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Numerical model of continental collision: comparison between Variscan (Bohemian Massif) and modern (Himalayan) orogeny

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Internal structure and dynamics of modern orogens are still uncertain, because geophysical methods provide only indirect information and geological observation is limited due to preservation of a rigid crustal lid. In contrast to this, the internal structure of ancient orogens can be directly studied at the surface, as the crustal lid is eroded during the final stage of an orogeny. An example of a well preserved ancient orogen is the Bohemian Massif consolided during the Variscan orogeny. For this orogen, a scenario of tectonic evolution has been established involving crustal thickening and growth of a topographic plateau, vertical extrusion of lower crust (in the Moldanubian domain) and subsequent subhorizontal channel flow above an inclined margin of a continental promontory. The Variscan orogeny was in spatial and time extent similar to the Himalayan orogeny and detailed comparison between the two systems shows further analogies in metamorphism, geometry of collisional process, and felsic middle/lower crustal composition which has been proposed in some regions.

We present results of 2D numerical modeling of continental collision, which we performed using the FE software Elmer (www.csc.fi/english/pages/elmer). For this purpose, we extended the software by procedures for compositional convection, visco-plastic deformation, erosion, sedimentation and flexural isostasy. The model well reproduces the main geological observables for the continental collision in the Bohemian Massif: Timing of the exhumation of the lower crust and related pressure-temperature paths, the subhorizontal flow, and topography evolution and sedimentation. The salient feature of the model is presence of the felsic heat-productive lower crust in the Moldanubian block. Not all sets of model parameters lead to efficient extrusion of the rocks to the surface. For the development of the subhorizontal flow, focusing effect of erosion is essential. Applied slope-dependent erosion focuses the flow to the steep front of the orogen while erosion at the orogenic plateau is small.

We then compare Bouguer anomaly and surface heat flow in our model with those measured for active orogens. The gravity anomaly in the model is built up progressively during crustal thickening and vertical mass transfer stages and remains stable during the subhorizontal flow stage. The anomaly has a similar shape but somewhat smaller magnitude (about -350 mGal) than the one of the Himalayan orogen. The heat flow grows during the building of the plateau up to about 90 mW/m^2, and evolves into a narrow positive anomaly above the front of the orogen during subhorizontal extrusion of rocks to the surface.