

Water-quality and induced seismic activity related to water-use and disposal for oil and gas development: A teaser on new work and products

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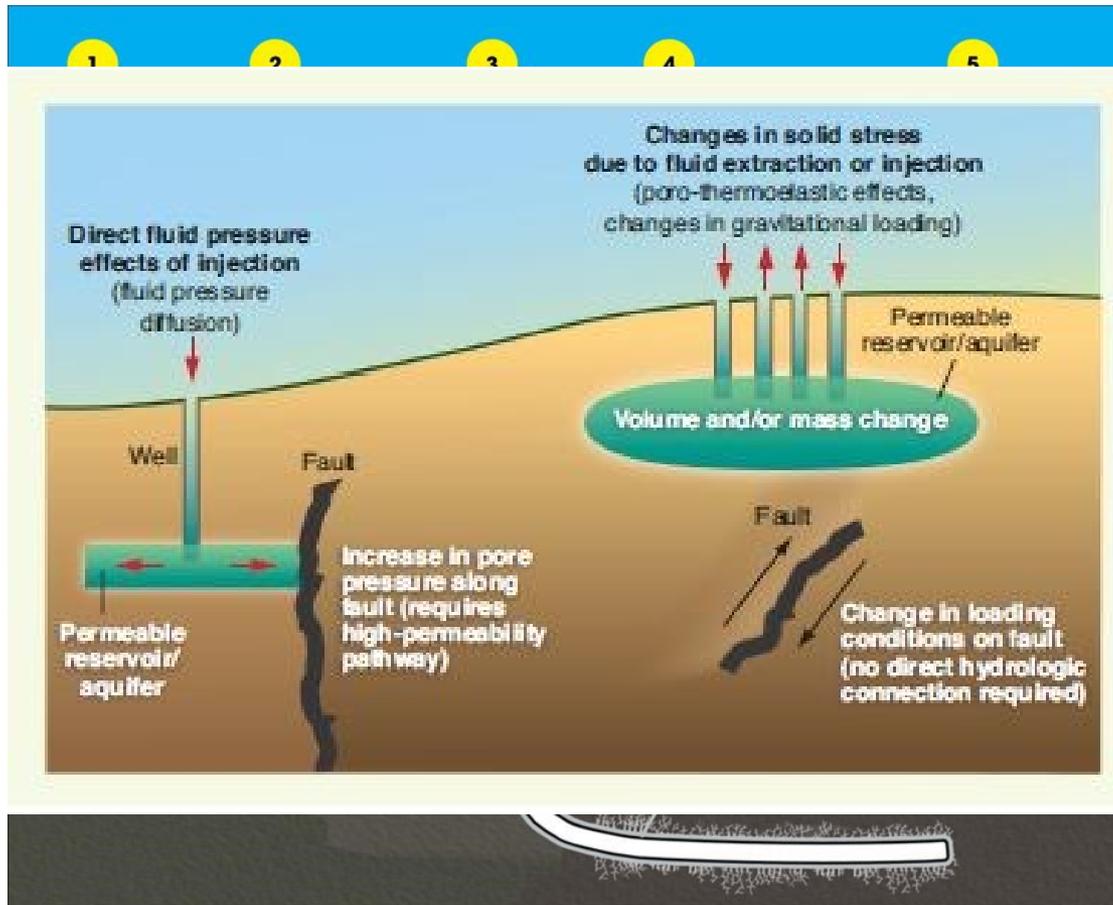
Seismic surge in Oklahoma

Earthquakes/year



Annual rate of earthquake sequences with at least one $M \geq 3$ earthquake in California (light blue) and Oklahoma (dark blue) since 1973. (Based on USGS earthquake catalog data from <http://earthquake.usgs.gov>.)

- Within the central and eastern United States, the earthquake count has increased dramatically over the past few years. More than 300 earthquakes with $M \geq 3$ occurred in the 3 years from 2010 through 2012, compared with an average rate of 21 events/year observed from 1967 to 2000
- In 2014, the rate of occurrence of earthquakes with magnitudes (M) of 3 and greater in Oklahoma exceeded that in California



- Fracking intentionally induces numerous micro-earthquakes, the vast majority with $M_w < 1$
- For the most part, fracking induces only micro-earthquakes (too small to be felt)
- There has been a growing realization that the principal seismic hazard from injection-induced earthquakes comes from those associated with disposal of wastewater into deep strata or basement formations

“To a large extent, the increasing rate of earthquakes in the mid-continent is due to fluid-injection activities used in modern energy production”

- Rate of seismicity may be controlled by adjusting the pore pressure at depth where earthquakes initiate
- Setting “traffic light” seismic activity thresholds
- Enhanced seismic monitoring for early detection of lower magnitudes to identify and related seismic hazards

Trends in Hydraulic Fracturing Distributions and Treatment Fluids, Additives, Proppants, and Water Volumes Applied to Wells Drilled in the United States from 1947 through 2010—Data Analysis and Comparison to the Literature
By Tanya J. Gallegos and Brian A. Varela, 2015 – USGS SIR)

Assessment of surface water chloride and conductivity trends in areas of unconventional oil and gas development—Why existing national data sets cannot tell us what we would like to know (Bowen, et.al. 2015 in *Water Resources Research*)

Coping with earthquakes induced by fluid injection (McGarr et al, 2015 in *Science* (Geophysics))

