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The Limits of a New ‘Five Question Test’ for Analyzing Texas Earthquakes

May 18, 2016 by Steve Everley — Leave a Comment

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This week, Texas researchers unveiled a new system designed to categorize Texas seismicity as natural or manmade. The system, unveiled in a report published by faculty at the University of Texas at Austin and Southern Methodist University, relies on a five-question "test" to assess the likelihood that a particular earthquake is tectonic (natural), possibly induced, probably induced, or almost certainly induced.

But a closer review of the test shows that it is based on a "subjective approach" that excludes the significance of conditions such as subsurface pressures and fluid movements that experts, including the lead author himself, consider essential to understanding induced seismicity.

In essence, the new system appears to recommend greater reliance on temporal and spatial elements, and less emphasis on trying to understand the subsurface physics that may increase the likelihood of an induced seismic event.

The 'Test'

The new report – whose lead author is Dr. Cliff Frohlich, the associate director at the Institute for Geophysics at the University of Texas – is actually a historical review of Texas earthquakes over the past century. The authors examine previous seismic events in the State through the lens of their new, question-based system. The five questions are:

- *Timing*: In this location, are earthquakes of this character known to begin only after the commencement of nearby petroleum production or fluid injection operations that could induce seismic activity?
- *Spatial correlation*: Are the epicenters spatially correlated with such production or injection operations (i.e., within 5 km for well-determined epicenters or within 15 km otherwise)?
- *Depth*: Is information available concerning focal depths of earthquakes at this location, and does this suggest some depths are shallow, probably occurring at or near production or injection depths?
- *Faulting*: Near production or injection operations, are there mapped faults or linear groups of epicenters that appear to lie along a fault? Here, "near" is within 5 km if the earthquake or earthquake sequence of interest has well-determined epicenters, or within 15 km otherwise.
- *Published analysis*: Is there a credible published paper or papers linking the seismicity to production or injection operations?

Each question can be answered with "Yes," "Possibly," or "No." A "Yes" answer is scored 1.0; a "Possibly" answer, 0.5 and a "No" answer is scored 0. After all five questions have been answered, the total "score" is computed. Based on that scoring, the researcher can allegedly assess whether the event was natural or induced:

- 0-1.0: Tectonic (natural)
- 1.5-2.0: Possibly induced
- 2.5-3.5: Probably induced
- 4.0-5.0: Almost certainly induced

What the Experts Say

Notably, the five question test contains nothing about assessing subsurface pressures — a glaring omission. Curiously, Dr. Frohlich developed a similar system in the 1990s: a seven-question test calling for an examination of fluid pressures

and subsurface structures that could provide a plausible pathway for fluids to lubricate faults. That system was first revealed in a study entitled "Did (Or Will) Fluid Injection Cause Earthquakes? Criteria for a Rational Assessment," published in 1993 by the Seismological Society of America. The questions were:

1. Are these events the first known earthquakes of this character in the region?

2. Is there a clear correlation between injection and seismicity?

3a. Are epicenters near wells?

3b. Do some earthquakes occur at or near injection depths?

3c. If not, are there known geological structures that may channel flow to sites of earthquakes?

4a. Are changes in fluid pressure at well bottoms sufficient to encourage seismicity?

4b. Are changes in fluid pressure at hypocentral locations sufficient to encourage seismicity?

The last three questions attempt to ascertain whether injected fluids have a pathway to a fault, and whether the injection pressures are sufficient enough to induce a seismic event. But none of these are a part of the new Frohlich (2016) paper.

Last year, more than a dozen state regulatory agencies – in consultation with experts from state geological surveys, academia, non-profits, industry, and federal agencies such as the U.S. Geological Survey, the U.S. Environmental Protection Agency, and the U.S. Department of Energy – published a primer on induced seismicity through the StatesFirst Initiative, which concluded:

> *"**Understanding induced seismicity requires knowledge about the relationship between injection activities and the activation or reactivation of faults, including the effects of pore pressure increases from injection** and the spatial and temporal relationships between injection and critically stressed faults." (p. 1; emphasis added)*

The StatesFirst report, which was peer-reviewed, also cited Dr. Frohlich's 1993 study, which it characterized as providing "an initial screening method using seven questions that address not only spatial and temporal correlations, but injection-related subsurface pore pressure changes in proximity to the fault." The StatesFirst report went on to observe:

> *"It is **not sufficient to look solely at temporal and spatial correlations** of seismicity or at changes in well pressures at well bottoms without also considering the potential pore pressure perturbations at the fault (hypocenter)." (p. 23; emphasis added)*

Research from the U.S. EPA has similarly established the importance of pressure and geologic pathways in assessing manmade earthquakes. The EPA's Underground Injection Control National Technical Workgroup (NTW) produced a

report last year, which observed:

> *"The NTW confirmed the following components are necessary for significant injection-induced seismicity: (1) **sufficient pressure buildup** from disposal activities, (2) Faults of Concern, and (3) a **pathway allowing the increased pressure to communicate** with the fault." (p. ES-2; emphasis added)*

The new UT/SMU report on Texas earthquakes effectively dismisses the guidance of the U.S. EPA, thirteen state regulatory agencies, and numerous other members of academia.

'A Subjective Approach Was More Reasonable'

The authors of the UT/SMU report defend their methods by arguing that the data necessary to determine if an earthquake is induced or manmade (i.e. pressure, focal depths, etc.) are not always available:

> *"However, the **application of strictly objective criteria has its limitations**, especially over century-long intervals in areas like Texas, where there were few seismograph stations, epicentral locations are highly uncertain, focal depths are (mostly) unknown, and the existence and quality of information about extraction and injection changes through time." (p. 15; emphasis added)*

In light of this, the authors "concluded that a subjective approach was more reasonable for assessing the Texas historical catalog."

Regarding the seven-question test that Dr. Frohlich had previously developed, the authors further acknowledge that they removed subsurface pressure considerations in this new system:

> *"We no longer include questions related to subsurface pressures and modeling; this information is available for few events and, when reported, often relies on somewhat arbitrary (and arguable) assumptions about subsurface structure and flow properties." (p. 4)*

The authors add that the new five-question system "already gives adequate credit for analysis and modeling," since one of the questions asks about published papers on the specific event. If a peer-reviewed paper links injection activities to seismic events, then presumably that paper would have considered pressures and other subsurface realities.

But that feature also highlights the limits of the new UT/SMU system.

For example, a study published by SMU researchers last year – many of whom are co-authors in this latest study – found that earthquakes near Azle, Tex., were "most likely" caused by brine production and wastewater disposal operations. According to the UT/SMU five-question system, the Azle study would yield a high score in that category for "almost certainly induced."

But an expert review panel later determined that the SMU team's Azle study "presents data indicating a weak temporal correlation between injection and seismic activities – too small, however, to imply a causal relationship without further corroborating evidence."

By removing pressure considerations and retaining an emphasis on time and space, the UT/SMU system appears to place greater importance on temporal and spatial factors – at the expense of properly examining subsurface conditions necessary to induce earthquakes.

Last year the Texas legislature recognized the importance of subsurface modeling with House Bill 2, which provided funding to the Bureau of Economic Geology at the University of Texas to pursue reservoir modeling for wells located in the vicinity of faults. The authors of the UT/SMU report said in a release that the new modeling and additional seismic monitors would "provide more consistent and objective data on induced earthquakes."

Conclusion

The SMU study on earthquakes near Azle, Tex., attempted to model underground pressures and fluid movements, which was an admirable attempt to advance the science in this field. As Energy In Depth observed at the time, the SMU researchers "deserve credit for developing a model that provides greater understanding of the conditions that can ultimately lead to induced seismicity." The SMU team recognized a major flaw in much of the research on this subject, namely an over-reliance on simple correlation in time and space to link human activities to seismic activity.

But the new five-question test that many of those same researchers have just developed, which doubles down on temporal and spatial correlation, appears to be an unfortunate step backwards.

None of this suggests that a question-based system is the wrong approach. Determining whether an earthquake was natural or manmade is difficult, to say the least, and will always be subject to differing interpretations. Any procedure that standardizes the methods by which we study these events can potentially help address those problems.

Moreover, the authors of the UT/SMU study readily acknowledge that "different individuals, after considering the observations, are likely to answer the questions differently." But since they will "seldom disagree on the answers to all five questions," according to the authors, the question-based system "serves to focus discussion on the critical aspects of the evidence."

The value of this should be self-evident. By illuminating the areas of broad agreement, a question-based approach helps scientists focus their efforts on the details over which there may be significant disagreement.

However, the problem with the UT/SMU test is that researchers who use it are prevented from even *having disagreement* over the key questions of induced seismicity – namely, whether subsurface pressure was sufficient to cause an earthquake, and whether a plausible pathway exists from the injection site to the fault.

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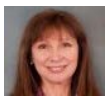

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