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The effect of fluid salinity on the reaction rates and molecular hydrogen (H_2) formation during peridotite serpentinization

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Serpentinization is a hydrothermal alteration of ultramafic rocks (typically komatiite and peridotite) at relatively low temperatures (i.e., ≤500 °C). Serpentinization greatly influences the geodynamics and volatile recycling in subduction zones [1,2]. Molecular hydrogen (H_2) and methane (CH_4) commonly form during serpentinization, and they are capable of supporting microorganisms in hydrothermal vent fields. Previous experiments on serpentinization processes were mostly performed with olivine and pure H_2O as starting reactants [3, 4], without considering the role of chlorine, an important fluid component in subduction zones [5]. The Cl abundance in the fluid inclusions from the subduction zone serpentines can be as high as 50 wt% [6], high enough to change the fundamentals of the serpentinization process. We performed hydrothermal experiments at 300 °C and 2.2-3.4 kbar using peridotite/olivine and starting fluids (H_2O, 0.5 M, 1.5 M and 3.3 M NaCl). The results show that saline solutions promote the hydrothermal alteration of olivine and peridotite. This disagrees with previous experimental findings, showing that saline solutions significantly slow down the serpentinization of olivine by around two orders of magnitude [7]. Medium- and high-salinity solutions inhibit H_2 formation during serpentinization, which is associated with the serpentinization of pyroxene especially clinopyroxene. For the first time, we show that iowaite (with an ideal chemical formula of $Mg_6Fe_2(OH)_{16}Cl_2(H_2O)_4$) forms directly from the hydrothermal alteration of peridotite. The redox conditions were calibrated based on dissolved H_2, with very reducing conditions during the serpentinization of olivine and peridotite. This study suggests that chlorine greatly influences the serpentinization of olivine and peridotite in natural geological settings. It also indicates that iowaite formation may not require oxidizing conditions as previously thought.

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