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Subduction-induced delamination and its surface expressions – three-dimensional numerical modelling

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Delamination during the long-term evolution of convergent plate boundaries has been interpreted as root cause for lithospheric mantle heterogeneities, and has been linked to surface observations in different stages of subduction-collision-lithospheric thinning systems. Amongst others, it has been invoked for the Apeninnes, Rhodope, and Pontides, for thinned or removed lithosphere in the Aegean and western Mediterranean, and for extensive topographic anomalies such as the Colorado or Hikurangi plateaus.

With the onset of collision, in order to balance mass and to achieve either further plate convergence, subduction, or foundering of subcontinental lithospheric mantle, there is an increasing need for a mechanism to separate relatively buoyant and less buoyant material. In independent geodynamic modelling studies carried out in 2D, delamination (sensu strictu) along a horizon of minimal rheological strength has been demonstrated to satisfy this requirement. Recent work has also shown that delamination marks a gradual transition of mobile topography from tectonically dominated to mantle dominated topography over long time scales. While first order features of major observables, such as topography, and imaged lithospheric mantle thickness, can generally be reproduced in a variety of models, there is an unsatisfactory lack of uniqueness in pin-pointing the underlying mode of lithospheric mantle removal occurring at depth. In addition, strong curvatures in many orogenic systems (e.g., Western Alps, Apennines, or Carpathians) indicate that their crustal and sub-crustal evolution are intrinsically three-dimensional.

To test how spatially confined delamination contributes to three-dimensional evolution, the complex arcuate curvature of resulting orogenic systems, and to the developing topography pattern, new three-dimensional models are presented. Based on recent methodological developments, and findings in 2-D delamination modelling and 3-D modelling of subduction/collision systems, we show first results from high-resolution experiments where the initial geometries of the subduction-collision system are varied, and provide an analysis of the developing tectonic regime and topographic pattern through time.