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Kinematics of an orogen and mass transfer during its growth: insights from a new balanced and restored cross-section across the Pyrenees

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Providing accurate estimates of shortening and duration of tectonic events in collisional belts is critical if we are to examine the kinematics and retroactions during mountain building. However, structural and geochronological constraints are usually lacking accuracy for the early stages of convergence that are generally overprinted by complex deformation patterns related to subsequent thickening. Moreover, unroofing history of internal units is not well defined by in-situ low-temperature termochronology due to complete removal of material by erosion. In this respect, geological data from the Pyrenees have demonstrated that the whole collision belt underwent little Alpine overprinting and an exceptional preservation of detrital sediments in the foreland basins. Hence the Pyrenees the perfect target to study long-term retroactions between surface and deep processes during mountain building.

Recently published in-situ thermochronometric constraints combined with our new detrital low-temperature thermochronometry (detrital AFT dating, (U-Th)/He on zircons) and geochronology (U/Pb ages on zircons) provided on both flanks of the orogen fill the lack of accuracy for the early stages of orogenesis. Together with the exceptional constraints on the propagation of thrust front these new data offer the unique opportunity to precisely determine the kinematics of the Pyrenean orogenic wedge from Late Cretaceous to Miocene. With the proposed cross-section based on the ECORS profile and intermediate sections reconstructed for well-suited and key time intervals (Early Oligocene, Middle Eocene, Cretaceous-Paleogene transition and Early Cenomanian) we discuss the previous estimates of rock mass transfer from eroding source areas to deposition in adjacent foreland basins. The results are also compared to the theoretical evolution of orogenic wedges from a constructive phase followed by a steady-state phase when erosion rates become sufficient to balance the accretionary fluxes and finally a destructive phase when plate convergence ceases.

This study shows that mountain building initiated during the late Cretaceous by the accretion of the European crust (inversion of North Pyrenean flysh basins) on top of reactived of S-dipping crustal detachment that previously exposed mantle to the surface during the extension phase (Pyrenean Lherzolites). The early Pyrenean mountain belt, was followed by accretion of the Iberian crust during the Eocene continuing until the late Oligocene, forming an antiformal stack of basement units in the backbone of the chain and a south-migrating fold-and-thrust belt.In order to deciphering between climate, tectonic or deeper (mantle) geodynamic forcing on Pyrenean mountain building, future works will combine the deduced long-term evolution of eroded volume of rock, unroofing history in the Axial Zone to the determination of volume of Cenozoic sediments deposited in forelands and the spatial distribution and period of activity of individual thrusts.