The Role of Multiple Detachments at Orogenic Fronts – First Results from Analogue Modelling

Fang-Lin Wang[(1,2)], Onno Oncken[(1,2)], Nina Kukowski[(1,3)], Charlotte Cederbom[(4)]

(flwang@gfz-potsdam.de) (1)Helmholtz-Centrum Potsdam (GFZ), Telegrafenberg, D-14437 Potsdam, Germany; (2)Freie Universität Berlin, Germany; (3)Friedrich Schiller Universität Jena, Germany; (4)Swedish Geotechnical Institute, Linkoping, Sweden

Accretionary wedges and foreland thrust belts develop two distinct types of structural associations. One type is characterized by forethrusting with a single detachment. A good example for this is the Nankai wedge in Southwest Japan. Another type involves dominant backthrusting or formation of a triangle zone with multiple detachments such as at the Cascadia Margin in Northwest America, or at thrustbelts like the Appenines or the Alps. From compilation and comparison of the lithological and mechanical stratigraphy of these types of orogenic fronts, we identify two generic groups: trench-style and foreland-basin-style mechanical stratigraphy. These two fundamentally different mechanical stratigraphies suggest that the strength contrast between sediments and weak detachments might relate to distinct types of orogenic fronts. Moreover, in the past, most studies focused on single-detachment systems only. As known from orogens worldwide, settings with two detachments are quite abundant. However, the extent to which results from single detachment modelling can be extrapolated to multiple detachment systems is unclear. Therefore, the frictional strength contrast between detachments and incoming layers, and multiple detachments are the key points of this study.

To better understand mass transfer geometry and deformation process, we choose 2D analogue modelling for understanding the role of frictional strength contrast and multiple detachments at orogenic fronts. The modelling is run in a glass-sided apparatus measuring (length, width, height) 200 x 20 x 40 cm. Three experiments were performed, varying in their compositions of the incoming layers and weak layers. For obtaining best imaging of strain localization and fault propagation with a high temporal and spatial resolution, we use Particle Imaging Velocimetry (PIV). The experimental results show the strength contrast to influence the activation of weak layers. For example, when the strength contrast (peak friction ratio) exceeds 1.2, multiple weak layers instead of a single weak layer become active detachments. This suggests that the level of strength contrast and number of weak layers controls different orogenic front types. Moreover, the forethrusts in the multiple detachment system originate from either the upper or lower detachment. At this moment, we still attempt to figure out if there is a specific rule for predicting from which detachment the forethrusts develop.

Yet none of these experiments has resulted in generating landward vergent thrusts as seen at the Cascadia margin. However, since we know the influence of strength contrast and multiple weak layers, we speculate that combining intrinsic properties of material at the orogenic front and factors such as erosion and sedimentation might have the chance to trigger backthrusts at the wedge front.