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Cyclic arc regimes over subduction zones at constant plate motion, due to folding over the 660 km transition zone. Insight from numerical models.

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As a starting point, a finite element benchmark of analogue models of subduction is presented, with strong visco-elastic plates and a rigid 660 km depth mantle discontinuity. This numerical approach neglects mantle viscosity and assumes that plate motion are contolled by "external" spatial constraints on the Earth's surface. Then, a relationship is established between such applied plate kinematics, deformation in the overriding plate and slab geometry. From the analysis of several simulations, two different styles of subduction are obtained depending on the (applied) overriding plate velocity Vop: the slab lays forward on the 660 km discontinuity (style 1) if Vop>0, or else the slab lays backward (style 2). We also obtain a cyclic pattern with slab folding repeatedly on itself when Vsp>0 and 2Vop + Vsp >0 (Vsp is the subducting plate velocity). In this case, periods of shallow slab dip associated to compression in the overriding plate are followed by periods of slab steepening associated with relative extension in the overriding plate. The periodicity of folding is controlled by slab viscosity and subduction velocity. When accounting for a low viscosity zone in the overriding plate, trench motion decouples from the far-field velocity of the overriding plate, and becomes directly sensitive to the slab's deep dynamics, as already known from "free-subduction" models. In a case of cyclic style 2 with forward folding of the slab, this weak zone in the overriding plate tends to increase the amplitudes of stress oscillations (and trench motion), and to increase the folding periodicity in time. Therefore the strength of the overriding plate also directly controls the dynamics of subduction. A model accounting for the Nazca and South American plates velocities produces cycles with a period of ca. 22 Ma and a minimal dip angle of 10°. Despite the absence of a viscous mantle, this model might explain episods of volcanic quiescience alternating with episods of shortening along the Andean margin.