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Impact of slab pull and incipient mantle delamination on active tectonics and crustal thickening in the Betic-Alboran–Rif system

Stephane Mazzotti (1), Laura-May Baratin (2), Jean Chéry (1), Philippe Vernant (1), Frédéric Gueydan (1), Abdelilah Tahayt (3), and Taoufik Mourabit (4)

(1) Géosciences Montpellier, Université de Montpellier, Montpellier, France , (2) School of Geography, Environment and Earth Sciences, Victoria University of Wellington, Wellington, New Zealand, (3) Scientific Institute, Mohammed V University, Rabat, Morocco, (4) Faculté des Sciences et Techniques de Tanger, Tanger, Morocco

In Western Mediterranean, the Betic-Alboran-Rif orocline accommodates the WNW–ESE convergence between the Nubia and Eurasia plates. Recent geodetic data show that present-day tectonics in northern Morocco and southernmost Spain are not compatible with this simple two-plate-convergence model: GPS observations indicate significant (2-4 mm/a) deviations from the expected plate motion, and gravity data define two major negative Bouguer anomalies beneath the Betic and south of the Rif, interpreted as a thickened crust in a state of non-isostatic equilibrium.

These anomalous geodetic patterns are likely related to the recent impact of the sub-vertical Alboran slab on crustal tectonics. Using 2-D finite-element models, we study the first-order behavior of a lithosphere affected by a downward normal traction, representing the pull of a high-density body in the upper mantle (slab pull or mantle delamination). We show that a specific range of lower crust and upper mantle viscosities allow a strong coupling between the mantle and the base of the brittle crust, thus enabling (1) the efficient conversion of vertical movement (resulting from the downward traction) to horizontal movement and (2) shortening and thickening on the brittle upper crust. Our results show that incipient delamination of the Nubian continental lithosphere, linked to the Alboran slab pull, can explain the present-day abnormal tectonics and non-isostatic equilibrium in northern Morocco. Similar processes may be at play in the whole Betic-Alboran-Rif region, although the fast temporal evolution of the slab – upper plate interactions needs to be taken into account to better understand this complex system.