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Crust or Asthenosphere: Who drives the flow in the Mediterranean continental back arc provinces?

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The kinematic relationships between the behaviour of slabs in the upper mantle and the tectonic history recorded in the crust are still widely unknown. Characteristic features of post-orogenic extension after crustal thickening, such as metamorphic core complexes in the back-arc region, retain significant information about these kinematic relations by deforming accordingly to the stress field imposed by the subduction dynamic. Understanding the modes by which back-arc regions form and evolve is thus critical to fully understand the coupling between the lithosphere and mantle.

The Mediterranean region shows a variety of metamorphic core complexes exhumed from the middle and lower crust. The Hellenic chain, the internal Apennines and the Betic-Rif, for example, underwent post-orogenic extension to form the Aegean Sea, the Tyrrhenian Sea and the Alboran basin, respectively, where extensional metamorphic domes outcrop today. A common feature in the Mediterranean back-arc domains is a highly asymmetric deformation with constant sense of shear (hangingwall motion relative to footwall) over large regions. However, the reason for this asymmetric deformation is not clearly understood and the correlation between the stretching lineation directions in the crust and fast splitting axis in the upper mantle leads one to question whether this asymmetry is controlled by mantle flow or crustal dynamics.

The structural data collected over the years in the Mediterranean area clearly show a trend with major detachments dipping top to the trench when the subduction dips normal to the plate motion (Tyrrhenian Sea - late Betic-Rif phase) and top away from the trench when the subduction dips in the same direction as the plate motion (Aegean - early Betic-Rif phase).

In order to capture both the dynamics of the subduction and the detailed deformation in the crust, we use very high-resolution numerical models to investigate how the coupling at the subduction zone and the rates of convergence influence the sense of shear in the crust. The parametric study focuses on the effect of the relative viscosity jump at the lower crust/upper mantle boundary and show how this effective contrast can partly be inferred from structural geology observations.