Development of an iron isotope biosignature for anaerobic photosynthetic Fe(II) oxidizing bacteria

LAURA R. CROAL[1], CLARK JOHNSON[2], BRIAN BEARD[2], SUE WELSCH[2], REBECCA POULSON[2], AND DIANNE K. NEWMAN[1]

[1]California Institute of Technology, Department of Geological and Planetary Sciences, Pasadena, CA 91125 U.S.A., (croal@its.caltech.edu, dkn@gps.caltech.edu)

[2]University of Wisconsin-Madison, Department of Geology and Geophysics, Madison, WI 53706 U.S.A. (clarkj@geology.wisc.edu, beardb@geology.wisc.edu, swelch@geology.wisc.edu,, rlpoulson@students.wisc.edu)

It has been suggested that the deposition of the most ancient banded iron formations may have been the result of biological activity. This hypothesis derives from two independent findings: one, certain anoxygenic phototrophs are capable of oxidizing dissolved ferrous iron (Fe(II)) to α-FeOOH in the absence of oxygen and two, the δ^{56}Fe value of early Proterozoic BIFs is anomalously heavy compared to the bulk of terrestrial igneous rocks and Fe meteorites. In an effort to develop an iron isotope biosignature with which to probe the BIF rock record, we have measured the Fe isotope fractionation by diverse, extant, Fe(II) oxidizing phototrophs.

Two phototrophic Fe(II) oxidizing consortia and one pure strain were cultured from an iron-rich ditch near Bremen, Germany and a marsh in Woods Hole, MA, respectively. We observed a diversity of phototrophic Fe(II) oxidizing bacteria amongst these cultures by Restriction Fragment Length Polymorphism analysis. Using physiological characterization in concert with 16S rDNA sequence analysis the pure strain was identified as a novel purple sulfur bacterium of the genus *Thiodyction*.

Iron isotope fractionation analyses of these cultures reveal that there is a relatively constant +1.5 per mil ^{56}Fe/^{54}Fe isotope fractionation between α-FeOOH and Fe(II). This isotope fractionation was independent of the rate of Fe(II) oxidation and was significantly different from that produced by abiotic oxidation. Similar experiments with the dissimilatory iron-reducing bacterium *Shewanella alga* grown on various iron oxide substrates also show approximately the same Fe isotope fractionation. This may suggest a common mechanism for biological iron fractionation that we propose is primarily the result of isotopic exchange between two soluble pools of Fe(II) and Fe(III) bound by biologically produced ligands.

The relevance of analogues for long-term prediction

J.L. CROVISIER[1] AND T. ADVOCAT[2]

[1] EOST, Centre de Géochimie de la Surface, 1, rue Blessig, 67000 Strasbourg, France. jlc@illite.u-strasbg.fr

[2] CEA, DIEC, Laboratoire des Matériaux et Procédés Actifs, Marcoule, Bât. Atalante, BP 171, 30207 Bagnols-sur-Cèze Cedex, France. advocat@amandine.cea.fr

The prediction of long-term performances of the materials containing potentially toxic elements (cements, fly or bottom ashes, glasses) , cannot solely be based on scientific laws resulting from experimentally deduced parameters. The geological environments in which one plane to store these matrixes are complex and are submitted to the influence of different parameters like temperature, nature of the fluids, climatic changes, etc...). Most parameters are interdependent and, therefore, the behaviour of toxic components is difficult to predict.

The natural analogues are often presented as a tool to reach the long term conditions by examining old natural systems comparable to the situation expected on the storage site and of equivalent complexity. They are also used to validate hypothesis chosen in predictive calculation models.

However, the use of natural analogues has sometimes been criticized because they may provide qualitative data obtained from too complex environments for which all parameters are not sufficiently identified (see for example Petit, 1992).

Experimental works are sometimes presented as "more scientific" than studies on natural analogues since they are supposed to provide precise data from perfectly controlled conditions. Experimental data are often directly used for model calculations to predict the long-term behaviour of materials. However, it is important to note that these data are only valid, like those from natural analogues, within a given paradigm. The complexity of real systems requires to confront experimental data to more complex natural systems. In other words, the laboratory data (rate measurements, alteration products) have to be compared with the data measured on natural analogues using model calculations.

In many publications concerning the performance assessment of storage, no reference to natural analogues is given although most of them are influenced from data of geological, mineralogical and hydrological studies.

References

Petit J.C. (1992), *Appl. Geoch.* S.I. **1,** 9-11.