American Mineralogist, Volume 98, pages 1738–1744, 2013

Aluminum speeds up the hydrothermal alteration of olivine

Muriel Andreani*, Isabelle Daniel and Marion Pollet-Villard

Laboratoire de Géologie de Lyon: Terre, Planètes, Environnement, UMR 5276, CNRS, Université Claude Bernard et Ecole Normale Supérieure de Lyon, 2 rue Raphael Dubois, 69622 Villeurbanne, France

Abstract

The reactivity of ultramafic rocks under hydrothermal conditions controls chemical fluxes at the interface between the internal and external reservoirs of silicate planets. On Earth, hydration of ultramafic rocks is ubiquitous and operates from deep subduction zones to shallow lithospheric environments where it considerably affects the physical and chemical properties of rocks and can interact with the biosphere. This process also has key emerging societal implications, such as the production of hydrogen as a source of carbon-free energy. To date, the chemical model systems used to reproduce olivine hydrothermal alteration lead to the formation of serpentine with sluggish reaction rates. Here, we use in situ diamond-anvil cell experiments and show that the presence of aluminum in hydrothermal fluids increases the rate of olivine serpentinization by one to two orders of magnitude. Aluminum increases the solubility of olivine and enhances the precipitation of aluminous serpentine. After two days, olivine crystals were fully transformed to aluminous serpentine under conditions typical for natural hydrothermal environments, i.e., 200 and 300 °C, 200 MPa. This result motivates a re-evaluation of the natural rates of olivine serpentinization and of olivine hydrolysis in general in a wide range of settings. This discovery also opens the potential of the serpentinization reaction for industrial scale production of hydrogen at economically feasible timescales and temperature.

Keywords: Olivine, hydrothermal, serpentinization, aluminum