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Experimental Study of Iron Isotope Fractionation

Alan Matthews (alan@vms.huji.ac.il)[1], **Xiang-Kun Zhu** (xiangz@earth.ox.ac.uk) & **Keith O'Nions** (keith.onions@earth.ox.ac.uk)

[1] Department of Earth Sciences, University of Oxford, Oxford OX13PR, UK

The technique of multiple collector inductively coupled plasma source mass spectrometry (MC-ICPMS) allows iron isotope ratios (masses 54, 56, 57) to be measured with an accuracy that permits the study of their natural variations (Belshaw et al., 2000). Recent studies on ferromanganese crusts show that low temperature variations in the ^{57}Fe/^{54}Fe isotopic ratio at least exceed 14 ε^{57}Fe units[1] (Zhu et al., 2000). The factors controlling the magnitude of these fractionations are only weakly understood. Initial experimental and theoretical studies have indicated that bacterially mediated reduction, iron oxidation state, and iron co-ordination chemistry may all contribute to iron isotope fractionation (e.g. Beard et al.,1999, Polyakov and Mineev, 2000, Anbar et al., 2000). Thus, detailed experimental study of the magnitude of isotope fractionations is necessary if natural variations are to be correctly interpreted.

Among the potential important controls of natural iron isotope fractionation is its oxidation state. We have commenced a program of experimental work aimed at defining the magnitude of ^{57}Fe/^{54}Fe fractionation among Fe(II) and Fe(III) solution species at room temperature. Solutions of varying Fe(II)/Fe(III) ratio were prepared by dissolving iron metal in dilute HCl and by subsequent controlled reduction or oxidation of this stock solution using hydrazine or hydrogen peroxide solutions, respectively. The Fe(II)/Fe(III) ratio of the solution was then fixed by complexing the Fe(II) ion with 2,2'-bipyridine solution. The two iron complexes, Fe (II) $[Fe(bip)_3]^{2+}$ and Fe(III) predominantly as $[FeCl_4]^-$, are quantitatively separated at 6 molar HCl strength using a strongly basic anion exchange resin (Popa et al.,1977). First MC-ICPMS measurements of the ^{57}Fe/^{54}Fe partitioning between these complexes suggest that potentially significant fractionations are occurring. Oxidation-reduction is an important process in the geochemistry of iron and our experimental results indicate that low-temperature iron isotope fractionation may accompany such processes.

[1] ε^{57}Fe is defined as the deviation in parts per 10^4 relative to a reference isotope standard.

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