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Rheology controlled mechanisms for subduction initiation at passive margin retrieved through analogue modelling.

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Passive Margins have been well explored through geological, geophysical and modelling studies. However, it is poorly understood how passive margins turn into active margins, eventually leading to the development of subduction zones. It is widely accepted that subduction initiation critically depends on the rheology of the continent-ocean transition and can only occur upon failure of the load-bearing layers. Additionally, it is still unclear where deformation, which will eventually lead to the initiation of subduction zones, localizes at passive margins, as controlling parameters are not well quantified. This physical analogue modelling study aims at exploring favourable rheological and kinematic conditions that lead to the development of subduction zones along passive continental margins and to better understand the mechanisms involved in the different stages of this process. Different to many numerical modelling studies, we do not invoke pre-existing fracture or weak zones to localise deformation, but test the role of lithospheric mantle strength, and convergence rate for subduction initiation. Our experiments consist of both continental and oceanic lithospheres which are separated by a wedge-shaped margin which simulate the necking zone of the common passive margins. We assume far-field forcing when inverting the passive margin. Experimental results show that rupture of the crust mainly depends on the difference in strength between the oceanic and continental crust, whereas failure of the lithospheric mantle strongly depends on the viscosity in its lower ductile part. Also, the convergence velocity controls the slab dip and will affect both the timing and amplitude of deformation as well as the topographic response at the surface. While low viscosities and convergence rate produce localized and low amplitude deformations, an increase of these parameter give rise to more spread deformations and global uplift along the continental edge. It results that subduction most likely occurs for an intermediate effective viscosity in the lithospheric mantle (1021Pa.s). Deformation starts with a phase of accretion where the oceanic crust deforms the passive margin by ocean-ward out-of-sequence thrusting commencing at the boundary between the ocean and the margin. Coevally the margin is flexed downward, cut by the evolving subduction fault and is being thrusted under the continent, leading afterward to its collapse and the decoupling of the continental lithosphere. Eventually, the development of a shear zone in the viscous part of the mantle lithosphere is necessary to accommodate the sinking of the subducting slab. This last stage highlights the importance of the viscosity in the lithospheric mantle for subduction initiation which depends on the age of the lithosphere but also on thermomechanical feedback mechanism. It leads to the (partial) subduction of the passive margin and could predict the juxtaposition of shallow water, platform-type deposits on deep marine sediments.