Flows and light element distribution in the outer core associated with heterogeneous growth of the inner core of the Earth

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Recent seismological observations suggest longitudinal heterogeneity of seismological wave velocity of the inner core of the Earth, which stimulates a discussion that phase change at the inner core boundary (ICB) does not occur uniformly in the horizontal directions. It is simply supposed from this suggestion that temperature is lower and concentration of light element is higher just above the solidification hemisphere at ICB, and vice versa. The heterogeneous structure of the inner core and thermodynamic properties just above ICB in the outer core is expected to be correlated, however, more recent analysis shows that distribution of seismological wave velocity anomaly does not correspond to longitudinal heterogeneity of the inner core.

There are two kinds of mechanisms explaining heterogeneous growth of the inner core. One of the mechanisms is that the heterogeneous thermal condition at the core mantle boundary (CMB) drives horizontal thermal convection which induces non-uniform temperature distribution at ICB. However, since this study uses co-density, which combines density variations by temperature and light element concentration, it cannot find distribution of the light elements just above ICB. Another mechanism is that hydrodynamic instability of the inner core surrounded by the phase boundary causes translational motion inside the inner core. However, since the theory assumes homogeneous light element distribution in the outer core, it is not clear this mechanism can explain the light element distribution above ICB.

In this study, by using a rotating spherical shell model in which temperature and light element concentration are independent variables, we perform numerical experiments of thermal and compositional convection related to two kinds of mechanisms. Obtained distributions of light element concentration are compared with the distribution of seismological wave velocity anomaly, and plausible dynamical regimes of thermal and compositional convection in the outer core are discussed.

Keywords: Heterogeneity, Inner core, Core-mantle boundary

