INVESTIGATING SHOCK DEFORMATION WITH LAUNCH-PAIRED MARTIAN SHERGOTTITES

R. P. Patel[1], G. Benedix[1], L. Forman[1], and N. Timms[1]. [1]School of Earth and Planetary Sciences, Faculty of Science and Engineering, Curtin University, Bentley, Western Australia, 6102

Introduction: In recent decades, the study of Martian meteorites has significantly impacted the planetary science community and has helped to build a greater understanding of the surface geology and processing on Mars [1]. Currently, there are ~60,000 known meteorites on Earth, with only ~200 known to have originated on Mars. Shergottites (~80% of Martian meteorites) are mafic to ultramafic achondritic meteorites with basaltic to lherzolitic compositions and are moderately to highly shocked, with substantially higher shock levels than most other meteorites [2]. Shock manifests itself in the deformation of minerals within the meteorites. Levels of shock have been qualitatively defined using experimental data and past literature, whilst referring to a new shock classification system proposed by Stöffler et al. (2018) [3]. We have examined 4 shergottites that have the same cosmic ray exposure age and span different shergottite classes to investigate the shock features of meteorites that likely sample from the same ejection event on Mars.

Samples and Methods: Thin and thick sections of RBT 04262, ALHA 77005, Los Angeles and LAR 06319/12011 were examined optically and with electron backscatter diffraction (EBSD) techniques on the TESCAN Mira 3 instrument located within the John De Laeter Centre, Curtin University. All these samples have a published preferred cosmic ray exposure age of ~3.1 Ma [2,4,5]. They are classified as poikilitic (RBT/ALHA), olivine-phyric (LAR), and diabasic (LA) and all have depleted rare earth element (REE) patterns, apart from ALHA 77005, which has an intermediate REE pattern. EBSD data was obtained, processed and reduced using integrated Oxford Instruments software: AZtecHKL (Aztec 3.3 SP1) and HKLChannel5 (HKLTango). Grain reference orientation deviation maps (GROD – the angle of deviation from the average orientation of a grain is determined for each pixel within that grain, for all grains within the mapped area); grain orientation spread maps (GOS – the angle of deviation from the average orientation of a grain for each pixel within that grain is averaged, for all grains within the mapped area – i.e. average of all GROD values within a grain); and maximum orientation spread maps (MOS – the maximum angle of deviation from the average orientation of all pixels within that grain – i.e. maximum GROD value within a grain) were constructed. Statistics on GOS and MOS values for each individual grain (minimum grain area of 3 pixels) in each map were compiled and analysed.

Results and Discussion: Recent advances in EBSD data reduction allow us to visualise deformation in crystals in thin/thick section [6]. We analysed a number of regions of interest on each thin/thick section using EBSD. Figure 1 shows a MOS map of Los Angeles,P10075 representing the maximum angle of deviation from the average orientation of all pixels within a number of pyroxene grains. For pyroxenes in all samples, the maximum MOS and GOS values range from 22.93˚ to 33.10˚ and 6.51˚ to 10.47˚ respectively, with the highest maximum for both found in Los Angeles. For olivines in all samples, the maximum MOS and GOS values range from 4.95˚ to 35.41˚ and 3.44˚ to 9.93˚ respectively, with the highest maximum for both found in RBT 04262. For opaque minerals in all samples, the maximum MOS and GOS values range from 12.18˚ to 17.30˚ and 5.15˚ to 6.37˚ respectively, with the highest maximum for both found in ALHA 77005. The findings of this project are significant as we can potentially differentiate between multiple lava flows (or a singular lava flow that has differentiated) and shock impacts in a specific volcanic region on Mars, and significantly enhance our knowledge of shock impact processes on Mars, and by extension such processes on Earth.

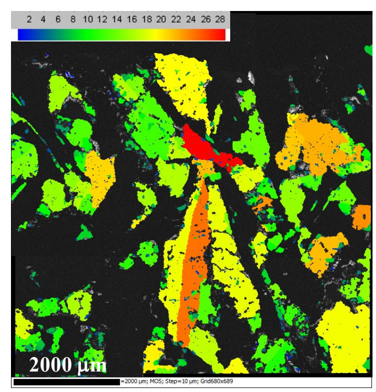

Figure 1: Maximum orientation spread (MOS) map of Los Angeles,P10075

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