Determination of the physical processes underlying observed slab dynamics

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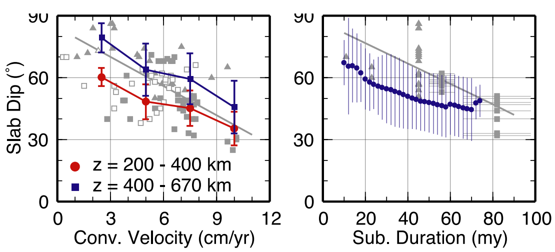
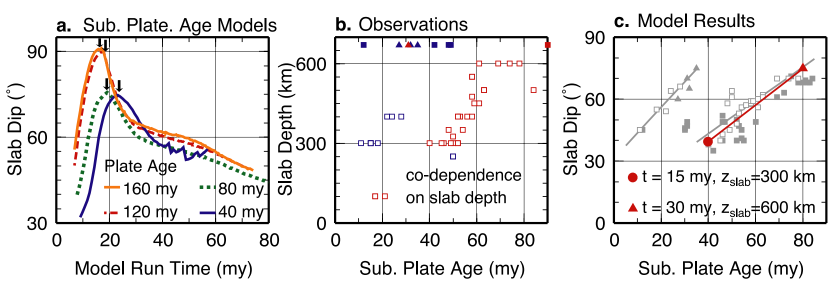
Comparison of slab dynamics from 2D numerical models to a suite of observations has allowed us to determine the physical processes underlying the observed correlations between slab dip, buoyancy, and convergence kinematics. We find that stiff slabs, with viscosity 5–6 orders of magnitude greater than the asthenosphere, experience three stages of evolution. Initially the slab is stiff enough to maintain small dips. Second, as the slab length and weight grow with progressive subduction, slab dip increases to near vertical until the slab reaches the lower mantle. If the lower mantle viscosity is greater than the upper mantle (and is Newtonian), then the slab will migrate laterally leading to smaller and smaller slab dips with time. This three-stage behavior leads to the observed range in slab dip, which is 30–90 , and the observation that slab dip decreases with subduction duration (Fig. Pt 1b, 2a). In addition, slab dip decreases with increasing rate of trench-perpendicular convergence (Fig. Pt 1a). Decreasing slab dip with time is caused by the longitudinal migration of the slab, which is faster for faster convergence rates, and by a small contribution from corner-flow suction at shallow depth. Finally, in both observed data and the models there is a correlation between increasing slab dip and plate age for young, upper mantle slabs. However, by examining the dynamics of the numerical models, we find that this is only an apparent correlation with age, and instead the true correlation is with slab length (Fig. Pt 2). In the observed data, subducting plate age is correlated with slab length for upper mantle slabs. So, the apparent correlation is actually a by-product of the progressive steepening of the slab with length while the slab is in the upper mantle.



Part 1: Comparison slab dip dependence on convergence velocity and subduction duration for the observations (gray symbols) and the model results.



Part 2: Apparent correlation of subducting plate age and slab dip is a by-product of slab dip dependence on slab length before slab enters the lower mantle.

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