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Experimental investigation of the kinetics of the spinel-to-garnet transformation in peridotite: A preliminary study

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Abstract

To study the kinetics of the spinel-to-garnet transformation in peridotite, we conducted reaction experiments in the garnet peridotite stability field (3.2 GPa, 1020–1220 °C, for 0.6–30 h) using a single spinel crystal embedded in monomineralic orthopyroxene powder or in a mixture of powdered orthopyroxene and clinopyroxene. The growth textures observed in the reaction rim between the spinel crystal and the polycrystalline pyroxenes show that the reaction rim grew in both the spinel and pyroxenes directions, suggesting mobility of both SiO_2 and R_2O_3 components (where R is a trivalent cation). Olivine grains formed only in the presence of monomineralic orthopyroxene and were present in some domains without forming reaction rims. Based on a diffusion-controlled growth model, the growth kinetics of the garnet reaction rim can be described by $[x(t)]^2 = k_0 \exp(-H^*/RT)t$, where $x(t)$ is the rim width at time t, R is the gas constant, T is the absolute temperature, and H^* is the activation enthalpy of reaction; k_0 and H^* are, respectively, $k_0 = 10^{-19.8 \pm 4.9}$ m^2/s and $H^* = 171 \pm 58$ kJ/mol. The development of a garnet reaction rim around a spinel core has been observed in alpine-type peridotitic rocks and mantle xenoliths. The reaction rims experimentally produced in this study are characteristic of corona textures observed in natural rocks, and the experimentally measured growth rate of the rims places important constraints on dynamic transformation processes involving spinel and garnet in peridotite. However, to reconstruct the *P-T-t* history of the corona texture based on these elementary processes, additional detailed studies on the textural evolution and quantitative kinetics of the garnet-rim growth stage are required.

Keywords: Spinel, garnet, peridotite, reaction rim growth, kinetics, experimental petrology, UHP metamorphism