Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7886

Sequestration of mantle CO_2 into the Ligurian Ophiolites of Central Tuscany

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The interaction between CO_2-rich fluids and ultramafic rocks triggers carbonation reactions that result in the bonding of CO_2 into the structure of newly formed carbonate minerals. This process is responsible for the genesis of magnesite deposits in ophiolite sequences and is generally considered the result of the downward infiltration of meteoric water enriched with CO_2 derived from surficial (atmosphere or soil) or shallow crustal (limestone decarbonation) reservoirs, in absence of significant tectonic activity.

Here we merge a petrologic and isotopic study with structural and field observations at the Castiglioncello magnesite deposit, which is hosted in the Ligurian ophiolites of Central Tuscany (Italy), to further constrain the role of tectonic and source of CO_2 in the natural carbonation of ultramafic massifs. Our results show that active tectonics had a key role in the formation of the magnesite deposit and that CO_2 was mostly derived from the Earth's mantle. Tectonic activity not only preconditioned the ophiolite sequence creating optimal conditions for the accumulation of CO_2-rich fluids in serpentinite lenses, but also had the pivotal role of producing crustal-scale fault zones that allowed the rising of mantle CO_2. Our study shows that carbonation of ultramafic massifs can be triggered by deep CO_2 during active tectonic and thus provides an alternative model to the dominant view of post-tectonic carbonation, where CO_2 and fluids are mainly derived from the surficial environment. While in the latter scenario there is a key role of reaction-driven cracking in sustaining permeability, the tectonically-driven model delineated here shows that high permeability during the genesis of ultramafic-hosted magnesite deposits could be mainly provided by fracturing and faulting. This research received funding from the European Union's Horizon2020 Research and Innovation Program under grant agreement No 818169 (Project GECO).