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Reactive transport of carbonatite melts: constraints from ex- and in-situ high PT experiments

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Carbonatite melts can play a crucial role in the deep carbon cycle, as major carbon carriers from the deep Earth to its surface. Indeed, due to their low viscosities ($<10^{-2}$ Pa.s), small wetting angles (< 30°), and large buoyancy relative to surrounding mantle rocks, these liquids are expected to form interconnected networks and to be efficiently extracted even at low melt fractions. From a chemical point of view, this connectivity along grains implies an important exchange surface that makes them highly reactive agents. Therefore, understanding the location, transport, and reactivity of carbonate-rich melt in the deep Earth is an important step toward apprehension of geochemical and geodynamical processes at depths.

In this work, we performed high-pressure/high-temperature infiltration experiments in peridotite minerals powders to investigate mantle metasomatism by those unusual magmas, as well as the dynamics and morphology of carbonate melt migration. Using real-time computed tomography (CT) imaging under extreme conditions (PSICHE beamline, Synchrotron SOLEIL) and Raman plus SEM-EDS on quenched samples (Laboratoire de Géologie de Lyon), we provide insights into the kinetics of melt infiltration and reactivity. Time-lapsed CT images exhibit the diffusive dynamics of capillary flow, and the observed infiltration rates of 5.3 – 5.9 mm/h confirm the high mobility of carbonate liquids relative to silicate ones. Chemical reactivity along specific grains, corresponding to matrix wherlitization, was also observed at a time scale comparable with the melt flow and was further investigated to address the interplay between chemical reactions and melt transport physics.