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Influence of erosion and sedimentation on the kinematics of thrust belts: results from sandbox simulations

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The interactions between tectonics and surface processes like erosion and sedimentation modify the morphology and the internal structure of the orogenic wedges. To understand the complex mechanics of wedge evolution, we performed a series of analogue modelling experiments. This approach allowed us to quantify dynamically the impact of surface processes on the evolution of the wedge, taking into account the regional structure and rheological behaviour of the upper crust units.

The development of the accretionary orogen simulated in a sandbox device is based on a basic geometry of a subduction zone using a classical model Coulomb wedge. Erosion is done to keep the mechanical equilibrium of the wedge. We apply contrasted rates of sedimentation to compare caricatural responses of the orogen. Due to shortening, a homogeneous orogenic lid overrides on a basal thrust the subducting plate formed by basement units pre-structured by inherited weak levels and their sedimentary cover. Two major types of mechanisms play simultaneously in the models: frontal accretion in the external parts leading to the development of a foreland thrust belt and underplating in the internal zones leading to the formation of an anticlinal nappe stack. The exhumation of the basement units may isolate the frontal part of the lid forming a tectonic klippe.

A detailed analysis shows the progression of both the active thrust front and the orogenic lid front. The lid front moves passively and regularly while the active front is very mobile and propagates by “jumps” over long distances. We also measured the eroded and sedimented volumes and linked the changes in rates to the activity of the

thrust front.

Variations in amounts of sedimentation lead to major structural differences. A high sedimentation is expressed by few slices intensively retrothrust and active for a long time, while little sedimentation favours the creation of a number of small slices briefly active. Similarly, a high rate of sedimentation inhibits the underplating and the exhumation of basement units.

Our analogue model highlights the importance of the sedimentation and erosion rates on the evolution of a mountain belt. The interactions between surface processes and tectonics govern the geometry and the dynamics of the orogen and the evolution of the foreland. We will compare our experiments to the Alpine orogen evolution. We will discuss our structural model evolution in comparison with the development of Western Alpine units, i.e. from north to south: Jura, Molasse basin, Prealpes klippen, crystalline massifs and Penninic.