# $^{147}Sm$-$^{143}Nd$ and $^{146}Sm$-$^{142}Nd$ chronology of basaltic eucrites

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Eucrites are interpreted to have originated from the asteroid 4-Vesta's crust. They are 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. Sm-Nd dating is one of the most suitable approaches for investigating the crust crystallization age. The Sm-Nd systematics has two chronometers: the long-lived $^{147}Sm$-$^{143}Nd$ ($T_{1/2}$ = $1.06 \times 10^{11}$ y) and the short-lived $^{146}Sm$-$^{142}Nd$ ($T_{1/2}$ = $1.03 \times 10^{8}$ y [1]) systematics. Bouvier et al. [2] revealed that the variation of Sm/Nd ratios for basaltic eucrites were several times smaller than the entire range of Sm/Nd ratios for all eucrites, making it difficult for obtaining the precise Sm-Nd whole-rock isochron age for basaltic eucrites alone.

In this study, we determine the $^{147}Sm$-$^{143}Nd$ and $^{146}Sm$-$^{142}Nd$ ages for bulk rocks of basaltic eucrites, (NWA 7188, Juvinas, NWA 5229, Nuevo Laredo and Agoult). The samples were decomposed with HF, $HClO_4$ and $HNO_3$. After the sample digestion, ~10% of the solution was removed and mixed with the $^{149}Sm$- and $^{145}Nd$-enriched spikes. The spiked solution was passed through TRU Resin (Eichrom) for separating REEs from the matrix elements. We measured the $^{145}Nd/^{146}Nd$ and $^{147}Sm/^{149}Sm$ ratios in the sample separated for determining the Sm/Nd ratios by ID-ICP-MS (X-series Ⅱ, Thermo) [3]. The remainder of the sample solution was used for highly precise Nd isotope analysis. The 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 Ln Resin (Eichrom) by oxidizing $Ce^{3+}$ into $Ce^{4+}$ using $KBrO_3$ [4,5], and 3) Nd was separated from Sm using Ln Resin [3]. We achieved Ce/Nd = ~$1.2 \times 10^{-5}$ and Sm/Nd = ~$5.2 \times 10^{-6}$ with >92% Nd recovery. The $^{142}Nd/^{144}Nd$ and $^{143}Nd/^{144}Nd$ ratios were analyzed by TIMS at Tokyo Tech (TRITON plus) with the dynamic multicollection method [6].

The whole-rock isochron ages of five basaltic eucrites yielded the $^{146}Sm$-$^{142}Nd$ and $^{147}Sm$-$^{143}Nd$ ages of $4565^{+41}_{-58}$ Ma and 4529 ±260 Ma, respectively. Although the error of the isochron is relatively large, the whole-rock $^{146}Sm$-$^{142}Nd$ age of basaltic eucrites is indistinguishable from that of cumulate eucrites obtained previously ($4556^{+30}_{-37}$ Ma). This implies that the whole-rock Sm-Nd isochron ages for basaltic and cumulate eucrites most likely represent the timing of global differentiation of the silicate part of Vesta. It is important to note that the timing of global silicate differentiation is nearly contemporaneous to the timing of metal-silicate segregation in the eucrite parent body deduced from the age obtained by the $^{182}Hf$-$^{182}W$ systematics [7]. The result supports an idea that eucrites formed by equilibrium and fractional crystallization of silicate part of the parent body immediately after a magma ocean.

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