Toward multi-element isotopic biosignatures: experimental investigation of microbial metal assimilation

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Utilization of transition metals by microorganisms is a key part of the biogeochemical cycles of these bioessential elements. Metal uptake by microorganisms both effects and is affected by changes in metal availability through time. Tracking these changes in the rock record is difficult, but measuring stable isotope fractionation of metals provides a relatively new way to approach this problem. Early efforts have focused on Fe isotope effects imparted during dissimilatory reduction or oxidation of Fe, but separating biotic from abiotic processes has remained a challenge. Thus, we are exploring the possibility of multi-element isotopic fingerprints resulting from biological metal assimilation. Isotope effects are likely because of changes in metal speciation, redox, etc., that often occur during cellular uptake. Although assimilatory isotope fractionation is not likely to be unique in direction or magnitude compared to other processes, it increases the number of elements that can be examined for biogenic isotope effects and thus enhances the possibility of unambiguous biosignatures.

We are conducting experiments to determine the direction and extent of Fe and Mo isotope fractionation during assimilation by *Azotobacter vinelandii*, an N-fixing soil bacterium with high demand for these metals. These experiments build on prior, preliminary isotopic investigations [1]. Our initial results confirm prior observations that light isotopes of Mo are preferentially taken up by the bacteria ($\Delta^{97/95}$medium-bacteria~0.4‰). Fe isotopes show a larger fractionation, with $\Delta^{56/54}$medium-bacteria up to 2‰. These early results are encouraging regarding the possibility of multi-element metal isotope fingerprints in weathering residues that signify biological activity.

References

[1] Liermann L.J., Guynn R.L., Anbar A.D. and Brantley S.L. (2005) *Chem. Geol* **220,** 285-302.