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Comparison of sequential and fully-coupled approaches for flow and geomechanics

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Choosing an appropriate modelling approach for fluid flow and stress field interaction in rocks belongs to the key problems within the context of several subsurface applications such as geothermal power generation, disposal of waste water, CO_2 storage or hydraulic fracturing. A central issue in this respect is the question of whether the equations for flow and geomechanics are solved in a fully-coupled manner or by using an operator splitting or a sequential scheme. The latter is a common choice to link existing codes for flow and mechanics. We present a concept that has both implementations available to allow for a detailed comparison. Following this, we introduce a sequential so-called "fixed-stress" scheme after Kim et al. (2010) and a fully-coupled multi-phase flow and geomechanics approach. Both are implemented in the open-source simulation toolbox DuMuX. We test the schemes on a realistic hydraulic fracturing scenario which examines the potential reactivation of a fault due to injection-induced changes of the pressure and stress field. This allows us to examine the applicability of our implemented approaches and, at the same time, provides us with a validity check of our results, as this scenario was previously studied by Rutqvist et al. (2013) using a sequential coupling of TOUGH2 and FLAC3D. Having a fully-coupled scheme at hand also enables us to compare the convergence behaviour and the computational effort of the different coupling schemes. While performing this, we gained insights in how to tackle the high non-linearity of the problem. Furthermore, the high dependence of the solution on the number of iterations performed for the sequential scheme is a key finding of this study.

References

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