Combining Microstructural and Isotopic Analysis of Baddeleyite to Unravel Solar System Bombardment

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Baddeleyite (monoclinic-ZrO_2) commonly crystallizes in mafic rock types where zircon ($ZrSiO_4$) does not, rendering it a key chronometer in silica under-saturated lithologies more prevalent on the Moon and Mars than on Earth. During shock-metamorphism, a series of high pressure (displasive) and temperature (martensitic) phase shifts alter the atomic configuration of the mineral, creating a series of microstructures that may be roughly correlated with severity of radiogenic Pb loss. Furthermore, *m*-ZrO_2 microstructure could be applied as a 'shock indicator', given the material's near-ubiquitous presence in achondrites as well as within a wide array of terrestrial magamatic settings. However, a fuller understanding of the effects of microstructure formation and Pb-loss is required to better faciliate such applications.

Here we present the first ground-truthing analyses from *m*-ZrO_2 bearing rocks in a terrestrial impact structure, using samples of Matachewan diabase dykes sampled at varying distances (and hence shock-conditions) from the Sudbury impact melt sheet. Electron Backscatter Diffraction (EBSD) mapping reveals a wide variation in microstructures. These range from simple twinning in unshocked grains ~100km from the impact, diagnostic of magmatic grains, to complete recrystallisation / reversion twinning and amorphisation in highly shocked grains adjacent (3km - 550m) to the impact melt sheet. We report micro- to atomic-scale geochemical and U-Pb isotopic analyses on highly shocked grains using single-shot laser ablation (SS-LA-MC-ICP-MS) and atom-probe tomography (APT), revealing atomic-scale heterogenities in elemental distribution, including clustering of Si, Ca, Fe and Al. These datasets provide new insights into the correlation between shock-induced phase changes and microstructural formation with implications on observed U-Pb age, greatly enhancing the potential application of baddeleyite as a planetary chronometer.