Memories of Earth formation in the modern mantle: W isotopic composition of flood basalt lavas

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Understanding Earth's mantle dynamics requires information about the initial state of chemical differentiation of the silicate Earth. Short-lived isotope systems can provide important information about Earth's primary differentiation and early chemical evolution. The Hf-W isotope system ($^{182}Hf \rightarrow {}^{182}W$, $t_{½}$ = 8.9 Ma) is particularly valuable for studying events that occurred during the first ~50 Ma of Solar System history. Existing high-precision W isotope data from modern mantle-derived samples suggest that early-formed heterogeneities were subsequently erradicated by mantle convection. Here we report data for samples from the ~ 60 Ma Baffin Island and the ~ 120 Ma Ontong Java Plateau lavas. Both large igneous provinces may have sampled a primitive, undegassed deep Earth reservoir that has remained isolated shortly after Earth formation [1] [2]. We characterize the chemical nature of this reservoir via W and highly siderophile element (HSE) concentrations, ^{182}W, Re-Os and He isotopic compositions of these samples. Tungsten concentrations for lavas from the Ontong Java Plateau and Baffin Island range from 11 ppb to 62 ppb, with the chilled glassy margins having systematically 30-50% more W than the cores of the pillows. The rim and core of one Baffin Island sample yield $\mu^{182}W$ anomalies of 9.9 ± 5.7 and 8.9 ± 2.2 ppb, respectively, compared to other young mantle-dervied rocks. These ^{182}W variations could reflect their derivation from a reservoir that was isolated from late accretionary additions [3]. However, the Os isotopic composition and HSE abundances of this sample are consistent with derivation from a source with normal HSE in chondritic relative abundance. Regardless of the cause of the ^{182}W isotopic anomaly, these results suggest that the mantle reservoir sampled by this lava formed during the first ~50 Ma of Solar System history and has survived to the present.

[1] Starkey *et al*, 2009, *EPSL* [2] Jackson and Carlson, 2011, *Nature*. [3] Willbold *et al*, 2011, *Nature*.