

OhioNET: State of Ohio's Response to Induced Seismicity

Steven Dade

Ohio Department of Natural Resources: Division of Oil & Gas
Resources Management



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Overview

I. State of the Ohio Utica Play

- Latest Utica Shale
- Latest Class II Brine Disposal

II. OhioNET Seismic Monitoring System

III. Induced Events

- Northstar #1 Injection Well
- Poland Township Hydraulic Fracturing
- Harrison County Hydraulic Fracturing

IV. Regulation & Mitigation Techniques

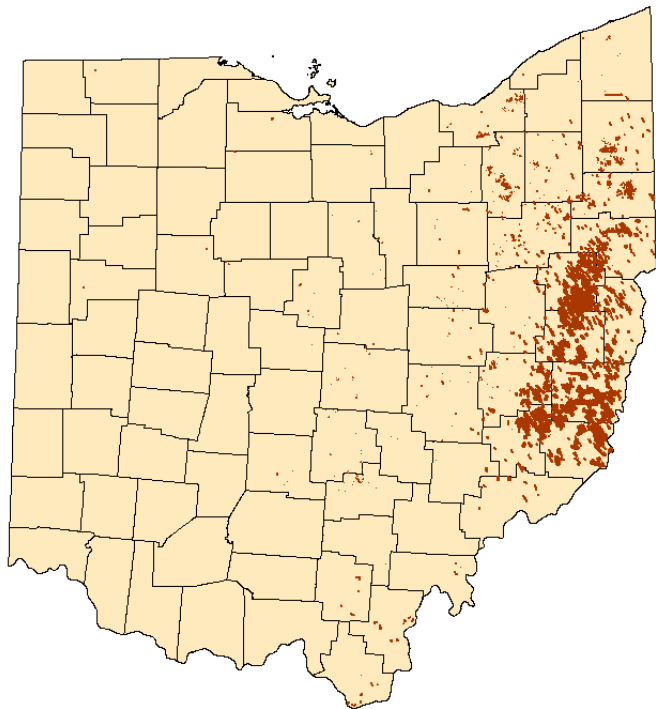
V. Interstate Collaboration

VI. Public Awareness & Educational Outreach



Latest Utica Shale

(as of 04/01/2017)



Utica

Permits

2,452

Drilled

1,950

Producing

1,528

Marcellus

Permits

46

Drilled

28

Producing

20



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Latest Utica Shale (continued)

Recent Per Year Totals

2014 Totals

Oil: 10,999,162 barrels

Gas: 452,866,564 Mcf

2015 Totals

Oil: 21,985,351 barrels

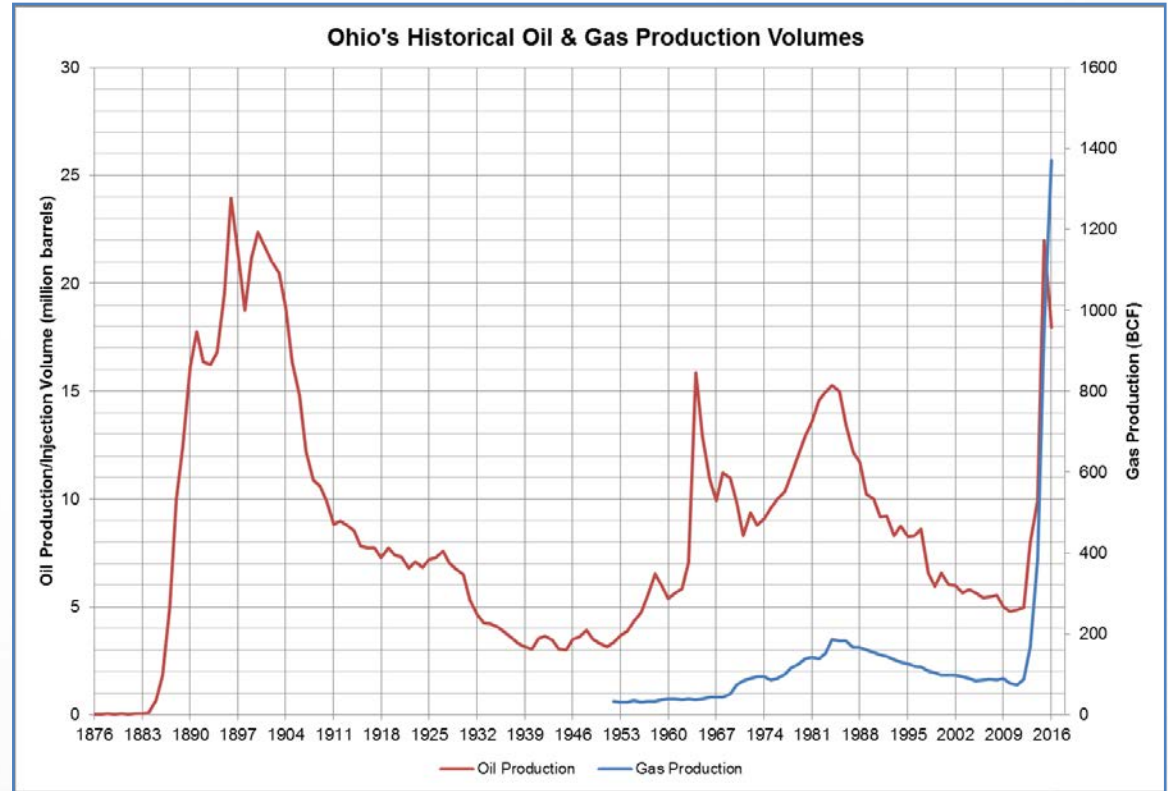
Gas: 954,748,118 Mcf

2016 Totals

Oil: 17,949,097 barrels

Gas: 1,370,220,834 Mcf

Annual Production Percent Change		
	2014 to 2015	2015 to 2016
Oil	99.90%	-22.14%
Gas	110.60%	43.39%

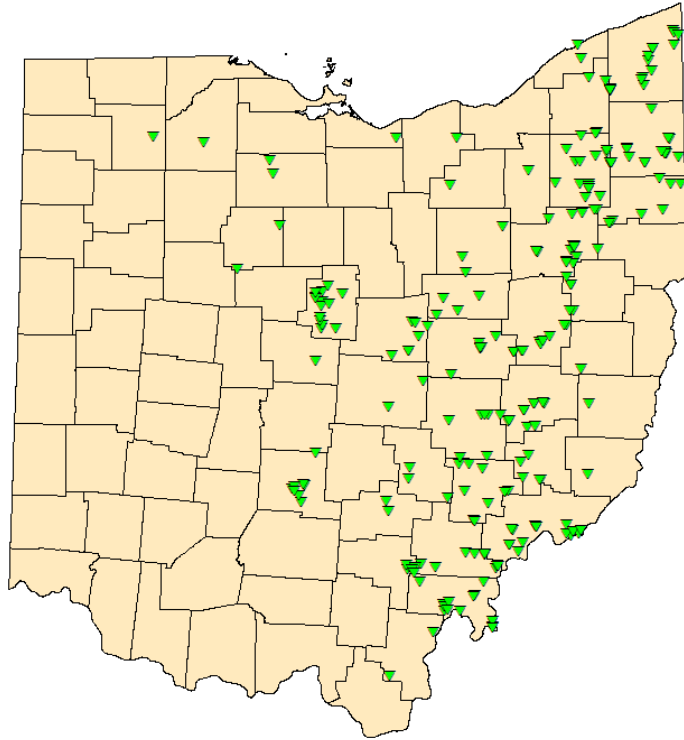


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Latest Class II Brine Disposal Numbers

(as of 03/18/2017)



Active Injection

217

Drilled

11

Drilling

1

Shut In

2

Newly Permitted

8



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Latest Class II Brine Disposal Numbers (continued)

Recent Per Year Totals

2012 Totals

Brine: 14,157,885 barrels

Active Wells: 146

2013 Totals

Brine: 16,383,043 barrels

Active Wells: 164

2014 Totals

Brine: 24,704,481 barrels

Active Wells: 185

2015 Totals

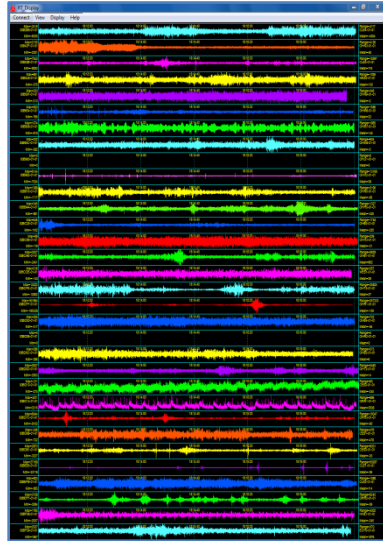
Brine: 32,023,496 barrels

Active Wells: 212



OhioNET Seismic Monitoring System

RekTek Waveform Display



RekTek State-of-Health Monitor

Ref Tek Network Monitor (4.0.8.0 - 2015Jun15) - List View								
Acquisition	Temp.	Input	Backup	Delay(s)	RAM(Kb)	Disk1(Mb)	Disk2(Mb)	GPS(h)
Start On	21°C	12.9V	3.3V	1	0%(6400)	0%(7621)	76%(3806)	U-Sleep (0.3)
Start On	23.4°C	12.7V	3.3V	1	0%(6400)	100%(7621)	26%(3806)	U-Sleep (0.3)
Start On	21.5°C	12.7V	3.3V	1	0%(6400)	67%(7621)	0%(3813)	U-Sleep (0.3)
Start On	21.3°C	12.5V	3.3V	1	0%(14592)	N/A	N/A	U-Sleep (0.3)
Start On	21.5°C	12.5V	3.3V	1	0%(14592)	N/A	N/A	U-Sleep (0.3)
Start On	22°C	12.7V	3.3V	1	13%(6400)	N/A	N/A	U-Sleep (0.3)
Start On	21.5°C	11.8V	3.3V	1	0%(14592)	N/A	N/A	U-Sleep (0.3)
Start On	22.4°C	12.9V	3.3V	3190	1%(6400)	N/A	N/A	U-Sleep (0.4)
Start On	20.3°C	12.6V	3.3V	0	0%(6400)	N/A	N/A	L-Awake
Start On	22.4°C	13.7V	3.3V	8814	0%(6400)	N/A	N/A	L-Awake
Start On	21°C	12.9V	3.3V	0	0%(6400)	N/A	N/A	L-Awake
Start On	20°C	12.6V	0.4V	3190	0%(6400)	N/A	N/A	L-Awake
Start On	25°C	12.8V	3.3V	568	0%(6400)	N/A	N/A	L-Awake
Start On	25°C	12.9V	3.3V	3815	0%(14592)	N/A	N/A	L-Awake
Start On	21.4°C	12.8V	0.4V	1	3%(6400)	100%(1873)	36%(1873)	L-Awake
Start On	21.3°C	12.8V	0.4V	0	14%(6400)	60%(15250)	0%(1873)	L-Awake
Start On	20.8°C	12.8V	0.4V	1	5%(6400)	60%(15250)	0%(1950)	L-Awake
Start On	20°C	12.9V	3.3V	1	0%(6400)	N/A	N/A	L-Awake
Start On	16.5°C	12.7V	3.3V	0	0%(6400)	N/A	N/A	L-Awake
Start On	23°C	12.8V	0.4V	2	1%(6400)	0%(1873)	62%(15250)	L-Awake
Start On	21.4°C	12.7V	3.3V	0	17%(6400)	100%(15250)	14%(15250)	L-Awake
Start On	21.4°C	12.7V	3.3V	0	15%(6400)	0%(3806)	58%(7621)	L-Awake
Start On	22.5°C	12.6V	3.3V	0	0%(6400)	N/A	N/A	L-Awake
Start On	18.9°C	12.6V	3.1V	0	13%(6400)	0%(1950)	87%(15250)	L-Awake
Start On	21°C	12.5V	3.3V	1	0%(6400)	N/A	N/A	U-Sleep (0.3)
Start On	21.5°C	12.7V	3.3V	1	0%(14592)	N/A	N/A	U-Sleep (0.3)
Start On	20.8°C	12.6V	3.3V	1	0%(6400)	N/A	N/A	U-Sleep (0.3)
Start On	21.5°C	12.9V	3.3V	0	9%(6400)	64%(7621)	0%(3806)	L-Awake
Start On	23°C	12.6V	0.4V	1	0%(6400)	N/A	N/A	L-Awake

Field Installs by ODNR



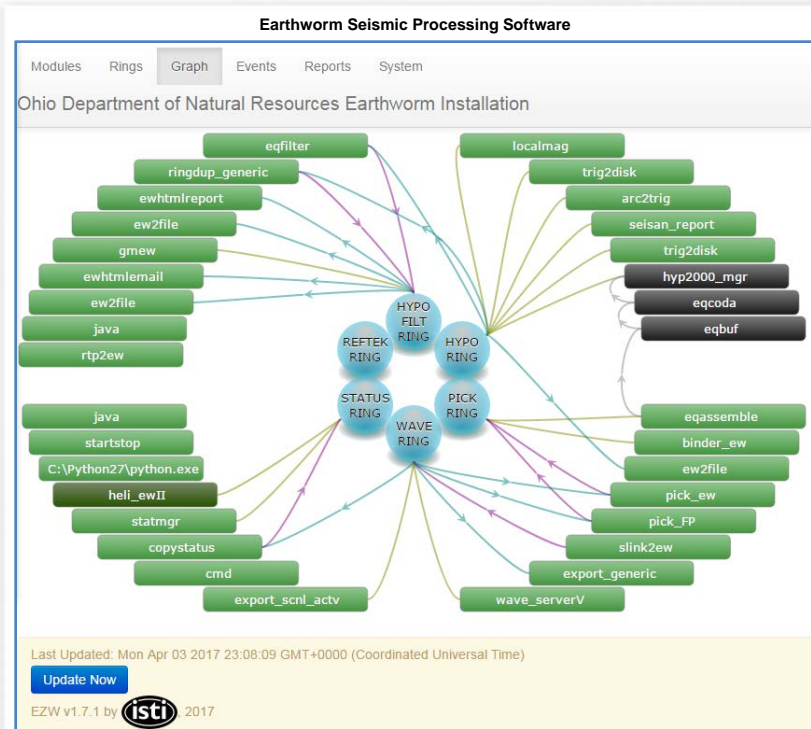
- 24/7, 365 real-time continuous seismic monitoring
- OhioNET receives data from almost 45 seismic stations from a combination of sources including ODNR, Operator, TA and CEUSN seismic stations
 - 12 additional stations are planned to be deployed this year, including ground motion sensors

Current Configuration

- 19 ODNR owned stations
- 10 operator leased stations
- 15 TA/N4 stations, USGS & CEUSN
- Total: 44 High quality 3-component stations**



OhioNET Seismic Monitoring System (continued)



Current module graph of OhioNET Earthworm System

Earthworm Automatic Email Alert

EW Event ID: 2239

Origin time	2014.03.10 15:44:05 Local Time
Latitude	41.0086
Longitude	-80.5203
Depth	2.7 km
Coda Magnitude	2.4 Md nobs=11
Local Magnitude	2.7 ±0.6 ML nobs=57
RMS Error	0.04 s
Horizontal Error	0.46 km
Depth Error	3.59 km
Azimuthal Gap	135 Degrees
Total Phases	20
Total Phases Used	15
Num S Phases Used	3
Quality	B

Waveforms: (StartTime: 2014.03.10 15:44:03 Duration: 60 seconds)

P|C|RES|EHZ|OH|00|2014.03.10 15:44:07 Local Time - Dur: 47 s - PickQuality 0 - Distance 9.2 km Mp#2.1

P|C|OH|N|EHZ|OH|00|2014.03.10 15:44:08 Local Time - Dur: 135 s - PickQuality 0 - Distance 10.8 km Mp#3.0

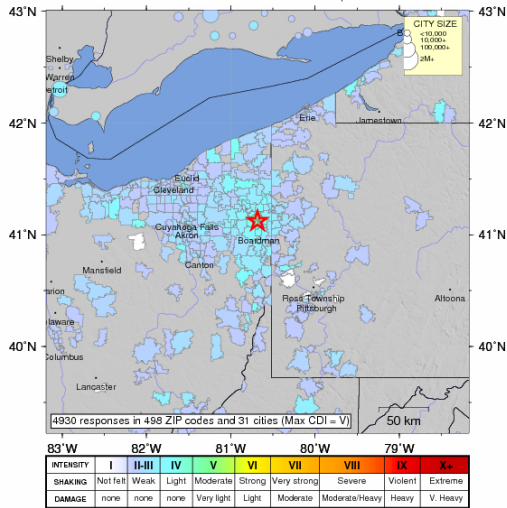
P|C|OH|E|EHZ|OH|00|2014.03.10 15:44:08 Local Time - Dur: 56 s - PickQuality 0 - Distance 12.3 km Mp#2.3

- Earthworm is an open source auto-picking earthquake processing software by ISTI
- Earthworm is custom built based on the end users specifications
- Provides automated email alerts to specific administrators and seismic staff of potential seismic events for further analysis within minutes of the event
- Emails contain important preliminary information including an auto-picked location, magnitude, depth, and error values
- Always someone on staff to answer alert and offer interpretation of data



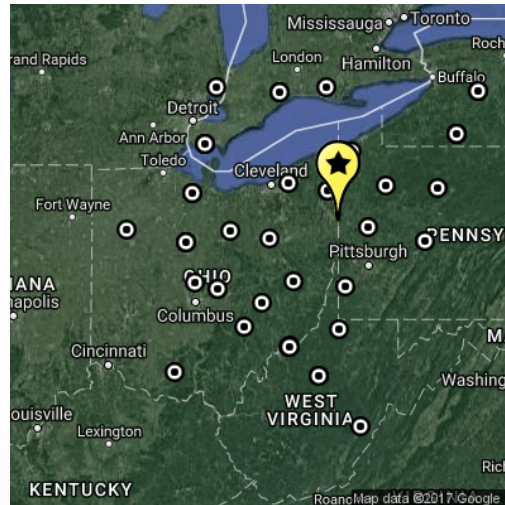
Induced Seismic Events

Northstar #1
 Youngstown, OH
 December 31, 2011
 M4.0



Injection Well Related

Poland Township
 Poland, OH
 March 10-11, 2014
 M3.0



Hydraulic Fracturing Related

Harrison County
 Freeport, OH
 September 2015
 M3.1

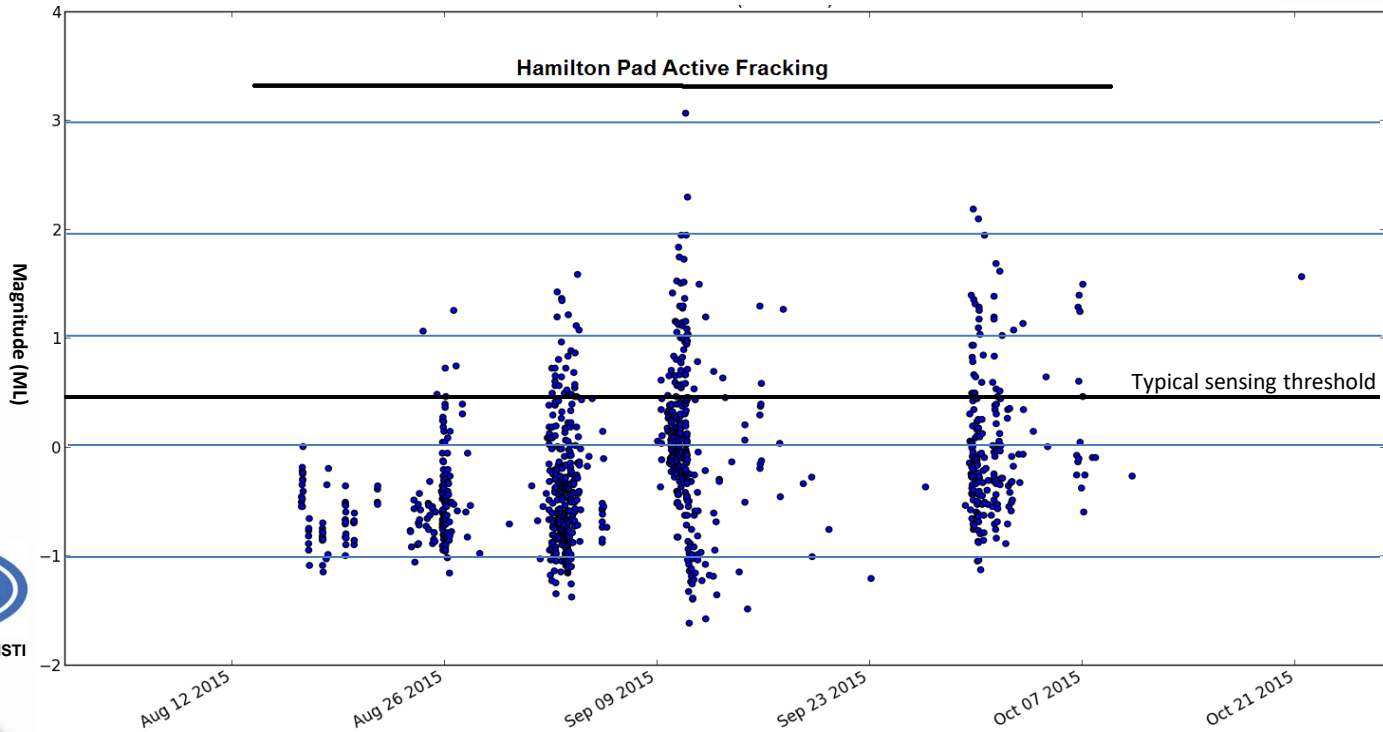


Hydraulic Fracturing Related



Induced Seismic Events (continued)

Plot of Induced Seismicity Events at Hamilton Pad



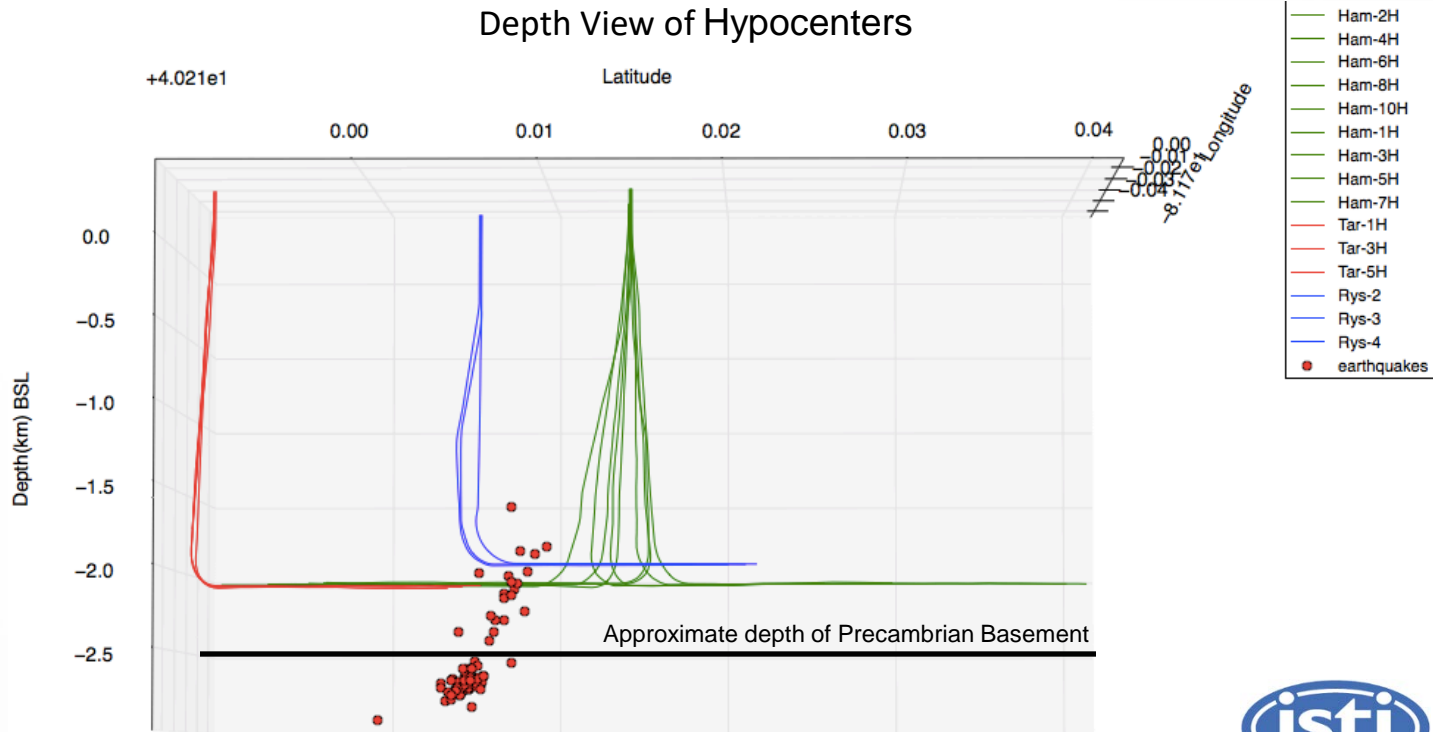
Source: Paul Friberg, ISTI



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Induced Seismic Events (continued)



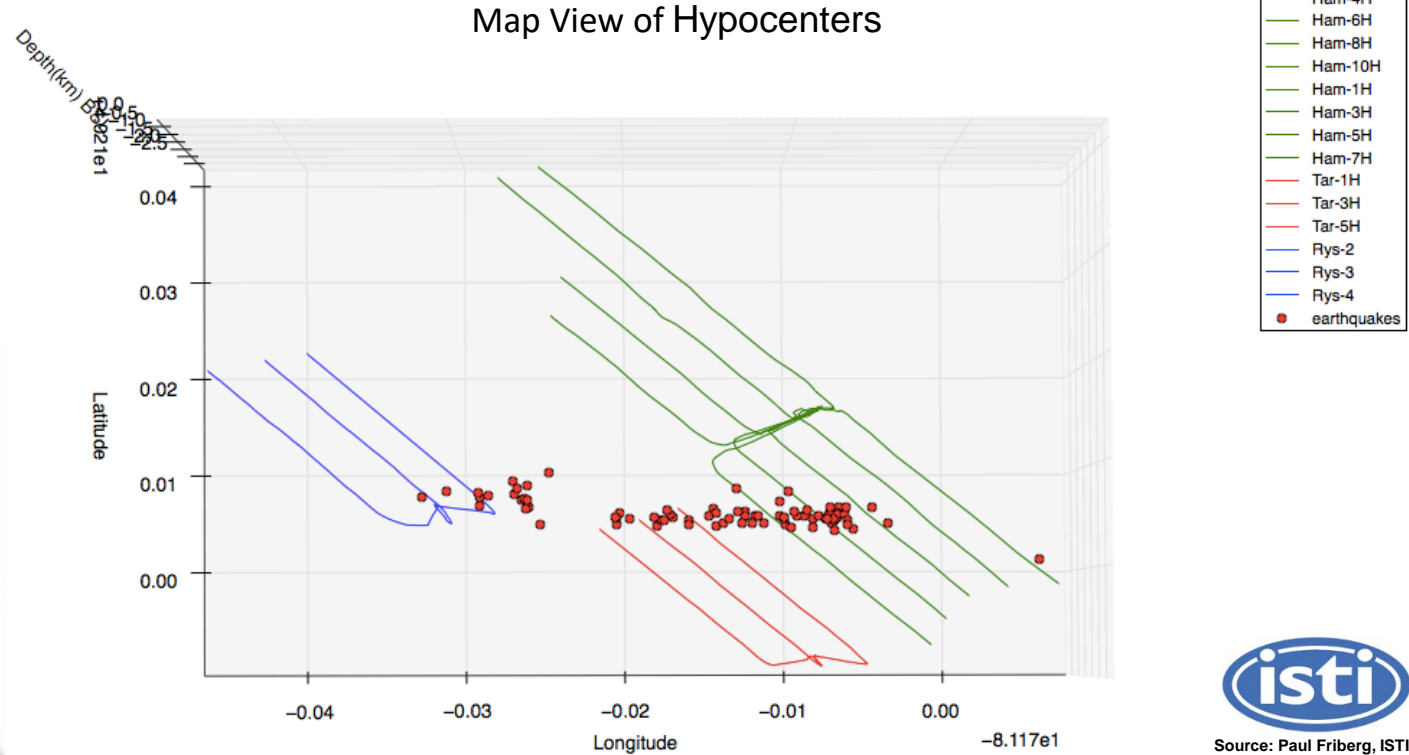
Source: Paul Friberg, ISTI



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Induced Seismic Events (continued)



Source: Paul Friberg, ISTI



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Regulation Techniques

Current Seismic Permit Conditions for Injection Wells

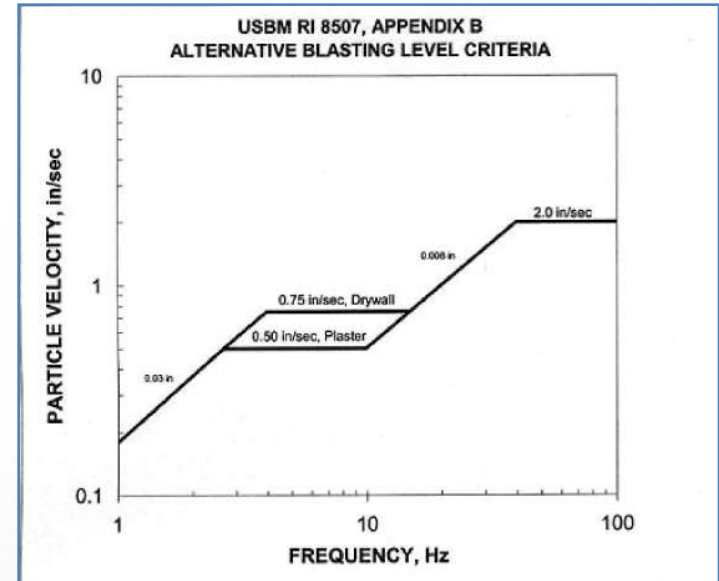
Ohio Revised Code Chapter 1501:0-3-06

The chief may require the following tests or evaluations of a proposed brine injection well, in any combination that the chief deems necessary:
Geological investigation of potential faulting within the immediate vicinity of the proposed injection well location, which may include seismic surveys or other methods determined by the chief to assist analysis.
Permit conditions may include seismic monitoring, pressure fall-off tests, spinner tests, radioactive tracer, geophysical and electrical logs and downhole pressure monitoring.

Current Seismic Permits Conditions for Horizontal Wells

Restrictions may be placed on wells drilled near faults or areas of known seismic activity, in which seismic monitors must be installed for a specified time period prior to completion operations.

- ML \geq 1.5 – Direct communication starts between operator and Division
- ML = 2.0-2.4 – Work with operator to proposed or modify operation
- ML \geq 2.5 – Temporary halt completions on lateral
- ML = 3.0+ – Completion on pad suspended until an approved plan is submitted by operator



Ground Motion

In the future, the Division will include ground motion as an additional way to monitor induced events. Provides 'ground truth' of shaking and allows for a better understanding of how induced events affects the surface and whether damage to a structure is possible or likely. Values based on the particle velocity and frequency of the seismic event, which are held to the same motion limitations as blasting operations.



Mitigation Techniques

Key Points

- Direct communication with the operator is essential
- Discussion of seismic events and stages of the operation in real-time
- Spatial analysis and time correlation with completion data during the operation

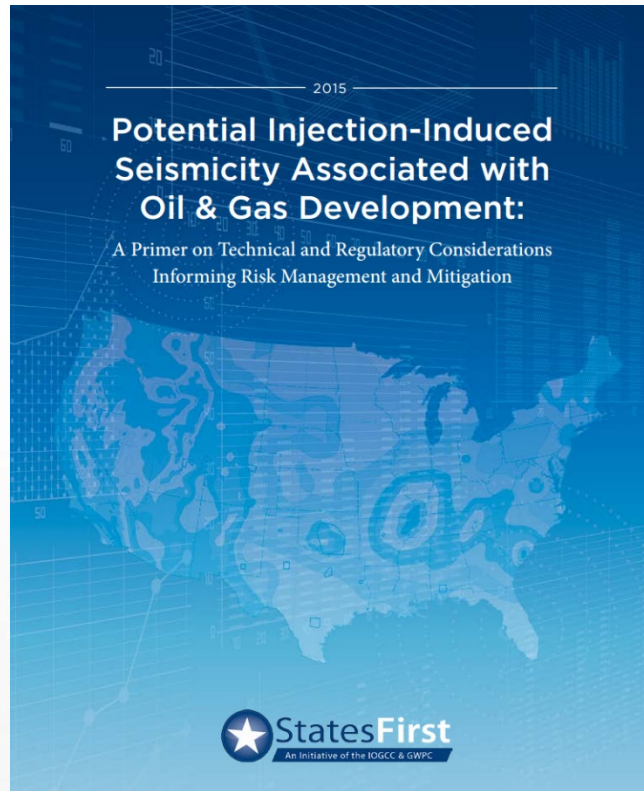
Mitigation techniques when induced seismicity occurs during hydraulic fracturing:

- Change from zipper fracking to stack fracking
- At least 20% reduction in volume and/or pressure
- Skipping stages may be necessary, especially if seismic events indicate a lineament or fault structure near a lateral of the operation
- Switch to smaller sieve sizes for proppant, full effect still unsure



Interstate Collaboration

- Ohio is a national leader and participant in the Interstate Oil and Gas Compact Commission and the Ground Water Protection Council
- ODNR continues to prioritize rule development that protects our citizens, the environment and our natural resources



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Public Awareness & Educational Outreach



Display station at Ohio State Fair in 2016



OOGEEP Education and Training Sessions in Marietta, OH



JULY 26 - AUG. 6, 2017



OHIO OIL & GAS ENERGY EDUCATION PROGRAM



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Summary

- Shale Oil and Gas development, along with brine disposal in Ohio, will continue to rise for the foreseeable future
- Real-time continuous monitoring is mandatory when trying to mitigate the risk of induced seismicity
- Having an aggressive stance and staying proactive has helped decrease induced seismicity occurrences in Ohio
- Proper policies and regulation have helped guarantee safe and proper extraction of oil & gas while offering less shutdown times for operators
- In the event of induced seismicity, direct communication with operators is essential for mitigation, along with modifying pad operations
- Sharing information with other states and the local community helps assist in tackling the problem of induced seismicity and aids in public confidence of their states regulatory agency



OhioNET Seismic Monitoring Staff

Contact Information



Dave Rush
Seismic Program Manager
ODNR-DOGRM
David.Rush@dnr.state.oh.us
614-265-6916



Steven Dade
Geologist 2
ODNR-DOGRM
Steven.Dade@dnr.state.oh.us
614-265-6946



James Gonsiewski
Geologist 3
ODNR-DOGRM
James.Gonsiewski@dnr.state.oh.us
614-265-6900



Jacqueline Mills
Geology Technician
ODNR-DOGRM
Jacqueline.Mills@dnr.state.oh.us
614-265-6925

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