沈み込み帯の深部水輸送・ダイナミクスにおける含水スラブマントルの効果

Effects of hydrous lithospheric mantle on deep water circulation and subduction zone dynamics

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Water stored in subducting oceanic plates is potentially an important factor in a variety of subduction zone dynamics because behavior of converging plates is affected by hydrous rocks in association with its small strength, viscosity, and density (e.g., Gerya & Meilick 2011; Nakao et al., 2016). A hydrous lithospheric mantle (HLM) below the oceanic crust can carry a significant amount of water to the deep mantle, and water content and distribution of the HLM seem various (e.g., Contreras-Reyes et al., 2008; Key et al., 2012; Fujie et al., 2013). In this study, we aim to investigate effects of the HLM on deep water circulation and subduction structure. For this purpose, by using the 2-D model of Nakao et al. (2016), the changes in plate velocities and slab geometries are systematically investigated as a function of water content and distribution in a subducting oceanic plate.

We have found that simulated water transport and resultant plate behavior significantly change depending on the HLM thickness. When a subducting plate has hydrous oceanic crust without HLM, most of the water is released from the slab at ~60 km depth, and a small amount of water enters the mantle wedge and back-arc zone. As a result, back-arc extension is weak and the slab penetrates the 660-km phase boundary. When the HLM exists as well as hydrous oceanic crust, more water is supplied to the mantle wedge as increasing the slab temperature. As the released water sufficiently weakens the overlying plate, back-arc extension occurs accompanied by slab rollback. During the rollback, the slab stagnates along the 660-km boundary. When the HLM thickness exceeds a critical value, dense hydrous magnesium silicates (DHMSs) appear in cold parts of the HLM. As the buoyant DHMSs reduce the slab pull force, plate convergence becomes slow, and back-arc extension and trench retreat are inhibited.

Variations in the simulated plate behavior indicate a great potential role of the HLM in actual subduction zones. For example, tectonics in Northeast Japan, characterized by trench retreat, rapid convergence, and a stagnant slab (Lallemand et al. 2008; Fukao & Obayashi 2013), can be explained by a thin HLM or its absence within the Pacific plate. The seismic velocities and anisotropic structures under Northeast Japan are also interpreted as the thin HLM within the Pacific slab (Zhang et al., 2004; Reynard et al., 2010).

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