A NEW OCCURRENCE OF SHOCKED XENOTIME: MICROSTRUCTURE AND U-Pb GEOCHRONOLOGY OF DETRITAL GRAINS FROM THE VREDEFORT DOME, SOUTH AFRICA

A. J. Cavosie,[1,2] Steven M. Reddy[1], Nicholas E. Timms[1], Chris L. Kirkland[1], Cristina Talavera[3], [1]Dept. Applied Geology, Curtin University, [2]NASA Astrobiology Institute, Dept. Geoscience, University of Wisconsin-Madison, [3]Dept. Physics and Astronomy, Curtin University. Email: aaron.cavosie@curtin.edu.au

Introduction: Studies of shock deformation in accessory minerals such as zircon, monazite, and baddeleyite provide new insights into impact histories in a variety of terrestrial and planetary materials [1-3]. These minerals are reliable U-Pb geochronometers, and can provide information on the age of the shocked target, and in some cases the age of the impact event. Impact-generated microstructures in accessory minerals are generally resistant to post-impact modification, and these phases survive as detrital grains in sedimentary rocks after impact craters erode [4]. Here we report a new occurrence of shocked xenotime, collected as detrital grains in colluvium, from the 2.0 Ga Vredefort Dome impact structure in South Africa. We use electron backscatter diffraction (EBSD) to document deformation microstructures, including {112} twins and other features, and secondary ion mass spectrometry by SHRIMP for in-situ U-Pb geochronology.

Shock Microstructures in Xenotime: Shock microstructures reported in xenotime are similar to those in zircon, as both are tetragonal minerals [5,6]. A previous study of xenotime from a shatter cone at the Santa Fe impact structure reported grains with sets of closely-spaced planar fractures, including some hosting up to three orientations of {112} deformation twin lamellae. Other features include planar deformation bands (PDBs), which are elongate bands of crystal-plastically deformed lattice domains misoriented from neighboring domains. PDBs in Santa Fe xenotime grains are a few 10s of µm long, and are misoriented by up to ~5° from the host grain. Formation of shock features in xenotime has not been experimentally calibrated. The Santa Fe xenotime grains occur in a shocked quartz-bearing shatter cone, and were inferred to have formed in the range of 5-20 GPa [5].

Shocked Xenotime from the Vredefort Dome: The detrital shocked xenotime grain was collected in the collar of the Vredefort Dome as colluvium in a drainage that intersects the road near Thabela Thabeng on Buffelskloof farm, ~25 km northwest of the center of the structure. The grain has three distinct sets of PDBs that each contain multiple sub-parallel discrete bands, producing a 'striped' pattern locally. Individual PDBs range from 2-5 µm in width and are misoriented up to 30° from the host grain. The PDBs have different orientations, but appear to have formed by the same slip system, <100>{010}, as all have misorientation axes parallel to [001]. The most conspicuous feature is a ~75 µm wide 'shear zone' that cuts across the grain, where high-strain deformation appears to have been concentrated. Features within the shear zone include two orientations of {112} deformation twin lamellae, as well as randomly orientated domains that have either been mechanically rotated or are recrystallized neoblasts. The shear zone is parallel to one of the PDB orientations, and thus may represent progressive deformation of xenotime.

SHRIMP U/Pb Geochronology of shocked xenotime: A total of 29 analyses of ~15 µm diameter spots made by SHRIMP ion microprobe targeted all of the microstructures described above, and were calibrated using in-house Archean xenotime standard XKARG. Sample data were matrix-corrected for [U], and form a coherent discordant age population that yields a $^{207}Pb/^{206}Pb$ upper intercept age of 3042±75 Ma (2σ, MSWD = 0.81, n=26/29), and a lower intercept age of 1505±75 Ma (2σ).

Discussion: A variety of features form in shocked xenotime, including PDBs, {112} twins, and profound plastic deformation (**Fig. 1**). The 3042±75 Ma target rock age is preserved, however, no impact age-resetting was detected. The Mesoproterozoic lower intercept is significantly younger than the 2020 Ma Vredefort impact, and likely represents a thermal and/or fluid event that effected the shock-damaged grain, resulting in variable Pb-loss.

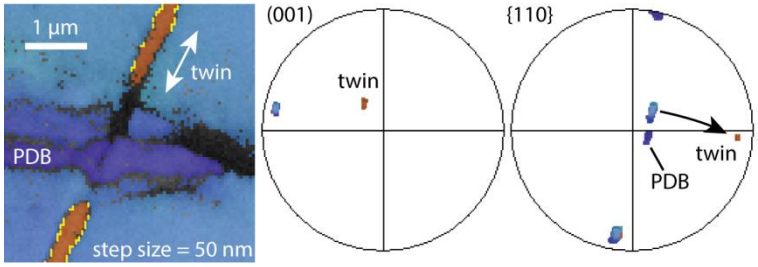

Figure 1. Example of {112} twin lamella and PDB in shocked xenotime from the Vredefort Dome (IPFz map). Pole figures show the twin is misoriented by 65°/<110> from host grain. The PDB is misoriented by ~15° from the host.

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