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Environment

Cracks showing in industry built on shaky ground



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Seismologists will be asking many questions about the magnitude 4.4 earthquake that struck Los Angeles this week, a sharp jolt that reverberated across densely populated southern California.

The quake, which hit at 6.25am on Monday local time, occurred beneath the Santa Monica Mountains on a little-known fault where faint tremors are the norm and which last slipped 80 years ago.

"You really are surprised to find an earthquake on a fault you didn't know about," Thomas Heaton, director of Caltech's Earthquake Engineering Research Laboratory, told the Los Angeles Times. It was a wake-up call on how little seismologists know about the labyrinth of mapped and hidden faults in what the US Geological Survey (USGS) told locals was "earthquake country".

Given fears that the Big One - a catastrophic rupture on the San Andreas fault between the Pacific and North American tectonic plates - is overdue, locals need little reminder

their world can snap in an instant. The last time the San Andreas fault slipped, in 1906, a magnitude 7.8 quake levelled San Francisco.

In December, a USGS report on a theoretical 7.8 quake warned Los Angeles, with 12.8 million people in the metropolitan area, was woefully unprepared and would be crippled by huge infrastructural damage.

Another report last year looked at a theoretical magnitude 9.0 quake in the Pacific Northwest, triggered by a slip in the offshore Cascadia fault system where the Gorda and Juan de Fuca plates slide below the North American plate.

The Cascadia system has produced California's two largest quakes - a magnitude 6.8 this month and a 7.2 in 2005 - over the past decade. In a region where debris from the Japanese 2011 tsunami has fetched up, officials fear a quake will generate a monster wave killing up to 10,000 and costing US\$70 billion (\$82 billion).

All of which seem good reasons for not tipping the scales to endanger life.

But according to a new study, released last week, from the Centre for Biological Diversity, Earthworks and Clean Water Action (CBD), that is exactly what is happening. The report *On Shaky Ground: Fracking, Acidising and Increased Earthquake Risk in California*, says injecting billions of litres of wastewater from hydraulic fracturing into empty deposit wells near active faults, in and around Los Angeles and other cities, dramatically increases the risk of quakes endangering the lives of millions of Californians.

It is the latest salvo against fracking the Monterey Shale, a swathe of oil-rich rock (estimated to contain 15.4 billion barrels) that stretches north along the coast from San Diego County, through the Los Angeles region and beyond and across part of the San Joaquin Valley, at times near the San Andreas fault.

Advocacy groups accuse state officials, intent on joining fracking booms in Oklahoma, Texas, North Dakota, Ohio, New Mexico and elsewhere, of ignoring the industry's dark side: air and water pollution, excessive water use, carbons that fuel climate change, the effects of 24/7 drilling on nearby communities and now, most sensationally, the threat of induced earthquakes.

Scientists have long known that injecting fluids near faults heightens pressure and may induce quakes. Mounting evidence suggests fracking raises this risk.

The process uses prodigious amounts of water which, laced with chemicals and sand, is forced underground to fracture oil or gas-rich rock.

The wastewater that flows back to the surface with oil and gas is reinjected deep below ground. The CBD report calculates that fracking the Monterey Shale would leave 34 trillion litres of water to be disposed of using injection wells. "The injection of wastewater can increase the pressure on rock formations," says Shaye Wolf, the CBD's climate science director and a co-author of the report.

"It can cause the natural friction on a fault - that's pinning the fault in place - to relax, causing the fault to slip and thus trigger an earthquake."

Opponents say the US fracking boom has precipitated swarms of small quakes. Seismologists are reaching the same conclusion.

In July, the journal *Science*, in a study funded by the USGS and the National Science Foundation, examined big quakes in Japan, Chile and Indonesia and found they triggered smaller quakes near injection wells in Texas, Oklahoma and Colorado, a warning to those who exploit nature's bounty of its endless, unseen connectivity. Lead author Nicholas van der Elst, from Columbia University's Lamont-Doherty Earth Observatory, said injected fluids "are driving the faults to their tipping point", heightening the risk of a quake.

The fracking industry says such events are "very rare" and more study is needed. The American Petroleum Institute contends decades of research only revealed "micro-seisms". The largest registered at magnitude 0.8 and was almost too small to read on instruments, with 2000 times less energy than a magnitude 3.0 quake, the level normally felt by humans. Despite the energy industry's efforts to shrug off concerns - echoing its denial of links between fossil fuel use and climate change - growing research paints a more disturbing picture.

The *Science* paper found an 8.8 quake in Chile in February 2011 induced a 4.1 quake in Prague, Oklahoma, 16 hours later. Swarms of small quakes followed near the Wilzetta fault, long considered dead by seismologists, in a state where quakes were once very rare indeed but where injection wells (there are 4400 active ones) are common. In November 2011, Prague was hit by a 5.7 quake that wrecked 12 homes, injured two people, fissured a US highway and was felt in 17 states, including Wisconsin, 1285km distant.

The journal *Geology* says Oklahoma's quake swarms are probably caused by injection wells. The USGS cites few quakes before 2008, when fracking hit the gas pedal, rising to more than a dozen that year, almost 50 in 2009, more than 1000 in 2010 and 1400 in 2011. Texas, Colorado, Arkansas and Ohio show similar arcs as the number of magnitude 3.0 quakes - about 40 a year in Oklahoma - climbs sharply.

The CBD report says quakes attributed to wastewater injection "include a 4.8 in Texas, 5.3 in Colorado, 4.7 in Arkansas and 3.9 in Ohio".

Oklahoma's insurance commissioner has recommended people buy earthquake insurance, one of the boom's unwelcome financial downsides, as the threat of class-action lawsuits against the industry grows.

It's not known if injection wells in California have helped trigger quakes, although three Los Angeles city councillors asked the question after Monday's quake. They drafted a motion that noted "active oil extraction activities were reportedly taking place near the epicentre".

The city voted 10-0 for a fracking moratorium last month, following concerns about water scarcity. The state's Independent Petroleum Association insists there is no link between fracking and Tuesday's 4.4 quake. But it raises the bar and puts the onus on the industry to prove fracking is safe.

The CBD report found 54 per cent of California's 1553 active wastewater injection wells were within 16km of a recently active fault.

Six per cent, or 87 wells, are within 1.6km. Researchers found dozens of quakes had occurred north of Los Angeles within 16km of the San Andreas fault in Kern County, which has a high concentration of fracked wells - hardly reassuring given evidence from Science of how quakes can trigger domino seismic events.

Seismology can be a frustrating science. No one can predict quakes, the holy grail. But growing evidence suggests the link between injection wells and quakes may be more causal than circumstantial.

Activists want to ban fracking in California. It's a tough call. But as public safety concerns multiply, so does pressure for tougher regulation, such as seismic monitoring near injection wells and mandatory data sharing. Meanwhile, there's a sense the energy industry is flying blind, chasing profits despite ominous warnings.