

Nucleosynthetic Strontium isotope variability in Allende CAIs

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Calcium and aluminum rich inclusions (CAIs) are composed of refractory mineral such as melilite, spinel or pyroxene and thought to be the first condensates in the early solar system. Most CAIs possess a variety of nucleosynthetic isotope anomalies for heavy elements. Brennecka et al. [1] reported that Sr, Mo, Ba, Nd and Sm isotope composition in CAIs were uniform, yet distinct from the solar system average compositions. However, most of previous studies analyzed "bulk" CAIs without detailed mineral description. CAIs are composed of various mineral assemblages depending on the environment and/or the timing of individual CAI formation. The difference of mineral assemblages can be observed even within a single CAI. Therefore, it is important to determine the isotope compositions of heavy elements not only for different types of CAIs, but also of multiple spots within a single CAI with detailed mineral description.

In this study, we performed *in-situ* measurements of $^{84}\text{Sr}/^{86}\text{Sr}$ ratios in two Allende CAIs using TIMS (Triton-plus, Tokyo Tech) coupled with a micro milling system (Geomill 326, Izumo) together with detailed mineral descriptions using SEM-EDS (JSM-5310, Univ. of Tokyo and Hitachi 3400, Tokyo Tech). Three specimens of the Allende meteorite were sliced into two respective slabs of which one sides were used for mineralogical analysis and the other sides were used for Sr isotope analysis. We selected three relatively large CAI grains; a cm-size fluffy type A (FTA) CAI, a type B CAI and a fine-grained spinel-rich (FS) inclusion. Using the micro-milling system, we sampled 8 spots from the FTA CAI, 3 spots from type B and 3 spots from the FS inclusion for the analysis of $^{84}\text{Sr}/^{86}\text{Sr}$ ratios. Samples were decomposed in a pressure digestion system (Digestec DAB-2, Berghof) with HF and HNO_3 . Sr separation for high precision isotope measurement was achieved by column chemistry with extraction chromatographic resin (Sr spec, Eichrom).

The mean $m^{84}\text{Sr}$ values (10^6 relative deviations from NIST 987) were 175 ppm for FTA, 129 ppm for type B and 56 ppm for the FS inclusion, respectively. Notably, one spot from the FTA CAI showed the greatest $m^{84}\text{Sr}$ value (273 ± 21 ppm) compared to those of CAIs ever reported. Assuming that FTA CAI predates type B CAI and the FS inclusion, our results would imply that the extent of Sr isotope anomaly in the CAI-forming region was large and heterogeneous at the earlier stage, which subsequently shifted towards low and relatively homogeneous $m^{84}\text{Sr}$ values when type B CAI and FS inclusion formed. The isotopic shift was most likely caused by the effective mixing of nebular dusts including p- and/or r-process-enriched carries (i.e., high $m^{84}\text{Sr}$) and isotopically normal grains.

References: [1] Brennecka et al. (2013) *PNAS*, 110, 17241.

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