Microbial mercury resistance in geothermal springs

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Mercury and Resistant Microbes in Hot Springs

High mercury (Hg) concentrations have been reported in geothermal environments [1, 2] raising questions on the modes by which microorganisms in such environments survive Hg toxicity. In mesophilic Bacteria, the Hg resistance (*mer*) system consists of the enzyme mercuric reductase (MerA), Hg transporters, and a regulatory protein, MerR [3]. Do microbes in geothermal environments use *mer*?

Results and Discussion

We used six degenerate PCR primer sets that together covered the known diversity of *merA* to detect *merA* gene homologs in microbial mats from Yellowsone springs. Canonical Correspondence Analysis showed that *merA* distribution was influenced by water temperature and pH, and by mat Hg conentration. DNA sequence and phylogenetic analyses of PCR products suggested that novel deep branching lineages of bacterial and archaeal MerA were found in springs with temperatures of > 62 °C. These results suggested that diverse *mer* systems were common in microbial mats and that the *mer* system might have originated in geothermal environments.

We characterized *mer* in *Thermus thermophilus* HB27, a thermophic bacterium similar to those common in Yellowstone springs. Unlike *mer* in mesophilic microbes, *mer* in HB27 lacked Hg transporters, was induced by Hg to a lesser extent than in mesophiles, and its MerA prefered NADH to NADPH as a cosubstrate [4]. Together with *mer* analysis in the crenarchaeote *Sulfolobus solfataricus* [5], our results show that *mer* systems in representatives of deep branching thermophilic lineages in the bacterial and archaeal domains are both unique and similar to *mer* in mesophiles that belong to late decending bacterial lineages.

In conclusion, further delineation of *mer* genes and functions in microbes form geothermal environments will likely lead to a better understanding of *mer* evolution.

[1] King *et al*. (2006) *Appl. Geochem.* **21**, 1868-1879 [2 Crespo-Medina *et al*. (2009) *L&O* **54**, 41-49 [3] Barkay *et al*. (2003) *FEMS Microbiol. Rev.* **27**, 355-384 [4] Wang *et al*. (2009) *FEMS Microbiol. Ecol.* **67**, 118-129 [5] Schelert *et al*. (2004) *J. Bacteriol.* **186**, 427-437.

Oxidation of ocean crust and the fate of seawater sulphate in axial hydrothermal systems

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Sulphate is largely absent in high-temperature hydrothermal vent fluids and the sulphide present in these fluids is isotopically closer to crustal than seawater values. Two models for the loss of seawater sulphate from the fluid in these systems have very different implications: (i) seawater sulphate may oxidise Fe in the crust and in turn be reduced to sulphide; or (ii) anhydrite may form, clogging porosity and depleting the fluid in Sr, and later dissolve as the crust cools.

If the precipitation of seawater sulphate is controlled by reduction of sulphate to sulphide, increased fluid-rock reaction should be recorded in samples of the sheeted dyke complex by correlated oxidation and formation of sulphides with elevated δ^{34}S. Alternatively, precipitation of seawater sulphate as anhydrite, and associated depletion of Sr in the fluids, would not be expected to lead to increasing bulk rock Fe^{3+}/Fe^{total} and δ^{34}S sulphide with $^{87}Sr/^{86}Sr$. Precipitation of anhydrite would change the Sr budget of hydrothermal fluid flow and fluid fluxes calculated from Fe oxidation would appear greater than from $^{87}Sr/^{86}Sr$.

We have investigated these models by analysing Fe^{3+}/Fe^{total}, $^{87}Sr/^{86}Sr$ and δ^{34}S in a suite of sheeted dyke samples from Pito Deep, Southern EPR. A wide range in δ^{34}S of -8 to +3‰ is observed in the sheeted dyke complex at Pito Deep with the very negative values suggesting that bacterial sulphate reduction has played a significant role in the sulphur cycle of the ocean crust at Pito Deep. The sheeted dyke complex at Pito Deep shows broadly correlated elevations in $^{87}Sr/^{86}Sr$ (0.7025-0.7029) and Fe^{3+}/Fe^{total} (0.03-0.40), which are associated with increased sulphide δ^{34}S (upto +3‰). These results support simultaneous oxidation of ocean crust and reduction of seawater sulphate to sulphide during hydrothermal fluid flow. Water/rock ratios calculated from Fe^{3+} and SO_4 mass balance during oxidation of ocean crust and Sr isotopes are similar suggesting that the major control on sulphate was reduction to sulphide and that anhydrite precipitation had an insignificant influence on the Sr budget.