Wastewater disposal may trigger quakes at a greater distance than previously thought

May 1 2014

Oil and gas development activities, including underground disposal of wastewater and hydraulic fracturing, may induce earthquakes by changing the state of stress on existing faults to the point of failure. Earthquakes from wastewater disposal may be triggered at tens of kilometers from the wellbore, which is a greater range than previously thought, according to research to be presented today at the annual meeting of the Seismological Society of America (SSA). As an indication of the growing significance of man-made earthquakes on seismic hazard, SSA annual meeting will feature a special session to discuss new research findings and approaches to incorporating induced seismicity into seismic hazard assessments and maps.

The number of earthquakes within central and eastern United States has increased dramatically over the past few years, coinciding with increased hydraulic fracturing of horizontally drilled wells, and the injection of wastewater in deep disposal wells in many locations, including Colorado, Oklahoma, Texas, Arkansas and Ohio. According to the U.S. Geological Survey (USGS), an average rate of 100 earthquakes per year above a magnitude 3.0 occurred in the three years from 2010-2012, compared with an average rate of 21 events per year observed from 1967-2000.

"Induced seismicity complicates the seismic hazard equation," said Gail Atkinson, professor of earth sciences at Western University in Ontario Canada, whose research details how a new source of seismicity, such as an injection disposal well, can fundamentally alter the potential seismic hazard in an area.

For critical structures, such as dams, nuclear power plants and other major facilities, Atkinson suggests that the hazard from induced seismicity can overwhelm the hazard from pre-existing natural seismicity, increasing the risk to structures that were originally designed for regions of low to moderate seismic activity.

A new study of the Jones earthquake swarm, occurring near Oklahoma City since 2008, demonstrates that a small cluster of high-volume injection wells triggered earthquakes tens of kilometers away. Both increasing pore pressure and the number of earthquakes were observed migrating away from the injection wells.

"The existing criteria for an induced earthquake do not allow earthquakes associated with the well activity to occur this far away from the wellbore," said Katie Keranen, assistant professor of geophysics at Cornell University, who led the study of the Jones earthquake swarm. "Our results, using seismology and hydrogeology, show a strong link between a small number of wells and earthquakes migrating up to 50 kilometers away" said Keranen. The study's result will be presented by co-author Geoff Abers, senior research scientist at Lamont-Doherty Earth Observatory.

While there are relatively few wells linked to increased seismicity, seismologists seek to anticipate when activity might trigger earthquakes and at what magnitude.

"It is important to avoid inducing earthquakes large enough to be felt, that is, earthquakes with magnitudes of about 2.5, or greater, because these are the ones that are of concern to the public," said Art McGarr, a geophysicist with USGS.

McGarr's research investigates the factors that enhance the likelihood of earthquakes induced by fluid injection that are large enough to be felt,

or, on rare occasions, capable of causing damage. The injection activities considered in McGarr's study include underground disposal of wastewater, development of enhanced geothermal systems and hydraulic fracturing. Of the three activities, wastewater disposal predominates both in terms of volumes of injected liquid and earthquake size, with magnitudes for a few of the earthquakes exceeding 5.

"From the results of this study, the total volume of injected fluid seems to be the factor that limits the magnitude, whereas the injection rate controls the frequency of earthquake occurrence," said McGarr.

Despite the increasing seismicity in the central and eastern US, induced earthquakes are presently excluded from USGS estimates of earthquake hazard. Justin Rubinstein, geophysicist with USGS, will present an approach to account for the increased seismicity without first having to determine the source (induced or natural) of the earthquakes.

The USGS is trying to "stay agnostic as to whether the earthquakes are induced or natural," says Rubinstein. "In some sense, from a hazard perspective, it doesn't matter whether the earthquakes are natural or induced. An increase in earthquake rate implies that the probability of a larger earthquake has also risen," said Rubinstein, whose method seeks to balance all of the possible ways the hazard might change given the changing earthquake rate.

But what's the likelihood of induced seismicity from any specific well?

"We can't answer the question at this time," said Atkinson, who said the complex problem of assigning seismic hazard to the effects of induced seismicity is just beginning to be addressed.

"There is a real dearth of regulations," said Atkinson. "We need a clear understanding of the likely induced seismicity in response to new

activity. And who is the onus on to identify the likely seismic hazard?"

More information: Other presentations during the daylong session, "Induced Seismicity," will feature case studies of induced seismicity in the United States (Oklahoma, Ohio, Texas and Arkansas), Spain and Italy. A searchable database of all abstracts for the session can be found here: http://bit.ly/RjGuyX

Provided by Seismological Society of America