

Hydration-dehydration processes in active subduction zones, and their geophysical signature

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Seismological and magneto-telluric methods are potential tools for imaging fluid circulation when combined with petrophysical models. Recent measurements of the physical properties of rocks, in particular serpentinites, have permitted to refine hydration of the mantle and fluid circulation in the mantle wedge from geophysical data.

In the slab lithospheric mantle, serpentinization caused by bending at the trench is limited to a few kilometers below the oceanic crust (<5 km). Double Wadati-Benioff zones, 20-30 km below the crust, are explained by deformation of dry peridotites, not by serpentine dehydration. It reduces the required amount of water stored in solid phases in the slab (Reynard et al., 2010).

In the cold (<700C) fore-arc mantle wedge above the subducting slab, serpentinization is caused by the release of large amounts of hydrous fluids in the cold mantle above the dehydrating subducted plate. Low seismic velocities in the wedge give a time-integrated estimate of hydration and serpentinization. Serpentinization reaches 50-100% in hot subduction, while it is below 10% in cold subduction (Bezacier et al., 2010; Reynard, 2012).

Electromagnetic profiles of the mantle wedge reveal high electrical-conductivity bodies. In hot areas of the mantle wedge (> 700C), water released by dehydration of the slab induces melting of the mantle under volcanic arcs, explaining the observed high conductivities. In the cold melt-free wedge (< 700C), high conductivities in electromagnetic profiles provide "instantaneous" images of fluid circulation because the measured electrical conductivity of serpentine is below 0.1 mS/m (Reynard et al., 2011). A small fraction (ca. 1% in volume) of connective high-salinity fluids accounts for the highest observed conductivities. Low-salinity fluids (< 0.1 m) released by slab dehydration evolve towards high-salinity (> 1 m) fluids during progressive serpentinization in the wedge. These fluids can mix with arc magmas at depths and account for high-chlorine melt inclusions in arc lavas.

High electrical conductivities up to 1 S/m in the hydrated wedge of the hot subductions (Ryukyu, Kyushu, Cascadia) reflect high fluid concentration, while low to moderate (< 0.01 S/m) conductivities in the cold subductions (N-E Japan, Bolivia) reflect low fluid flow. This is consistent with the seismic observations of extensive shallow serpentinization in hot subduction zones, while serpentinization is sluggish in cold subduction zones.

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