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Constraints from carbonate-bearing peridotites (Ulten Zone, Italian Alps) on carbon storage and release in a continental subduction channel

Bibiana Förster (1), Sonja Aulbach (2), and Roberto Braga (1)

(1) Dip. di Scienze Biologiche Geologiche e Ambientali, Università di Bologna, Bologna, Italy (r.braga@unibo.it), (2) Institut für Geowissenschaften, Goethe-Universität, Frankfurt am Main, Germany

The fluid- to melt-mediated transfer of C in subduction zones exerts a first-order control on its long-term cycling. The subduction of sediments and altered oceanic lithosphere has received much attention, showing for example that the slab-mantle interface could be the site of either carbon storage or carbon release into subduction fluids [1]. In contrast, the transfer of carbon in a subduction channel developed during continent-continent collision is less well-explored.

Here, we present evidence for carbon storage and release recorded in metasomatic peridotite of the Ulten Zone (Italian Eastern Alps). The Ulten Zone hosts peridotites that initially experienced refertilization by carbon-bearing mafic melts during the Late-Silurian/Early Devonian, at the onset of the Variscan orogenic cycle. The transport of peridotites closer to the slab-mantle interface during the subduction of a continental slab resulted in intense metasomatic alteration by slab-derived, carbon-bearing fluids. Subsequently, since late Carboniferous times, these peridotites were incorporated into the crustal slab during exhumation and ultimately exhumed in a crust-mantle mélange.

Throughout this complex tectonometamorphic history, carbon was mainly stored in the form of dolomite as well as organic carbon species. The latter are yet to be identified, but our new combustion results show that organic carbon generally accounts for half of the carbon budget of the Ulten Zone peridotites. The release and mobilization of carbon is testified by calcite-brucite pseudomorphs after dolomite and by calcite and magnesite veinlets. These microstructures are prominent in peridotites showing a higher degree of serpentinization [2].

Our findings indicate that subduction channels of collisional orogens are not only responsible for carbon transport to mantle depths, but also for carbon introduction into the overlying wedge by subduction fluids and the eventual return of carbon from mantle depths to the crust during exhumation of orogenic crust-peridotite associations. Conversely, carbonates formed in continental mantle wedge peridotites that escaped entrainment in exhuming slabs may contribute to long-term storage of carbon in lithospheric mantle, which constitutes a hitherto underappreciated part of the deep carbon cycle [3].

[1] Scambelluri et al. (2016) Earth Planet. Sci. Lett. 441, 155-166. [2] Förster et al. (2017) Ofioliti 42, 105-127; [3] Foley and Fischer (2017) NatGeosci. 10, 897-902.