Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.32082

Hydrogen Generation in Peridotite Cores Fractured by Electrical Reservoir Stimulation

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The recent focus on clean energy and energy security has increased interest in geologic hydrogen (H_2) as a carbon-free, non-weather-dependent energy source [1]. Geologic H_2 is formed via serpentinization, a process turning Fe^{2+}-bearing olivine into Fe^{3+}-bearing secondary minerals (*e.g.*, serpentine, magnetite) [2]. This serpentinization process occurs naturally over geologic timescales, however, it can also be replicated and enhanced to occur at industrial rates. For stimulated geologic H_2 to become economical, the low permeability and available reactive surface area of (ultra)mafic formations must be increased by several orders of magnitude [2].

In this work, we report on novel electrical fracturing of impermeable (~10^{-21} m^2) peridotite cores from the Oman Ophiolite utilizing pulsed power stimulation at lab scale under in-situ conditions of 400 m depth (~7 MPa confining pressure, ~4 MPa pore pressure, 40-100°C). Following fracturing, the cores are placed into core flooding cells, capable of replicating in-situ pressures and temperatures. Type I and Type II fluids, commonly observed in the Oman Ophiolite [3], were injected into the cores, and H_2 is generated over days to months of reaction. The extent of the serpentinization reaction is tracked via pore fluid geochemical analysis (ICP-OES), dissolved H_2 concentrations (gas chromatography), as well as pH, conductivity, and Eh changes relative to starting fluids. Additionally, the changes in mineralogy and Fe-redox state of the reacted cores are investigated using optical microscopy, X-ray diffraction, chemical titrations, Raman microspectroscopy, and synchrotron-based X-ray fluorescence mapping coupled with Fe XANES spectroscopy.

Under batch and flow-through reactor core flooding experiments, substantial increases in pore pressure are observed within 24 hours of the reaction. Additionally, H_2 generation rate increases throughout the first two months of the experimental duration, correlated with changes in Si activity. Hydrogen generation from cores fractured with pulsed power are compared to baseline (unfractured cores), single-fracture cores, and powdered peridotite to determine the impact of varying permeability and reactive surface area. Early results suggest increased reaction progress and H_2 production rates due to higher fracturing degree and faster flow rate.

[1] Yedinak (2022), *Joule* **[2]** Templeton *et al.*, (2024) *Front. Geochem*. **[3]** Leong *et al.*, (2021) *JGR Solid Earth*.