Isotopic evidence for the origin and fate of the late veneer

ROBERT C. J. STEELE[12]*, CHRISTOPHER W. DALE[3], CARSTEN MÜNKER[4] AND MARIA SCHÖNBÄCHLER[1]

[1]ETH Zürich, Switzerland [2]University of St Andrews, UK, [3]University of Durham, UK, [4]University of Cologne, Germany. (*rcjs@st-andrews.ac.uk)

The 'late veneer', or late accretion, is an enduring idea in the study of Earth's formation. First invoked to explain the over-abundance of highly siderophile elements (HSE) in the modern, post-core formation, mantle [1], it has been refined to include delivery of volatile elements. There is evidence that terrestrial building blocks were depleted in volatile elements during the first few million years of Solar System evolution [2]. Thus, delivery of volatile material during late accretion is a convenient solution and has significant implications for the habitability of terrestrial planets and the search for habitable exoplanets. However, estimates of important parameters such as the mass and composition of material delivered during this significant stage of accretion remain relatively poorly constrained.

Several recent studies have observed small differences in $\varepsilon^{182}W$ between samples of the Archean Isua suite and modern mantle [3,4,5]. These data can be used to estimate the mass and composition of the late veneer. Combined with HSE contents, these data were interpreted as evidence that these samples record a mantle that had received 60% of the late accreted material present in the modern mantle [4,5].

However, this interpretation is one end-member of a family of mixing models in which late accreted material is mixed in different proportions with the post-moon-forming impact mantle. To examine this parameter space, $\varepsilon^{182}W$ compositions [3,4,5] have been combined with Cr isotope measurements of samples from Isua [6] and modelling of the isotopic evolution of the early mantle. These models place tighter constraints on the mass, composition and mixing proportion of the late veneer. A CI late veneer must have low total mass (<0.5% Earth mass) unless homogenised with >65% of the mantle at the formation time of the Isua source. Importantly, this is an independent constraint from Cr isotope compositions alone. These models have implications for the formation and habitability of terrestrial planets and survival of primordial mantle domains.

[1] Chou. 1978, *LPSC*, 219–230. [2] Palme et al. 2003, *ToG*, 2, 1–38. [3] Willbold, et al. 2011, *Nature*, 477 (7363), 195–198. [4] Rizo, et al. 2016, *GCA*, 175, 319–336. [5] Dale, et al. 2017, *EPSL*, 458, 394–404. [6] Steele, et al. 2017, *Gold. Abs.*, (3762).