Energy

Oil extraction linked to Oklahoma earthquakes

Pumping waste water into the ground – a by-product of new oil and gas extraction processes – was the likely cause of a recent surge of earthquakes in the US state of Oklahoma, according to researchers in the US (*Science* 10.1126/science.1255802). Oklahoma is typically a seismically quiet region, having averaged only two tremors of magnitude 3.0 or higher per year between 1978 and 2008. But since 2009 the rate has skyrocketed, with 109 quakes last year and more than 200 to date in 2014 – making Oklahoma more active than any other US state except Alaska.

Oil and gas extraction methods produce huge volumes of waste water that is disposed of by injecting it into the ground. Geologists have known for decades that an influx of water can reduce the friction in a fault, making it more susceptible to slippage – and thus an earthquake. But no-one was sure if this was the case in Oklahoma, where the earthquakes were far from water disposal wells.

Led by Katie Keranen of Cornell University, the team modelled the injection of waste water from the 89 largest disposal wells in central Oklahoma. The computer simulations show that the waste water produced an expanding underground region of high fluid pressure that matches how earthquakes have spread across the state. "They seem to be getting bigger and growing in the same manner as the model," says Geoff Abers of Cornell, a co-author of the study. The calculated changes in pressure also pass the threshold needed to cause quakes. And, he says, the waste water is pumped to depths where a quarter to a third of all the earthquakes occurred.

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Rumbling on
Oklahoma has suffered more than 200 tremors of magnitude 3.0 or higher this year, compared with averaging only two per year between 1978 and 2008.

The Cornell team's analysis reveals that earthquakes could be generated up to 35 km from disposal wells, a wider range of influence than had been thought, as tremors had previously been linked only to wells a few kilometres away. The researchers also found that it is the high-volume wells – such as the four in south-east Oklahoma City that produce about four million barrels of waste water per month – that have the biggest impact.

A technique called hydraulic fracturing – or fracking – has been blamed for causing earthquakes. But while it can spawn at least tiny earthquakes, Abers says fracking is probably not the main culprit in Oklahoma. Fracking is a highly controlled process involving relatively small volumes of water. However, the vast majority of Oklahoma's waste water is from other processes such as "dewatering", which pulls a mixture of water and oil from the ground.

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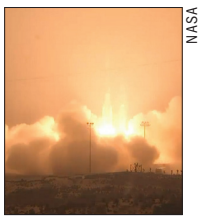
Earth observation

Reborn carbon mission blasts off after five-year wait

NASA has successfully launched a mission to measure carbon dioxide (CO_2) levels in the Earth's atmosphere in unprecedented detail. The $465m Orbiting Carbon Observatory (OCO-2) took off last month on a Delta 2 rocket from Vandenberg Air Force Base in California. OCO-2 was put in an orbit around the Earth at an altitude of 705 km, where its instruments will now be calibrated before being put into full use.

OCO-2 is a reincarnation of the $270m Orbiting Carbon Observatory (OCO), which crashed into the Pacific Ocean near Antarctica on 24 February 2009 shortly after takeoff, following a rocket malfunction. Later that year the US government decided to build an identical mission, which had been scheduled for launch in February 2013. But when NASA's $424m Glory satellite, which would have studied how the Sun and aerosols in our atmosphere affect the Earth's climate, also failed in a similar manner to OCO after takeoff on 4 March 2011, agency officials delayed the launch of OCO-2. NASA also decided to send OCO-2 into space using a bigger Delta 2 rocket – rather than the Taurus rocket that had been used for OCO and Glory's launch – which added to the cost of launching the new mission.

"OCO-2 will not only allow many of us who worked on the original OCO mission to complete unfinished business, but to take the next step in an important journey to understanding our home planet," says OCO-2 project manager Ralph Basilio from NASA's Jet Propulsion Laboratory in California. Weighing 454 kg, OCO-2 is NASA's first spacecraft dedicated to making space-based observations of atmospheric CO_2. OCO-2 carries a single instrument that it will use to produce "concentration maps" of carbon sources and sink throughout the world. As sunlight is reflected from the Earth's surface, gases such as CO_2 and oxygen absorb this light at specific wavelengths. OCO-2 contains three spectrometers tuned to detect changes in the intensity of this absorption.



NASA

Carbon hunter
NASA's $465m Orbiting Carbon Observatory will measure carbon-dioxide levels on Earth.

"OCO-2 will deliver on the promises made on the original OCO mission – to obtain space-based measurements of carbon dioxide with the precision, resolution and coverage to improve our understanding of the carbon cycle and climate-change process," says Basilio. OCO-2 now joins the "A-train", a set of six Earth-observing satellites that are already in orbit. These include the CALIPSO and Cloudsat satellites looking at the levels of aerosols in the Earth's atmosphere and monitoring cloud formation, which were both launched in April 2006.

Michael Banks