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Pre-Late Accretion ^{182}W Constraint of Silicate Earth

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We present a five-reservoir open-system model for the ^{182}Hf-^{182}W isotope evolution of the Earth that constrains the timing and rate of core formation and the pre-late accretionary ^{182}W ($\mu^{182}W$) of the bulk silicate Earth (BSE). Core formation, by far, has the most significant influence on the ^{182}Hf-^{182}W isotopic evolution of the silicate Earth. It determines the ~200 ppm offset between bulk silicate Earth's $\mu^{182}W$ ($\mu^{182}W_{BSE} \sim 0$) and chondrites ($\mu^{182}W_{chondrite} = -200$ ppm), whereas late accretion adds no more than ~10% of BSE's W and changes the $\mu^{182}W_{BSE}$ by ~several 10s ppm. In our model, core formation is complete within 30-100 Myr after solar system formation. Late accretion adds bulk Earth-like material to the mantle after core formation. The model comprises a series of differential equations computing the changing abundance of isotope species in each reservoir, which are solved using the Runge-Kutta fourth-order iterative method from the beginning of Earth formation ($t = 4.56$ Gyr) to the present-day ($t = 0$ Gyr). Results show that the ^{182}W evolution is compatible with models in which core formation is complete by at least 45-60 Myr after solar system formation, limiting the addition of late accreted material to Earth to ~1-0.5% of Earth's mass. Our results highlight the interdependence of model parameters, such as core formation time (and more importantly, the rate), the concentration of W in the BSE, pre-late accretion $\mu^{182}W_{BSE}$, and the mass of late accreted material. Unfortunately, all of these parameters have large uncertainties.

Reducing the uncertainty on the present concentration of W in the BSE, however, would allow constraining the timing of core formation, the present pre-late accretion $\mu^{182}W_{BSE}$ value, and the amount of late accreted material more precisely; for the model presented here, but also for any other ^{182}Hf-^{182}W based model. Finally, we discuss the uncertainty on the $\mu^{182}W_{BSE}$ evolution, which results in a considerable uncertainty on the amount of late accreted material inferred from the ^{182}Hf-^{182}W isotope systematics.