

Faster orthopyroxene versus olivine serpentinization rates during experimental peridotite hydration at 230 °C and 13.4/20.7 MPa: pressure effects on spinel dissolution and reaction kinetics

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Serpentinization reactions are key to understand hydrogeothermal activity near plate boundaries and mafic-ultramafic massifs, as well as fluid and element transfer between the Earth's mantle and crust. However, fluid-rock element exchange and serpentinization kinetics under shallow hydrothermal conditions is still largely unconstrained. Here we present two constant temperature (230 °C) time-series of natural peridotite serpentinization experiments: at 13.4 MPa; and 20.7 MPa [1].

Al-enriched lizardite was the main secondary mineral in all runs after olivine (olv) and orthopyroxene (opx) serpentinization (without any detectable brucite, talc or magnetite), while primary spinel and diopside partially dissolved during the experiments. Estimated average serpentine content indicates fast serpentinization rates of 0.55 and 0.26 wt%.day⁻¹ at 13.4 and 20.7 MPa, respectively. Circa 2x faster serpentinization kinetics at lower pressure is likely linked to enhanced spinel dissolution (corroborated by thermodynamic modelling) leading to one order of magnitude higher available Al in solution, which accelerates olivine serpentinization while delays orthopyroxene dissolution.

Mass balance constrains suggests olv:opx react at ~5:2 and ~3:2 molar ratios, resulting in Si-deficient and Si-saturated serpentines at the end of the low-pressure series (13.4 MPa) and high-pressure series (20.7 MPa), respectively. Elevated starting peridotite olv:opx ratio (7.94:1) therefore indicates orthopyroxene serpentinization is ~3.3x and ~5.4x faster than olivine at 13.4 MPa and 20.7 MPa, respectively. These results contradict previous assumptions that olivine should dissolve faster than orthopyroxene at experimental conditions e.g. [2]. Although additional data is necessary, results by [3] and our experiments suggest peridotite serpentinization rates at 230 °C

rapidly decrease with increasing pressures at least up to 35 MPa. This agrees with steep and non-linear decrease in serpentinization degree with depth observed in nature e.g. [4]. Whether pressure directly influences olivine and orthopyroxene serpentinization kinetics or indirectly controls reaction rates due to spinel dissolution under hydrothermal conditions deserves further investigation.

References

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