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The effects of increased sedimentation on orogenic wedges – dynamic model results in comparison with critical taper theory

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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 Himalayas. In addition to rheological properties and the amount of crustal shortening, 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 two-dimensional thermo-mechanical models to investigate the potential role of rapidly changing sedimentation rate on the development of orogenic foreland fold-and-thrust belts. The evolution scenario explored here is common in orogenic foreland basins; hence our results have broad implications for orogenic belts such as the Western Alps.

Our model results indicate that an increase in sedimentation rate will temporarily disrupt the formation of an otherwise regular, outward-propagating basement thrust-sheet sequence. The basement thrust active at the time of a sudden increase in sedimentation rate remains active for a longer time and accommodates more shortening than the previous thrusts. As the propagation of deformation into the foreland fold-and-thrust belt is strongly connected to the basement deformation, this transient phase appears as a period of slow migration of the distal edge of foreland deformation.

We explain our findings in terms of minimum work theory and quantitatively compare our results to critical taper theory considerations. Moreover, we present a qualitative comparison of our results with the Western Alps and its northern foreland fold-and-thrust belt.