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Carbonated serpentinites in Tuscany (Italy): a geological analogue to carbon dioxide sequestration

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CO_2 sequestration by carbonation of magnesium silicate minerals is one storage mechanism being considered for implementation on an industrial scale. Mineral carbonation binds CO_2 into the lattice of carbonate minerals forming stable and environmentally benign by-products such as magnesite. This process is considered the only method for disposing CO_2 on a geologic time-scale with minor risk of leakage. Although the reaction has proven difficult to induce in the laboratory, the rock record of the process is ubiquitous in serpentinite terrains.

Fossil mineral carbonation systems, which occur as magnesite deposits hosted by intensively altered serpentinites, are well-exposed in Tuscany (Italy), at Elba Island (San Piero and Sant'Ilario deposits), at Monti livornesi (Castiglioncello and Campolecciano deposits) at the Colline pisane (Monterufoli-Malentrata and San Dalmazio deposits) and at Val d'Elsa (Querceto deposit). Two main carbonation types, intimately associated, have been observed: (1) metasomatic replacement of the serpentinites; (2) infill precipitation in stockworks and discrete veins/lodes.

Elba deposits are mainly stockwork-type deposits, characterized by a complex system of randomly oriented, cm-thick veins, which affect thermometamorphic metaserpentinites lying between the intrusive contact with the Monte Capanne pluton and a high-angle extensional fault delimiting the thermometamorphic aureole. The other deposits are serpentinite- and gabbro-hosted sub-vertical veins up to 4 m thick and hundred meters wide (Castiglioncello and San Dalmazio deposits) with minor stockworks. The mineralised veins have N-S or NNO-SSE trend, parallel to the general trend of the extensional structures bounding the Tuscan Neogene sedimentary basins.

The deposits are essentially made by magnesite (up to 80-90 % $MgCO_3$) with minor amount of chalcedony, opal, dolomite and iron hydroxides.

The interplay between the regional and the local, hydrothermally-induced, stress field produced different fracture geometry and spatial arrangement which concurred to the final shape and size of the magnesite deposit. The goal of this study is to compare the structural styles of the mineralization with: (1) the extent of the carbonation of the host rocks and, (2) the distribution and zonation of characteristic mineralogical transformation.

This geological, structural and petrographic work provides the base for future geochemical, isotopic and fluid inclusion studies devoted aimed at improving the knowledge of the *in situ* mineral carbonation processes and CO_2 sequestration.