Extracting environmental information from Phanerozoic sulfur isotope records

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The concentration of atmospheric oxygen throughout the Phanerozoic relates directly to the burial histories of organic carbon and pyrite sulfur. Unlike carbon, however, the sulfur cycle is less well understood and as such, presents an opportunity to further refine these related histories. Through the incorporation of minor isotope measurements, particularly ^{33}S, the extraction of even more information is possible. The information collected about the behavior of the sulfur cycle can then be parlayed into reconstructions of atmospheric O_2 budgets. Here we present an overview of two philosophically different approaches to understanding the Phanerozoic sulfur cycle. First, we present a microbial approach, where sulfate reduction experiments conducted over a wide range of rates serve to define a relationship between isotopic fractionation (in $^{34}S/^{32}S$ and $^{33}S/^{32}S$) and metabolic rate (*1*). This can be viewed as an attempt to translate environmental variability in seawater sulfate and sedimentary sulfide isotope records into changes in the rate of sulfate reduction in marine sediments. This allows the interrogation of linkages to long timescale changes in the availability and extent of organic-rich sea floor. Our parallel approach relates to how well defined the Phanerozoic sulfur isotope record actually is. Here we present an emerging data set on the multiple sulfur isotope composition of seawater sulfate that represents a significant step forward in articulating this record. Together these approaches will serve to unlock the mystery behind the large and highly variable nature of these isotope records. Only through this articulation will we come to better understand the role of the sulfur cycle in the great history of atmospheric oxygen.

[1] W. D. Leavitt *et al* (2013) *PNAS*.