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Are narrow retreating subduction zones oceans invaders?

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Narrow retreating subduction zones, such as the Scotia subduction zone, the Caribbean, or Gibraltar, exhibit distinct geometries where oceanic subduction sometimes interacts with continental margins. These subduction zones are currently propagating towards the Atlantic Ocean and one of the key questions is: are they going to expand and recycle large portions of, or even the entire oceanic floor (and hence invade the Atlantic, Duarte et al., 2013), or are they rather going to narrow and decline until slab detachment?

Here, we investigate this question by using high-resolution 3D thermomechanical models, in which narrow retreating subduction zones propagate by tearing of an oceanic plate. We initiate spontaneous retreating subduction by prescribing a laterally limited region of young and weak oceanic lithosphere with strong age contrast to the surrounding older and stronger plate. Using this setup, we study the evolution of self-sustained retreating subduction zones in purely oceanic domains, as well as in domains bordering one and two passive continental margins.

According to our results, the retreating subduction zones develop by paired tears spontaneously propagating through the interior of the oceanic plate. The paired-tear propagation pattern depends on the dominant rheological plate deformation mechanism and alternates in between 1) converging mode-III (out of plane shear) tears (narrowing subduction zones controlled by dominance of brittle-plastic strain-weakened plate rheology) and 2) diverging mode-I (opening) tears (expanding subduction zones, controlled by dominance of ductile power-law plate rheology). Initial plate structure seems to play a subordinate role.
In simulations involving passive continental margins, slabs are initially retreating along the margins, which influences the retreat velocities as well as the subduction zone geometry. However, even though the final shape of the subduction zone appears to depend on the initial geometry, all of our simulations with brittle-plastic strain-weakening plate rheology exhibit subduction zone narrowing, deviating from the continental margins. Taking into account the geometrical similarity of narrowing subduction zones between experiments and natural analogues, we conclude that mode-III tear controls the geometry of retreating subduction zones in nature, which should in turn prevent them from invading oceans.

Reference:
Duarte, J.C., Rosas, F.M., Terrinha, P., Schellart, W.P., Boutelier, D., Gutscher, M.-A., Ribeiro, A. (2013) Are subduction zones invading the Atlantic? Evidence from the southwest Iberia margin. Geology, 41, 839-842.