Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MIS01-17 Room:302 Time:May 22 10:00-10:15

Stellar Nucleosynthesis and Isotope Anomalies in Geologic Samples

YOKOYAMA, Tetsuya[1*]

[1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Surface environment of the Earth has been dramatically changed throughout its 4.6 Byr history. The change has continued intermittently with episodic events that caused extraordinary shifts regarding chemical and biological conditions on the Earth. The fingerprints of such events can be found in a variety of geologic samples (e.g., oxygenation of ocean and atmosphere, global glaciations, and mass extinctions). Recently, a large number of geochemical data have emerged that suggests extraterrestrial cause for the major events which modified the surface environment significantly. A prominent example is the mass extinction at the K/T boundary due most likely to an asteroid impact, evidenced by anomalously high Ir abundances in deep-sea limestones of 65 Ma, from Italy, Denmark and New Zealand (Alvarez et al. 1980). It has been also argued that nearby supernova explosions could have caused drastic environmental changes on the Earth (Ellis and Schramm, 1995). The signature of supernova input would be identified by detecting the excess of short-lived radiogenic isotopes such as ^{10}Be, ^{26}Al and ^{60}Fe in deep-sea sediments (Ellis et al., 1996; Basu et al., 2007; Fitoussi et al., 2008). Because the half-lives of these nuclides are less than a few million years, the technique cannot be applied to geologic samples older than ~10 Ma. To overcome this, here we propose to search for stable isotope anomalies of heavy elements in geologic samples. Isotopes heavier than iron are produced mainly by stellar nucleosynthesis of the s-process, r-process and p-process (Burbidge et al., 1957). The s-process and r-process are slow and rapid neutron capture reactions, respectively. The s-process is thought to occur during H- and He-shell burning in the AGB (asymptotic giant branch) phase of a low mass star with a C/O core, while core collapse supernovae are favored for the possible source of the r-process isotopes. In contrast, the p-process is either a proton capture reaction with the emission of gamma radiation or photosynthetic disintegration reactions that strip off neutrons, both of which might occur in the core-collapse supernova. The s-, r- and p-processes are characterized by the production of isotope compositions drastically different from each other. A good example is a platinum group element, Os: ^{184}Os is a pure p-process isotope, two isotopes (^{189}Os and ^{192}Os) have large (~90%) contributions from the r-process, and ^{186}Os and ^{187}Os are mainly produced by the s-process. The remaining two isotopes, ^{188}Os and ^{190}Os, are mainly r-process but have moderate (10-20%) contributions from the s-process. Such an isotopic characteristic was extremely effective for detecting nucleosynthetic isotope anomalies residing in meteorites, including the information about the origin of the isotopically anomalous carriers (e.g., Yokoyama et al., 2010). We will apply the methodology to terrestrial materials in order to search for any sign of extraterrestrial inputs recorded in geologic samples, especially those in the Neoproterozoic and early to mid-Phanerozoic period. The isotopic signature would prove the possible sources of the extraterrestrial input (e.g., meteorite impact, nearby supernova, or collision of large molecular clouds). Possible targets are deep-sea clays and cap carbonates around the Sturtian and Marinoan glaciations, or sediments from the Triassic-Jurassic boundary.

References

Alvarez, L.W. et al. (1980) Science 208, 1095-1108.
Ellis, J. and Schramm, D.N. (1995) PNAS 92, 235-238.
Ellis, J. et al. (1996) ApJ 470, 1227-1236.
Basu, S. et al. (2007) PRL 98, 141103.
Fitoussi, C. et al. (2008) PRL 101, 121101.
Yokoyama, T. et al. (2010) EPSL 291, 48-59.

Keywords: surface environmental change, extraterrstrial input, nearby supernova, meteorite, isotope anomaly, nucleosynthesis