Complex Twinning in Baddeleyite from the Martian Meteorite North West Africa (NWA) 11522; Preliminary Results.

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Introduction: Martian meteorite NWA 11522 is a pair with NWA 7034, colloquially known as "Black Beauty" [1]. The sample is a polymict regolith breccia, rare among Martian meteorites, and contains both lithic and mineral clasts in a fine grained matrix; most lithics are mafic rocks [1]. Previous studies have characterized shock microstructures and geochemistry in baddeleyite from Martian meteorites [2,3,4]. Here we present electron backscatter diffraction (EBSD) maps of baddeleyite and zircon grains from the matrix of NWA 11522.

Methods: NWA 11522 was analyzed using a Tescan MIRA 3 field emission scanning electron microscope (SEM) at Curtin University to collect backscattered electron images and electron backscatter diffraction (EBSD) maps in order to characterize microstructures within individual grains. EBSD maps were collected for a total of 7 zircon and 3 baddeleyite grains. Whole grain maps ranged in step size from 50 nm to 100 nm.

Results: All baddeleyite and zircon grains are situated within the fine-grain matrix. Baddeleyite grains range in length from ~ 2 µm to ~ 5 µm, and all grains containing complex twinning. Individual twin domains range in size from 0.1 to 3 µm (Fig. 1). All twins are mutually orthogonal, and occur in up to four crystallographic orientations within a single grain. Twin boundaries define misorientation relationships including 180° / <001>, <00-1>, <101>, and <-10-1>; 115° / <1-1-1>, <-1-1-1>, and 90° / <001>, <00-1>. Misorientation within individual twins domains is typically <10°, as most domains appear to be minimally strained.

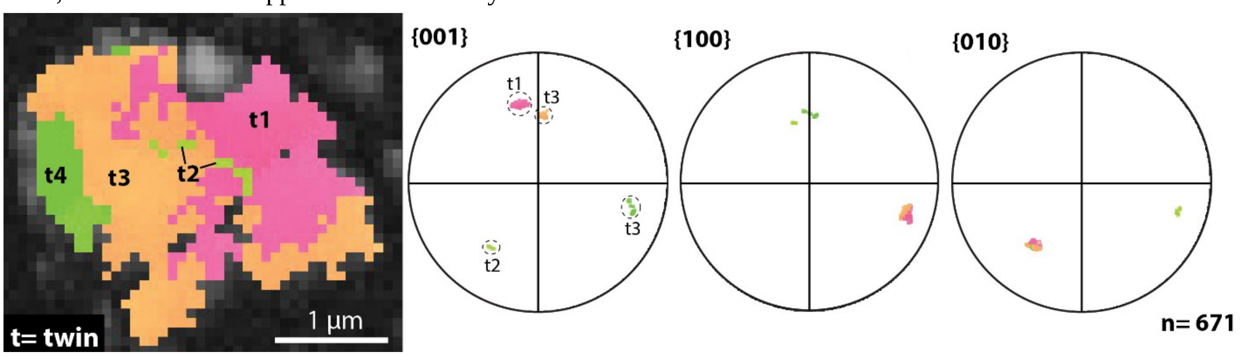

Figure 1. Orientation map of baddeleyite grain using an inverse pole figure color scheme (IPFz). B) Pole figures showing relationship of the four twins within the baddeleyite grain. Clusters are orientated orthogonally to each other.

Two zircon grains within the seven surveyed contain lattice misorientation up to ~10°. One baddeleyite grain is in contact with a clast edge and exhibits a granular zircon rim, with individual granules oriented in a broad distribution about the main axes of zircon.

Discussion: The orthogonal twinning observed within the baddeleyite grains in NWA 11522 has been reported in other studies of terrestrial samples [e.g. 4,5], and is thought to result from reversion of higher symmetry zirconia polymorphs (cubic, tetragonal, orthorhombic). Past studies have reported shock pressures of ~5-15 GPa within NWA 7034 [6], but there may be heterogeneities of shock pressures experienced by different clasts and matrix within the breccia. All baddeleyite grain are found within the matrix and have likely reacted with either a melt or fluid to form a zircon rim [3]. At this stage it is unknown if the twin microstructures were produced during high-pressure or high temperature inversion. Continuing studies of the shock and thermal history of baddeleyite-bearing clasts may resolve the origin of the twins and thus provide new insights into the history of the sample. Atom probe analysis of the matrix proximal to this grain will be presented at this meeting [7], and further work will look at analysis the baddeleyite grains by atom probe.

References: [1] Cohen B.E. et al., (2018), *LPSCXLIX*, 2083. [2] Moser D.E et al., (2011), *Nature*, 499, 454-457. [3] Darling J.R. et al., (2016), *EPSL*, 444, 1-12. [3] Herd C.D.K et al., (2018) *Microstruct. Geochron., 137-166.* [4] Timms, N. et al. (2017*) Earth-Sci. Rev., 165,185*–202. [5] White L.F. et al., (2018) *Microstruct. Geochron.*, 351-367. [6] Wittman A., et al., (2015), *MAPS*, 50, 2, 326-352. [7] Daly L. et al., (2018, this meeting) *Metsoc.*