Constraining the evolution of Earth’s atmosphere with mass-independent isotope fractionation

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The evolution of Earth’s atmospheric composition encompasses some of the great questions in Earth systems science, including: the causes (and consequences) of the most dramatic biogeochemical event in Earth’s history, the Great Oxidation Event (GOE) ; why it took more than a billion years after the GOE for the second great rise in oxygen, coincident with (and allowing for) the radiation of macroscopic life and motile animals; and finally, what was the composition of Earth’s reducing atmosphere prior to the GOE? Despite recent advances in understanding the general pattern of atmospheric evolution, detailed compositional constraints remain elusive.

I will discuss recent advances in constraining the chemistry of the Archean atmopshere using multiple sulfur isotopes ($\Delta^{33}S$ and $\Delta^{36}S$), as well as preliminary work on constraints obtainable from multiple oxygen isotopes ($\Delta^{17}O$) in the Proterozoic and Phanerozoic. A careful merging of experiments, field work, analytical methods, and numerical modelling is needed to provide a step-change in our ability to quantitatively constrain the evolution of the atmosphere. I will highlight plans from a recently funded European Research Council project which aims to establish better quantitative constraints on the evolution of atmospheric composition from the mass-independent isotope fractionation seen in the sedimentary rock record (Figure 1).

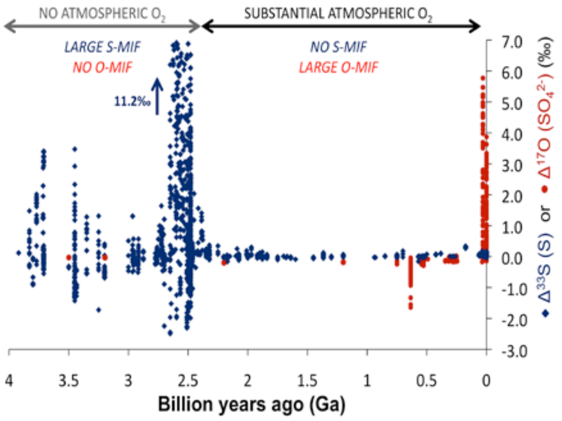

Figure 1. S- and O-MIF records (inspired by Bao et al., 2014). These data constrain the broad evolution of atmospheric oxygen, but a wealth of untapped information remains to be intpreprted from these data sets.