Numerical simulation of water transportation along subducting slabs and implications for intraslab earthquakes

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It has been argued that water is abundant enough across subducting slabs to trigger lower seismic planes (i.e., >40-km-thick hydrous mantle; Peacock, 2001). Geodynamic modeling, however, suggests that the Pacific slab has a low water content beneath Northreast Japan (NEJ) (Nakao et al., 2018), despite presence of the clear lower seismic plane. The model shows that the thickly serpentinized slab mantle (>10 km for 100-Ma slab) causes slow plate convergence, stationary trenches, and slab penetration into the 660-km boundary, in contrast to the case of NEJ (Lallemand et al., 2008; Fukao & Obayashi, 2013). Moreover, seismic velocity and anisotropy structures also indicate a small amount of water around the lower plane in the Pacific slab (Zhang et al., 2004; Reynard et al., 2010). To address this discrepancy, we performed numerical simulations of water transport within and along the subducting slab of a variable age and initial water content. It is demonstrated that the loci of fluid liberation from the subducted slab of an old age (130 Ma) broadly correspond to the upper seismic plane beneath NEJ. On the other hand, loci of any dehydration reaction within the old slab may not explain the lower seismic plane. Instead, the loci of chlorite breakdown for a 36-Ma slab correspond to the lower plane beneath NEJ. In this case, the breakdown and formation of chlorite repeatedly occur, and liberated fluid forms a long curved-linear locus similar to the shape and extent of lower seismic plane in the Pacific slab beneath NEJ. We suggest that the repeated chlorite breakdown which effectively reutilizes a small amount of water contained initially in the slab may trigger the long lower seismic plane beneath NEJ.

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