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A numerical study of subduction parameters

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Subduction dynamics is studied by numerical simulations. The relation between slab dip and subduction velocities (upper plate velocity, subducting plate velocity, convergence rate, etc.) has been studied by many authors and some empirical laws has been proposed. With a numerical approach we can isolate the different parameters acting on the subduction system and evaluate its influence on the subduction geometry.

Our thermo–mechanical model is based on a X–FEM numerical technique, which includes a power-law rheology, shear heating, density depending on temperature and pressure, taking into account major mineral phase changes (olivine, espinel, perovskyte), viscosity depending on temperature, pressure and strain rate and thermal conductivity as a function of temperature and pressure. The domain under study is a 8000 km width and 1000 km thick rectangle. On the top of the domain the velocity is set to be zero on the left half, whereas on the right side we prescribe a horizontal velocity. At the central point we prescribe a downward velocity (55° with the horizontal) to simulate the contact between plates. On the bottom a free slip condition is adopted. On the lateral sides periodic boundary conditions are imposed.

In order to relate convergence velocity and the slab dip, a series of simple ocean–ocean subduction models was run. Varying only the convergence rate we find a negative correlation between this velocity and the slab dip (correlation coefficient $R = -0.71$). This correlation is even better for slabs lying on the 660 km discontinuity ($R = -0.93$). We obtain mean velocities of dip change of 2 degrees/Myr for shallowing slabs and 2.7 degrees/Myr for steepening slabs. The fact that the dip does not correlate with the length of the subducted slab but with the subduction velocity, may be interpreted as the mechanical viscous forces rather thermal state as a first order control of the slab dip.