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# From localised to homogeneous deformation of porous rocks – insights from laboratory experiments

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Hydraulic stimulation of geothermal wells is often used to increase heat extraction from deep geothermal reservoirs. Initiation and propagation of fractures due to pore pressure build-up increase the effective permeability of the porous medium. Understanding the processes controlling the initiation of fractures, the evolution of their geometries and under which conditions they can be maintained is therefore crucial for enhanced geothermal energy production. In this study, we present an approach including laboratory results of tri-axial experiments on sandstones, micro-structure analysis and numerical modeling aiming at better understanding and identifying the processes controlling the rheology of porous rocks under high differential stress.

Three tri-axial experiments under drained conditions were conducted at room temperature on cylindrical sandstone samples (Bentheim sandstone) under different confining pressures (40, 70 and 100 MPa). In addition, continuous porosity measurements were conducted during these experiments.

To better identify the physical processes controlling the different deformation behaviours, micro-structure analysis has been conducted including X-ray Powder Diffraction (XRD), Electron Microprobe (EMP) and three-dimensional CT scanning. These analyses showed evidences of micro-cracking processes and help quantifying distribution and extend of a damage domain around the localised fracture planes. Evidences of pore collapse were also identified.

We make use of a damage visco-poroelastic model as implemented in the LYNX open-source simulator to account for the physical processes mentioned above. The LYNX simulator in its core compartments relies on the Multiphysics Object-Oriented Simulation Environment (MOOSE), which provides a powerful and flexible platform to solve for multiphysics problems implicitly and in a tightly coupled manner on unstructured meshes, thus providing an efficient computational base to tackle the non-linear, multiphysics problem at hands. In this study, we present some key capabilities of the physical framework which can be used to model long-term rheology of lithospheric porous rocks and how it was constrained using the laboratory experiments. In particular, we emphasize both in terms of laboratory observations and modelling results that porosity evolution plays a major role on the onset of inelastic strain and localised deformation.