Towards micromechanics-based numerical models of brittle deformation

Léo Petit[1], **Jean-Arthur Olive**[1], **Harsha S. Bhat**[1], **Paul Betka**[2], **Laetitia Le Pourhiet**[3]

[1] Laboratoire de Géologie de l'École Normale Supérieure de Paris, PSL Research University, CNRS UMR 8538, 24 rue Lhomond, 75005 Paris, France
[2] Lamont-Doherty Earth Observatory, Columbia University, USA
[3] Sorbonne Université, CNRS-INSU, Institut des Sciences de la Terre de Paris, ISTeP UMR 7193, F-75005 Paris, France

Keywords: Rock mechanics & Geodynamics

Abstract

A detailed understanding of the processes involved in strain localization within the brittle crust is critical in the study of the structure formed at the plates boundaries. Mountain ranges and sedimentary basins are indeed usually shaped by cumulative strain across fault systems. At the scale of the brittle crust as well as at the scale of the laboratory experiment, faults are known to be the result of distributed damage growth and coalescence. Damage build-up is however missing from the brittle deformation models used in long term tectonics evolution models (LTTEMs) that instead prescribe a modified Mohr-Coulomb plasticity criterion to model the upper crust as an elasto-plastic material. This approach was shown to to show a great sensitivity to unconstrained empirical parameters and does not account for the strain rate dependence of damage models. After showing how damage can be linked to the rheology of the upper crust in the Sandia mountain range (New Mexico, USA), we present a way to design a new generation of models indexing the nucleation of a fault to the growth and coalescence of an initial population of flaws. The continuum damage model of Ashby and Sammis (1990) was used to formulate contitutive relationships between stress and strain, as well as a damage growth rate in order to implement a damaged brittle rheology into the LTTEM SiStER code. The model setup was modified to perform numerical analogs of triaxial press laboratory experiments, as benchmarks for further validation of the micro-mechanical model. Preliminary results give very promising behaviors with the emergence of (1) a weakening of material elastic properties associed with damage growth, (2) a strain rate dependence of the deformation related to the activation of a brittle viscosity as damage increases.