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The brittle-ductile transition signature in accretionary prism, insight from thermomechanical modeling. Application to Makran

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Long-term tectonics numerical modelling at accretionary margin scale is a powerful tool to retrieve the influence of many parameters such as the spatial variations of the frictional properties along a simplified interface and its feedback on the deformation. Despite significant analogue and numerical studies on the evolution of accretionary prism, none of them account for heat conservation or temperature-dependent rheological transitions. Since Makran is one of the thickest accretion prisms in the world, the contribution of heat to the rheology of the prism cannot be ignored. Here, we solve for advection-diffusion of heat with imposed constant heat flow at the base of the model domain to allow the temperature to increase with burial. We start with a simple setup of one décollement layer to capture how the brittle-ductile transition affects the structures and geometry of the accretionary prism.

Our results show that a mature brittle-ductile wedge forms four different structural segments that can be distinguished based on topographic slope and deformation. An initial purely frictional segment is characterized by an imbricated zone and active in-sequence thrusts faults at the toe of the wedge. Its topographic slope is controlled by the basal friction of the décollement and is consistent with the critical taper theory prediction. The presence of the smectite-illite transition (dehydration reaction) leads to a flat topographic slope by the drop of friction. This flat segment produces little internal deformation and appears during the early stage of the accretionary prism formation. The third segment is marked by an increase of the topographic slope that begins with the onset of internal distributed viscous deformation in between brittle structures. Viscous deformation appears once the base of the model reaches 180°C while the décollement remains brittle. We refer to that segment as the brittle-ductile transition where both brittle and ductile deformation co-exists within the wedge together with high internal deformation. The last segment of deformation corresponds to the onset of the ductile deformation along the décollement by reaching a temperature of 450°C with an approximate flat zone without effective internal deformation. The topographic slope is again consistent with the critical taper theory, considering that a viscous décollement is equivalent to a brittle décollement of extremely low friction.

Knowing the impact of temperature transitions, we include more complexity in our simulations to increase the relevance of the models with the Makran accretionary prism. We calibrate the basal

heat flow from BSR visible along seismic profiles. An intermediate décollement, essential for underthrusting to occur at the rear of the wedge, is added to the simulations. We show that the onset of underthrusting is controlled by the brittle-ductile transition. As tomographic models on land indicate packages with a higher velocity at depth, seamount subduction is another hypothesis tested. We conclude that the subduction of large seamount is accompanied by deep-rooted listric normal faults, whose location migrates through time. Seamount subduction also permits the formation of a large thrust slice zone and lateral variation of basal-erosion which can be followed in seismic profiles of Nankai and Makran subduction zones.