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Kinetic fractionation during orthopyroxene rim growth

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Local equilibrium is an important concept in Earth sciences and in physical chemistry. It comes from theoretical thoughts about chemical interaction between solid and fluid phases via interfaces. However, often such phases remain in a metastable state. Here we present results on orthopyroxene rim growth between chemically doped olivine and quartz, and the subsequent element distribution and evolving interface morphology. For our experiments forsterite was synthesized with several wt% of either Ni, Co, Mn, Zn, or dopands in combination. Reactions between silica and olivine are believed to be important for mantle metasomatism and the chemistry of Earth's lithosphere. Experiments were performed at "wet" (i.e. solid state apparatus; fluorite as pressure medium) and "dry" conditions (Al-oxide pressure cells). Water-saturated runs were done at 1223 K and held for 48 hours. The distribution style of the dopands is linked to their equilibrium fractionation as known from the literature, but in all cases leads to zoning within the reaction products and non-equilibrium compositions. In "dry" experiments flat and stable interfaces evolve. The presence of water, even in low amount, leads to needle-like crystal growth at interfaces, mosaic structure within the product rims and chemical enrichments within the Opx reaction products concurring with interface-destabilisation. Dopand enrichment even occurs within the forsterite reactant grains or at the opposite quartz-orthopyroxene interface, and along grain boundaries. All these effects are so far not part of theoretical models of diffusion-controlled rim growth formation and deserve closer notice.