Sulfur organomineralization: significance and mechanism

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Elemental sulfur – S(0), an important intermediate of the S cycle, is formed through diverse biotic and abiotic oxidation pathways. Given the restricted geochemical conditions under which S(0) should persist, the mechanisms whereby S(0) can be stabilized in the environment are not fully understood. It was recently discovered that S(0) will precipitate through the reaction of aqueous sulfide with dissolved organic carbon (DOC) in the presence of oxygen, giving rise to the self-assembly of carbon/sulfur microstructures, where S(0) is encapsulated in an organic envelope with spherical and filamentous morphologies [1]. The mechanism of this process, called S(0) organomineralization, as well as its environmental significance, are however still unknown.

In this talk, we will show that the production of C/S microstructures can occur in a wide range of geochemical conditions, through reactions between sulfide and a diversity of dissolved organic compounds, suggesting that S(0) organomineralization in the environment is likely ubiquitous. We will furthermore present new results from nano-scale X-ray spectromicroscopy, x-ray diffraction, and transmision electron microscopy showing that the morphology and crystal structure of the S(0) is controlled by the type of organics involved in the reaction. In particular, we will show that high-temperature S(0) allotropes (β- and γ-S_8), can be formed and remain stable at low temperature when they are encapsulated within C/S microstructures. Similar processes might account for the recent discovery of β-S_8 formation in cold spring deposits [2]. More broadly, the high reactivity between sulfide and DOC may significantly affect the production and preservation of S(0) in numerous environmental systems. Thus we will also present experimental data that helps to constrain the mechanisms of S(0) organomineralization, with a particular focus on the reaction kinetics.

[1] Cosmidis & Templeton (2016), Nature Communications 7, 12812

[2] Lau, Cosmidis, Grasby, Trivedi, Spear, & Templeton (2016), Geochimica et Cosmochimica Acta 200, 218–231