The production of molecular hydrogen and methane during serpentinization: Influence of pyroxene and spinel

RUIFANG HUANG[1], WEIDONG SUN[2], XING DING[3], WENHUAN ZHAN[4]

[1]Guangzhou Institute of Geochemistry, CAS, rfhuang@gig.ac.cn; [2] Guangzhou Institute of Geochemistry, CAS, weidongsun@gig.ac.cn
[3] Guangzhou Institute of Geochemistry, CAS, xding@gig.ac.cn;[4] South China Sea Institute of Oceanology, CAS, whzhan@scsio.ac.cn

Fluids derived from serpentinite-hosted hydrothermal fluids typically contain abundant molecular hydrogen (H_2) and methane (CH_4) that can support communities of microorganisms in the hydrothermal vent fields. However, the mechanisms that control the production of H_2 and CH_4 are poorly understood. Olivine serpentinization produces smaller quantities of H_2 and CH_4 than peridotite serpentinization [1], possibly resulting from the influence of pyroxene and spinel. To test the hypothesis, we performed experiments were performed at 300 °C and 3.0 kbar in cold-seal hydrothermal vessels with mechanical mixtures of olivine (<30 μm of grain sizes) and spinel, pyroxene, Al_2O_3, or Cr_2O_3 powders as starting material. Molecular hydrogen and hydrocarbons were analyzed using Agilent 7890A Gas Chromatography. The results show that the production of H_2 and CH_4 increased significantly with the addition of spinel, Al_2O_3, or Cr_2O_3 powders, e.g., the production of H_2 and CH_4 in olivine-only experiments after 27 days was 80 mmol/kg and 0.46 mmol/kg, respectively. It became around two times higher with the presence of spinel, Al_2O_3 and Cr_2O_3 powders over the same period. By contrast, the production of H_2 in experiments with the addition of pyroxene was 15 mmol/kg after 27 days, which was around one order of magnitude lower than that with the presence of spinel, Al_2O_3, and Cr_2O_3. Pyroxene can release more SiO_2 into fluids during serpentinization, possibly leading to a decrease in H_2 production [2]. This study suggests that pyroxene and spinel released some of aluminium and chromium during serpentinization, which results in an increase in the production of H_2 and CH_4 during peridotite serpentinization. Olivine in natural geological settings typically has intimate associations with pyroxene and spinel; consequently, the production of H_2 and CH_4 during serpentinization may be much higher than previously thought.

[1] Huang et al. (2015), *Sci. China: Earth Sci.*, 58, 2165-2174; [2] Seyfried et al. (2011), *Geochim. Cosmochim. Acta*, 75, 1574-1593.