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Combined microstructural analysis and *in-situ* U-Pb chronology of baddeleyite within shergottites Northwest Africa (NWA) 7257, NWA 8679 and Zagami

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Baddeleyite (monoclinic; *m*-ZrO_2) is an important U-Pb chronometer within mafic lithologies from many planetary bodies. Recent *in-situ* U-Pb dating of micro-baddeleyite within shergottites has been key in confirming recent magmatic activity on Mars. However, despite a high U-Pb closure temperature (≥900 °C) and the retention of robust U-Pb isotope systematics to ~57 GPa within experimental studies, up to 80% Pb loss within baddeleyite has been reported from the highly-shocked shergottite Northwest Africa (NWA) 5298. Significantly, U-Pb isotopic disturbance has been shown to be strongly linked with baddeleyite internal microstructure, generated by partial to complete reversion from meta-stable, high P-T zirconia polymorphs during shock metamorphism. NWA 5298 has experienced elevated shock metamorphism, and particularly post-shock temperatures, in comparison to many other shergottites; in the absence of microstructural analyses, the magnitude of baddeleyite U-Pb isotopic disturbance within more moderately shocked shergottites remains unknown.

To address this, we combine electron backscatter diffraction (EBSD) microstructural analysis and in-situ U-Pb chronology of baddeleyite within three enriched shergottites: NWA 7257, NWA 8679 and Zagami. Studied samples have undergone shock conditions typical of shergottites, with complete transformation of plagioclase to maskelynite and pervasive fracturing of pyroxene, phosphates and oxides. Small veinlets of shock melt cross-cut NWA 8679 and Zagami, and shock melt pockets are present in all samples. Baddeleyite is abundant and ubiquitously associated with late-stage igneous assemblages, rather than shock melt.

We document a wide range of baddeleyite microstructures. These include crystal-plastically deformed magmatic twins, domains with a marked decrease in crystallinity, and complex, nanostructured domains with orthogonal orientation relationships that are interpreted to have resulted from complete reversion from high P-T polymorphs. Magmatic twins are only locally preserved due to shock heterogeneity. Despite this, and in contrast to NWA 5298, we find no link between baddeleyite microstructure and U-Pb isotope systematics. Analyses fall along well-defined discordia within Tera-Wasserburg plots for each sample, with the U-Pb isotopic composition of analyses controlled by overlap with surrounding phases and fractures rather than baddeleyite microstructure. We therefore determine two new, microstructurally constrained ages from discordia lower intercepts: 195 ± 15 Ma (95% confidence; MSWD 5.6) for NWA 7257 and 220 ± 23 Ma (95% confidence; MSWD 2.2) for NWA 8679. For Zagami, our findings support the previously reported magmatic crystallisation age of ~180 Ma. These results provide further confirmation that high post-shock temperatures are required to induce resolvable U-Pb isotopic disturbance baddeleyite, even within highly shocked samples, and that reversion from high P-T zirconia polymorphs alone does not necessitate U-Pb isotopic disturbance. While we caution the continued requirement for detailed microstructural analyses of baddeleyite prior to isotopic analyses, this study underlines the utility of baddeleyite chronology within martian meteorites and other shocked planetary materials.