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Surface and crustal expression of ocean subduction retreat vs delamination (sub-crustal retreat): Implications for the Apennines tectonics

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Many geological and geophysical observations in the Mediterranean (Apennines-Tyrrhenian, Betic/Rif –Alboran, and the Hellenic-Aegean) orogenic belts postulate that syn-convergent extension may be a common geological processs in response to deep slab-mantle interactions. Two primary geodynamic processes have been suggested for the onset of lithospheric scale extension that occurs contemporaneous with shortening: (1) retreating ocean subduction with significant overriding plate extension/thinning (e.g back-arc basin formations); and (2) inferred post-collisional lithospheric delamination (sub-crustal retreat) following subduction retreat. In a series of computational geodynamic experiments, we quantitatively investigate the surface and crustal response to these two deep lithospheric thinning/removal mechanisms, identified by transient surface tectonics. Surface topography associated with retreating ocean subduction indicates a broad region of surface subsidence leading to the formation back-arc basin. Models of lithospheric delamination predict initially elevated surface topography due to hot mantle upwelling (after removal) then more localized surface depression with crustal weakening and gravitational collapse. In both retreat and delamination models, maximum surface subsidence occurs in response to the subduction/delamination slab mobilization but the delamination process may develop more rapidly depending on the weakness of the lower crust. The delamination hinge/subduction trench is associated with crustal shortening and extension/thinning in the "back-arc zone" due to the retro-ward motion of the hinge, although calculated stretching factors (β) are higher in delamination experiments. The thermal expression of extending back-arc zone in delamination experiments is dominated by significant thermal perturbation of the crust caused by the underlying sub-lithospheric mantle flow. With subduction retreat experiments, the amount of crustal heating is dependent on the initial (pre-extensional) thickness of the back-arc mantle lithosphere, but upwelling mantle flow can still elevate the thermal conditions of the lithosphere. To aid in the comparison between two geodynamic hypotheses, we compared and contrasted our model results against the geological and seismological evidence for the Apennines orogenic belt of Italy, where there is strong evidence for both delamination and ocean slab retreat.