Geochemical modeling of vent fluid-seawater interactions

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Within seafloor hydrothermal systems, a variety of interactions occurs between vent fluid, seawater, minerals, and biota, resulting in a range of thermal and chemical environments. Conditions within these environents can be assessed using quantitative models of the physical processes and chemical reactions that occur as seawater and vent fluid mix beneath or at the seafloor, within walls of vent structures, and/or within clusters of organisms These types of calculations allow constraints to be placed on key variables (e.g., temperature, pH, redox, metal concentrations) and metabolic energy available to organisms.

Over the past 30 years a number of software tools have been developed for these purposes, including chemical equilibrium modeling packages and reactive transport modeling codes. These programs require input files that define the problem, set boundary conditions, and provide existing data (e.g., fluid and mineral compositions, information about the physical properties of the media, and thermodynamic and kinetic properties of aqueous species, minerals and gases). One of the most powerful aspects of these programs is the ability to examine the sensitivity of the system to differences in key variables and assumptions such as temperature, pressure, pH, or assumptions about whether or not equilibrium between two species is attained. For example, Shock and Holland (Wilcock et al., eds., Geophysical Monograph Series 144, AGU, 2004) demonstrated that estimates of energy available for metabolic activity in mixtures of vent fluid and seawater are highly sensitive to assumptions about whether aqueous hydrogen and oxygen equilibrate abiotically. Results of assuming different styles of mixing or consideration of transport through porous media by diffusion and/or advection can also be examined systematically. For example, calculated pH at different temperatures, and the predicted temperature of the transition from oxidized to highly reduced conditions, are sensitive to both vent fluid composition and to styles of mixing (Tivey, 2004, Wilcock et al., eds., Geophysical Monograph Series 144, AGU). In this presentation, different tools and databases available for study of different hydrothermal environments will be described, methods for setting up specific problems will be given, and examples that demonstrate the sensitivity of results to a range of different parameters and assumptions will be presented.

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