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# Some non-stationary processes in planet mantle

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## Abstract

By modern conception the terrestrial planets have shell structure. The planet rotation is differential. In result of this, the tangential stress occurs on the shell boundary and can results in sliding of theshells.
If it is some thermal heterogeneities in the core (on the boundary mantle-core), such sliding causes reconstruction of mantle convection (for example, shift of vertical boundary of the convection cell together with heat source).
The numerical experiment was made for imitation of such convection structure reconstruction. The preliminary results considers in this presentation.

## 1. Introduction

It is absolutely clear, that sharp tectonic changes on the surface of solid Earth, is not able without sharp changes of the condition of leaking the process of heat-and-mass transfer in the deep interior of Earth, and it is more probable such changes on the boundary of the layers. We assume, that these changes occur on the boundary mantle-core. On this boundary sometime it is occur the sharp changes of temperature and, probably, pressure distributions, and after that it is set in stabilization of the system condition, i.e. it begins again smoothly evolve.

For the present we do not set the question about a cause of such transition from one state to another. We interest, how was the system behavior, and for which parameters of system and velocities of heat source shifting its influence shows upon surface just only the final point of movement, i.e. we observes the jumping of the spreading axis from one position to another.

## 2. Model

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## 3. Numerical experiment

Below, you will find an example of an included figure. You should use the "Figure_caption" auto-formatting style for the caption. Calculation of the mantle convection for several variants of the value of source power $\mathbf{q}_{max}$ ($\mathbf{q}_{max} \approx 0.4$ and 0.2 Wt/m$^2$) and several velocity $\vec{\mathbf{c}}$ ($0.22 \cdot 10^{-8}, 0.55 \cdot 10^{-8}$, $1.1 \cdot 10^{-8}$ and $5.5 \cdot 10^{-8}$ m/sec) of its motion was made. The values, appeared in equation as parameters was chose as: $D = 29 \cdot 10^5$ m - (the mantle thickness), $k = 32 \cdot 10^{-3}$ Wt/(m·K) – coefficient of mantle heat conductivity, $\Delta T = 3700$ K – temperature difference on lower and upper mantle boundaries.

.Then $\frac{D^2}{k} = 26.28125 \cdot 10^{13}$,

$\frac{k}{D} = 1.1 \cdot 10^{-8}$, $\frac{k \Delta T}{D} = 40.82 \cdot 10^{-6}$.,

Two values of Rayleigh number $\mathbf{R_a} = 10000$ and $\mathbf{R_a} = 30000$ was used.

Heat exchange coefficient on the mantle-core boundary was taken equal $\lambda' = 10000$, or, in dimensional unit $\lambda = \frac{k\lambda'}{D} \approx 1.1 \cdot 10^{-4}$ Wt/(m·K).

The region of calculation size was equal L×H=10D×D=29000km×2900km.

The horizontal size of convectional cell changed subject to Rayleigh number $\mathbf{R_a}$ value. With $\mathbf{R_a} = 10000$ five cells locates jn calculated region, that is its averaged horizontal size is equal 5800 km, and with $\mathbf{R_a} = 30000$ - eight cells, that fits the averaged horizontal size of cell – 3625 km. By present estimation horizontal size of the convection cell actually equal roughly 2000 km., so, Rayleigh number must be larger.

The problem solved numerically by the finite-difference method. For solving of the difference heat conduction equation the scheme of variable direction was used, and for solving of the Poisson's equation the matrix screw die method was used.

It was received the patterns of the convection cells evolution, caused by heat source motion, for the different values of the Rayleigh number, source power and velocity of its motion.

Here we describe some of the obtained variants.

1-st variant ($\mathbf{R_a} = 10000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 0.22 \cdot 10^{-8}$ m/sec)

For such parameters the more heated upflow as if sticks to moving source and moves with it. Meanwhile the left cell expands, what supports by additional warming up from source (downstream stays on place). The right cell also expands, seemingly, at the expense of additional warming up (downstream moves to the right), but weakly than left. The remaining three right cell several narrows, remained meanwhile equal.

2-nd variant ($\mathbf{R_a} = 10000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 0.55 \cdot 10^{-8}$ m/sec)

For such velocity of movement and power of source, at first the source pulls upflow on itself, but then breaks off, having time just only a little widens left from it convection cell and a few narrows the right. Then it stops under the next upflow, and convection cell structure reverts as cooling down.

3-rd variant ($\mathbf{R_a} = 10000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 1.1 \cdot 10^{-8}$ m/sec)

For such velocity the pattern is more complex. Firstly upflow follows the source, expanding the left convection cell roughly on a third, and then the source draws out upflow and drives to the next one, on the path heating the lower layers of the right convective cell. Then history repeats itself already with the next pair of cells. Meanwhile all cells except rightmost one, for which does not stay place, and as a result we receive the structure with four convection cells.

4-th variant ($\mathbf{R_a} = 10000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 5.5 \cdot 10^{-8}$ m/sec)

For such parameters the source movement practically does not influence on the convection structure.

Consider now the situation with the Rayleigh number $\mathbf{R_a} = 30000$.

Here the situation is far complex. The reconstruction of convection structure provides to be far more significant. If for the Rayleigh number $\mathbf{R_a} = 10000$, the reconstruction of convection structure generally comes to the shift of upflow and downflow, and the quantity of convection cells staying invariable, for $\mathbf{R_a} = 30000$, it takes place the reconstruction with lessening of the number of convection cells. It, seemingly, connects with the larger structure instability and bios to appearing of turbulences.

5-th variant ($\mathbf{R_a} = 30000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 0.22 \cdot 10^{-8}$ m/sec)

For such parameters at the very beginning of the source movement it is going on warming up with the initiation of turbulence in the convective cells, adjacent to upflow, connecting with the heat source, caused the expanding of this cells. As a result the expanding cells absorb neighbouring with them upflow, and in convection structure it is stayed the five cells instead of the eight ones

6-th variant ($\mathbf{R_a} = 30000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 0.55 \cdot 10^{-8}$ m/sec)

For such velocity at first all goes on as in previous variant, then the heat source tries to ðull upflow on itself, but its head stays put that caused the deformation of upflow. Because of the additional warming up it is appearing the nucleus of additional upflow, i.e. it is strongly deforming its cell and heat distribution in it. The two cells, which experience the deformation, as a result occupy three-quarter of the reference area, caused the remaining three cells narrow. The upflow of the deformed cells oneself strongly shifts to the right.

7-th variant ($\mathbf{R_a} = 30000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 1.1 \cdot 10^{-8}$ m/sec)

For such velocity at first all goes on as in previous variant, and by the further movement it takes place the dividing of the group from two cells, which occurs the larger part of the reference area into two ones. At the result the second cell group, deforming (developing) consumes the rightmost cell and it stays the structure from four cells.

8-th variant ( $\mathbf{R_a} = 30000$, $q_{max} \approx 0.4$ Wt/m$^2$, $\vec{\mathbf{c}} = 5.5 \cdot 10^{-8}$ m/sec)

For such parameters the convective structure evolves similarly to preceding variant.