Isotopic memory of the life history of sulfate-respiring microbes

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Sulfur isotope fractionation during microbial sulfate reduction is controlled by the respiratory metabolism of sulfate reducing microorganisms. This metabolism responds to variability in the local environment, with the response determined by the underlying genotype. In the course of experiments that examined the response of S isotope fractionation to evolutionary adaptation of *Desulfovibrio vulgaris* Hildenborough (DvH), we developed a high-precision assay of the fractionation factor associated with sulfate respiration. Although the uncertainty of this assay approached that associated with the isotopic measurements themselves, the biological variability (as determined by repeat measurements on separate cultures) was always much greater, sometimes by an order of magnitude. Despite the extremely simple growth environment (same media, same organism – DvH) provided in our evolutionary experiments, this standing source of variability in isotopic fractionation, prior to any evolutionary effects, was perplexing.

In order to investigate the cause of this variable fractionation, we designed a fractionation experiment in which the only parameter that was varied was the life history of the DvH population that was used to inoculate the experimental cultures. We found that the past physiological state of the inoculum exerted a significant influence on the S isotope fractionation. For example, the sulfide produced by an inoculum taken from exponential growth was depleted in $^{34}S/^{32}S$ by 3.1 ‰ relative to the coeval sulfate, while a stationary phase inoculum produced sulfide that was depleted by 9.2 ‰. These differences in fractionation did not correlate with changes in respiration rate, within the limits of our experimental uncertainty on rate measurements.

Our results suggest that the S isotope phenotype of sulfate-respiring microbes may respond to environmental change on timescales that are greater than generational. From new models of respiratory S isotope fractionation, the lack of variation with respiration rate points towards controlling roles played by enzyme levels and the ratio of reduced to oxidized electron carriers. Whatever the root cause, an isotopic memory of past physiological states may enable new insights into life at the limits, especially if its historical footprint extends deeper than generational.