ORIGIN OF DETRITAL SHOCKED ZIRCONS FROM DIFFERENT SEDIMENTARY ENVIRONMENTS AT THE SUDBURY IMPACT STRUCTURE, ONTARIO CANADA.

O. A. Thomson[1]*, A. J. Cavosie[1], H. A. Radovan[1] and D. E. Moser[2], [1]Univ. Puerto Rico, [2]Univ. Western Ontario. (*correspondence: olivia.thomson@upr.edu)

Introduction: The presence of shock-metamorphosed minerals is a diagnostic feature used to confirm meteorite impacts [1]. Planar fractures (PFs) are a shock deformation microstructure in zircon created by the shock wave passing through the target rocks at the impact site. Zircon is known for its high resistance to chemical and mechanical weathering and its stability at high and low temperatures [2-4]. PFs were documented in South African detrital zircons that show sedimentary abrasion [5,6]. Here we report occurrences of detrital shocked zircon from multiple locations and environments across the Sudbury impact structure that show that even shallowly eroded large impact basins contribute a widespread detrital record of shocked minerals. This study adds to the Vredefort detrital story, as deposits at Sudbury permit a new opportunity to compare detrital shocked zircon populations in fluvial and glacial deposits.

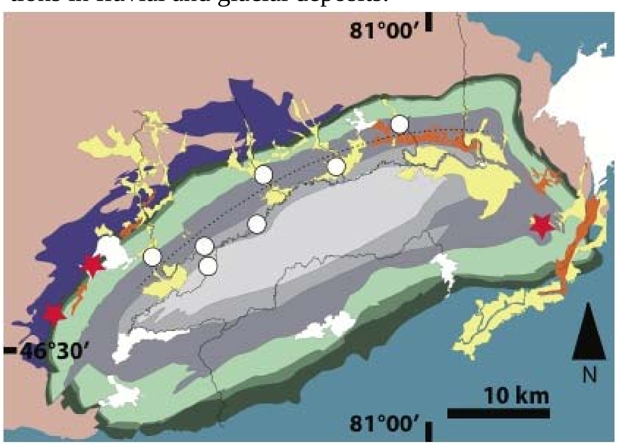

Figure 1. Simplified gologic map of the Sudbury impact structure showing locations where detrital shocked zircons have been identified in sediments (after [15]). Circles are fluvial river samples; stars are Holocene glacial deposits.

Sudbury impact structure: The 1850 Ma Sudbury impact structure in central Ontario, Canada is one of the oldest known terrestrial impact structures on Earth [7,8]. The elliptical multi-ring basin is the second largest known impact structure and is similar in size to the Vredefort Dome, with a proposed original diameter ~250-300 km prior to tectonic thrusting and deformation [8] (Fig. 1). Krogh et al. [9] documented shocked zircons from the Levack Gneiss and granitic clasts in the Onaping Fm. (fallback breccia). The shocked zircons from granitic clasts in Onaping Fm. are morphologically similar to those in the Levack Gneiss; they are rounded and variously fractured along crystallographically oriented planes. Shocked zircon has also been reported in the Copper Cliff rhyolite [10]. Recently, detrital shocked zircon has been reported in modern fluvial sediments in the Onaping River that cross cuts the NW sector of the Sudbury basin [11].

The Sudbury impact structure preserves a variety of Quaternary glacial deposits around the impact basin. Glaciers began retreating from the Sudbury basin about 11,200 years B.P. [12]. Complete deglaciatation occurred when the Cartier II Glacier retreated 10,400 years B.P. [11].

Sudbury samples: Four main tributaries of the Vermillion River flow southward across the North Range of the Sudbury structure, each crossing the Levack gneiss and/or Onaping Fm. Vermillion tributaries are the Onaping, Rapid, Nelson, and Sandcherry Creek Rivers. The Vermillion River crosses the length of the stucture from northeast to southwest. Glacial deposits, including eskers and glaciofluvial outwash deltas, occur across the North and East ranges of the Sudbury impact structure and occur in orientations consistent with southwest directed ice flowpaths [13].

Sediment samples from the modern channel of the Vermillion and the four tributaries, as well as Holocene glacial esker and deltas were collected and examined for the presence of detrital shocked zircon. Here we report results for 10 samples (7 modern fluvial and 3 glacial). The total number of detrital zircons examined in each sample ranged from 28 to 162, and shocked zircons were identified in each sample using BSE imaging with an SEM (Table 1). The shocked grains range from euhedral to subhedral, and all show evidence of sedimentary abrasion (Fig. 2, 3).

Discussion: Detrital shocked zircons occur in modern siliciclastic sediments in all of the main fluvial systems in the North Range of the Sudbury structure in abundances from 1 to 6%. The rivers either cross or begin in the Levack Gneiss or the Onaping Fm., suggesting that one or both of these units are the source of the detrital shocked zircons. Detrital shocked zircons were found in 3 Holocene glacial deposits in abundances of 1 to 29%. The location of the glacial deposits that yielded shocked zircons suggests that these grains also originated in the Levack Gneiss and/or Onaping Fm. This is the first report of detrital shocked zircons found in glacial eskers and deltas. These results further demonstrate that shocked zircons eroded from a Precambrian impact basin can survive post-impact conditions and enter various sedimentary systems as long as 2 Gyr after an impact event.

Table 1. Description of samples in this study.

Sample location & name	Total zircons	Shocked zircons	% shocked zircons
Rapid 10SU_30	162	9	6
Nelson 10SU_31	116	6	5
Sandcherry 10SU_23	113	3	3
Onaping 10SU_06 10SU_21	109 125	5 1	5 1
Vermillion 10SU_25 10SU_07	118 90	2 1	2 1
Glacial esker 10SU_42	113	13	12
Glacial delta 10SU_37 10SU_45	131 28	1 8	1 29

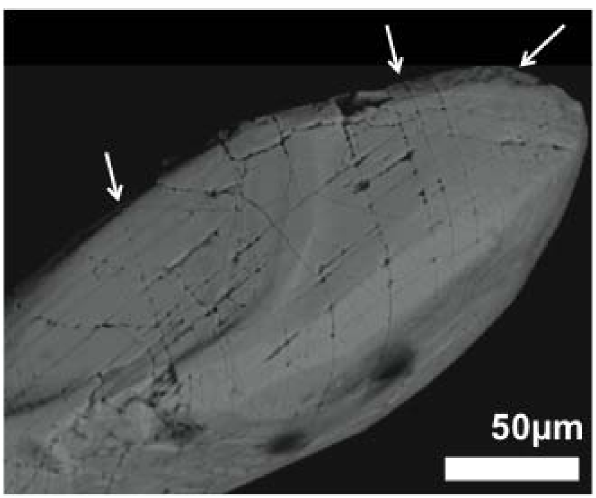

Figure 2. BSE image of shocked zircon in sample 10SU_23 from Sandcherry Creek. Two orientations of PF cross multiple crystal faces (see arrows). PFs occur in c-axis parallel orientation [either (010) or (100)] and in an {hkl} orientation, similar to {112} orientations in detrital shocked zircons from the Vredefort Dome [14].

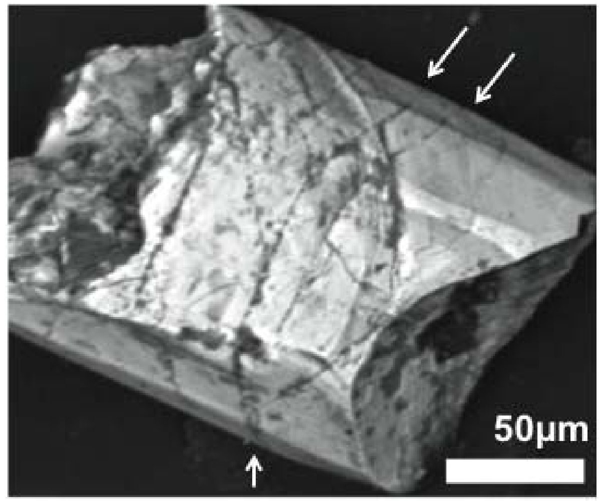

Figure 3. BSE image of a broken detrital shocked zircon from sample 10SU_45, a glacial outwash delta deposit. One orientation of PF is visible that cross multiple crystal faces (see arrows).

References: [1] French and Koeberl (2010). [2] Cavosie et al (2010) GCA. [3] Reimold et al. (2002). [4] Valley et al. (2005). [5] Cavosie et al. (2010) GSA Bulletin. [6] Erickson et al. (2010). [7] Krogh et al. (1982). [8] Grieve et al. (2000). [9] Krogh et al., 1984. Ont. Geol. Surv. Sp. Pub. [10] Corfu et al. (2003). [11] Thomson et al. (2010) LPSC. [12] Karrow et al. (1975). [13] Burwasser (1979). [14] Erickson et al. (2011) GSA. [15] Ontario Geologic Survey (1984).