Role of water in subduction zone dynamics

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Within the solid Earth system, water plays crucial roles in both physical and chemical aspects, e.g., reducing rock strength and density, decreasing melting temperature, and redistributing elements and isotopes effectively during water-rock interactions. Although each effect has been vigorously studied, less attention has been paid to their interplay. As an example in subduction zone, dehydration of a subducting slab hydrates the overlying mantle wedge, reducing the viscosity. Then, the flow-thermal field is modified to accommodate the extent and the locus of dehydration and melting, which in turn affects again the viscosity and thermal-flow field, forming a non-linear feedback system [1]. We investigate such systems by numerical simulation of two-phase mantle convection models, involving water transport, hydrous phase relation, fluid generation and migration, and fluid-rock reactions. The water transport and the mantle convective flow are interactive through rheology, density and phase relation for hydrated-dehydrated rocks.

Based on the numerical models, we demonstrate how the influences of water on phase relation, rheology, density, and flow-thermal structure appear as observable variables and phenomena, such as the location of arc volcanic zone, the subduction velocity and angle of plate, slab morphology, stress field, trench migration and back-arc spreading. One of the key parameters is effective viscosity of hydrous minerals, which is not tightly constrained at present: e.g., development of serpentinite just above the subducting slab critically controls the mechanical coupling between the slab and the mantle, leading to various flow-thermal structures depending on the viscosity. It has been also found that rheological weakening of the continental lithosphere by fluid upwelling as well as effective density reduction of the hydrated slab have significant impacts on the back-arc basin formation, trench mobility and convergence rate, and determine the subsequent evolution of slab morphology over the global scale [2]. The observed variations in subduction mode, at least partly, could be attributed to different degrees of water effects (e.g., water content of slab) on subduction dynamics.

[1] Horiuchi & Iwamori (2016) *JGR* doi:10.1002/2015JB012384. [2] Nakao, Iwamori, Nakakuki (2016) *JpGU* abstract.