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Metamorphic reaction kinetics at "dry" and "wet" conditions in the binary MgO-SiO_2 system

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Reaction rims contain a wealth of information that can be used to decipher the P-T-t-X history of metamorphic and metasomatic rocks. One of the most important parameters that controls reaction rim growth dynamics is the presence of volatiles such as H_2O and fluorine, which can affect rim thicknesses, phase stabilities and the development of rim microstructures [1]. This implies that in a well-calibrated system, reaction rims have the potential to let us constrain and quantify the composition and amount of volatiles down to the ppm level that were present during fluid-mediated metasomatic reactions. This requires that we understand in detail and are able to quantify the effect of water and other volatile components on reaction rim growth dynamics and kinetics.

We performed reaction rim growth experiments to investigate net-transfer reactions in both “dry” and “wet” systems. Reaction rims were produced between single crystals of quartz and periclase in an internally heated pressure vessel (IHPV) at 0.4 GPa and 1100-1200 °C for 66 h to 168 h. In “wet” experiments, a ppm amount of water was introduced by pre-annealing periclase single crystals at water saturated conditions. During the experiments, the OH-doped reactant is consumed as the reaction rim grows, so that minute amounts of water are gradually released.

First results show the formation of single enstatite or forsterite and double enstatite-forsterite reaction rims in the “dry” and “wet” systems respectively. When water-doped periclase is used as reactant, reaction rim growth rates increase from $10^{-18.23\pm0.18}$ to $10^{-17.67\pm0.03}$ m^2/s at 1100 °C and from $10^{-16.95\pm0.06}$ to $10^{-16.16\pm0.01}$ m^2/s at 1200 °C, which is caused by the transition from anhydrous to fluid-mediated kinetics during the course of the experiment.

These findings show that there is a clear distinction between a “dry” and “wet” system in terms of reaction and nucleation kinetics. This implies that reaction rims allow us to discriminate between kinetically “dry” and “wet” systems and may additionally provide important clues on the dynamics of metamorphic reactions in natural systems.

References:

[1] Franke and Joachim-Mrosko (2022) The effect of fluorine on reaction rim growth dynamics in the ternary CaO-MgO-SiO^2 system. American Mineralogist. 10.2138/am-2022-8123CCBY.