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Numerical model of a collisional orogen: Application to the Bohemian Massif

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Although the modern orogens have been intensely studied by means of geological and geophysical (gravity, seismic and magnetotelluric) methods, their internal structure and dynamics are still uncertain, as the geological observation is limited due to preservation of a rigid crustal lid (the Tibetan plateau in Himalaya, the Altiplano plateau in Andes), and geophysical methods provide only indirect information. During the final stage of the evolution of an orogen, the crustal lid is disrupted and eroded, and the interior of the former orogenic root is exposed at the surface. The internal structure of the modern orogens thus can be studied on their analogues among ancient orogens. An example of a well preserved ancient orogen is the Bohemian Massif that was consolided during the Variscan orogeny and since then has undergone only minor changes. Combined structural and petrological studies of the Bohemian Massif revealed that its orogenic lower crust (high-pressure granulites and mafic eclogites in the Moldanubian domain) was vertically extruded from depths of about 60 kilometers along the steep margin of the promontory of the Brunia basement. The resulting vertical fabrics were then reworked by flat fabrics, that can be interpreted as a result of a (sub)horizontal flow in a channel between the upper boundary of the basement promontory and the overlying orogenic lid.
We present a thermomechanical model of a collision of two continental blocks which leads to a growth of orogenic root and subsequent indentation of this root by a stiff basement promontory. The modeling is performed using the open source finite element software for multiphysical problems Elmer which we extended for this purpose by procedures for compositional convection, visco-plastic deformation of crustal materials, surface processes (erosion and sedimentation) and flexural isostatic compensation. The modeling is carried out in a two-dimensional Cartesian domain representing a vertical cross section through an orogenic root and a stiff indentor. The initial stratification of the model domain and the rheological properties of individual layers correspond to the expected composition of the Brunia basement and the Moldanubian domain prior to the thickening and indentation process at the end of the Variscan orogeny. We test the hypothesis that a felsic lower crust rich in radiogenic elements was emplaced beneath the previously thinned crust of the Moldanubian domain during the initial stage of the continental collision [1]. These rocks now belong to the high-grade Gföhl unit in the Moldanubian domain and they can also be observed in gravity and seismic data [2, 3]. The models that include the felsic lower crust reproduce the processes inferred from the geological record in the studied region: crustal scale folding, vertical extrusion of the orogenic lower crust, channel flow and flat deformation of the exhumed rocks. The surface heat flow and Bouguer anomaly computed for our model are comparable to those of active orogens.

References
[1] Lexa, O., Schulmann, K., Janoušek, V., Štípská, P., Guy, A., Racek, M. (2011). Heat sources and trigger mechanisms of exhumation of HP granulites in Variscan orogenic root, Journal of Metamorphic Geology, 29, 1, 79-102.
[2] Guy, A., Edel, J.-B., Schulmann, K., Tomek, Č., Lexa, O. (2011). A geophysical model of the

Variscan orogenic root (Bohemian Massif): Implications for modern collisional orogens. Lithos, 124, 144–157
[3] Růžek B., Hrubcová P., Novotný M., Špičák A., Karousová O. (2007). Inversion of travel times obtained during active seismic refraction experiments CELEBRATION 2000, ALP 2002 and SUDETES 2003. Studia Geophysica et Geodaetica, 51, 141-164.