Summary

The tectonic evolution of orogenic belts, such as the Alps, is described using the orogenic wedge model. First models where made using sands and thus assume that rocks deformed in a brittle-frictional behaviour. More recent studies use numerical models to quantify rock deformation and wedge formation. However these numerical models are often simplified (e.g. elasticity is neglected) or strain localization is not physics-controlled but predefined by, for example, strain softening algorithms.

In this thesis, we want to model and understand the mechanisms involved in strain localization leading to the formation of an orogenic wedge during lithospheric shortening. Orogenic wedges are characterised by *i*) their shape, *ii*) the presence of a first order basal shear zone, *iii*) a sequence of second order shear zones in the upper crust, *iv*) the distance between second order shear zones, *v*) the time of activity of the different shear zones, *vi*) the relative displacement induced by the shear zones and *vii*) the thickness of the shear zone. To achieve our goal, we use a 2D numerical model based on the finite element method. The model considers viscoelastoplastic deformation and thermo-mechanical feedback.

The thesis is divided into 3 chapters written as scientific publications together with a general introduction and conclusion. In *Chapter* 2, we investigate the effect of the elasticity on a lithosphere under compression. Indeed, most numerical models use a viscous rheology and by definition do not consider elasticity. However, when using thermo-mechanical modelling, we show that elasticity plays a fundamental role as it allows for storing a fraction of the mechanical work as elastic energy which can then be released locally during strain localization. In *Chapter* 3, we demonstrate that a basic thermo-mechanical model captures the spontaneous formation of an orogenic wedge. Moreover, basic characteristics of a wedge, such as distance between shear zones or time of activity of the shear zones, are analysed. In *Chapter* 4, we focus on the evolution of the shear zones and their physical parameters such as temperature, stresses or strain rate.

The wedge characteristics mentioned above are all generated in our numerical model. We are able to reproduce the general shape of single-vergent and doubly vergent orogenic wedges as well as their first order structures such as the main basal shear zone and the sequence of upper crustal shear zones. Data of temperature, stresses and strain rates agree with field data. Spacing between second order shear zones are on the order of 50 km and the time of activity of the shear zones is typically between 2 and 5 My. Modelled spacing and timing agree with estimates from field data. Moreover, the shear zones thickness is of the order of ~ 5 km and nappes forming in the wedge show displacements of 40-100 km. Modelled thickness and displacement also agree with observations in orogens such as the Alps.