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Not My Fault: Not all earthquakes are natural and it's not just fracking

Lori Dengler/For the Times-Standard
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Last week I highlighted an unusual east coast magnitude 4.1 earthquake. Since I then, two more M 4 earthquakes have occurred in the lower 48 states - a 4.2 in Oklahoma and a 4.0 east of San Diego, California. Both made an impression on the several thousand people who felt each tremor but neither made much of a news blip.

No surprise about the California quake. It was where I'd expect awell-behaved California earthquake to be – on a fault associated with the San Andreas transform plate boundary. Last week's 4 was near the Elsinore and San Jacinto fault zones, where more than 30 earthquakes of this size have been recorded since 1980. Bigger quakes can happen here too like ones in 1910 and 1918 and future ones could reach the mid 7-size range.

And for the past five years, earthquakes of this size are no surprise in Oklahoma either. It was the sixth M 4 to strike Oklahoma this year and last year there were 21 4 or larger tremors in the state. Oklahoma is a very long way from any plate boundary and yet for the past three years, Oklahoma has been the felt earthquake capital of the lower 48. While there are fault systems in the Midwest, one needs to dig deeper to get the full story of Midwestern quakes.

Oklahoma's climb to the top of the lower 48 felt capitol is a recent one. Magnitude 3 is the level where an earthquake is likely to be felt. In 2007, only one earthquake in Oklahoma reached this size. In 2008, there were two. In 2009 the number jumped to 20. The numbers continued to climb, reaching 622 in 2014 and 863 in 2015. Not only were the numbers of small earthquakes increasing, but larger ones were too. A M 5.5 in 1952 was the only moderate-sized tremor ever recorded in Oklahoma prior to 2010. Since 2011, four have reached the M 5 threshold. A 5.7 in 2011 injured two and caused some damage to homes and roads. That quake was surpassed in 2016 by a M 5.8 that was felt throughout Oklahoma and also in neighboring Arkansas, Missouri and Kansas.

What happened between 2008 and 2009 to cause such a notable change in earthquake activity? I know some of you are waving your hands frantically and ready to shout out "fracking." Not so fast. While hydrofracturing and the development of oil shale is part of the story, it is more of a sidebar than the direct cause.

Oil is big in Oklahoma. The first commercial oil well was drilled in Bartlesville a full decade before statehood. Between 1900 and 1935 Oklahoma ranked first among the Mid-Continent states in oil production. The state continued as a major contributor to US oil production throughout the century but fields began to deplete and extraction went into decline in the 1980s. By 2005, production hit historic lows, about a quarter of what it had been in the boom of the 1920s.

Then came new technologies for recovering more hydrocarbons from older fields and the oil shale boom. 2010 showed a sharp turn around for Oklahoma's oil fortunes and by 2014, production had more than doubled from the 2005 low. Part of the boom is due to hydrofracturing or 'fracking,' but oil production from conventional wells has increased as well.

All hydrocarbon extraction involves fluids. And it isn't just oil or gas that comes up the well. Much of the fluid is a briny mixture of water and salts that has no commercial use. Prior to 1985, this waste was typically dumped in reservoirs. By the 2000s, state and federal legislation required this material to be injected into deep wastewater wells where it would be less likely to affect the environment.

Wastewater wells sprang up all over the country. These wells are thousands to tens of thousands of feet deep so that there is no chance of the materials coming back up to the surface. There are at least 3500 injection wells in Oklahoma and similar numbers in other oil-producing states.

And as oil production again boomed in Oklahoma, the earthquake rate began to increase. It's been known for decades that the injection of subsurface fluids can trigger earthquakes. As the number of earthquakes in Oklahoma increased, scientific attention did too. After the 2011 M 5.7, seismologists began to look closely at the relation between waste injection and earthquakes. One of the puzzling questions was why, with tens of thousand of wells throughout the country, only a few dozen were causing quake activity. While the details aren't clear, they agreed that injection increased water pressure at depth and in a few areas where natural fault systems existed, the pressure triggered earthquake activity.

It took a bit longer for the State of Oklahoma to recognize the threat. But a spate of lawsuits that threatened to hamper the oil and gas industry led to state restrictions on reinjection rates in May 2016 and since then, Oklahoma seismicity has diminished. This year it looks like Oklahoma will still edge out California in magnitude 3 and larger quakes but just barely.

Note – information about Oklahoma's oil history from the US Energy Information Agency and the American Oil and Gas Historical Society.

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