Penetration of compositional convection into the upper stably stratified layer in the Earth's outer core

*Shin-ichi Takehiro[1], Youhei Sasaki[2]

1. Research Institute for Mathematical Sciences, Kyoto University, 2. Department of Mathematics, Kyoto University

It is suggested from high-pressure experiments and first principle calculations that the values of thermal conductivity under conditions of planetary cores are larger than those considered so far (Pozzo et al. 2012, 2014; Gomi et al. 2013). By using 1-dimensional thermal balance models with the updated values of thermal conductivity, generation and existence of stably stratified layer in the Earth's outer core is discussed (Gomi et al. 2013, Labrosse 2015). Their results show that a stable layer whose thickness of O(1000km) could be produced when the heat flux across the core-mantle boundary (CMB) is small.

They assume that the region with negative heat flux is stably stratified. This assumption seems to be appropriate when convection is driven only by thermal effects, however, it is not correct for compositional convection, which is driven by buoyancy of light elements released at the inner core boundary through freezing and growth of the inner core. When compositional convection is sufficiently vigorous enough to overcome thermally stable stratification, it would mix up the stable layer and would make it neutral.

We propose to use radial distribution of power induced by thermal and compositional buyancy (rate of kinetic energy production) as measure of occurence of thermal and compositional convection. The power consists of the terms proportional to heat flux and compositional flux. The region with positive power is considered that convection is active there because kinetic energy can be produced by buoyancy force. On the other hand, in the region with negative power convection is supressed and stably stratified layer may be produced.

We constructed a 1-dimensional thermal and compositional balance model of the Earth's core, and calculated radial distributions of power for various values of CMB heat flux Q_{cmb}. When $Q_{cmb} > 9.3$ TW, it is suggested that convection occurs in the whole outer core, however, a stable layer with O(100km) thickness could be produced below CMB when $Q_{cmb} < 4.8$ TW.

References

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