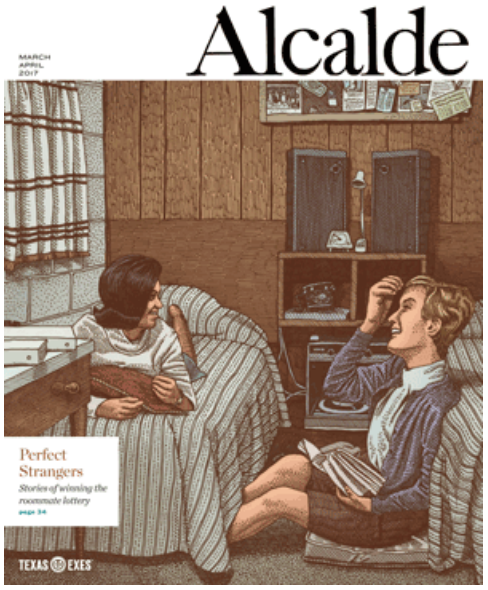
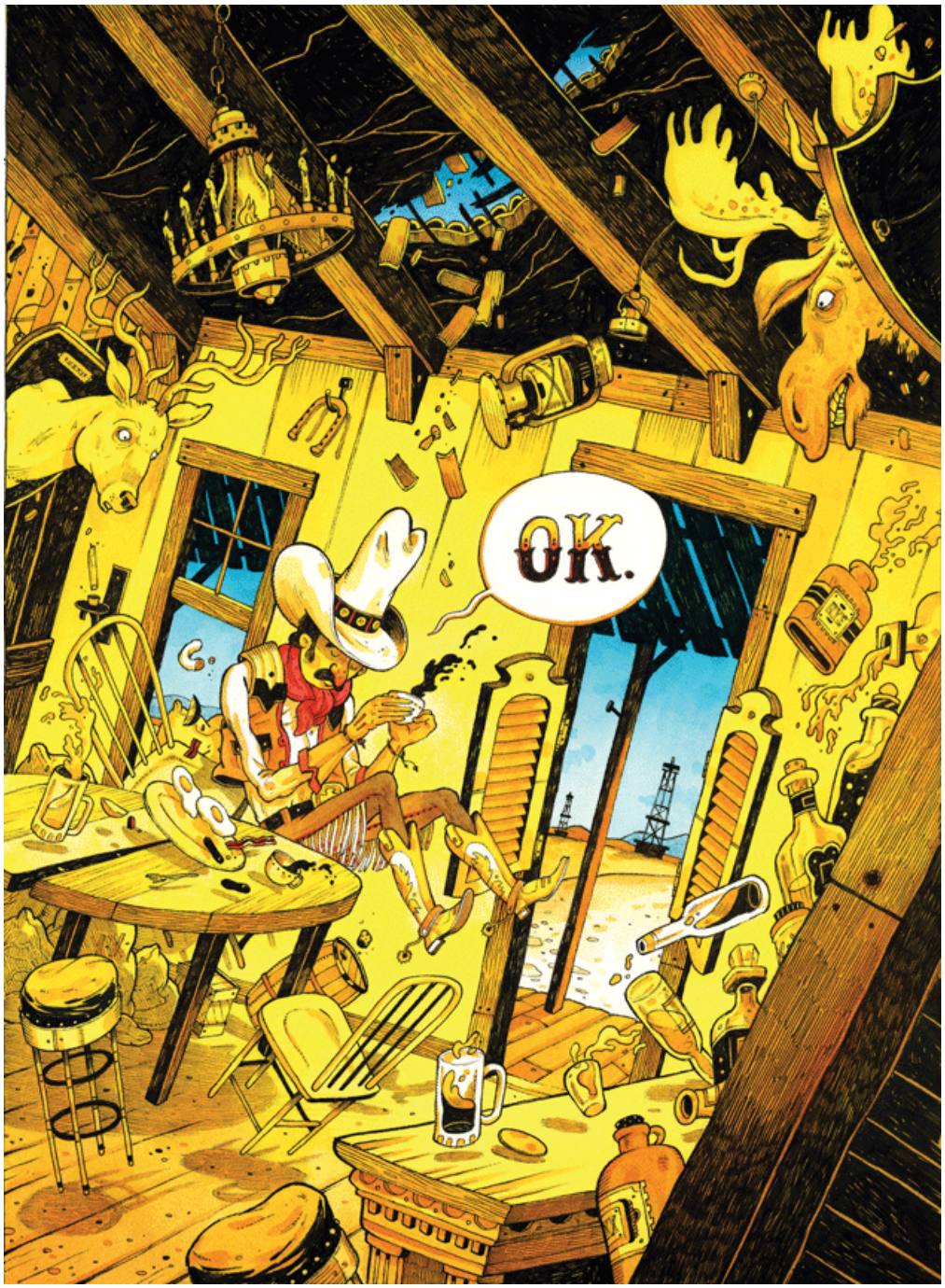
Shaky Ground

BY JOE HANSON IN FEATURES, JAN | FEB 2017, SPECIAL ON JANUARY 3, 2017 AT 11:55 AM | 1 COMMENT

As oil and gas production has boomed again in Texas and Oklahoma, earthquakes have become a startling byproduct.





Gordon Laird was standing at the foot of the bed. He was about to say goodbye to his wife and go buy tractor parts when the shaking started. The earthquakes were coming almost every day now, but they usually only lasted a second or two.

As he counted past three seconds, then four, it became clear that this time was different. The bed, upon which his wife sat, was now jumping up and down and trying its best to throw her onto the floor. Seven seconds. Eight seconds. The bathroom cabinets joined in by ejecting their contents. Nineteen, 20 seconds. In the next room, deer and elk mounts fell to the ground as if they had come to life and forgotten they were no longer attached to bodies. Just as Laird began to wonder if the house was going to last through this one, everything stopped. By his watch, the shaking lasted 37 seconds.

Moments earlier, several miles underground, two massive pieces of the Earth's crust had slipped past each other, sending untold centuries of accumulated stress rippling under Pawnee County and the Laird family's bedroom. The magnitude 5.8 earthquake that struck there on Sept. 3, 2016 was the strongest ever recorded in Oklahoma, and one of a growing number to hit the state in recent years.

In 2011, Oklahoma recorded just 63 earthquakes of magnitude 3.0 or greater. But in 2015, that number grew to 907. Only perennially shivering Alaska tallied more in that time, while California, a state typically associated with seismic shaking, saw just 130 quakes that year. It's increasingly clear that Oklahoma's surge in earthquake activity is linked to the state's oil and gas production, but exactly how remains the subject of much debate.

Texas has felt its own uptick in seismic activity, although to a lesser degree than Oklahoma, which adds confusion to what was already a conundrum. Consider that each state is home to thousands of active wells that operate in much the same way on either side of the Red River. No one's really sure why Texas isn't shaking as much or how long that may last.

What's certain is that researchers and regulators still have much to learn about what happens when we pump massive amounts of stuff in and out of the Earth's crust. A new research center at UT-Austin hopes to change that.

To call the Center for Integrated Seismicity Research a multidisciplinary effort would be a bit of an understatement. Based at UT-Austin's Bureau of Economic Geology, CISR's roster includes seismologists; geophysicists; civil, architectural, and petroleum engineers; social scientists; and even a couple of advertising professors. Several oil and gas companies have committed expertise and data, and the Texas state legislature has chipped in $4.5 million to establish TexNet, an update to the state's seismic monitoring network.

CISR's mission is simple: to learn how we might distinguish between natural and human-induced earthquakes, and among the latter, figure out what we're doing to trigger them.

Scott Tinker sits at the helm of this new alliance. He's adamant about being objective and following where the science leads, but as director of the Bureau of Economic Geology, he knows CISR's work will have far-reaching impacts on energy policy, the environment, and the economy. These are powerful interests for a scientist to take on, but Tinker relishes any opportunity to bring opposing forces together around hard data. "I call that the radical middle," he says. "It's radical because there are not many people there."

There's also not much hard data there yet. There are currently just 17 permanent seismic stations across Texas. TexNet will eventually more than double that number, but right now researchers are woefully uninformed about the state's seismic activity. This highlights the crucial role oil and gas companies, and their decades worth of data, are expected to play in the collaboration. It's likely that no one knows more about what goes on beneath the Lone Star state than the people who make their money there.

The oil and gas business would be much easier if their product came out of the ground like the spewing geysers that made Spindletop famous, but that's generally not how it works. The stuff they're after is often locked away in porous rock, so to free it, fluids are injected at high pressures, forming fractures that allow the oil and gas to flow more freely up to the surface. This is what's known as hydraulic fracturing, or fracking.

It's commonly claimed that fracking causes earthquakes, but as is often the case in science, the truth is a lot more complicated.

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It's logical to think that creating a bunch of tiny cracks deep within the Earth could lead to catastrophic seismic instability, but except for in a few special cases, this isn't what's happening. The real culprit is water. The problem is that oil and gas, fracked or not, rarely come to the surface on their own.

Tinker puts it this way: "When you drill a well, you're drilling into rocks that are full of fluids in little tiny holes, and that's mostly saltwater, old oceans."

Oil and gas are the long-buried leftovers of things that lived in those oceans, and no matter how they're brought to the surface, they bring a lot of old ocean with them in the form of briny wastewater. This wastewater is often contaminated with fracking chemicals or even trace amounts of natural radioactivity from within the crust. "You produce all that saltwater, and you have to do something with it," Tinker says. "It used to get dumped on the surface in man-made mud pits and into streams. More and more, it's injected and disposed back into rocks."

The idea is that pumping this wastewater into deep wells keeps it permanently locked away from the biosphere. The Environmental Protection Agency has monitored the process since 1974, but with a focus on groundwater safety rather than seismic activity. Today it's one of the most widely used methods for disposing of waste from a number of industrial processes, oil and gas included.

There's broad agreement among seismologists that the recent earthquake spikes are linked to wastewater injection wells. They've known this was possible since at least the 1960s, when the U.S. Army triggered a series of earthquakes near Denver after pumping contaminated water into the ground from the Rocky Mountain Arsenal chemical weapons center. But seismologists are a small club, and few of them were asking questions about induced earthquakes before 2008, when, for the first time ever, a series of small quakes hit the Dallas-Fort Worth area. When big cities suddenly start shaking, seismologists like UT-Austin's Cliff Frohlich start paying attention.

"If you study stress in the crust, there's stress everywhere, and there are faults everywhere, but most of them are stuck," Frohlich explains. "It's not that the injection is causing stress or changing the stress, but it's changing the friction." In a sense, all this wastewater is lubricating faults, making it easier for them to slip and slide. Or at least that's true in some places.

Texas is home to more than 8,300 active disposal wells, many of which have been in operation for decades. Clearly, the vast majority aren't causing earthquakes, but according to post-quake studies done by Frohlich and others, a few have caused faults to slip. The problem is, right now no one can predict which wells are safe and which might set off a quake.

There's an old adage in science that correlation doesn't equal causation. To put that another way, just because you see two things happen in close proximity doesn't mean one necessarily caused the other. This tying of cause to effect is the most deceivingly difficult task in science. TexNet and CISR researchers are deeply mindful of this. They acknowledge there are notable differences among disposal wells, including the volumes injected and the concentration of wells in a given area. They know that some seismic activity may be natural. But most of all, they know that oil and gas production make up a huge part of the Texas economy, and rash or incorrect scientific guidance would have serious ramifications.

If and for how long we should continue to pump oil and gas out of the ground in a warming world is certainly a worthwhile scientific question, but it's not one that CISR is tasked with answering. They simply recognize that as long as wastewater is coming out of the ground, we must find a strategy to dispose of it safely.

Even if scientists are unable to link individual wells to individual earthquakes, they can still learn a lot from the bigger picture. Frohlich likens the problem to smoking and cancer. It sounds like medical sacrilege to say so, but it's difficult to say for sure that any single smoker's death was caused by smoking. It's also difficult to say for sure why a person who smoked their whole life ends up not dying from a smoking-related disease. It's equally difficult to comprehend why a person who never smoked a day in their life ends up getting lung cancer. For all of these questions, if scientists study large groups of people they can tell you with confidence how many out of a hundred smokers or non-smokers will die and by what cause.

Large-scale studies like these are how seismologists like Frohlich have been able to draw cause and effect relationships between wastewater disposal wells and past seismic activity. Now, their task is taking what they've learned and applying it to the future.

Historical data can only provide hints about an area's seismic risk in days to come, and Texas earthquake monitoring has been sparse at best. If CISR and TexNet accomplish anything, it will be to fill in these gaps, so that even if there are no certain answers, we'll be better informed about the risks. If you happen to live on top of a wastewater injection well, this is exactly what you want to know.

UT-Austin civil engineering professor Ellen Rathje and her colleagues were on the ground in Pawnee, Oklahoma, within days of September's quake. As part of CISR, their role is to examine what's going on above the ground rather than what's happening in it. Rathje has traveled around the world to places like New Zealand, Japan, and Haiti to study how buildings and infrastructure are affected by earthquakes, and in doing so she meets a lot of recently shaken people.

When discussing the strength of Texas and Oklahoma's recent seismic events, mainly magnitudes between 3.0 and 4.0, she jokingly suggests that most of the earthquakes here wouldn't disturb folks in California.

"They laugh when they say, 'Oh, those Oklahoma people, they're just not used to it,' but the fact is they're getting events that can cause your dishes to fall off your shelves. Okay, you've got to get new dishes. You get a little crack on your wallboard. You've got to patch it," Rathje explains. She's willing to bet people in Berkeley, California would change their tune if they were living through this every day.

"When we went up to do the Pawnee reconnaissance, the people, they're mad. They're upset," Rathje says. "It's really disturbing to have a felt event almost every week and significant events probably every month."

Laird echoes that. "It kind of sets you on your nerves a little bit," he says. "Like when the air conditioning comes on, that kind of little sound, that little jolt you'll feel. Everybody's heart speeds up."

In places like California and Japan, buildings, bridges, and roads are designed to survive large earthquakes. The same can't be said for most of the central United States. Generally, structures are designed to withstand historical seismic risks, so a sudden increase in the magnitude and frequency of earthquakes means older designs are no longer ideal. "It's not like these buildings and bridges are going to be collapsing," says Patricia Clayton, another UT-Austin civil engineer who was on the ground in Pawnee. "They're robust, but things may respond differently in earthquake shaking than they do in wind."

One of those things is the stone facade covering the front of Laird's house. Enough large rocks fell off during the September earthquake that the Lairds have told their four grandchildren who live with them if another earthquake strikes, it's too dangerous to escape through the front door.

So far, the UT-Austin team's research suggests there's no immediate threat to major infrastructure, but

no one's certain how the effects of one large earthquake compare to the cumulative effects of many smaller ones. "Once you're at a thousand earthquakes with a little bit of damage," Rathje says, "then you may be talking about a lot of damage."

Anxious citizens might be as big a risk to the oil and gas industry as electric cars and solar panels. Ultimately, these companies know their ability to do business requires more than just a legal license to operate or a stamp from regulators. They also rely on a public license to operate. In the practical sense, an earthquake-fearing landowner isn't likely to grant a drilling lease on their property, but on a larger scale, sufficient public anxiety could force regulators to make drastic decisions regardless of whether that anxiety is warranted.

The people making those decisions work for the state's oldest and most misnamed regulatory agency: the Railroad Commission of Texas. In recent years, the agency has come under fire from many environmental groups and scientists for not speaking up loudly or clearly enough about the link between earthquakes and oil and gas production. Commissioner Ryan Sitton is trying to change that.

"The commission has been very public about the fact that we recognize the potential for links between disposal wells and seismicity," Sitton says. "The question, of course, is to what degree is that link a reality and in which areas are the risks the highest? We don't know because we don't have good data, or we don't have complete data. That's why the efforts of CISR and TexNet are so important."

Acknowledgment of the link between disposal wells and earthquakes is a recent shift for the Railroad Commission, and many hairs have been split over wording like "the potential for links," but Sitton insists that Texas is taking a more proactive role than any other state when it comes to preventing induced seismic activity. After the Pawnee quake, Oklahoma ordered the shutdown of 37 nearby disposal wells, but Sitton and the Railroad Commission would prefer to prevent risky wells from ever being drilled in the first place. According to RRC spokesperson Ramona Nye, their office has received 64 disposal well applications in areas with historic seismicity since 2014, and of these, 34 were approved with special conditions such as limits on injection volumes. The office has also added their first staff seismologist and is heavily involved in the deployment of TexNet's seismic stations. Whether this is enough remains to be seen.

"It's our job to give the people of this state, all 27 million Texans, confidence in how the energy industry is operating," Sitton says. "In doing that we have a much more scientific and technical job than almost any role, I think, in all of elected office. We take a lot of pride in that."

In both an economic and very real physical sense, the Texas we know was built on oil and gas. Tomorrow's Texas may be built on something else, but for the time being, hopefully we can sleep tight knowing a diverse team of smart people are meeting in the middle to make sure that future, however murky, isn't built on shaky ground.

What's clear is that the openness with which CISR and TexNet's data will be assembled and distributed represents a major change in how the state's varied and often opposing groups approach this kind of far-reaching problem. If you were feeling poetic, you might even call it a seismic shift.

Illustration by John Hendrix

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