Origin and evolution of distinct isotopic variabilities for Sr, Mo, and Nd within CC and NC reservoirs

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The findings of nucleosynthetic isotope anomalies in bulk meteorites indicate planetary-scale heterogeneities in the multi-elemental isotope systems of refractory heavy elements. In particular, carbonaceous chondrites (CCs) and other meteorites (noncarbonaceous meteorites; NCs) form distinct clusters in the isotope spaces including ε^{50}Ti–ε^{54}Cr and μ^{95}Mo–μ^{94}Mo, suggesting that the source materials feeding the CC and NC parent bodies were widely separated in the early solar system, with larger heliocentric distance for CCs than NCs [1-2]. Moreover, different classes of meteorites within the CCs and NCs show isotopic variations for some elements. Such isotopic characteristics recorded in meteorites would reflect the dynamic history of material transport and mixing in the early solar system.

We investigated the isotopic variabilities for Sr, Mo, and Nd in CCs and NCs [3-4]. Although the CCs form an s-process mixing line (SML) in the μ^{95}Mo–μ^{94}Mo space, the data deviate from the SML in the μ^{84}Sr–μ^{150}Nd space. The inconsistency resulted from the involvement in CCs of isotopically anomalous calcium-aluminum-rich inclusions (CAIs) in which large proportions of Sr and Nd are hosted. In fact, the data for CAI-subtracted CCs are plotted on the SML in the μ^{84}Sr–μ^{150}Nd space. The isotope variabilities for Sr, Nd, and Mo within the CCs indicate that s-process matter distributed heterogeneously throughout various chondritic components in the different outer solar system materials.

In contrast, the Mo isotope variability for NCs suggests the presence of two end-member components in the NC reservoir (i.e., NC-A and NC-B), where the involvement of an additional nucleosynthetic component other than the s-process is required. Two models are proposed to account for the observation; (i) Mo isotopic composition of the NC region changed gradually from NC-A- to NC-B-like components as a function of the heliocentric distance, or (ii) a fractionation process involving chondritic matrix and metal, which most likely occurred locally in time and/or space, has generated the Mo isotope variability in the NC region.

[1] Warren, 2011, *EPSL* **311**, 93. [2] Kruijer et al., 2017, *PNAS* **114**, 6712. [3] Fukai and Yokoyama, 2019, *ApJ* **879**, 79. [4] Yokoyama et al., 2019, *ApJ* **883**, 62.