Geophysical Research Abstracts
Vol. 20, EGU2018-6755, 2018
EGU General Assembly 2018

The sources and sinks of H_2O in subduction zones

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The transfer of H_2O between hydrous phases, fluids and nominally anhydrous minerals in the slab and mantle wedge is crucial for mass transfer and deformation behaviour in subduction zones and is responsible for key aspects of crustal growth, modification and recycling. This contribution focuses on the way H_2O, or colloquially "water", is transported to mantle depth by subduction of serpentinites, on fluid liberation during serpentinite breakdown and on the incorporation of hydrogen in olivine in the slab and the mantle wedge.

The P-T stability of antigorite and chlorite in subducted slabs coupled to slab geotherms determines to what depth water can be transported in hydrous phases. New experimental results show that chlorite has a higher thermal stability at 100-150 km depth than previously thought. Serpentinites are dominated by sheet silicates that make rocks extremely weak. These rocks are thus important for the decoupling of the deformation between the slab, the overlaying accretionary prism and the mantle wedge.

The liberation of aqueous fluids through the breakdown of antigorite and chlorite impacts not only on the deformation behaviour of the slab, but also initiates mass transfer through fluid-rock interaction. The released aqueous fluid interacts with altered oceanic crust and sediments, leading to mineral dissolution and melting. These modified fluids then enter the mantle wedge and promote wet melting that is manifested in arc magmatism, representing growth of continental crust. This fluid-mediated recycling process provides one of the most important ways to fractionate the silicate Earth.

The transfer of water from hydrous phases to nominally anhydrous minerals, such as olivine, in the subducted slab and the mantle wedge determines (i) how much water is recycled back through arc magmatism and (ii) how much water can be transported to the deeper mantle. New experimental data and observations from natural, high pressure rocks indicate that 50-150 ppm (μglg) of water can be incorporated into olivine in the slab and the adjacent mantle wedge. Hydrogen is replacing Si through a hydrogrossular and/or Ti-clinohumite point-defect substitution, potentially leading to a hydrolytic weakening of peridotites in the mantle wedge