Ghost-hunting in the sulfur cycle: lessons for biosignature research

BENJAMIN BRUNNER[1,], AMANDA L. LABRADO[1], GAIL L. ARNOLD[1]

[1]Dept of Geological Sciences, University of Texas at El Paso, El Paso, TX, 79968, USA, bbrunner@utep.edu

After carbon, sulfur is probably the next obvious element targeted in biosignature research. Sulfur is an essential component of life, has been detected on Mars, Titan and Europe, and occurs in various redox states that can be used by organisms for energy metabolism (catabolism). Stable isotope signatures are preserved over long time spans and changes in environmental conditions - thanks to the stability of the sulfate ion and its salts, as well as the stability of sulfide minerals, and native sulfur.

If we would point out one 'flaw' in sulfur biosignature research, we would say that it is our precieved familiarity with the modern sulfur cycle. This blinds us to hidden signatures in the present and may oversimplify our interpretations of the past on Earth and elsewhere. What particularly biases/narrows our view on sulfur cycling is that biological sulfate reduction operates through a metabolic bottleneck, the conversion of sulfate to adenosine phosphosulfate, and that catabolic sulfate reduction only yields on product: sulfide. This constraint leads to 'accepted notions,' for example, that the formation of native sulfur and pyrite must involve some form of sulfur oxidation – notions that may not be applicable to sulfur biosignature research.

We argue that looking for processes, that based on the conventional expectations "should not be there," is essential to drive innovation in biosignature research. It forces us to develop new tools and rethink element and isotope mass balances. Pinning down cryptic sulfur cycling in marine sediments and exploring the genesis of native sulfur in the absence of light or an oxidant are tasks that allow us to develop those skills and tools.

We present evidence for the existence of these ghosts in the sulfur cycle and discuss how the lessons learned from the hunt for these processes can be tranlated into improved strategies for biosignature detection and interpretation.