Sulfur isotope systematics in a modern analogue of Precambrian environments

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Sulfur isotope systematics (essentially $\delta^{34}S$, $\Delta^{33}S$) of the sedimentary rock record is commonly used to reconstruct the evolution of redox state during the Precambrian, to identify the main S-metabolizing organisms and/or to constrain the cycle of oceanic sulfate. Yet, these interpretations often remain ambiguous, especially when only based on sedimentary $\delta^{34}S$ values and their secular variations. To gain more insights into the processes controlling sedimentary $\delta^{34}S$ values we present here $\delta^{34}S$ results from the Dziani Dzaha Lake located on Mayotte Island (Indian Ocean, France), a new modern analog of Precambrian oceans in which sulfate has been massively depleted.

This saline and alkaline tropical volcanic crater lake presents a unique combination of analogies with some Precambrian environments: water column is permanently anoxic in depth (below 1.5 meter) in spite of seasonal mixing; biomass is mainly dominated by prokaryotes [1]; and several kinds of microbialites and carbonate-rich sediments are found. Sulfate concentration is close to 3 mM, except below the chemocline during stratified seasons when it drops to zero while sulphide concentration increase sometimes reaching 6 mM. Compared to the sulfate concentration of the ocean (28 mM), from which the lake water originates, sulfate has thus been strongly depleted.

The $\delta^{34}S$ values of sulfate and sulfide in the water column are close to 33.5‰ and 37‰, respectively. The high $\delta^{34}S$ value of sulfate compared to that of the ocean (21‰) can be interpreted in terms of bacterial sulfate reduction (BSR) and sulfide burial over time, assuming a low apparent fractionation factor of 5‰ for BSR. This is compatible with the fact that, at present, the $\delta^{34}S$ value of H_2S is slightly more positive than that of sulphate. This is unexpected and remains to be further understood, but would be compatible with the idea that the sulfate reservoir is often exhausted and regenerated by sulfide oxidation during stratified seasons, preventing the expression of the isotope fractionation associated with BSR. Implications for the interpretation of past sulfur signatures will be discussed at the conference.

[1] Leboulanger et al. 2017, PLoS One 12(1) pp.e0168879.