4.3.48

Microbial activity in anoxic estuarine sediments: Kinetic studies using a flow-through reactor approach

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Chemical cycling in aquatic sediments is strongly influenced by microbial activity, so knowledge of rates and mechanisms of geomicrobial processes is necessary for predictive environmental modelling. Reaction rates in sediments have traditionally been obtained from core incubations or slurry experiments. Here, we use recently developed plug flow-through reactors containing intact slices of sediment. Major advantages of this approach are that solute transport rate and concentration are controlled, and reaction rates can be measured under quasi-steady state conditions. A reactive transport model of the reactor system is used for data processing, allowing calibration of kinetic expressions for biogeochemical reactions under conditions where the physical, chemical and microbial structures of the natural porous medium are preserved. We focused on the kinetics of dissimilatory sulphate and nitrate reduction in temperate estuarine sediments sampled along a salinity gradient. Flow-through reactor experiments were run to determine the vertical distributions of potential reaction rates within these sediments, and to investigate which factors control sulphate and nitrate reduction *in situ*.

The potential reduction rates measured at freshwater, brackish and marine sites follow Michaelis-Menten kinetics with respect to concentrations of the electron acceptors, sulphate or nitrate. The maximum reaction rates (R_{max}) were obtained from steady state rates at high concentrations of the electron acceptors. The half-saturation concentrations (K_m) were obtained by fitting outflow substrate concentrations vs time with the reactive transport model, using K_m as an adjustable parameter. Interestingly, the highest potential rates of sulfate reduction were measured at the freshwater site. For the three sites, the highest potential rates were found in the topmost sediment layer. In spring, R_{max} of sulfate reduction in depth interval 0-2 cm was 35, 7 and 30 nmol $SO_4^{2-}.cm^{-3}.h^{-1}$, for the freshwater, brackish and marine sites respectively. The K_m values were in the range of 100-400 µM SO_4^{2-}. Freshwater reactors run from 10 to 30°C showed a strong effect of temperature on sulfate reduction, with an apparent activation energy (E_a) of 67 $kJ.mol^{-1}$ or a Q_{10} of 2.6. In depth interval 0-1 cm, R_{max} of nitrate reduction showed a pronounced seasonal variation with values ranging from 300 in winter, to 360-400 in spring and 600-1000 nmol $NO_3^-.cm^{-3}.h^{-1}$ in summer. The K_m values for nitrate reduction were in the range 80-400 µM NO_3^-. Preliminary results indicate that reactor-based rates of nitrate reduction agree well with rates derived in the field using in situ microprofiling data.

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FeMO: An observatory for the study of iron-oxidizing bacteria

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The importance of metals to life has long been appreciated. Iron (Fe) is the forth most abundant element, and the second most abundant redox-active element in Earth's crust, rendering it the most important environmental metal. In recognition of this, a recent surge in research on microbial Fe redox transformations in the environment has resulted in many exciting discoveries and enhanced appreciation for the importance of these processes. Most of these studies, however, have focused on the reductive Fe cycle and organisms such as the *Geobacteraceae.* This is in part because Fe-oxidizing organisms, particularly those who inhabit circumneutral pH habitats, have been notoriously difficult to culture and conduct laboratory studies on. However, recent successes on this front have resulted in the isolation of a number of novel chemolithoautotrophic Fe-oxidizing bacteria (FeOB). Studies on these have revealed a remarkable diversity, both physiologically and phylogenetically. This perhaps should not be surprising given that Fe is the most abundant lithoautotrophic energy source in Earth's crust, but is not in keeping with the present attention given to their study.

We have initiated an observatory to study FeOB ("FeMO") at the Hawaiian Seamount, Loihi. The major purpose of FeMO is to elucidate the full physiological, phylogenetic, and biochemical diversity of this long-neglected group of environmentally and ecologically important prokaryotes. Loihi is an ideal site for FeMO because: (1) FeOB have been recognized and studied there previously; (2) Loihi displays a wide-range FeOB habitats: from hydrothermal fluids to rocks, from low-flow, low-T (10°C) seeps to high-flow, high-T (>60 °C) vents; (3) previous studies provide an excellent geochemical framework to base these studies; and (4) Loihi is very accessible, located only 25 miles SW of the big island of Hawaii.

Results of initial studies will be presented including field colonization studies, mineralogical analyses, enrichment and pure culture studies, and laboratory biochemical and genetic studies.