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Sulfur biomineralization of peridotites undergoing low-temperature serpentinization

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Peridotite rocks undergoing low-temperature serpentinization can produce hyperalkaline fluids with up to millimolar concentrations of dissolved hydrogen, a potent electron donor for sustaining microbial metabolism. In the Samail ophiolite in Oman, some of the dominant H_2-dependent organisms detected in deep subsurface fluids include methanogens (e.g. *Methanobacterium sp.*), acetogens (e.g. *Acetothermia sp.*) and sulfate reducers (e.g. *Thermodesulfovibrio, Desulfovibrio, Desulfonatronum sp.*). Sulfate reducers can comprise up to 90% of the microbial population where dissolved sulfate is available at concentrations varying from 10 micromolar to 1mM.

Microbial sulfate reduction (SR) rate assays can detect biological SR in the serpentinite fluids and rocks, with rates varying from ~1 fmol to ~1 pmol/ml or cm^3/day, although rates drop precipitously when the system pH is above 10.5. This sulfate reduction activity appears to be occurring through an enormous volume of hydrating peridotite. Thus we are trying to determine the extent of the geochemical imprint imparted by biological SR on the secondary mineralogy of the serpentinites, and to identify biomarkers of SR activity (e.g. lipid biomarkers and biominerals) that are preserved within the rocks and fluids.

To date, we have evidence that where the geochemical conditions are conducive to biological SR, even at exceedingly slow rates, extensive optical darkening occurs across hundreds of meters of depth within the serpentinites. Although the total sulfur content of the altered rocks is low (<1 wt%), sulfur biomineralization is widespread. Using a combination of bulk x-ray diffraction and microscale synchrotron-based X-ray absorption spectroscopy and Raman hyperspectral imaging, we can detect a variety of Fe, Cu and Ni sulfides, as well as hydroxysulfides such as tochilinite-vallerite group minerals. We are currently investigating the direct and indirect mechanisms of biological sulfide mineral formation during production of sulfide within a rock matrix dominated by highly ferric serpentine ($Fe(III)/Fe_T$ ~30-90%). In addition, intact polar lipids diagnostic of sulfate-reducing bacteria, such as non-isoprenoidal diether glycolipids, dominate the IPLs extracted from fluid biomass. We are now characterizing the lipid biomarkers within the sulfurized rock to determine their preservation potential as a biosignature for extensive geochemical transformation of the mineralogy and optical properties of low-temperature serpentinites.