Tectonically controlled carbonation of serpentinites in the Ligurian ophiolites: The genesis of the Castiglioncello magnesite deposit

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The interaction between CO_2-bearing fluids and ultramafic rocks produces stable carbonates. In ophiolitic sequences this process led to the formation of magnesite deposits which can provide insights onto natural carbonation and help refine engineered CO_2 sequestration strategies. Even though reactions and thermodynamics involved in the genesis of these deposits are relatively well understood, the role of tectonics is still unclear [1].

In this study we consider the Castiglioncello magnesite deposit hosted in serpentines belonging to the Ligurian ophiolites of Southern Tuscany (Italy). Our results indicate that at Castiglioncello an exceptionally high carbonation efficiency was achieved thanks to an optimal interplay between tectonics and geochemistry. Tectonic events related to the Apennine orogenesis produced isolated serpentinite lenses completely embedded in low permeability sedimentary formations, where the CO_2-bearing fluids could be efficiently concentrated. In these sealed serpentinite reactors fluids became enriched in Mg^{2+} by transforming serpentine into a montmorillonite and amorphous silica assemblage. Further deformation led to the opening of large fractures confined in the serpentinite lenses. This drawn the fluids into open spaces where they experienced boiling and precipitate massive magnesite. Therefore, the Castiglioncello example shows that tectonics can enhance serpentinite carbonation by: i) favouring optimal conditions for the enrichment of CO_2-bearing fluids in Mg^{2+}, required to form magnesite; ii) providing empty spaces for the precipitation of carbonates outside the reaction zone, that would otherwise passivate the system; and iii) maintaining a high permeability by repeatedly reactivating the fractures. This research received funding from the European Union's Horizon2020 Research and Innovation Program under grant agreement No 818169 (Project GECO).

[1] Boschi C., Dini A., Dallai L., Ruggeri G., Giannelli G., 2009. Enhanced CO_2-mineral sequestration by cyclic hydraulic fracturing and Si-rich fluid infiltration into serpentinites at Malentrata (Tuscany, Italy), Chemical Geology, 265, 209-226.