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Numerical modelling of subglacial sediment deformation

Anders Damsgaard Christensen (1), David Lundbek Egholm (1), Jan A. Piotrowski (1,2)

(1) Aarhus University, Department of Earth Sciences, Aarhus C, Denmark (anders.damsgaard@geo.au.dk), (2) University of Sheffield, Department of Geography, Sheffield, United Kingdom

Numerical simulation of subglacial sediment deformation on micro- to intermediate scale offers detailed insight into the origin of structural and textural features related to progressive shear strain. The Discrete Element Method (DEM) is used to simulate the behaviour of granular material under conditions mimicking subglacial shear stress, normal stress and shearing velocities.

Based on a Lagrangian approach, each particle is an unbreakable spherical entity with spatial and rotational degrees of freedom and inertia. Treating the particles as elastic bodies with friction at contact surfaces approximates inter-particle contact forces. By discretizing time into small steps, the resulting movement is calculated by Eulerian integration of Newton's second law of motion. The particle assemblage is subjected to gravity and forced by a set of fixed boundary conditions, moving in a shearing fashion with periodic lateral boundaries, allowing high strain simulations with a limited number of total particles. The numerical approach offers complete user control of material properties, simulation parameters and boundary conditions while yielding a very high continuous data output readily available for high-precision statistical analysis.

We use laboratory ring-shear experiments on granular material as benchmark experiments for validating the numerical model. Comparisons between laboratory- and computational experiments are presented. Also presented are preliminary results from a research project concerning pressure-distributing force chain patterns, parameter dependence of the mechanical rheology of the material, and analysis of particle advection and intergranular mixing during high-strain shear experiments.

The future work plan involves code modification to include porewater flow for investigating mechanical and thermal feedbacks between the granular flow and porewater flow (e.g. during three-dimensional plowing movements). The higher computational requirements are supported by acceleration available from general-purpose graphics processing units (GPGPUs).