IMPACT CRATER ENVIRONMENTS AS POTENTIAL SOURCES OF HADEAN DETRITAL ZIRCONS.

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Introduction: Constraining the origin of very ancient detrital zircons has unique potential for reconstructing the nature of the Earth's very early crust and Hadean geodynamics. Previous applications of the Ti-in-zircon thermometer to > 4 Ga zircons have identified a population with relatively low Ti contents of *c.* 5 ppm, corresponding to crystallization temperatures (T_{zir}^{xtln}) of *c.* 685 °C [1]. This was argued to be indicative of wet minimum-melting conditions producing granitic melts during plate tectonic interactions on the early Earth [1], in contrast to primitive crusts of basaltic compositions on other rocky planets. As an alternative, here we thoroughly test the hypothesis that impact melt sheets may have been a major source of the Hadean detrital zircon population. We then build on this by exploring the potential of other impact crater-related envrionments in which zircons crystallise.

Results: Here we present details of the first comprehensive ion microprobe study of zircons from a transect through the differentiated Sudbury impact melt sheet, Ontario, Canada [2]. It is found that zircon Ti contents (measured by secondary ion mass spectrometry – SIMS), and corresponding T_{zir}^{xtln}, fully overlap with those of the Hadean zircon population. Previous studies, which measured Ti in impact melt sheet zircons did not find this wide range because they analyzed samples only from a restricted portion of the melt sheet [3] and because they used laser ablation analyses that can overestimate true Ti content and hence T_{zir}^{xtln} [4]. It is important to note that internal differentiation of the impact melt is likely a prerequisite for the observed low T_{zir}^{xtln} in zircons from the most evolved rocks and, on Earth, melt sheet differentiation appears to be strongest in subaqueous impact basins. This may be due to thick deposits produced by violent water-melt interactions [4], which are absent in subaerial craters, insulating the impact melt and thus allowing slower cooling.

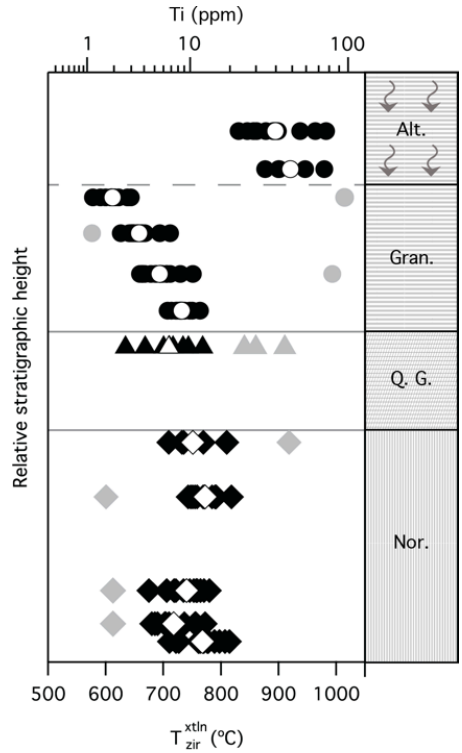

Figure 1: *Ti content and Ti-in-zircon crystallization temperature (T_{zir}^{xtln}) throughout the differentiated impact melt sheet at Sudbury, Canada. Error on individual analyses is less than symbol size. Outliers, shown in light gray, were excluded when calculating sample means, which are shown by open symbols. Elevated Ti contents of uppermost two samples are considered to be related to alteration and are not representative of the grains' original igneous composition. Nor. = norite; Q. G. = quartz gabbro; Gran. = granophyre; alt. = altered.*

Conclusion: Titanium contents, and corresponding T_{zir}^{xtln}, in the Hadean zircon population may not uniquely require wet, minimum-melting conditions on the early Earth and the implied plate tectonic interactions, but may also have been produced in melt sheets caused by the intense meteorite bombardment of an early, hydrosphere-covered protocrust. Our findings are consistent with the latest bombardment model of the Hadean Earth in which the age distribution of Hadean zircons matches the modeled production of impact-generated melt on the early Earth [5].

Where to next: We discuss the possibility that Hadean zircons could have crystallised not only in impact melt sheets but also in annuli of increased crustal temperatures surrounding large impact craters – as proposed in the model of [5]. We discuss our efforts to identify eutectic melting of crust buried by superheated impact melt at Sudbury and the nature of zircons in these melts – including their U-Pb age distributions and Hf isotope compositions.

References: [1] Watson E. B. and Harrison T. M. 2005. *Science* 308:841-844. [2] Kenny G. G. et al. 2016. *Geology* DOI: 10.1130/G37898.1. [3] Wielicki M. M. et al. 2012. *Earth and Planetary Science Letters* 321:20-31. [4] Darling J. 2009. *Geology* 37:927-930. [5] Marchi S. et al. 2014. *Nature* 511:578-582.