mrt
https://www.mrt.com/business/oil/article/Researchers-study-Permian-for-answers-on-13464846.php

Researchers study Permian for answers on injection-induced earthquakes

Concerns about seismicity could shake up energy activity

By Mella McEwen, MRT.com/Midland Reporter-Telegram

Updated 11:32 am CST, Monday, December 17, 2018

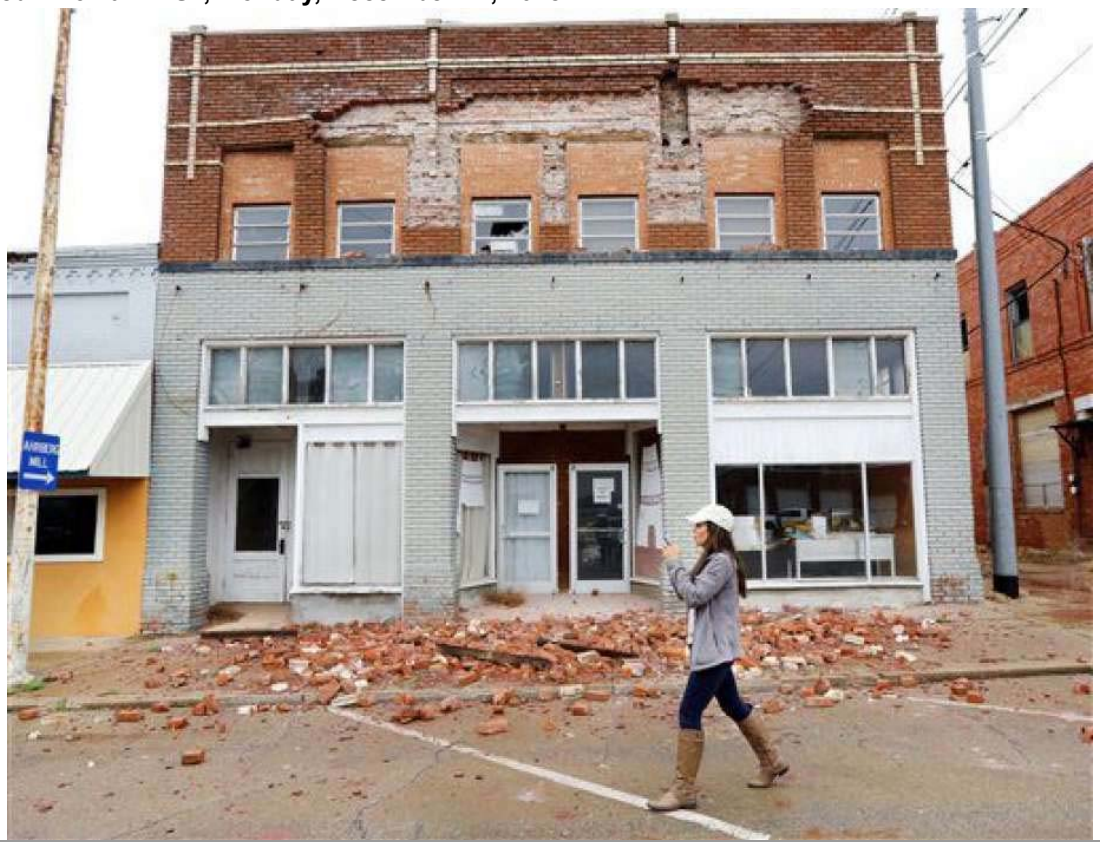

IMAGE 1 OF 7 **Buy Photo**

A television reporter takes video as she walks past a damaged building in Cushing, Okla. caused by Sunday night's 5.0 magnitude earthquake, Monday, Nov. 7, 2016. Dozens of buildings sustained "substantial ... more

Concerns about human-caused earthquakes could shake up water disposal in in the oil patch.

Seismicity and research into injection-induced earthquakes were the focus of a recent visit to Midland by researchers with Stanford University's Stanford Center for Induced and Triggered Seismicity.

Mark Zoback, Benjamin M.

Page professor of geophysics and director of the Stanford Natural Gas Initiative, is co-director of Stanford's seismicity center. In his presentation, Zoback listed three factors to be studied in assessing potential fault slips related to injection-induced earthquakes: state of stress, fault orientation and pore pressure perturbations.

"Occurrences of reservoir-induced seismicity indicates very small pore pressure perturbations can trigger seismicity," he said. "In retrospect, the faults responsible for every significant earthquake in Oklahoma could have been identified as being problematic if the fault itself had been identified in advance."

OIL REPORT: Goodnight Midstream settles into new Permian regional office

It is possible to take proactive steps to prevent the occurrences of injection-induced seismicity, he said.

"The ability to pre-identify pre-existing faults is the most challenging element of applying this technology."

The center offers software, Fault Slip Potential, to help identify potentially active faults. But Zoback said this software should be thought of as a screening tool and some potentially active faults will be missed. Still, he said, the software can be helpful in preventing injection near potentially active faults.

Jens-Erik Lund Snee, a doctorate candidate at Stanford, said, "across the planet, no places are more 'highly stressed' than others. Earthquakes are possible pretty much everywhere; they just occur in some places more often than others due to how rapidly tectonic activity is happening. Industry activity can simply make earthquakes happen sooner than they would have happened elsewhere, but nowhere -- including the Permian Basin -- is 'overstressed' or 'understressed.'

"I emphasize this because I want to be clear that, at least from the stress data, there is nothing especially dangerous -- or unusually safe, either -- about the Permian Basin from an earthquake point of view," he said.

Lund Snee said most of the Delaware Basin and Northwest Shelf are in a normal

faulting stress state, meaning faults of certain orientations to allow extension when they slip will be potentially active. Further east, in the Central Basin Platform and Midland Basin as well as southeast parts of the Delaware, he said the stress state is normal/strike-slip, meaning pre-existing faults that are oriented correctly for extension – normal faulting – as well as those oriented correctly for side-to-side offset – strike-slip faulting – are potentially active.

"The other piece for understanding the stress state is the orientation of the maximum horizontal stress direction. This is a measure of the direction of maximum horizontal compression that one would feel at depth in the Earth's crust. These measurements are routinely collected by oil and gas companies, some of which have contributed these data to SCITS," Lund Snee said.

He said researchers were surprised to see the remarkable change in the orientation of maximum horizontal stress direction from north to south across the Delaware Basin, from rotating smoothly about 150 degrees clockwise southward, from north-south in the northern Delaware Basin to southeast-northwest in the southeast. However, he said, further east, maximum horizontal stress direction is more or less east-west over much of the Central Basin Platform and the Midland Basin, including under Midland and Odessa.

OIL REPORT: **Natural gas coalition exceeds methane emission cuts 7 years early**

"This has implications for understanding which faults are of concern for wastewater injection and production, and which faults are not of concern. Using both the faulting regime and the orientation of maximum horizontal stress direction, we can predict those problematic and non-problematic fault orientations. Our FSP program allows operators and regulators to do just that. If they know their fault orientations and they use our map, they can estimate the chances that wastewater injection could make a fault potentially problematic," he said.

He said stress orientations and faulting regimes also help operators decide which directions to drill their wells.

Peter Hennings, research scientist and lecturer at the Bureau of Economic Geology and Center for Integrated Seismicity Research (CISR) -- the research arm of the BEG's

TexNet seismic monitoring program -- said the center is pursuing many branches of study in the Permian Basin and in the Delaware Basin, specifically “with the technical disciplines involved at the University of Texas and with our partnering institutions in Texas and elsewhere."

“We are actively studying the entirety of the Delaware Basin for the studies that need to be conducted at that larger scale to gain a better understanding of the subsurface characteristics of the earthquakes, including the monitoring of seismicity, geological studies and more," Hennings said. “Detailed modeling studies need to focus on more local area; therefore, we are currently working on the shallower levels now, including the intervals being currently used for most of the saltwater disposal wells, the Delaware Mountain Group stratigraphy. In 2019, those studies of the shallow levels will continue, and we will add more detailed modeling studies of the deep levels where most of the earthquakes are occurring."

He reported good progress in developing a new tectonic model and map of the Delaware Basin that will become available in a preliminary status next year. Hennings said many new faults are being identified.

“Earthquakes, for better or worse, are helping us to locate previously unidentified faults, but that's not really how we prefer to map faults. It would be better to have greater access to active-source seismic reflection data for mapping of potentially problematic faults but that economically valuable data is mainly held as proprietary by seismic vendors and industry," he said. “However, even reflection seismic data has limits on the size of faults that can be resolved; many of the earthquakes occur on smaller faults."

Hennings said that many of the CISR sponsors – Anadarko, Apache, Chevron, Cimarex, ConocoPhillips, Devon, EOG Resources, ExxonMobil and its XTO Energy subsidiary, Marathon, Occidental Petroleum, Pioneer Natural Resources, QEP Resources, Shell and SM Energy -- also are members of Stanford's seismicity center and are providing valuable assistance. He said member companies aid in placing seismometers in key areas and have indicated they intend to help CISR technically in other ways as research evolves.

Placing those seismometers in key areas to better monitor earthquakes will help

researchers get a better handle on the exact depth of the earthquakes, which Hennings said is a key concern.

“The subsurface environment of induced earthquakes in West Texas and the operational influences that may be contributing to them (are) far more geologically and geomechanically complex than in other areas such as north-central Oklahoma and the Dallas-Fort Worth area, and that makes it especially interesting, scientifically," he said. “It's possible that each of the dozen or so small magnitude earthquake clusters identified to date in West Texas may have its own particular mix of factors, both from human and natural influences. In the coming months and years, we will learn a lot about induced and natural earthquakes that will better enable us to mitigate their occurrence. The Texas Railroad Commission and our partner companies are closely watching our work, and we are doing everything in our power to advance our data and studies to provide what they need, as quickly as possible, given the complexity of the problem."

TexNet, the state-funded network of both permanent and mobile seismometers, has identified several clusters of activity in the Permian Basin, according to Alexandros Savvaidis, manager of TexNet and principal investigator in seismology at CISR.

Since TexNet began providing data in January 2017, there have been about 40 earthquakes with magnitude of 1.5 or less along the Midland-Ector county line. The Snyder area, primarily around the Cogdell area, has had a higher number of higher-magnitude earthquakes, about 20 of 2.5 magnitude. The area between Pecos and Fort Stockton has reported earthquakes with the highest magnitude, five of 3 magnitude or higher.

Savvaidis said TexNet is utilizing different methods, including geophysical, seismological and geomodelling, to identify faults. He said the center is currently working on research to find a correlation between oilfield activity -- from water injection, saltwater disposal wells or hydraulic fracturing -- and seismic events.

Like Hennings, he said producers who are members of CISR are supportive of the research efforts, providing access to land to deploy seismometers or access to proprietary seismic data.

Mella McEwen is the Oil Editor and covers the latest business and energy news.

You can read more from her **here.** |mmcewen@mrt.com|