Geophysical Research Abstracts,
Vol. 11, EGU2009-9999, 2009
EGU General Assembly 2009

An overturn-cyclic regime of the thermochemical two-mantle evolution

V. Kotelkin (2) and L. Lobkovsky (1)

(2) Moscow State University, Moscow, Russian Federation (kotelkin55@mail.ru), (1) P.P. Shirshov Institute of Oceanology, RAS, Russia (llobkovsky@ocean.ru /Phone: +7(499)1245990)

Many researchers interpret seismic tomography data as indication of the whole-mantle convection, the pure thermal convection model being used as the basis. We suppose that in order to explain better the current seismic tomography pattern it is necessary to consider thermochemical model of mantle convection.The proposed thermochemical model takes into account a generation of light and heavy substances. Lately many authors considered mantle convection model with active markers of chemical origin. Unlike the above model in the proposed model light and heavy substances are generated during convection process. So, if the current temperature in the transition boundary layer D" exceeds the melting temperature, then the differentiation of material takes place and a light substance is generated. The core growth is controlled by this differentiation. Our model is includes the generation of heavy substance in subducting zones (at eclogitization depths, 80-100 km).

We use the Boussinesq approximation. The mantle material is assumed to be a noninertial isoviscous liquid, small inhomogeneities of density being due to thermal, chemical and phase transformation. A numerical realization of the model includes the finite difference approximation of the differential equations of the model on a regular grid of the Cartesian coordinates. In the calculations the spherical layer was enclosed in a cube with 257x257x257 nodes. The spatial dynamics of substance within a spherical layer is illustrated by video records.

The chemical light generation activates convection, and the convection activates chemical generation because it supplies a fresh material and a heat flow. Therefore, a thermal-chemical-convective resonance (nonlinear effect being absent in a purely thermal model) becomes possible. Numerical experiments give local jets (avalanches or plumes), in which only the central part of the jet is well pronounced. The backward motion of the material, compensating for the direct jet flow, spreads over the entire surrounding convective cell. In other words, an avalanche or a plume does not have own outer boundary, and its role is played by boundary of the surrounding convective cell. Thus, plume tectonics is incorporated into plate tectonics via common outer boundaries.

On the contrary, during slow convection, chemical processes slow down or, if the temperature is insufficient, stop altogether and thermal convection is maintained solely. So chemical processes lead to a nonlinear impulsive regime of convection, they significantly affect the intermittent pattern of mantle convection, facilitating the overcoming of the 670-km endothermic phase barrier. The numerical experiment shows that regional avalanches are observed with the frequency of the geological Bertrand cycles (175 Myr). This result explains the modern seismic tomography data.

The main result of our thermochemical modeling is the phenomena of mantle overturn. In case of critical density stratification between upper and lower mantle a new phenomena of self-organization of mantle convection was observed in numerical experiments which can be described as a one global mantle sink overturn flow (super-avalanche). As the result this single sink leads to closure of oceans and assembling of continents. The stabilization of sink positions explains the asymmetry of the Earth and fixed placement (opposite sinks) of the Pacific Ocean. The cyclicity of sink formation results in migration of oceans of the atlantic type and supercontinent constructions, it explains the Wilson cycles.

To reach critical stratification and realize the overturn-cyclic regime special condition of initial unstable equilibrium state of the mantle is necessary. Such initial state corresponds to new astrophysical data (Hf-W chronometry), i.e. the short time of hot planet accumulation. From the unstable initial state the mantle convection begins with power mantle overturn, and it repeats several times. A considerable time (650-900 Myr) is required to reach the critical mantle stratification. A global overturn is characterized by intense competition for the capture of material, which results in the formation of bilaterally accentuated boundaries of convection cells. This means that extended systems of collisional belts and mid-ocean ridges are formed and a long-lived convection structure accounting