Investigating cell-mineral interactions and the geochemistry of methanogenic activity in a low-temperature serpentinizing system

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Water-rock reactions are thought to be a major energy source for chemolithotrophic life in extreme environments such as the deep subsurface. We investigate the possibility that *in situ* anaerobic H_2-utilizing microorganisms directly influence the rates and alteration products of water-rock reactions. To explore how microorganisms may potentially catalyze the hydration of mafic rocks, we have conducted laboratory experiments to monitor the growth of a methanogenic Archaea as $H_{2\ (g)}$ is produced from low temperature water-Fe°-basalt or water-basalt-olivine reactions. Time series measurements of gas concentrations, aqueous chemistry, and spatially-resolved synchrotron-based analyses of microscale mineralogy, trace element distribution and iron oxidation state, have been used to characterize changes in the geochemistry both with and without the presence of the methanogen over a year long experimental period. In abiotic batch experiments, H_2 production occurs at a peak rate of ~2μmol/g mineral/day. In biotic experiments, microbial consumption of H_2 leads to the production of CH_4 at a rate of ~0.5μmol/g mineral/day. Mass balance analysis of the amount of CH_4 suggests that the total H_2 production in microbial experiments does not exceed the abiotic experiments. Soluble Si and Fe concentrations appear to be buffered to a relatively constant concentration, while Mn concentrations are variable between the biotic and abiotic experiments. Analyses of the solid phase chemistry suggest that a complex suite of secondary minerals containing both reduced and oxidized iron have formed in the experiments. Fluorescence and scanning electron microscopy are used to explore the physical nature of the cell-mineral interactions in these systems. We will present a long-term characterization of the geochemical environment and cell-mineral interactions occurring in these water-rock systems. This research has implications for understanding life and its signatures in environments such as the deep subsurface throughout Earth's history and on other planets.

Marine iron-oxidizing bacteria and steel corrosion

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Iron-oxidizing bacteria (FeOB) are abundant in the ocean at sites associated with iron-rich hydrothermal vents; however, they have not been observed in normal coastal marine habitats. Additionally, the role of FeOB in marine steel corrosion remains enigmatic. Laboratory and field studies were undertaken using cultivation-dependent and -independent approaches to investigate the potential for FeOB to colonize, grow, and produce corrosion products on mild steel. We isolated a novel mesophilic, neutrophilic, iron stalk-forming FeOB (strain GSB2) from an iron oxide deposit in a salt marsh. The 16S rRNA gene of the isolate is 96% similar to that of *Mariprofundus ferrooxydans* PV-1, a deep-sea FeOB that forms helical iron oxide stalks, and is a member of the candidatus phylum 'Zetaproteobacteria'. GSB2 grows microaerophilically on Fe (0) or Fe (S) with bicarbonate as the only source of carbon. In microcosm experiments with GSB2 added to artificial seawater and a mild steel substrate, there was abundant cell growth and stalk formation, indicating GSB2 can colonize steel surfaces. Field incubations of mild steel were routinely colonized by iron oxide stalk-forming bacteria. Using 16S primers specific for Zetaproteobacteria, a single 16S rRNA gene sequence was recovered from an exposed steel surface. This sequence was also closely related to PV-1 (94% similar). Fluorescent *in situ* hybridization (FISH) analyses of parallel samples showed an association of Zetaproteobacteria with iron oxide stalks. A quantitative PCR (qPCR) assay will be used to quantitate Zetaproteobacterial abundance in the steel sample corrosion products. This work illustrates that FeOB are commonly associated with iron oxidation in marine environments, and they are able to use steel surface corrosion as a source of Fe (II) for lithotrophic growth. These organisms are easily recognized by the stalks they produce, and likely play an important role as early surface colonizers that influence biofilm formation on steel. These results are also significant in terms of the biogeography of FeOB and Zetaproteobacteria, which were previously mostly observed in deep-sea environments; it now appears they are also ubiquitous in the near-shore marine environment.