Serpentinization and hydrothermal venting at slow-spreading ridges

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In this poster, we examine the link between hydrothermal convective cells, and the serpentinization of exhumed mantle-derived peridotites at slow spreading ridges by comparing serpentinization rates estimated by two methods: 1) segment scale estimations from geological data and seismic velocity distribution; and 2) vent-scale estimations from the hydrogen and methane flux measured at ultramafic-hosted hydrothermal vent fields. Each approach has its own uncertainties and yields estimates that concern distinct temporal and spatial scales : segment-scale estimates are integrated over the time it takes for the exhumed material to leave the axial domain, while vent-scale estimates are instantaneous. For the segment-scale approach uncertainties are primarily attached to the use of seismic velocities to derive degree of serpentinization and the proportion of magmatic rocks in sections of exhumed mantle. This approach leads us to propose a serpentinization rate of 11 to 18 m^3 of fresh peridotite per year and per kilometer of axis in areas of active exhumation, for an exhumation rate of 10 mm/yr. For the vent-scale approach, uncertainties are large and primarily attached to the estimation of hydrothermal fluid fluxes, and to the behavior of iron as serpentinization proceeds. This vent-scale approach leads us to propose that the large ultramafic-hosted Rainbow vent field requires on-going serpentinization at rates of 100 to 3000 m^3 of fresh peridotite per year.

The comparison of these two estimates indicates : 1- that fluids expelled at such high-temperature fields probably provide an outflow for most serpentinization-related fluids produced at this ridge location during the period of activity of these hydrothermal fields ; and 2- that during the periods of activity of these high-temperature hydrothermal fields, serpentinization in the footwall of axial exhumation faults must occur at rates significantly faster than the time-averaged rates we derived from the segment-scale method. We tentatively expand our comparative approach to lower temperature ultramafic-hosted vent fields such as Lost City, and we discuss a conceptual model that links time-variable serpentinization rates to hydrothermal convection in the footwall of axial detachment faults.

Bioenergetics in hydrothermal systems

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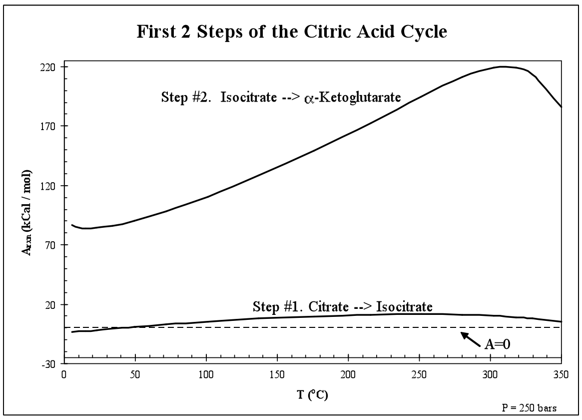
Combining theoretical models of rock alteration with biomolecule synthesis allows a quantitative approach to predicting the energetics of microbial metabolisms as functions of temperature, pressure, fluid composition and the extent of rock alteration. Recent results show that syntheses of alkanes, alkenes and some carboxylic and amino acids are often thermodynamically favored in submarine hydrothermal ecosystems, but this is rarely the case for energy-intensive biomolecules such as carbohydrates, purines, and pyrimidines [1]. These calculations can be taken further by exploring metabolic pathways at hydrothermal conditions. The figure depicts the affinity for the first two steps in the citric acid cycle as vent fluid from the Rainbow field on the Mid-Atlantic Ridge mixes with cold seawater.



The second step is thermodynamically favored (i.e. A>0) at all temperatures in this range, while the first step is favorable throughout the temperature regime inhabited by thermophiles. Thermophiles utilizing this metabolic pathway reap large amounts of energy that can be used for the synthesis of the energy-intensive biomolecules. Full analysis of this fundamental pathway can shed light on analyte cycling, prebiotic metabolism [2], and carbon fixation in the deep.

[1] Shock & Canovas (2010) *J. Geofluids* in press.
[2] Wachtershauser (1990) *Proc. Natl. Acad. Sci.* **87**, 200–204.