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Subduction dynamics: effects of downgoing-plate density and strength

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Subduction dynamics are a crucial component of plate tectonics. Although the negative age-dependent buoyancy of the downgoing plate is the primary driving force, subduction behaviour cannot be described simply as a function of age. Interaction with global mantle flow, the upper plate and the resistance of the downgoing plate to deformation may all influence plate and trench motions and subducting slab morphology and stress. 2- and 3-D models of free subduction, driven solely by the buoyancy of the downgoing plate, and resisted by a passive viscous mantle and downgoing plate strength provide a useful end-member scenario to start unraveling the relative importance of the different subduction forces. The comparison of motions and morphology predicted by such models with Cenozoic subduction motions at major trenches show that 80% of the slabs move as expected if controlled by upper-mantle slab pull. Only in a few cases, do young plates move at velocities that require a higher driving force (possibly supplied by lower-mantle-slab induced flow). In free subduction, trenches retreat, except for viscoelastic plates of high strength, and about 80% of the Cenozoic trenches retreat. However, retreat accounts for only about 10% of the Cenozoic convergence, much less than for most modeled free-subduction cases. Furthermore, trench motions are often very oblique to the direction of downgoing plate motion, indicating that the upper-plate and/or mantle exert an important control on movement of the trench. High present-day slab dips are compatible with largely upper-mantle slab-pull driven subduction of relatively weak plates, where motion partitioning and slab geometry adjust to external constraints/forces on trench motion.