: (i) calcite e-twin stress analysis, which is a widely applied method to infer stress orientations in terrestrial rocks [e.g. 4, 5], and high resolution X-ray computed tomography (XCT).

Methods: A small irregular sample of Murchison was embedded in a block of resin and polished to colloidal silica level on three perpendicular faces. The final size of the block was 9×7×6 mm. For calcite e-twin stress analysis the crystallographic orientations of calcite grains and their e-twins on each of the three polished sides (A, B & C) was determined by electron backscatter diffraction using a FEI Quanta 200F field emission scanning electron microscope following the method of [6]. High resolution (XCT) was also performed on the same sample using a Metris X-tek XTH225 scanner at the Manchester X-ray Imaging Facility. Chondrules were segmented from the tomography volume using the Avizo™ software. The preferred orientation of the chondrule population was then calculated using the Blob3D software [7].

Results and Discussion: Calcite e-twin stress analyses of 23 twinned calcite grains from A, B & C show that the greatest intensity of stress was oriented semi-vertically to the plane of side B. The XCT data shows that the chondrules are flattened and aligned with a preferred orientation of tertiary axes (greatest stress) also oriented semi-vertically to side B. Work is ongoing to more precisely constrain the directions of stress related to the e-twins and chondrules. The semi-vertical coincidence of axes of greatest stress as measured by calcite twins and chondrules could be a result of that flattening and calcite twinning took place during the same deformation event, e.g. shallow crustal compaction or impact "gardening". Impacts are the most likely explanation, since the static pressure required to generate calcite e-twins is unlikely in a shallow crustal setting of the parent body [6].

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