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Influence of temperature and rock chemistry on hydrogen generation from serpentinization of (ultra)mafic rocks

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Hydrogen production via serpentinization of (ultra)mafic rocks largely depends on rock chemistry (e.g., mineral composition and Fe speciation) and temperature. Most studies have focused on high temperatures (≥200°C), leaving H_2 production rate at low temperatures—particularly below 25 °C—poorly constrained. Moreover, variations in rock types and geochemical parameters (e.g., water/rock ratio) complicate cross-study comparisons. Here, we examine the influence of rock chemistry and temperature on H_2 production by reacting two samples each of peridotite, gabbro, and basalt with artificial seawater. Samples were characterized by X-ray fluorescence, X-ray diffraction, scanning electron microscopy-energy dispersive spectroscopy, and Mössbauer spectroscopy to determine their elemental composition, mineralogy, and Fe speciation. Kinetic experiments were then conducted at 4, 23, and 250 °C to monitor H_2 production. At low temperatures, there was small differences of H_2 yields between 4 and 23 °C. Greater H_2 yields were observed for PR-HR-DN (dunite from Horoman River, Japan), GB-DL (gabbro from Duluth, USA), and BS-SS (basalt from Sinsanri, Korea). At 250 °C, all samples produced reduced gases—including H_2 and hydrocarbons (methane, ethylene, and ethane)—with H_2 production approximately 1700-2200 times higher than at 23 °C. Despite the lower forsterite contents, both GB-DL and BS-SS generated H_2 levels comparable to PR-HR-DN, likely due to higher Fe(II) in their forsterite (Fo_{60-70}) and the presence of Fe(II) in other minerals. The temporal trends of hydrocarbons varied: CH_4 and C_2H_4 initially increased before declining, whereas C_2H_6 remained stable or increased. These patterns appear to be influenced by available H_2 and the catalytic effects of mineral constituents. Ongoing post-reaction analyses will examine secondary mineral formation and Fe(II)/Fe(III) distribution, along with solution-phase analyses of aqueous Si, pH changes, and organic compounds. This work advances our understanding of hydrogen production through serpentinization, with implications for the origin of life, CO_2 sequestration, and clean energy.