Method predicts size of fracking earthquakes

Scientists develop way to forecast worst-case tremor scenario.

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'Fracking' operations have been known to cause earthquakes.

Small earthquakes are a recognized risk of hydraulic fracturing, or 'fracking', a procedure in which companies unlock energy reserves by pumping millions of litres of water underground to fracture shale rock and release the natural gas trapped inside. Researchers now say that they can calculate the highest magnitude earthquake that such an operation could induce — though it won't determine the likelihood of a quake occurring.

The model is crude, but it should be “good enough” to use in the field, says Arthur McGarr, a geologist at the US Geological Survey in Menlo Park, California, who presented the work yesterday at the annual meeting of the American Geophysical Union in San Francisco, California. “The method could help engineers trying to plan for future earthquakes know what to plan for,” he adds.

McGarr's team says that the quantitative method is applicable to any operation that involves injecting fluid deep underground. Apart from fracking, such activities include the disposal of fracking fluids — in which companies get rid of their drilling water by pumping it into disposal wells — as well as geothermal-power generation and carbon dioxide sequestration.

It is rare, but not unheard of, for fluid-injection operations to cause detectable earthquakes. The number of such tremors has increased over the past decade as the amount of deep fluid injection has risen, says McGarr. Fracking itself is thought this year to have spurred quakes in Lancashire, UK — of magnitude 2.3 and 1.5 — and Gavin County, Oklahoma, of up to magnitude 2.8 (see 'Fracking caused British quakes').

Straightforward relationship

McGarr and his team studied seven cases of quakes induced by fluid injection. They included the Oklahoma fracking site where 8,900 cubic metres were injected; a scientific bore hole in Germany, where an injection of 200 cubic metres of salt water caused a magnitude 1.4 earthquake; a geothermal-energy project on the outskirts of Basel, Switzerland, that was terminated after an injection of 11,600 cubic metres of water triggered a series of quakes of magnitude up to 3.4; another in Cooper Basin, Australia, where a 20,000-cubic-metre injection resulted in a magnitude 3.7 quake; and a liquid-waste-disposal project in Colorado in the 1960s, where an injection of 631,000 cubic metres triggered earthquakes of magnitude up to 5, the largest yet seen as a result of fluid injection.

The researchers found a proportional relationship between the volume of fluid injected and the magnitude of the earthquake.

“If you inject about 10,000 cubic metres, then the maximum sized earthquake would be about a magnitude 3.3,” says McGarr. Every time the volume of water doubles, the maximum magnitude of any quake rises by roughly 0.4. “The earthquakes may end up being much smaller, but you want to be prepared for the worst-case scenario,” says McGarr. The relationship is straightforward, but it is the first time that anyone has quantified it, he adds.

McGarr has also developed a similar method — now in standard industrial use — to work out the maximum size of earthquake that can be triggered as ore is extracted in underground mining[1]. This work “builds on the same concept”, he says.

He notes that the latest work doesn't give the probability of an earthquake actually occurring: that depends on other factors, such as the strength and permeability of the rock.

Max Wyss, director of the World Agency for Planetary Monitoring and Earthquake Risk Reduction in Geneva, Switzerland, said that the study was a “good review” of the situation but did not achieve what is really needed — working out the maximum induced earthquake that can be tolerated at any given location. “We need to do better at estimating the risk for society from the earthquakes,” he says.

McGarr’s team hopes to submit the work for publication soon, with further case studies.

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References

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