The role of microbial processes in Banded Iron Formation (BIF) genesis as constrained by Fe, C, and O isotopes in BIF carbonates

A. HEIMANN[1,2]*, C.M. JOHNSON[1,2], B.L. BEARD[1,2], J.W. VALLEY[1,2] AND M.J. SPICUZZA[1,2]

[1]Univ. of Wisconsin – Madison, USA
(*correspondence: aheimann@geology.wisc.edu)
[2]NASA Astrobiology Institute

Iron-rich carbonates from the ~2.5 Ga Kuruman banded iron formation (BIF), South Africa, were investigated at a sub-millimeter scale for Fe, C, and O isotope variations. The C isotope contrast between ankerite and siderite ($\delta^{13}C$ = -2 to -12 ‰) and platform calcite/dolomite ($\delta^{13}C$ ~0 ‰) cannot be explained by compositional effects on C isotope fractionation factors, but instead reflect distinct C pathways. A strong negative correlation between $\delta^{13}C$ and Fe contents in BIF and Ca carbonates, along with small-scale isotope heterogeneity, suggest a constant ocean $\delta^{13}C$, which would indicate that no ankerite or siderite were in C isotope equilibrium with seawater, but instead reflect contributions from organic carbon oxidation coupled to dissimilatory Fe(III) reduction (DIR). Stoichiometric relations associated with production of siderite by CH_2O oxidation and Fe(III) reduction suggest that $\delta^{13}C$ values of ~ -8 ‰ or lower reflect carbonate formation by biogenic processes. $\delta^{18}O_{SMOW}$ values vary from +19 to +21 ‰ and do not correlate with $\delta^{13}C$ values or Fe contents; this range overlaps that measured in previous studies of ~2.5 Ga Transvaal carbonates, and rules out extensive post-lithification diagenesis.

$\delta^{56}Fe$ values for BIF carbonates range from +1.0 to -1.0 ‰, and nearly the entire range can be found in low-$\delta^{13}C$ samples. BIF carbonates that have positive $\delta^{56}Fe$ values tend to have micron-size hematite inclusions, although these inclusions are insufficient to control the Fe isotope compositions. Instead, their occurrence, in combination with their negative $\delta^{13}C$ values, suggests near-complete DIR. Lower $\delta^{56}Fe$ values in Fe-rich BIF carbonates that have low $\delta^{13}C$ values reflect mobilization and transport of low-$\delta^{56}Fe$ $Fe(II)_{aq}$ produced by partial Fe(III) reduction in the sediment, followed by siderite precipitation.

The combination of C and Fe isotope measurements on the same carbonates is essential for determining the formation pathways of Archean/Proterozoic Fe-rich carbonates, which in turn bears on the use of Fe isotope compositions of carbonates as tracers of ancient seawater compositons or microbial cycling in restricted marine environments or the soft sediment section prior to lithification.

Cosmogenic dating of 'old' glacial events in Patagonia

A.S. HEIN[1]*, N.R.J. HULTON[1], T.J. DUNAI[1], C. SCHNABEL[2], M.R. KAPLAN[3], S. XU[2]

[1]University of Edinburgh, Edinburgh, UK
(*correspondence: a.s.hein@sms.ed.ac.uk, tibor.dunai@ed.ac.uk, nick.hulton@ed.ac.uk)
[2]S.U.E.R.C. East Kilbride, UK
[3]LDEO, Columbia University, NY, USA

In Argentinean Patagonia, outlet valleys of former Patagonian ice sheets commonly preserve three to four distinct groups of moraines and associated outwash terraces that pre-date the LGM, which are as old as ca. 1.1 Ma. Importantly, few of these deposits are dated. Preservation of clear moraine ridges from the oldest deposits attests to low erosion rates and long-term landform stability in the region, making it ideal for cosmogenic surface exposure dating methods. However, exposure dating of moraine boulders becomes increasingly problematic on older moraines due to the increasing uncertainties in boulder erosion rates and exposure histories with time. In this study, we demonstrate the stability and suitability of outwash terrace sediment to date specifically 'old' glacial events in the Lago Pueyrredón valley, 47.5° S, Argentina. ^{10}Be and ^{26}Al exposure ages from cobbles located on the outwash terrace surface are compared to exposure ages from associated moraine boulders. The outwash cobbles consistently yield older exposure ages than the moraine boulders. A ^{10}Be concentration depth-profile in the outwash terrace sediment was measured to further constrain the deposition age, terrace erosion rate, average nuclide inheritance and stability of the outwash sediment. These data yield a well defined exponential profile indicating the long-term stability of the surface. A best-fitting model establishes that 1) nuclide inheritance is negligible 2) the terrace erosion rate is low and 3) the deposition age is consistent with exposure dates from the oldest surface cobbles. Based on these findings we use the oldest surface cobbles to date the deposit. These indicate a major advance of a Patagonian ice sheet occurred at ca. 260 ka (MIS 8). In contrast, the associated moraine boulders underestimate the age of the deposit by a full glacial cycle. If the stability of outwash terraces is a common feature in the region, it should be possible to date older glacial events by this method, and thereby reconstruct the long-term glacial history across Patagonia.