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Crash, bang, crustal nuclei?

CHRISTOPHER L. KIRKLAND[1], TIM JOHNSON[2], MICHAEL BROWN[3] AND PHIL SUTTON[4]

[1]Timescales of Mineral Systems Group
[2]School of Earth and Planetary Sciences, Curtin University
[3]Laboratory for Crustal Petrology, Department of Geology, University of Maryland
[4]School of Mathematics and Physics, University of Lincoln
Presenting Author: c.kirkland@curtin.edu.au

The early Archean Earth was very different to our modern planet, arguably more akin to present day Venus, with, for some period, a stagnant-, squishy-, sluggish lid, and a high impact flux. Two non-mutually exclusive scenarios exist to produce crustal nuclei on our young planet: A/ bottom-up melting produced in plumes or some other return of fractionated products of greenstone drips; and B/ top-down melts produced via impacts. Zircons from the oldest dated felsic crust, the Idiwhaa gneiss of the Acasta Gneiss Complex, Canada have been used to provide important constraints on early Earth's felsic crust. However, these zircon grains have been affected by multiple stages of overprinting metamorphism, which renders understanding of primary versus secondary processes challenging. Ion imaging of these zircon grains helps to better understand their primary isotopic signatures. Although ion images reveal pervasive recrystallization fronts, pockets of amorphous, but nonetheless concordant, c. 4.0 Ga zircon have escaped post-magmatic fluid-mediated modification. Primary oxygen isotope signatures from these ancient zircon cores preserve two components—one at the heavy end of mantle values and another isotopically lighter than mantle. The isotopically-light component demands interaction with fluids either directly, or via partial melting of low-$\delta^{18}O$ rocks that themselves had previously undergone high-temperature hydrothermal alteration by surface waters. Globally, a similar secular pattern with oscillations between normal and non-normal distributions of zircon oxygen isotopes supports an interpretation of periodic enhanced surficial melting. A c. 190 Ma periodicity of asymmetric oxygen isotope distributions corresponds to predicted higher impact flux, based on an astronomical galactic arm solar system transit model. Furthermore, this periodicity correlates with step changes in zircon Hf isotopes from most Archean Cratons, consistent with enhanced rates of crust production and reworking during both entry into and exit from the galactic spiral arms. A similar periodicity in hypervelocity impact craters on the more modern Earth gives credence to the interpretation that episodic shallow melting from impacts modified the lithosphere and spawned Earth's early crustal nuclei during the voyage of the solar system through the Milk Way.