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Metamorphic record of high-pressure dehydration of antigorite serpentinite to chlorite harzburgite in a paleo-subduction setting

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The pattern and amount of water-rich fluid released from subducting oceanic lithosphere exerts a fundamental control on the subduction dynamics. Although the cyclic nature of metamorphic dehydration events is subduction zones is attested by intermediate-depth seismicity, the hydrodynamics of fluid expulsion during the high-pressure, breakdown of antigorite (atg) in these settings are still barely known. This is due to the complexity of the system and the paucity in the geological record of arrested dehydration fronts. The antigorite dehydration front in the Cerro del Almirez ultramafic massif (Nevado-Filábride Complex, Betic Cordillera, SE Spain) offers an unique opportunity to investigate the high pressure prograde breakdown of antigorite serpentinite (Atg-serpentinite) to chlorite harzburgite (Chl-harzburgite; Ol+Opx+Chl) in a paleo-subduction setting.

In this massif we differentiate two types of Chl-harzburgite with similar mineral assemblages but displaying contrasting textures: (i) a first textural type, overlooked in previous studies, that we refer here to as Chl-harzburgite granofels made up of coarse anhedral olivine, chlorite flakes (2-3 mm), and prismatic orthopyroxene, with an interlocked texture; and (ii) a second textural type characterised by arborescent crystals of olivine (up to 12 cm in length), centrimetric radial aggregates of orthopyroxene and relatively fine grained chlorite (200-300 μm in length) referred to in previous studies to as spinifex-like texture. Granofels and spinifex-like textures alternate in intricate decimetric bodies throughout the Chl-harzburgite sequence in a relative proportion of approximately 4:6. The transition of granofels to spinifex-like textures is very sharp and convoluted.

We ascribe different textures of Chl-harzburgite as due to shifts of the growth rate of reaction products caused by temporal and spatial fluctuations of the affinity of the antigorite-breakdown reaction driven by cyclic variations of the fluid pressure in the dehydrating system. Crystallization at a low affinity of the reaction, corresponding to the Chl harzburgite granofels, was attained by slowly draining of fluids at the antigorite dehydration front. During the advancement of the dehydration front overpressured domains were left behind preserving Atg-serpentinite that was highly metastable under lithostatic pressure. Brittle failure of rocks surrounding the overpressured domains would result in a sudden increase of their permeability, drop of fluid pressure towards hydrostatic pressure, and a displacement of Atg equilibrium towards the prograde products. This process resulted in the crystallization of Chl-harzburgite assemblages under a high affinity of the Atg-breakdown reaction, accounting for disequilibrium enhanced growth of spinifex-like texture. Chl-harzburgite in the Cerro del Almirez hence witness the feedbacks between the hydraulic and metamorphic reaction in a dehydrating system and record the cyclic dynamic of metamorphic fluid expulsion in subduction settings.