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3D numerical modeling of thermal regime and mantle flow associated with subduction of the two oceanic plates

JI, Yingfeng[1*] ; YOSHIOKA, Shoichi[1]

[1]RCUSS, Kobe University, [2]Graduate School of Science, Kobe University

Based on a thermal convection model for an arbitrarily curved oceanic plate, we newly constructed a 3D model for subduction of two oceanic plates, and investigated its thermal regime and mantle flow. The 3D parallelepiped modeled domain for numerical simulations is a length of 840 km, a width of 840 km, and a depth of 300 km, with 72∗72∗72 grids, and the total calculation time up to 15 Myr. Geometry of one continental plate and two oceanic plates are prescribed in the simulation. The two oceanic plates subduct with prescribed velocities beneath the continental plate along neighboring two trenches, adjoining with a right angle. The upper oceanic plate and the lower oceanic plate contact each other at their intersection zone. Both of the oceanic plates are assumed to be 30 km in thickness. Giving boundary conditions of adiabatic and permeable walls, half-space cooling and rigid upper surface, and stratified initial temperature condition, we solved equations of mass conservation, momentum, and energy, using the finite difference method (FDM) and Finite Volume Method (FVM). In this study, the dynamical properties of the thermal regime associated with double subduction are investigated in detail. In our numerical simulation for the subducting two oceanic plates, the convergent rate of the upper oceanic plate should be paralleled to the intersection line of the two plates so as to reach a stable and sustainable subduction. Dip angles of the two oceanic plates, obliquity of the lower oceanic plate, and subduction velocity are assumed to be 10 deg, 0 deg ˜75 deg, and 5 cm/yr, respectively. As a result of numerical simulation, we found that there are remarkable low temperatures in the inter-slab zone due to subduction of the two cold oceanic plates. We also found that obliquity and relative directions of plate subduction velocities contribute to the obliquity of subduction-induced mantle flow convection adjacent to the two oceanic plates, and spiral mantle convection may be produced by the difference of the obliquity of two oceanic plates.

Keywords: thermal regime, plate tetonics, subduction, numerical simulation