Geophysical Research Abstracts
Vol. 19, EGU2017-13629, 2017
EGU General Assembly 2017

Computational Models of Rock Failure

Dave A. May (1) and Marc Spiegelman (2,3)

(1) Department of Earth Sciences, University of Oxford, Oxford, United Kingdom (david.may@earth.ox.ac.uk), (2) Department of Earth and Environmental Sciences, Columbia Univsersity, New York, USA, (3) Lamont-Doherty Earth Observatory, Columbia Univsersity, Palisades, USA (mspieg@ldeo.columbia.edu)

Practitioners in computational geodynamics, as per many other branches of applied science, typically do not analyse the underlying PDE's being solved in order to establish the existence or uniqueness of solutions. Rather, such proofs are left to the mathematicians, and all too frequently these results lag far behind (in time) the applied research being conducted, are often unintelligible to the non-specialist, are buried in journals applied scientists simply do not read, or simply have not been proven.

As practitioners, we are by definition pragmatic. Thus, rather than first analysing our PDE's, we first attempt to find approximate solutions by throwing all our computational methods and machinery at the given problem and hoping for the best. Typically this approach leads to a satisfactory outcome. Usually it is only if the numerical solutions "look odd" that we start delving deeper into the math.

In this presentation I summarise our findings in relation to using pressure dependent (Drucker-Prager type) flow laws in a simplified model of continental extension in which the material is assumed to be an incompressible, highly viscous fluid. Such assumptions represent the current mainstream adopted in computational studies of mantle and lithosphere deformation within our community. In short, we conclude that for the parameter range of cohesion and friction angle relevant to studying rocks, the incompressibility constraint combined with a Drucker-Prager flow law can result in problems which have no solution. This is proven by a 1D analytic model and convincingly demonstrated by 2D numerical simulations.

To date, we do not have a robust "fix" for this fundamental problem.

The intent of this submission is to highlight the importance of simple analytic models, highlight some of the dangers / risks of interpreting numerical solutions without understanding the properties of the PDE we solved, and lastly to stimulate discussions to develop an improved computational model of rock failure suitable for geodynamic studies.