



Rate and state dependent seismicity during fluid injection in rocks

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Dieterich (1994) developed a theoretical frame of seismicity evolution from a background seismicity due to stress changes in a medium. The theory assumes a volume density of seismic faults with a specific initial slip velocity distribution upon which the stress changes act. Each fault then follows the rate and state dependent frictional law where instabilities develop, but not as Coulomb failure. The evolution is expressed in the form of a differential equation, which can be adapted for the case of fluid pressure changes resulting from injection and even linearized to allow for analytic insight into the properties of the solution. For a constant injection rate the seismic activity increases at a given distance from the injection point once the pressure exceeds a threshold value. If the pressure rate is high enough the seismic activity becomes proportional to the pressure rate in accordance with criticality theory of Shapiro (2002). Once the rate drops the seismicity is reduced to lower levels. Shut off and variable injection rates must be evaluated numerically but lead to results comparable to the criticality theory. The presentation outlines the physical concept of the rate and state approach in comparison to the criticality approach and shows the main analytic and numerical results.