



Fluid path-dependent, hydrodynamic micro-environments govern serpentinization textures of harzburgite hydration in a flow-through reaction cell

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Despite of their rather simple chemistry, peridotites develop a rich variety of characteristic textures during serpentinization. Bastite, hourglass and mesh textures are indicative of their precursor minerals, while varying and often successive generations of serpentine veins (early transgranular veins, extensional "Frankenstein" veins, late crack-seal events) point to a polyphase hydration history in terms of changing hydrodynamic conditions throughout the rock. Starting from the observation that magnetite in a mesh texture always occurs near the rims of a cell and not dispersed within the serpentine halo around the olivine core, we want to clarify, whether hydrodynamic gradients are also active on the grain scale upon the formation of pseudomorphic textures such as meshes. As serpentinization is a fluid-assisted mineral replacement reaction dominated by an interface-coupled dissolution-precipitation mechanism, any mobility differences among the chemical species involved should have an expression in the developing reaction textures.

In order to survey harzburgite dissolution and related element transport, we performed flow-through experiments at 200 and 220°C and 50 bars for 26 and 70 days, respectively. N₂-saturated water was percolated through a pre-fractured minicore of a harzburgite sample. The composition of fluid samples taken during the run was analyzed using ICP-OES, reacted materials were inspected by SEM and EDX.

These compositions of the outflow solutions indicate dissolution and transport of silica, magnesium and calcium, while iron is absent. Correspondingly, SEM investigations reveal that olivine and pyroxenes dissolve rapidly, causing a pitted texture on the cut rock surfaces. We further observe the formation of Fe-rich precipitates and magnetite on the dissolving minerals, in places associated with serpentine needles.

The results show that the iron released from olivine and pyroxene dissolution becomes readily immobilized and precipitates in close proximity to its former host phase. With reference to the absence of magnetite in a mesh or hourglass texture, we propose that iron is mobile within the serpentine sponge but is immobilized by changing redox or pH conditions near the rim. With regard to the occurrence of magnetite or awaruite linings in early transgranular veins, we suggest that the fixation of iron at the mesh rims is governed by a change of the hydrodynamic micro-environment towards increasing flow.

Our results also show that the dissolution of olivine proceeds at rates faster than the precipitation of serpentine. These rate differences create permeability, which facilitates the pervasive nature of the serpentinization process.