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Hydrogen generation during serpentinization of variably altered peridotites from the Bay of Islands Ophiolite constrained by experimental hydrothermal reactions relevant to natural hydrogen systems

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Serpentinization of ultramafic rocks is increasingly recognized as a major geological source of natural hydrogen (H_2), attracting growing interest for its potential as a carbon-free energy resource. However, quantitative constraints on how initial extents of serpentinization and temperature influence hydrogen production remain limited. Here we present hydrothermal experiments designed to evaluate H_2 generation potential in peridotites with variable extents of prior alteration, using samples from the Bay of Islands Ophiolite Complex, Newfoundland, a well-characterized exposed mantle section representative of natural hydrogen–prospective ultramafic terranes.

A range of serpentinization from weak to strong, as determined by loss-on-ignition (LOI), were reacted with synthetic seawater in sealed hydrothermal vessels at 150 °C, 200 °C, and 250 °C under constant pressure of 10 MPa. Hydrogen concentrations in reacted fluids were measured by gas chromatography to quantify production efficiency.

Results show that H_2 concentrations systematically increase with temperature for all samples, indicating enhanced serpentinization kinetics under higher thermal conditions. At identical temperature and pressure, weakly serpentinized peridotites consistently generate higher H_2 yields than moderately and strongly serpentinized samples. This trend suggests that the abundance of unaltered ferrous iron in primary olivine and pyroxene exerts primary control on hydrogen generation, whereas highly serpentinized rocks have already depleted much of their reactive iron reservoir during earlier alteration.

These experiments demonstrate that both temperature and initial alteration state strongly regulate hydrogen productivity during ongoing serpentinization. Given the widespread distribution of variably serpentinized ultramafic rocks in ophiolite belts and exhumed mantle sections, our results provide experimental constraints for estimating natural hydrogen fluxes and assessing the resource potential of rock-based hydrogen systems.