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Underground wastewater disposal in the US linked to increase in earthquakes

The number of earthquakes of magnitude 3 or greater in the central and eastern US has increased significantly in recent years, from about 21 a year between 1967 and 2000, to over 300 between 2010 and 2012. Most of this increase seems to be linked to the deep injection of wastewater in underground wells, according to a recent review of seismic activity.

In addition to natural causes, earthquakes can be triggered by a number of human activities, including damming water in reservoirs, mining activities, the extraction of oil and gas and injecting fluids deep into the ground, e.g. for the purposes of harnessing geothermal energy. However, this review of earthquakes caused by human activities suggests much of the recent seismic activity in the US has been associated with the injection of wastewater from oil and gas developments into underground disposal wells.

Earthquakes can be triggered when an existing and susceptible fault is weakened and slips. This can happen, for example, when the stress on the fault increases, or the pressure of fluid in the rock pores increase (e.g. from pumping wastewater into underground rocks), weakening the fault and causing it to slide. In injection-induced earthquakes, the source of the stress or pressure change may be nearby or kilometres away from where the earthquake occurs.

Hydraulic fracturing ('fracking') also involves pumping fluids underground at high pressure. This routinely generates micro-earthquakes (less than magnitude 2) that are too small to be felt on the surface and that create fractures in rock formations, allowing trapped oil or gas to flow up the well to the surface.

This method has been used for over 50 years in the US, mainly to increase the recovery of oil and gas in older wells, however, the use of fracking to extract oil and gas from tight shale formations has increased significantly since the late 1990s. Despite over 100 000 wells being recently fracked in the US and Canada, the largest earthquake associated with fracking (in British Columbia) was of magnitude 3.6, not large enough to be a serious threat to public safety or the environment.

It appears that disposing of fracking wastewater by injecting it deep underground poses more of a threat in inducing larger earthquakes than hydraulic fracturing itself. Nevertheless, most of the 30 000 Class 11 wastewater disposal wells associated with oil and gas production in the US do not appear to cause seismic activity and the risk of earthquakes from these wells is considered to be low. Analysis of previous injection-induced earthquakes suggests that the rate at which the fluid is injected, as well as the total amount injected, affects the risk of earthquakes. It is also possible for earthquakes to occur even long after injection has ceased.

Methods to reduce the risk of injection-induced earthquakes have been proposed in the US. One approach involves a traffic-light system to monitor seismic activity, so that the rate of injection or injection pressure can be reduced or stopped if a threshold of seismic activity is reached. In addition, monitoring seismic activity below magnitude 2 in areas where there is a concentration of injection wells, as well as improving the collection and reporting of injection data, would be beneficial, particularly as the use of deep injection to dispose of wastewater is likely to increase with future oil and gas developments in the US.

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