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The ^{182}W and ^{142}Nd inventory of the Proterozoic lower mantle: Hadean silicate reservoirs vs. core leakage

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Analyses of ^{182}W and ^{142}Nd, the decay products of the extinct ^{182}Hf-^{182}W ($T_{1/2} \approx 8.9$ Ma) and ^{146}Sm-^{142}Nd ($T_{1/2} \approx 92$ Ma) decay systems, revealed anomalous W and Nd isotope signatures in the source of modern OIBs [1,2] that were established during the first 60 and 500 Myrs after Solar System formation. These signatures have either been ascribed to the presence of (recycled) Hadean silicate components or to core-mantle interaction [1,2,3,4]. However, no clear consensus has been reached on which process is dominant, and the process may differ across distinct OIB suites, complicating interpretations [1,2,4]. Investigation of ancient plume-derived rocks may help to deconvolute different processes that influence the sources of modern OIBs and determine whether core-mantle interaction was a continuous process.

We present new high-precision μ^{182}W and μ^{142}Nd data for Neoarchean to Mesoproterozoic volcanic provinces from West Africa (Birimian terrane), Western Australia (Fortescue Group), South Africa (Ongeluk Formation), and southern Sweden (Transscandinavian Igneous Belt), whose origins have been explained by mantle plume involvement. After disentangling the effects of crustal assimilation and metamorphic fluids, we find small but resolvable negative μ^{182}W and μ^{142}Nd anomalies for some samples, as well as resolvable average μ^{142}Nd values for samples from the same locations, both of which likely only represent conservative limits of possible isotope variations. Nevertheless, our data hint towards a Hadean-enriched silicate component that survived in the lower mantle. We suggest that the recycling of oceanic crust with high Nd/W over Earth's history may explain the lack of resolvable μ^{142}Nd anomalies compared to negative μ^{182}W anomalies in modern OIBs, in agreement with previous suggestions [2,5]. Thus, our results imply that core-mantle interaction is not necessarily required to explain the μ^{182}W and μ^{142}Nd range identified in modern OIBs, but may provide an explanation for the currently lower μ^{182}W in modern OIBs compared to Proterozoic plume-derived rocks.

[1] Mundl et al., 2017, Science, 356
[2] Peters et al., 2021, G-Cubed, 22
[3] Tusch et al., 2022, PNAS, 119
[4] Pakulla et al., 2025, EPSL, 653
[5] Hyung et al., 2023, EPSL, 622