

## Illinois Should Benefit From Ohio's Experience With Fracking Induced Seismicity

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Prior to shale gas development the state of Ohio had suffered slightly over 200 felt earthquakes since 1776. Many of them were near Anna, Ohio which sits in an extension of the New Madrid and Wabash Valley seismic zones. Since then 3 counties, all aseismic, have suffered over 1,000 positive magnitude earthquakes. All of the earthquakes were human induced due to fracking for shale gas. The quakes are restricted to four locations, two housing injection wells and two fracking well pads.

Locality	County	Year	Induced Cause	Recorded Quakes	Reported on ODNR Website	Reference
Youngstown	Mahoning	2011-14	Injection	566	12	Kim, 2013 Skoumal, 2014, Skoumal, et al 2014a
Uhrichsville	Harrison	2013	Fracking	400	0	Friberg et al, 2014
Poland	Mahoning	2014	Fracking	77	5	Skoumal, et al 2014b
Niles	Trumbull	2014	Injection	2	1	Linert, 2014 Runyan, 2014
TOTALS				1045	18	

After the first swarm of earthquakes triggered by the Northstar 1 injection well in Youngstown, Ohio (2011-present) the Ohio Department of Natural Resources (ODNR) issued new rules regarding injection wells, which includes mandatory seismic monitoring.

*Ohio will seek the following reforms to its Class II deep injection well program:*

- 1) Requires a review of existing geologic data for known faulted areas within the state and avoid the locating of new Class II disposal wells within these areas;*
- 2) Requires of a complete suite of geophysical logs (including, at a minimum, gamma ray, compensated density-neutron, and resistivity logs) to be run on newly drilled Class II disposal wells. A copy of the completed log, with analytical interpretation will be submitted to ODNR;*
- 3) Evaluates the potential for conducting seismic surveys;*

- 4) Requires operators to plug back with cement, prior to injection, any well drilled in Precambrian basement rock for testing purposes.*
- 5) Requires the submission, at time of permit application, of any information available concerning the existence of known geological faults within a specified distance of the proposed well location, and submission of a plan for monitoring any seismic activity that may occur;*
- 6) Requires a measurement or calculation of original downhole reservoir pressure prior to initial injection;*
- 7) Requires conducting a step-rate injection test to establish formation parting pressure and injection rates;*
- 8) Requires the installation of a continuous pressure monitoring system, with results being electronically available to ODNR for review;*
- 9) Requires the installation of an automatic shut-off system set to operate if the fluid injection pressure exceeds a maximum pressure to be set by ODNR;*
- 10) Requires the installation of an electronic data recording system for purposes of tracking all fluids brought by a brine transporter for injection;*

Unfortunately rule number 10 has never been implemented. Had it been, it may have prevented the owner of the Northstar 1 well from illegally dumping up to 40,000 gallons of toxic and radioactive fracking waste into the Mahoning River. The cleanup has cost Ohio taxpayers over three million dollars.

At the time these rules were announced I recommended requiring a sonic log in addition to the required gamma ray, compensated density-neutron, and resistivity logs. The sonic log can identify faults transected by the bore hole, the others can't. This is important if the well drills through a fault plane. This was very relevant to the Youngstown injection well because the borehole penetrated about 200 feet into the basement rock and actually penetrated a fault. Normally, basement faults cannot be detected by any logs in the wells limited to the sedimentary layers.

Faults in the sedimentary layers above the (generally Precambrian) basement are rarely the source for the larger, potentially damaging earthquakes. Experience in Ohio and elsewhere indicates that these dangerous induced earthquakes occur in the basement rocks.

Therefore a minimum recommendation is the installation of at least one initial seismometer near every well targeted for fracking or waste disposal should be required. If activity above a yet to be defined threshold magnitude near the well is then detected, an array of at least 4 sensitive stations need to be added before fracking or injection can resume. The Ohio injection well monitoring plan currently requires 4 sensitive seismic stations. These seismic stations have come into play because both the Youngstown injection well and one or both of two 2014 injection wells in Niles, Ohio have triggered additional earthquakes.

Fracking has also triggered earthquakes in Ohio. Two of the only five reported cases, worldwide, are in the Buckeye state. The induced seismicity due to fracking in Ohio drew public attention in March of this year when 77 earthquakes ruptured at least 300 meters of a previously unknown fault under a municipal waste landfill. It now turns out that in October of 2013, over 400 earthquakes were generated due to fracking in Harrison County, about one hundred kilometers to the south. This information was kept secret from the public until the publication of a scientific

journal article about the event (ref. C). Several of the 2013 earthquakes were magnitude 2.0 or greater and met the criteria for listing on the ODNR OhioSeis website. They were not posted.

After the March 2014 fracking earthquakes the ODNR made the following statement:

*New permits issued by ODNR for horizontal drilling within 3 miles of a known fault or area of seismic activity greater than a 2.0 magnitude would require companies to install sensitive seismic monitors. If those monitors detect a seismic event in excess of 1.0 magnitude, activities would pause while the cause is investigated. If the investigation reveals a probable connection to the hydraulic fracturing process, all well completion operations will be suspended. ODNR will develop new criteria and permit conditions for new applications in light of this change in policy. The department will also review previously issued permits that have not been drilled.*

In Ohio activities will pause at a Magnitude 1.0 event. After England's fracking-induced earthquakes, the cut-off was set at Magnitude 0.5. The seismic magnitude cut-offs in the Illinois traffic light approach (Green <2, Yellow 2 to 4, and Red >4) appear too high and are not restrictive enough to provide an appropriate level of public safety. For example, the observed seismicity due to fracking in the Horn River Basin of British Columbia, Canada were from Magnitudes 2.2 and 3.8 (British Columbia Oil and Gas Commission, 2012) These quakes were strong enough to deform the well casings in the lateral portions of nearby wells. This would fall in the Illinois Yellow zone, which requires nothing mandatory until three such events, after which there would be a consultation. The Northstar 1 well in Youngstown was shut down on December 30, 2011 and was followed by a Magnitude 4.0 earthquake the next day, that caused damage to peoples' homes. In his report, Dr. Kim of Columbia University concluded "that continued injection of fluid at Northstar 1 well could have triggered potentially large and damaging earthquakes."

If I understand correctly the Illinois rules apply only to injection wells, not fracking wells. I recommend that in Illinois you apply your seismicity rules to shale oil and gas production wells in addition to injection wells.

In regards to the geology, the 1000+ eastern Ohio earthquakes occurred on inactive faults that are over one-billion years old. These faults would not have moved, if there had been no injection or fracking. In Illinois you have two know seismic zones, The New Madrid and Wabash Valley seismic zones. Your state already has a known seismic risk. You need to write rules that are more restrictive than Ohio, not less. You also need to work with geologists and geophysicists, that have no conflicts of interest regarding oil and gas, to delineate regions of the state that are off-limits to both fracking and injection wells. Given what is already known about the historical seismicity in the region, to not do so, would be irresponsible and willfully ignorant.

Finally, it is important to realize that rules or permit conditions do not prevent earthquakes, in Ohio or anywhere else.

## References cited

British Columbia Oil and Gas Commission, 2012, Investigation of Observed Seismicity in the Horn River Basin, <http://www.bcogc.ca/investigation-observed-seismicity-horn-river-basin> Viewed November 3, 2014

Friberg, P.A., Besana-Ostman, G.M., and Dricker, I., 2014 Characterization of an Earthquake Sequence Triggered by Hydraulic Fracturing in Harrison County, Ohio, Seismological Research Letters Volume 85, Number 6 November/December 2014

Kim, W. Y., 2013, Induced seismicity associated with a fluid injection into deep well in Youngstown, Ohio, J. Geophys. Res. 118, 3506– 3518,

Linert, B. J., 2014, Scientists search for clues in quake, September 3, 2014 Warren (OH) Tribune Chronicle, (<http://www.tribtoday.com/page/content.detail/id/615078/Scientists-search-for-clues-in-quake.html?nav=5021>) Viewed November 3, 2014

Ohio Department of Natural Resources, Division of Geological Survey, Recent Events List, <http://www2.ohiodnr.com/geosurvey/earthquakes-ohioseis/ohioseis-home> Viewed November 3, 2014

Runyan, E., 2014, Earlier Weathersfield quake accompanied increase in pressure at well September 13, 2014 Youngstown (OH) Vindicator <http://www.vindy.com/news/2014/sep/13/odnr-more-seismic-activity-occurred/> Viewed November 3, 2014

Skoumal, R. J., 2014, Optimizing Multi-Station Earthquake Template Matching Through Re-Examination Of The Youngstown, Ohio Sequence, Master 's Thesis, Miami University, Oxford, Ohio

Skoumal R. J., Brudzinski M. R., Currie B. S., Levy J., 2014a, Optimizing multi-station earthquake template matching through re-examination of the Youngstown, Ohio, sequence, Earth and Planetary Science Letters v. 405 p. 274–280

Skoumal, R. J., Brudzinski, M. R. and Currie, B. S. , 2014b, Induced earth- quakes during hydraulic fracturing in Poland Township, Ohio, Bull. Seismol. Soc. Am. (submitted) and personal communication