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Design, Rheology and Scaling of Granular Rock-Analogue Materials (GRAM) for Multi-scale Fault-Fracture Simulations

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The complexity of fault-fracture processes in the Earth crust that we can observe in fault zones exists on all scales ranging from regional scales of fault systems to the mesoscopic scale of fracture systems in fault damage zones and the microscale of fractures. Accurate physical modelling of these fault-fracture processes is critical to our understanding of this fundamental complexity and the underlying multi-scale processes.

Currently, none of the analytical, numerical, or analogue models and lab-based rock material tests can accurately describe the physical processes on all relevant scales. However, accurate multi-scale physical modelling techniques and derived predictive tools are critical to many areas of geoscience ranging from our need for the search and management of natural resources as well as the analysis and mitigation of environmental hazards, which have strong societal impact.
We therefore aim to design new granular rock-analogue materials (GRAM) capable to simulate multi-scale fault-fracture processes physically correct in 3D over all observational scales (structure-fault-fracture) in scaled analogue experiments.

We aim to develop new cohesive Granular Rock-Analogue Materials (GRAM) with non-linear elastic-frictional-plastic properties capable to simulate the complex material behaviour (e.g. stress-strain evolution) of brittle rocks ranging from tensile failure to shear failure under variable stress conditions in the upper Earth crust.

Based on GRAM this project will develop integrated material science concepts and physical experiments with high-resolution strain monitoring utilising DIC/DVC (Digital image/volume correlation) for the simulation of multi-scale non-linear fault-fracture processes in brittle crustal fault zones in scaled analogue experiments on all relevant spatial and temporal scales ranging from structural to sample scales and from discrete deformation events to geological time scales.

Scaled analogue experiments using GRAM can:
(1) Analyse the underlying fundamental processes,
(2) Provide the basis for the development of accurate numerical forward-modelling methods
(3) Can help to develop predictive models for the analysis of fault and fracture processes.

This new integrated material design & physical modelling approach has long-term research potential for the simulation of crustal deformation processes ranging from long geological time scales to short earthquake fault events.