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September 11, 2019

Ms. Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street, Second Floor
Harrisburg, PA 17120

RE: Second Addendum to First Addendum (September 9, 2019) and Comments on Docket No. L-2019-3010267 Advanced Notice of Proposed Rulemaking Order (August 2, 2019)

Dear Secretary Chiavetta,

As State House Representative of the 156th Legislative District in Pennsylvania, I am submitting a second addendum to my previous comments on Docket No. L-2019-3010267 of August 2, 2019 and first addendum of September 9, 2019. I apologize for not including this in my previous communications to you.

My new recommendation is:

- Require that regulators "consider gathering data on wastewater fluid properties as part of the permitting process for new wells. Understanding density differences between wastewater and subterranean water ahead of time could help scientists forecast earthquake hazards for years to come." – Ryan Pollyea in "Even if Injection of Fracking Wastewater Stops, Quakes Won't" by Anna Kuchment, *Scientific American*, September 9, 2019 - https://www.scientificamerican.com/article/even-if-injection-of-fracking-wastewater-stops-quakes-wont/ - The article is also attached.

Again, I think that we have an opportunity to establish effective regulations and oversight particular to NGLs, which have their own unique qualities and dangers. This is a responsibility that we must not take lightly. An urgent response is needed. We owe it to ourselves, our fellow citizens, and to the generations to come.

Thank you very much for your consideration. Please do not hesitate to contact me should you have any questions.

Sincerely yours,

Carolyn T. Comitta

Representative Carolyn T. Comitta
156th Legislative District

CTC/jml

Even if Injection of Fracking Wastewater Stops, Quakes Won't

Salty fluid sinks and puts pressure on rock, potentially triggering faults in Oklahoma for years to come

By Anna Kuchment on September 9, 2019

Fracking pumpjacks in an oil field. Credit: Getty Images

Jacob Walter likes to remind people that what has transpired in Oklahoma over the past decade is unprecedented in human history.

Walter is Oklahoma's state seismologist, and he is talking about the surge of earthquakes that has plagued his state since its most recent oil-and-gas boom. Production techniques—including hydraulic fracturing, or fracking—led to large-scale underground wastewater disposal, which scientists have tied to the state's 900-fold increase in quakes since 2008. After 2015, when oil demand fell as prices dropped and Oklahoma instituted new wastewater-disposal rules, earthquake rates fell sharply.

Still, the state continued to see rare but damaging tremors triggered by the fluids that had already been shunted underground. "I don't think people fully appreciate the scale, the amount of water that was injected over the years," Walter says, adding that humans have now caused four of the five largest earthquakes in Oklahoma's recorded history.

Since the surge began, scientists have grappled with how to manage the quakes without crippling one of the state's most lucrative industries. Two new studies show how the continuing movements of injected wastewater can trigger earthquake activity—knowledge that sheds light on how to forecast and mitigate tremors. The findings suggest the effects of wastewater disposal can persist for years after injection rates slow or stop, as pressure from the wastewater continues to spread belowground and rupture ancient faults.

As well operators pump gas and oil up through production wells, brackish water that existed in the same ground layer as the oil and gas comes up, too. This water is then separated and pumped down a deeper set of disposal wells into a porous, permeable layer of rock called the Arbuckle formation. As wastewater seeps into pores in the rock, it changes the pressure within those pores. These pressure changes can interact with faults that are primed to slip, triggering earthquakes. But quakes have been set off in layers that are far deeper than the bottoms of the disposal wells, indicating the wastewater fluid and the pressure it exerts are not confined to the layer the wells are in. In a process termed pressure diffusion, the wastewater can migrate into a deeper layer of rock called the "basement"—where the vast majority of Oklahoma's earthquakes have occurred. A key question is how that happens.

Injection Triggers an Earthquake

Large volumes of extremely salty brine, and chemicals, come back up gas and oil wells (*left and right, respectively*). Companies often inject this wastewater down a shaft (*blue*) into a deep layer of porous rock for permanent disposal, which can trigger an earthquake (*inset diagrams below*).

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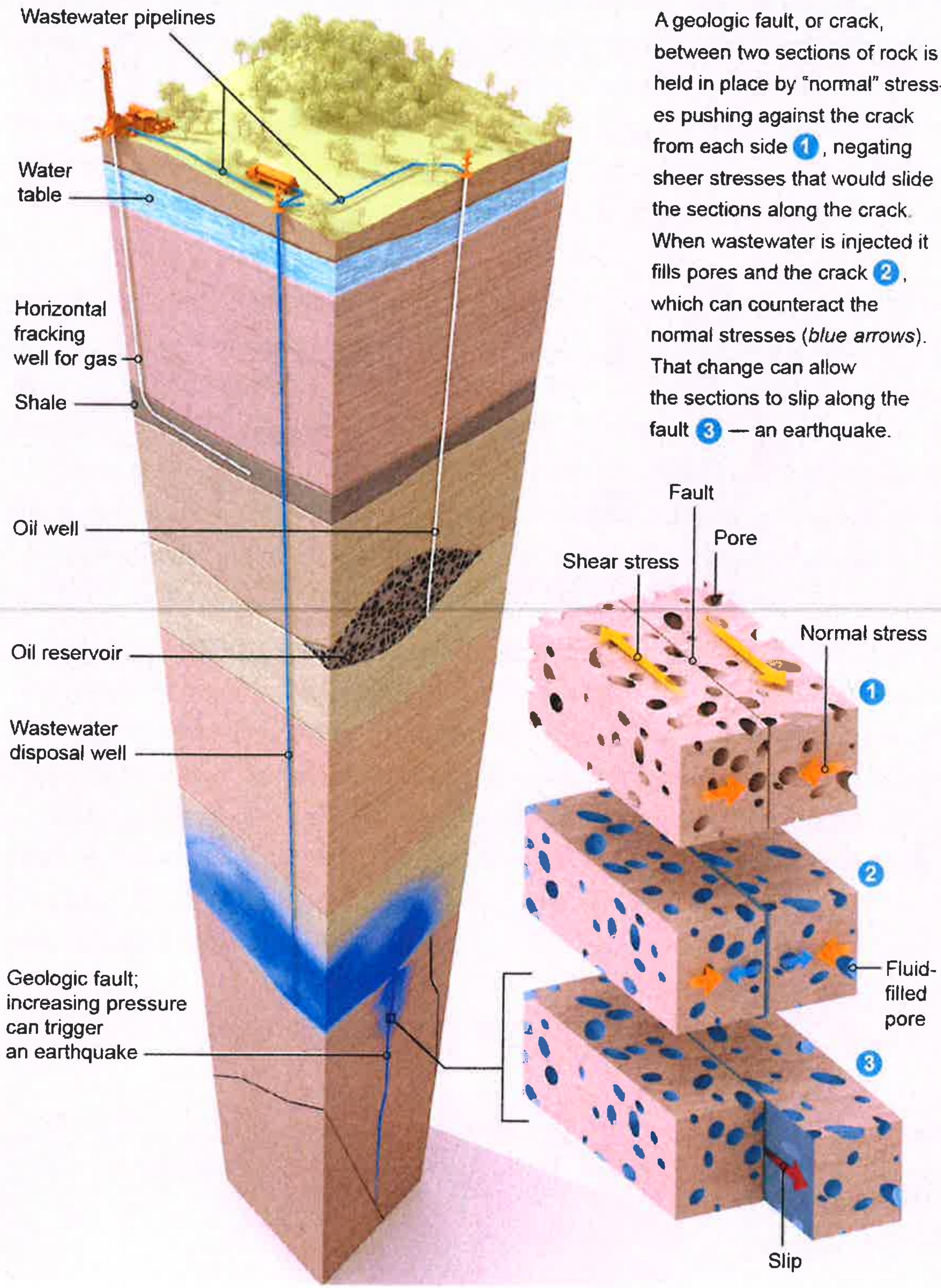

Credit: Bryan Christie Design

Ryan Pollyea, a hydrogeologist and assistant professor at Virginia Tech, wanted to see if differences in density between the brackish wastewater fluids and the water naturally residing in the basement could play a role in letting the wastewater penetrate what is a comparatively impermeable layer of rock. "All the models that have been put out there about fluid pressure propagation during and after wastewater injection have considered the fluids to be the same everywhere, and they're just not," says Pollyea, whose study was funded by a grant from the U.S. Geological Survey and was published on July 16 in *Nature Communications*. "So we wanted to try to understand 'What does that mean in terms of the earthquake hazard?'"

Because Oklahoma's oil- and gas-bearing rock contains the remnants of ancient seas, the wastewater is extremely salty. It can have two to three times as much dissolved salt as water found within deeper rock layers, according to USGS data on subterranean waters throughout the country. This difference causes wastewater to be 5 to 15 percent denser than the deeper water, Pollyea and his colleagues found. The high-density water causes greater pressure within the rock pores—and because it is denser, it can sink farther down than less dense water, taking that increased pressure deeper.

To see how this situation might change the earthquake hazard, Pollyea and his colleagues studied Oklahoma's Alfalfa County, a place that saw rapid increases in wastewater injection and earthquake rates beginning in 2013. The researchers compared actual earthquake locations and depths with a computer model they created of a high-volume injection well. They found that the levels at which earthquakes originated in Alfalfa County migrated downward at about half a kilometer per year—the same rate as their modeled pressure front. "That gave us pretty strong evidence that the density effects of the water sinking may indeed be driving earthquakes deeper underground," Pollyea says.

A house in central Oklahoma was damaged by a magnitude 5.6 earthquake on Nov. 6, 2011, that was linked to injection into deep wastewater disposal wells. Credit: Brian Sherrod *USGS*

He and his colleagues' analysis also found that the percentage of high-magnitude earthquakes increased with the depth at which those quakes originated. This connection happens because deeper faults are under more stress and thus those faults can release more energy when they rupture, Pollyea says.

A second study, published on July 29 in *Proceedings of the National Academy of Sciences USA,* used a different model to explain how pressure from wastewater disposal triggers earthquakes. Guang Zhai, a postdoctoral researcher at Arizona State University, and his colleagues combined pressure diffusion and the rock's "elastic response" to the pressure into a new earthquake model for Oklahoma. (Elastic response is a term that describes how fluid pressure physically pushes and pulls the rock.) They found that adding the rock's stress response to their model amplified the effect of pressure diffusion alone on earthquake rates by up to a factor of six.

This model also incorporated injection records from more than 700 Oklahoma wastewater wells stretching back 24 years along with subsurface geology and fault orientations. Zhai says the model could be used to assess earthquake potential on specific fault segments, as well as to forecast regional induced-earthquake hazards.

Both studies looked at how quickly the influence of wastewater injection would cease after a hypothetical scenario in which regulators decreased wastewater injection in Oklahoma or stopped it altogether. Zhai's group found that quakes would likely continue for at least six more years, while Pollyea's came up with more than 10 years. "Even after pumps are turned off, the water is still in the ground," Pollyea says. "It's still sinking, and it's still increasing fluid pressure."

He adds that regulators should consider gathering data on wastewater fluid properties as part of the permitting process for new wells. Understanding density differences between wastewater and subterranean water ahead of time, Pollyea says, could help scientists forecast earthquake hazards for years to come.

Art McGarr, a USGS seismologist who studies human-induced quakes, says that the new models are among the most sophisticated around and could eventually be helpful in better prediction—but that getting more actual measurements of attributes such as pore pressure is a bigger priority. "The modeling is getting somewhat ahead of the available data," he says. He would like to see a repeat of a classic experiment conducted in the late 1960s and 1970s in Colorado's Rangely Oil Field. In that experiment, USGS researchers took over wells belonging to Chevron and figured out how much pressure was required to set off earthquakes in the area. As long as they kept their disposal volumes and pressures below a certain threshold, the earth stayed quiet.

Walter, the Oklahoma state seismologist, agrees with the need for more data and cautions that the models are not likely to lead to safer injection practices. "There's just too many unknown factors," he says, including unmapped faults that could unexpectedly rupture—which happened in 2016 with a magnitude 5.8 earthquake in Pawnee, Okla. But "I think it's a fundamental step forward," he says of Zhai's paper. (Walter and McGarr were not involved in either study.)

Until more data emerge to feed into the models, Walter is focusing on raising awareness among Oklahomans that although they may be experiencing fewer quakes, their chances of feeling a strong one remain elevated.

ABOUT THE AUTHOR(S)

Anna Kuchment

Anna Kuchment is a contributing editor at *Scientific American* and a staff science writer at the *Dallas Morning News.* Previously a reporter, writer and editor with *Newsweek* magazine, she is also author of *The Forgotten Cure*, which

is about bacteriophage viruses and their potential as weapons against antibiotic resistance.

Credit: Nick Higgins