

# States show they can sometimes stop earthquakes

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Kansas and Oklahoma, which acknowledge that humans are causing earthquakes, have shown they can stop them.

After restricting oil and natural gas operations in certain hotspots, Oklahoma has an average of two earthquakes a day, compared with about six a day last summer. Kansas is getting about a quarter of the quakes it once did.

Using a growing body of research [\[?\]](#) and trial and error [\[?\]](#) scientists and state regulators are gradually getting closer to pinpointing the cause of the startling increase in earthquakes in the Central and Eastern U.S., and preventing them.

The general cause, scientists have found, is not drilling, but what happens after, when operators dispose of wastewater that comes up naturally during oil and gas extraction. The operators inject the wastewater into [disposal wells](#) that go thousands of feet underground, which can increase fluid pressures and sometimes cause faults underneath or nearby to move.

Since March 2015, Kansas and Oklahoma have limited how much wastewater each operator in certain areas can dispose of at a given time.

To gather more data, Oklahoma, Pennsylvania and Texas are expanding their seismic monitoring systems this year, placing permanent stations across the states and moving temporary stations to new hotspots. And

Oklahoma and Texas hired more staff or are contracting with scientists to study the geology of areas where earthquakes are occurring, the details of the quakes that happen, and the oil and gas activity that may be associated with them.

About 7 million people in the Central and Eastern U.S. are at risk of man-made earthquakes powerful enough to crack walls, according to a one-year United States Geological Survey forecast released in March. The report outlined the risk from man-made earthquakes for the first time, listing the states with the highest risk in order as Oklahoma, Kansas, Texas, Colorado, New Mexico and Arkansas.

The tension below ground brought rise to political tension, too. Many of the epicenters are in rural towns in conservative states, which generally shy away from government regulations. The oil industry regulators in Oklahoma and Texas are elected officials, with campaigns often funded in part by contributions from the industry, said Cliff Frohlich, a seismologist with the University of Texas at Austin who has studied man-made quakes in Texas.

In Oklahoma, Republican Gov. Mary Fallin was at first hesitant to connect wastewater disposal with the quakes. Now, she's taking action. In January, she allotted \$1.4 million in emergency funds to the state's regulators and scientists to increase monitoring and research.

"Like many other Oklahoma residents, I have felt my walls shake from earthquakes that have struck our state with increasing frequency over the past few years," Fallin wrote that month. "I'm committed to funding seismic research, bringing on line advanced technology and more staff to fully support our regulators as they take meaningful action on earthquakes."

States in the Central U.S. really weren't ready for earthquakes - they

didn't need to be. From 1973 to 2008, the region saw on average 24 earthquakes of magnitude 3 or stronger each year, according to USGS. Those are quakes that can cause minor damage or more.

The USGS tallied 1,010 earthquakes in the region last year, a number that has increased steadily from 318 in 2009. Parts of the historically aseismic region, such as northern Oklahoma and southern Kansas, are now as seismically active as California.

"Every scientist working in the midcontinent of the U.S. is pretty confident that the vast majority of these earthquakes are induced," said Tандis Bidgoli, assistant scientist and geologist for the Kansas Geological Survey. "Especially where you are having swarms of earthquakes."

The increased number of earthquakes corresponds with the drastic increase in oil and gas operators' use of hydraulic fracturing, or fracking - a technique in which water, sand and chemicals are pumped at high pressures underground, fracturing rock and freeing trapped oil and gas. Fracking has allowed operators to drill in new places and get much more oil from each site. While fracking itself is rarely the cause of quakes, it is one reason why there is so much more wastewater to dispose of, Bidgoli said.

Injection wells have been safely used for wastewater disposal for decades. With the permission of the U.S. Environmental Protection Agency, operators have buried the water thousands of feet below ground to avoid surface contamination. But now, the EPA is looking for other options. In Oklahoma, Fallin created a group in December to study how the wastewater could be recycled or reused.

Meanwhile, scientists are trying to pin down answers: Is the wastewater buried too deep, or is too much buried, or are large amounts buried too

quickly?

The regions most likely to get earthquakes associated with wastewater disposal are areas where there is more water naturally in the ground, such as in south-central Kansas, where extracting one barrel of oil means having to dispose of at least 16 barrels of wastewater, Bidgoli said.

States' responses to the quakes have varied. But scientists and regulators say that's mostly a good thing, because the geology of the areas varies.

Since 2008, Arkansas, Colorado, Ohio and Texas have put new restrictions on the disposal of wastewater in injection wells, although those haven't affected operations as broadly as the new rules in Kansas and Oklahoma.

Kansas was studying the issue in 2014 when a magnitude 4.8 [earthquake](#) hit southwest of Wichita. That day, Republican Gov. Sam Brownback announced the expansion of the state's seismic monitoring system. In March 2015, the Kansas Corporation Commission, which regulates the industry, began limiting wastewater disposal in five zones and two counties.

Since then, the state has had fewer earthquakes. In the last six months of 2015, there were 39 quakes of magnitude 2.8 or stronger, compared with 48 such during in last six months of 2014. In the first six months of 2016, only 11 were recorded by the USGS. This is probably a result of the new restrictions and the slowdown in oil and gas production, said Rex Buchanan, interim director of the Kansas Geological Survey. The number of oil and gas wells drilled in the state fell almost 64 percent in a year, to 2,080 in 2015.

Oklahoma was slower to make broad changes, although it began regulating the wells in 2013. In spring 2015, the state asked all operators

to prove they weren't drilling too deep. But when quakes continued to increase, they decided that volume cutbacks were needed. In March, the Oklahoma Corporation Commission began restricting how much wastewater operators dispose of in about 600 of its 3,800 disposal wells, in certain hotspots.

Since the regulations began, Oklahoma operators have drilled a million barrels fewer each day, a decrease driven by both the new rules and lower oil and gas prices, said Jeremy Boak, a geologist and director of the Oklahoma Geological Survey.

Oklahoma had 619 earthquakes of magnitude 2.8 or higher from January through June, compared with 701 during the comparable period last year, according to USGS data.

While regulators in Kansas and Oklahoma have acknowledged a connection between earthquakes and wastewater injection, the Texas Railroad Commission, which regulates the industry there, has not clearly done so.

The state takes the issue seriously, said Ramona Nye, spokeswoman for the Texas commission. It put in place rules restricting use of disposal wells in areas of seismic activity, hired a seismologist, and gave staff the authority to set volumes and pressures on wells, and to close a well if there is a correlation between it and a [quake](#).

And Texas Gov. Greg Abbott, a Republican, signed a bill last year to spend \$4.5 million to study the issue. About 26 percent of the earthquakes of magnitude 3 or higher in the state since 1925 were almost certainly induced, according to a study by Frohlich at the University of Texas at Austin and others.

The funding will go toward installing 22 permanent stations and buying

36 portable seismometers to monitor seismic activity across the state. It will also pay for research run by the University of Texas at Austin.

Regulators in Kansas and Oklahoma say [oil](#) and gas companies resisted the new rules at first, but they are now cooperative, even helpful, in providing information about their land and operations.

"At the end of the day, they just want the earthquakes to slow down and eventually stop," said Steve Everley, spokesman for Energy in Depth, an advocacy branch of the industry-backed Independent Petroleum Association of America. "If that means do this, or do that, they are willing to do that."

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