DETRITAL SHOCKED ZIRCON PROVIDES NEW CONSTRAINTS ON THE AGE AND SIZE OF THE SANTA FE IMPACT STRUCTURE, NM (USA)

P. E. Montalvo[1], A. J. Cavosie[1,2,3], T. M. Erickson[2], C. L. Kirkland[2], N. J. Evans[2], B. J. McDonald[2], C. Talavera[4], C. Lugo-Centeno[5], [1]Dept. of Geology, Univ. of Puerto Rico, Mayagüez, PR. E: pedro.montalvo1@upr.edu, [2]Dept. of Applied Geology, Curtin Univ., [3]Dept. of Geoscience, Univ. of Wisconsin-Madison, [4]Dept. of Physics and Astronomy, Curtin Univ., [5]Dept. of Earth Sciences, Syracuse Univ.

Introduction: Terrestrial impact structures are prone to erosion, burial and tectonic deformation, providing incentive to further develop new methods for the reconstruction of the impact record on Earth. Shocked zircon has been previously reported to survive both extreme distal fluvial transport in modern alluvium and colluvium at distances up to ~2000 km [1] from the Vredefort Dome (South Africa), and in Holocene glacial deposits at Sudbury (Canada) [2]. Zircon {112} twins are considered diagnostic evidence of shock deformation, and have been identified at several impact structures such as Vredefort [1,3,4,5], Sudbury [2], Ries [6], Rock Elm [7], and in lunar impact breccia [8]. Shocked minerals, such as xenotime, apatite, and quartz, have previously been reported at the Santa Fe impact structure [9,10]. Here, we report the first occurrence of shock-twinned zircon from both sediments and bedrock, sampled away from known shatter cone localities at the Santa Fe impact structure [11].

Background: The Santa Fe impact structure is one of only five confirmed impact structures in western USA [12], and is located ~8 km northeast of Santa Fe, New Mexico. Shocked rocks are best exposed in Proterozoic crystalline basement rocks that outcrop along Highway 475 and contain well-formed shatter cones [11]. The basement uplift where shock-deformed rocks are located is called the Santa Fe range, which is comprised of Proterozoic intrusive igneous and supracrustal rocks. The occurrence of shatter cones and planar deformation features in quartz confirmed this impact structure [11]. The impact age and crater diameter have been estimated to range from 350 – 1200 Ma and 6 – 13 km, respectively [11]; however, both are poorly constrained.

Samples and Methods: Detrital zircon grains from thirteen colluvium and two alluvium samples were hand-picked and placed onto scanning electron microscope (SEM) stubs from thirteen colluvium and two alluvium samples. Two shatter cones were also analyzed to search for shocked zircon in bedrock. Backscattered electron images were obtained using a Hitachi S3400 SEM at the University of Wisconsin-Madison. Electron backscatter diffraction (EBSD) maps were obtained using a Tescan Mira3 field emission gun SEM in the John de Laeter Center (JdLC) at Curtin University. Detrital zircon U-Pb ages were obtained using the sensitive high resolution ion microprobe (SHRIMP II) at the JdLC. Additional U-Pb analyses on grains from five samples, which include three samples that contain shocked grains and two others collected in proximity to those locations, were made via laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) in the JdLC.

Results: A total of 6619 grains from the fifteen sediment samples and two rock samples were surveyed; seven shocked grains were identified (7/6619 = 0.1%). One shocked grain was identified in a shatter cone of biotite schist. Of the seven shocked zircon grains, five were EBSD mapped, and three were analyzed with multiple SIMS spots. EBSD mapping revealed {112} deformation twin lamellae in each of the five zircon grains. U-Pb geochronology for three grains yield crystallization ages from 1715±22 to 1472±35 Ma. LA-ICPMS U-Pb ages provide information on the crustal age structure of the bedrock surrounding the impact structure.

Conclusion: This study revealed the first confirmed shocked zircon at Santa Fe by surveying ~6600 detrital zircon grains. Zircon, in addition to xenotime and quartz, is the third confirmed shocked mineral occurring at Santa Fe; its occurrence indicates that exposed bedrock experienced shock pressures of at least 20 GPa. The crystallization age for a shocked zircon of 1472±35 Ma offers the first reliable maximum impact age constraint. The new detrital shocked zircon sites indicate that shocked rocks and minerals are distributed over an area of 9 km^2 from which scaling laws indicate a crater diameter of 9 – 14 km.

References: [1] Montalvo et al. (2017) Am. Min. 102, 813-823, [2] Thomson et al. (2014) GSA Bull., 126, 720-730, [3] Cavosie et al. (2017) AGU Mon., *in press*, [4] Erickson et al. (2013a) Am. Min., 98, 59-65, [5] Moser et al. (2011) Can. Jour. Earth Sci., 48, 117-139, [6] Erickson et al. (2017) Cont. Min. Pet., 172, 6, [7] Cavosie et al. (2015) Geo., 43, 315-318, [8] Timms et al. (2012) Met. Plan. Sci., 47, 120-141, [9] Cavosie et al. (2016) Geo., 44, 803-806, [10] Montalvo and Cavosie (2015) 46th LPSC abs. 1337, [11] Fackelman et al. (2008) EPSL, 270, 290-299, [12] Earth Impact Database (2011), accessed (02/05/2017).