Mantle heterogeneity and the late veneer

Francis Nimmo (UC Santa Cruz) and Dave O'Brien (Planetary Sciences Institute)

The mantles of the Earth and Mars were initially isotopically heterogeneous; this heterogeneity was subsequently reduced by mantle mixing and stirring [1,2]. For moderately and highly siderophile elements, delivery of isotopically distinct material as part of the late veneer can result in increased mantle heterogeneity and/or a secular change in mantle isotopic characteristics. The constancy of the measured $\varepsilon^{100}Ru/\varepsilon^{92}Mo$ ratio in Earth and meteorites [3,4] suggests that late veneer material was sourced from the same region as the main mass of the Earth. This outcome can discriminate between different N-body simulation results [5,6,7]. A secular change in terrestrial isotopic characteristics can potentially be detected by comparing the Moon – which experienced a different late veneer history [8] – to the Earth.

The degree of measured mantle isotopic heterogeneity depends on: the heterogeneity of the source material (which in turn likely depends on the width of the feeding zone); the size distribution of impacting material [8]; the efficiency of mantle stirring; and the size of the sampling region [9]. Models combining these different aspects will probe the details of the waning stages of planet formation.

[1] Willbold et al. Nature 2011 [2] Rizo et al. Nature 2012 [3] Dauphas et al. EPSL 2004 [4] Burkhardt et al. EPSL 2011 [5] O'Brien et al. Icarus 2006 [6] Raymond et al. Icarus 2013 [7] Walsh et al. Nature 2011 [8] Bottke et al. Science 2010 [9] Kellogg et al. EPSL 2002.