Clarifying the haze: Biological control as an atmospheric primer to the GOE

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The early Palaeoproterozoic oxygenation of Earth's surficial environment fundamentally altered the chemistry and ecological structure of our planet. The canonical view holds that Archaean atmospheric O_2 was initially low (< 10^{-5} present atmospheric level), rising irreversibly to a fraction of present-day levels between ~2.45–2.3 Ga during the Great Oxidation Event. This view, however, is being challenged by geochemical data derived from ~3.0–2.5 Ga sedimentary rocks, which have been interpreted to reflect transient or localised oxygenation as well as periods of more reduced atmospheric chemistry, associated with enhanced atmospheric methane (CH_4) concentrations.

In particular, recent geochemical analyses suggest that the Neoarchaean atmosphere was periodically dominated by a hydrocarbon-rich haze produced when CH_4:CO_2 ratios exceed 0.1. Evidence for episodic haze development is based on correlations between variations in mass-independent S-isotopes preserved in pyrite (for both $\Delta^{33}S$ and $\Delta^{36}S$, calculated as a slope change $\Delta^{36}S/\Delta^{33}S_{Dev}$) and ^{13}C-depleted sedimentary organic matter ($\delta^{13}C_{Org}$) in ~2.6–2.5Ga sediments from South Africa and Western Australia. These co-variations ("termed C-S anomalies") imply a change in global atmospheric sulphur chemistry during periods of increased CH_4 cycling within the oceans and atmosphere. However, the role of biological feedbacks in mediating CH_4 production and consumption (via methanogenesis and methane oxidation, respectively) remain unclear.

We have previously speculated that these C-S anomalies reflect enhanced nutrient availability, which facilitated the proliferation of the oxygenic photosynthetic/methanogenic biosphere, amplifying global biogenic CH_4 and O_2 fluxes and altering atmospheric chemistry. We will show the S- and C-isotope data to inform on the workings of the terminal Neoarchaean atmosphere, which in turn, shows the terminal-Neoarchean represented a time in Earth's history where biology tightly regimented atmospheric chemistry.