An experimental study of CO_2-bearing basaltic melt and lherzolite interaction

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The earth crust contains a significant amount of carbonate due to hydrothermal alteration. Subduction and delamination recycle the crustal materials in to the mantle. Partial melting of recycled crustal materials generates CO_2-bearing melts which react with mantle peridotite during their ascent. Interaction between mantle peridotite and CO_2-bearing melt may be responsible for the formation of a range of clinopyroxene-rich lithologies (such as wehrlite and pyroxenite) in mantle xenoliths brought to the surface by magmatism. To better understand the reaction processes involving CO_2-bearing melt operating in the mantle, we conducted a series of CO_2-bearing basalt and lherzolite interaction experiments at 1275-1375°C and 1.5-3 GPa (3 hrs) using graphite-lined Pt capsules. The starting materials were a synthetic basalt with 5 wt% CO_2 and a fertile lherzolite. In all the experiments, the starting basalt is completely molten, and the lherzolite is partially molten with melt fraction lower than 5%. At 1375°C and 3 GPa, a significant amount of lherzolite (~ 300 μm thick) is dissolved in the melt, and the reaction produces a clinopyroxene + melt reactive boundary layer at the interface. Compared with clinopyroxenes in the lherzolite, clinopyroxenes in the reactive boundary layer are larger in grains size, higher in Al_2O_3, MnO, Na_2O contents, and lower in Mg#. The clinopyroxene-to-orthopyroxene ratio in the lherzolite increase towards the interface. At 1325°C and 2 GPa, the amount of lherzolite dissolution decreases (180 μm thick). A thin layer of clinopyroxene (10-20 μm thick) is precipitated at the interface, although the clinopyroxene-to-orthopyroxene ratio also increases at the reaction front. At 1275°C and 1.5 GPa, CO_2 is unmixed from the melt, and plagioclase and a small amount of clinopyroxene are crystallized at the interface. Results of the experiments underscore the effect of melt CO_2 and pressure in determining the lithology of the reactive boundary layers developed during melt-rock reaction. At high pressures, CO_2 and carbonate are miscible with silicate melts, and the CO_2-bearing silicate melt convert orthopyroxene to clinopyroxene during reaction with peridotite. The enrichment of clinopyroxene in mantle xenoliths may be related to CO_2-bearing basalt and peridotite interaction in the lithospheric mantle.