Hydration and dehydration of oceanic plates at subduction zones

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Hydrated oceanic plates may deliver significant amounts of water to the Earth’s interior, which has strong implications for the dynamics of our planet.
Oceanic plate hydration is thought to occur principally by seawater downward percolation along cracks and fault zones and is normally associated with a decrease of the seismic velocities, lower heat fluxes, small magnitude seismicity (high b-values) and relatively high electrical conductivities. Extensive hydrothermal alteration of the oceanic plate has been reported in the trench-rise system of several subduction zones where bending across the trench of the oceanic lithosphere causes brittle extensional (compressional) deformation in the upper (mid-lower) portion of the plate and diffuse intraslab seismicity ranging from microearthquakes of $Mw < 3$ to large intraplate and tsunamigenetic earthquakes of $Mw > 8$. The opening of fractures during brittle deformation provides a natural pathway for seawater percolation, which is aided by the establishment of dynamic sub-hydrostatic pressure gradients along the normal faults and, when an interconnected fracture network is present, by hydrothermal convection.
As the hydrated plate subducts, pressure and temperature conditions increase leading to the dehydration of the slab. Slab dehydration is normally linked to an increase of the pore-pressure, which in turn reduces the effective normal stress sufficiently to bring the system into the brittle regime. Water stored in pore space and loosely bounded water (H_2O^-) in clays and zeolites of the upper oceanic crust and sediments is mostly expelled beneath the accretionary prism and the outer forearc, strongly affecting the mechanical behaviour of the megathrust and of the overlying upper plate. On the other hand, structural water (H_2O^+) is progressively released at greater depths by metamorphic dehydration reactions during slab unbending. Most dehydration reactions are temperature sensitive and therefore are expected to occur at greater depths for colder slabs, with the dehydration front migrating from the hotter outer portions toward the cold core of the slab.
Seismic tremor and intraslab deep seismicity with high b-values together with anomalous Vp/Vs ratios are often taken as evidence of ongoing metamorphic dehydration reactions of most abundant hydrous minerals such as serpentine, chlorite, amphibole and lawsonite.
In this contribution I will critically review the present-day knowledge relative to the hydration and dehydration of subducting oceanic plates (which is mostly based on geophysical observations and numerical predictions acquired over the last decade), and discuss the implications of these processes for the observed seismicity at subduction zones.

Keywords: subduction, slab hydration/dehydration, fluid-triggered seismicity

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