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Subducting Plate Velocity as a Parameter controlling Slab Geometry and Hinge-Migration

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Geological observations indicate that along two active continental margins (East Asia and Mediterranean) major phases of overriding plate extension, resulting from subduction hinge-retreat, occurred synchronously with a reduction in subducting plate velocity. Fluid dynamic models have been built to test the influence of the velocity of the subducting plate on the hinge-migration velocity and on the geometry of the slab. Results show that hinge-retreat increases an order of magnitude with an order of magnitude decrease in subducting plate velocity. This behaviour could indeed explain the initiation of extension in East Asia, as the decrease in subducting plate velocity from $\sim$13 cm/yr to $\sim$4 cm/yr was relatively large. In the Mediterranean, the subducting plate velocity decreased from $\sim$3 cm/yr to $\sim$2 cm/yr at the time of initiation of extension, and modelling shows that this decrease is insufficient to promote a rapid increase in hinge-retreat. Model results show that it is more likely that the progressive increase in slab length is the main cause for the onset of rollback and hinge-retreat in this region.

The experiments further show that phases of hinge-retreat alternate with phases of hinge-stability and hinge-advance for relatively high subducting plate velocities due to interaction of the slab with the bottom of the box, simulating the upper-lower mantle discontinuity. Such slab kinematics could explain the episodic behaviour of back-arc opening observed in convergent settings. The geometry of the slab and the kinematics of subduction are significantly affected by the velocity of the subducting plate. Three subduction modes with accompanying slab geometry can be recognised. A relatively low subducting plate velocity is accompanied by relatively fast hinge-retreat

with backward sinking of the slab and a backward draping slab geometry. With increasing subducting plate velocity hinge-migration is relatively small, resulting in subvertical sinking of the slab and a folded slab piling geometry. For a very high velocity the hinge migrates forward, resulting in forward oriented subduction vectors and a forward draping slab geometry. These slab geometries are also observed in seismic tomography. Slab draping geometries are observed underneath the Calabrian and Carpathian arcs, where subduction has been primarily accomplished by slab rollback. A subvertical folded slab is observed underneath the Mariana arc, where hinge-migration is minimal and subduction is fast. Underneath the Himalayas, a forward draping slab geometry is observed, which resulted from rapid subduction and a forward migrating hinge. It is concluded that the hinge-migration velocity and the velocity of the subducting plate are principal parameters in determining the kinematics of subduction and the geometry of the slab.