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Subduction zone hydration

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H2O release from subducting slabs has been proposed to be a major process in subduction zone development and an important mechanism for triggering arc magmatism. Data from a subducted Alpine ophiolite suggest, however, that the subducted slab does not undergo continuous dehydration along the prograde metamorphic path and that the slab releases only a small part of the H2O stored in the slab.
Subducting oceanic slabs contain mafic volcanics, oceanic mantle and a thin sediment cover. Typical of oceanic basement rocks is, that they are only partially hydrated when entering the subduction zone. The rocks contain a limited amount of H2O fixed in solids and free aqueous fluid phase is typically absent in such rocks. This is because free water will be fixed to hydrous minerals by hydration reactions. The reactions desiccate the subducting rocks efficiently early in the subduction process at relatively shallow depth. At greater depth, the fluid-absent rocks, basalts, gabbros and peridotites, contain some hydrous minerals of the subgreenschist facies and the blueschist facies. The rocks do not dehydrate but the reactions transfer H2O from low grade to higher grade hydrous minerals. They do not reach water-saturated conditions. The density of the mafic rocks remains relatively close to that of anhydrous oceanic basement rocks, whereas partly serpentinized mantle is always buoyant relative to peridotite.
At some critical depth in the subduction zone (typically 80 - 100km), the fluid regime changes dramatically and the rocks become water saturated. The consequence is that all rocks reaching this depth undergo extensive hydration and equilibrate with an aqueous fluid. The mafic rocks increase their water content dramatically and also density of the hydrated mafic rocks is significantly higher than that of anhydrous basalt/gabbro. The zone of hydration in the slab is related to the antigorite breakdown reaction progressing in the partially hydrated oceanic mantle serpentinites. It creates a water saturated zone in the slab that expands and grows with time. Its depth depends on the thermal regime in the slab and on the subduction angle.
The serpentinite dehydration water is used to completely hydrate incoming peridotite above the Atg-out isograd and locally hydrate (serpentinize) peridotite of the overriding mantle wedge. The water is also used to convert incoming igneous mafic rocks into wet eclogite (e.g. gabbro to eclogite transition of Allalin gabbro). The hydration of basalt/gabbro is a consequence of progressing serpentinite dehydration a few km down-slab. The water saturated zone extends for about 10km up-slab to a temperature of about 500°C. At shallower depth and lower T the slab rocks are devoid of a free aqueous fluid phase. It is first generated at Atg-out isograd. The model density evolution of the slab rocks shows that serpentinites in the water saturated zone above the Atg-out isograd are buoyant. Buoyant serpentinites generated above Atg-out may wrap incoming slices of eclogite and make the packages buoyant. Serpentinite and eclogite imbricates are buoyant relative to surrounding rocks of the slab and mantle wedge and are returned to the point of equal density (∼30km depth). Rocks of the descending slab that have crossed the antigorite-out isograd cannot be returned to the surface and disappear at depth.