Fluiddynamic representation of plate boundaries-Numerical simulation-

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[Introduction] Following the idea outlined in the previous talk, a simple numerical modeling is made for the convection driven by velocity discontinuities in a two-dimensional ridge-trench system.

[Model] The lithosphere and asthenosphere are modeled as two incompressible, viscous fluid layers with a large viscosity contrast in two-dimensional space (Figure 1). Either ridge or symmetric trench is represented by along-dip velocity discontinuities across 45-deg dipping, conjugate fault planes. Ridges and trenches are alternatated regularly. Velocity discontinuities in a ridge are equal in amplitude and opposite in direction to those in a trench. Free slip condition is imposed on the top of the media. Horizontal velocity and shear traction are continuous across the lithosphere-asthenosphere boundary, where vertical velocity is zero except ridge and trench zones. In ridge and trench zones not only shear but also normal tractions are continuous across the lithosphere-asthenosphere boundary.

[Simulation results] Figure 2 shows an example of the results of the numerical simulation, where the values of the stream function are contoured. The flow pattern depends little on the viscosity ratio between the lithosphere and asthenosphere if it is greater than 100 and the figure shows the case of an infinitely large viscosity ratio. The ridge fault system pulls fluid in the asthenosphere into the lithospheric layer and changes the resultant vertical flow to horizontal flow. This horizontal flow is fast and remains horizontal between the ridge and trench. The trench fault system changes this horizontal flow to vertical flow and expels fluid in the lithosphere out to the asthenosphere. The counter flow in the asthenosphere is slow and spreads widely.

[Coupled convection] The above is the convection in System I. We are underway in simulating the convection driven by density heterogeneity in the asthenosphere (convection in System II). By superposing the convections in the two systems so that the resultant shear stresses on the plate boundaries be minimum, the plate-like flow in the lithospheric layer would by realized in response to the density-driven convection in the asthenosphere.

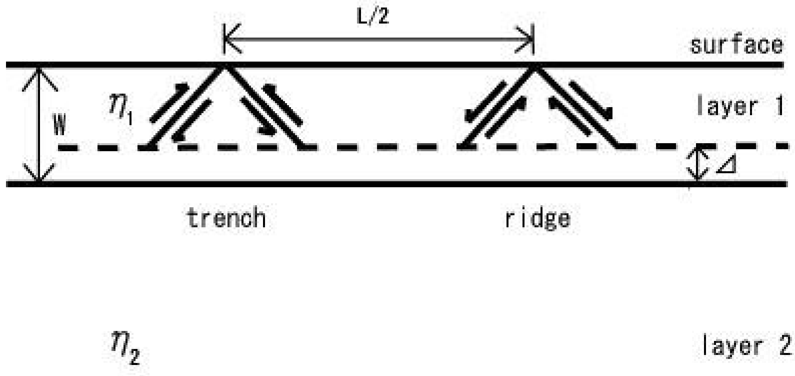

Figure 1. Trench & ridge system

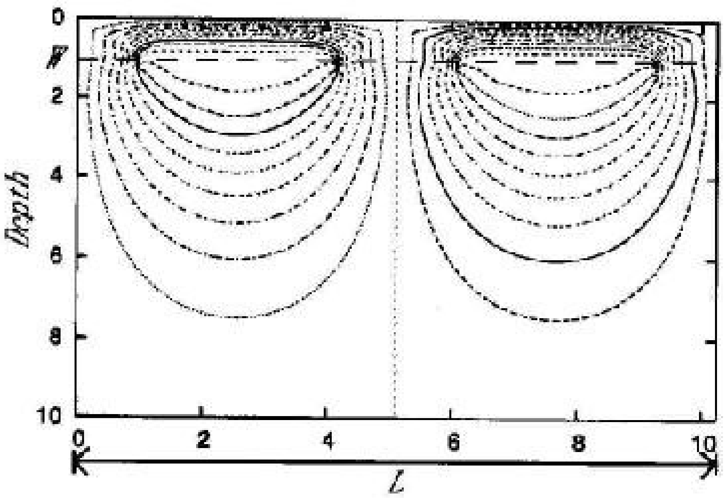

Figure 2. Stream function