Relation between water associated with plate subduction and deep LFEs and the 410-km non-equilibrium phase transformation

Shoichi Yoshioka[1]

[1] Dept. of Earth and Planetary Sci., Kyushu Univ.

The existence of water is important when we consider dynamics of a subducted slab. In this presentation, two different topics will be presented: One is water dehydration of hydrous minerals included in subducted oceanic crust at shallow depths in relation to generation of deep low-frequency earthquakes, and the other is the effect of water content in a slab on phase structure related to the non-equilibrium olivine-spinel phase transformation.

In the first topic, we will present recently identified three possible deep low-frequency earthquakes (LFEs) beneath eastern Kyushu, Japan, a region in which LFEs have never before been identified. To assess these data, we analyzed band-passed filtered velocity seismograms and relocated LFEs and regular earthquakes using the double-difference method. The results strongly suggest that the three events were authentic LFEs, each at a depth of about 50 km. We also performed relocation analysis on LFEs recorded beneath the Kii Peninsula and found that these LFEs occurred near the northwest-dipping plate interface at depths of approximately 29-38 km. These results indicate that LFEs in southwest Japan occur near the upper surface of the subducting Philippine Sea (PHS) plate. To investigate the origin of regional differences in the occurrence frequency of LFEs in western Shikoku, the Kii Peninsula, and eastern Kyushu, we calculated temperature distributions associated with PHS plate subduction. Then, using the calculated thermal structures and a phase diagram of water dehydration for oceanic basalt, the water dehydration rate (wt%/km), which was newly defined in this study, was determined to be 0.19, 0.12, and 0.08 in western Shikoku, the Kii Peninsula, and eastern Kyushu, respectively; that is, the region beneath eastern Kyushu has the lowest water dehydration rate value. Considering that the Kyushu-Palau Ridge that is subducting beneath eastern Kyushu is composed of tonalite, which is low in hydrous minerals, this finding suggests that the regionality may be related to the amount of water dehydration associated with subduction of the PHS plate and/or differences in LFE depths. Notable dehydration reactions take place beneath western Shikoku and the Kii Peninsula, where the depth ranges for dehydration estimated by thermal modeling agree well with those for the relocated LFEs. The temperature range in which LFEs occur in these regions is estimated to be 400-500^{o}C.

In the second topic, we will present the effect of water content on phase structure in the mantle transition zone in the Mariana slab. Recent studies of high P-T experiments indicate that metastable olivine might persist in a cold core of a slab due to the low rate of reaction associated with the olivine-spinel phase transformation. Recent seismological observation detected the existence of a metastable olivine wedge which survives to a depth of about 630 km in the Mariana slab. To consider a problem of non-equilibrium phase transformations, we developed a 2D numerical code which incorporates the effect of kinetics of phase transformations in addition to a conventional model of thermal convection. We considered kinetics of grain-boundary nucleation and growth for the olivine-spinel phase transformation. Effects of water content on the kinetics of the olivine-spinel phase transformation within a slab as well as the latent heat release associated with a non-equilibrium phase transformation were taken into account. In general, the results show that the depth of the metastable olivine wedge decreases with water content. We also tried to explain the seismological observation in the Mariana slab, by calculating the temperature and phase structure. When we assume that the age of the Mariana slab is 150 Myr, subducting velocity is 10 cm/yr, and water content is 800 wt.ppm, the metastable olivine wedge survives to a depth of about 630 km, which is in good agreement with the seismological observation.