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

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Now many researchers interpret the seismic tomography data as an indication of whole-mantle convection. This reason may be too believable of the pure thermal convection model. We are supposed that to explain the modern seismic tomography it's enough made the some chemical expansion of thermal mantle model. Our thermochemical model take's into account the generation of light and heavy substances. Last years many authors are considered convection with active markers of chemical origin. Underline that in our model light and heavy substances are generate (or not!) into modeling 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 are generate. The core growth is controlled by this differentiation. Our model is included the generation of heavy substance in subducting zones (at eclogitization depths, 80–100 km) although.

To see the physical essence of our thermochemical modeling process, we use the Boussinesq approximation. The mantle material is assumed to be a noninertial isoviscous liquid, whose small inhomogeneities of density are due to thermal, chemical and phase transformation. A numerical realization of the model included 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 activate convection, and the convection activate chemical generation because it's supply a fresh material and a heat flow. Therefore, a thermal-chemical-convective resonance (nonlinear effect absent in a purely thermal model) becomes possible. The numerical experiments give local jets (avalanches or plumes), in which only the central part of the jet is well pronounced. The backward motion of material, compensating for the direct jet flow, is spread 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 the 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 leads 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 a frequency the geological Bertrand cycles (175 Myr). This result well explains the modern seismic tomography data.

The main result of our thermochemical modeling is the phenomena of mantle overturn. In the case of critically density stratification between upper and lower mantle in numerical experiments is observed the new phenomena of self-organization an overturn flow into a structure with one global-mantle sink (superavalanche). As a result this single sink leads to the closure of oceans and the assembling of continents. The stabilization of sinks position explains the Earth's asymmetry and fixed placement (opposite sinks) of Pacific Ocean. The cyclicity of sinks formations results migration of oceans of atlantic type and supercontinent constructions, it's explains well the Wilson cycles.

To reach critical stratification and realize the overturn-cyclic regime in practice is necessary a special conditions. In our experiment it's due the initial unstable equilibrium state of the mantle. Such initial state corresponds well a new astrophysical data (Hf–W chronometry) the short time of the hot planets accumulation about. From the unstable initial state the mantle convection begins with power mantle overturn, and it repeats then several times. A considerable time (650-900 Myr) is required to reach the critically mantle stratification. A global overturn is characterized an intensely 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 form and a long-lived convection structure accounting for the functioning of plate tectonics arises. The mantle cooling leads to fragmentation of global overturns into regional avalanches.