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Thermochemical differentiation and intermittent convection of the Earth's mantle

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The numerical experiments are based on the thermochemical model of mantle convection. The model includes the description of the endothermic phase transition at the upper/lower mantle boundary. The aim of this work is the influence of thermochemical processes on mantle convection. As regards the thermochemical differentiation takes place near the mantle boundaries. The differentiation in the D" layer is due to melting with the rise in temperature and the descent of molten iron-bearing components of mantle material into the core. This process generates the lighter fraction, particularly produces the lower mantle plums. It takes place only if the current temperature exceeds the melting temperature. The differentiation near the outer mantle boundary is due to extracting the lighter mantle components into the crust. These thermochemical processes take place when the hot substance is lifting and the pressure falls. The growth of the continental crust on the outer surface is modeling. The oceanic crust returns into mantle throw the subducting zones. The modeling includes the "gabbro-eclogite" transition of oceanic crust. As regards the generation of heavy eclogitic material is located at the depths 80–100 km. Seismic tomography of deep mantle layers showed that the mantle really contains large inclusions of heavy, supposedly eclogitic material.

The numerical experiments give a strong nonlinear interaction (either accelerating or slowing down) between the thermochemical processes and mantle convection. It leads to an impulsive character of geodynamics and promotes the formation of different cycles in the evolutionary process. Periods of gradual evolution are interrupted by the geodynamic activity outbursts. These peaks of geodynamic activity play a key role in the geological history of the Earth.

Analogous oscillations of geodynamic process produce interaction heavy and light density inhomogeneities with the endothermic phase transition. When convection is layered then the heavy substance is accumulate above and the light substance below phase boundary. In this situation the chemical inhomogeneities help thermal buoyancy to overcome phase barrier. As a result, avalanches become more numerous in the thermochemical case. Due to plum and avalanche events the mantle became a stable: the cold eclogite substance is situated at the bottom and the hot light substance floats at the top of mantle. Such density distribution brakes thermal convection. In this moment the endothermic phase barrier causes a switch again to layered convective regime.

The differentiation processes significantly affect the intermittent pattern of mantle convection. The modeling results have a good correlations with geological and geochemical data concerning different cycles of evolution, as well as seismic tomography of the Earth's mantle.