FAQs ON INDUCED SEISMICITY

www.usgs.gov/faq/index.php?action=show&cat=125

Do all wastewater disposal wells induce earthquakes?

No. Of more than 150,000 Class II injection wells in the United States, roughly 40,000 are waste fluid disposal wells for oil and gas operations. Only a small fraction of these disposal wells have induced earthquakes that are large enough to be of concern to the public.

How does the injection of wastewater at depth cause earthquakes?

Earth's crust is pervasively fractured at depth by faults. These faults can sustain high stresses without slipping because natural "tectonic" stress and the weight of the overlying rock pushes the opposing fault blocks together, increasing the frictional resistance to fault slip. The injected wastewater counteracts the frictional forces on faults and, in effect, "pries them apart", thereby facilitating earthquake slip.

Is the recent sequence of earthquakes near Youngstown, Ohio, related to the wastewater disposal activities there?

There is a credible connection between the wastewater injection activities near Youngstown and the recent earthquakes, including the magnitude 4 earthquake that occurred on New Year's Eve, 2011. This connection is based on the close proximity of the earthquakes to the injection well and depth of injection, and the observation that these events began soon after the start of the injection activities.

How large are the earthquakes induced by fluid injection?

Of the case histories for which there is a scientific consensus that an injection operation induced earthquakes, the largest are magnitude*5. At the Rocky Mountain Arsenal well, near Denver, Colorado, a large volume of wastewater was injected between 1962 and 1966. A substantial earthquake sequence was induced by these injection activities. Injection was terminated in 1966 due to the induced earthquakes. More than a year after injection ceased, three earthquakes with magnitudes near 5 occurred, after which the earthquake sequence finally decayed. Over the years, even larger magnitude earthquakes have been tentatively associated with fluid injection activities, but more research is needed to establish if there is a connection for any of these recent cases.

Are earthquakes induced by fluid-injection activities always located close to the point of injection?

No. Given enough time, the injected fluids can migrate substantial horizontal and vertical distances from the injection location. Induced earthquakes commonly occur several kilometers below the injection point. In some cases, the induced earthquakes have been located as far as 10 km (6 mi.) from the injection well.

Is there any possibility that a wastewater injection activity could interact with a nearby fault to trigger a major earthquake that causes extensive damage over a broad region?

So far, there is no conclusive example linking injection operations to triggering of major earthquakes, however we cannot eliminate this possibility. More research is needed to either confirm or refute this possibility.

Is it possible to anticipate whether a planned wastewater disposal activity will trigger earthquakes that are large enough to be of concern?

Currently, there are no methods available to do this. Evidence from some case histories suggests that the magnitude of the largest earthquake tends to increase as the total volume of injected wastewater increases. Injection pressure may also be a factor. More research is needed to determine the answer to this important question.

Can you prevent large earthquakes by making lots of small ones, or by "lubricating" the fault with water or another material?

Seismologists have observed that for every magnitude 6 earthquake there are 10 of magnitude 5, 100 of magnitude 4, 1,000 of magnitude 3, and so forth as the events get smaller and smaller. This sounds like a lot of small earthquakes, but there are never enough small ones to eliminate the occasional large event. It would take 32 magnitude 5's, 1000 magnitude 4's, 32,000 magnitude 3's to equal the energy of one magnitude 6 event. So, even though we always record many more small events than large ones, there are never enough to eliminate the need for the occasional large earthquake.As for "lubricating" faults with water or some other substance, injecting high pressure fluids deep into the ground is known to be able to trigger earthquakes to occur sooner than would have been the case without the injection. However this would be a dangerous pursuit in any populated area, as one might trigger a damaging earthquake.

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Can we use a lot of explosives to cause small earthquakes in order to prevent having large ones?

No. Even huge amounts of explosive almost never cause even small earthquakes (see previous FAQ), and it would take hundreds and thousands of small earthquakes to equal a large one, even if it could be done. In addition, we wouldn't have any control over the size of the earthquake being created if it worked, since small and large earthquakes all start out in exactly the same way. It's just not physically possible.

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Does the production of natural gas from shales cause earthquakes? If so, how are the earthquakes related to these operations?

To produce natural gas from shale formations, it is necessary to increase the interconnectedness of the pore space (permeability) of the shale so that the gas can flow through the rock mass and be extracted through production wells. This is usually done by hydraulic fracturing ("fracking"). Fracking causes small earthquakes, but they are almost always too small to be a safety concern. In addition to natural gas, fracking fluids and formation waters are returned to the surface. These wastewaters are frequently disposed of by injection into deep wells. The injection of wastewater into the subsurface can cause earthquakes that are large enough to be felt and may cause damage.

Can we cause earthquakes? Is there any way to prevent earthquakes?

Earthquakes induced by human activity have been documented in a few locations in the United States, Japan, and Canada. The cause was injection of fluids into deep wells for waste disposal and secondary recovery of oil, and the use of reservoirs for water supplies. Most of these earthquakes were minor. The largest and most widely known resulted from fluid injection at the Rocky Mountain Arsenal near Denver, Colorado. In 1967, an earthquake of magnitude 5.5 followed a series of smaller earthquakes. Injection had been discontinued at the site in the previous year once the link between the fluid injection and the earlier series of earthquakes was established.

Other human activities, even nuclear detonations, have not been linked to earthquake activity. Energy from nuclear blasts dissipates quickly along the Earth's surface. Earthquakes are part of a global tectonic process that generally occurs well beyond the influence or control of humans. The focus (point of origin) of earthquakes is typically tens to hundreds of miles underground. The scale and force necessary to produce earthquakes are well beyond our daily lives.

We cannot prevent earthquakes; however, we can significantly mitigate their effects by identifying hazards, building safer structures, and providing education on earthquake safety.

Source:

Nicholson, Craig and Wesson, R.L., 1990, *Earthquake Hazard Associated with Deep Well Injection--A Report to the U.S. Environmental Protection Agency*: U.S. Geological Survey Bulletin 1951, 74 p.

What work is the ODNR-DOGRM doing to better understand the occurrence of injection-induced earthquakes?

ODNR-DPGRM has deployed seismometers at sites of known or possible injection-induced earthquakes in Mahoning and Washington counties, and has additional deployment planned to other counties with newly permitted deep injection wells. These seismic networks will enable ODNR-DOGRM to monitor and identify if the earthquakes near and adjacent the injection wells are generated by injection well(s), which would allow for dynamic regulation and immediate decision to maintain public and operational safety. The ODNR-DOGRM is also working together with the Environmental Protection Agency and USC-ISC (University of South California-Induced Seismicity Consortium) through the IOGCC (Interstate OIL AND GAS Compact Commission) and its subcommittee (ERRT-Energy Resources, Research, and Technology Committee) on how to assess the earthquake hazard associated with wastewater injection activities at Class II disposal wells.