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Mitigation of Seismic Hazards from Hydraulic Fracturing Using Cyclic Injection

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Hydraulic Fracturing (HF) aims at enhancing the permeability of oil and gas production reservoirs by injecting fluids at high pressures into the formation. However, this practice has been a concern to researchers; it causes perturbation to the underground system, alters the pressures and stresses along the nearby dormant faults, and may therefore, induce earthquakes under specific conditions. In this work, we study the efficacy of using a newly emerging technique, Cyclic Hydraulic Fracturing (CHF), to reduce the risk of induced seismicity while efficiently enhancing the reservoir permeability. Instead of injecting the fluid all at once at a high pressure during each stage, CHF increases the connectivity of the reservoir by injecting the same volume in a stage through different cycles. Each cycle represents a pressurization (injection) phase and a depressurization (zero-injection) phase. The effect of CHF on the stability of a fault at a close proximity to the HF operations is assessed using different injection strategies: conventional HF (constant injection per stage) and 2 CHF schemes (3 or 5 cycles per stage). For each strategy, we calculate the Coulomb Failure Stress (CFS) and the rate of seismicity along the fault using a 2D Finite Element poroelastic model. Our numerical simulations show that CHF delays the pore pressure diffusion along the fault due to the depressurization phases that allow the relaxation of the pore fluid pressure. It also reduces the seismicity rate on the fault when compared to conventional HF. Our results suggest that the mitigation of induced seismicity is possible by using a CHF procedure optimized to reduce the seismicity rate i.e., optimized number of cycles and pressurization/depressurization periods. This development paves a way to exploit sites that are abandoned due to seismic hazards.