Final ID: V11E-02

Sm-Nd and Lu-Hf isotope composition of chondritic components

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Body: The ^{146}Sm-^{142}Nd, ^{147}Sm-^{143}Nd and ^{176}Lu-^{176}Hf radiogenic isotopic systems are widely used as chronometers and tracers of planetary evolution. These involve refractory lithophile elements and thus it is assumed that the average Sm-Nd and Lu-Hf composition of bulk terrestrial planets should be the same as that of chondrites (CHUR). We previously revised the CHUR compositions with 0.1960 ±0.0004 for ^{147}Sm/^{144}Nd and with 0.0336 ±0.0001 for ^{176}Lu/^{177}Hf using unequilibrated ordinary (OC) and carbonaceous (CC) chondrites [1], and proposed these should apply to the bulk silicate Earth (BSE). Recent studies suggest that BSE may have a super-chondritic Sm/Nd (~5%) and Lu/Hf (~10%) composition and could explain the Nd and Hf isotopic systematics of Earth and planetary materials [2, 3]. Here, we present additional Sm-Nd and Lu-Hf compositions of chondrites and chondritic components to evaluate potential isotopic heterogeneities present in the protoplanetary disk. Isotopic analyses were carried out by Neptune MC-ICPMS at ASU. Analytical details are in [1, 4].

We extend our study to homogenized whole-rock (WR) powders of 4 equilibrated OC to investigate the scale of Lu-Hf isotopic heterogeneities as consequences of thermal metamorphism on the OC parent bodies (PB) [1]. Their ^{147}Sm/^{144}Nd and ^{176}Lu/^{177}Hf vary from 0.1954 to 0.1969, and 0.0298 to 0.0341 respectively indicating that open metasomatism associated with crystallization of phosphate [1] occurred at least at the cm scale on the OCPB.

We also present the first Lu-Hf and coupled Sm-Nd isotopic data of 6 single or pooled chondrules, and 2 calcium aluminum-rich inclusions (CAIs) from 5 type 3 OC & CC. The ^{147}Sm/^{144}Nd and ^{176}Lu/^{177}Hf ranges are 0.1956-0.1969, and 0.0331-0.0341 respectively for chondrules, and 0.1947-0.2147, and 0.0392-0.0501 respectively for CAIs. The chondrules are within the range of our earlier Sm/Nd and Lu/Hf CHUR-BSE estimates but the CAIs have significantly higher values, especially for Lu/Hf. Thus, only CAIs have strongly fractionated Sm/Nd and Lu/Hf, likely due to high temperature fractionation of elements in the early solar nebula. Based on evidence from Cr and Ti isotope systematics in CC [9], however, it appears unlikely that the Earth accreted in the CAI-forming region. Basaltic eucrites, which were differentiated early, also have chondritic ratios [10]. A super-chondritic Earth would thus imply accretion from large differentiated parent bodies that significantly fractionated Sm/Nd and Lu/Hf by igneous processes. This would require a late final accretion and homogenization which does not seem consistent with timing and global mixing models proposed in the accretion zone of terrestrial planets [11].

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