Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PPS21-33 会場:A02 時間:5 月 25 日 11:00-11:15

大質量スーパーアースのマントル対流の活発さと対流レジームダイアグラムについて
The vigor and the regime diagram of thermal convection in the mantle of massive super-Earths

宮腰 剛広 [1*] ; 亀山 真典 [2] ; 小河 正基 [3]
MIYAGOSHI, Takehiro[1*] ; KAMEYAMA, Masanori[2] ; OGAWA, Masaki[3]

[1] 海洋研究開発機構, [2] 愛媛大学, [3] 東京大学
[1]Jamstec, [2]Ehime University, [3]University of Tokyo

Understanding thermal convection in the mantle of super-Earths is a key to clarifying their thermal history and habitability. In massive super-Earths, the strong adiabatic compression influences thermal convection in the mantle in contrast to the Earth's one. In this paper, we present numerical models of thermal convection in massive (ten times the Earth's mass) super-Earths calculated at the relevant adiabatic compression effect and various values of Rayleigh number *Ra* and temperature-dependent viscosity contrast *r*.

Strong effects of adiabatic compression reduce hot plume activity significantly, while keeping cold plume activity high. The effects on hot plumes become more prominent as *r* increases, because the lithosphere becomes thicker as *r* increases and the potential temperature of the isothermal core increases. This results in decreasing difference of potential temperature between hot plumes and surround material, thus in decreasing buoyancy force of hot plumes.

We also studied the convective regime diagram on the plane of *Ra* and *r*. The threshold value of *r* for transition to the stagnant lid regime from small viscosity contrast regime increases as *Ra* increases in super-Earths in contrast to the diagram of the earlier Boussinesq model [*Kameyama and Ogawa*, 2000]. At high *Ra* relevant to massive super-Earths, the threshold value is larger than that expected in the Earth. To understand the reason why the threshold value of *r* increases as *Ra* increases, we present the viscosity contrast between the surface of the planet and the bottom of the lithosphere *reff*. In contrast to the increasing the threshold value of *r*, the *reff* is constant even the Rayleigh number increases. Thus, the *reff* is more relevant to transition to the stagnant lid regime rather than the viscosity contrast *r* in the whole mantle.

We also found that the Nusselt number *Nu*, which is the efficiency of heat transport by thermal convection, is considerably reduced compared with the earlier Boussinesq model. At $Ra=10^{10}$ and $r=10^{7}$, the *Nu* is only 2.7 and 14% of the value expected from the earlier Boussinesq model. The thickness of the lithosphere is about 30% of the depth of the whole mantle. From systematic numerical simulation, *Nu* is fitted as a function of *Ra* and *r*. The power index on *Ra* is 0.27. This value is somewhat smaller than that in the earlier Boussinesq model (0.31) [*Christensen*, 1984].

The thick lithosphere shown in our model implies that plate tectonics is difficult to operate in super-Earths. However, the high threshold value in *r* for regime change suggests that the lithosphere moves in a way different from plate tectonics. Thermal convection may be in the small viscosity contrast regime in super-Earths and the surface may be fully involved in the convective current.

Keywords: super-Earths, mantle, thermal convection, compressible fluid, stagnant lid, numerical simulations