

Isotopic evidence for episodic mantle melting in the Hadean

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The scarcity or absence of ancient material in the exposed rock record is a major hindrance in constraining the early silicate differentiation of the Earth, between 4.5 and 3.8 Ga. It also limits the reconstruction of Earth's early geodynamic evolution, which, is primarily inferred from numerical modelling. However, using extinct radioisotope systems such as the ¹⁴⁶Sm-¹⁴²Nd chronometer, it is possible to constrain early Earth processes even in the absence of a physical rock record. Using this approach, remnants of Hadean crustal and depleted mantle components have been identified in rocks from some of the oldest cratons^[1,2]. The majority of these ancient components preserve a record of a single crust-mantle differentiation event at 4.4 Ga^[3]. Apart from this event, little is known about the evolution of the Hadean crust-mantle system.

Here we present coupled ^{146,147}Sm-^{142,143}Nd isotope systematics of chemically diverse rocks from the well-characterized Paleoproterozoic Bastar and Singhbhum cratons in central and eastern India^[4-6]. A comparison of tonalite-trondhjemite-granodiorites (TTGs) from the two terranes reveals no ¹⁴²Nd anomalies in the Bastar Craton, while TTGs from the Singhbhum Craton define a trend in $\mu^{142}\text{Nd}$ vs $\epsilon^{143}\text{Nd}$ isotope space that extends from the primitive mantle composition up to $\mu^{142}\text{Nd} \approx +6$ ppm and $\epsilon^{143}\text{Nd} = +5$ (± 2.5 ppm, 2 S.D.).

Despite the near-synchronous formation of the Paleoproterozoic TTG crust in the two cratons, between ca. 3.5 and 3.3 Ga, these results demonstrate that their protoliths sampled distinct reservoirs, indicating heterogeneity of the Archean mantle. The investigated samples from the Singhbhum Craton derived from a mantle reservoir that first differentiated in a so-far undocumented event at 4.19 Ga. This discrete record of crust-mantle differentiation is mirrored in the Hf isotopic evolution of >4 Ga zircon, suggesting that mantle differentiation in the Hadean proceeded in large-scale, possibly global pulses of increased magmatic activity and crustal rejuvenation.

References: [1] Caro et al. (2003), *Nature* 423, 428-432. [2] O'Neil, et al. (2008), *Science* 321, 1828-1831. [3] Morino et al. (2017), *EPSL* 463, 136-150. [4] Maltese et al. (2019), *Goldschmidt Conference*. [5] Upadhyay et al. (2014), *Precambrian Res.* 252, 180-190. [6] Pandey et al. (2019), *Chem. Geol.* 512, 85-106.