Isotopic variations of solar planetary materials caused by neutron capture reactions in space

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Background/Purpose: The surficial parts of solar planetary materials without the atmospheric layers have been exposed to cosmic rays consisting mainly of high-energy protons, and have occurred nuclear reactions such as spallation and neutron-capture by the interactions of cosmic-ray irradiation. Then, the accumulation of thus nuclear reactions produces the variations of isotopic compositions of several elements. Here in this talk, I would like to introduce my recent topics about the isotopic work to characterize the extraterrestrial materials from the cosmic-ray irradiation conditions.

Materials & Methods: The samples used in this study were lunar surface materials returned by the Apollo mission [1,2]. The samples weighting about 40-50 mg were digested by acid and made solutions. Rare earth elements (REEs) and Hf in each solution were chemically separated by conventional resin chemistry [3]. The isotopic compositions of these elements were measured by mass spectrometric techniques.

Results: Our recent techniques make possible to collect most isotopic data within 0.01 % of analytical precisions. In particular, the detection of depletion degrees of ^{168}Yb caused by ^{168}Yb(n,$\gamma\beta^{+}$)^{169}Tm using a sensitive amplifier board connected with Faraday cup detector [3].

Conclusion: ^{149}Sm, ^{155}Gd and ^{157}Gd react sensitively with thermal neutrons (E<0.1 eV) rather than epithermal neutrons (0.1 eV <E< 0.5 MeV), whereas ^{167}Er, ^{168}Yb, ^{177}Hf and ^{178}Hf react with thermal as well as epi-thermal neutrons because of their large principal resonance peaks in the epi-thermal energy regions. Systematic isotopic analyses of Sm, Gd, Er, Yb and Hf collected from a single material can be practically used to reconstruct neutron energy spectra in a wide energy range from thermal to epithermal regions.

References:

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