Three-dimensional thermal modeling associated with subduction of the Philippine Sea plate at the Ryukyu Trench, and its relation to the occurrence of interplate seismic events

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Interplate seismic events such as short-term slow slip evens (S-SSEs) (Nakamura, 2017), low-frequency earthquakes (LFEs) (Ando et al., 2012), and shallow very low-frequency earthquakes (VLFEs) (Nakamura et al., 2015) have been identified at the Ryukyu Trench, southwestern Japan. As the specific characteristics of these distributions, depths where S-SSEs and LFEs occur at the plate interface beneath the Okinawa island, whose depth is ranging from 15 km to 25 km, is about 10-20 km shallower than that beneath the Yaeyama islands, whose depth is ranging from 35 km to 50 km.

In this study, we constructed three-dimensional parallelepiped thermal convection model associated with subduction of the Philippine Sea (PHS) plate beneath the Amurian (AM) plate at the Ryukyu subduction zone. We considered subduction history of the PHS plate in the model region, referring to the plate rotation model (Mathews et al., 2016). We performed the numerical simulation as the time-dependent problem in the last 15 Myr to elucidate relationships among calculated thermal structures, dehydrations from the subducting plate, and the interplate seismic events. We used observed heat flow data to constrain thermal structures.

As a result at 0 Ma, we found that interplate temperature where S-SSEs and LFEs occur beneath the Yaeyama islands is lower than that beneath the Okinawa island when compared with the same depth along the direction of the trench axis. This is mainly because the convergence rate (PHS-AM) becomes gradually fast toward the southwest. Therefore, interplate temperatures where S-SSEs and LFEs occur were estimated ranging from 500℃ to 700℃ both beneath the Okinawa island and the Yaeyama islands.

We also calculated water content distribution within the PHS plate, using the calculated thermal structures and the phase diagram of MORB in an oceanic crust (Omori et al., 2008) and ultramafic rock in a slab mantle (Hacker et al., 2003). As for dehydration of MORB, we found that epidote eclogite transforms into amphibole eclogite in the neighboring area where S-SSEs and LFEs occur beneath the Okinawa island, and amphibole eclogite transforms into eclogite beneath the Yaeyama islands. The former and the latter dehydrate a total amount of 1.4 wt% and 0.7 wt% associated with their phase transformations, respectively.

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