Hidden microearthquakes illuminate large earthquake-hosting faults in Oklahoma and Kansas

August 26 2022

Credit: Pixabay/CC0 Public Domain

Using machine learning to sift through a decade's worth of seismic data, researchers have identified hundreds of thousands of microearthquakes along some previously unknown fault structures in Oklahoma and Kansas.

The newly identified microearthquakes allowed the seismologists to map and measure earthquake clusters in the region, which has experienced unusual levels of seismicity due to unconventional oil and gas production
.

As they report in *The Seismic Record*, the researchers found that 80% of the magnitude 4 and larger earthquakes that occurred in the past decade could have been anticipated based on the spatial extent of seismicity clusters that included the large earthquake before it occurred.

They also found that once a cluster reached a length scale large enough to host a magnitude 4 or larger earthquake, there was nearly a 5% chance that it would do so within a year of achieving that length scale, according to Yongsoo Park, a Ph.D. student at Stanford University and colleagues.

The cluster information could be used by companies and regulators to monitor oil and gas operations in the future, Park and colleagues suggest.

With little natural seismicity and incomplete mapping of faults in Oklahoma and Kansas before unconventional hydrocarbon development, researchers have been looking for new ways to understand the region's seismic hazard.

Park and colleagues had used a machine learning technique to find almost 90,000 unknown microearthquakes in Arkansas in a previous study. "We were impressed with the result, especially because the catalog revealed previously unknown clusters," said Park. "We knew that most earthquakes in the Oklahoma-Kansas area occurred on hidden faults in the basement, so we wanted to apply the workflow to reveal these faults."

The researchers reanalyzed seismic data collected from 17 publicly available seismic networks in Oklahoma and Kansas from 2010 to 2019. Using a neural network to detect earthquakes and their P and S-wave arrival times, they found over 300,000 earthquakes in the data.

When mapped, the additional microearthquakes "connected the dots" between scattered earthquakes and the small clusters formed by the 60 magnitude 4 or larger earthquakes included in the study. The newly detected microearthquakes illuminated the surprising presence of many previously unknown faults, said Park.

"However, the more surprising part was that many of the clusters that were thought to be separated in previous studies were in fact connected by microearthquakes. In other words, finding small earthquakes is probably no longer an option, but rather a requirement when we are trying to do clustering analysis on earthquake data," he said.

Park said that regulators could adapt the usual "traffic light" protocol—which oil and gas operators use to monitor and stop or slow their activities to mitigate seismic hazard—to incorporate the length scale of an earthquake cluster.

The original traffic light protocol is guided by observed earthquake magnitudes and controlled by the largest magnitude event. Estimating earthquake magnitudes from the length scale could make this process proactive, and controlled by both large and small earthquakes, the researchers note.

"But because the magnitudes are only estimates, the required actions to be taken should probably be different," Park explained. If a length scale of the cluster raises concern, for example, "the regulators could ask the operators to deploy more seismometers around the concerning cluster to better map the hidden fault."

More information: Yongsoo Park et al, Basement Fault Activation before Larger Earthquakes in Oklahoma and Kansas, *The Seismic Record* (2022). DOI: 10.1785/0320220020

Provided by Seismological Society of America