Nanoscale characterization of shock twinning in zircon by EBSD, TKD, ToF-SIMS, TEM, and atom probe

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Shock deformation of zircon produces microstructures diagnostic of hypervelocity processes. Deformation twins in {112} planes have only been observed in static experiments at 20 GPa [1], and in impact environments, including the Vredefort Dome [2-4] and elsewhere. Electron backscatter diffraction shows the {112} twins are polysynthetic, <1 μm wide, and their crystallographic relation with the host grain is 65°/<110>. Element mobility associated with twin formation has not been explored; twinned zircon generally does not record impact-age resetting of U-Pb at the ~20 μm scale [4]. Characterizing the microstructure and element behaviour of shock-twins at the nano-scale may provide new avenues for dating impacts and other associated processes.

We report data for a ~1 μm wide twin lamella from a detrital shocked zircon eroded from the ~2.0 Ga Vredefort impact structure [4]. ToF-SIMS mapping of the trace of the twin on the polished surface reveals conspicuous enrichments in Ca, Y, and other trace elements along the host-twin boundary. TKD analyses (25 nm step size) of the boundary in needles prepared for atom probe show low band contrast in a ~20-40 nm zone along the twin interface. TEM analysis of an adjacent lift-out confirms the 65°/<110> orientation relationship of the twin with the host grain, and further reveals that the host-twin interface is defined by a narrow zone, 10s of nm wide, consisting of disordered (metamict?) zircon, possibly due to high actinide concentration. Atom probe microscopy reveals rare trace element clusters (~1 per needle), which include radiogenic Pb, suggesting minimal post-impact heating. These results reveal different nano-scale microstructures and evidence of element mobility associated with twin lamellae in shocked zircon.

[1] Morozova, 2015, UWO MS. [2] Moser et al., 2011 Can J Earth Sci. [3] Erickson et al. 2013 Am Min. [4] Cavosie et al. 2015 Geol.