A Hadean enriched mantle source revealed by W isotopes

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There is active debate about how W isotope heterogeneities in the Archean mantle were produced. Observed ^{182}W enrichments could have been generated by grainy late accretion, early Earth differentiation, or a combination of these processes. All ^{182}W anomalies reported so far are positive and ≤15 ppm relative to modern terrestrial standards [1,2,3]. These observations may be difficult to reconcile with an early differentiation model, which requires the existence of a complementary ^{182}W-poor reservoir. To further investigate W isotope variability among Archean rocks, we obtained W and Nd isotopic data for the 3.55 Ga komatiites from the Schapenburg Greenstone Remnant (Barberton GB, South Africa).

All Schapenburg komatiites are characterized by well-resolved ^{182}W and ^{142}Nd deficits, that average -7.8 ± 1.1 ppm (2SE,) and -4.9 ± 1.9 ppm (2SE) respectively, but positive initial $\varepsilon^{143}Nd$ of +2.3 ± 0.2 (2SE). The ^{182}W deficit could reflect a contribution from core-derived materials or a mantle source that incorporated more late accreted materials than the present-day mantle. However, these interpretations are inconsistent with the highly siderophile element concentrations estimated for the mantle source of these komatiites, which are ~3 times lower than those in the present-day mantle estimates [4]. Instead, the negative ^{182}W anomalies were most likely produced by *in situ* radioactive decay of ^{182}Hf in an early, chemically enriched mantle domain with low Hf/W. This domain may have resulted from crystallization of a magma ocean less than 60 Myr after Solar System formation. This early differentiation event may also account for the generation of the subchondritic Sm/Nd ratio, which over time translated into a ^{142}Nd deficit. The apparent decoupling of the ^{142}Nd and ^{143}Nd data requires that this early enriched reservoir experienced at least one subsequent depletion event, after ^{146}Sm became extinct.

[1] Touboul et al., (2012) *Science* **335**, 1065-1069. [2] Touboul et al. (2014) *Chem. Geol.* **383**, 63-75. [3] Willbold et al., (2011) *Nature* **477**, 195-199. [4] Puchtel et al. (2009) *Chem. Geol.* **262**, 355–369.