

Pervasive Hydration of Mantle Wedge Peridotites by Slab-Derived Fluids

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The interaction between fluids and various lithologies within subduction zones influences deep volatile recycling, mass transfer, and the rheology of the megathrust. While fossil subduction channels provide insights into fluid-rock interactions within the slab and along the subduction interface, the extent and dynamics of these processes in the overlying mantle remain largely unexplored.

This study presents new field, microstructural, and geochemical analyses of the Almklovdaalen peridotite (Western Gneiss Region, Norway), a fragment of Laurentian subcontinental lithospheric mantle (hanging wall) reworked in a Caledonian subduction zone and enclosed within Baltican crystalline basement (footwall). Structural analysis suggests continuous deformation from garnet-peridotite to spinel-peridotite facies. This deformation was concurrent with aqueous fluid percolation, transforming the original dry garnet-peridotite assemblage (D₁) into a hydrated chlorite-peridotite assemblage (D₂ and D₃), reflecting hydration during decompression at temperatures above the antigorite stability.

Microstructural evidence from olivine and orthopyroxene porphyroclasts suggest dynamic recrystallization via dislocation creep. However, the presence of film-like Opx neoblasts between Ol porphyroclasts, strain-free neoblasts, and pinning microstructures involving olivine + orthopyroxene with platy chlorite and phlogopite indicate concomitant dissolution-precipitation. The strengthening of the shape-preferred orientation among porphyroclasts and neoblasts, coupled with a weaker crystal-preferred orientation (Ol J-index: 2.5→1.8), suggests neoblast formation via fluid-assisted dissolution-precipitation. Additionally, peridotite hydration is associated with an increase of externally derived K, Na, C, Rb, and Ba content in bulk chemistry and the formation of a texturally equilibrated olivine + orthopyroxene + chlorite + spinel + phlogopite + amphibole + carbonates assemblage.

Chemical changes indicate interaction with slab-derived fluids; however, hydration is not limited to structural discontinuities or lithological boundaries that typically act as fluid conduits. Instead, evidence such as (i) pervasive and penetrative foliation in chlorite-peridotite, (ii) kilometer-scale folding, and (iii) widespread fluid-assisted dissolution-precipitation microstructures suggests synkinematic pervasive hydration of the mantle wedge. Rb-Sr dating of coeval mica will provide the first direct age constraints on upper-plate mantle

wedge deformation during Caledonian subduction, offering new insights into the mechanisms by which mantle wedge material was pervasively incorporated during collision.

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