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Creating primordial heterogeneous mantle domain

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Noble gasses from Earth's interior may indicate that the mantle possesses a primordial heterogeneity. For instance, Xenon isotopes measured in basalt samples from mid-ocean ridge and plume associated volcanism appear to demonstrate distinct I/Xe ratios between plume sources during the 100 Myr lifetime of short-lived 129I (Mukhopadhyay 2012; Peto et al., 2013). In this work, we assess the factors that control the creation of heterogeneous mantle domains due to the accretion history of Earth (and planets in general). Using the planetary growth histories from astrophysical N-body simulations that reproduce many of the key features of the inner Solar System, we track how this material is likely incorporated into the growing planet (Jacobson & Morbidelli, 2014; Nesvorny et al., 2021). In particular, our model assesses the factors that control the size and compositional heterogeneity of deep mantle domains while reproducing a bulk silicate and core composition that is similar to Earth's today. After each large accretion event, we assess impact melting using scaling laws developed from high resolution soft-particle hydrocode simulations (Nakajima et al., 2021) and mixing using models appropriate to magma ocean and early mantle geodynamics (Solomatov 2015). We find that the frequency and size of giant impacts is a major control on the creation and survivability of diverse domains within the mantle.

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