Distribution of hydrous minerals in the Pacific slab inferred from travel-time tomography

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Hydrous minerals in oceanic plates become unstable with increasing pressures and temperatures, and consequently dehydration reactions take place accompanied by the release of water to the surroundings. The water thus released is believed to trigger arc magmatism. This study summarizes recently-obtained detailed 3D seismic velocities in the subducting Pacific slab in terms of water transportation in subduction zones.

Our recent studies (Tsuji et al. 2008, GRL; Nakajima et al., 2009, GRL) revealed that the depth extent of the low-velocity (hydrated) oceanic crust varies along the arc. The low-velocity oceanic crust is subducting to depths of 120-150 km beneath Kanto, which is 40-70 km deeper compared to NE Japan. Such a deeper preservation of the low-velocity oceanic crust can be explained by lower-temperature conditions in the Pacific slab as a result of the subduction of the Philippine Sea slab immediately above it. These observations suggest that water is carried to such depths through hydrous oceanic crust and phase change of crustal materials accompanied by large velocity changes are controlled principally by temperatures, not by pressures. We also found prominent low-velocity anomalies along the lower plane of the double seismic zone and above the aftershock area of the 1993 Kushiro-oki earthquake (M7.8) (Nakajima et al., Gondwana Research, 2009). Since seismic velocities of unmetamorphosed peridotite are much higher than the observations, hydrous minerals are expected to exist in the lower plane as well as the hypocentral area of the 1993 earthquake. In contrast, regions between the upper and lower planes, where seismic activity is not so high compared to the both planes, show relatively high velocities comparable to those of unmetamorphosed peridotite. These observations suggest that hydrous minerals exist even in the mantle of the Pacific slab with implications for dehydration embrittlement hypothesis as a cause of earthquake in the subducting slab.