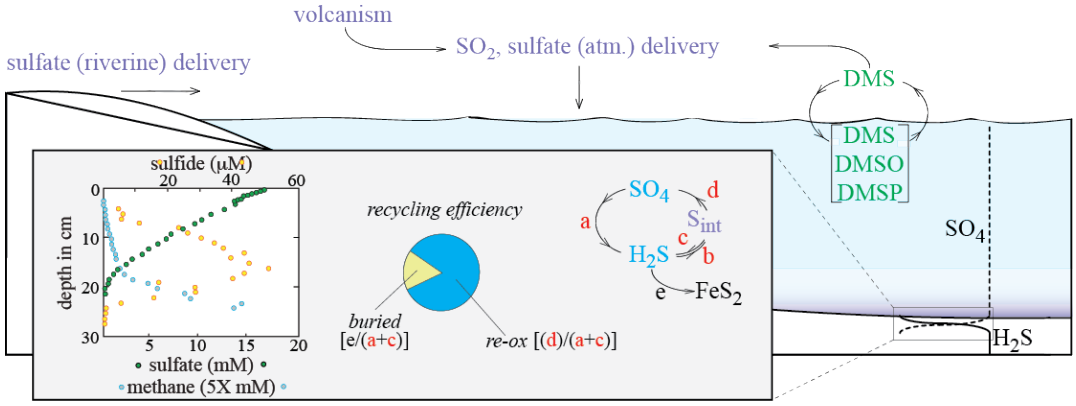
A focused discussion about the lessons and potential of sulfur cycle research

David Johnston (Harvard U) and David Fike (Washington U)

Sulfur is a major biogeochemically active element and intimately related to all scales of Earth surface processes. From contributing to the evolution of surface oxidant budgets on geological timescales to the requisite incorporation into key amino acids on biological time and spatial scales, tracking and understanding the (bio-)(geo-)(biogeo-)chemistry of sulfur cycling is an attractive target. In the four days that follow, sulfur cycling across a range of spatial and temporal scales will be interrogated and discussed with an eye for the current cutting-edge and emerging targets. Although many bridges are already in place to learn and draw from seemingly disparate research trajectories within the S cycle, of course the areas of opportunity are also often at these interfaces. The goal of this workshop is to catalyze the rate of that cross-fertilization.

Environmental reconstructions of the ancient sulfur cycle are rooted in understanding a wide range of modern natural environments. These often include marine (*26, 27*), or lacustrine (*20*) settings, through to interrogations of wetlands (*4, 10*), the deep biosphere (*1*), and other unique extreme environments (*12*) on Earth – or on Mars (*28*). Targeting any particular environment thus identifies numerous interesting interactions, syntrophies (*5*) and symbionts (*11*), then allowing for metabolism-scale decoding of intracellular inter-workings and biochemistry. From studies of sulfate reducers (*2, 3*) through to sulfide oxidizers (*6, 7, 9*) and disproportionation reactions (*8*), our collective understanding of the catalysts at the core of the S cycle is coalescing.



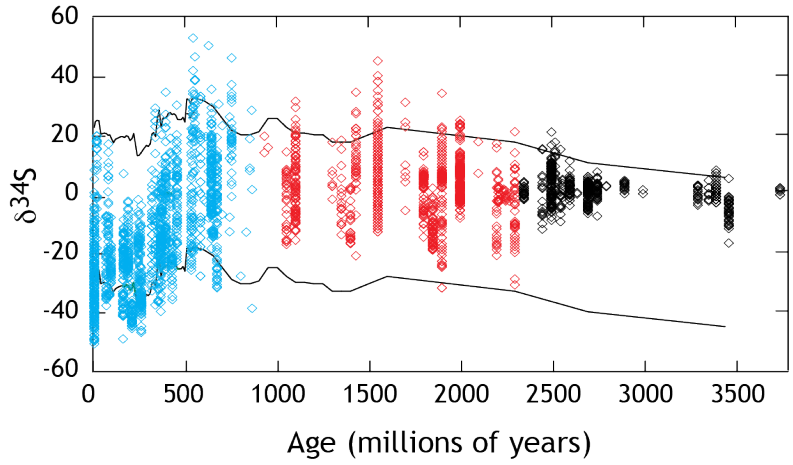
A simple cartoon depicting a few of the many features of the sulfur cycle.

The information gained through biological and modern environmental studies is often translated to geological timescales through the applications of stable isotope geochemistry. This requires that many of those same biochemical reactions be calibrated at the cellular (*13*) and intracellular scale (*14*), as well as building a more theoretical context (*15*) for these approaches and types of data to be extended. With versions of that bridge in place, sulfur cycle research serves as a useful tool in accessing information about large scale

(space and time) changes in both fluxes into and out of the ocean (*24*) and the inter-workings and generation of isotopic signals locked in authigenic minerals (*25*). Given tight, quantitative ties to the carbon cycle, more focused studies are also possible -- think extinctions and environmentally driven biological turnovers (*22, 23*).

Over the last decade, the totality of the framework philosophically outlined above was brought to bear on anomalous isotope effects identified in Archean records (reviewed by *17*). Thought to be linked to atmospheric processes (*16*), the deposition and reworking of these MIF signals now serve as a wonderful tracer of ancient weathering environments (*18*) and how marine signals (*21*) come to be captured in the rock record (*19*).

Together, our viewpoints from biochemistry and molecular microbiology, microbial ecology, geochemistry, and field geology are integrating to develop a deep understanding of the microbial sulfur cycling and its (often-times cryptic) evolution over the course of Earth history.



The classic record of $\delta^{34}S$ vs. time as recorded in sedimentary sulfides (diamonds) and related estimates for seawater sulfate. Modified from numerous papers by Don Canfield.

Oral presentations, in order of workshop schedule:

1. Tim Ferdelman, 2. Inês Pereira, 3. Judy Wall, 4. Alexander Loy, 5. David Stahl, 6. Christiane Dahl, 7. Heide Schulz-Vogt, 8. Kai Finster, 9. Robert Blankenship, 10. Lizzy Wilbanks, 11. Nicole Dubilier, 12. Alexis Templeton, 13. Alex Bradley, 14. Wil Leavitt, 15. Boz Wing, 16. Mark Thiemens, 17. Shuhei Ono, 18. Chris Reinhard, 19. Woody Fischer, 20. Sean Crowe, 21. James Farquhar, 22. Benjamin Gill, 23. Stefano Bernasconi, 24. Itay Halevy, 25. David Johnston, 26. David Fike, 27. Alex Sessions, 28. Nick Tosca.