

Hf-W chronometry of Allende chondrules and matrix

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Constraining the age and genetic relationship of chondrules and matrix—the major constituents of chondrites—provides unique insights into the early evolution of the solar system and earliest stages of planetary accretion. We present a new approach for dating chondrules, which makes use of the chemical complementarity of chondrules and matrix [1] [2] and dates the fractionation of siderophile elements between them [2] using the short-lived ^{182}Hf - ^{182}W system. We analyzed 2 matrix and 6 chondrule separates (each consisting of 10^2 – 10^3 chondrules), which were prepared by freeze-thaw disaggregation and gradually crushing a slice of Allende. Hf and W concentrations as well as W isotope compositions were determined using a Neptune *Plus* MC-ICP-MS.

The chondrule and matrix fractions display large and complementary nucleosynthetic W isotope anomalies (relative to Earth), reflecting different proportions of at least one presolar component in chondrules and matrix. The origin of this heterogeneity is unclear, but one possibility is that it reflects the sorting of presolar grains according to their size or type, presumably during formation of chondrule precursors. Because bulk Allende (CV3_{OX}) shows only small if any anomalies, the isotopic complementarity of chondrules and matrix implies that both formed from a single reservoir, followed by rapid accretion onto the parent body.

After correction for nucleosynthetic W isotope anomalies, the chondrule (high Hf/W and $\epsilon^{182}\text{W}$) and matrix (low Hf/W and $\epsilon^{182}\text{W}$) separates define an isochron, which we interpret to date Hf-W fractionation during chondrule formation at ~ 2 Ma after CAI formation. This age is in good agreement with ^{26}Al - ^{26}Mg and ^{207}Pb - ^{206}Pb ages for individual chondrules ranging from ~ 1 to ~ 3 Ma after CAI formation ([e.g., 3]). This does not exclude that some chondrules formed earlier, perhaps as early as CAI [4], but our data show that the majority of Allende chondrules formed ~ 2 Ma later than CAI and within an interval of $\sim \pm 0.5$ Ma. Formation of Allende chondrules, therefore, appears to have been coeval to that of ordinary and CO chondrite chondrules ([e.g., 3]).

[1] Palme *et al.* (2015) *EPSL* **411**, 11-19. [2] Bland *et al.* (2005) *PNAS* **102**, 13755-13760. [3] Kita *et al.* (2013) *MAPS* **48**, 1383-1400. [4] Connelly *et al.* (2012) *Science* **338**, 651-655.