Inferences on Hadean geodynamics using ^{182}Hf-^{182}W isotope systematics in an open-system model of the Earth

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Short-lived and now extinct radioactive decay systems such as ^{182}Hf-^{182}W ($t_{1/2}$ = 8.9 Myr) provide information about early planetary differentiation processes and their timescales. Although W is moderately siderophile during core formation, it behaves as a highly incompatible lithophile element during silicate earth differentiation after core formation. Hafnium (Hf) is strongly lithophile, but less incompatible element than W, thereby imparting a comparatively lower Hf/W ratio in the melt relative to the source. Early silicate differentiation, during the lifetime of ^{182}Hf (ca. 60Myr) may have led to formation of chemically heterogeneous reservoirs in the Hadean, whose preservation or subsequent distribution has a large impact on the isotopic evolution of the present-day crust-mantle system. In this study, we have developed an open-system model of the Earth, which starts with a solar-system initial composition, followed by core formation and differentiation of the silicate Earth into crust and mantle, with a phase of prolonged accretion after core formation ("late veneer"). We quantitatively assess how these various processes affect the $^{182}W/^{184}W$ ratios of early-formed crust and mantle. The changing mass and abundance of isotope species in silicate reservoirs (crust and mantle) and core are quantified using a series of first order linear differential equations that are solved numerically using the fourth order Runge–Kutta method at 1 Myr time steps for 4.56 Gyr (the age of the Earth). Critical parameters are the timing of core formation, and the timescale and mass of late veneer material accreted to the silicate Earth, in addition to the timing and rate of silicate Earth differentiation. The model quantitatively evaluates the various geodynamic processes, in particular, during Hadean that could lead to the observed ^{182}W signatures in both Archean and modern mantle-derived rocks.