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The fate of continental collision: from slab detachment to delamination

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The transition from oceanic subduction to continental collision is complex and diverse, and may evolve into different end-members (slab detachment vs. delamination). One of the main features that leads to these various evolutions is the rheological structure of the subducting continental lithosphere. We study the effect of a rheological layered continental crust on the dynamics of continental subduction by performing two-dimensional dynamical self-consistent numerical models. In particular, we focus our attention on slab migration following the continental collision. Our results show that models with a strong continental lower crust, typical of cratons or, more generally, of continents with a cold geotherm, break-off is more likely to occur. We found that in these models the slab starts to advance once the continent enters the subduction zone and continues to migrate until few million years after the ultimate slab detachment. We suggest that the advance is first induced by the locking of the subduction zone and the subsequent steepening of the slab, and next by the sinking of the deepest oceanic part of the slab, during stretching and break-off of the slab. These processes are responsible for the migration of the subduction zone by triggering small-scale convection cells in the mantle that, in turn, drag the plates. The amount of advance ranges from 40 to 220 km depending on the rheology of the lithosphere. We show that the advancing mode is favoured and, in part provided by, the intrinsic force balance of continental collision. On the other hand, the presence of a weak lower crust, typical of young continents with a hot geotherm, might lead to the decoupling between the positively buoyant upper crust and the lithospheric mantle, and, therefore, to delamination. In this case the continuation of subduction of the lithospheric mantle leads to a roll-back of the slab. Finally, we compare our results to the central Mediterranean subduction system, where the occurrence of both slab detachment (African plate) and delamination (Apennines) has been suggested.