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Single well pore pressure preconditioning for EGS

Barnaby Fryer[1], Mathias Lebihain[2], and Marie Violay[1]
[1]Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland (barnaby.fryer@epfl.ch)
[2]Laboratoire Navier, Champs sur Marne, France

The stress state in the subsurface has been shown to be a hugely important parameter for a wide variety of considerations related to seismicity, both natural and anthropogenic. Industrial operations have been shown to be capable of influencing this subsurface state of stress, as most notably evidenced by instances of induced seismicity related to mining, reservoir impoundment, and reservoir-engineering applications such as production- and injection-induced seismicity related to pore pressure increase. The recognized significance of the stress state for many industrial operations as well as operators' proven ability to influence it, has led to the notion that the stress state can be intentionally preconditioned prior to an operation to that operation’s eventual benefit. The idea of preconditioning was first introduced by the mining industry in the late 1950's as a way to improve rockburst conditions in mines, by blasting to relieve stress in near-face regions. This idea of stress preconditioning has since been extended to the petroleum industry, beginning in the 1970’s and typically focused around hydraulic fracturing. Enhanced Geothermal Systems (EGSs) have been plagued by a number of instances of high-profile induced seismicity, most notably in Basel, Switzerland. This has led to the realization that the development of new reservoir stimulation techniques is crucial for the development of EGS. Here, we propose that the effective stress along a fault intersected by an EGS well be preconditioned prior to stimulation through an extended period of fluid production. Following this production phase, the fault is stimulated through high-pressure injection. Through analytical models related to pressure diffusion, earthquake nucleation, and earthquake rupture, it is suggested that this methodology would result in the halting of near-well nucleated events as they rupture towards the zone of reduced pore pressure. These models assume a constant permeability, linear slip weakening, and a near-critically stressed fault. The investigation is supported by a scaling analysis, shedding light on the suggested required magnitude of the preconditioning phase.

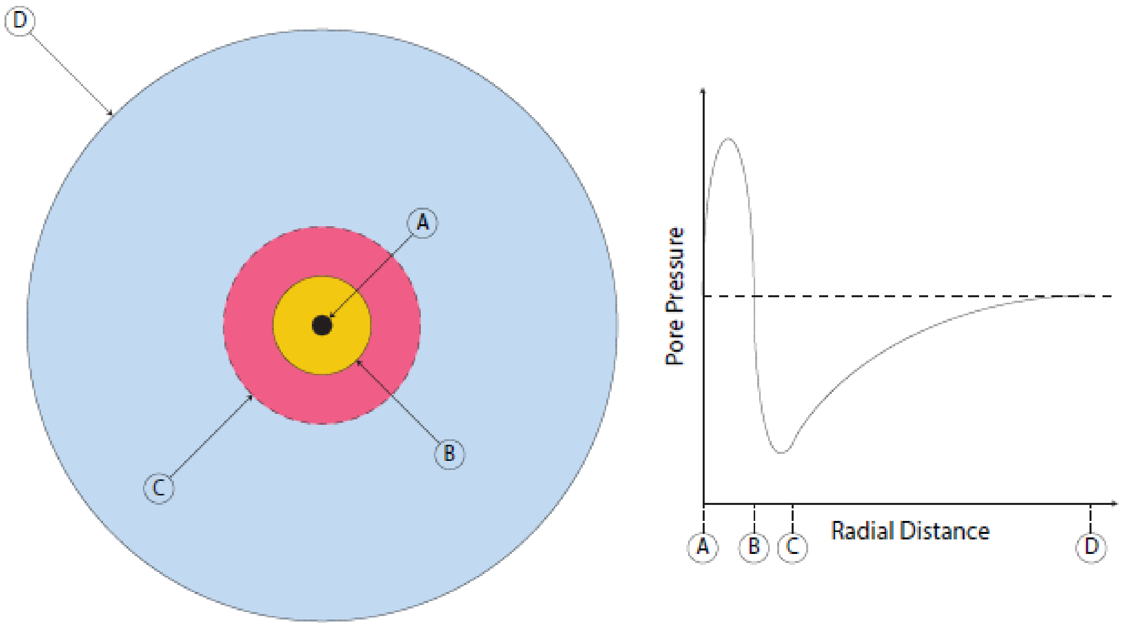

Figure: A schematic illustrating the proposed strategy. On the left, a well (A) is drilled into a fault, shown in plane-view. Fluid is produced from this well, reducing the pore pressure. This production is continued for a significant amount of time, allowing the reduction of pore pressure to be significant and far reaching (D). The well is then stimulated with a short high pressure burst of injection (B). The stimulated zone shears near the well in this high-pressure zone, but is halted by the low-pressure zone (C). The corresponding pore pressure as a function of the radial distance is plotted on the right.