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How to build mountain belts at passive continental margins? - insights from numerical and analytical modelling.

Boris J.P. Kaus (1), Clare Steedman (2), Thorsten W. Becker
(1) Geophysical Fluid Dynamics, Institute of Geophysics, ETH Zurich, Switzerland (kaus@erdw.ethz.ch), (2) University of Southern California, Los Angeles, USA

Deformation patterns resulting from subduction of a passive continental margin are insufficiently understood. Here we perform 2-D numerical simulations to explore the effects of continental lithosphere entering a subduction zone. The model setup consists of a subduction zone in which the oceanic part of a passive continental margin initially subducts beneath an oceanic plate. A particle-based 2-D visco-elasto-plastic thermo-mechanical finite element code (SloMo) is employed to study the dynamics of the system. A novel feature of the code is that it allows to study both mantle-scale and surface-near processes (including free-surface effects and erosion) simultaneously. In the present study, this feature is employed to study how crustal scale processes around the subduction zone are influenced by surface processes and by flow in the upper mantle. We are particularly interested in understanding whether subduction and following collision of the passive continental margin can create small-scale (few hundred km wide) mountain belts.

Initial results indicate that such belts may indeed form if a weak lower continental crust is present. Erosion greatly localizes the deformation in the belt once it has been formed. Slab break-off, on the other hand, does not result in a small mountain-range but rather in a broad region of isostatic uplift. Moreover, mantle flow patterns are very similar even if the crustal deformation is different. This suggests that there is only a moderate coupling between mantle and crustal-scale processes.

In order to obtain additional insight in the physics of this mountain-building process, we derive analytical solutions for a simplified system consisting of a multilayered lithosphere with depth-dependent properties in the presence of erosion. The relative strength contrast between upper and lower crust is the key parameter that controls the modes of deformation. Numerical simulations are in reasonable agreement with the analytical predictions.