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Deformation of the overriding slab during incipient subduction in centrifuge modeling and its tectonic significance

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Analog models of subduction-related structural deformation emphasize the significance of differences in density and friction between the adjacent plates on the distortion of the overriding slab and its possible effect on the subduction procedure. Centrifuge experiments juxtaposed miniaturized lighter and denser lithospheres, which were floating on denser but less viscous asthenosphere. The lithosphere in the tests comprised brittle and ductile strata, which showed diversified styles of deformation, while factors of equivocal tectonic significance, such as lateral push or negative buoyancy, were not introduced into the experiments. The tests show that the juxtaposition of lighter and denser lithospheres would suffice to drive the denser lithosphere as a wedge between the asthenosphere and the lighter lithosphere, and that the rate of the process would depend on the rate of friction between the slabs, as well as on differential viscosity. It seems that the reduced friction in Nature was derived from the generation of serpentinites, which could be the main agent of lubrication. The underthrusting of the denser lithosphere leads to the uplift and collapse of the edge of the lighter slab, where extension, thinning, normal faulting and rifting took place, and diapiric ascent of parts of the ductile layer of the lighter slab occurred along several rifts. The analog experiments were carried out only to the stage where the denser slab was thrust under the lighter one, but the penetration of the lithosphere into the asthenosphere was not achieved. It seems plausible therefore, that only after eclogitization, and the upward motion of serpentinites, increased the density of the underthrust slab, would it dive and penetrate into the asthenosphere.

The experiments indicate the plausibility of the constraints imposed on the subduction process by the deformation of the overthrust slab. The normal faults and rifts in the overthrust block could serve as conduits for the ascent of the lighter mineralogical fraction emanating from the heated and pressurized subducting plate, as well as from the upper mantle material displaced by the subducted slab and their accretion on the lighter plate. The denser fraction of the subducting slab would be eclogitized, and thus pull the underthrust slab into the mantle. The experiments suggest further that ocean-continent juxtaposition is not a prerequisite for subduction, which could also initiate between two lithologic slabs of different densities that were juxtaposed due to transform faulting.