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Hydraulic fracturing experiments on a laboratory scale for numerical codes verification

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Engineered Geothermal System (EGS) techniques are utilised in deep and dense hot dry formations to extract heat where conventional geothermal exploitation is not possible due to extremely low permeability of rocks. EGS enhance reservoir permeability by creating new fractures or activating existing fault zones by hydraulic stimulation. It has been estimated that EGS have a potential of generating 4155 TWh of electric energy per year in Germany under most optimistic assumptions (Jain et. al, 2015). However, achieving economically desired results from these systems depends strongly on how well connected and permeable the created fractures are between the injection and the production wells. In hydrocarbon industry, hydraulic stimulations have been performed since the 1950s but estimating the performance of the created fractures has never become trivial or even routine.

In order to overcome this challenge, we attempt to produce a set of hydraulic fracturing data under controlled conditions, which could be utilized to verify different numerical hydraulic stimulation design tools. We conduct experiments at a scale, which is controllable in the laboratory but, at the same time, is realistic enough to provide a reliable data set for verifying the simulation codes, which are used for field-scale stimulation design.

We designed a triaxial compression system where large igneous rock samples sized 300 × 300 × 450 mm^3 are fractured hydraulically in the laboratory by injecting high-pressure fluid into the specimen. Fracture growth and propagation within the rock is monitored by recording acoustic emissions using transducers attached to the specimen. Experiments are performed under controlled conditions, and for a number of injection protocols and stress boundary conditions. For each experiment set, a series of experiments were conducted to ensure reproducibility and accuracy of the measurements. The boundary conditions and results of this benchmark experiment series are distributed amongst several leading research institutes in Europe for verifying the performance of their hydraulic stimulation codes without any further parameter adjustment.

The mismatch observed between the experiments and simulations are attributed to several factors, some of which may be controlled additionally in the laboratory. Currently, we are improving our experimental setup with minor modifications in view of new fracturing experiments to be used as a benchmark for verifying numerical simulation codes.

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