SM AND ND ISOTOPIC COMPOSITIONS OF CAIs

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Introduction: The use of ^{146}Sm-^{142}Nd systematics as a precise chronometer for early planetary differentiation has recently become problematic. The initial ^{146}Sm/^{144}Sm Solar System ratio was calculated at 0.0085 ±0.0007 from internal isochrons of achondrites using a half-life of 103 Ma [1]. This ratio was revised to 0.0094 ±0.0005 using a new ^{146}Sm half-life of 68 Ma [2]. This difference causes variations of up to 150 Ma in age determinations and also hampers modeling of early Earth silicate differentiation processes and timescales. Also Sm and Nd isotopic anomalies and in particular ^{144}Sm isotopic anomalies affect the determination of ^{142}Nd/^{144}Nd ratios in planetary materials [3, 4].

Results: We have measured the Sm and Nd stable and radiogenic isotopic compositions of bulk samples and mineral separates (melilite and fassaite) of two individual Calcium, Aluminum-rich Inclusions (CAIs) from the CV3 carbonaceous chondrites (CC) NWA 2364 and NWA 6991. The bulk and mineral ^{147}Sm-^{143}Nd for the two CAIs together is 4562 ±110 Ma (MSWD =0.81, ^{143}Nd/^{144}Nd$_i$= 0.50668±0.00016). The most precise bulk and mineral ^{146}Sm-^{142}Nd isochron is obtained on NWA 6991 with a Solar System initial ^{146}Sm/^{144}Sm ratio of 0.0070 ±0.0024 consistent with an Allende CAI [5]. Sm stable isotope compositions of the analyzed CAIs indicate that galactic cosmic rays did not affect the ^{142}Nd/^{144}Nd compositions, but deficits are found in the pure p-process ^{144}Sm nuclide (-240 to -290 ppm/ standard). The ^{142}Nd is mainly produced by s-process and the contribution of p-process is estimated to range from 4 % to 20% [3, 4]. These deficits may thus translate to ^{142}Nd deficits of several ppm.

Discussion: The μ^{144}Sm values in whole rock CC have an average of -80 ppm [6] as a signature of p-process deficiency, while no anomalies are found in most of the ordinary or enstatite chondrites (OC and EC) [3]. A mixing model shows that adding between 2 to 5% of CAIs with a constituent similar to OC and EC can explain the ^{144}Sm signature of the bulk CV3 chondrites. This model does not work for CI chondrites (-102 ppm ^{144}Sm [7]) in which p-process deficiency must be present in the matrix.

The initial ratio of NWA 6991 CAI is in better agreement with the ratio of [1] defined using the ^{146}Sm half-life of 103 Ma, instead of the value obtained using the half-life of 68 Ma [2]. NWA 6991 CAI ^{146}Sm-^{142}Nd internal isochron passes through a ^{142}Nd/^{144}Nd ratio of -6 ±6 ppm relative to the terrestrial standard at a chondritic ^{147}Sm/^{144}Nd of 0.1960 [7]. This value is also identical to the enstatite chondrite average and the ^{142}Nd/^{144}Nd ratio of the lunar mantle, as defined recently by [8] using a chondritic Sm/Nd and Lu/Hf [7] for the bulk Moon. While the determination of the Sm-Nd reference parameters for the bulk Earth is still contentious, the difference in ^{142}Nd/^{144}Nd between modern terrestrial rocks and meteorites analyzed so far is now <10ppm.

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