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Exploring the Causes of ^{182}W Heterogeneity in Earth

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Variations in $^{182}W/^{184}W$ among early solar system materials were produced as a result of fractionations in Hf/W, coupled with the short, ~9 m.y. half life of ^{182}Hf. The largest Hf/W fractionations were produced by metal-silicate segregation, most notably as related to core formation processes, but also as a result of other metal-silicate processes, as well as silicate crystal-liquid fractionation.

Although the ^{182}Hf-^{182}W system was effectively dead 60 m.y. into solar system history, positive and negative anomalies in $^{182}W/^{184}W$, relative to a putative bulk silicate Earth reference, are now well established for Archean supracrustal and volcanic rocks, as well as for some recent volcanic rocks. Several models have been proposed to account for the anomalies, including initially grainy late accretion, magma ocean processes involving metal-silicate equilibration or silicate-silicate crystal-liquid fractionation, and core-mantle interactions. Perhaps not surprisingly, no single model can well explain the range of isotopic variations observed, especially when the ^{182}W anomalies are coupled with concentrations of highly siderophile elements, which are also strongly affected by metal-silicate processes, as well as grainy late accretion.

One type of process that could strongly affect the distribution of ^{182}W in the mantle, and that involves both late accretion and core formation, is late stage accretion of differentiated, large (1500-2500 km diameter) planetesimals. Planetesimals of this size have been suggested to be the dominant components of late accretion. Models we will present show that impacts involving objects of this size will result in the disaggregation of the core and mantle of the impactor, leading to the creation of mantle domains enriched in the silicate portion of the impactor, as well as domains enriched in core metal. The preferrential addition of either type of material to a mantle domain could lead to positive or negative anomalies of the magnitudes observed in the rock record. The likely preferrential transfer of impactor core to the Earth's core implies that the late accreted mass may have been 2 to 5 times greater than previously thought, based on mantle abundances of highly siderophile elements.