Fe isotopes in Martian meteorites: role of water and possibility of life on Mars

Conference or Workshop Item

FE ISOTOPES IN MARTIAN METEORITES: ROLE OF WATER AND POSSIBILITY OF LIFE ON MARS M. Anand[1], E. Mullane[1], M. Grady[1], [1]Dept. of Mineralogy, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK (E-mail: M.Anand@nhm.ac.uk)

Introduction: The suggestion of McKay et al. [1] that one of the Martian meteorites (ALH 84001) has preserved traces of Martian bacterial life led to a surge in scientific research on Martian meteorites. This has also resulted in the discovery and identification of more Martian meteorites from various places on the Earth. The total number of Martian meteorites known till date stands at 30 (53 numbered individuals); almost a three-fold increase in the total number of known Martian meteorites in the last decade. The majority of these are shergottites, which account for 22 samples. The next most common group of meteorites are nakhlites (6), followed by a sample each of Chassigny and ALH 84001.

The tantalizing possibility that life might once have existed on the red planet has stimulated much of the scientific community for quite some time. However, as we know it, for life to survive, the presence of liquid water is essential. The present day climate on Mars is inhospitable for sustaining any life form. Data from several orbiter, lander, and robotic missions have demonstrated convincingly that Mars was once a warmer and wetter place, as a result of a higher atmospheric pressure, leading to active circulation of fluids between atmosphere, hydrosphere and lithosphere [e.g., 2].

Until we have a returned sample mission from Mars, one of the ways to look for past evidence of aqueous activity on Mars is through mineral, chemical and isotopic studies of primary and secondary minerals in Martian meteorites. The focus of this research is on understanding the action and effects of water on Mars by using fractionation of iron isotopes (which can be significant during low temperature aqueous processes), in conjunction with other transition metal isotopes, to trace the alteration of primary to secondary minerals by water on Mars. Previous research has resulted in recognition and characterization of an evaporite sequence preserved within nakhlites [3, 4]. This finding highlighted different alteration processes affecting Martian meteorites and Mars, and has profound implications for the timing, extent and duration of hydrous activity at the planet's surface.

Methodology and Samples: The goals of the project are pursued through a detailed study of the elemental and isotopic composition of components within Martian meteorites. Iron is an important constituent of rock-forming minerals, produced at the elevated temperatures experienced during magma genesis. Iron has four stable isotopes and is also an important constituent of secondary minerals produced by alteration of primary minerals, occurring in clay minerals and carbonates. Kinetic, equilibrium and nuclear processes fractionate the isotopes, in the same way as is commonly observed for light elements. Iron isotopes are also thought to be fractionated by biological processes, and thus have potential in providing bio-signatures in a sample. However, in order to differentiate abiotic and biotic fractionation signatures in Martian samples, a highly sensitive instrumentation, such as MC-ICP-MS is required. Preliminary whole-rock iron isotope data, obtained by MC-ICP-MS technique, on some Martian meteorites indicate limited but distinct fractionation patterns compared to terrestrial and lunar samples [5].

Discussion: We have just begun the first phase of the project wherein we are characterizing primary magmatic fractionation processes on Mars by elemental and isotopic analysis of bulk samples from Martian meteorites. Once the baseline fractionation patterns are established, individual primary and secondary minerals will be analyzed for their isotopic characteristics. Suitable terrestrial analogues, such as some Proterozoic lava flows and sedimentary rocks, are also being studied for their transition metal isotopic signatures. Results obtained from this study will be compared with representative samples from ‘dry’ and ‘wet’ asteroidal parent bodies to constrain the end member fractionation patterns among solar system materials.

It is anticipated that this approach will help in identifying the cause of the transition metal isotopic fractionation in Martian meteorites and the role of water, and possibly of life, on Mars.

References: [1] McKay et al., (1996), *Science*, 273, 924-930. [2] Squyres S. W. and Kasting J. F., (1994) *Science 265,* 744-749; [3] Bridges J. C. and Grady M. M., (2000) *Earth Planet. Sci. Lett. 176,* 267-279; [4] Bridges J. C. et al., (2001) In: *Chronology and Evolution of Mars*. Eds. R. Kallenbach et al., Kluwer, Dordrecht. 365-392; [5] Poitrasson et al., (2004) *Earth Planet. Sci. Lett.* 223, 253-266.