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The fate of carbon and CO_2—fluid-rock interaction during subduction metamorphism of serpentinites

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Given to its large relevance for present and past climate studies, the deep carbon cycle received increasing attention recently. However, there are still many open questions concerning total mass fluxes and transport processes between the different carbon reservoirs in the Earth's interior. One key issue is the carbon transfer from the subducting slab into fluids and rocks in the slab and mantle wedge. This transfer is controlled by the amount and speciation of stable carbon-bearing phases, which have a strong impact on the pH, redox conditions and trace-element budget of slab fluids. As recent experiments and thermodynamic modeling have shown, water released from dehydrating serpentinites has a great potential to produce CO_2-enriched slab fluids by dissolution of carbonate minerals. To constrain the fate of carbon and CO_2-fluid-rock interactions during subduction metamorphism of serpentinites, we have studied carbonate-bearing serpentinites recording different prograde evolutions from antigorite schists to Chl-harzburgites in high-P massifs of the Nevado-Filabride Complex (Betic Cordillera, S. Spain). Our results indicate that dissolution of dolomite in marbles in contact with dehydrating serpentinites is spatially limited during prograde metamorphism of carbonate-bearing serpentinites, but it can lead to the formation of silicate-rich zones in marbles close to the contacts. In lower grade serpentinite massifs (1.0-1.5 GPa / 550 °C), the presence of marble lenses in contact with antigorite schists appears to promote local dehydration of serpentinite coupled with carbonation of antigorite, forming Cpx-Tr-Chl-bearing high grade ophicarbonate zones. At the Cerro del Almirez ultramafic massif, where a dehydration front from antigorite-serpentinite to prograde Chl-harzburgite is preserved (1.9 GPa / 680 °C), a significant amount of carbon is retained in prograde Chl-harzburgites and Tr-Dol-marble lenses. This observation is at odds with thermodynamic models that predict efficient carbonate dissolution during dehydration of carbonate-bearing antigorite serpentinite, and indicates that in natural systems substantial amounts of carbon can be recycled into the deep mantle via subduction of carbonate-bearing serpentinite.