Prebiotic Chemistry and Habitability in Serpentinizing Hydrothermal Systems on Early Earth and Other Worlds

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Serpentinization environments generate free energy driven by redox, pH, chemical, and thermal gradients; these gradients are known to sustain life in hydrothermal systems and may be significant for the emergence of life on Earth. Serpentinization has likely occurred on Mars and similar hydrothermal systems may also be present on ocean worlds such as Europa and Enceladus, and therefore are of great interest to astrobiologists in the search for life. Hydrothermal sediments and chimney precipitates in hydrothermal systems on the early Earth could have contained reactive minerals such as iron (-nickel) sulfides and iron oxyhydroxides. Behaving like flow-through chemical reactors, these mineral precipitates may have promoted various reactions towards the emergence of life including amino acid synthesis, concentration and retention of organic products, phosphorus redox and polymerization, and rudimentary energetic processes by electrochemistry. In vents today, and perhaps on the early Earth and / or other worlds, the precipitation of electrically active or reactive minerals can create geological fuel cell systems that may support life via electron transfer processes. We have utilized various experimental systems for simulating physicochemical gradients and geochemical redox reactions in serpentinizing systems, including the formation and characterization of simulated hydrothermal chimneys, synthesis of reactive hydrothermal sediments over a range of pH / redox states, and use of fuel cells as planetary habitability test-beds to simulate redox geochemistry of vents. I will discuss these experimental approaches for simulating astrobiologically relevant chemistry in hydrothermal vents, as well as how understanding serpentinization is significant for the search for life on other worlds.