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Rapid differentiation of small planets, high precision evidence from Hf-W chronometry.

A. Scherstén(1), T. Elliott(2), C. Hawkesworth(2), S. Russell(3) and J. Masarik(4)

(1) Faculteit der Aard- en Levenswetenschappen, Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, Netherlands, (2) Department of Earth Sciences, University of Bristol, Will's Memorial Building, Queen's road, Bristol BS8 1RJ, UK (3)Department of Mineralogy, Natural History Museum, London SW7 5BD, UK (4)Department of Nuclear Physics, Komensky University, Mlynska dolina F/1, SK-842 48 Bratislava, Slovakia
(Anders.Schersten@falw.vu.nl / Phone: +31 20 598 7335)

Segregation of an iron rich core is a first order process in planetary evolution and hafnium-tungsten (Hf-W) chronometry provides a powerful tool in the determination of the timescales. W isotope data suggest that core formation in magmatic iron meteorite parent bodies occurred $\leq$1 Myr after the formation age of the oldest known solar system objects, refractory calcium aluminium rich inclusions (CAI). This extremely early differentiation is coeval with the first chondrules and argues against an extended nebular period of several million years and ordered formation of larger bodies. Formation of later chondrules and by inference some parent bodies of chondritic meteorites occurred in the presence of planetesimals large enough to possess iron cores. Furthermore, early planetary accretion and differentiation was sufficiently fast for ^{26}Al-decay to be an important heat source.

Some magmatic ε^{182}W are lower than the solar system initial (SSI) ε^{182}W, which results in improbable negative model ages. However, exposure ages seem to correlate with ε^{182}W such that the anomalously negative samples have older exposure ages. We conclude that spallation caused these data and that the current $\varepsilon^{182}W_{SSI}$ is correct.

Non-magmatic irons probably formed as small impact generated melt pools, and they show greater variations of ε^{182}W and range to values distinctly more radiogenic than magmatic irons. The W isotopic systematics in these irons is the result of variable but incomplete isotopic exchange with silicate during the late impact induced segregation of the metal. Disequilibrium between accreting silicate and metal phases has been proposed, on a much larger scale, to account for the mismatch in Hf-W and U-Pb chronologies of the early Earth. Likewise the two-stage Hf-W model ages of the Earth's core are much younger ($\sim$30 My after CAI) than the exceedingly rapid timescales for magmatic metal segregation underlined in this work. Our observations further emphasise the need for some isotopic exchange between the early separated iron and residual silicate during continued planetary growth and the possibility of disequilibrium allows the inconsistent Hf-W and U-Pb core formation ages to be reconciled.