^{182}W–^{142}Nd constraints on the early differentiation of Mars

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Mars likely represents one of the earliest-formed larger planetary bodies in the solar system [*e.g.* 1], but the time scales and processes involved in the early differentiation of Mars remain enigmatic. For instance, currently available data suggest protracted crystallization of a martian magma ocean, perhaps lasting until ~100 Ma after CAI formation [2]. However, whether mantle differentiation on Mars was a global event, or rather involved more localized processes, is debated. Moreover, the timing of crust formation on Mars has not yet been precisely dated. Quantitative insights into Mars' early differentiation can be gained from the extinct ^{182}Hf–^{182}W ($t_{1/2}$ = 8.9 Myr) and ^{146}Sm-^{142}Nd ($t_{1/2}$ = 103 Myr) systems. We report high-precision ^{182}W and ^{142}Nd data for a suite of martian meteorites, including several shergottites and nakhlites, orthopyroxenite ALH 84001 and polymict breccia NWA 7034. These data provide new insights into Mars' earliest differentiation, because (i) several of the samples have not been analyzed before and (ii) the ^{182}W data are much more precise than previous data.

Our results show that martian meteorites exhibit distinct $\varepsilon^{182}W$ that are broadly correlated with $\varepsilon^{142}Nd$, suggesting that silicate differentiation (and not core formation) is the main cause of the observed $\varepsilon^{182}W$ variability. However, the ^{182}W-^{142}Nd systematics cannot be explained by a single differentiation event at ~60 Ma [3], mainly because ^{182}Hf was effectively extinct at that time. This is especially apparent for ALH 84001 and NWA 7034, which show distinctly lower $\varepsilon^{182}W$ and $\varepsilon^{142}Nd$ than any of the shergottites, indicating derivation from enriched sources with low Hf/W and Sm/Nd. Specifically, the low $\varepsilon^{182}W$ of these samples reflects silicate differentiation within 30 Ma after CAI formation, most likely due to early crust formation on Mars. If Mars had a magma ocean, then such early crust formation would alleviate the need for a late [2] or protracted [3] interval of magma ocean crystallization, and would be consistent with Mars' early accretion and core formation within a few Ma after CAI [1].

[1] Dauphas N. & Pourmand A. (2011) *Nature* 473, 489-493. [2] Borg L.E. et al. (2016) *GCA* 175, 150-167. [3] Debaille V. et al. (2007) *Nature* 450, 525-528.