Dehydration-earthquake-temperature link in subducted slab and its implication to fluid in the subduction zones

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We present a comprehensive interpretation about the distribution of earthquakes, temperature and fluid behavior in the subducted slab, on the basis of the dehydration-induced earthquake hypothesis. We show how a link established among dehydration, intraslab earthquake, and thermal structure in the subducted slab by employing a phase diagram calculation for the slab material, the double-difference relocation of hypocenters in NE-Japan, and a brute-force search for the best-fit thermal structure. Our results strongly suggest that dehydration-induced origin of the structure of hypocenter distribution. Therefore, the observation of intraslab earthquake will yield information about fluid and temperature in the subducted slab those are critical to understand subduction-zone phenomena.

The Wadati-Benioff zone is a distinct subduction-zone structure of hypocenter distribution, and it marks the position of a downgoing oceanic plate. The maximum depth of these subduction-related earthquakes is about 700 km, and there is a bimodal depth distribution of global seismicities. The first peak occurs at very shallow depths of ca. 50 km and the frequency of earthquakes decreases downward toward ca. 200 km. In this range of depth, the double seismic zone (DSZ) is a distinct seismic structure in cross-section of subducting plate. Hypocenters in the DSZ distribute in two zones, upper and lower, along the descending plate. These zones are parallel in each other in shallower and gradually merges toward deeper. Part of the upper zone of the DSZ is located in the oceanic crust, which is probably composed of hydrated MORB. In Kurikoma-yama section, NE-Japan, the earthquakes in the MORB layer are limited in the depth shallower than 120 km, and separate into three clusters. We tested which P-T path of the subducting MORB layer could establish the link between the depth distribution of the hypocenter clusters and dehydration reactions in the MORB system, by brute-force algorithm generating all possible P-T paths, and we got unique P-T path as a result. Same method was also applied to the slab peridotite, and whole thermal structure surrounding the DSZ was estimated. The estimated thermal structure shows qualitatively reasonable shape compared with the thermal calculations. However, the temperatures are estimated to higher than those by previous calculations, e.g. 200^{o}C higher in the MORB layer. We also show that this method can reveal regional variation in the thermal structure in the subducted slab, implying what controls the thermal condition of subduction zone.