Serpentinization and Cl-rich fluids in subduction zones

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Water is recycled to the Earth's interior at subduction zones, and a large portion of the subducting fluid is mobilised at depths shallower than 150 km. Seismological and magneto-telluric methods are potential tools for imaging fluid circulation when combined with petro-physical models. Measurements of the physical properties of hydrous phases such as serpentine allow refining fluid circulation in the mantle wedge from geophysical data.

In the cold melt-free fore-arc mantle wedge above the subducted 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 image of extensive hydration and serpentinization within the stability of serpentine below 700°C. Using elastic properties, the amount of serpentinization is calculated to reach 50-100% in hot subductions, while it is constrained below 10% in cold subduction. This amount corresponds to a time-integrated reaction of water-rich fluids originated from the dehydrating slab with the overlying mantle wedge.

Electromagnetic profiles of the mantle wedge reveal high electrical-conductivity bodies. In hot areas of the mantle wedge (> 700°C), water released by dehydration of the slab induces melting of the mantle under volcanic arcs, explaining the observed high conductivities. In the cold wedge (< 700°C), high conductivities in electromagnetic profiles provide "instantaneous" images of fluid circulation.

Small fractions (*ca.* 1% in volume) of connective high-salinity fluids are required to account for the highest observed conductivities. Modelling shows that low-salinity fluids (≤ 0.1 *m*) released by slab dehydration can evolve towards high-salinity (≥ 1 *m*) fluids during progressive serpentinization in the wedge. These fluids can mix with arc magmas at depths to produce high-chlorine melt inclusions in arc lavas.

Electrical conductivities up to 1 $S.m^{-1}$ are observed in the hydrated wedge of the hot subduction zones (Ryukyu, Kyushu, Cascadia), while moderate conductivities are observed in the cold subductions (N-E Japan, Bolivia), reflecting low fluid flow in the cold wedge of the latter. This is consistent with the seismic observations of extensive shallow serpentinization in hot subduction zones, while serpentinization is sluggish in cold subduction zones.