

Evidence #1: Wastewater injected into the ground change the stress in Earth's crust.

Recent geological data shows that this deep well injection may increase the internal forces within Earth's crust. Scientists commonly call these internal forces *stress*. Deep well injection may affect stress in Earth's crust in three ways, as shown in Figure 1 below. First, injection may increase the shear stress, which is the internal force along major cracks in Earth's crust, called faults. Second, injection may reduce the normal stresses that typically hold Earth's crust steady. Third, injection may increase pressure within the pore spaces in Earth's crust, particularly along faults.

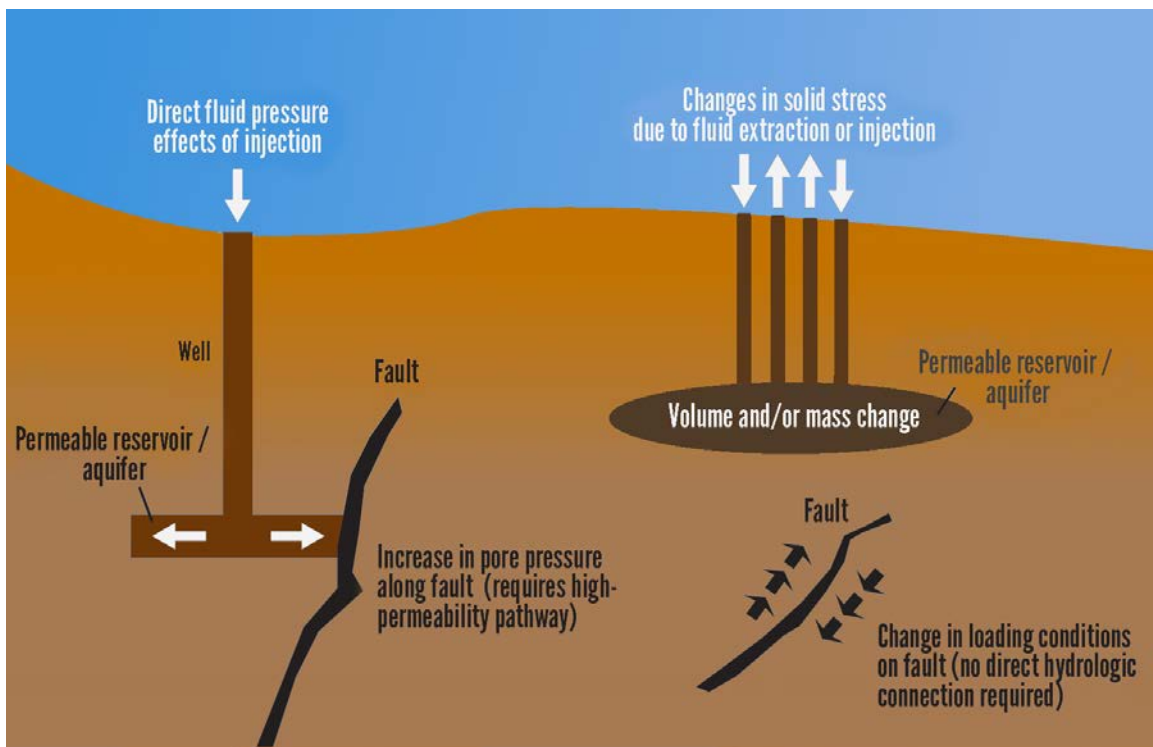


Figure 1. Stresses in Earth's crust potentially caused by wastewater injection. Credit: Wright Seneres

Evidence #2: During recent years, the number of earthquakes near fracking sites was 11 times higher than the 30-year average.

Significant earthquakes are increasing within the continental interior of the United States. Figure 1 below shows the number of earthquakes in Oklahoma since 1978. The first bar is the average number of earthquakes over the period 1978-1999. Each line after that is one year. In 2011 alone, there were five earthquakes of magnitude greater than 5.0. This increased earthquake activity has occurred at the same time that nearby fracking activities have increased.

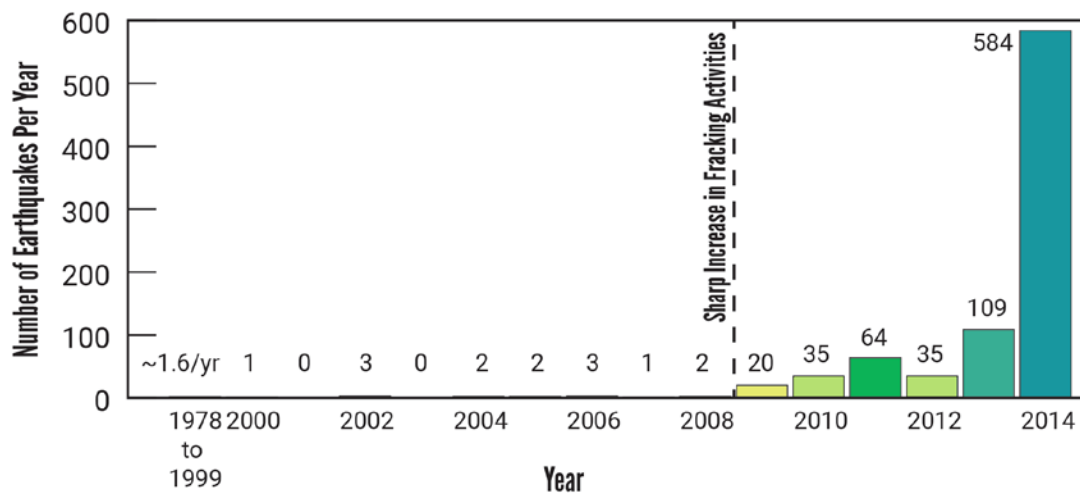


Figure 1. Annual number of earthquakes in Oklahoma from 1978 to 2014. Credit: Wright Seneres

Evidence #3: Convection of hot but solid and ductile rocks in the upper mantle creates stresses in Earth's crust. These stresses cause Earth's crust to fracture.

An *earthquake* is what happens when two blocks of the crust suddenly slip past one another. The surface where the blocks slip is called the *fault* or *fault plane*. The *hypocenter* is the location below Earth's surface where the earthquake starts. The location directly above it on the surface of Earth is called the *epicenter*.

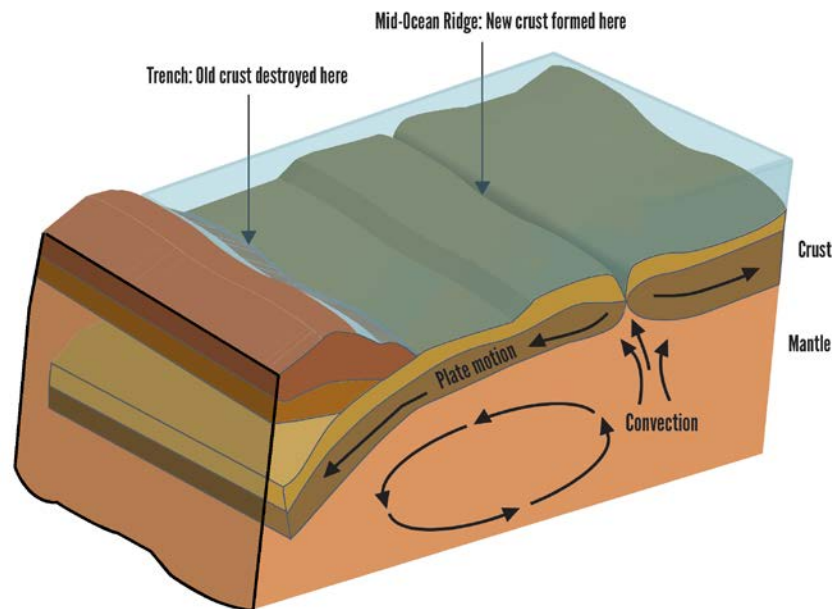


Figure 1. Convection in Earth's mantle causes plates to move. Credit: Wright Seneres

Figure 1 above shows two of Earth's four major layers: the *mantle* and *crust*. The crust and the top of the mantle make up a thin skin on the surface of our planet. But this skin is not all in one piece—it is made up of many pieces like a puzzle covering the surface of Earth. These puzzle pieces keep slowly moving around, sliding past one another and bumping into each other. These pieces are *tectonic plates*, and the edges of the plates are called the *plate boundaries*.

The plate boundaries are made up of many faults, and most of the earthquakes around the world occur on these faults. The edges of the plates are rough and get stuck, but the rest of the plate keeps moving. Because of this movement, pressure builds up. When the plate has moved far enough, the edges unstuck on one of the faults and there is an earthquake.

While the edges of faults are stuck together, the energy that would normally cause the blocks to slide past one another is stored. However, the blocks may rupture (break) when the force is very large. Ruptures can free the large blocks from sticking together and all that stored up energy is released. The energy radiates outward from the fault in all directions in the form of *seismic waves*—like ripples on a pond. The seismic waves shake Earth as they move through it. When the waves reach Earth's surface, they shake the ground and anything on it—like our houses and us!

Evidence #4: Many earthquakes are currently occurring in regions surrounding fracking sites.

A recent study released by the United States Geological Survey reveals that many earthquakes have been recently occurring in Oklahoma (Figure 1). Many earthquakes have struck Oklahoma in a short period of time. When earthquakes strike the same area in a short period of time, they are called *earthquake swarms*. Scientists do not have any evidence that earthquake swarms occurred in Oklahoma in the more distant past.

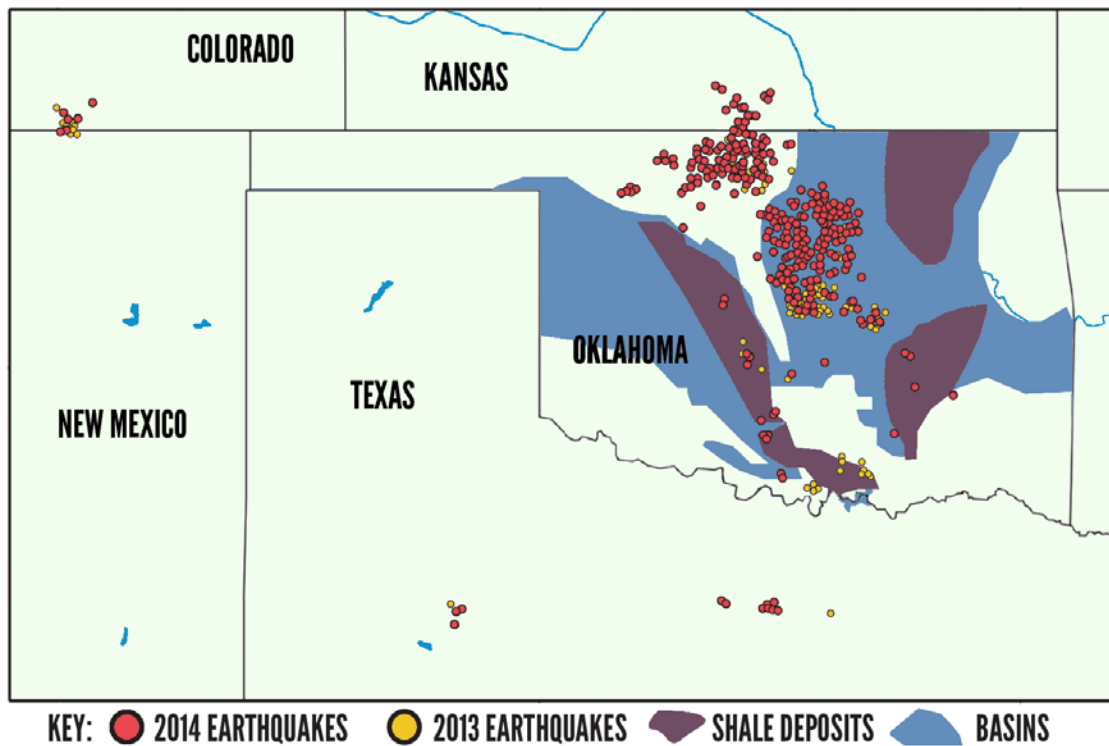


Figure 1. Areas of recent earthquake swarms. The red dots show earthquakes in 2014. The yellow dots show earthquakes in 2013. Each symbol represents earthquakes of magnitude 2.7 or greater.

Credit: Wright Seneres

The Oklahoma earthquake swarms are occurring over the same region that saw a sharp increase in deep wastewater injections associated with fracking. Earthquakes pose a potential risk to public safety. In 2011, a magnitude 5.6 earthquake near a fracking wastewater injection site in Prague, Oklahoma, injured two people and destroyed 14 homes. A magnitude 5.3 earthquake struck a remote part of Colorado. This remote site was also near a fracking wastewater injection site.