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

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Eucrites are interpreted to have originated from the asteroid 4-Vesta which differentiated into crust and mantle. The chronology of eucrites is important to understand the formation and differentiation of planets/ planetesimals in the early Solar System. The combination of two chronometers, short-lived ^{146}Sm-^{142}Nd system ($T_{1/2}$=6.8$\times$10^{7}yr) and long-lived ^{147}Sm-^{143}Nd ($T_{1/2}$=1.06$\times$10^{11}yr), is useful to decode the thermal history of the eucrite parent body, because they have the same closure temperature [1]. To obtain precise Sm-Nd ages for eucrites and other achondrites, it is indispensable to develop highly precise Nd isotope analysis.

We investigated the ^{147}Sm-^{143}Nd and ^{146}Sm-^{142}Nd chronometers for a brecciated basaltic eucrite, Juvinas. We examined samples of whole rock powder (W.R.), 400 mesh grains, plagioclase (Pl), and pyroxene (Px). Plagioclase and pyroxene grains were obtained by handpicking. Samples were dissolved using a mixture of concentrated pure acid ($HClO_4$, HF, and HNO_3) and heating at 195 ℃. About ten percent of the solution was removed and spiked with ^{149}Sm-^{145}Nd in order to precisely measure Sm and Nd concentrations by ID-ICP-MS (Thermo X-series II at Tokyo Tech). We separated Nd from the rest of the solution via a four-step column chemistry. Nd isotope ratios in W.R., 400mesh, Pl, and Px were analyzed by TIMS (Thermo TRITON-plus at Tokyo Tech) with the dynamic multicollection method.

The ^{147}Sm-^{143}Nd mineral isochron diagram of Juvinas, yielded an age of 4610$\pm$410 Ma. In contrast, the ^{146}Sm-^{142}Nd systematic for Juvinas yielded an initial ^{146}Sm/^{144}Sm ratio of 0.0157$\pm$0.0074. This gives ?4618?_(-63)ˆ(+38) Ma for the age of Juvinas when an initial solar system ratio of ^{146}Sm/^{144}Sm=0.0094 at 4568 Ma is assumed [1]. The self-consistency of the ^{147}Sm-^{144}Nd and ^{146}Sm-^{142}Nd ages for Juvinas supports early crust-mantle differentiation on the eucrite parent body as was proposed by previous chronological studies on basaltic eucrites (e.g., Pb-Pb, Al-Mg, Mn-Cr, and Hf-W; [2-5]).

It has been suggested that cumulate eucrites provide internal isochron ages younger than basaltic eucrites due to a longer history in the deep crust or late thermal disturbance during later meteorite bombardment event(s) [6]. Because of the limited Sm/Nd variation in the meteorite components analyzed, the Sm-Nd ages obtained in this study have uncertainties several times larger than those in previous studies [6]. The ^{147}Sm-^{143}Nd age and the initial ^{143}Nd/^{144}Nd ratio for Juvinas are consistent with those obtained by the mineral isochrons of three cumulate eucrites within analytical error (4546$\pm$8 Ma; [6]). However, our ^{146}Sm-^{142}Nd age is older than the proposed ^{147}Sm-^{143}Nd age for cumulate eucrites, indicating that the crystallization of basaltic eucrites predates the timing when the Sm-Nd systematics for cumulate eucrites reached a closure temperature. It should be noted that Juvinas is a brecciated basaltic eucrite which may not record a correct Sm-Nd age. Further investigation is required to obtain more precise Sm-Nd ages utilizing unbrecciated basaltic eucrite to reveal the thermal history on the eucrite parent body.

References: [1] N. Kinoshita et al., (2012) Science, 335, 1614 [2] S.J.G. Galer and G.W. Lugmair, (1996) MAPS, 31, A47. [3] M. Wadhwa et al., (2003) LPSC XXXIV, 2055. [4] G.W. Lugmair and A. Shukolyukov, (1998) GCA 62, 2863. [5] T. Kleine et al., (2004) GCA 68, 2935.
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