

Neutron energy spectrum at the surface of the moon studied from the REE isotopic compositions

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Thermalized neutrons arising at the surface of solar planets are produced from the interaction of cosmic rays with the surficial materials by spallation reactions. Since the thermalization degree of the neutrons depends mainly upon the depths and the chemical compositions including the water contents of the materials [1], the fine structure of the neutron energy spectrum may provide some insights into the existence of water in the planetary material in the past [2]. In this study, the neutron energy spectrum in the range between thermal and epi-thermal region at the lunar surface was investigated from the combination of the isotopic variations of Sm and Gd by the thermal neutron capture reactions, and of Dy, Er and Yb by the epi-thermal neutron capture reactions.

Seven lunar soils with different depths from the drill core samples taken from the Apollo 15 landing site (A-15) were used in this study. The A-15 core is best to study the depth dependence of the interaction with galactic cosmic-ray irradiation, because the depth information of each sample is well documented and the core has been undisturbed for a long time [3-5]. Each sample weighed 30 to 40 mg was decomposed by HF-HClO₄ 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. Using a two-step of resin chemistry, 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 isotopic analyses of Sm, Gd, Dy, Er and Yb. Isotopic variations caused by neutron capture reactions and their depth-dependence were found in Sm, Gd, and Er of all seven samples. The isotopic measurements of Dy and Yb are now in progress. The detailed comparison of their isotopic variations may help to construct a neutron energy spectrum at the surface of the Moon.

[1] Lingenfelter et al. (1972) *EPSL* **16**, 355-369. [2] Albalat et al. (2015) *EPSL* **429**, 147-156. [3] Russ (1972) *EPSL* **15**, 172-186. [4] Nishiizumi et al. (1997) *EPSL* **148**, 545-552. [5] Hidaka et al. (2000) *MAPS* **35**, 581-589.