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Quantification of lateral variation of basal friction on the kinematics and mass transfer patterns of accretionary wedge

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In the last few decades the kinematics and mechanics of accretionary wedges have been extensively studied utilizing analogue sandbox experiments as well as numerical simulation techniques. In accordance to the critical taper theory, all theses studies revealed that internal and basal friction are key factors controlling the kinematics and mechanics of accretionary prisms. Particularly internal deformation mode, mass transfer patterns, and wedge geometry, e.g. slope taper, dip angle of accretionary faults and out-of-sequences thrusts, are basically controlled by friction conditions at the basal décollement. In addition, three-dimensional changes along strike are commonly observed in nature, e.g. along fold and thrust belts (e.g. McDougall & Khan, 1990). Resulting transfer zones are manifold and can e.g. be related to pre-existing basement faults, variation in lithological thicknesses, and especially changes in basal friction or basal rheology.

However, to date only few studies have dealt with the investigation of deformation behavior, fault kinematics, and mass transfer patterns of accretionary wedges with varying basal friction and/or rheology at the décollement. Hence, less is known about the geometry, internal deformation and mass transport pathways of the transfer zones between these different wedge domains. Consequently, main purpose of this study is to determine the influence of lateral variations of basal friction conditions on the mechanics and kinematics of accretionary wedges. In particular, we focus on wedge geometry and mass transfer patterns as a function of basal friction. To achieve this, the evolving wedge taper and the wedge extension, the position and geometry of faults, as well as particle transport pathways are analyzed as a function of the spatial distribution of basal friction along the décollement.

For these studies, we use a numerical particle-based method - the Discrete Element Method (DEM), which allows investigation of such complex deformation processes in the upper brittle crust in three dimensions. This technique enables the testing of a wide range of material parameters and model configurations. Furthermore, detailed information about wedge evolution, internal structures and mass transfer modes at arbitrary horizontal or vertical slices could be retrieved. This results in a high temporal and spatial resolution of deformation processes and mass transfer modes. Hence, these 3D models reveal a deeper understanding of long-term accretion modes.

In all experiments classical accretionary wedges evolve in accordance to the Critical Taper Theory due to continuous subduction. In accordance to the different basal frictions a flat, gently shaped frontal wedge evolves in case of low basal friction whereas a steeper slope could be observed at a strong basal décollement. In addition, the frontally accreted wedge has a larger extension in the direction of convergence compared to the basal accreted wedge. In both wedges' domains typical mass transfer patterns could be observed where most of the material is transported in the direction of subduction. Consequently, the deformation front shows a remarkable offset at the position of the transfer zone between the two different frictional décollement. Here, the outer flank (side wall) of the frontally accreted wedge destabilizes and material slides. Besides, no lateral mass transport occurs at the transfer zone; particle paths follow the direction of convergence perpendicular to the deformation front.