IGPP Virtual Seminar Series

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Why do induced earthquakes occur far from injection wells in California and Oklahoma?

Date: Wednesday, Oct 21, 2020
Time: 12:00 pm, Pacific Time
Host: Tianze Liu

Zoom link:
https://ucsd.zoom.us/j/99714186467?pwd=RWZhV3lnRzE0TVVRRUo1eTYrVnBSdz09
(Password: induced)

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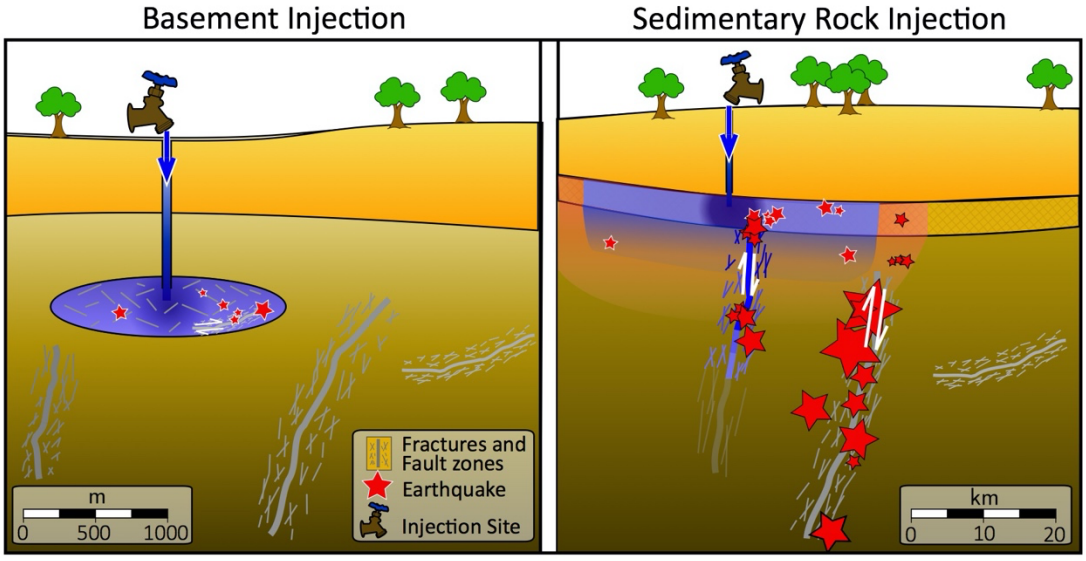

Fluid-injection induced seismicity, at times, occurs at distances and depths of several kilometers from the targeted reservoir. We explored the role of poroelastic stress changes in inducing such deep and distant events. We examine the distance decay of induced events from reservoir and basement injectors in a recently compiled global dataset of

point source injectors and compare the observations with the stress decay in poroelastic models. The observed spatial decay of induced events can be described by a power law for shallow injectors with events occurring at peak distances of more than 10 km. Although injection is above basement, the majority of these events occur well within the basement. Injection directly into basement more commonly leads to spatially compact seismicity sequences that rapidly decay within 1 km from the well.

We investigate the extent and functional form of the expected spatial decay of induced stresses in a coupled poroelastic model, consisting of a high-permeability reservoir with high coupling (i.e. Biot-Willis ~ 1) and low permeability basement with low coupling (i.e. Biot-Willis ~ porosity). Depth-dependent permeability values are taken from average hydrological measurements, and changes in Bio-Willis coupling coefficient are taken from laboratory measurements at different confining pressures. Shallow injection into sedimentary rocks lead to far-reaching pressure changes and coupled reservoir deformation. Elastic deformation of the reservoir induces stresses at larger depths i.e. within the basement even when direct pressure changes are negligible in the basement. Elastic stresses in the basement are amplified by an increase in elastic moduli from sediments to granite. Injection directly into basement leads to locally high pore pressures and small elastic stress changes due to inefficient poroelastic coupling. The resolved fluid/solid stress interaction in our model potentially explain several observations: 1) Earthquakes induced by shallow injection may occur deep within the basement even if faults are not hydraulically connected; 2) injection above the basement can lead to spatially extensive induced earthquake sequences; and 3) deeper injection into basement leads to spatially-compact seismicity if permeability and poroelastic coupling are small.