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Permian Earthquakes: A Produced Water Story

A spate of earthquakes in Texas and Oklahoma are linked to injection of produced water from unconventional reservoirs.

By Jennifer Pallanich, Hart Energy Wed, 09/13/2023 - 02:31 PM

Earthquakes, both felt and detected through instruments, have risen during the shale boom, and researchers are studying the role of produced water injection in that increase. *(Source: Shutterstock)*

Earthquakes, both felt and detected through instruments, have risen during the shale boom, and researchers are studying the role of produced water injection in that increase.

Deep and shallow earthquakes have been associated with deep and shallow water injection wells, said Katie M. Smye, principal investigator of the Center for Injection and Seismicity Research (CISR)—a research center managed by the Bureau of Economic Geology at the University of Texas at Austin—during the "Injection-induced Seismicity in the Permian Basin Region" lunch at IMAGE on Aug. 30.

"This earthquake story is really a produced water story," she said. "We need to understand where water is coming from, what the volumes are and where it's going because it's so closely linked to the rate of earthquakes."

While the Permian has been producing oil for decades, the "earthquakes are recent, and they're associated with unconventional production," she said.

Smye said the scale of development in the basin is one reason "unconventional production is causing more earthquakes than we see with conventional" drilling.

Additionally, conventional water production plateaued around 1980 whereas unconventional water production has increased, she said. And when water was produced from conventional reservoirs, she added, it was typically reinjected into the same reservoir, including for EOR purposes.

"This is a much more pressure-balanced kind of thing than we see in unconventionals, where the water produced in the basins from shales doesn't go back into shale. It goes into other reservoirs that are already full of fluids," which increases the pressure in those reservoirs, Smye said.

Katie M. Smye of the Center for Injection and Seismicity Research speaking about "Injection-induced Seismicity in the Permian Basin Region" during a lunch event at IMAGE on Aug. 30. *(Source: Hart Energy)*

Understanding seismicity in the Permian is important because 40% of U.S. oil comes from the basin, she said. That knowledge also serves as an analog for other processes, such as for carbon storage, hydrogen storage and geothermal activity.

That makes research into seismicity critical, she said. Researching induced seismicity requires access to earthquake data, location of injection wells, the rate of injection and the volume injected, among other things, she said.

"Then we have to do a lot of hard work on characterizing the geology," she said. "We need to know something about the injection reservoir. What are the rocks like? What are their porosity and permeability, because that's what we use to populate pore pressure models."

One difficulty in researching the phenomena is that while earthquakes happen in real time, data reported on water injection typically trails behind by months.

"In some cases, we had an 18-month lag in monthly injection monitoring. So it's impossible to do research in that environment," Smye said.

Mapping faults is crucial and a work in progress, she said, acknowledging the adage that "you can't have earthquakes without faults."

Even with high-quality data, she said, sometimes researchers aren't seeing faults until earthquakes occur.

A key question, Smye said, is where injecting produced water won't cause major problems or pose a business threat to operators in the Permian region.

This question has never been more important, she said, because of the expectation that "several hundred billion barrels of water will need to be either handled, managed or safely disposed of" due to future Permian production, where water cuts are high and expected to grow.

The challenge isn't going to go away with future production, she said, and the answer is complicated because the earth's subsurface is extraordinarily complex. For example, large seismic events can be triggered by activity 20 km away, she said.

"You don't have to be right next to a critically stressed fault to cause a large event," she said. "And small events are important too."

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