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A new strategy for the geological use of discrete element numerical sandbox models

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Due to a wish to understand the dynamics and kinematics of observed geological structures, modelling has been used since the last decades of the 19th century. First analogue mechanical experiments and later in the 20th century - as a consequence of increasing computer power - numerical simulations have contributed with important insight into how geological structures evolve as a consequence of dynamic loads. In the lab or on the computer the structures can be observed as they form. The experiments may be repeated with varying initial and boundary conditions, and in this way the kinematic and dynamic principles behind the structures can be pursued.

The great advantage of the numerical modelling techniques, as compared to analogue techniques, is that they provide the modeller with good control of the mechanical properties of the material involved. Further, the numerical models do not have to be scaled to fit the spatial or temporal limitations of a physical laboratory, and they can easily be reproduced and visualized.

One such numerical technique is the Discrete Element Method (DEM) providing a computationally straightforward scheme for simulating the complex behaviour of granular matter at very large strains. The method involves calculating the kinematic advancement of a large number of spherical particles (grains) from their mutual contact forces and using Newtonian physics.

However, as a modelling tool in the field of structural geology, the use of DEM is limited by the method's inherent difficulty in reproducing the frictional properties of real rocks. Particularly, the angle of internal friction of a DEM particle assembly does not correspond to the micro-mechanical angle of friction specified for the particles. Hence, the angle of internal friction of e.g. a layer of model sand is not directly specified by the modeller, but can at best be estimated from a series of calibration experiments.

To improve this situation a new computational strategy for discrete element simu-

lations (named SDEM) is presented here. SDEM reproduces friction angles, as the internal friction angle of a SDEM particle model matches the micro-mechanical friction angles specified for the particles. As a consequence, in SDEM models faults and shear zones form at angles as expected from the Mohr-Coulomb failure criterion.
This contribution outlines the theory behind SDEM and presents results from SDEM sandbox models including propagating thrusts, normal faults and fault propagating folding. Results of the numerical experiments are checked against results of analogue experiments and seismic images of real fault systems. The good correlation between modelled structures and specific natural structures from the Danish North Sea is furthermore used to infer the dynamics behind the observed natural structures.