

REDBACK: an Open-Source Highly Scalable Simulation Tool for Rock Mechanics with Dissipative Feedbacks

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Abstract

Multiphysics modeling of geomechanical and geophysical processes has become an indispensable tool for geoscientists to simulate the complex behaviours observed in their various fields of study where multiple mechanisms are involved, including thermal, hydraulic, mechanical and chemical (THMC) laws. This modelling activity involves simulations that are computationally expensive and its soaring uptake is tightly linked to the increasing availability of supercomputing power and easy access to powerful nonlinear solvers such as PETSc (<http://www.mcs.anl.gov/petsc/>). The Multiphysics Object-Oriented Simulation Environment (MOOSE) is a finite-element, multiphysics framework (<http://mooseframework.org>) that can harness such computational power and allow scientists to develop easily some tightly-coupled fully implicit multiphysics simulations that run automatically in parallel on large clusters. This open-source framework provides a powerful tool to collaborate on numerical modelling activities and we are contributing to its development with REDBACK (<https://github.com/pou036/redback>), a module for Rock mEchanics with Dissipative feedBACKs.

REDBACK builds on MOOSE to provide a THMC simulator for Geomechanics, where the energetic formulation highlights the importance of all dissipative terms in the coupled system of equations. We show first applications of fully coupled problems, including the problem of dehydration reactions triggering episodic fluid transfer through shear zones (Alevizos et al, 2014) and clay/shale formations. The physics-based approach used allows focusing on the critical underlying mechanisms which are driving the resulting behaviours observed. REDBACK provides a collaborative and educational tool which captures the physical and mathematical understanding of multi-physical material responses and provides an easy way to apply this knowledge to realistic scenarios, where the size and complexity of the geometries considered, along with the material parameters distributions, add as many sources of different responses.

References:

Alevizos, S., T. Poulet, and E. Veveakis (2014), J. Geophys. Res., 119, 4558–4582, doi:10.1002/2013JB010070