Microbial sulfate reduction rates in fluids from low temperature serpentinizing mantle rocks

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The generation of H_2 by the reaction of rock and water suggests the potential to power life in rocks independent of the photosynthetic biosphere, because H_2 is a key energy source for microbial metabolism. This is of particular interest in understanding the role of water-rock reactions in generating habitable conditions on and beyond Earth. Dissimilatory sulfate reduction (SR) is among the oldest known microbial processes on Earth and it is the predominant anaerobic microbial process in sulfur-rich marine sediments. Sulfate is plausibly available in several of the water-bearing environments now known beyond Earth, making SR a potentially important metabolism in those systems. The inferred presence of both sulfate and peridotite rocks in ophiolites points toward a potential niche for sulfate reducers and highlights the need to understand how and under which conditions SR occurs in serpentinizing systems on Earth.

We incubated formation fluids sampled from the Semail Ophiolite (SO) in Oman and from the California Coast Range Ophiolite (CRO) with a radio-labelled tracer ($^{35}SO_4^{2-}$) and determined the rates of in-situ microbial SR. The selected fluids represent different environmental conditions. Fluids collected at both sites cover a range from pH 7.6 to pH 12.7. However, they differ in substrate concentrations, i.e. sulfate (SO: 0.1-1.5 mM, CRO: 0.01-0.03 mM) and H_2 (SO: >1 µM, CRO: <100 nM) and in-situ temperature (SO: 30-35°C, CRO: 13-18°C). We found active microbial SR at very low rates in almost all fluids which shows that microbial SR is a process occurring in these environments today. This observation is supported by the recent findings of DNA from potentially sulfate reducing microorganisms. SR in the CRO fluids were with 0.2–20 $fmol^{-1}$ mL^{-1} d^{-1} generally lower than in the SO with 2–2000 $fmol^{-1}$ mL^{-1} d^{-1}, and sometimes below detectability (<0.1 fmol mL^{-1} d^{-1}). This might suggest that the low level of metabolic substrates in the CRO fluids represents a limitation for SR these rocks. In the SO, the lowest SR rates were associated with the hyperalkaline fluids (pH > 10) that had also the lowest sulfate concentration. In line with previously determined species richness in these fluids, this suggests that, besides substrate concentrations, also pH is an important parameter for habitability in this environment.