ISOTOPIC VARIATIONS OF SM, GD, DY, ER AND YB INDUCED FROM THE NEUTRON CAPTURE REACTIONS ON THE MOON.

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Introduction: Thermalized neutrons (E<0.1 eV) are produced by the interaction of cosmic rays with the surficial materials of planets. The thermalized degree of arising neugrons depends largely upon the chemical compositions and the size (depth) of the target materials [1,2]. Recent isotopic studies suggest that the neutron energy spectrum is richer in high-energy region (E>0.1 eV) than that proposed by previous study [3-5]. Since ^{149}Sm, ^{155}Gd and ^{157}Gd have very large thermal neutron capture cross sections, their isotopic variations induced from the neutron capture reactions of ^{149}Sm(n,γ)^{150}Sm, ^{155}Gd(n,γ)^{156}Gd and ^{157}Gd(n,γ)^{158}Gd can be useful indicators to understand thermalized degree of the arising neutrons [6,7]. On the other hand, ^{161}Dy, ^{164}Dy, ^{167}Er and ^{168}Yb are sensitively react with epithermal neutrons, because they have significant resonance integrals in the energy range above thermal energies [3,5]. In this study, isotopic analyses of Sm, Gd, Dy, Er and Yb in a series of lunar surface materials were performed to reconstruct a neutron energy spectrum on the lunar surface. A combination of the isotopic data set from individual lunar samples is expected to provide a detailed information on the neutron energy spectrum on the surface of the moon.

Samples and Experiments: Deep lunar drill samples of Apollo mission have been effectively used to understand the interaction of cosmic rays with depth-dependence in the lunar surface [6-10], because the depth of each sample is well documented. Seven lunar soils with different depths in the drill core samples taken from the Apollo 15 (A-15) landing site, 15001.375, 15002.747, 15003.74, 15004.129, 15005.129, 15005.14, 15006.310, were used in this study. The A-15 samples were often used to study the interaction of cosmic rays with lunar surficial materials as a function of depth, because they have not been disturbed by major impact in the last 500 Ma [6]. Each sample weighed 30 to 40 mg was decomposed by HF-HClO$_4$ with heating. The sample solution was divided into two portions: A minor portion for the determinations of elemental abundances by ICP-MS and another major portion for the isotopic work by TIMS. Through a two-step of column chemistry using cation exchange resin and lanthanide-specific (Ln) resin, Sm, Gd, Dy, Er and Yb were chemically separated for the isotopic analyses. A TRITON TIMS equipped with nine Faraday cup collectors was used for the determination of the isotopic compositions of Sm, Gd, Dy, Er and Yb. The isotopic data were corrected for instrumental mass fractionation by an exponential law.

Results and Discussion: As already reported in previous studies [6,7], the isotopic variations of ^{150}Sm/^{149}Sm, ^{156}Gd/^{155}Gd and ^{158}Gd/^{157}Gd are functions of depth with a maximal peak at the depth around 190 gcm^{-2}. In addition, isotopic shifts of ^{164}Dy/^{163}Dy and ^{168}Er/^{167}Er also showed a similar trend in A-15 samples, while those of ^{162}Dy/^{161}Dy were unclear. From the detailed comparison of the isotopic data set between Sm and Gd (thermal) and Dy, Er and Yb (epithermal) may help to reconstruct a fine structure of the neutron energy spectrum at the surface of the Moon. The isotopic measurements of Yb are now in progress.

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