Contrasted effect of pyroxene and spinel on the production of molecular hydrogen (H$_2$) during serpentinization of olivine

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In recent years, serpentinization has received considerable attention as a source of molecular hydrogen (H$_2$) for communities of microorganisms in hydrothermal vent fields. However, the mechanisms controlling H$_2$ production, especially the influence of pyroxene and spinel, still remain poorly understood. We performed hydrothermal experiments at 311-500 °C and 3.0 kbar, showing a contrasted effect of spinel and pyroxene minerals on H$_2$ produced after serpentinization at 311 °C and 3.0 kbar, i.e., spinel promotes H$_2$ generation by around two times, whereas pyroxene minerals significantly decrease H$_2$ production by around one order of magnitude. The contrast may be attributed to releases of aluminum and chromium from spinel during hydrothermal alteration, and an increase in H$_2$ production was observed for experiments with mechanical mixtures of olivine and Al$_2$O$_3$ or Cr$_2$O$_3$ powders. Pyroxene minerals released not only aluminum but also silica during serpentinization, and silica may greatly decrease H$_2$ generation. A decline in the effect of spinel was observed with increasing temperatures (400-500 °C), but a slight increase in H$_2$ production was still found for experiments with the addition of spinel. In contrast, pyroxene minerals have negligible effect on H$_2$ production. Olivine in natural geological settings is commonly closely associated with pyroxene minerals and spinel, and therefore H$_2$ generation can be greatly influenced.