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Hydrogen generation during peridotite serpentinization: an experimental study

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Serpentinization is a geochemical process in which ultramafic rocks react with water, producing serpentine, magnetite, and hydrogen (H_2). Serpentinization occurs in a variety of geological settings such as ocean floor, mid-ocean ridges, and subduction zones. Hydrogen generation during serpentinization is critical for sustaining subsurface microbial ecosystems and has implications for understanding the origin of life and planetary habitability. In spite of the significance, previous experiments have suggested that hydrogen produced during the serpentinization of olivine was very low even after a long reaction period (*e.g.*, one year), around 1-2 orders of magnitude lower compared to hydrogen predicted based on thermodynamic models [1, 2]. The controlling factors for hydrogen formation still remain poorly constrained. We performed a series of serpentinization experiments at 300 °C and 3.0 kbar, and found that hydrogen formation during peridotite serpentinization can be greatly influenced by the relative rates of olivine and pyroxene serpentinization [3]. With the addition of acidic (pH=2.50), alkaline (pH=13.5), and low-salinity solutions (0.5 M NaCl), the rates of olivine serpentinization are much faster than the kinetics of pyroxene hydrothermal alteration, resulting in an increase in hydrogen production. Spinel, aluminum, and chromium also have a promoting effect on the rates of olivine serpentinization, and hydrogen formation can be enhanced. In contrast, highly acidic solutions (2 M HCl) and more concentrated saline solutions (1.5 M and 3.3 M NaCl) increase the rates of pyroxene serpentinization, resulting in a great decrease in hydrogen production. Consistently, for experiments using mixtures of orthopyroxene and clinopyroxene, hydrogen production is around one order of magnitude lower compared to hydrogen formed in olivine-experiments. Our experiments strongly suggest that serpentinization kinetics is an important factor for hydrogen formation.

References:

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