147SM-143ND AND 146SM-142ND SYSTEMATICS OF BASALTIC EUCRITES. S. Kagami[1], T. Yokoyama[1], and T. Usui[1], [1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, (2-12-1 Ookayama, Meguro, Tokyo 152-8551, Japan, e-mail: kagami.s.ab@m.titech.ac.jp).

Introduction: Eucrites are interpreted to have originated from the asteroid 4-Vesta's crust [1]. They are petrographically classified into two groups; basaltic eucrites with subophitic texture quenched near the surface, while cumulate eucrites having gabbroic texture are the residual melt crystallized slowly deep in the crust [2]. The eucrite parent body has experienced magma ocean associated with core formation and silicate differentiation within several years after the formation of the solar system as investigated by the ^{182}Hf-^{182}W and ^{53}Mn-^{53}Cr systematics [3, 4].

Sm-Nd dating is one of the most suitable approaches for investigating the crust crystallization age because both Sm and Nd are lithophile elements. The Sm-Nd systematics has two chronometers: the long-lived ^{147}Sm-^{143}Nd ($T_{1/2}$ = 1.06×10^{11} y) and the short-lived ^{146}Sm-^{142}Nd ($T_{1/2}$ = 1.03×10^{8} y [5]) systematics. Bouvier et al. [6] presented the ^{147}Sm-^{143}Nd isochron age for bulk rocks of 23 basaltic and cumulate eucrites to be 4532 ± 170 Ma. That study 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. To obtain highly precise age data, we applied the techniques developed in our previous studies for determining the Sm/Nd ratios and Nd isotope compositions in meteorite samples [8, 9]. We report the ^{147}Sm-^{143}Nd and ^{146}Sm-^{142}Nd ages of five basaltic eucrites, and compare the results with the ages obtained from previous studies on basaltic and cumulate eucrites using different radiometric dating methods.

Samples: We investigated five basaltic eucrites, NWA 7188, NWA 5229, Juvinas, Agoult, and Nuevo Laredo, all of which are classified into monomict [10–14]. Of these, NWA 7188 is slightly affected by brecciation while Agoult is unbrecciated.

Experimental: The meteorite chips were cleaned with acetone and Milli-Q water, then powdered using an agate mortar and pestle. The powdered samples were decomposed using a high-pressure digestion system (DAB-2, Berghof) with HF and HNO_3 to completely dissolve refractory minerals including zircon. Subsequently, the samples were treated with $HClO_4$ to eliminate insoluble fluorides. 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 isotope dilution using a quadrupole ICP-MS at Tokyo Tech (X-series II, Thermo).

The remainder of the sample solution was used for highly precise Nd isotope analysis. The solution was first passed through a cation exchange column filled with a 1:1 mixture (w/w) of AG50W-X8 and AG50W-X12 (Bio-Rad) to separate REEs from major elements. Next, Ce was removed from the rest of REEs by passing through Ln Resin (Eichrom), during which Ce^{3+} in the sample solution (10M HNO_3) was oxidized into Ce^{4+} using $KBrO_3$ [15, 16]. Finally, Nd was separated from Sm using Ln Resin in HCl media. We achieved Ce/Nd = ~3×10^{-5} and Sm/Nd = ~4×10^{-5} with >91% 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. The reproducibilities of the ^{142}Nd/^{144}Nd and ^{143}Nd/^{144}Nd ratios for a standard JNdi-1 (500 ng) were 4.8 ppm and 3.7 ppm (2σ), respectively.

Results and Discussion: For the ^{147}Sm-^{143}Nd system, the basaltic eucrites examined in this study yielded an isochron age of 4538 ± 220 Ma with an initial ^{143}Nd/^{144}Nd of 0.50660 ± 0.00030 (MSWD = 0.104; Fig. 1). This ^{147}Sm-^{143}Nd whole-rock isochron age is consistent with the whole-rock ^{147}Sm-^{143}Nd isochron age for 23 basaltic and cumulate eucrites obtained previously (4532 ± 170 Ma [6]). In addition, we obtained the ^{146}Sm-^{142}Nd whole-rock isochron age for the basaltic eucrites to be 4565^{+42}_{-59} Ma (MSWD = 4.1; Fig. 2) by assuming an initial Solar System ratio of ^{146}Sm/^{144}Sm = 0.00828 at 4567 Ma and $T_{1/2}$ = 103 Myr for ^{146}Sm as suggested in [5]. Boyet et al. [7] investigated the ^{146}Sm-^{142}Nd evolution diagrams for bulk rocks of three basaltic and three cumulate eucrites. By applying the same initial ^{146}Sm/^{144}Sm and $T_{1/2}$ for ^{146}Sm, the ^{146}Sm-^{142}Nd age is recalculated to be 4556^{+30}_{-37} Ma. It should be noted that the recalculated age of Boyet et al. [7] was determined dominantly by the data for three cumulate eucrites with variable Sm/Nd ratios, thereby most likely representing the age of cumulate eucrites for a differentiation event. Although the analytical uncertainties are large, this age is consistent with that for basaltic eucrites determined in this study, suggesting that the parent body processes associated with the last Sm-Nd isotopic closure were contemporaneous for basaltic and cumulate eucrites.

According to the Pb-Pb systematics [17], the mean age for small zircons found in basaltic eucrites was 4541 ± 11 Ma, which was consistent with the ^{146}Sm-^{142}Nd age for basaltic eucrites obtained in this study (4565^{+42}_{-59} Ma) within analytical uncertainties. This suggests that the ^{146}Sm-^{142}Nd age may be likely the crystallization age of the crust from basaltic magma. Kleine et al. [3] presented the Hf-W whole-rock isochron age for 7 basaltic and 1 cumulate eucrites to be 4563.2 ± 1.4 Ma. This most likely represents the formation age of the basaltic eucrite source reservoir. The ^{146}Sm-^{142}Nd age in this study for basaltic eucrites and the Hf-W whole-rock isochron age are consistent with each other within analytical uncertainties. This implies that there is no apparent age difference between the formation of source mantle for basaltic eucrites and the crystallization of the crust represented by basaltic eucrites.

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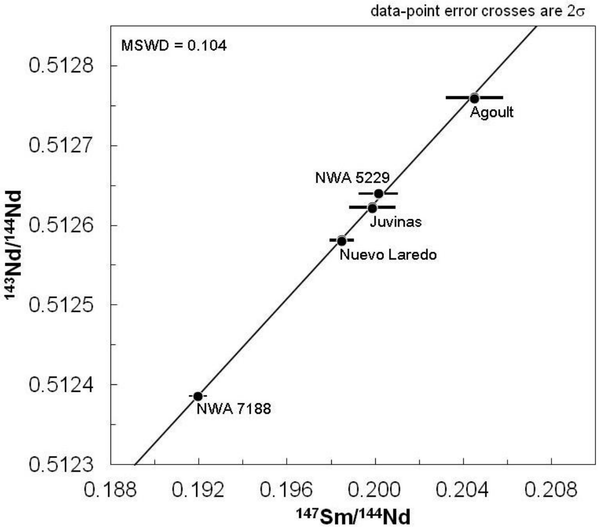

Fig.1 *^{147}Sm-^{143}Nd isochron diagram for basaltic eucrites. Error bars are 2SE, of which the y- axis is smaller than the size of symbols.*

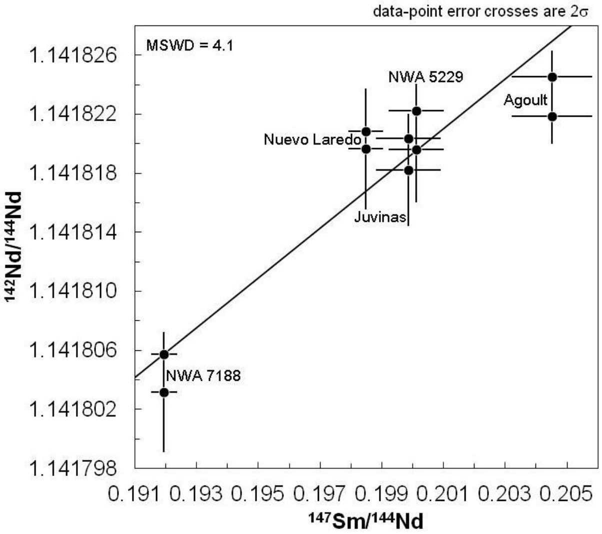

Fig.2 *^{146}Sm-^{142}Nd isochron diagram for basaltic eucrites. Errors bars are 2SE.*