Fluiddynamic representation of plate boundaries-Concept-

Yoshio Fukao[1], Mamiko Takaku[2]

[1] Earthq. Res. Inst., Univ. of Tokyo

IFREE/JAMSTEC, [2] Earthq. Res. Inst.,Univ.of Tokyo

[Introduction] Seismic tomography has been used to map density heterogeneity and to model mantle convection driven by it. The resultant convection models have been compared to the geoid, dynamic topography and heat flow distribution with success. A major difficulty in this approach is how to generate plate-like motions with equal energy partition of poloidal and toroidal components in a highly viscous surface layer. We propose a fluiddynamic representation of plate boundaries that may resolve this difficulty.

[Plate boundary representation] We first present a point source representation for the three elements of plate boundaries, ridge, trench and transform fault, in an incompressible, highly viscous fluid. We then show that a distribution of these point sources on a plane produces a velocity discontinuity across this plane that accompanies a shear stress change. Transform fault can be represented by along-strike velocity discontinuity across a vertical fault plane. Trench is represented by along-dip velocity discontinuity across a dipping fault plane. Ridge or symmetric trench is represented by along-dip velocity discontinuities across a pair of 45-deg dipping fault planes.

[Plate motion modeling] The surface high viscous layer is internally bounded by fault planes across which parallel velocity is discontinuous. Its top surface can slip freely. This lithospheric layer is chemically distinct from the underlying asthenospheric layer so that there is no vertical flow across their boundary except at ridges and trenches. Ridges and trenches are unique zones at which vertical flow is allowed and traction is continuous. We denote the convection system driven by velocity discontinuities across plate boundaries System I.

[Density-driven convection] The asthenospheric layer is laterally heterogeneous in density. We present a point source representation for excess (or deficient) mass by which convection is driven. The density heterogeneity can be represented by a volumetric distribution of these point sources. We denote the convection system driven by a density heterogeneity System II.

[Coupling of two convection systems] When a density heterogeneity is given in the asthenosphere, convection in System II is set up and the lithospheric layer is stressed. Convection in System II occurs in response to this stress change so that the resultant shear stresses on the fault planes (=plate boundaries) be minimized. imposition imposes stresses are. Strong coupling is expected to occur in this case between the two convection systems even if the viscosity contrast is very large so that the flow in the lithospheric layer is plate-motion like, involving a substantial amount of shearing flow along transform faults.