

Mass Transfer between Crustal and Mantle Rocks in Subduction Zones: Insights from the High-Pressure Voltri Massif (Ligurian Alps, Italy)

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Exhumed high-pressure rocks offer the most direct way to constrain mass-transfer processes occurring in subduction zones. However, accurate interpretation of these rocks requires distinguishing high-pressure metasomatic processes in subduction zones from inherited oceanic signatures prior to subduction and from exhumation. Here we investigate the phase petrology, petrophysical properties, and geochemistry of a metasomatic reaction zone in the Voltri massif (Ligurian Alps) to better understand the mass transfer between mafic and ultramafic rocks. We integrate petrography, mineral and bulk-rock chemical data with thermodynamic phase equilibria and reaction path modeling to constrain (i) how (fluid advection vs diffusion-controlled), (ii) where (subduction zone vs ocean floor), and (iii) when metasomatism occurred (inherited oceanic, prograde subduction, or retrograde exhumation). We show that the formation of the metasomatic reaction zone in the Voltri massif is mainly driven by gradients in the Mg-activity between serpentinite and eclogite. In eclogite, the replacement of garnet, pyroxene and sulfides and formation of epidote, amphibole and chlorite towards the lithologic contact is mirrored by talc alteration of serpentinite. Coupled phase equilibria and reaction path modeling suggest that the mass transfer likely occurred at post-peak eclogite-facies conditions. Convergent evidence suggests that the metasomatic reaction zone in the Voltri massif likely formed by diffusion-dominated mass transfer between crustal and mantle components within the slab or at the slab–mantle interface in a *mélange* zone. It is unrelated to seafloor alteration processes. We then discuss the geochemical consequences of this mass transfer in view of global element cycling in subduction zones.