Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.21447

Investigating the Stability of Sulfurized Organic Carbon Using State-of-the-Art Synchrotron-based Techniques

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Sulfurization of organic matter (OM) is considered an important process through which enormous amounts of carbon (C) are preserved in the sedimentary record. However, this process is believed to be controlled by the availability of iron (Fe). In anoxic/euxinic oceans where sulfate is reduced and reactive Fe is present, the reaction between reduced inorganic sulfur (S) and Fe species is preferential over OM. This process is continuous until all Fe in a system is exhausted, after which remnant reduced S can react with OM to form S-rich OM that can survive remineralization and be preserved. This is a widely accepted concept; however, it remains unclear to what extent sulfurized OM is stable, especially during an influx of fresh, reactive Fe species to the ocean and pore water. A series of experiments reacting sulfurized glucose (carbohydrate type OM) with iron(II) chloride were completed. Results indicate, for the first time, that some S in the sulfurized glucose was utilized by Fe to form metastable FeS materials, which were subsequently converted to minerals with coordination of S and Fe that is similar to the coordination environment and oxidation state of S and Fe in S^{-2} Fe sulfide minerals (likely pyrrhotite or troilite). Some of these S^{-2} minerals further converted to form traces of a more stable S^{-1} iron sulfides (likely pyrite). However, there was still sulfurized glucose in the product after Fe treatment. This suggests that potentially specific parts of the S originally bound to the glucose were lost during the experiments. The metastable FeS materials were likely formed from that part of the sulfurized glucose with weak S-S bonds, while the stronger C-S bonds were stable and could be preserved for millions of years. However, it cannot be excluded that it is a matter of time before all S in the sulfurized glucose would be stripped off to form iron sulfides. Overall, the reaction between OM and S could be said to be partially reversible in the presence of reactive Fe species.