



Earthquake Hazards Program

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

A:

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.

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Q: How does the injection of wastewater at depth cause earthquakes?

A:

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.

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Q: How large are the earthquakes induced by fluid injection?

A:

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.

^{*} [definition of earthquake magnitude](#)

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Q: What work is the USGS doing to better understand the occurrence of injection- induced earthquakes?

A:

USGS supports both internal and external (university-based) research on the causes of induced earthquakes. This research has a focus on injection-induced earthquakes, both from wastewater disposal and from enhanced geothermal technologies. USGS and its university partners have also deployed seismometers at sites of known or possible injection-induced earthquakes in Arkansas, southern Colorado, Oklahoma and Ohio. The USGS is also providing advice to the Environmental Protection Agency about how to assess the earthquake hazard associated with wastewater injection activities at Class II disposal wells.

For more information, contact the USGS Office of Communications, 703-640-4460

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Q: 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?

A:

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.

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Q: Do all wastewater disposal wells induce earthquakes?

A:

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.

^{*} More information on wastewater disposal wells and the [EPA's Underground Injection Control \(UIC\) program](#)

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

A:

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.

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

A:

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.

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

A:

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.

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