

## Nitrogen recycling through arc volcanism

TOBIAS P. FISCHER<sup>1</sup>, LONG LI<sup>2</sup>, ZACHARY D. SHARP<sup>1</sup>  
AND DAVID R. HILTON<sup>3</sup>

<sup>1</sup>Dept. of Earth and Planetary Science, University of New Mexico, USA (fischer@unm.edu)

<sup>2</sup>Dept. of Earth and Atmosph. Sciences, University of Alberta, Canada (long4@ualberta.ca)

<sup>3</sup>Scripps Institution of Oceanography, Univ. of California San Diego, USA (drhilton@ucsd.edu)

Subduction is the main pathway of surface N transfer into the mantle, whereas arc volcanism can short-circuit that transfer via magmatic gas release into the atmosphere. A fundamental question is the efficiency of N recycling at subduction zones. The Central American (CA) and Izu Bonin Marianas (IBM) subduction systems are relatively well characterized in terms of N input and output and are the best candidates for evaluating N mass balance in arcs.

Stable (N) and noble gas (He) isotope and abundance characteristics show that N output at CA is dominated by the slab component ( $\delta^{15}\text{N} \approx +7\text{‰}$ , consistent with that of subducted Cocos Plate sediments, 5.7‰ [1]). N output fluxes vary significantly along the CA arc with Costa Rica only contributing  $\sim 1 \times 10^7$  mol/yr compared to  $\sim 7 \times 10^8$  mol/yr from Nicaragua [2,3]. The average slab-derived N output from the entire CA arc is estimated at  $2.7 \times 10^9$  mol/yr [2], significantly higher than the input sedimentary N of  $9.3 \times 10^8$  mol/yr from the Cocos Plate [1]. This imbalance implies additional N must be supplied from AOC [4] and/or subduction erosion [1]. However, both potential sources remain poorly-constrained, preventing further evaluation of N recycling efficiency and excess N delivery to the deep mantle. In contrast, the sedimentary N output flux at IBM represents only 11–51% of the input, implying that up to 90% of subducted N is potentially transferred to the deep mantle [5].

The difference in recycling efficiencies is likely related to the different thermal regimes and geometries of the two subduction zones. The contribution of crustal material by subduction erosion may also play a role. More work is needed to further constrain the processes of N release from different lithologies of subducting plates and the variability of volcanic N fluxes in arcs globally.

[1] Li & Bebout (2005), *J. Geophys. Res.* 110, B11202, doi:10.1029/2004JB003276. [2] Elkins, *et al* (2006), *Geochim. Cosmochim. Acta* 70, 5215-5235. [3] Zimmer, *et al* (2004), *Geochem. Geophys. Geosyst.* 5, Q05J11, doi:10.1029/2003GC000651. [4] Li, *et al* (2007), *Geochim. Cosmochim. Acta* 71, 2344-2360. [5] Mitchell, *et al* (2010), *Geochem. Geophys. Geosyst.* 11, Q02X11, doi:10.1029/2009GC002783.

## Sedimentary and genomic insights into the evolution of iron oxidation

WOODWARD W. FISCHER<sup>1</sup>, JENA E. JOHNSON<sup>1</sup>, JAMES HEMP<sup>1</sup>, LAURA A. PACE<sup>2</sup>, NOAH J. PLANAVSKY<sup>1</sup>  
AND SAMUEL M. WEBB<sup>3</sup>

<sup>1</sup>California Institute of Technology (wfischer@caltech.edu)

<sup>2</sup>University of Utah

<sup>3</sup>Stanford Synchrotron Radiation Lightsource

Iron is the most abundant redox-active element on the Earth and provides a rich source of electrons that impacts all biogeochemical cycles. Detailed observations of iron formations (IF) in the geological record demonstrate that this has been broadly true for much of Earth history, though key differences in the facies, textures, geochemistry, and mineralogy define varying styles of geobiological processes and different modes of petrogenesis.

Environmental iron oxidation processes fall broadly into four categories: abiotic photochemical, abiotic and biotic reactions with  $\text{O}_2$ , and photobiology (e.g. anoxygenic photosynthesis). Oxidation plays an important role in concentrating iron in sediments, either by forming poorly ordered hydrous oxides or ferric and mixed-valence silicate phases. To understand processes of oxidation in ancient IF requires the ability to look through complex diagenetic and metamorphic transformations common to these deposits: in particular, the tendency toward post-depositional reduction by organic matter is common. Late Archean and earliest Paleoproterozoic IF have Fe(III)/Fe(II) that vary with paleoenvironmental depth with more oxidized facies occurring in deeper water, suggesting oxidation by anoxygenic photosynthesis. Mid-Paleoproterozoic iron formations have similar overall valence states, but the depth gradient is reversed and reflects the locus of the major oxidant at that time,  $\text{O}_2$ . An important process outlier is provided by Neoproterozoic IF, associated with 'Snowball Earth' glacial deposits, are composed of nearly exclusively ferric iron, and reflects simple abiotic titration of environmental  $\text{O}_2$ .

In this talk, we'll discuss how these geological patterns highlight changing modes of biological iron oxidation processes through time. Since iron oxidation rates vary greatly with pH, acidophilic and neutrophilic aerobic iron-oxidizing microbes have evolved separate biochemical strategies for oxidizing iron. We use phylogenomics to show that both strategies are evolutionarily derived, implying that aerobic iron oxidation is a relatively late innovation. A similar pattern emerges from the secular distribution of filamentous microfossils interpreted to reflect aerobic iron-oxidizing microbes, which appear in the fossil record after the rise of  $\text{O}_2$ .