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The role of extensional inheritance and surface processes on mountain belt evolution

Erdos, Z.[1], Huismans, R.S.[1]
[1]Department of Earth Science, Bergen University, Bergen, Norway

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The crustal structure of collisional orogens around the world shows a wide range of deformation styles from narrow, asymmetric doubly vergent wedges like the Pyrenees to wide, plateau-like orogens such as the Zagros mountain belt in Iran. Inherited structures and surface processes are widely regarded as factors playing a significant role in the evolution of such mountain belts. These parameters have been studied extensively throughout the last decades, yet questions still remain about their exact effects on the style of orogenic development.

We use lithospheric scale plane-strain thermo-mechanical model experiments to study the effects of extensional inheritance and surface processes on the internal structure of contractional orogens and their foreland basins. Extensional inheritance is modelled explicitly by forward modelling the formation of a rift basin before reversing the velocity boundary conditions to model its inversion. Surface processes are modelled through the combination of a simple sedimentation algorithm, where all negative topography is filled up to a prescribed reference level, and an elevation-dependent erosion model. We test the sensitivity of our models to the amount of crustal extension, and to the length of post-rift thermal relaxation. Moreover, the interaction of thin-skinned and thick-skinned tectonics is explored with the use of a shallow frictionally weak detachment at the base of a pre-deformation sedimentary layer.

Our results show that extensional inheritance facilitates the propagation of basement deformation in the retro-wedge and increases the width of the orogen. Additionally, sedimentation increases the length-scale of both thin-skinned and thick-skinned thrust sheets and results in a wider orogen while erosion helps to localize deformation resulting in a narrower orogen. However, the length of post-rift thermal relaxation seems to have very little effect on the following mountain building.

A comparison of modelled behaviours to the High Atlas, the Pyrenees and the Central Alps, three extensively studied natural examples characterized by different stages of inversion, is presented to support the predicted controls of surface processes and extensional inheritance on orogenic structure.