Evidence of micro-faulting within ureilite Miller Range (MIL) 090980

H. Lowe[1*], L.Daly[1,2,3,4], M.R. Lee[1]. [1]School of Geographical and Earth Sciences, University of Glasgow, UK, (H.Lowe.1@research.gla.ac.uk) [2]Space Science and Technology Centre, School of Earth and Planetary Sciences, Curtin University, Australia. [3]Australian Centre for Microscopy and Microanalysis, The University of Sydney, Australia. [4]Department of Materials, University of Oxford, UK.

Introduction: The ureilites are the second largest group of achondrite meteorites. The mineralogy of the ureilites is typically comprised of olivine and pyroxene with some minor carbonaceous phases, including diamond and graphite. The unusual abundance of diamond/graphite (up to 8.5 wt% [1]) in the group has been used to attempt to constrain the conditions of the ureilite parent body (UPB) with some authors hypothesizing the presence of diamonds is due to a large parent body with static high pressures [2]. Other authors believe the diamonds are a consequence of high shock pressures from a large impact that may be responsible for the ultimate break up of the UPB [3]. Olivine is a particularly well constrained recorder of both tectonic and shock deformation [4-5]. Thus, studying the deformation microstructures of olivine within ureilites could constrain the origin of diamonds further, especially with regards to shock and breakup of the UPB. MIL 090980 is a ureilite meteorite that contains equigranular and aggregate olivine crystals up to 1 mm in size with core compositions of Fa_{22}, surrounded by carbon rims [6]. This sample was chosen for this study as it has not been explored in great detail compared to other ureilites. Here we used quantitative petrological analysis using electron microscopy techniques to provide new evidence of the deformation history of the ureilite parent body.

Methods: MIL 090980 was analysed on a Zeiss sigma variable pressure scanning electorn microscope (SEM) at the ISAAC facility at the University of Glasgow. Energy dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction (EBSD) data were acquired to identify the chemical, mineralogical and structural characteristics of the sample.

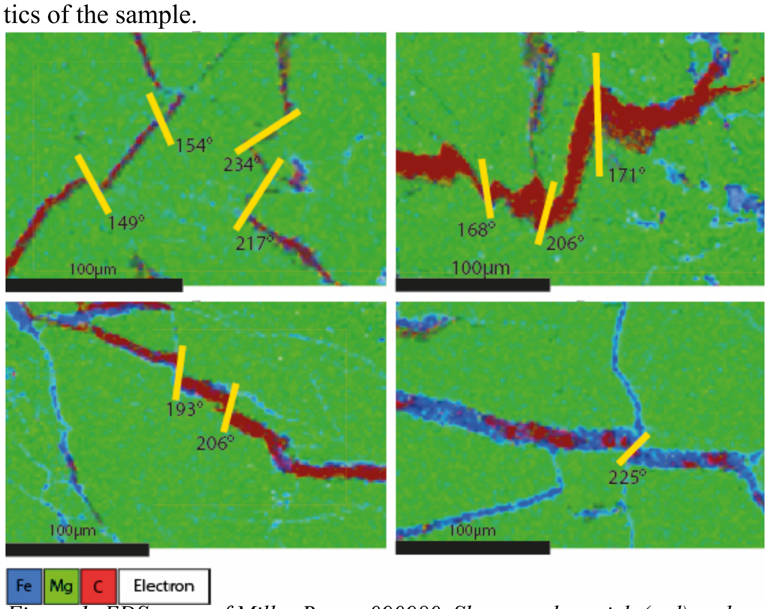

Figure 1: EDS maps of Miller Range 090980. Shows carbon-rich (red) and iron-rich (blue) veins within magnesium-rich (green) silicate minerals that have been affected by ductile and brittle deformation (yellow lines), orientations of which are labelled in black. .

Results: As shown in Fig. 1 the carbon (red) and iron (blue) are largely contained within vein networks that pervade the sample. These veins have then been displaced by micro-faults and possible ductile deformation (top right image).

Discussion: The micro-faults cross cut the carbon veins and so postdate their formation. There does appear to be a general preferred orientation of micro-fault orientations across the sample. This suggests one prevalent stress field was experienced over the whole sample. One exception to this is the top right image which shows conjugate sets of faults with opposite senses of displacement. This could suggests multiple deformation events or alternatively an alteration of the stress field during deformation. EBSD will be conducted on these regions to determine the formation mecahnism of these deformation micro-structures and results will be presented at the conference.

References:

[1] Goodrich, C.A., (1992). *Meteoritics,* 27(4), pp.327-352.
[2] Nabiei, F., et al., (2018). *Nature communications*, *9*(1), pp.1-6.
[3] Nestola, F., et al., (2020) *Proceedings of the National Academy of Sciences*, *117*(41), pp.25310-25318.
[4] Karato, S. I., et al., (2008).*Annu. Rev. Earth Planet. Sci.*, *36*, 59-95.
[5] Stöffler, D.,et al., (1991) *Geochimica et Cosmochimica Acta*, *55*(12), 3845-3867.
[6] Metbull (2021) Meteoritical bulletin (https://www.lpi.usra.edu/meteor/metbull.php) accessed on 24/05/21

Acknowledgements: We thank the Smithsonian Institution for loaning the sample used for this work.