Multiple S-isotope evidence for environmental stability throughout the Archean?

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The Nuvvuagittuq greenstone belt (NGB, Northeastern Superior Province, Canada), is an Eoarchean volcano-sedimentary suite that was emplaced prior to 3.75 Ga [1], and possibly as early as 4.28 Ga [2]. The NGB includes two distinct sedimentary lithologies (a banded iron formation (BIF) with cm-scale quartz-rich and magnetite-rich laminations, and a sulfide-bearing silica formation) that may represent the oldest remains of the sedimentary record on Earth.

We performed multiple S-isotope ratios measurements ($\delta^{33}S$, $\delta^{34}S$, $\delta^{36}S$, $\Delta^{33}S$, $\Delta^{36}S$) in samples covering the entire lithological suite of the NGB. Samples from the silica-formation and BIF display a narrow range of $\delta^{34}S$ values ($0.8‰ \leq \delta^{34}S \leq 3.3‰$), in good agreement with ranges reported so far from early Archean sediments [3, 4]. The same samples exhibit non-zero $\Delta^{33}S$ and $\Delta^{36}S$ values (respectively ranging from 0.18 to 2.27‰ and from -2.9‰ to -0.6‰) that are negatively correlated ($\Delta^{36}S \approx -0.9\ \Delta^{33}S$) and conform to the linear array that characterizes most of the Archean Eon [5]. Finally, the NGB BIF and silica formation reveal a compact correlation between $\Delta^{33}S$ and $\delta^{34}S$ values ($\Delta^{33}S \approx 0.9\ \delta^{34}S$) that matchs previous observations from Neoarchean and Paleoarchean samples [6, 7, 8].

For the best investigated sample suites, the $\delta^{34}S$- $\Delta^{33}S$- $\Delta^{36}S$ correlations have been taken to reflect both a retricted chemistry of the atmosphere and a dynamic microbiologically-dominated sulfur cycle during the Neoarchean. We will discuss the implications of a straightfoward uniformitarian application of this interpretation in light of the unique events that characterized Earth's earliest history (e.g., the late heavy bombardment).

[1] Cates & Mojzsis (2007). [2] O'Neil *et al.* (2008) [3] Mojzsis *et al.* (2003). [4] Whitehouse *et al.* (2005). [6] Farquhar *et al.* (2008). [6] Ono *et al.* (2009). [7] Kaufman *et al.* (2007). [8] Ueno *et al.* (2008).

Nitrogen isotopes study of the 2.73Ga Mesoarchean Tumbiana Formation (Pilbara, Western Australia)

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Stable isotopes of key elements for life were extensively studied in Archean rock records since decades allowing the reconstruction of biogeochemical cycles on the early Earth. The ancient nitrogen cycle and early nitrogen metabolism, however, are only poorly constrained. Here, we report nitrogen and organic carbon isotopes for the slightly metamorphosed sedimentary Tumbiana Formation at 2.73 Ga (Pilabara Craton, Western Australia).

Bulk $\delta^{15}N$ was measured in 3 lithologies: mudstones, stromatolites and siltstones, along the 100 meter depth PDP-1 diamond drill core at the ppm level using a "Static – IRMS" at the IPGP. Nitrogen content and $\delta^{15}N_{AIR}$ values vary markedly at the meter scale and range from 0.6 to 14.6 ppm and 8.6 to 50.4 ‰, respectively. N content and atomic C_{org}/N ratio do not show any obvious correlation with $\delta^{15}N$ suggesting that the ^{15}N-enrichment cannot be explained by preferential loss of the ^{14}N isotope during metamorphic devolatilization. Moreover, a negative correlation between decreasing $\delta^{13}C_{org}$ (ranging from -23.8 to -55.9 ‰) and increasing ^{15}N-enrichment supports the interpretation that a primary nitrogen isotopes signature was preserved in the shallow water Tumbiana Formation.

The $\delta^{13}C_{org}$ negative excursion recorded in these samples, namely the Fortescue Excursion" most likely results from a drastric increase of secondary biomass production by methanotrophic microorganisms in response to a "local" redox increase. Accordingly, we propose that a slight increase of oceanic redox conditions, at around 2.7 Ga, may have been the driving force of both low $\delta^{13}C_{org}$ and high $\delta^{15}N$, 100 Ma before the oxygenation of the ocean.