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Scaled Analogue Models of the Evolution of Normal Fault Systems in Carbonates

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Sandbox modeling has been used extensively over the last decades to study structural evolution. The materials used to date are however not well scaled for studying rocks with a high brittleness index, i.e. materials that are strong in comparison to the mean effective strength. Typically, materials like sand and clay do not develop brittle, dilatant structures observed in rocks like basalt and carbonate at shallow crustal depth.

In this work we present a scaled analogue model using a fine-grained, cohesive powder (CaSO4 $^1/_2$ H2O). Deformation experiments document material properties that allow scaling with respect to the natural prototypes.

The tensile strength of the powder is approximately 40 Pa, depending on the state of consolidation. Compression and shear tests show that the material parameters (Young's modulus, cohesion, porosity) also depend on the state of consolidation/compaction, whereas the friction angle remains virtually constant. The behavior of these criteria allows analogue models of brittle rocks at scales between 1:15,000 and 1:600,000 depending on the properties of the prototypes carbonate or basalt.

A model of a graben structure is presented using homogeneous or layered material sequences. In the layered sequences, sand was used to decouple the layers forming a mechanical stratigraphy. Deformation is documented by time-lapse digital photography. These datasets are analyzed by Particle Imaging Velocimetry, which produces a

high resolution displacement field as a function of time with associated measures like strain or vorticity.

First results show – among others - mode-I fractures, mode-II faults with dilatant jogs, fragmentation processes in asperities, vertical gravity-driven mass transport along the fault zones, and the importance of mechanical stratigraphy