SAMARIUM ISOTOPIC COMPOSITIONS OF LUNAR METEORITES

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Introduction: It is known from the analytical data of long-lived cosmogenic nuclides like ^{10}Be, ^{26}Al, ^{36}Cl, and ^{41}Ca that most lunar meteorites have complicated cosmic-ray exposure (CRE) histories with relatively longer CRE ages than the other stony meteorites, and that their transfer durations from Moon to Earth are quite short [1]. This suggests that most lunar meteorites have long CRE ages in the lunar surface by 2π irradiation and short CRE ages in space by 4π irradiation for the transit from the Moon to the Earth. Besides the cosmogenic nuclides, neutron-captured isotopes like ^{150}Sm and ^{158}Gd produced by cosmic-ray irradiation also provide useful information to discuss the CRE records of extraterrestrial materials [2]. There are many reports on long-lived cosmogenic nuclides of lunar meteorites [e.g., 1,3,4], while there are few on their neutron-captured isotopes [2,5]. In this study, CRE records for seven lunar meteorites were characterized from the systematic data set given by cosmogenic nuclides and neutron-captured isotopic shifts of ^{149}Sm-^{150}Sm.

Samples and Experiments: Seven lunar meteorites, NWA 2996, NWA 3163, NWA 4734, NWA 4932, Dhofar 081, Dhofar 910, and Dhofar 911, whose abundances of several cosmogenic nuclides were already reported [e.g., 3,4], were used to obtain additionally new information on the CRE records from their Sm isotopic data. 30-50 mg of each powdered sample was completely decomposed by mixed acid of HF - $HClO_4$. After then, the residue was redissolved in 1 mL of 1.7 M HCl. The sample solution was divided into two portions: Approximately 90% of the solution was used for conventional two-step of resin chemistry to separate Sm and some other rare earth elements (REE), Gd, Dy, and Er, for their isotopic analyses by a thermal ionization mass spectrometer [6], and the other 10% of the solution was used for the determination of the elemental abundances of REE by an ICP-MS.

Results and Discussion: The burial depths on the Moon, CRE duration, and neutron fluences for the seven samples were estimated from the combination of the data given by cosmogenic nuclides and neutron-captured Sm isotopes. All seven samples show significant ^{149}Sm-^{150}Sm isotopic shifts in the range from ε_{150Sm}=+123.4 for Dhofar 910 to +6.2 for Dhofar 911, which correspond to the neutron fluences from 11.6×10^{16} to 0.6×10^{16} ncm^{-2}. The systematic data set suggest that five of seven samples, NWA 2996, NWA 3163, NWA 4734, Dhofar 081, and Dhofar 910, had resided for 160-740 Ma at the depth levels between 200 and 330 g cm^{-2} in the Moon. On the other hand, the burial depths of NWA 4932 and Dhofar 911 in the Moon estimated from the abundances of the cosmogenic nuclides are more than 1000 g cm^{-2}, which is apparently inconsistent with their Sm isotopic shifts. It is unlikely to produce the significant degree of Sm isotopic shits by neutron capture at the deeper level over 1000 g cm^{-2} in the Moon, considering the depth-dependence of Sm isotopic shifts observed in the lunar regolith drill core [7,8]. It is reasonable to consider the two-stage irradiation model in the Moon to explain the systematic data of NWA 4932 and Dhofar 911. We propose the model that these two meteorites had once resided at shallower depth, preserved the Sm isotopic shifts, and then migrated at the deeper level over 1000 g cm^{-2} before the ejection from the Moon.

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