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Interaction between subducting plates: results from numerical and analogue modeling

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The tectonic setting of the Alpine-Mediterranean area is achieved during the late Cenozoic subduction, collision and suturing of several oceanic fragments and continental blocks. In this stage, processes such as interactions among subducting slabs, slab migrations and related mantle flow played a relevant role on the resulting tectonics. Here, we use numerical models to first address the mantle flow characteristic in 3D. During the subduction of a single plate the strength of the return flow strongly depends on the slab pull force, that is on the plate's buoyancy, however the physical properties of the slab, such as density, viscosity or width, do not affect largely the morphology of the toroidal cell. Instead, dramatic effects on the geometry and the dynamics of the toroidal cell result in models where the thickness of the mantle is varied. The vertical component of the vorticity vector is used to define the characteristic size of the toroidal cell, which is $\sim$1.2-1.3 times the mantle depth. This latter defines the range of viscous stress propagation through the mantle and consequent interactions with other slabs. We thus further investigate on this setup where two separate lithospheric plates subduct in opposite sense, developing opposite polarities and convergent slab retreat, and model different initial sideways distance between the plates. The stress profiles in time illustrate that the plates interacts when slabs are at the characteristic distance and the two slabs toroidal cells merge. Increased stress and delayed slab migrations are the results. Analogue models of double-sided subduction show similar maximum distance and allow testing the additional role of stress propagated through the plates. We use a silicon plate subducting on its two opposite margins, which is either homogeneous or comprises oceanic and continental lithospheres, differing in buoyancy. The modeling results show that the double-sided subduction is strongly affected by changes in plate buoyancy. While the stresses propagated through the mantle can slow down the slab migrations, stresses propagated through the plate eventually lead to the complete cessation of one of the two subductions.
We discuss the relevance of the modeling results for the tectonic history of the whole Mediterranean area.