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What's Shaking in Timpson: Why All the Earthquakes?

Leslie Leathers
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Abstract

They say that everything is bigger in Texas, and that is especially true of the vast oil fields located throughout the state. Today, Texas is the #1 oil producer in the U.S., producing more than a million barrels per day. Since the start of the most recent oil boom, the Lone Star State has seen a huge increase in seismic activity. Although earthquakes have been happening for years, scientific data has proven the recent events in the small town of Timpson can be attributed to oil field practices. However, state regulators and politicians still say this science is far from infallible. The issues of property and structural damage, the decline in property value, and the potential damage to infrastructure are all growing concerns to people who reside in these affected areas. Researchers have suggested ways to reduce the likelihood of these induced quakes, but Texans wonder if the oil and gas industry will ever be held accountable.

Timpson, Texas

Timpson is located at the junction of U.S. Highways 87, 84, and 59 in Northwest Shelby County. It was founded in 1885 and named after P.B. Timpson, an engineer for the Houston, East and West Railway. Timpson was made famous in a Tex Ritter folk song named, "Tenaha, Timpson, BoBo, and Blair." Stringing the town names together is said to have begun during World War I when soldiers from Shelby County discarded the cadence of, "hup, two, three, four," and replaced it with the names of their home towns. Later, dice players took up the chant when trying to roll a ten.

Today, Timpson is famous for a different reason: earthquakes. In 2011, tiny quakes started to rattle the town and then on May 17, 2012 at 3am, residents were awoken by a 4.8 magnitude tremor: the largest ever measured in the eastern half of the state. What could be causing this small Texas town to shake, rattle and roll? In some studies, researchers argue that humans have been causing quakes throughout the state. However, despite the mounting evidence that oil and gas activity is the probable cause, Texas regulators have consistently questioned the link between the two. Ragan Dickens with the Louisiana Oil and Gas Association says that the earthquakes could be caused by a fault line:

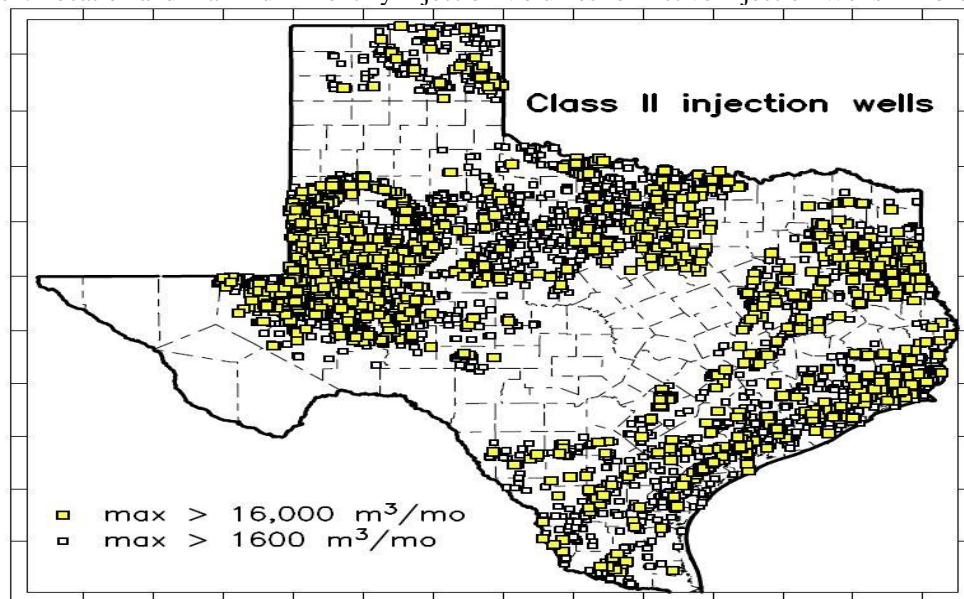
It's hard to say exactly what causes these plates in the earth to shift, but what we can look at is historic data. Historic data shows that there is an earthquake fault line in East Texas that has been around since the early 1800's and there's been well over 100 earthquakes recorded over this time period. So now that earthquakes are again happening in this region, it's easy for opposition or the other side of the argument to pinpoint it to hydraulic fracking or wastewater disposal, but the fact is these earthquakes have been going on for well over 100 years, whereas hydraulic fracking first got its start in 1949.¹

Does Fracking Cause Earthquakes?

The United States Geological Survey (USGS) defines hydraulic fracturing, or “fracking,” as a drilling process that injects millions of gallons of water, sand, and chemicals into a well. The high pressure cracks the rocks and releases natural gas and oil. Dr. Cliff Frohlich, Associate Director of and Senior Research Scientist at the Institute of Geophysics at the University of Texas at Austin, says that for years he did not believe that fracking itself caused earthquakes, but now he thinks differently.² Frohlich acknowledges that there have been at least three well-documented cases tying fracking to earthquakes, but adds that the quakes were very small and, considering that there are millions of frack jobs, these related earthquakes are rare. “The last thing a frack engineer wants is to have the fluids go through a fault and go somewhere,” he said in a 2013 interview. “It’s like pouring water through a drain. So if you’re a frack engineer doing their job, they’re avoiding faults. People injecting are less concerned about that, so they’re more likely to get to a fault.”³ Although his research shows that fracking can trigger minor earthquakes, the main culprit is not the act of drilling but rather the *disposal* of injection fluid.⁴

Texas is the nation’s number one oil and gas producer, with many injection and disposal wells located throughout the state. The vast majority (82%) of wells in Texas are injection wells (see Figure 1). These wells are used by operators to increase or maintain pressure in an oilfield that has been depleted by oil production and also to displace or sweep more oil toward producing wells.⁵ Since this is routinely practiced on a large commercial scale, in some occurrences, increased rates of seismic activity are reported in the vicinity of injection wells and attributed to fluid injection.⁶ According to the Texas Railroad Commission website, as of June 2015, there were more than 54,700 permitted disposals (of which 34,200 were active) which serviced more than 315,618 drilling wells. On average, each well is using about 4.5 million gallons of chemical-laced water.⁷

Figure1. Location and Maximum Monthly Injection Volumes for Active Injection Wells in Texas



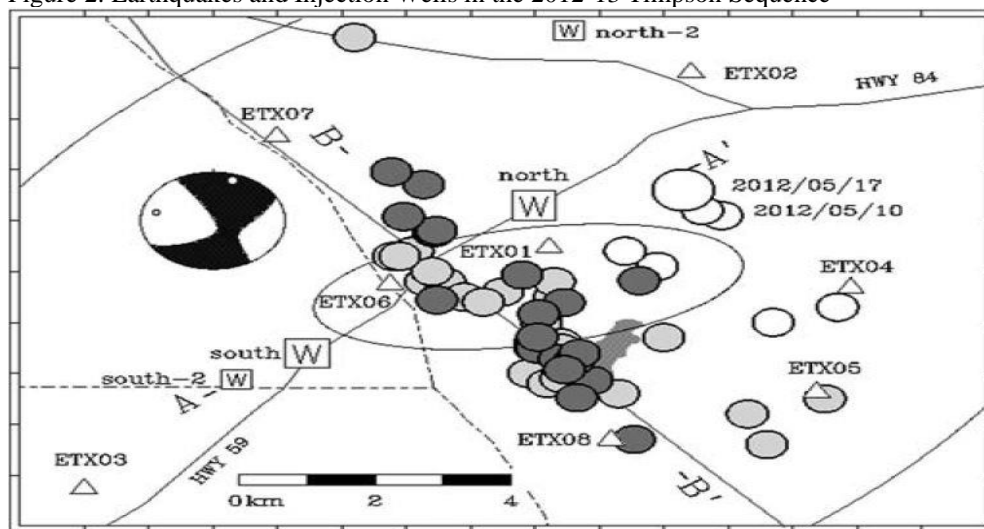
Source: C. Frohlich, “Induced or triggered earthquakes in Texas: Assessment of current knowledge and suggestions for future research,” *Final Tech. Rept. U.S. Geol. Surv.*, (2013): 44, reprinted in Cliff Frohlich, Heather DeShon, Brian Stump, Chris Hayward, Matt Hornbach, and Jacob I. Walter, “A Historical Review of Induced Earthquakes in Texas,” *Seismological Research Letters* 87, no. 4, (July/August 2016): 4,

<https://www.smu.edu/-/media/Site/News/NewsSources/EarthquakeStudy/earthquake-study-17may2016.pdf?la=en.Frohlich>

Fluid Injection and the Timpson Quakes

A 2016 satellite study by scientists from Stanford University, Arizona State, University of Colorado Boulder, University of Liverpool (UK), and UC Berkley confirmed that the 4.8 quake that shook Timpson in 2012 was, in fact, manmade or induced.⁸ “Our research is the first to provide an answer to the question of why some wastewater injection causes earthquakes, where it starts, and why it stops,” said co-author William Ellsworth, a geophysics professor at Stanford’s School of Earth and Environmental Sciences.⁹ Ellsworth and his co-authors used a remote sensing technique called Interferometric Synthetic Aperture Radar (InSAR), to measure ground deformations near the wells in Timpson where the quake occurred.¹⁰ The focus was on four wells located near the epicenter of the quake (see Figure 2). According to the Texas Railroad Commission records, these wells began operation between 2005 and 2007 and injected nearly 200 million fluid gallons per year underground. “You can think of wastewater as ancient ocean water,” Ellsworth said. “It’s too salty and too contaminated with other chemicals to treat economically, so the only viable solution at present is to put it back in the ground.”¹¹

Figure 2. Earthquakes and Injection Wells in the 2012-13 Timpson Sequence



Circles are earthquakes, triangles are temporary seismic stations, and squares are injection Disposal wells. White circles were epicenters for earthquakes occurring prior to installation of the temporary network, including the 17 May 2012 M 4.8 event. Light gray circles are epicenters determined when the network was partially installed; dark gray circles are the best located hypocenters occurring after installation of all eight stations.

Source: C. Frohlich, W. L. Ellsworth, W. A. Brown, M. Brunt, J. H. Luetgert, T. MacDonald and S. Walter, “The 17 May 2012 M 4.8 earthquake near Timpson, east Texas: an event possibly triggered by fluid injection,” *J. Geophys. Res. Solid Earth* 119, (2014): 581-593, reprinted in Cliff Frohlich, et al., “A Historical Review of Induced Earthquakes in Texas,” *Seismological Research Letters* 87, no. 4, (July/August 2016): 10, <https://www.smu.edu/-/media/Site/News/NewsSources/EarthquakeStudy/earthquake-study-17may2016.pdf?la=en>.

A main point in the well study determined that *where* the wastewater was injected made a huge difference in earthquake occurrence. Injecting at a depth of over one mile, two of the wells were determined to lie directly above where the quake occurred. The remaining two wells were shown to have similar volumes injected, but at shallower depths of just over a half mile below the surface. The InSAR measurements revealed that in the two shallow wells, there was detectable ground uplift or change.¹² However, unlike the deeper wells, a thick layer of impermeable rock prevented the pressure from migrating down towards the deep, faulted rock layer where earthquakes originate. “The detection of uplift when combined with well-injection records provides a new way to study wastewater injection,” says Manoochehr Shirzaei, a geologist from Arizona State.¹³ Yet the situation was different in the deeper well sites. There, the stiffer, impermeable rock from above actually allowed the pressure to be forced downward and build up until it triggered the earthquakes in 2012 along an ancient fault line.¹⁴

The Timpson tremors ended in late 2013, when pressures began to decline after water injections were considerably scaled back. These findings highlight the importance of understanding the local geology for wastewater operations. “Moving forward, we need to predict where pressures will increase in order to reduce the potential for inducing earthquakes,” Ellsworth said. “Our research uncovers new possibilities for operating wells that reduce earthquake hazard.”¹⁵

Regulators View on the Earthquakes

The Railroad Commission of Texas (RRC) is the agency responsible for regulating all petroleum and natural gas activity statewide. The RRC no longer has any control over railroads, as the Department of Transportation has jurisdiction. The authority over injection of underground fluids was delegated to the RRC by the U.S. Environmental Protection Agency (EPA) and follows national requirements under the Safe Drinking Water Act.¹⁶ According to the RRC website, the Oil and Gas Division’s main role is:

(1) [to] prevent waste of the state’s natural resources, (2) to protect the correlative rights of different interest owners, (3) to prevent pollution, and (4) to provide safety in matters such as hydrogen sulfide [related to the natural gas/propane industry]. The division accomplishes these goals by permitting and reporting requirements; by field inspections, testing programs and monitoring industry activities in the field; and through programs to remediate abandoned wells and sites through the use of fees and taxes paid by industry.¹⁷

The Railroad Commission is one of the only statewide regulatory offices in Texas in which regulators are elected and not appointed. Historically, commissioners have had long careers in the oil and gas industry and accept millions of dollars in campaign contributions from oil and gas interests, says David Prindle, a government professor at the University of Texas at Austin.¹⁸ This situation makes a conflict of interest almost inevitable and this agency has been criticized in the past for being too focused on promoting the energy industry and shielding it from any earthquake accountability.

“Between 1980 and about 2010 there were one or two earthquakes per year in the entire state. Between 2010 and 2015 that rate of seismicity changed to up to 15 small earthquakes per year,” says Peter Hennings, a veteran of the petroleum industry and now a co-principal investigator

at the Center of Integrated Seismicity Research (CISR).¹⁹ The number of earthquakes in Texas has continued to rise, with 28 on record in 2016. “Everybody wants to know what is going on. What has changed? And what can be done about it?” asks Hennings.²⁰

Amid mounting pressure in 2014, the Commission hired a seismologist to strengthen the Commission’s ability to understand and evaluate new research, as well as to coordinate an exchange of information regarding seismic activity that might be related to oil and gas activities.²¹ Then in October, later that year, the Commission adopted rule amendments designed to address disposal well operations in areas of seismic activity. The main components, effective November 17, 2014 were:

- Requiring applicants for new disposal well permits to conduct a search of the U.S. Geological Survey seismic database for historical earthquakes within a circular area of 100 square miles around the proposed, new disposal well;
- Clarifying Commission staff authority to modify, suspend, or terminate a disposal well permit, including modifying disposal volumes and pressures or shutting off a well if scientific data indicates a disposal well is likely to be or determined to be contributing to seismic activity;
- Allowing Commission staff to require operators to disclose the current annually reported volumes and pressures on a more frequent basis if staff determines a need for this information; and
- Allowing Commission staff to require an applicant for a disposal well permit to provide additional information, including pressure front boundary calculations, and to demonstrate that disposal fluids will remain confined if the well is to be located in an area where conditions exist that may increase the risk that the fluids may not be confined.²²

Since then, the RRC has received 51 disposal well applications, per their website. Of these, 22 disposal permits were issued with special conditions, such as requirements to reduce daily maximum injection volumes and pressures and to record these daily as opposed to monthly. Nine were issued without special conditions, and the rest were either withdrawn, protested, or are still pending.²³

However, in 2017 and 2018, this area saw a noticeable increase of oilfield activity, including an increase of fluid injection. Then, on September 4, 2018, the USGS confirmed that a 3.2 magnitude earthquake had hit about 4.3 miles northwest of Timpson, followed by a 2.5 magnitude occurrence a week later.²⁴ After this occurrence, the saltwater disposal site located close to the epicenter was shut down by the RRC. “Anytime there is seismic activity we’ve now developed a policy in Texas that you can no longer dispose of water or even drill for oil and gas in line with a fault in the earth that we know of,” explained Wayne Christian, Railroad Commissioner and Shelby County resident.²⁵

How to Reduce Earthquake Hazards

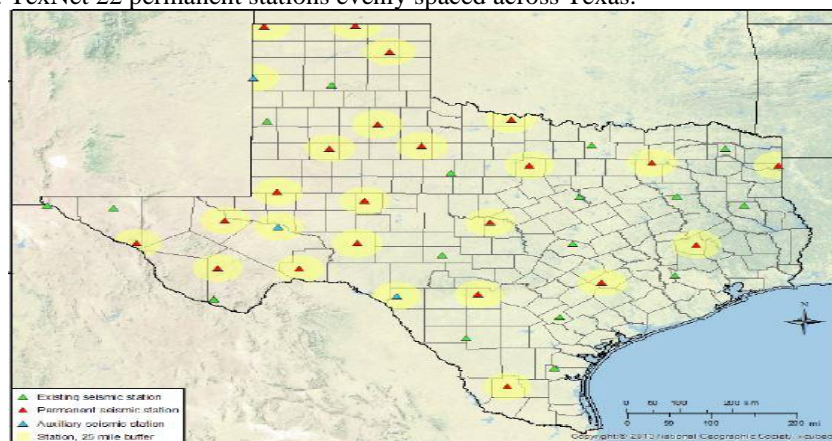
In reference to the 2016 satellite study, the risk of earthquakes can be reduced or even prevented. The findings have the potential to transform oil and gas industry practices, ASU geophysicist Manoochehr Shirzaei said, calling it “very ground breaking” and “very new.”²⁶ His conclusions suggest that disposal wells shouldn’t go too deep; or at least, they should only deposit

into rock protected from the underlying fault system.²⁷ The study also shows that researchers can estimate how much pressure is increasing underground, allowing a chance for injections to be stopped before the buildup reaches a critical stage.²⁸ Eventually, when the pressure has returned to normal, the injections could resume.

Another leading study, from scientists at the University of Texas at Austin and Southern Methodist University, agrees that the quakes in Timpson are definitely triggered by human activity. This new historical review of the evidence was published online May 18, 2016 in *Seismological Research Letters*. According to Cliff Frohlich, the study's lead author and senior research scientist, the research suggests that there is a lengthy history of induced seismicity in Texas going back to 1925. "For me, the surprise was that the oil field practices have changed so much over the years, and that probably affects the kinds of earthquakes that were happening at each time," he said. In the 1920s and 1930s, oil companies would find an oilfield and hundreds of wells would be drilled. They would suck oil out of the ground as fast as they could, which would shake the earth as the volume of underground oil was rapidly extracted.²⁹ When those fields were depleted in the 1940s through the 1970s, companies started being more aggressive, using water flooding or water injecting. However, his research showed that no evidence exists that can single out any industry practice that could be managed or avoided to stop these earthquakes from occurring.³⁰ "I think we were all looking for what I call the silver bullet, supposing we can find what kinds of practices were causing the induced earthquakes, to advise companies or regulators," he noted, "but that silver bullet isn't here."³¹

In June 2015, Texas Governor Greg Abbott and the 84th Legislature authorized \$4.47 million for TexNet.³² "TexNet is an array of seismometers across Texas that helps us better locate and identify earthquakes, but also measures the levels of ground shaking from these events," said Ellen Rathje, a professor at UT at Austin's Cockrell School of Engineering. TexNet plans to install at least 22 new permanent stations evenly spaced across Texas (see Figure 3).³³ These earthquake monitors stream data back to the Bureau of Economic Geology, and the data helps researchers understand when and where the seismic activity is occurring. "This research is developing fundamental understanding of the process that causes earthquakes and how they impact people, their infrastructure and their businesses," said Rathje.³⁴ However, planning the prime locations for the monitors has been challenging, given the size of Texas.

Figure 3. TexNet 22 permanent stations evenly spaced across Texas.



Source: Bureau of Economic Geology, used by Sar Sara Robberson Lentz, "Why is Texas shaking?", *Science X Network*, accessed October 22, 2018, <https://phys.org/news/2017-03-texas.html>.

Effects of Earthquakes on Communities

An earthquake has the potential to affect the lives of thousands, not only in the community but in the surrounding region. While structural damage is the most obvious effect, earthquakes can have far worse consequences. They can do significant damage to buildings, bridges, railways, pipelines, water lines, water towers and other structures. Earthquakes with a magnitude of 2.0 on the Richter scale or less are generally too small to be felt, while those of 5.5 or greater are capable of causing building and infrastructure damage. The Richter scale assigns a number to quantify the energy released by an earthquake, where each increase in whole numbers represents a tenfold increase in size and an increase in energy of 33 times.³⁵ Even though magnitude can be determined, damage can only be measured after the fact. As the earth moves, it can cause buildings and homes to shake. This movement can cause items to fall, walls or roofs to begin falling, or entire structures to collapse. As this structural damage occurs, it can cause injuries and/or death to the people inside. The economic factors in the aftermath include disruption in business services and productivity, rise in insurance costs or the loss of coverage, decrease in property value, and changes to neighborhoods as residents might have to relocate.

Certainly, earthquakes of different magnitudes and intensities will have different effects. Differing impacts also may be related to the condition of the affected area, whether its buildings and infrastructure are old and aging or new and robust. Other factors include the types of structures in existence, the extent to which earthquake insurance is available and affordable, and the extent to which mitigation efforts have been undertaken. For example, in an area like Timpson, where the buildings are old, the probability of significant loss is high. In 2014, Senator Robert Nichols hosted a meeting which included Texas RRC representatives and residents of Timpson and the surrounding areas to discuss concerns about the recent quakes. Jerry Woods, a downtown property owner, remarked that some of the commercial properties are over 50 years old, and earthquake insurance is not available for buildings that old.³⁶ “The folks that have insurance on their houses and have got earthquake insurance, not only do they have a huge fee to pay for it, a huge deductible but that will not cover their brick veneer,” said Woods. “Insurance problems are inherent here and I think that I could own a beach house, and probably some folks here have had them through the years, you can get Texas windstorm insurance and the state of Texas helps underwrite that windstorm insurance.” Woods went on to say that he would like to see the legislature establish a program to provide for the underwriting of affordable and effective earthquake insurance in this area of East Texas.³⁷

Impacts on Property Value

Wastewater disposal has already caused small earthquakes in East Texas, and now homeowners could face an even bigger aftershock: falling home prices. Property values will surely decline if the area suffers from damages due to disasters, including earthquakes. Also, homes will depreciate until the damaged areas have been restored. With minimal to no earthquake coverage, most homeowners are unable to fix their homes after damage from the quakes. Home and property owners should review their insurance policies with agents, brokers, or directly with insurers to determine whether their insurance policies adequately cover the potential losses. This research has observed that a decline in value is not only associated with earthquake activity, but with the property on or near these disposal wells.

The Oil and Gas industry is butting up against the American principles of property rights and the value of one's home. Increased truck traffic, chemicals, noise, lights, heavy equipment, harmful air emissions, and water contamination are all liabilities for landowners. A 2010 study of the Texas real estate market in the heavily drilled suburban-Dallas area concluded that "homes valued at more than \$250,000 and within 1,000 feet of a drilling pad or well site saw values decrease by three to fourteen percent."³⁸

Earthquake Emergency Management

Unlike some other natural hazards, most earthquakes strike without warning. Government leaders in an area at risk for earthquakes need to be prepared *before* earthquakes occur. Preparing for earthquakes involves learning what should be done before, during, and after a quake. Every at-risk city should have an emergency management coordinator in place. According to the Federal Emergency Management Agency (FEMA), emergency management is an organized, four-phased process by which communities:

- **Prepare** for hazards that cannot be prevented, or mitigated;
- **Respond** to emergencies that occur;
- **Recover** from emergencies to restore the community to its pre-emergency condition; and
- **Mitigate** risks by reducing or eliminating damage and disruption from future disasters.³⁹

Preparedness ensures that there are procedures in place to get those affected by a disaster through it as safely as possible. This means figuring out what a community, family, or business will do if essential services are lost, developing a contingency plan, and actually practicing the plan. The next phase is response; this begins as soon as a disaster threatens or is detected. It involves mobilizing emergency equipment and personnel; getting people out of danger; providing for necessities like food, water, shelter, and medical services; and bringing damaged services and systems back into operation. Recovery is the task of rebuilding; this can take months or even years to accomplish. Lastly, hazard mitigation is the ongoing effort to lessen the impact disasters have on people's lives and property.⁴⁰ The main mitigation measures that Timpson will need to implement are the engineering of building and infrastructure to withstand earthquakes, and possibly retrofitting existing buildings to reduce future damages.

Conclusion

In May of 2014, for the first time in its history, the state legislature held a meeting on earthquakes. They were not talking about natural tremors, but those induced or man-made. Texas has seen quakes measuring 3.0 and higher increase tenfold since an oil and gas boom several years ago.⁴¹ In a meeting hosted by Senator Robert Nichols that same year, he told the representatives of the Railroad Commission, "I would hope that you would take this area of the state, and raise it up into a priority status as far as trying to come to a resolve on the seismic activity. We all think we know what causes it, you the regulatory body does, so you're the ones who are going to have to reach the scientific evidence of how it connects," said Nichols. "I encourage you to do that as fast as you can. If there's something we can do, Representative Paddy and I can do in the legislature

to help you all do that if you need something passed this next session where you could have the authority to modify your rules, if that's what it takes, just let us know. But I think you have all the authority you know you need if you can come up and prove the science of how it works."⁴² Four years later, it is still not completely understood why earthquakes occur in some environments and not others. Cliff Frohlich has done extensive studies on the Timpson quakes. "It's like smoking and lung cancer, some people smoke and never get lung cancer. Some people get lung cancer and never smoke. And that's sort of the situation with injection wells," claims Frohlich.⁴³ For Timpson and the state of Texas, it is anticipated that this understanding will improve as seismic networks improve and more data is collected.

One suggestion on how to mitigate these unwanted tremors: find new ways of disposing drilling related wastewater.⁴⁴ "If disposal is causing earthquakes, you can find a different way to dispose of it. You can dispose of the stuff in a different well, or you can even take it to a fluid treatment plant," Frohlich says.⁴⁵ This sounds like an easy fix, but oil and gas companies are currently using the *cheapest* route that is generally considered safe in their disposal of fluid. So, what does this mean for the citizens of Timpson? Are the tremors going to stop? Will they continue? Could they get worse? It will all depend on the State's enforcement of regulations along with the involved industries' willingness to implement the costly, but necessary, measures to stop these earthquakes from occurring.

Notes

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¹² Manoochehr Shirzaei, et al., “Surface uplift and time dependent seismic hazard due to fluid injection in Eastern Texas.”

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⁴⁴ Kelly Connelly, David Barer, and Yana Skorobogatov, “How Oil and Gas Disposal Wells Can Cause Earthquakes.”

⁴⁵ *Ibid.*