Covert impact-induced heavy O in zircon: Implications for the Hadean

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The only direct physical evidence for the geology of Earth's earliest history comes from detrital zircon crystals, dating >4.0 Ga. The majority of Hadean zircons display O isotope signatures within analytical uncertainty of mantle values, but subtle elevations towards heavier O are recorded in a few grains. These display primary growth zoning and REE patterns compatible with an igneous origin. Combined, the evidence has been interpreted to not only require liquid water on the Hadean Earth's surface but also Hadean "plate boundary interactions" akin to modern subduction [1].

The cratering histories of the Moon and Mercury, however, predict that the Hadean geology of the Earth's surface was dominantly influenced by giant impacts. It is currently unknown how impact-induced shock metamorphism and resulting planar fractures (PFs) could have affected the diffusivity of oxygen in zircon.

Here we present new data from the submarine 1.85 Ga Sudbury impact basin fill. We show that in impacted zircon, $\delta^{18}O$ became elevated above mantle values, with increasing distance towards the impact-dated lower intercept of a discordia line. The target rocks display zircon $\delta^{18}O$ averaging 6.43 ‰ (1SD=0.62; n=80), whereas six recrystallised, fully U-Pb age reset grains cluster tightly at 6.86 ‰ (1SD=0.22; n=12). Partly reset, discordant zircons approach this value with increasing distance along the discordia line. Critically, many of these discordant zircons display PFs on their *exteriors*, which are not visible on the *interiors*, e.g. in CL, where igneous growth zoning and REE remain.

Thus, the few Hadean zircons with elevated $\delta^{18}O$ may have received this signature during late-Hadean impact(s). Modest modern Pb loss on Hadean zircon tends to hide evidence of earlier impact-induced discordance. Consequently, elevated $\delta^{18}O$ values in detrital Hadean zircons may not be trusted as a primary igneous feature and impact-induced discordance has likely shifted the Hadean zircon age distribution into a smooth curve centred on 4.1 Ga.

Accordingly, whereas impact-induced resetting of O-isotopes in zircon does require hydrous fluid and possibly a liquid ocean, heavy O in zircon can be produced without subduction-like processes on the very early Earth.

[1] Harrison (2009), *Annu. Rev. Earth Planet. Sci.* **37**, 479-505