

Decollement controls on pro versus retro wedge deformation in mountain belts

Arjan Groot (1,2), Ritske S. Huisman (2), and Mary Ford ()

(1) CRPG, Université de Lorraine, 15 Rue Notre Dame des Pauvres, 54501 Vandoeuvre-les-Nancy, France, (2) Bergen University, Earth Sciences, Bergen, Norway

Doubly vergent orogens have a pro-wedge (lower plate) and a retro-wedge (upper plate). Most shortening is accommodated on the pro-wedge while retro-wedge shortening is typically limited. For example, the Eastern Pyrenees have experienced about 145 km of convergence, of which about 125 km (86%) was accommodated in the pro-wedge and about 20 km (14%) in the retro-wedge. Strain partitioning between pro- and retro-wedge is influenced by several factors, some of which have been identified in past work: Extensional inheritance and syn-orogenic sedimentation can help to increase the percentage of total shortening accommodated in the retro-wedge while erosion promotes pro-wedge shortening. We use high-resolution 2D numerical models to investigate factors that control pro- versus retro-wedge shortening. For a total convergence similar to the Eastern Pyrenees, our models predict that variations in extensional inheritance and syn-orogenic sedimentation will result in a maximum of 10% of total shortening being accommodated in the retro-wedge. Here, we investigate the role of 1) the rheology and 2) distribution of a decollement layer.

Our models show that: 1) Decollement rheology has a first order control on strain distribution between the pro- and the retro-wedge. After 145 km of total convergence, a model with a weak frictional ($\varphi=2$, shale-like) decollement will only accommodate 9% of total shortening in the retro-wedge. In contrast in models with a weak viscous ($\mu=1018$, salt-like) decollement retro-wedge shortening amounts to 18% and a stronger, but still weak, viscous decollement ($\mu=1019$) leads to 21%. 2) Décollement distribution influences the timing of the first outward propagation of thick-skinned deformation in the retro-wedge. In the Eastern Pyrenees, thick-skinned deformation propagated out into the retro-wedge within 145 km of total convergence. In models with a decollement on both sides of the orogen this only occurred after 240 km. If, as in the Eastern Pyrenees, the decollement is missing in the model's retro-wedge, the required convergence would be reduced to 180 km.

Assuming deformation localizes along the path of least resistance, meaning a force balance exists between the pro- and retro-wedge, anything that changes the force required to deform one side of the orogen will have direct consequences for the other side as the strain distribution adjusts. In our models a viscous decollement enables the sedimentary cover of the pro-wedge to be transported into the pro-foredeep, increasing the force required for pro-wedge frontal accretion and thus promoting shortening in the retro-wedge. In models with no decollement in the retro-wedge, higher friction along existing crustal shear zones will accelerate formation of a new, more external shear zone. This mechanism alone cannot explain frontal accretion in the retro-wedge after only 145 km of convergence, meaning other factors such as more pre-existing extensional shear zones may also play a role in the Eastern Pyrenees.