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Olivine vs orthopyroxene: controls on iron partitioning during serpentinization

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Serpentinization of mantle peridotite is accompanied by oxidation of Fe^{2+}, which produces hydrogen to sustain microbial activity within the oceanic lithosphere. Mantle peridotite commonly contains olivine (Ol) and orthopyroxene (Opx), and the reaction pathways and relative rates of serpentinization depend on temperature and local silica activity [1]. However, the systematic experimental studies on iron partitioning and hydrogen generation as a function of temperature and starting minerals (Ol vs. Opx) are still limited [2].

In this study, we conducted two series of batch type experiments in the systems of Ol-H_2O and Ol-Opx-H_2O at vapor saturated pressure, using mineral powders. First series was conducted at varying temperature in a range of 200-400°C at a constant duration of 576 h. Second series was conducted at 300°C with the temporal evolution from up to 6212 h. After each run, the reaction products were analyzed by thermogravimetry, EPMA (electron probe microanalyzer), VSM (Vibrating Sample Magnetometer), and XAFS analysis (X-ray Absorption Fine Structure).

The product of Ol-H_2O was serpentine + brucite + magnetite, and those of Ol-Opx-H_2O was serpentine + magnetite talc, respectively. At temperatures lower than 260°C, the areal ratio of altered olivine to altered orthopyroxene is higher than 1.0 (1.4-0.75 at 200-280°C, whereas at temperature higher than 250°C, the ratio is lower than 1.0 (0.75-0 at 280-400°C), meaning that the dominant mineral of serpentinization shifts from Ol to Opx with increasing temperature.

In Ol-H_2O system, the amount of magnetite linearly increases with time, and as temperature increases in the range of 200-310°C. In contrast, the magnetite amount was much smaller in Ol-Opx-H_2O system regardless temperature and duration. The preliminary results of XAFS analyses reveals the proportion of ferric iron in the products (Fe^{3+}/Fe_{total}) of 4248 h to be 0.31 and 0.08, indicating that the determined Fe^{3+}/Fe_{total} of serpentine was 0.23 in Ol-H_2O and 0.22 in Ol-Opx-H_2O systems, respectively. We will show more detailed iron partitioning in magnetite and serpentine minerals as a function of time and temperature in both systems.

Reference

[1] Schwarzenbach et al., 2016, Contrib Mineral Petrol, 171:5

[2] McCollom et al., 2020, Geochimica et Cosmochimica Acta, 282, 55-75