

Investigations of the roles of minerals in hydrothermal organic geochemistry

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Hydrothermal systems receive inputs of organic compounds from exogenous sources as well as endogenous processes including microbial activities and abiotic synthesis. Whatever their original source, organic compounds in hydrothermal environments are susceptible to degradation to CO₂ or to other organic compounds. Minerals surfaces within the hydrothermal systems doubtlessly play a prominent role in many of these transformations. Among the likely roles played by minerals include: providing catalytic surfaces, altering the concentrations of dissolved inorganic compounds that affect the reactivity of organic compounds, and providing oxidants and reductants for carbon redox reactions. In this presentation, I will draw on the results of recent laboratory experiments by myself and others to assess current understanding of the contribution of minerals to hydrothermal organic geochemistry, focusing on abiotic organic synthesis and the stability of carboxylic and amino acids. In the former case, laboratory experiments have successfully documented synthesis of simple hydrocarbons under conditions relevant to natural environments, but formation of more complex and ‘biotically interesting’ compounds has remained more elusive. In the latter case, minerals effect reactivity of organic acids both through interactions with mineral surfaces and by influencing fluid chemistry, particularly the speciation of dissolved sulfur compounds.

Hydrogen generation for microbial activity in ultramafic-hosted hydrothermal systems

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Ultramafic-hosted deepsea hydrothermal systems are noteworthy for producing high concentrations of molecular hydrogen (H₂) in circulating fluids as a consequence of serpentinization of the host rock [e.g. 1, 2]. This H₂ is thought to support communities of chemolithoautotrophic microorganisms both at the seafloor and in the subsurface [1, 3-7]. The capacity for ultramafic systems to support hydrogen-based microbial communities depends on the amount and rate of H₂ production during serpentinization, yet the factors that control this production remain poorly understood. Drawing on results of experimental studies, numerical models, and petrologic observations, we will discuss potential constraints on the rate of H₂ generation. Recent thermodynamic models have indicated that the temperature-dependent partitioning of Fe among serpentine, brucite, and magnetite may impose significant limitations on H₂ production at low temperatures [8]. Laboratory experiments [ref. 9, as well as our own unpublished results] and petrologic studies [10] indicate that kinetic constraints on both mineral dissolution and precipitation will also play a significant role in controlling how much and when H₂ is generated as serpentinization progresses. Together, these factors indicate there is considerable variability in the amount and duration of H₂ generated under different environmental conditions that will greatly influence the supply of H₂ to hydrogen-based microbial communities.

- [1] Kelley *et al.* (2005) *Science* **307**, 1428–1434. [2] Charlou *et al.* (2002) *Chem. Geology* **191**, 345–359. [3] Schrenk *et al.* (2004) *Environ. Microbiol.* **6**, 1086–1095. [4] Takai *et al.* (2004) *Extremophiles* **8**, 269–282. [5] McCollom (2007) *Astrobiology* **7**, 933–950. [6] Alt J. & Shanks (1998) *J. Geophys. Res.* **103**, 9917–9929. [7] Alt *et al.* (2007) *Geochem. Geophys. Geosyst.* **8**, 10.1029/2007GC001617. [8] McCollom & Bach (2009) *Geochim.Cosmochim. Acta* **73**, 856–875. [9] Seyfried *et al.* (2007) *Geochim. Cosmochim. Acta* **71**, 3872–3886. [10] Klein *et al.* (2009) *Geochim. Cosmochim. Acta* **73**, 6868–6893.