Pumir A.*, Barelko V.V.** Auto-wave theory of catastrophically rapid transformations of metastable phases in solids: a new approach to deciphering of the mechanism of geotectonic events and earthquakes

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In the present study, we attempted to create a bifurcation theoretical model for description of the mechanisms of exiting and dynamics of temporal and spatial development of geotectonic processes and earthquakes. The basis for the model is "gas-free detonation" and ultrasonic rates of transition processes, worked out in [1] for explanation of rapid decay of metastable phase states in solids.

The proposed approach is based on the hypothesis, which implies that geotectonic processes and earthquakes are a result of catastrophic explosion-like phase transformations in metastable crustal rocks. The classic theory of polymorphism describes numerous metastable states existing in the Earth's crust. However, it does not solve a problem on a dynamics and dynamic mechanisms of the decay of such states.

The considered non-linear model admits an existence of a relation between transformation of an initial phase and mechanical characteristics of a reactional solid media, as well as a role of self-destruction of this media as a factor of exiting of the metastable phase decay. The metastable state exists stably until its continuity is disturbed, until a local destruction. Fresh surface of destruction is a non-equilibrium media with high activity, where existed states form (radicals, ions, ionic complexes), emission of charges and radiation occur. These facts compose a basis for the classical mechanochemistry (tribochemistry) [2], where phase transformations are the results of artificial "griding" (dispersing). In the considered mechanism, the tribochemical effect occurs in the regime of dispersing, which forms a running and self-supporting front of decay of the metastable state of solid matrix, i.e. a running front of its re-crystallization. A source of a necessary mechanical influence is a difference of densities of the initial solid compound and the product of its transformation. That is a reason for appearance in the wave front of the destroying hit against the non-reacted compound. The qualitative scheme of the process allowed creation of a mathematical model by means of introduction of the solidity threshold (the transformation proceeds at overcome of this parameter), a functional dependence of the elastic modulus of the solid matrix on the degree of transformation, and an autocatalytic (branch-chained) scheme of the transformation.

Analytical and numerical investigation of the proposed scheme is carried out. The temporal and spatial regularities of the development of the catastrophic decay of metastable phases are established. A consistency of the model with the explosion-like transformations of metastable amorphous semi-conductive matrixes (Si, SiO_2, Ge) [3] is shown. These transformations can be considered as laboratorial model for the crustal processes. It is found that at some parameters, the above auto-wave transformations can proceed in the dynamical regime of super-sonic rates, i.e. in the catastrophic regimes of the "gas-free detonation". Within the model, we consider mechanisms of earthquakes as a response to local mechanical disturbance in rocks.

A problem of the laboratorial modeling of earthquakes by example of super-rapid decay of metastable silicate glasses, chemical analogies of crustal rocks (explosions "Prince Ruppert Drops" [4] and "Tempered Glasses" [5]), is regarded.

An analysis of published data concerning to mechanisms and dynamics of geotectonic events showed that there were some studies [6, 7], which considered hypotheses close to the above model [1, 8].

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