

High Resolution SIMS-based Sulfide $\delta^{34}\text{S}$: A New Approach for Characterizing Microbial Metabolic Activity

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Introduction: The stable isotopic compositions of sulfur in sedimentary sulfates and sulfides are useful for understanding modern microbial ecology and for reconstructing paleoenvironmental conditions associated with the deposition of ancient sediments. In many modern microbially-dominated sedimentary environments, such as microbial mats or methane seeps, the redox gradients can be steep with transitions from oxic to sulfidic conditions occurring over the space of a few millimeters. In these environments, it is frequently difficult to collect samples at a sufficiently high resolution to capture the detailed geochemical and microbiological changes associated with these redox transitions. Here, we focus on sulfur cycling, particularly the production of hydrogen sulfide by microbial sulfate reduction and its oxidation by biological or abioblogical means, and use the isotopic composition ($\delta^{34}\text{S}$) of that sulfide to constrain microbial activity. We build upon earlier work [1], capturing aqueous sulfide as silver sulfide in a manner that preserves spatial variability. This sulfide can then be analyzed for its stable isotopic composition by secondary ionization mass spectrometry (SIMS) using a Cameca NanoSIMS 50L or 7F/Geo. Analyses can be conducted at a spatial resolution down to $\sim 1 - 50 \mu\text{m}$. This allows for the construction of 2D isotopic datasets that document vertical isotope gradients as well as lateral heterogeneity [2,3]. Here we present the application of this sulfide capture technique to three different modern environments: (1) microbial mats from Guerrero Negro, Baja California Sur, Mexico; (2) the chemocline of meromictic Lake Mahoney, British Columbia, Canada; and (3) methane seep-associated marine sediments offshore Costa Rica. Coherent variations up to 20‰ in $\delta^{34}\text{S}$ are observed over ranges as small as 1 mm, and can be linked to varying rates of sulfate reduction and sulfide oxidation. This study highlights the additional ecological information that can be extracted from high resolution isotopic data, which may improve our understanding of the microbial activity that drives biogeochemical cycling in these systems.

References:

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