EGU21-13590
https://doi.org/10.5194/egusphere-egu21-13590
EGU General Assembly 2021

Analogue modelling of strike-slip tectonics from basin to structural-scale comparing silica sand and new rock-analogue materials

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Strike-slip fault zones commonly display complex 3D geometries, with high structural variability along strike and with depth and their architecture and evolution are difficult to analyse. In this regard, analogue modelling represents a powerful tool to investigate the structural, kinematic and mechanical processes in strike-slip fault systems with variable scales. In detail, dynamically scaled experiments allow the direct comparison between model and nature. The geometrical scale factor defines the model resolution, in terms of model/prototype length equivalence, and depends on the physical properties of prototype and model material. Therefore, the choice of the analogue material is critical in scaled analogue experiments.
Granular materials like dry silica sand are ideal for the simulation of upper crustal deformation processes due to similar non-linear strain-dependent deformation behaviour of granular flow and brittle rock deformation. Comparing the geometrical scaling factor of the common analogue materials applied in tectonic models, we identified a model resolution gap for the simulation of fault-fracture processes corresponding to the structural scale (1 m – 100 m) observed in fault zones and damage zones in outcrops, field studies or subsurface well data. We developed a new Granular Rock-Analogue Material (GRAM) for the simulation of fault-fracture processes at the structural scale. GRAM is an ultra-weak sand aggregate composed of silica sand and hemihydrate powder capable to deform by tensile and shear failure under variable stress conditions. Based on dynamical shear tests, the new GRAM is characterised by a similar stress-strain curve as dry silica sand and has a geometrical scaling factor $L^* = L_{model}/L_{nature} = 10^{-3}$ (1 cm in model = 20 m in nature).
We performed strike-slip experiments at two different length scales, applying as model material dry silica sand and the new GRAM. Digital Image Correlation (DIC) time-series stereo images of the experiments surface allowed the comparison of the developed structures at different stages of dextral displacement above a single planar basement fault. The analysis of fractures localisation and growth in the strike-slip zone with displacement and strain components enabled the comparison of the different structural styles characterising dry silica sand and GRAM models. The application of the developed GRAM in scaled experiments can provide new insights to the multi-scale investigation of complex deformation processes with analogue models.