Investigating fault sinuosity using discrete element modelling in 3D

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Scaled numerical models of faults are useful complements to geological data and by providing insights into fault dynamics they can improve our understanding of the different stages of development of normal fault systems, from nucleation through to localisation and maturity.

In this work, we use Particle Flow Code in three dimensions, which implements the Distinct Element Method (DEM), to study the development of systems of normal faults. The modelling is based on spherical particles that interact via a linear force-displacement law. Cohesion is modelled by adding linear elastic bonds to particle-particle contacts. These bonds break if the critical normal or shear strength is exceeded, thus creating a fracture surface within the rock volume. Model boundaries are represented by rigid and frictionless walls enclosing the modelled volume vertically and at the ends, with periodic lateral boundaries. Extension is replicated by slowly moving the end walls away from the centre while maintaining a constant confining pressure.

The DEM models replicate many aspects of the geometry and dynamics of natural fault systems with stages of fault nucleation, propagation, interaction and linkage. Here we focus on the sinuosity of model fault map traces which show a similar variability to that seen in nature. In the models, fault trace sinuosity is negatively correlated with the Young's modulus of the rock, so that faults become less sinuous as the stiffness of the solid medium increases. This relationship supports a model in which the lengths of fault segments formed at the early stages of extension are smaller in rocks with lower Young's modulus than in rocks with higher Young's modulus. Longer initial fault segments become connected as displacement increases, to give lower sinuosity faults.