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How does mantle viscosity influence the subduction process. Insights from laboratory models

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Three-dimensional laboratory models have been realized to investigate the role played by the mantle viscosity in controlling the style of subduction. Our models are setup with a viscous plate of silicone (lithosphere) subducting under its negative buoyancy in a viscous layer of glucose syrup (mantle). For our goal, the lithosphere/upper mantle viscosity contrast have been systematically changed ranging between $\sim$10 and $\sim 10^5$. We found that subduction characterized by a retreating mode is enhanced for viscosity ratios $> 10^4$, subduction characterized by both a retreating mode and an advancing mode is enhanced for viscosity ratios ranging between $\sim 10^4$ and $\sim 10^2$while for ratios $<10^2$ the process is quasi-stationary. It is further found that the lithospheric radius of curvature, and in turn the bending resistance, play a primary role in the subduction system that depends not only upon plate characteristics (stiffness and thickness) but also upon the mantle viscosity. By combining our experimental results and both geometric and kinematic data from current subduction zones in different absolute reference frames we observed that a lithosphere/upper mantle viscosity contrast of about 300 is necessary to obtain realistic trench/subducting plate velocity ratio as well as the variability of subduction styles recognized in nature.