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Thermochemical Model of Geodynamical Evolution

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Differentiation in the transitional zone D" at the mantle-core interface leads to transition of metallic components from the mantle into the core and to formation of a light fraction in the mantle. Additionally, the eclogite-alteration effect of the downwelling oceanic crust in subduction zones has been taken into consideration, because it determines the appearance of a heavy fraction in the mantle. The model has taken the origin and drift of light crustal substance, which forms with differentiation of upwelling hot substance, into consideration. The cause of mantle layering in our model is restricted by the combined action of the phase transition, chemical heterogeneities, and surges in density and viscosity at this interface.

Thermochemical convection differs for its nonlinear character, which causes pulsed surges of geodynamical activity. Plumes, thin rapid streams of thermochemical nature, which parasitize on large convective cells, are logically explained by this. Plume tectonics is incorporated into plate tectonics in such a way that the constantly acting plate tectonics dominates in the geodynamical process, but plume tectonics comes to the forefront in the periods of chemical activity. Heavy and light chemical heterogeneities help convection to penetrate the complex barrier at 670 km depth episodically. Therefore, avalanches and plumes in the thermochemical model occur regularly and these events determine Bertrand geological cycles and explain the data of seismotomography.

According to the new astrophysical and cosmochemical data, the hot equilibrium instable initial state of rest has been chosen for modeling. Thence, a cubic form convection emerges, an abrupt mantle overturn into a stable state occurs, and a long (Archean) epoch of two-level convection is settled. Formation of six eocratons – thick shields of the ancient continental crust – is a direct consequence of cubic convection.

In the case of separated convection, the upper mantle cools faster than the lower one and instability starts to accumulate in the two-layer mantle. When a critical level is attained, thermochemical convection self-organizes during the consequent penetration: a collective common-mantle downwelling is formed in the place of penetration, and transport of lower mantle material into the upper one is implemented via 3-5 superplumes. Resulting in an overturn, the two-layer mantle restores its stable state and a new Wilson cycle starts. Numerical modeling has shown that, in such a model and at certain conditions, there is a possibility for occurrence of several global mantle overturns.

Two regularities have been found: (1) location of collective downwelling stabilizes, (2) branches of upwelling superplume streams move away from downwelling, making the configuration of the overturned dipole. These properties of thermochemical convection explain the supercontinental and oceanic histories of the Earth and the planet's asymmetry. After two Wilson cycles, the common-mantle downwelling, which determines pulsing behavior of the Atlantic type oceans and build-up of supercontinents, acts in one (continental) hemisphere, while light superplumes pulse in another (oceanic) hemisphere and form the basin of the Pacific Ocean. The pulsed character of convection determines step-by-step evolution observed by geochemists.

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