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147Sm-143Nd and 146Sm-142Nd chronology of a basaltic eucrite, NWA 7188

KAGAMI, Saya[1*] ; YOKOYAMA, Tetsuya[1] ; USUI, Tomohiro[1] ; FUKAI, Ryota[1]

[1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Eucrites are achondritic meteorites originating from the Vesta's crust. They can be petrographically classified into basaltic and cumulate eucrites. Determination of precise ages for eucrites will constrain the period of igneous activity and the following thermal metamorphism of Vesta and may further provide insights into its differentiation and thermal history. We investigate the long-lived ^{147}Sm-^{143}Nd ($T_{1/2}$ = 1.06×10^{11} yr) and the short-lived ^{146}Sm-^{142}Nd ($T_{1/2}$ = 6.8×10^{7} yr [1]) systematics of a basaltic eucrite, NWA 7188 and compare the results with the ages obtained in previous chorological studies on cumulate and basaltic eucrites. To obtain highly precise age data, we developed the techniques for determining Nd and Sm concentrations and Nd isotope compositions in meteorite samples.

NWA 7188 was crushed and sieved into four sizes; G1) 500 — 1700 μm, G2) 250 — 500 μm, G3) 106 — 250 μm, and G4) $\leq$106 μm. G3 and G4 were separated into pyroxene and plagioclase grains by handpicking. We determined the ^{147}Sm-^{143}Nd and ^{146}Sm-^{142}Nd ages of NWA 7188 using G1, G3-px, G4-px, G3-pl, and G4-pl. These were dissolved using a mixture of concentrated pure acids ($HClO_4$, HF, and HNO_3). After the sample digestion, ~ 10% of the solution was removed and mixed with ^{149}Sm- and ^{145}Nd-enriched spikes to determine the Sm and Nd concentrations by ID-ICP-MS (X-series Ⅱ, Thermo). The remainder of the sample solution was used for highly precise Nd isotope analysis by TIMS (TRITON plus) with the dynamic multicollection mode. Nd was separated by a three-step column chemistry procedure; 1) major elements were removed by passing through a cation exchange resin, 2) Ce was removed using the LN resin (Eichrom) by oxidizing Ce^{3+} into Ce^{4+} using $KBrO_3$ [2] and 3) Nd was separated from Sm using the LN resin. We achieved Ce/Nd = ~ 3×10^{-5} and Sm/Nd = ~ 4×10^{-5} with $\geq$91% Nd recovery.

The ^{147}Sm-^{143}Nd mineral isochron of NWA 7188 yields an age of 4203±970 Ma. In contrast, we obtained a much older ^{146}Sm-^{142}Nd mineral isochron age of $4549\pm^{28}{}_{40}$ Ma when an initial solar system ratio of ^{146}Sm/^{144}Sm = 0.0094 at 4568 Ma was applied [1]. It is presumed that thermal metamorphism on the Vesta has some effects on the ^{147}Sm-^{143}Nd age while the ^{146}Sm-^{142}Nd age represents the timing of the last Sm-Nd isotopic closure. Therefore, we use the ^{146}Sm-^{142}Nd age of NWA 7188 in the following discussion.

The ^{146}Sm-^{142}Nd age ($4549\pm^{28}{}_{40}$ Ma) for NWA 7188 is consistent with the ^{147}Sm-^{143}Nd age for cumulate eucrites (4546±8 Ma [3]) within analytical uncertainties. This suggests that the parent body processes associated with the last Sm-Nd isotopic closure were contemporaneous for basaltic and cumulate eucrites. Likewise, the ^{146}Sm-^{142}Nd age of NWA 7188 is not resolvable from the metamorphic age of Agoult [4]. According to the ^{53}Mn-^{53}Cr systematics [5], the last global Mn/Cr fractionation in the mantle of the Vesta occurred at 4564.8±0.9 Ma, the timing when basaltic magmas have formed in the mantle. This implies that basaltic eucrites quenched rapidly on the surface of eucrite parent body, but thermal metamorphism may have affected both Sm-Nd and U-Pb systematics. No apparent age difference between basaltic and cumulate eucrites implies that both types of eucrites might have experienced similar cooling history as opposed to their petrographic distinction, or more likely that the time difference is too subtle to be resolved by the ^{146}Sm-^{142}Nd system.

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