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The structural expression of laterally changing subduction polarity during continental collision: a lithospheric-scale analogue modelling perspective

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The lateral change of subduction polarity in collision zones is studied by lithospheric-scale analogue modelling focussing on (1) the surface expression of the polarity change and (2) the influence of laterally changing mantle rheology on the structural evolution of a collision zone. Natural examples of such subduction/collision settings are found in New Zealand and, as shown recently by high resolution teleseismic tomography also in the European Alps.

The model lithosphere, which floats on a denser model asthenosphere, consists of a brittle upper crust (dry quartz sand), a viscous lower crust (silicone mixture I), and a strong viscous upper mantle (silicone mixture II). Inclined boundaries between the colliding plates (foreland and indenter plate) with opposite dip direction in each half of the model have been adopted for models with uniform mantle strength (Group A). In Group B models the mechanical properties of the upper mantle is assumed to vary laterally within both colliding plates, such that a weak mantle is always in contact with a strong mantle.

Group A: Activation of the doubly vergent system is documented at the surface by oppositely dipping thrust faults, which are subsequently separated by a transfer zone with dominant strike-slip displacement. As shortening continued thrusting was accompanied by folding, but remained the dominant mode of deformation until the end of the experiment (18% bulk shortening). Noteworthy, is that the direction of thrusting reversed at both sides of the transfer zone after $\sim$ 11% bulk shortening. The cross sections reveal lithospheric-scale underthrusting and late-stage buckling.

Group B: The first response to shortening was thrusting in the weak part of the foreland plate. Subsequently this thrust propagated laterally into the strong domain of that plate and remained active throughout the experiment. Additionally, contraction resulted in bending of the lower plate. In contrast to what the surface observations suggest, underplating of the foreland plate by the strong upper mantle of the indenter is inferred from the cross-section. Such lithospheric structure demands crust-mantle decoupling at the level of the viscous lower crust.

From our experiments we infer that lateral propagation of structures within the brittle upper crust, are insensitive to lateral strength variations in the upper mantle due to decoupling at the lower crust level. For the same reason contrasting upper crust and upper mantle geometries may arise from a single progressive collision event. Consistent with natural examples our experiments predict the presence of a strike-slip transfer zone separating plates of different subduction polarity.