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Dynamics of subduction and plate motion in laboratory experiments:

insights into the ”plate tectonics” behavior of the Earth

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3-D laboratory experiments have been designed to investigate the way slab-bearing plates move during subduction inside the mantle. In our experiments, a viscous plate of silicone (lithosphere) subducts under its negative buoyancy in a viscous layer of pure honey (mantle). Varying thickness, width, viscosity, density of the plate and mantle, three characteristic modes of subduction are observed: a retreating trench mode (Mode I), a retreating trench mode following a transient period of advancing trench (Mode II), and an advancing trench mode (Mode III). These modes are characterized by different partitioning of the amount of subduction into plate and trench motion. Our experiments show that the velocity of subduction can be modelled by the dynamic interaction between acting and resisting forces, where lithospheric bending represents 75% to 95% of the total resisting forces. However, our experimental results also show the impossibility to predict a priori the plate velocity only from the velocity of subduction without considering trench migrations. We find experimentally that the lithospheric radius of curvature, which depends upon plate characteristics (stiffness and thickness) and the mantle thickness, exerts a primary control on the trench behaviour. Our results suggest that the complexity of the style of subduction could be controlled by geometrical rules of a plate bending inside a stratified mantle. The Earth system is in the crucial range for the interplay between the rigidity of the plate and the mantle stratification: this setting may be the responsible for the complexity of the past and present tectonic styles.