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Multiple Hadean mantle extraction events recorded by short-lived isotope systems in coeval Archean rocks from a single craton

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A good understanding of early mantle differentiation processes on Earth is essential to infer the evolution of different mantle reservoirs with time and their respective contribution to the formation of the continental crust. Heterogeneities in $^{142}Nd/^{144}Nd$ and $^{182}W/^{184}W$ ratios have been used to understand these differentiation processes, which can provide further insights into the geodynamics of early Earth. These isotope ratios only record radiogenic ingrowth during the Hadean and thus overcome challenges of long-lived isotope systems used to constrain post-emplacement metamorphism and alteration of Archean rocks.

This study presents high-precision measurements of $^{142}Nd/^{144}Nd$ and $^{182}W/^{184}W$ ratios acquired via TIMS [1] and MC-ICP-MS [2], respectively, on nearly contemporaneous Archean mafic and felsic rocks from the Dharwar Craton, India. Till date, these rocks are scarcely studied by multi-dimensional long-lived and short-lived isotope systems. The correlation of $\mu^{142}Nd$ and $(^{147}Sm/^{144}Nd)_{src}$ of the analysed TTG suites in the Dharwar craton yields an age of $4.45_{-0.12}^{+0.06}$ Ga. This age can be considered as the time of chemical differentiation of the primary mantle source of the TTGs. The age obtained from the combined dataset of all the granitoids (TTGs and granites) is $4.38_{-0.48}^{+0.12}$Ga. The larger uncertainty is due to the scatter of the data and may reflect mixing of material derived from different source reservoirs. Coeval mafic and komatiitic rocks from the craton that are spatially proximate define a significantly younger mantle differentiation age of $4.15_{-0.12}^{+0.07}$Ga. These different ages for mafic and felsic suites implies that source components with different early Hadean heritage were involved in the petrogenesis of granitoids as well as that of the coeval mafic suites. Their distinct mantle sources differentiated multiple times during the Hadean. Juxtaposition of material from ancient mantle domains with different fractionation histories requires an active horizontal movement of material, similar to modern plate tectonics. The $\mu^{182}W$ values TTGs show no resolvable variation compared to modern mantle ($\mu^{182}W$ average = 0.4 ± 3.0), consistent with a differentiation age of <4.50 Ga, when ^{182}Hf was extinct.

[1] Garçon et al. (2018), ***Chem Geol*** 476, 493-514
[2] Tusch et al. (2022), ***PNAS*** 119(18)