Dating metal-silicate fractionation among chondrite parent bodies

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The distinct metal-to-silicate ratios of ordinary chondrites (defining the subgroups H, L and LL) most likely reflect nebular metal-silicate fractionation just prior to chondrite parent body accretion. Until now, however, the timing of this metal-silicate fractionation event, and whether it was coeval to chondrule formation, has not been determined. To address these issues, we applied the short-lived ^{182}Hf-^{182}W chronometer to a suite of ordinary chondrites, with the ultimate goal of constraining the timing of metal-silicate fractionation among the H, L and LL ordinary chondrite subgroups. Owing to their distinct metal-to-silicate ratios, H, L and LL chondrites exhibit different bulk Hf/W, and so each group should have followed distinct Hf-W evolutionary paths after metal-silicate fractionation. To determine these evolution paths and hence, the time at which the distinct Hf/W ratios were established, we obtained Hf-W isochrons for thirteen H, L and LL chondrites of petrologic types 4-6.

For all samples, precise Hf-W isochrons were obtained, corresponding to ages of between ~3 and ~11 Ma after formation of CAIs. For most LL chondrites, metal typically plots below the isochron defined by corresponding silicate fractions, indicating a slightly earlier closure of the Hf-W system in the metal. Overall, our results demonstrate that type 6 chondrites have younger Hf-W ages than type 4 chondrites, implying slower cooling for chondrites of higher petrologic type and consistent with a concentrically layered structure of chondrite parent bodies, where more strongly metamorphosed samples are located at greater depth [1]. In a plot of initial ^{182}W isotopic composition *vs.* time, H, L and LL chondrites define distinct evolution paths that intersect at ~2-3 Ma after CAIs. Thus, the distinct bulk Hf/W (LL>L>H) were established at this time. This time of metal-silicate fractionation is consistent with Al-Mg ages of chondrules of ~2 Ma after CAIs [*e.g.* 2]. As chondrule formation likely was followed by rapid accretion to a parent body [*e.g.* 3], our results thus show that chondrule formation, metal-silicate fractionation and chondrite parent body accretion all were coeval at *ca.* 2-3 Ma after CAI formation.

References: [1] Trieloff M. et al. (2003) *Nature, 422,* 502–506. [2] Kita N.T. and Ushikubo T. (2012) *MAPS*, *47,* 1108–1119. [3] Alexander C.M.O. et al. (2008) *Science, 320,* 1617–1619.