The microstructural record of high-pressure modulated deserpentinisation

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Aqueous fluids released during dehydration of a subducting slab largely affect the volatiles cycling at convergent margins. It has been recently proposed that high-pressure (HP) serpentine dehydration (deserpentinisation) can be promoted by the coeval influx of reducing external fluids (i.e., modulated deserpentinisation) that modify the serpentinite intrinsic redox conditions. Here we investigate this new model based on field relationships, microstructures and petrology of Cerro Pingano ultramafic massif (Betic Cordillera, S. Spain). Detailed mapping of this massif shows the transformation of HP antigorite (Atg-)serpentinite, through chlorite (Chl-)serpentinite to Chl-harzburgite, which, until now, had only been described in Cerro del Almirez (Padrón-Navarta et al. 2023 and references therein). In Cerro Pingano, the transition can be traced across a ~50 cm wide reaction front marked by the appearance of chlorite first and then by the disappearance of antigorite. The Atg-serpentinite shows a gently NW-NWW dipping foliation and Chl-harzburgite a weak compositional layering with the same orientation, both obliquely cut by the reaction front, steeply NW dipping.

Antigorite has a strong Crystal Preferred Orientation (CPO) with $[001]_{Atg}$ perpendicular to the foliation. Randomly oriented, euhedral tremolite overgrows this fabric. Similarly, olivine in Chl-harzburgite has a low-strain appearance with a CPO characterized by $(010)_{Ol}$ perpendicular to the layering, consistent with a macroscopic topotactic relationship $(001)_{Atg}||(010)_{Ol}$. Orthopyroxene and tremolite show $(010)_{Opx/Tr}$ perpendicular to, and $[001]_{Opx/Tr}$ defining a girdle within the layering plane. Magnesite —present in some Chl-harzburgite samples— has a CPO of [0001] parallel to $(010)_{Ol}$. The transition from Atg-serpentinite to Chl-harzburgite is associated with a relative decrease of $Fe^{3+}/\Sigma Fe$ (from 0.73 to 0.23), consistent with infiltration of reducing external fluids during the coeval dehydration (Padrón-Navarta et al., 2023). Chl-harzburgite samples are also enriched in C (496 - 1601 µg/g) compared to the Atg-serpentinite precursor (<120 µg/g). This trend explains the occurrence of magnesite in harzburgites (< 6 vol.%) and the lack thereof in serpentinites. Textural equilibrium of magnesite within the assemblage Ol + Opx + Chl + Tr + Mgs + Mag indicates it was formed by fluid-rock interaction and was stable at peak conditions, a unique feature of Cerro Pingano compared to other prograde Chl-harzburgite examples. Furthermore, tremolite in Atg-serpentinite contains low Na+K content (~0.05 apfu), but shows increasing Na+K content from transitional lithologies to Chl-harzburgite (up to 0.20 apfu, with invariant Na/K ratio).

The structural analysis suggests that the reaction front at Cerro Pingano does not follow structural discontinuities, nor does it propagate along the rock fabric. The correlation of antigorite CPO (Atg-serpentinite) with olivine, orthopyroxene, tremolite, and magnesite CPOs (Chl-harzburgite) suggests that the Chl-harzburgite fabric is inherited from Atg-serpentinite or was obtained during dehydration, but is not a result of dynamic recrystallization. However, while these features can be attributed to *in-situ* dehydration, the changes in bulk chemistry (enrichment in magnesite) indicate interaction with an externally derived aqueous fluid, possibly originating from graphite-bearing metasediment host rocks.

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References

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