Variability in the Biological Potential of Serpentinzing Systems

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Serpentinizing systems have potential to provide biological communities with long-lived sources of hydrogen or reduced carbon, but also present challenges in the form of elevated pH, carbon limitation, and potentially elevated temperatures. Serpentinzed fluids in nature span orders of magnitude in hydrogen concentration and several units of pH, and the two do not always co-vary. Thus, the biological potential of serpentinizing systems may vary strongly across the range of naturally occuring conditions.

We modeled the effects of parent and alteration mineral composition, fluid composition, water:rock ratio, and temperature on biological potential for H_2-utilizing methanogenesis, as defined by a cellular energy balance. Geochemists Workbench was used to model equilibrium fluid chemistry across a range of input conditions, and the results were numerically coupled to a cell-scale reaction-transport model that calculates the energy yield available in methaongenic metabolism.

The modeled ratio of metabolic energy generation:demand is shown to vary by up to three orders of magnitude across the range of conditions considered, and peaks in an intermediate range of water:rock ratio. Calcium and iron content in parent minerals strongly affect pH and hydrogen generation, respectively, and these are the primary factors underlying the observed variation. Calculated cellular energy balance for a range of naturally occurring serpentinized fluids spans a comparably broad range.