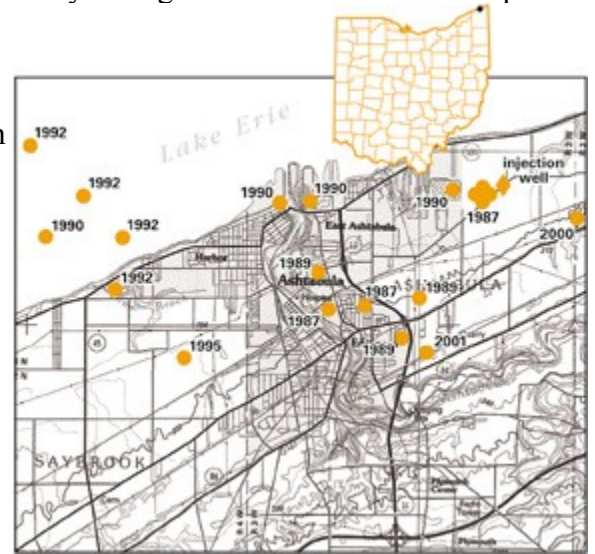


Triggering quakes with waste

Seismologists believe that millions of gallons of hazardous waste injected nine years ago into a 1.8 kilometer-deep well are leaking into the surrounding rock pores and causing local earthquakes in Ashtabula Township, Ohio. The liquid waste was injected under high pressure into the well from 1986 to 1993. The fluid naturally found pores and cracks to fill, but in this case seems to have given an ancient unknown fault the lubrication necessary to slip.

The industrial port city on Lake Erie experienced its first known earthquake swarm about a year after the well began receiving waste. Before that time, no record existed of an earthquake ever striking within 30 kilometers of the township. Then a magnitude-3.8 quake with multiple aftershocks struck on July 13, 1987. John Armbruster and Leonardo Seeber, both of the Lamont-Doherty Earth Observatory at Columbia University in Palisades, N.Y., immediately started investigating the earthquakes and determined the epicenters were only 700 meters from the well.



Epicenter locations for earthquakes greater than magnitude 2.0 in Ashtabula, Ohio, from 1987 through 2001. Courtesy of the Ohio Department of Natural Resources.

They discovered a previously unknown strike-slip fault at a depth of about 2 kilometers. Now, they say, the injected fluids have migrated further from the well and are triggering the slip of a second fault, about 4.5 kilometers away but still around 2 kilometers deep.

“The injection well is of concern because it reaches the depth where earthquakes can occur,” Seeber says. “About one mile down, the rock formation becomes permeable and fluid migrating out from the well alters the pore pressure.” This weakens the fault and triggers an earthquake, he says.

While most of the earthquakes following the 1987 event had a magnitude less than 3.0, on Jan. 25, 2001, a temblor of magnitude 4.5 shook the township. “That did damage to 50 homes and businesses,” says geologist Michael Hansen of the Ohio Department of Natural Resources. “Ceiling tiles fell, plaster cracked and gas lines broke causing people to evacuate. Since 1987 we had felt predominately smaller ones and this one brought Ashtabula into focus again.”

Ashtabula is not the first example where fluids under high pressure put deep into the earth have induced earthquakes. The classic case occurred in the 1960s at the Rocky Mountain Arsenal near Denver, Colo. The Army pumped 165 million gallons of fluid waste over a four-year period into a well about 3.7 kilometers deep. The seismic records showed swarms of small earthquakes whose frequencies correlated with the volume of fluid pumped each month. “The Army stopped using the well because of the earthquakes and the largest event, in the magnitude 5 range, occurred after they stopped,” Seeber says. Eventually the seismic activity subsided.

It’s difficult to determine when an injection well may pressure a fault to slip. “There are a number of injection wells in Ohio. And elsewhere companies are injecting hazardous waste as deep as they can get it in the sedimentary rock, into the basement and away from drinking water sources,” Hansen says. “In most cases it’s never a problem. Indeed, I haven’t seen it in any other injection well in Ohio.”

Beginning in 1989, after federal restrictions prohibited dumping hazardous wastes on land, companies like Environmental Resources Service, which drilled the Ashtabula well, had to prove that anything injected into the ground stayed in place for 10,000 years. Before granting operating permits, the Ohio Environmental Protection Agency at this time also began evaluating each site to determine if it needed seismic monitoring.

Still, injection wells aren’t the only culprits. The potential for an earthquake exists any time that humans change the stress or pressure of the rocks at depth, Seeber says. Pumping fluid into the earth, operating rock quarries or deep oil wells are also likely activities known to trigger earthquakes around the world, he says. “It’s not easy to investigate the situation. The first thing we need to do is realize this is a problem and assess it and face it. Yes, we need oil and mineral resources, and it is necessary to pump fluids in and out of the ground. But we need to recognize that earthquakes are a byproduct.” - **Christina Reed**