Subduction dynamics and rheology control on forearc and backarc subsidence: Numerical models and observations from the Mediterranean

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The dynamics of oceanic and continental subduction zones is linked to the rise and demise of forearc and backarc basins in the overriding plate. Subsidence and uplift rates of these distinct sedimentary basins are controlled by variations in plate convergence and subduction velocities and determined by lithospheric rheological structure and different lithospheric thicknesses.

In this study we conducted a series of high-resolution 2D numerical models applying the thermomechanical code 2DELVIS (Gerya and Yuen, 2007). The model, based on finite differences and marker-in-cell techniques, solves the mass, momentum, and energy conservation equations for incompressible media; assumes elasto-visco-plastic rheologies and involves erosion, sedimentation and hydration processes.

The models show the evolution of wedge-top basins lying on top of the accretionary wedge and retro-forearc basins in the continental overriding plate, separated by a forearc high. These forearc regions are affected by repeated compression and extension phases. Higher subsidence rates are recorded in the syncline structure of the retro-forearc basin when the slab dip angle is higher and the subduction interface is stronger and before the slab reaches the 660 km discontinuity. This implies the importance of the slab suction force as the main forcing factor creating up to 3-4 km negative dynamics topographic signals.

Extensional back-arc basins are either localized along inherited crustal or lithospheric weak zones at large distance from the forearc region or are initiated just above the hydrated mantle wedge. During trench retreat and slab roll-back the older volcanic arc area becomes part of the back-arc region. Back-arc subsidence is primarily governed by crustal and lithospheric thinning controlled by slab roll-back. Onset of continental subduction and soft collision is linked to the rapid uplift of the forearc basins; however, the back-arc region records ongoing extension. Finally, during hard collision the forarc and back-arc basins are ultimately under compression.

Our results are compared with the evolution of the Mediterranean and based on the reconstructed plate kinematics, subsidence and heat flow evolution we classify the Western and Eastern Alboran, Paola and Tyrrhenian, Transylvanian and Pannonian Basins to be genetically
similar forearc-backarc basins, respectively.