

## Sr isotope evidence for the origin of chondrules

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Chondrules and matrices compose more than 80 vol.% of all types of chondrites. The identification of the formation mechanism for chondrules and matrices would be crucial for understanding how nm- to mm-sized dust grains have formed and evolved into the building blocks of rocky planets.

We performed major elements, trace elements, and Sr isotope analyses for individual chondrules (dia. = 0.9–3.6 mm, n = 8) embedded in polished slab specimens of the Allende meteorite (CV3). In addition, we analyzed Allende chondrule grains separated by the freeze-thaw method (n = 10). Sr isotopic measurements were performed by TIMS (TRITON plus). The  $^{84}\text{Sr}/^{86}\text{Sr}$  ratios are reported in the  $\mu^{84}\text{Sr}$  unit,  $10^6$  relative deviation from the average of standard (NIST 987). The  $\mu^{84}\text{Sr}$  values in Allende chondrules ranged from +23 to +147 ppm. The  $\mu^{84}\text{Sr}$  values showed a clear negative correlation with the size of individual chondrules. In contrast, the  $\mu^{84}\text{Sr}$  values do not present any correlation with the mineral chemistry (e.g., Mg#) of chondrules analyzed.

One convincing hypothesis to explain the observed  $\mu^{84}\text{Sr}$  variation is that two precursor materials with different  $\mu^{84}\text{Sr}$  values were involved in the chondrule formation; CAI fragments with higher  $\mu^{84}\text{Sr}$  values (110–210 ppm [1]) and fine-grained matrix-like grains with lower  $\mu^{84}\text{Sr}$  values (–50 ppm [2]). Prior to the chondrule formation, CAI fragments coexisted with matrix-like dust grains in a same region, forming composites which had CAI fragments in the core with matrix-like dusts coagulated as mantle in varying proportions. A subsequent heating event caused partial to complete melting of the composites, generating chondrules with various  $\mu^{84}\text{Sr}$  values depending on the matrix/CAI ratio of the composites. Assuming that the size of chondrules is controlled dominantly by the volume of matrix-like dust grains accumulated on CAI fragments, the resulting chondrules gain lower  $\mu^{84}\text{Sr}$  values as the chondrule sizes increase. This scenario is in concordance with recent finding of chondrule-matrix complementarity within single chondrites [3], suggesting the formation and co-evolution of chondrules and matrices in a closed system before planetesimal accretion.

[1] Moynier et al. (2012) *ApJ* **758**, 45. [2] Yokoyama et al. (2015) *EPSL* **416**, 46. [3] Palme et al. (2015) *EPSL* **411**, 11.