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Numerical simulations of temperature distributions associated with subduction of the Philippine Sea plate, southwest Japan

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Large megathrust earthquakes have occurred repeatedly along the Nankai Trough with recurrence interval of about 90 to 150 years, which have been caused by plate motion of the Philippine Sea (PHS) plate in the NW direction subducting beneath southwest Japan. Deep low-frequency earthquakes have occurred beneath Shikoku and the Kii Peninsula. These earthquakes that have occurred in the convergent plate boundary have close relation to thermal state produced by plate subduction. The PHS plate embraces the Shikoku Basin in its northern part. The Kinan seamount chain is located in the central part of the Shikoku Basin. This is the fossil ridge which had been spreading in the ENE-WSW direction. The fossil ridge and its surrounding region are subducing along the Nankai Trough, and the direction of the plate motion of the PHS plate is considered to be changed to the current direction at about 3 Ma (Takahashi, 2004). We constructed a 2-D thermal convection model to simulate temperature field associated with subduction of the PHS plate along the Nankai Trough. Then, we evaluated the reliability of the calculated temperature field, by comparing it with observed heat flow data. In this study, we constructed the numerical model, taking account of spatio-temporal change of the age of the PHS plate, kinematics of the past and present plate motion of the PHS plate, and the up-to-date shape of the upper surface of the PHS plate. We calculated temperature distribution and heat flow along three profiles passing through northern Kyushu, Shikoku, and the Kii Peninsula, and compared these results with the observed heat flow data. We used Hi-net heat flow data (Matsumoto, 2009) as well as borehole and heat probe (Tanaka et al., 2004) and BSR (Ashi et al., 1999, 2002) data. The calculated heat flow fits well with the observation for all the three profiles within the range of horizontal distance of about 100km landward from the trough axis. But the observation values increased gradually at about 100km, and decreased at more landward. On the other hand, the calculated results tended to decrease gradually toward just above the mantle wedge when we only considered the effect of plate subduction. To explain high heat flow values obtained by Hi-net, we took into account the effect of large-scale hot plume in our model, which was indicated by seismic tomography results. We also incorporated the effect of yield stress and thinner conductive continental plate into our model. The calculated results showed higher heat flow values with short wavelength, which was consistent with the observation. This suggests that high heat flow values observed by Hi-net may be explained by the existence of large-scale hot plume reaching shallow depths in addition to plate subduction.