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Lateral propagation of slab tear during transition from retreating subduction to arc-passive margin collision: 3D thermomechanical modeling and implications for the evolution of Apennines

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Retreating oceanic plate subduction is common in nature and can terminate by collision of the retreating arc with a passive continental margin. The collision is associated with rapid topographic changes and can result in partial or complete detachment of the oceanic slab by a laterally propagating tear, which develops on the time scale of few Myr (e.g., Faccenna et al., 2014). Here we investigate this geodynamic transition by using 3D high-resolution thermomechanical models, in which a retreating subduction zone limited by two spontaneously propagating STEP faults collides with a passive continental margin oriented at an angle to the slab retreat direction. Realistic visco-plastic rheology is used for the slab and the mantle, which takes into account both brittle/plastic strain weakening and grain size reduction assisted by Zenner pinning (Bercovici and Ricard, 2014). Arc-margin collision results in the rapid growth of continental topography and triggers rotation of the arc toward the margin-parallel direction. Slab tear initiates at shallow depths at the earlier-collided part of the margin and rapidly propagates sub-horizontally toward the other end of the yet forming curved arc-continent collision zone. The tearing process is controlled by a combination of plastic yielding and ductile strain localization caused by grain-size reduction in the deforming lithosphere of the passive margin. Slab tearing and subsequent detachment produce rapid uplift, which marks transition from compression to extension in the forming orogen. Numerical experiments reproduce some essential aspects of the recent evolution of the Apennines related to the formation and enlargement of a slab window in this region in the past 2 Myr (e.g., Faccenna et al., 2014).

Bercovici, D., Ricard, Y. (2014) Plate tectonics, damage and inheritance. Nature 508, 513–516.
Faccenna, C., Becker, T.W., Miller, M.S., Serpellonic, E., Willett, S.D. (2014) Isostasy, dynamic topography, and the elevation of the Apennines of Italy. Earth Planet. Sci. Lett., 407, 163–174.