Discrete element modelling experiments on the formation of layer-parallel veins in multilayer sequences
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Mechanical anisotropy caused by layering in rocks and the occurrence of pre-existing layer-parallel veins can have an influence on formation of subsequent layer-parallel veins. We use Discrete Element Modelling (DEM) with the ESyS-Particle code [1] to gain insight into the parameters that control the formation, spatial and thickness distribution of layer-parallel veins in multilayer sequences.

Virtual rock samples are represented numerically in 2D by packings of spherical discrete elements. An insertion-based algorithm generates isotropic, randomised particle packings with a power-law particle-size distribution. These spheres interact with each other through frictional and bonded interactions. Brittle failure is represented by the breaking of these bonds. The coalescence of multiple broken bonds represents a fracture. These fractures can subsequently be filled with new discrete elements, effectively modelling the formation of veins.

Four parameter sets of mechanical micro properties of inter-particle bonds are defined in the models, essentially yielding (1) a competent and (2) incompetent matrix, (3) a vein material and (4) a vein-matrix interface. Each combination of parameters and particle packings is calibrated to fit a predetermined Mohr-Coulomb type failure envelope, via an automated calibration procedure.

Several multilayer models are generated and these numerical specimens are brought to extensional failure under constant strain rates by gradually changing effective stress states at the model boundaries. Different types of veins and vein generations can be modelled, ranging from single veins, over crack-seal veins to anastomosing veins, by varying the mechanical strength of competent and incompetent matrix, vein and interface material. Our approach allows a systematic study of the mechanical parameters controlling the progressive formation of layer-parallel veins, vein spacing and fracture and vein thickness distributions. In particular, the influence of mechanical anisotropy caused by lithological layering and/or pre-existing veins can be assessed.

Here we present preliminary results on these DEM experiments and some first insights gained from the parameter sensitivity study. We tentatively compare the modelling results with some natural vein systems, which will be the focus of further study.

References: