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Post-orogenic evolution of Pyrenees and Liguro-Provençal rifting, the role of mantle flow

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The Late Eocene and Oligocene saw a first order change in subduction dynamics in the Mediterranean realm. The western and eastern Mediterranean subduction zones started to retreat and back-arc basins formed at the expense of mountain belts build previously. In the western Mediterranean, the slab subducting below Provence and Sardinia-Corsica started a fast SE-ward retreat forming the Liguro-Provençal Basin. The present-day situation is an abrupt end of the Pyrenees in the Gulf of Lion passive margin where the eastern extension of the belt used to be. The syn-rift period in this margin is exactly contemporaneous with a fast exhumation of the eastern part of the Pyrenees Axial Zone, as documented by LT-thermochronology, with continuing S-ward thrusting over the southern foreland basin. Exhumation then migrated westward along strike until the early Miocene. At the same period, the Alps show a transition from flysch to molasses and the westward thrusting of the External Crystalline Massifs. While this first order event in the Alps has been previously related with the initiation of the Apennine slab retreat, the contemporary Pyrenean Axial Zone exhumation has not yet been explained. We discuss this question here and propose that the mantle flow related with the Apennine slab retreat has (1) exhumed and thinned the continental mantle below the Gulf of Lion and the eastern Pyrenees, leading to the observed fast exhumation and then (2) exhumed the lower crust, leading to crustal thinning and subsidence and formation of the Gulf of Lion margin. This simple model is discussed based on seismic profiles across the belt and the margin. It explains the apparent paradox of crustal thinning without major normal faults in the upper crust. The wide distribution of syn-rift volcanism in the transition between the Gulf of Lion and Valencia Trough is also in line with the geometry observed in the margin suggesting ductile deformation of a weak continental crust, typical of volcanic margins. The direction of SKS-waves seismic anisotropy below the Pyrenees as well as the observed migration of exhumation toward the west also fits this simple model. Both uplift and removal of upper mantle, inducing an increase of potential energy of the chain, may explain why thrusting continued in the Pyrenees while rifting was still active nearby along strike.This study is part of the Orogen research project, a tripartite partnership between academy and industry (Total, BRGM, CNRS).