DETRITAL SHOCKED ZIRCONS IN CENOZOIC FLUVIAL TERRACES OF THE VAAL AND ORANGE RIVERS, SOUTH AFRICA

P.E. Montalvo[1], A.J. Cavosie[1], N.O. Cintron, H.A. Radovan[1], D.E. Moser[2], R.J. Gibbon[3]
[1]Univ. Puerto Rico, [2]Univ. Western Ontario, [3]Univ. Witwatersrand

Introduction: Provenance studies have used microstructural and isotopic data to demonstrate that detrital shocked minerals in modern sediments in the Vaal River, South Africa originate from the Vredefort Dome impact structure [1,2,3], including at distal locations up to 750 km [4,5]. In addition to modern sediments, detrital shocked minerals have also been reported in Pleistocene fluvial deposits (river terraces) of the Vaal River at distances up to 500 km from the Vredefort Dome [6,7]. Here we report occurrences of detrital shocked zircons in Pleistocene, Pliocene, and Miocene deposits at distal locations in the Vaal and Orange Rivers that extend the record of detrital shocked minerals eroded from the Vredefort Dome further across southern Africa in space and time.

Background: The Vredefort Dome is the oldest and largest impact structure on Earth with an age of 2.02 Ga [8]. The structure, located in the Kaapval craton, is believed to have a 300 km original diameter, but only 90 km diameter is presently exposed [8]. Shocked minerals have been previously reported in a variety of rocks at the the Vredefort Dome [9-12], in modern sediments within the structure [1] and at distal locations in the Vaal River [4,5]. The Vredefort Dome is currently being eroded by the Vaal River, which joins the Orange River 750 km downstream. Ancient fluvial deposits, with ages from Holocene to Miocene, occur throughout the Vaal River valley. The documentation of detrital shocked minerals eroded from bedrocks at the Vredefort Dome and deposited in Cenozoic fluvial deposits is the focus of this study.

Samples: In this study, we report the occurrence of detrital shocked minerals in 6 samples from three Vaal River Cenozoic terraces at distal locations from the Vredefort Dome: (1) The 12-14 m Pleistocene age Rietputs Fm. [13] at Barkley West (590 km) and at Douglas (760 km), near the confluence with the Orange River. (2) The 20-40m Pliocene age Wedburg terrace at Sydney-on-Vaal (625 km) and the Proksch Koppie terrace at Windsorton (500 km) [14]. (3) The 60m Miocene age Holpan terrace at Windsorton [15,16]. In addition, we report the first detrital shocked minerals in the Orange River, from a 40m (Pliocene) fluvial terrace ~40 km downstream from the Vaal confluence, approximately 800 km from the Vredefort Dome. All of the terrace deposits consist of coarse gravel and conglomerate and were sampled where exposed by fluvial diamond mining. Detrital zircons were separated from the sandy matrix around the pebbles and cobble clasts. The degree of diagenetic alteration varied from sample to sample.

SEM results: Deformation microstructures were documented using backscattered electron (BSE) imaging, and detrital shocked zircons were identified in each of the terrace samples. The shocked zircons are medium-sized (up to ~500 μm), subhedral to euhedral, and many are rounded grains with no identifiable crystal faces. The number of zircons surveyed per sample ranged from 42 to 152. The resulting percentages of shocked grains ranged from 1 to 18%. The lowest abundances occurred in the Pliocene 40m terrace on the Orange River, which yielded a single shocked zircon. The highest abundances were in the Rietputs Fm. at Douglas (8 of 77 grains, 10%) and in the Wedburg terrace at Sydney-on-Vaal (11 of 60 grains, 18%). The shock microstructures preserved in these zircon are planar fractures (PFs) [1]. PFs occur in up to four different crystallographic orientations, but most grains preserve only one or two conspicuous PF orientations.

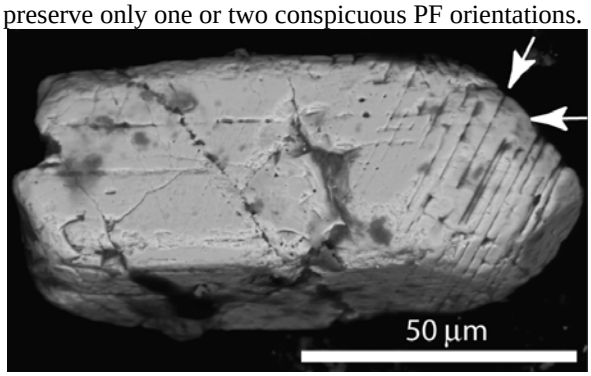

Figure 1. BSE image of detrital shocked zircon from the Rietputs Fm. at Douglas, 750 km from the Vredefort Dome (sample 09VD40). Arrows show two orientations of planar fractures (PFs) visible on the grain surface.

Discussion: The planar fracture (PF) microstructures documented in the Cenozoic terrace detrital zircons are indistinguishable from microstructures found in shocked zircons from bedrock at the Vredefort Dome. These results, in conjunction with U/Pb ages reported previously [6,7] demonstrate that detrital shocked zircon grains survive up to ~800 km of transport in siliciclastic sediments in both the Vaal and Orange River systems, as well as burial over geologic time (Pleistocene to Miocene). Detrital shocked zircon abundances of 10-18% at distances of 625 to 760 km from an impact site indicate that detrital shocked zircons provide a durable, long-lived record of ancient, eroded impact structures in sedimentary rocks.

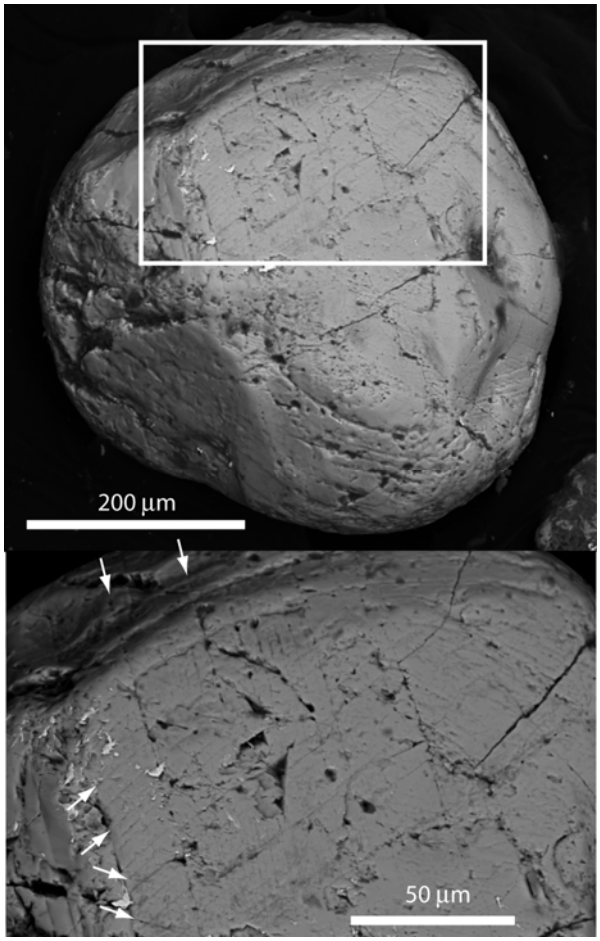

Figure 2. BSE image of a detrital shocked zircon from a 40m Pliocene terrace on the Orange river, 800 km from the Vredefort Dome (sample 09VD37). Arrows show three PF orientations.

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