Dg-P002 Room: Poster Time: June 11 11:00-13:00

Numerical Simulation of Plumes due to Plate Subduction at the Circum-Pacific Ocean and its Implications for Spherical Mantle Flow

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To investigate the effect of the lithosphere subduction along the circum-Pacific Ocean on the large-scale plume activity etc., we developed new programs with the finite difference method regarding 3-D spherical mantle convection. We carried out simulations with the initial condition of a cool ring at the base of the upper mantle along the equatorial great-circle in addition to the horizontally uniform thermal field. Our simulation result indicates that the major site of the large-scale upwelling is at the latitude of 30 to 40 deg., as a response function of the zonal down-flows due to the equatorial cool ring. Weak rising of the deep mantle material occurs at the polar regions. Our result may reveal one of the elementary large-scale mantle flow processes.

To make clear the basic and fundamental nature of mantle convection dynamics including unsteady large-scale plume activity, we must carry out numerical simulation with various initial and boundary conditions as well as constraints for rheology parameters such as viscosity and temperature, etc. Eguchi (1994) proposed a concept of 'cool mantle doughnut' (hereafter, CMD) with the great circle dimension, inferred from recent studies of the global seismic tomography and plate subduction history, etc. The CMD may involve the zone of major energy dissipation associated not only with the plate convergence but also with the global mantle downgoing flow. The CMD corresponds to a global-scale zone of relatively lower temperature zone than average, within the mantle layer behind subduction zones surrounding the Pacific Ocean. Subduction zone history study of Richards and Engebretson (1992) suggests that the lifetime of the currently existing CMD seems to be longer than 1 x 10**2 Ma. To study the mantle flow process associated with the CMD, we developed new codes for three-dimensional numerical simulations of the spherical mantle convection. The basic three equations are for the continuity, the motion with the Boussinesq (incompressible) approximation, and the (thermal) energy conservation. The simulation codes developed newly incorporate the temperature-dependent viscosity, etc. Our programs are based on the finite difference method. After checking the calculation accuracy of the programs, we carried out several simulations for modeling the mantle dynamics due to the CMD. For simplicity, we adopted a referential coordinate with the equatorial CMD. We, then, assumed the initial condition including a 'cool ring' at base of the upper mantle along the equatorial great-circle in addition to the horizontally uniform thermal field. The preliminary results show that large-scale zonal upwelling flows will be exited at the latitude of 30 to 40 deg., after a certain period, as a dynamic response of the equatorial lithosphere subduction. Our simulation result, however, constrains that the sites of the large-scale upwelling cannot directly reach the North and South poles, although we can recognize some obscure polar rising pattern. All results obtained show active, iso-latitudinal, zonal rings of the mantle upwelling. This implies that the simulation based on our initial condition is not sufficient to initiate the activity of upwelling mantle plumes at isolated localities. If we want to degenerate the zonal upwelling into several small-scale plume activities at the latitude of 30 to 40 deg., some additional dynamic source(s) at the low latitudes must be requested. Moreover, we must incorporate numerically the effect of unknown lateral flow dynamics at the lowermost mantle layer, i.e., D" layer. Numerical simulations with the additional dynamic origins, stated above, are all to be carried out in the future study.

References

Eguchi, T., Dynamics due to 'Cool Mantle Doughnut,' EOS, Am. Geophys. Union, 1994.

Richards, M. A., and D. C. Engebretson, Large-scale mantle convection and the history of subduction, Nature, 355, 437-440, 1992.