High precision Sr isotope measurements for bulk chondrites with complete sample digestion

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Nucleosynthetic isotope anomalies have been discovered in bulk chondrites and differentiated meteorites for various refractory heavy elements (e.g., Cr, Ru [1, 2]). In the most cases, the extent of isotope anomalies is variable across different types of meteorites. These results point to the existence of planetary-scale isotope heterogeneities, which are most likely due to the incomplete mixing of dust grains and/or selective destruction of presolar grains during thermal processing in the early solar nebula. However, the processes that have led to the observed isotope heterogeneity are not fully understood.
High precision stable Sr isotope analyses on bulk meteorites have been conducted in some previous studies ([3–5]). These studies found isotopic variations of ^{84}Sr/^{86}Sr ratios across three types of chondrites (enstatite, ordinary, and carbonaceous chondrites). However, the extent of Sr isotope heterogeneities across entire classes of chondrites remains unclear due to the limited number of Sr isotope data with sufficiently high precision. In addition, not all studies have performed complete digestion of samples that contained acid resistant presolar grains.
In this study, we revisited high precision Sr isotope analysis of chondrites coupled with a robust sample digestion technique that confirmed complete dissolution of presolar grains. We also improved the analytical reproducibilities of Sr isotope measurement from previous studies by adopting the dynamic-multicollection method with TIMS.
The reproducibilities for NIST 987 standard obtained in a single analytical campaign were 16 ppm for ^{84}Sr/^{86}Sr ratio (n = 7, 2SD), which are two times superior to those in previous studies [3–5]. We investigated four enstatite chondrites (EH and EL), seven ordinary chondrites (H, L, and LL), and four types of carbonaceous chondrites (CI, CM, CO, and CV). Three types of ordinary chondrites possess generally uniform μ^{84}Sr values* (= −12 ±29 ppm; 2SD). By contrast, enstatite and carbonaceous chondrites possess variable Sr isotopic compositions depending on each subgroup. For instance, EL chondrites show the lowest μ^{84}Sr values (= −30 ±26 ppm) among all types of chondrites, while EH chondrites show μ^{84}Sr values indistinguishable from ordinary chondrites (= −12 ppm ±36 ppm). On the other hand, a CI chondrite (Y-980115) shows μ^{84}Sr values (= 14 ±14 ppm) that is resolved from those of CV chondrite (Allende) showing the highest μ^{84}Sr values (= 36 ±21 ppm) among all types of chondrites. The observed global trend for the μ^{84}Sr value that range from −30 ppm for EL chondrites to 36 ppm for CV chondrites is consistent with the results of other heavy refractory elements (e.g., Mo [6], Ru [2], Nd [7]), which have been induced most likely by the selective destruction for presolar grains via nebular thermal processing. Furthermore, the existence of the local trend observed in carbonaceous chondrites would reflect the additional processes that may have occurred in the outer Solar System before the accretion to each parent body for carbonaceous chondrites.

* Parts par 10^6 relative deviation from the standard, NIST 987

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