Geophysical Research Abstracts,
Vol. 11, EGU2009-8503, 2009
EGU General Assembly 2009

Modelling to very high strains

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Ductile strains in shear zones often reach extreme values, resulting in typical structures, such as winged porphyroclasts and several types of shear bands. The numerical simulation of the development of such structures has so far been inhibited by the low maximum strains that numerical models can normally achieve. Typical numerical models collapse at shear strains in the order of one to three. We have implemented a number of new functionalities in the numerical platform "Elle" (Jessell et al. 2001), which significantly increases the amount of strain that can be achieved and simultaneously reduces boundary effects that become increasingly disturbing at higher strain.

Constant remeshing, while maintaining the polygonal phase regions, is the first step to avoid collapse of the finite-element grid required by finite-element solvers, such as Basil (Houseman et al. 2008). The second step is to apply a grain-growth routine to the boundaries of polygons that represent phase regions. This way, the development of sharp angles is avoided. A second advantage is that phase regions may merge or become separated (boudinage). Such topological changes are normally not possible in finite element deformation codes. The third step is the use of wrapping vertical model boundaries, with which optimal and unchanging model boundaries are maintained for the application of stress or velocity boundary conditions. The fourth step is to shift the model by a random amount in the vertical direction every time step. This way, the fixed horizontal boundary conditions are applied to different material points within the model every time step. Disturbing boundary effects are thus averaged out over the whole model and not localised to e.g. top and bottom of the model. Reduction of boundary effects has the additional advantage that model can be smaller and, therefore, numerically more efficient.

Owing to the combination of these existing and new functionalities it is now possible to simulate the development of very high-strain structures.

Jessell, M.W., Bons, P.D., Evans, L., Barr, T., Stüwe, K. 2001. Elle: a micro-process approach to the simulation of microstructures. Computers & Geosciences 27, 17-30.

Houseman, G., Barr, T., Evans, L. 2008. Basil: stress and deformation in a viscous material. In: P.D. Bons, D. Koehn & M.W.Jessell (Eds.) Microdynamics Simulation. Lecture Notes in Earth Sciences 106, Springer, Berlin, 405p.