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Lithosphere tearing at STEP faults: dynamic consequences of slab edges in the Central Mediterranean

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Slab edges are a relatively common feature in plate tectonics. Two prominent examples are the north end of the Tonga subduction zone and the southern end of the New Hebrides subduction zone. Near such horizontal terminations of subduction trenches, ongoing tearing of oceanic lithosphere is a geometric consequence. We refer to such kink in the plate boundary as a Subduction-Transform Edge Propagator, or STEP. Other STEPs are the north and south ends of the Lesser Antilles trench, the north end of the South Sandwich trench, the south end of the Hikurangi trench, the south end of the Vranchea trench, and the north and south Ionian trench. Volcanism near STEPs is distinct from typical arc volcanism. In some cases, slab edges appear to coincide with mantle plumes.

Using 3D mechanical models, we establish that STEP faults are stable plate tectonic features in most circumstances. In the (probably rare) cases that the resistance to fault propagation is high, slab break-off will occur. Relative motion along the transform segment of the plate boundary is often non-uniform, which is therefore not a transform plate boundary in the (rigid) plate tectonics sense of the phrase. STEP propagation may result in substantial deformation, rotation, topography and sedimentary basins, with a very specific time-space evolution. GPS velocities are substantially affected by nearby STEPs.

We asses the mechanical consequences of STEP faults using a geodynamic model that is specific for the area. This model includes STEPs fault on northern and southern ends of the Tyrrhenian Sea. The southern STEP, just north of Sicily, represents the fault zone formed by the Southern Tyrrhenian strike-slip duplex. We propose that the STEP propagated along this zone until it encountered the Malta escarpment, where it changed direction to the location of the present trench edge. The northern STEP is less visible in the geology and, in the model, is assumed to connect the 41-degrees Fault with the north end of the Calabria trench. The Calabria slab resulted from subduction of Mesozoic Ionian lithosphere. The geometry of our model slab is derived from the Benioff zone and matches tomography. Observed topography and Moho topology are accounted for in the model, giving a realistic distribution of continental and oceanic lithospheres. We investigate the response to density sinking of the slab combined with the observed plate velocity between continental Africa and Europe, and compare the models with regional observations.