Effects of continental buoyancy on subduction dynamics

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At some point during their evolution, most trenches encounter continental lithosphere. Because average continental lithosphere is positively buoyant, collision is often the result. However, there is evidence that some continental crust and lithosphere does get subducted. For example, CW Mediterranean kinematic reconstructions show that Cenozoic subduction consumed a highly heterogeneous lithosphere including small oceanic basins and substantial portions of the flanking continental lithosphere, which had undergone various degrees of extension.

Here we study how continental lithosphere can affect the subduction process in general, and to what extent it can be responsible for the complexities of Cenozoic Mediterranean subduction in particular.

We model a visco-elastic slab, which subducts without external forcing into a passive viscous mantle. We find that lithospheric buoyancy is the primary control on continental subductability. Only if a significant amount of upper crust is stripped off, and the mantle lithosphere is not strongly melt depleted, does continental lithosphere become negatively buoyant. In the Mediterranean orogens, there is ample evidence of large amounts of upper crustal detachment. If in addition, the lower crust is eclogitized, continental lithosphere can even be as negatively buoyant as old oceanic lithosphere. Oceanic slab pull has a minor effect on continental subductability. It defines, with rheology, how much continental material is subducted to which depth (usually between 100 and 400 km) before subduction stalls, but can not change whether sustained continental subduction occurs or not. The influence of rheology is complex. For example, when buoyant lithosphere arrives at the trench, not only does slab pull reduce, but lowered convergence velocities give more time for viscous relaxation making slab pull less efficient at driving further subduction.

We investigate how the combination of continental buoyancy, slab pull and rheology can influence subduction velocities, depth and amount of continental subduction, and stress concentration in the slab, which may lead to detachment.