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Numerical investigation of micro-scaled localization and micromechanics in a granular soil specimen

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For many geological deformation processes the existence of a mechanically weak layer is presumed. There is an ongoing debate concerning the exact nature of shear localization in these layers.

To address this question, we use numerical shear box tests utilizing the Discrete Element Method (DEM). The advantage of such numerical tests over analogue ones is the control of a finite set of boundary conditions. Our focus lies on modelling micro-scaled localization patterns and micromechanical properties. Specifically, we study the influence of (1) stratification and (2) fault surface roughness. The influence of stratification is analyzed by shearing a numerical specimen where a numerical clay layer is sandwiched between (a) two silt layers and (b) two clay layers with varying properties. Fault surface roughness is modelled by systematically changing boundary surface roughness of the numerical shear test apparatus.

Our results indicate that overall frictional strength of a material package is a result of different deformation modes which also govern localization phenomena. An important role plays the ability of single particles to slide, roll or rotate, which to a large extent is influenced by particle friction contrast. We show that localisation switches from one layer to adjacent ones even if differences of material properties are very small.

Variation in boundary roughness leads to differences in stress transmission onto the sample. Depending on the maximum particle diameter of the sample, we found an upper and lower threshold level of roughness. In between these values, deformation is distributed throughout the sample; above and below shear becomes highly localized.