Abstract

Application of multivariate statistical methods for analysis of thermomechanical numerical models of diapirism

Most of the thermo-mechanical processes, that are associated with the geodynamic evolution of the lithosphere, can be derived from the laws of conservation of mass, momentum and energy in a continuous conception of space. The study of such dynamical systems reveals their strong sensitivity to variation of the initial conditions.

For testing the applicability of multivariate statistics in analyzing the influence of the initial conditions, two independent 2D thermo-mechanical multilayer numerical models of crustal diapirism of the Moldanubiam zone were created. The diapirism in central part of Moldanubian zone is characterized by exhumation of HP-HT granulites during the Variscan orogeny (Lexa et al., 2011) which is influenced by density contrast of the middle mafic and lower felsic crust, the ratio of the amount mafic and felsic material, radiogenic heat productivity of the felsic lower crust and shape of the interface of this two layers.

The initial setup of this models reflects the situation in future central part of the Bohemian Massif after subduction of the Saxothuringian continental crust and after redistribution of felsic material beneath a base of a lower-crustal area of the Moldanubian zone (after model of Schulmann et al., 2009). Both model domains have the same lithological structure representing the unified upper and middle felsic crust, mafic middle and felsic lower crust.

The first model tests the impact of changes in values of amplification of mafic middle and felsic lower crust interface, thickness of felsic lower crust and radiogenic heat productivity of felsic lower crust on the overall evolution of the model domain and various parts of the diapir body and mafic middle crust. The second model has only different variational parameters that represent the density of mafic middle crust, the density of felsic lower crust and the radiogenic heat productivity of the felsic lower crust.

The evolution process of most simulations of both models, which are characterized by higher exhumation rate and material deformation, can be characterized by the following development: 1) initial redistribution of felsic material into future core of diapir body, 2) the initial rapid heating of the lower crust, 3) exhumation of felsic material and formation of diapir body; 4) decreasing of exhumation rate and relamination of felsic material in unified upper-middle crust.

For comparison of all simulations of both models two classes of output model parameters were created. The first parameter type combines the P-T conditions in key areas of the model domain and the extent and rate of displacement of material segment in the same areas. The second parameter type characterizes the model domain from a global perspective, based on the average values of temperature and strain rate in the model domain at the moment of highest global deformation rate. Other global parameters represent rate and time of felsic material transfer during the exhumation.

By applying multivariate statistics on the output model parameters it was found that the highest importance to change the dynamics of the model can be attributed to a variation of felsic lower crust thickness and density contrast of both basal layers. Conversely, the lowest significance can be attributed to amplify of mafic and felsic crust interface. Radiogenic heat productivity is proving to be an important factor, however, becomes secondary in the context of increasing values of the density contrast. Weight of increase of radiogenic heat productivity lies in the increase temperature-pressure differences in simulations with variable felsic crust thickness and increase felsic material exhumation rate in simulations with variable density contrast of the basal crustal layers.

Keywords: numerical model, diapirism, initial conditions, multivariate statistics