SYSTEMATIC ISOTOPIC VARIATIONS OF STRONTIUM, BARIUM AND REE OF SURFICIAL LUNAR SOILS

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Introduction: Solar cosmic rays (SCR) irradiation on the surfaces of planetary bodies leads to space weathering. Our preliminary study suggests that space-weathered regolith particles of meteorite and lunar soil have accumulated the spallogenic products [1,2]. In this study, systematic isotopic analyses of Sr, Ba, Ce, Nd, Sm and Gd were performed on the chemical separates of lunar soils collected from very surficial layers on the Moon. Most of the elements treated in this study include minor abundance isotopes like ^{84}Sr, ^{130}Ba, ^{132}Ba, ^{136}Ce, ^{138}Ce and ^{144}Sm which are considered to be possible tracers to find spallogenic products from their isotopic variations. Furthermore, Sr, Ce and Nd include radiogenic components in ^{86}Sr, ^{138}Ce, ^{142}Nd, and ^{143}Nd isotopes which provide chronological information. Sm and Gd isotopic data can be used to evaluate the cosmic-ray exposure histories of individual samples from the isotopic shifts caused by neutron capture reactions, ^{149}Sm(n,γ)^{150}Sm and ^{157}Gd(n,γ) ^{158}Gd.

Samples and Experiments: Five of the Apollo soils, 78481, 10084, 12001, 14259, and 15011, were used in this study. These five samples were collected within a few mm depth from lunar surface. Sequential acid-leaching treatments were carried out to obtain chemically different phases from the single samples. About 50 mg of each sample was leached using 5 mL of 0.5 mM HNO_3 + 0.002 mM HF, 2 M HCl, and aqua regia, successively. Finally, the residue was decomposed by treatment with HF-$HClO_4$ with heating [1]. The four leaching fractions are designated L1, L2, L3, and L4, respectively.

The four leachates (L1 to L4) were taken to dryness and redissolved in 1 mL of 2M HCl. The solutions were divided into two portions: the main portion for isotopic measurements by TIMS and the rest for the determination of elemental abundances by ICP-MS. For the isotopic study, each solution was treated with conventional resin chemistry to separate Sr, Ba Ce, Nd, Sm and Gd.

Results and Discussion: The estimates from the Sm and Gd isotopic shifts due to neutron capture reaction in the samples provide neutron fluences of (3.6 to 6.7)x10^{16} ncm^{-2} for individual samples, which correspond to the range of neutron fluences of Apollo 15 deep drill-core soils. Some of the chemical fractions in all five soils show isotopic excesses of ^{84}Sr, ^{130}Ba, ^{132}Ba, ^{136}Ce, and ^{144}Sm. The systematic isotopic excesses are particularly dominated in L1 fractions from all of five soils. Since ^{138}Ce include the decay products from ^{138}La, its extra-excess except for the radiogenic component is unclear in all fractions. Interestingly, these excesses observed in L1 fractions show slightly negative correlations with neutron fluences. The data suggest that the isotopic excesses were resulted from spallation and neutron capture reactions.

References: [1] Hidaka and Yoneda. 2014. *Astrophysical Journal* 786: 138 (8pp). [2] Hidaka and Yoneda. 2014. *Meteoritics & Planetary Science* 49: #5120.