Coupled dehydration-decarbonation in high-pressure ophicarbonate: Implications on carbon cycling in subduction zones

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The strong increase in atmospheric CO_2 concentration recently turned attention on C storage in minerals and on devolatilization/melting of carbonated rocks. These processes control the long-term C evolution in Earth and its release to the atmosphere. Much of this activity occurs at subduction zones, where carbonation/decarbonation of rocks plays a major control on surface C emission.

The C subduction cycle is poorly constrained: uncertainties exist on its residence in subducting plates, fore-arc and sub-arc mantle at changing P-T and fluid composition. Experiments and close-system modelling of carbonated rocks document the large pressure-temperature stability of carbonates and a scarce C release to fluids. However, high CO_2 output from arc volcanoes and finding of (i) carbonic and diamond-bearing fluid/melt inclusions in HP-UHP rocks, and of (ii) hydrated-carbonated assemblages in peridotites from the slab-mantle interface and from mantle wedge, challenge the idea of C immobility and impose a re-evaluation of metamorphic processes of carbon release during subduction. C mobility is also suggested by thermodynamic modelling under open-system conditions, by experiments and natural occurrences of carbonate dissolution in aqueous fluids. Still unclear is the fate of COH fluids when interacting with serpentinized slab and mantle wedge. Here we address this issue by examining the subduction evolution of Alpine serpentinite, marble and carbonated serpentinite. We show that high-pressure serpentinite dehydration releases aqueous fluids triggering breakdown of dolomite in associated marbles and C release to the fluid. Carbonate and olivine veins document flow of the COH fluid within the rock sequence. Interaction of this fluid with serpentinite causes carbonation of rock-forming olivine, diopside and antigorite, and formation of high-pressure ophicarbonate domains. We discuss this finding in terms of fluid/rock interactions controlling the fate of carbon in slab and in supra-subduction mantle serpentinite. We suggest that C remains stored in slab and mantle wedge carbonates until subarc heating leading to substantial rock decarbonation.