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Location of Wastewater Disposal Drives Induced Seismicity

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The depth of the rock layer that serves as the disposal site for wastewater produced during unconventional oil extraction plays a significant role in whether that disposal triggers earthquakes in the U.S., according to a new study that takes a broad look at the issue.

The research published in *Seismological Research Letters* reviewed data on wastewater disposal for oil sites in Oklahoma, eastern Montana, western North Dakota, Texas and New Mexico.

Seismicity levels are higher in Oklahoma compared to the other states in part because wastewater is injected deeper into the ground in Oklahoma, nearer to the underlying basement rock, according to Bridget Scanlon, study author from the University of Texas at Austin, and her colleagues.

The cumulative volume of wastewater injected into the earth in Oklahoma is also higher than in the other oil-producing areas, and can also be linked to increased rates of seismicity in the state, the researchers said.

The findings differ from an earlier study based on data in the mid-continent, which did not find a significant correlation between total disposed wastewater volume, or between depth of injection, and increased seismicity.

The new study contains an additional 3.5 years' worth of data on injection volume and seismicity in Oklahoma, however, and also uses a new map of basement rock depth, said Scanlon.

Unconventional U.S. oil production, which extracts oil from shales and tight rocks using hydraulic fracturing and horizontal wells, has been linked to an increase in human-induced earthquakes across the mid-continent of the U.S. for nearly a decade. The main driver of this increase in seismicity is the injection of wastewater produced by extraction, which increases pore pressure within rocks and can affect stress along faults in the rock layers selected for disposal.

The "tightness" of the oil-producing rock layers at these sites means that wastewater can't be injected back into the same layers, so companies have instead found "looser," more permeable rock layers in which to drill disposal wells.

The study by Scanlon and colleagues examined wastewater injection rates, cumulative regional injection volumes and injection proximity to basement rock for tight oil plays in Oklahoma, the Bakken play (Montana and North Dakota), the Eagle Ford play (Texas) and the Permian play (Texas and

New Mexico).

Many of the wastewater disposal wells in Oklahoma are drilled into a rock layer called the Arbuckle Formation, which lies adjacent to the basement and is much deeper than the rock layers used for disposal in the Bakken, Eagle Ford and Permian plays.

Wells drilled into the Arbuckle drain water into the formation without the need for pressure at the wellhead, and the rock zone is highly permeable, which makes it an appealing disposal site, said Kyle Murray, a co-author on the study from the Oklahoma Geological Survey. The Arbuckle also has extraction wells only “in a few small areas, so disposal does not diminish producing wells.”

The ease of using the Arbuckle as a disposal site might be one reason why oil producers have chosen deeper disposal sites in Oklahoma compared to the other regions, “but drilling shallower wells and disposing in shallower zones in other plays may be related to economics. Deeper wells are much more expensive and not always successful,” he added.

Murray said oil field operators in these other regions may also know about the studies linking the increase in seismicity in Oklahoma to injection proximity to basement rock, causing them to avoid deep disposal at their sites.

The researchers noted that their findings are consistent with the reduced seismicity documented in Oklahoma after directives by the Oklahoma Corporation Commission in 2014 and 2016 to reduce injection rates and regional injection volumes, as well as to plug disposal wells drilled into the basement. These directives have led to a 70 percent reduction in the number of magnitude 3.0 or larger earthquakes in the state in 2017, relative to 2015.

There are tradeoffs between injecting wastewater into shallow versus deep rock layers, the researchers note. Shallower wells, which often cost two to three times less than deeper wells and would appear to trigger lower levels of seismicity, could contaminate aquifers with saltwater or interfere with oil production wells.

Scanlon and colleagues say one way to reduce the amount of overall wastewater injection might be to repurpose the wastewater for hydraulic fracturing.

“The value of reusing produced water for hydraulic fracturing is similar to re-injecting produced water for water flooding in conventional oil reservoirs, to maintain pressure,” said Scanlon. “Reusing produced water for hydraulic fracturing would reduce water sourcing issues and water depletion related to that, and would also reduce wastewater disposal and related potential seismicity.”

This strategy might work best in places where the wastewater produced is roughly similar to the amounts needed for hydraulic fracturing, however. In Oklahoma, for instance, hydraulic fracturing operations would use up only 10 percent of the amount of produced wastewater.

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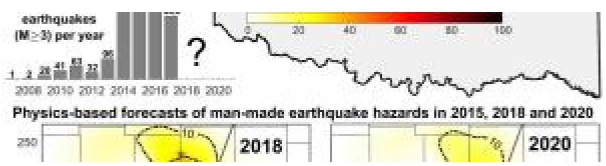

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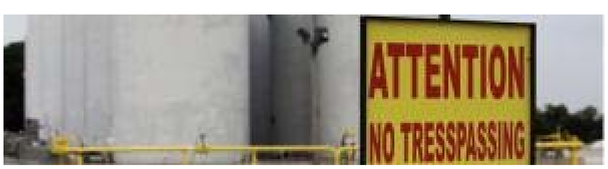

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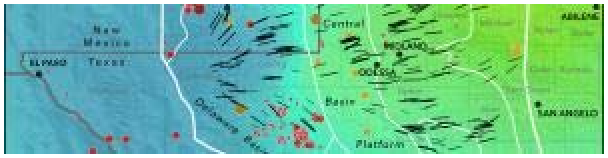

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