Cosmic-ray exposure histories of eucrtes studied from Sm abd Gd isotopic compositions

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Previous studies of cosmic-ray exposure (CRE) ages for HED meteorites show the existence of two major clusters of the CRE ages around 20-25 Ma and 35-42 Ma and of other three minor clusters around 6-7 Ma, 10-12 Ma, and 14 Ma (Eugster and Michel, 1995; Welten et al., 1997). Our concern is whether the Sm and Gd isotopic shifts of eucrites also show the consistent trend with the CRE age clusters. ^{149}Sm and ^{157}Gd have very large thermal neutron capture cross sections, and change thier isotopic abundances by ^{149}Sm(n,γ)^{150}Sm and ^{157}Gd(n,γ)^{158}Gd reactions, respectively, induced from cosmic-ray irradiation. Providing that the CRE information from the Sm and Gd isotopic shifts are different from the ^{81}Kr-Kr data, there is a possibility that the inconsistency of the CRE information occurred by the pre-irradiation on the eucritic parent body. In this study, eight basaltic eucrites (DaG 380, DaG 391, DaG 411, DaG 443, DaG 480, Juvinas, Stannern, and Millbillillie) were used. DaG series were found in the Libyan Desert, and they were weakly shocked: DaG 380 is a monomict, and DaG 391, DaG 411 and DaG443 are polymict (Grossman 1999; 2001). As far as the CRE ages of eucrites are concerned, 41.1-42.0 Ma for Stannern, 9.6-10.8 Ma for Juvinas, and 24.8 Ma for Millbillillie are given by ^{81}Kr-Kr ages of previous studies (Schutz and Freundel, 1986; Shukolyukov and Begemann, 1996).

Each sample weighing 0.3 to 0.4 g was powderized, and decomposed completely by HF-$HClO_4$ with heating. After evaporation to dryness, the residue was redissolved in 5 mL of 2M HCl. This sample solution was divided into two portions, the main portion for isotopic measurements of Sm and Gd by TIMS after the chemmical separation with two-step of resin chemistry (Hidaka and Yoneda, 2007), and the minor portion for the determination of elemental abundances of rare earth elements (REE) by ICP-MS.

The Sm and Gd isotopic compositions of the individual eucrites show the variations of ^{149}Sm-^{150}Sm and ^{157}Gd-^{150}Sm isotopic shifts caused by neutron capture reactions induced from cosmic rays irradiation. Figure 1 shows isotopic shifts of Sm and Gd of the eucrites These Sm and Gd isotopic shifts correspond to the neutron fluences ranging from 3.2 to 6.1x10^{15} n cm^{-2}. Since the production rate of neutrons induced by cosmic-ray irradiation varies with the size, the depth, and the chemical constitution of the target, the detailed comparison of our Sm isotopic shifts with Kr-Kr CRE ages collected from the different data source is not appropriate. However, the degrees of Sm and Gd isotopic shifts of Stannern, Millbillillie and Juvinas are almost consistent with the lengths of CRE ages given by ^{81}Kr-Kr data.

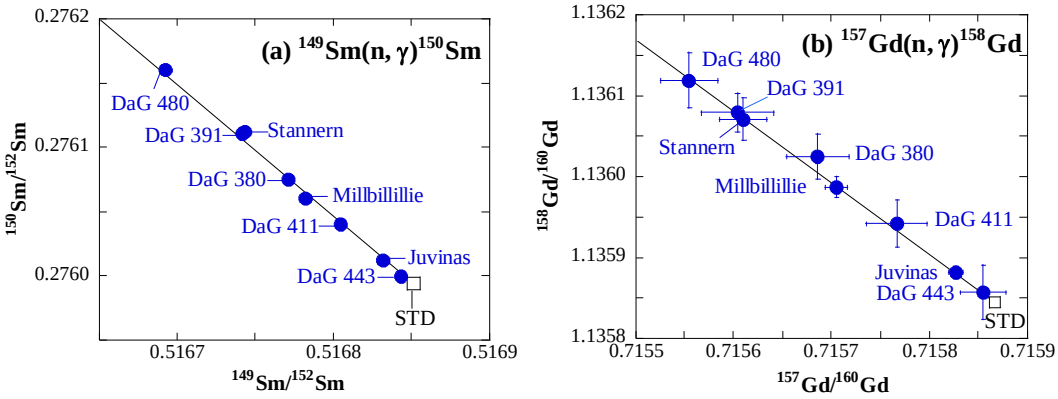

Figure 1. Isotopic shifts of (a) ^{149}Sm-^{150}Sm, and (b) ^{157}Gd-^{158}Gd of eight eucrites used in this study.

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