

## Flow patterns in spherical mantles with small size of core; the effect of temperature dependent viscosity

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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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