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A slab expression in the Gibraltar arc?

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The present-day geodynamic setting of the Gibraltar arc region results from several Myrs of subduction rollback in the overall (oblique) convergence of Africa and Iberia. As for most rollback settings in a convergence zone, the interaction of these two components is complex and distinctly non-stationary. Gibraltar slab rollback is considered to have stalled, or at least diminished largely in magnitude, since the late Miocene/early Pliocene, suggesting that the effect of the slab on present-day surface motions is negligible. However, GPS measurements indicate that the Gibraltar arc region has an anomalous motion with respect to both Iberia and Africa, i.e. the Gibraltar arc region does not move as part of the rigid Iberian, or the rigid African plate. A key question is whether this surface motion is an expression of the Gibraltar slab.

Seismic activity in the Gibraltar region is diffuse and considerable in magnitude, making it a region of high seismic risk. Unlike the North African margin to the east, where thrust earthquakes dominate the focal mechanism tables, a complex pattern is observed with thrust, normal and strike-slip earthquakes in a region stretching between the northern Moroccan Atlas across the Gibraltar arc and Alboran Sea (with the Trans-Alboran Shear Zone) to the Betics of southern Spain. Even though no large mega-thrust earthquakes have been observed in recent history, slab rollback may not have completely ceased. However, since no activity has been observed in the accretionary wedge, probably since the Pliocene, it is likely that the subduction interface is locked.

In this study, we perform a series of numerical models in which we combine the relative plate convergence, variable magnitude of friction on fault segments, regional variations in gravitational potential energy and slab pull of the Gibraltar slab. We seek to reproduce the GPS velocities and slip sense on regional faults and thereby determine whether the Gibraltar slab has an effect on surface motion.

Slab shape and slab continuity to the surface, allowing slab pull to be transfered to the surface lithosphere, are key factors controlling the force balance in the region. We explore slab geometries with or without continuity at the Betics (with a slab window between the known subduction interface and a possible Betics connection) and/or continental material attached to the slab (which lowers the slab pull magnitude). Through our methodology, we are able to study which slab shape of those proposed in the literature best fits the surface data.