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Plates boundary migration via STEP faults propagation dynamics

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Plate boundaries migrate over time due to plate/mantle interactions. Retreating subduction zones such as the Scotia arc are a remarkable example of moving plate boundaries. There, slab retreat is allowed by fracturing at STEP faults, which are located at the edges of the subducting plate. The trajectory for slab retreat and hence the plate boundary movements is strongly bound to the fracture dynamics at these faults. The fracturing process is influenced by material properties such as lithosphere and asthenosphere rheology. We performed 3D numerical modelling of retreating subduction zones similar to the Scotia subduction settings. STEP faults propagate due to slab pull in the asthenosphere. We varied the rheology of the lithosphere and asthenosphere to favour either ductile or brittle deformation. Our results show that favouring ductile behaviour of the lithosphere and asthenosphere (no strain weakening during deformation) leads to diverging fracturing paths at the edges of the slab. This leads to a widening of the slab associated to a slow down of the retreat. Conversely, favouring brittle behaviour (strain weakening during deformation) leads to converging fracturing paths leading to a narrowing of the slab over time. Ultimately, the slab detaches in this set of simulations, resulting in a arched trench.
When varying the mantle viscosity (e.g. activation volume), we observe similar trends in the retreat trajectories, however, the resulting slab shape and dynamics of the retreat differ.