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小さいコアを持つ球殻マントルでの対流パターン：粘性の温度依存性の影響
Flow patterns in spherical mantles with small size of core; the effect of temperature dependent viscosity

柳澤 孝寿 [1*] ; 小河 正基 [2] ; 亀山 真典 [3]
YANAGISAWA, Takatoshi[1*] ; OGAWA, Masaki[2] ; KAMEYAMA, Masanori[3]

[1] 海洋研究開発機構, [2] 東京大学大学院総合文化研究科, [3] 愛媛大学地球深部ダイナミックス研究センター
[1]Japan Agency for Marine-Earth Science and Technology, [2]Graduate School of Arts and Sciences, Univ. of Tokyo, [3]Geodynamic Research Center, Univ. of Ehime

Clarifying the effects of three-dimensional spherical geometry on mantle convection is a major issue of mantle dynamics in terrestrial planets. We study in detail the nature of thermal convection of a variable viscosity fluid in the basally heated spherical mantle of small planets with a small core, keeping in mind the application of our numerical models to the Moon. Spherical geometry affects mantle convection mildly when the ratio of the core-radius to the planetary radius r_{CMB} takes an Earth-like value of 0.55, while it is thought to affect strongly when r_{CMB} is small like Moon around 0.2. Here, we investigate the flow pattern systematically for r_{CMB} from 0.1 to 0.6 with small to large viscosity dependence on temperature. We first estimate the critical Rayleigh number Rc for the onset of convective motion at various r_{CMB} and the magnitude of temperature-dependence of viscosity by a linear perturbation analysis. Then, we study the convective flow pattern of thermal convection above Rc by numerical simulation. The result of our simulation is in good agreement with the linear analysis. The nature of convective flow pattern considerably changes as r_{CMB} smaller than about 0.4. The flow pattern has smaller number of up- and down-wellings. We established regime diagrams of convection pattern in relation to the Rayleigh number and the temperature dependence of viscosity, for various value of r_{CMB}. Stronger temperature dependence of viscosity is necessary for realizing the stagnant-lid regime of convection for smaller r_{CMB}. It is due to the relatively smaller volume of high temperature region near the CMB. The horizontally averaged temperature at mid mantle remains low despite the strong temperature variation of viscosity when r_{CMB} is small.

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