Preliminary study on formulation of a slab stagnation model unifying temperature, fluid, and kinetics

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I show preliminary formulation to unify thermal-fluid and thermo-kinetic coupled numerical models to reveal physical mechanism of slab stagnation around a depth of 660 km, which has been identified by seismic tomography. I developed the former in Yoshioka and Sanshadokoro (2002). Regarding the latter, I also developed its basic part in Yoshioka et al. (1997). I will modify the latter model, incorporating the latest results in high pressure and high temperature experiments such as the effect of water, and grain nucleation inside and along grain boundaries associated with phase transformations in a slab.

In this unified model, although I carry out thermal-fluid calculation in a conventional method, I calculate temperature distribution, taking account of latent heat release associated with phase transformations in a slab in the energy equation. From the temperature and pressure distributions, I calculate nucleation and growth rates of grains of high pressure phase of olivine based on its kinetics, and obtain grain sizes and degree of phase transformation. From the grain sizes, I estimate final grain size distributions after union of each grain associated with decrease in surface energy, using a grain growth law. In the portion dominated by diffusion creep, I calculate viscosity distribution in the slab from these grain sizes, and let it reflect in the momentum equation. I solve the coupled problems using the three basic equations as a time marching problem, by employing numerical methods such as finite difference method, ADI method, Runge-Kutta method, and DASPK method. Then, I develop a numerical model to calculate dynamic behavior of a slab in the mantle transition zone, temperature distribution in the slab, and viscosity distribution in the slab calculated from the grain sizes simultaneously.