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Subduction and exhumation of continental crust: insights from laboratory models

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When slivers of continental crust and sediment overlying oceanic lithosphere enter a subduction zone, they may be scraped off at shallow levels, subducted to depths of up to 100 – 200 km and then exhumed as high pressure (HP) and ultra-high pressure (UHP) rocks, or subducted and recycled in the mantle. To investigate the factors that influence the behavior of subducting slivers of continental material, we use three-dimensional dynamically consistent laboratory models. A laboratory analogue of a slab–upper mantle system is set up with two linearly viscous layers of silicone putty and glucose syrup in a tank. A sliver of continental material, also composed of silicone putty, overlies the subducting lithosphere, separated by a syrup detachment. The density of the sliver, viscosity of the detachment, geometry of the subducting system (attached plate vs. free ridge), and dimensions of the sliver are varied in 34 experiments. By varying the density of the sliver and viscosity of the detachment, we can reproduce a range of sliver behavior, including subduction, subduction and exhumation from various depths, and offscraping. Sliver subduction and exhumation requires sufficient sliver buoyancy and a detachment that is strong enough to hold the sliver during initial subduction, but weak enough to allow adequate sliver displacement or detachment for exhumation. Changes to the system geometry alter the slab dip, subduction velocity, pattern of mantle flow, and amount of rollback. Shallower slab dips with more trench rollback produce a mantle flow pattern that aids exhumation. Steeper slab dips allow more buoyancy force to be directed in the up-dip direction of the plane of the plate, and aide exhumation of subducted slivers. Slower subduction can also aide exhumation, but if slab dip is too steep or subduction too slow, the sliver will subduct to only shallow levels and not exhume. Smaller slivers are most easily subducted and exhumed and influenced by the mantle flow.