EGU Galileo Conference
GC4-Subduction-34, 2018
Exploring new frontiers in fluids processes in subduction zones

Stability of serpentinite-hosted ophicarbonate during subduction metamorphism and antigorite dehydration

Manuel Menzel (1), Carlos Garrido (1), Vicente López Sánchez-Vizcaíno (1,2), Claudio Marchesi (1,3), and Károly Hidas (1)

(1) CSIC, INSTITUTO ANDALUZ DE CIENCIAS DE LA TIERRA (IACT), Armilla (Granada), Spain (manuel.menzel@csic.es), (2) Dpto. de Geología (Unidad Asociada al IACT-CSIC), Universidad de Jaén, Escuela Politécnica Superior, Linares, Spain, (3) Dpto. de Mineralogía y Petrología, Facultad de Ciencias, Universidad de Granada, Granada, Spain

Dehydration reactions play a critical role in the release of carbon in subduction zones because they supply fluids that trigger decarbonation reactions and carry dissolved carbon into the overlying mantle wedge, with implications for the long-term carbon balance between Earth′s mantle, crust, and atmosphere throughout Earth's history [1]. Natural case studies of the impact of fluids generated by serpentinite dehydration on carbon mobility are rare. Here we show meta-ophicarbonate lenses within prograde Chl-harzburgites in the Almirez ultramafic massifs (Betic Cordillera, S. Spain) that record high-pressure subduction metamorphism of an oceanic, serpentinite-hosted ophicalcite protolith. They occur in a portion of mantle subducted to conditions beyond the high-pressure breakdown of antigorite, providing an unprecedented insight into the stability of carbonates during subduction metamorphism and serpentinite dehydration. These meta-ophicarbonates are composed of a high-grade assemblage of olivine, Ti-clinohumite, diopside, chlorite, dolomite, calcite, Cr-bearing magnetite and rare aragonite inclusions. Thermodynamic modelling indicates that they reached the same peak metamorphic conditions as the host Chl-harzburgites (1.7 – 1.9 GPa; 680 °C; $XCO_2 < 0.008$), and therefore experienced high fluid-fluxes produced by breakdown of antigorite in the host rock. Despite the high capacity of antigorite dehydration fluids to mobilize carbon, the ophicarbonate retains high amounts of carbonate (40 – 45 vol% dolomite and calcite), suggesting limited fluid infiltration and that the fluid composition remained rock-buffered. Likewise, stable isotope compositions of carbonate (δ18O = 13 – 17 ‰ V-SMOW and δ13C = –0.5 to –1.7 ‰ V-PDB) do not indicate a major fluid-induced decarbonation. We use the recent implementation of the Deep Earth Water model in Perple_X [2,3] to calculate aqueous speciation and total carbon solubility and mass transfer in high-P serpentinite dehydration fluids as a function of ophicarbonate composition, the integrated flux of serpentinite-derived fluids and the thermal regime of the subduction zone. The modeling results and the preservation of the meta-ophicarbonates at Almirez beyond the antigorite stability indicate that even in high-flux regimes such as during deserpentinization, mineral dissolution and decarbonation are largely governed by local equilibrium between infiltrating fluid and the rock composition. We show that carbon release from serpentinite-hosted ophicarbonates is predicted to be limited in any thermal subduction regime. Therefore, despite their relatively low contribution to the carbon budget of modern subducting slabs, subduction of ophicarbonates may represent a significant carbon flux pathway beyond sub-arc depths.

References:
[1] Kelemen & Manning, 2015, Proceedings of the National Academy of Sciences 112.
[2] Sverjensky, Harrison & Azzolini, 2014, Geochimica et Cosmochimica Acta 129.
[3] Galvez, Manning, Connolly & Rumble, 2015, Earth and Planetary Science Letters 430.

Funding: We acknowledge funding from the People programme (Marie Curie Actions - ITN) of the European Union FP7 under REA Grant Agreement n°608001, and grant CGL2016-75224-R from the Ministry of Economy, Industry and Competitiveness (MINECO, Spain).