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Analog modelling of obduction processes

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Obduction corresponds to one of plate tectonics oddities, whereby dense, oceanic rocks (ophiolites) are presumably 'thrust' on top of light, continental ones, as for the short-lived, almost synchronous Peri-Arabic obduction (which took place along thousands of km from Turkey to Oman in c. 5-10 Ma). Analog modelling experiments were performed to study the mechanisms of obduction initiation and test various triggering hypotheses (i.e. plate acceleration, slab hitting the 660 km discontinuity, ridge subduction; Agard et al., 2007).
The experimental setup comprises (1) an upper mantle, modelled as a low-viscosity transparent Newtonian glucose syrup filling a rigid Plexiglas tank and (2) high-viscosity silicone plates (Rhodrosil Gomme with PDMS iron fillers to reproduce densities of continental or oceanic plates), located at the centre of the tank above the syrup to simulate the subducting and the overriding plates - and avoid friction on the sides of the tank. Convergence is simulated by pushing on a piston at one end of the model with velocities comparable to those of plate tectonics (i.e. in the range 1-10 cm/yr).
The reference set-up includes, from one end to the other (∼60 cm): (i) the piston, (ii) a continental margin containing a transition zone to the adjacent oceanic plate, (iii) a weakness zone with variable resistance and dip (W), (iv) an oceanic plate - with or without a spreading ridge, (v) a subduction zone (S) dipping away from the piston and (vi) an upper, active continental margin, below which the oceanic plate is being subducted at the start of the experiment (as is known to have been the case in Oman). Several configurations were tested and over thirty different parametric tests were performed. Special emphasis was placed on comparing different types of weakness zone (W) and the extent of mechanical coupling across them, particularly when plates were accelerated. Displacements, together with along-strike and across-strike internal deformation in all plates were systematically measured, allowing for a very precise and reproducible tracking of deformation.
Experiments demonstrate that obduction chiefly depends on how the overall shortening (or convergence) is partitionned between the weakness zone (W) and the preexisting subduction zone (S). Conditions favorable to obduction are shown to correspond to a specific range of coupling across (S) and resistance across (W). Our results thereby (1) constrain the range of physical conditions required for obduction to develop/nucleate and (2) underline the key role of acceleration for triggering obduction (rather than ridge subduction or slab resistance to penetration at the 660 km discontinuity). They also demonstrate that the emplacement of dense, oceanic material on continental lithosphere is not a mysterious process but results from some large scale, normal subduction process that do not require exotic boundary conditions.

Agard P., Jolivet L., Vrielynck B., Burov E. & Monié P., 2007. Plate acceleration : the obduction trigger? Earth and Planetary Science Letters, 258, 428-441.