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3D Wilson cycle: structural inheritance and subduction polarity reversals

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Many orogenies display along-strike variations in their orogenic wedge geometry. For instance, the Alps is an example of lateral changes in the subducting lithosphere polarity. High resolution tomography has shown that the southeast dipping European lithosphere is separated from the northeast dipping Adriatic lithosphere by a narrow transition zone at about the "Judicarian" line (Kissling et al. 2006). The formation of such 3D variations remains conjectural. We investigate the conditions that can spontaneously induce such lithospheric structures, and intend to identify the main parameters controlling their formation and geometry.

Using the 3D thermo-mechanical code, I3ELVIS (Gerya and Yuen 2007) we modelled a Wilson cycle starting from a continental lithosphere in an extensional setting resulting in continental breakup and oceanic spreading. At a later stage, divergence is gradually reversed to convergence, which induce subduction of the oceanic lithosphere formed during oceanic spreading. In this model, all lateral and longitudinal structures of the lithospheres are generated self-consistently, and are consequences of the initial continental structure, tectono-magmatic inheritance, and material rheology.

Our numerical simulations point out the control of rheological parameters defining the brittle/plastic yielding conditions for the lithosphere. Formation of several opposing domains of opposing subduction polarity is facilitated by wide and weak oceanic lithospheres. Furthermore, contrasts of strength between the continental and oceanic lithosphere, as well as the angle between the plate suture and the shortening direction have a second order effect on the lateral geometry of the subduction zone.

In our numerical experiments systematic lateral changes in the subduction lithosphere polarity during subduction initiation form spontaneously suggesting intrinsic physical origin of this phenomenon. Further studies are necessary to understand why this feature, observed in nature, is recurrent in our models. It is necessary to determine whether it is controlled by rheological properties, and/or is constrained by inherited lithospheric structures.

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