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Downgoing plate controls on overriding plate deformation in subduction zones

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Although subduction zones are convergent margins, deformation in the upper plate can be extensional or compressional and tends to change through time, sometimes in repeated episodes of strong deformation, e.g, phases of back-arc extension. It is not well understood what factors control this upper plate deformation. We use the code Fluidity, which uses an adaptive mesh and a free-surface formulation, to model a two-plate subduction system in 2-D. The model includes a composite temperature- and stress-dependent rheology, and plates are decoupled by a weak layer, which allows for free trench motion. We investigate the evolution of the state of stress and topography of the overriding plate during the different phases of the subduction process: onset of subduction, free-fall sinking in the upper mantle and interaction of the slab with the transition zone, here represented by a viscosity contrast between upper and lower mantle. We focus on (i) how overriding plate deformation varies with subducting plate age; (ii) how spontaneous and episodic back-arc spreading develops for some subduction settings; (iii) the correlation between overriding plate deformation and slab interaction with the transition zone; (iv) whether these trends resemble observations on Earth.