Geophysical Research Abstracts, Vol. 8, 04299, 2006
SRef-ID: 1607-7962/gra/EGU06-A-04299

Three-dimensional numerical analysis of geodynamic evolution of the Earth based on a thermochemical model of mantle convection

V. Kotelkin (1), **L. Lobkovsky** (2)

(1) Mechanical-Mathematical Faculty of the Moscow State University, Russia (kotelkin@mech.math.msu.su /Phone: +7(495)9393949), (2) P.P. Shirshov Institute of Oceanology, RAS, Russia (llobkovsky@geo.sio.rssi.ru /Phone: +7(495)1245990)

Evolution of the Earth mantle from a hot initial state is modeled in the Boussinesq approximation within the framework of a thermochemical model. Our approach is a synthesizing development of the well-known investigations of mantle convection: ˜ the generation of lighter mantle material at the core/mantle boundary in the D" layer due to melting with a rise in temperature and the descent of molten iron-bearing components of mantle material into the core; ˜ the important role of the heavy eclogitic fraction forming near at the outer crust/mantle boundary; ˜ the intermittent convection pattern due to the endothermic phase transition at the 670-km upper/lower mantle boundary (Machetel and Weber, 1991). A basically new result of the numerical modeling is that convection developing from an unstable hot initial state gives rise to global mantle overturns decaying with cooling material and remarkably correlating with data of historical geology on Wilson cycles. The spatial dynamics of substance within a spherical layer is illustrated by video records. The geodynamic process starting from an unstable initial state attains a nearly cubic pattern of whole-mantle convection with vigorous hot plumes rising from interiors of the planet toward the surface and with eight heavy avalanches penetrating the mantle at triple junctions of convective cells: this is the first overturn in the Earth's history. At this stage, the velocity reaches its maximum value (40 cm/yr) and the layer rapidly assumes a stable state. This stage is followed by an epoch of slow small-scale Archean evolution. At a time moment when critical thermochemical partitioning between the upper and lower mantle is attained, the motion is dramatically reorganized, giving rise to a well-pronounced post-Archean mantle overturn that involves one descending flow in the region of the equatorial plane

two ascending superplumes at the poles. The post-Archean overturn (the second in the history of the Earth) forms a qualitatively different, global system of rare collisional belts; i.e. large lithospheric plates form on the planet. A new mantle overturn develops 700 Myr later; this time, a funnel-shaped sink of heavy upper mantle material forms in another place of the equator and a powerful superplume (along with the polar superplumes) is observed in contrast to a few isolated plumes in the part of the layer opposite to the sink. Thus, this overturn leads to the opening of three oceans and a reorganization of the system of outer collisional belts. The fourth and fifth overturns display qualitatively similar evolutionary patterns, but a concentrated funnel-shaped sink is displaced from the equatorial plane and video record displays more adequately vast horizontal movements of material and the reorganization of the plate system in the lithospheric shell of the planet. It is clear that the energy of such powerful global phenomena as overturns is sufficient for assembling supercontinents and opening oceans, making the appearance of the planet asymmetric; and contrariwise, it is difficult to find other mechanisms of such transformations. Thus, the numerical experiment presented in this work provides the best explanation of the Wilson cycles. In practice, an important factor prerequisite for this phenomenon to occur is a concentrated primary impetus that can ensure an unstable post-accretionary state of the planet. Within the framework of our model, it is also natural to assume that the Bertrand cycles (170Myr) are controlled by the differentiation of mantle material at the boundary of the iron core and the Stille cycles (35Myr) (Khain, 2000) are controlled by the chemical partitioning of the mantle at its boundary with the crust and the subsequent eclogitization of mantle material.