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Influence of differential stress on the growth of wet enstatite and enstatite-forsterite reaction rims

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Reaction rim growth experiments provide insight into mass transport phenomena, which are important for metamorphic rock-forming processes and deformation mechanisms. To determine the influence of differential stress on reaction rates under wet conditions, we investigated experimentally the formation of enstatite ($MgSiO_3$) single rims between quartz (SiO_2) and forsterite (Mg_2SiO_4) and of enstatite-forsterite double rims between quartz and periclase (MgO) using porous polycrystalline starting materials. About 3 wt% water was added, acting as a catalyst for reactions. Experiments of mainly 4 and 23 hours duration were performed in a Paterson-type deformation apparatus at 1000°C temperature and 400 MPa confining pressure. Simultaneously, differential stresses between 0 and 46 MPa were applied perpendicular to the sample stacks with planar interfaces. The resulting reaction rim width varies between <1 μm and $\approx$ 23 μm, depending on duration and type of reaction product. At isostatic pressure conditions, i.e. without differential stress, our data indicate that rim growth is proportional to time, controlled by dissolution-precipitation processes at interfaces of interconnected fluid-filled pores. In contrast, under non-isostatic stress conditions the reaction rim thickness increases non-linearly with time, which implies diffusion-controlled growth. The magnitude of differential stress has no systematic influence on the reaction rate within the investigated range. Microstructural observations suggest that deformation-induced reduction of interconnected porosity causes this change in rate-controlling mechanism in experiments with and without differential stress. For a natural MgO-SiO_2 system, the results infer that fast interface-controlled reaction in the presence of high amounts of water is easily suppressed by concurrent deformation.