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Feedback mechanisms in mineral replacement networks: an experimental investigation of the ultramafic model system

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The overall rates of multi-component reaction networks are known to be controlled by feedback mechanisms. Feedback mechanisms represent loop systems where the output of the system is conveyed back as input and the system is either accelerated or regulated (positive and negative feedback respectively). In other words, feedback mechanisms control the rate of a reaction network without external influences. Feedback mechanisms are well-studied in a variety of reaction networks (e.g. bio-chemical, atmospheric); however, in fluid-rock interaction systems they are not researched as such. Still, indirect evidence, theoretical considerations and direct observations attest to their existence [e.g. 1, 2, 3]. It remains unknown how mass and energy transport between distinct reaction sites affect the overall reaction rate and outcome through feedback mechanisms. We propose that feedback mechanisms are a missing critical ingredient to understand reaction progress and timescales of fluid-rock interactions. We apply the serpentinization of ultramafic silicates as a relatively simple reaction network to investigate feedback mechanisms during fluid-rock interactions. Recent studies show that theoretical timescale-predictions appear inconsistent with natural observations [e.g. 4, 5]. The ultramafic silicate system is ideal for investigating feedback mechanisms as it is relevant to natural processes, is reactive on timescales that can be explored in the laboratory, and natural peridotite typically consists of less than four phases. Our preliminary observations indicate a feedback between pyroxene dissolution and olivine serpentinization. Olivine serpentinization appears to proceed faster in the presence of pyroxene. Furthermore, the bulk system reaction rate increases with increasing fluid salinity, which is opposite to the salinity effect on the monomineralic olivine system. Dunite (>90% olivine) is rare, which is why it is crucial to explore the more common pyroxene-bearing systems. The salinity effect is important to investigate due to the inevitable increase in fluid salinity from the boiling-induced phase separation and OH-uptake in the formation of serpentine. Here we present preliminary textural and chemical observations, which will subsequently be used for kinetic modelling of feedback.

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