Experimental study on H_2 generation by reactions between komatiite and CO_2-rich seawater

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Deep-sea hydrothermal system has been considered as one of the favorable environments for the emergence and early evolution of life on Earth. In particular, H_2-rich hydrothermal fluids generated through the serpentinization of ultramafic rocks potentially drove prebiotic chemical evolution and the acquisition of energy metabolism [e.g., 1, 2]. The H_2-rich seafloor hydrothermal environments would have been predominantly driven by komatiite volcanism in the Hadean ocean. Previously, hydrothermal alteration experiments have been conducted to understand the potential for H_2 generation during the serpentinization of komatiites under CO_2-free conditions. However, atmospheric CO_2 levels prior to the late Archean were likely much higher than the modern level, as suggested by theoretical calculations and geological records [e.g., 3,4].

We conducted two hydrothermal serpentinization experiments using synthetic komatiites and CO_2-rich acidic NaCl fluids at 250 °C and 350 °C, 500 bars. We revealed that the difference in temperature influences the precipitated carbonate species (Fe-rich dolomite at 250 °C and calcite at 350 °C) during the serpentinization of komatiites. The steady-state H_2 concentration at 250 °C is approximately 0.024 mmol/kg, which is significantly lower than that under CO_2-free condition. Ferrous iron incorporation into dolomite at 250 °C likely suppressed iron oxidation and concomitant H_2 generation. On the other hand, H_2 concentration at 350 °C reached up to 2.9 mmol/kg, which is equivalent to those in modern serpentinized hydrothermal systems. These results suggest that high-temperature komatiite-hosted hydrothermal systems had the potential to generate H_2-rich hydrothermal environments, in contrast to low-temperature equivalents, even under the CO_2-rich conditions in the Hadean ocean.

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