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A fully implicit collocated finite volume scheme for modelling induced seismicity

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The poromechanical response of subsurface formations is critical for the performance and stability of many geo-energy systems. Evaluation of this response often requires the use of different numerical schemes to approximate mass, energy, and momentum balance. Integration of these schemes within one simulation platform allowed for an accurate and efficient coupling. However, different modeling techniques applied for the solution imposes sufficient difficulties and brings complexity to the code. Recently developed Finite Volume (FV) schemes [1, 2, 3] for poromechanics present a unified approach for modeling conservation laws for geo-energy applications.

In this study, we integrate FV collocated discretization schemes for the simultaneous approximation of mass, momentum, and energy balance in Delft Advanced Research Terra Simulator (DARTS) platform. The scheme is based on multi-point flux and multi-point stress approximations [3]. Such a scheme enables a natural integration of conservation laws on the same cell-centered computational grid. Faults are represented by the conformal discrete fracture model [4] where the contact problem with non-linear friction laws is considered. A fully implicit strategy is used for the coupling of fluid, heat, and momentum fluxes. Within this framework, the performance of block-partitioning preconditioning strategies is assessed.

We investigate the stability and convergence of the proposed FV scheme in several benchmark tests. Thereafter, we demonstrate the applicability of the approach to investigate the issue of induced seismicity. The framework is used to model friction experiments at laboratory scale and identify the parameters of friction laws. The proposed unified approach is conveniently integrated with advanced modelling techniques implemented in DARTS, such as operator-based linearization, adjoint gradients and GPU-offloaded linear solvers.

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