The Science of Shale Gas: Geology, Seismology and Environmental Impacts

Dr. Ray Beiersdorfer

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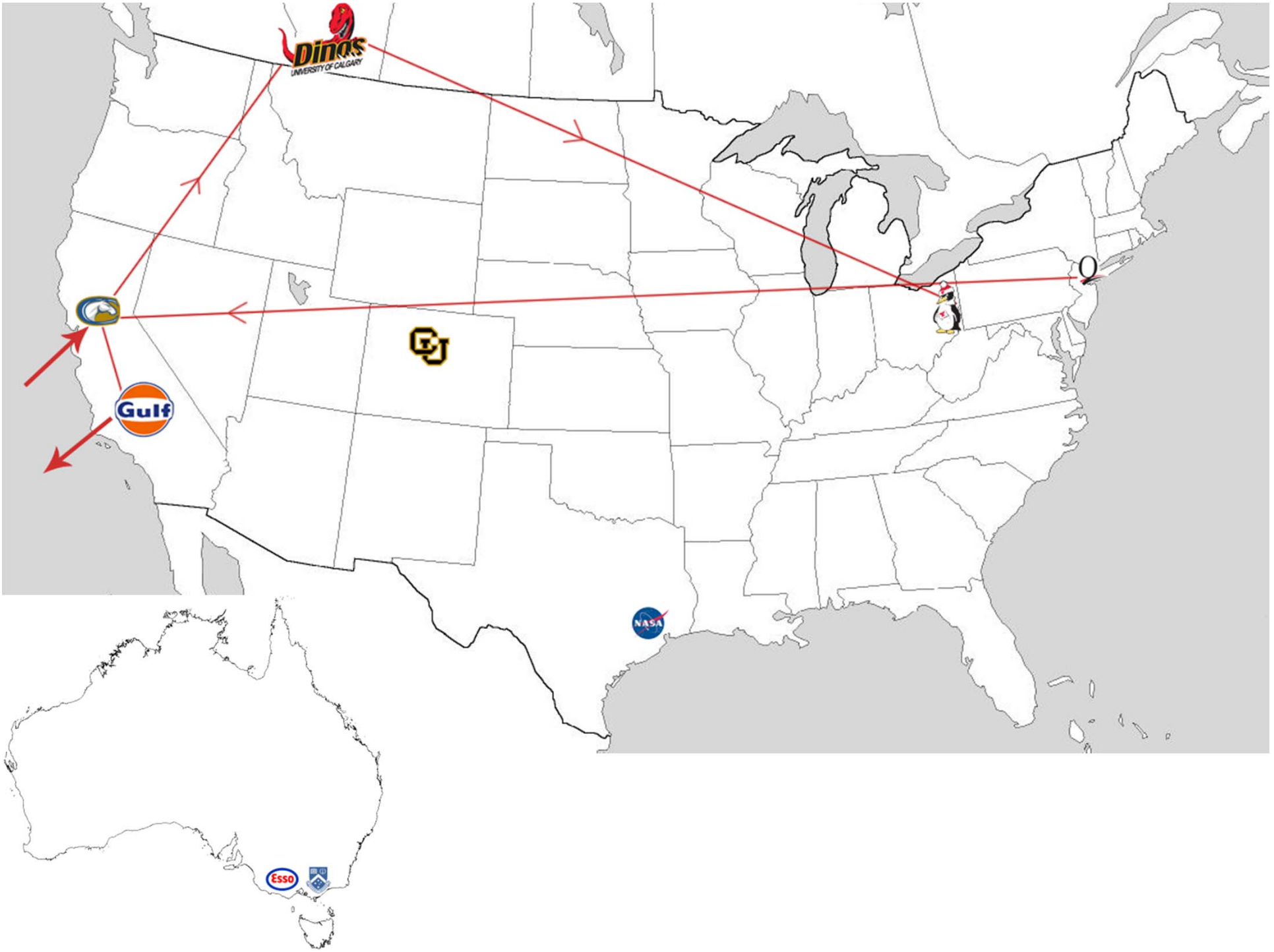
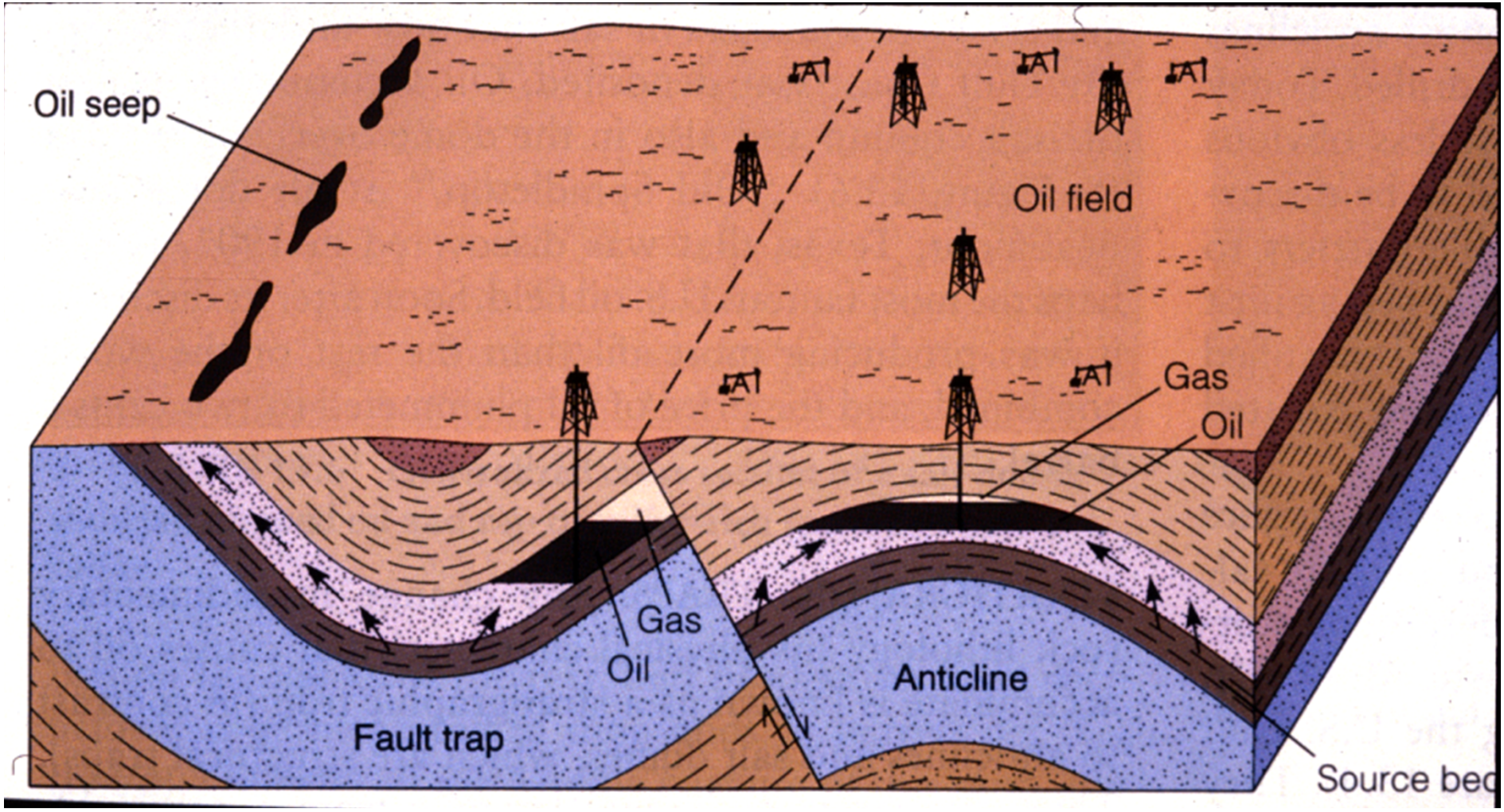

Dinos
UNIVERSITY OF CALGARY
Gulf
NASA
Esso

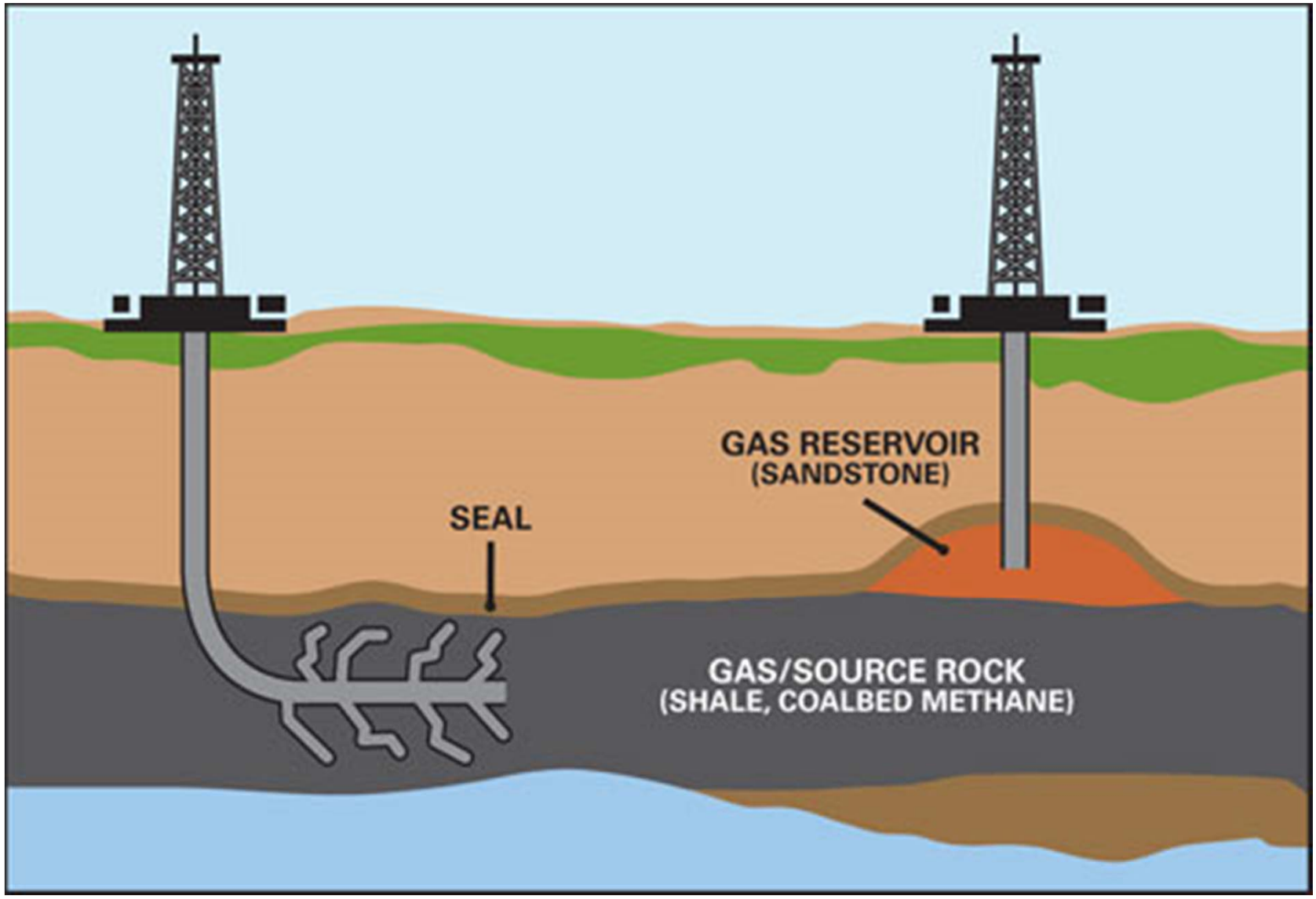

Gulf

www.psehealthyenergy.org

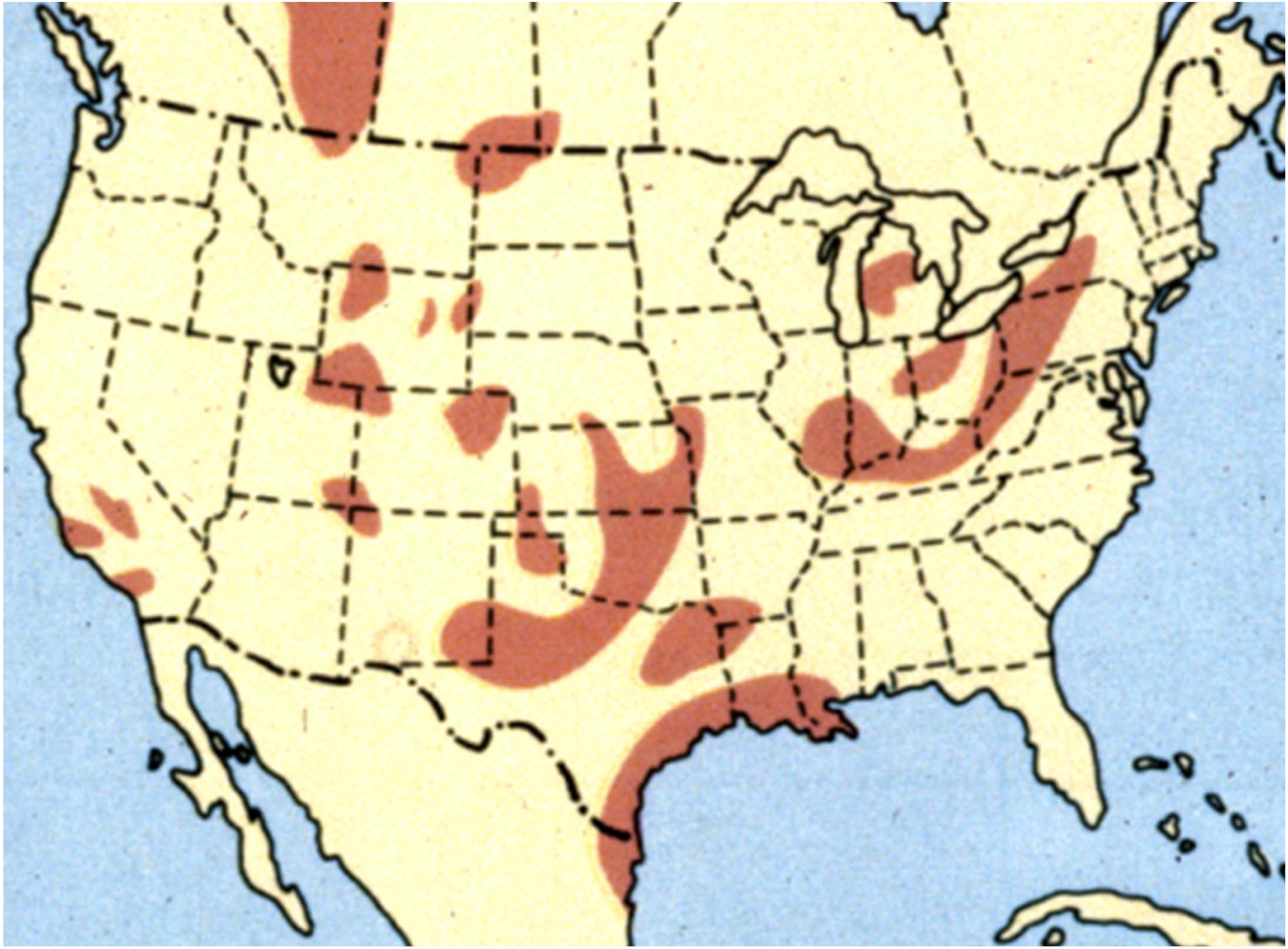
Hydrocarbon Deposit Formation

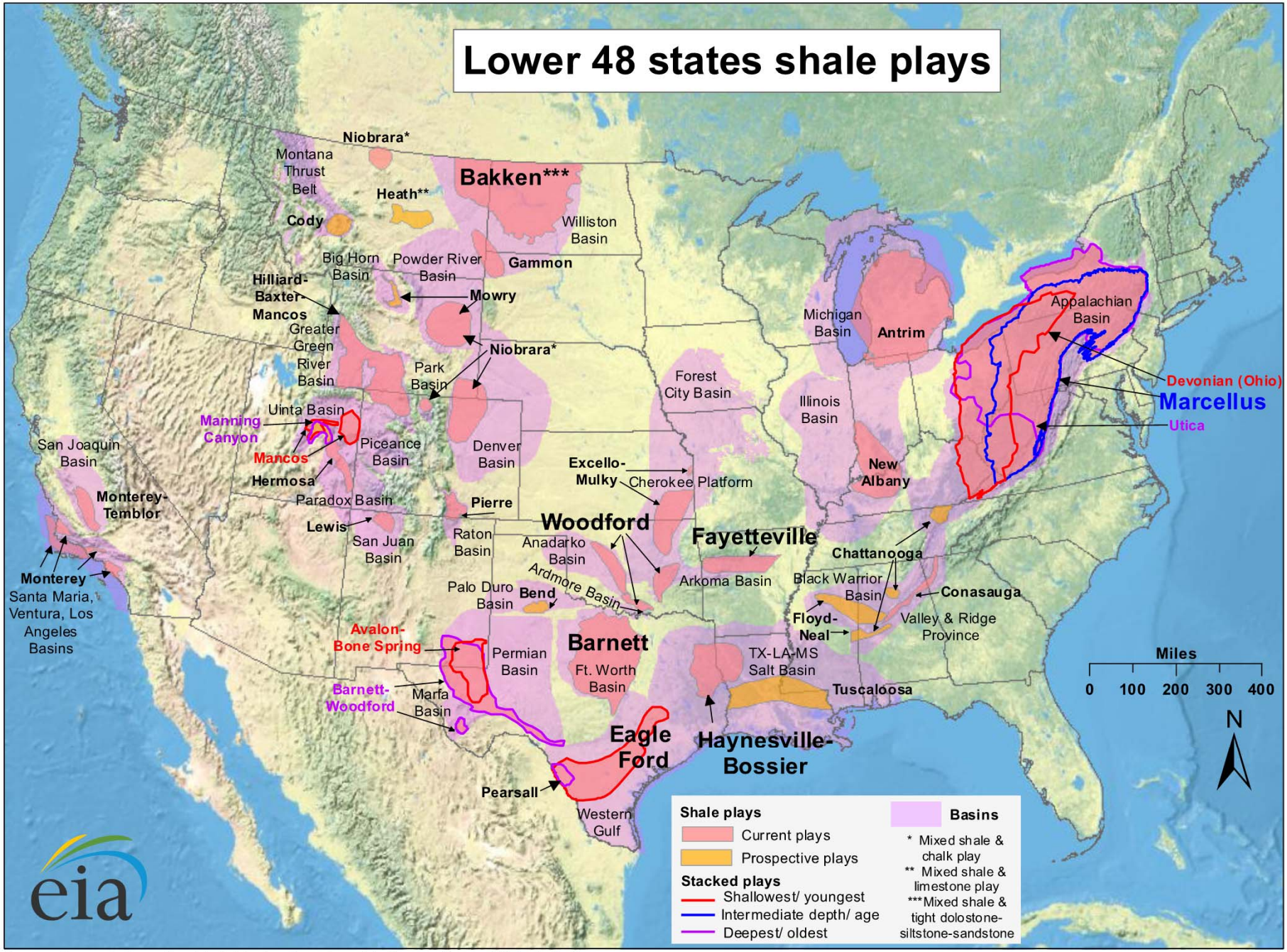
- **Four conditions needed:**
  1. Source rock
  2. Reservoir rock
  3. Geological Trap
  4. Deep enough burial


Oil seep
Oil field
Gas
Oil
Gas
Oil
Anticline
Fault trap
Source bed



lmenergy.co.nz

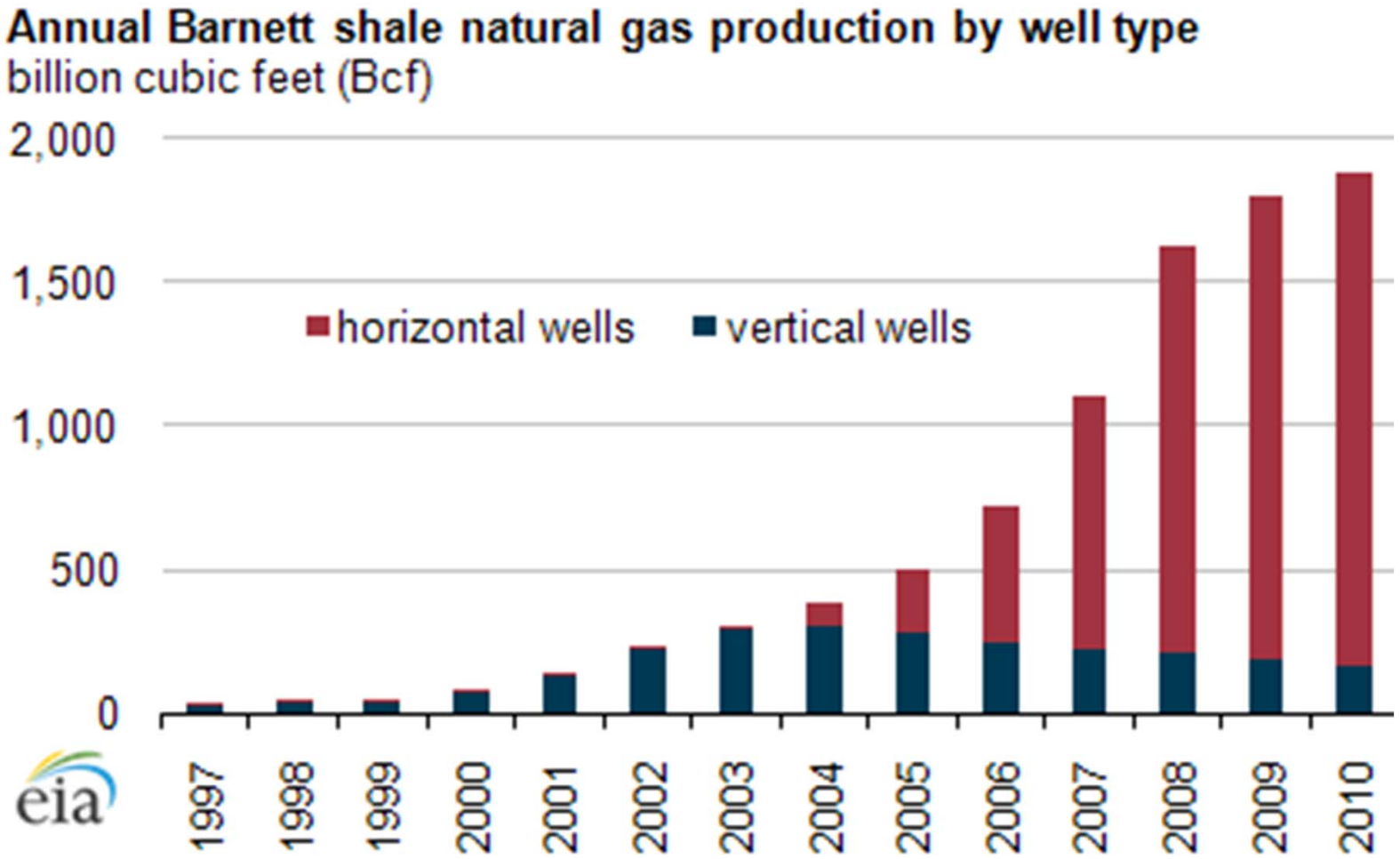




Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

"Commercial drilling in Ohio has been happening since 1860, and we've had hydraulic fracturing in the state since the 1940s," Zeigler notes. "This isn't new to Ohio. There's not a case of the hydraulic fracturing process contaminating water."

Director, American Petroleum Institute, 2014



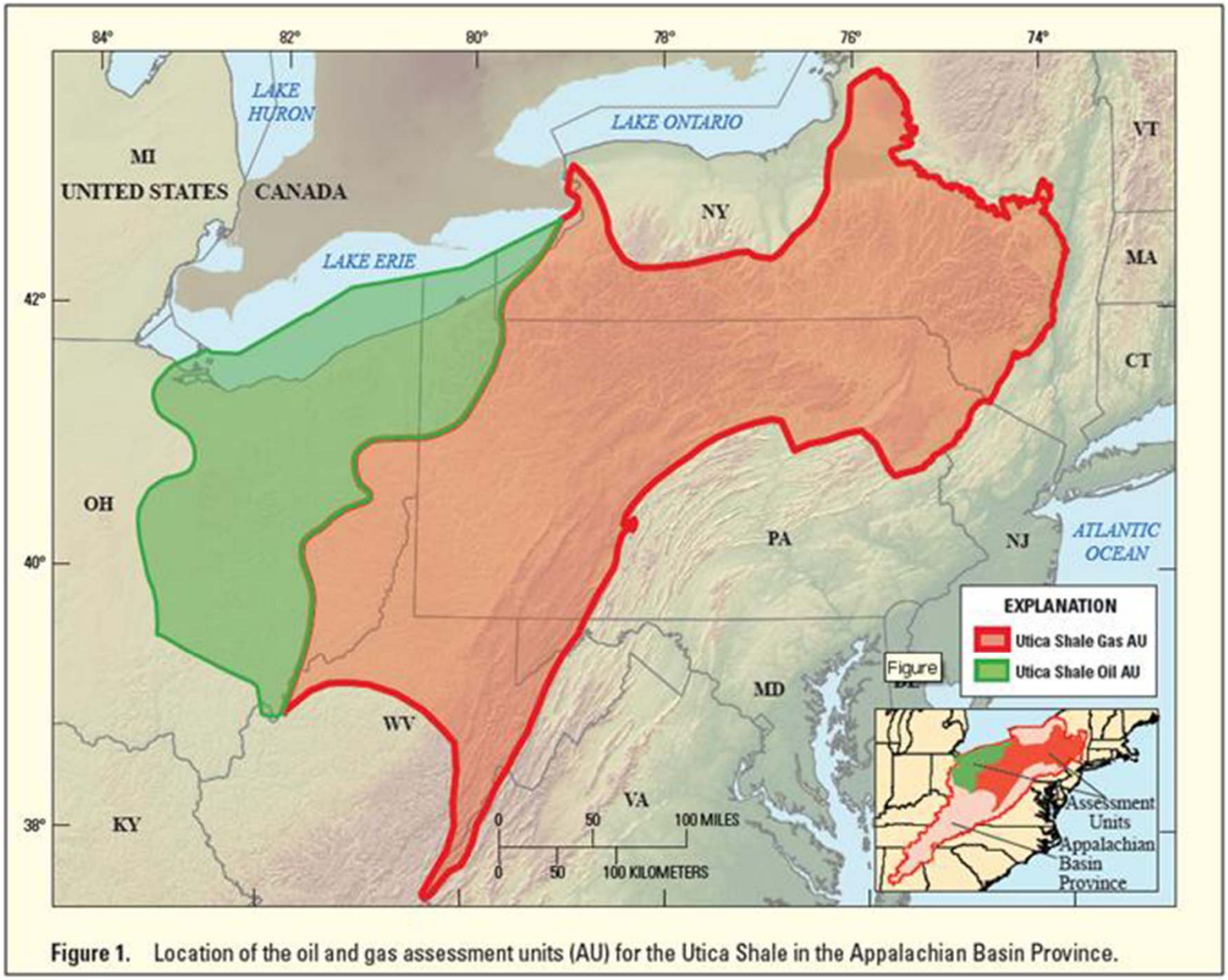
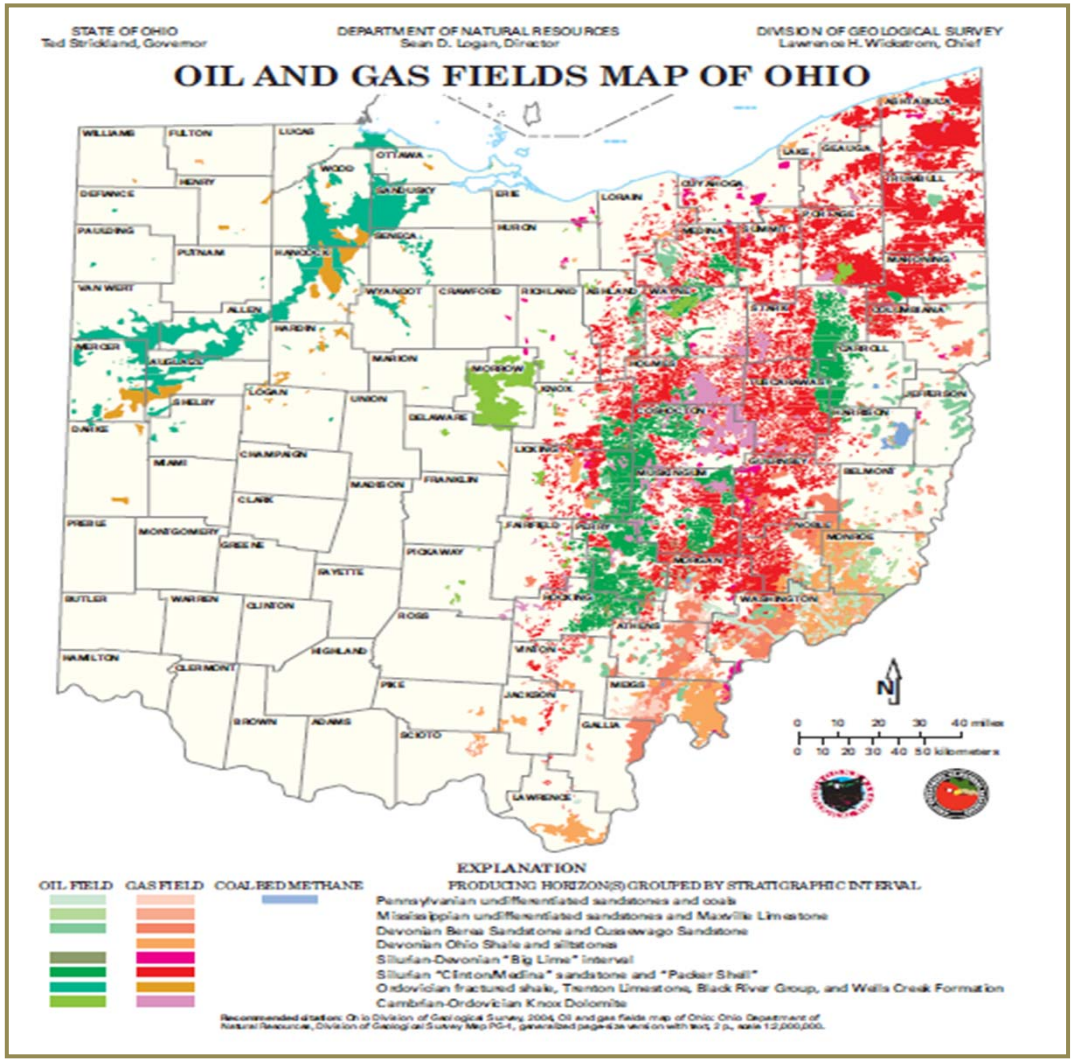


Figure 1. Location of the oil and gas assessment units (AU) for the Utica Shale in the Appalachian Basin Province.

Source: USGS

OIL AND GAS FIELDS OF OHIO



ODNR Geological Survey, 2011

OIL

GAS

Coal Bed Methane

- **Total Oil Production: 1.13 BBO**
- **Total Gas Production: 8.40 TCF**
- **Total # Wells: > 274,000**
- **Active # Wells: > 64,000**

Orphaned Wells: > 200,000

Source: Dr. Jeff Dick

PRODUCTIVE INTERVALS IN OHIO

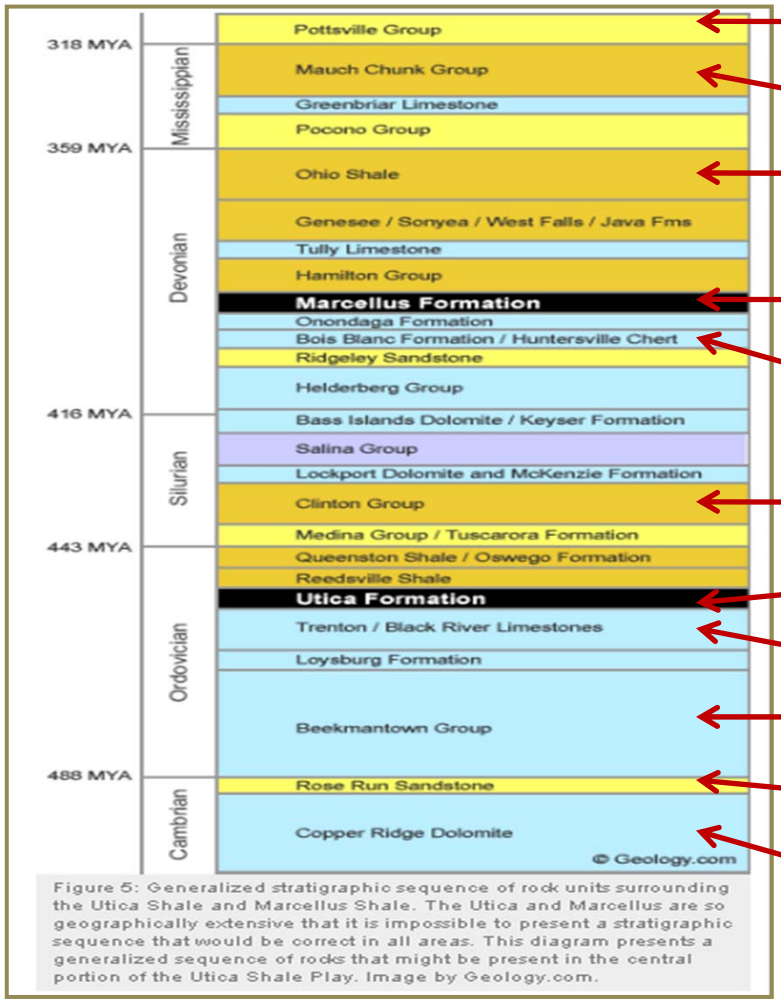


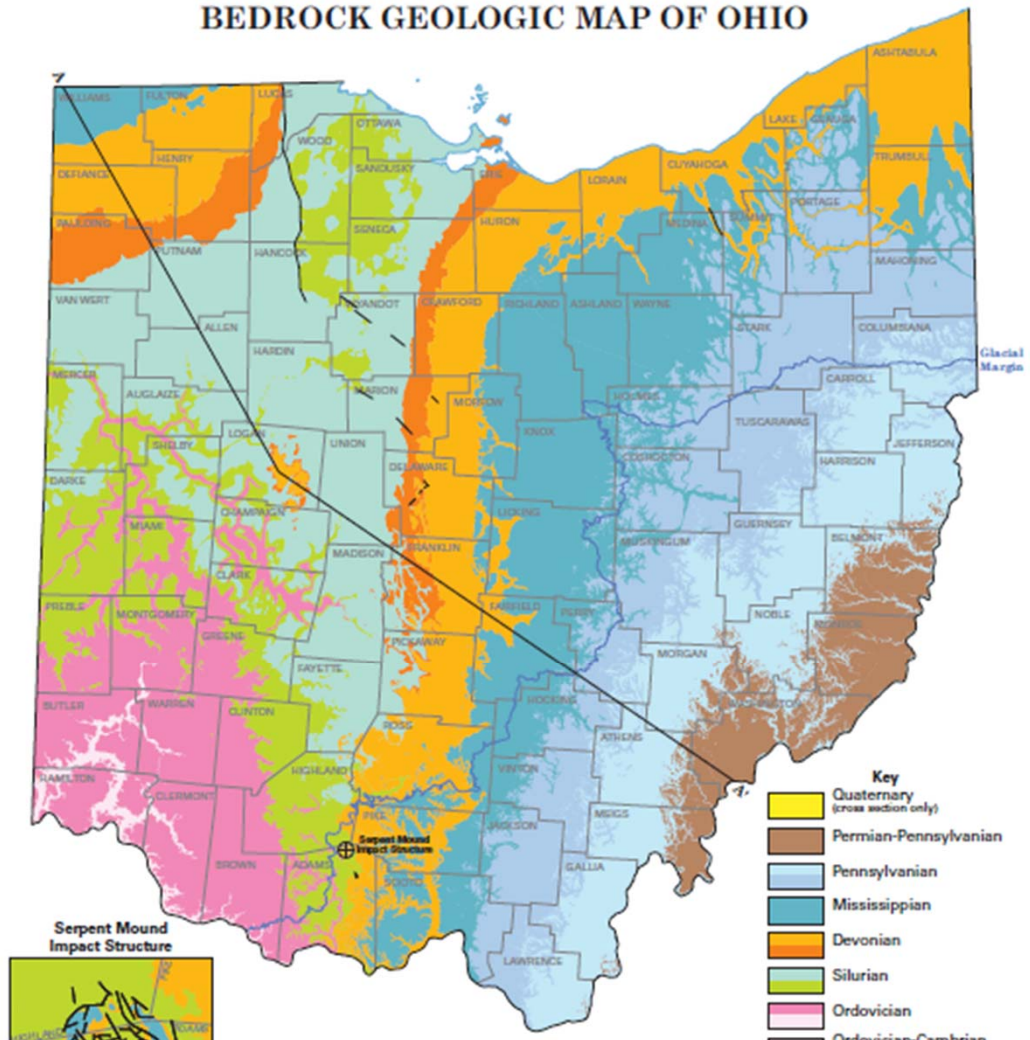
Figure 5: Generalized stratigraphic sequence of rock units surrounding the Utica Shale and Marcellus Shale. The Utica and Marcellus are so geographically extensive that it is impossible to present a stratigraphic sequence that would be correct in all areas. This diagram presents a generalized sequence of rocks that might be present in the central portion of the Utica Shale Play. Image by Geology.com.

Coal Bed Methane
Berea Sandstone
Chagrin-Ohio Shale
Marcellus Shale
Big Lime Intervals
Clinton Sandstone
Utica Shale
Trenton Limestone
Beekmantown Dolomite
Rose Run Sandstone
Trempealeau Dolomite

Source: Dr. Jeff Dick

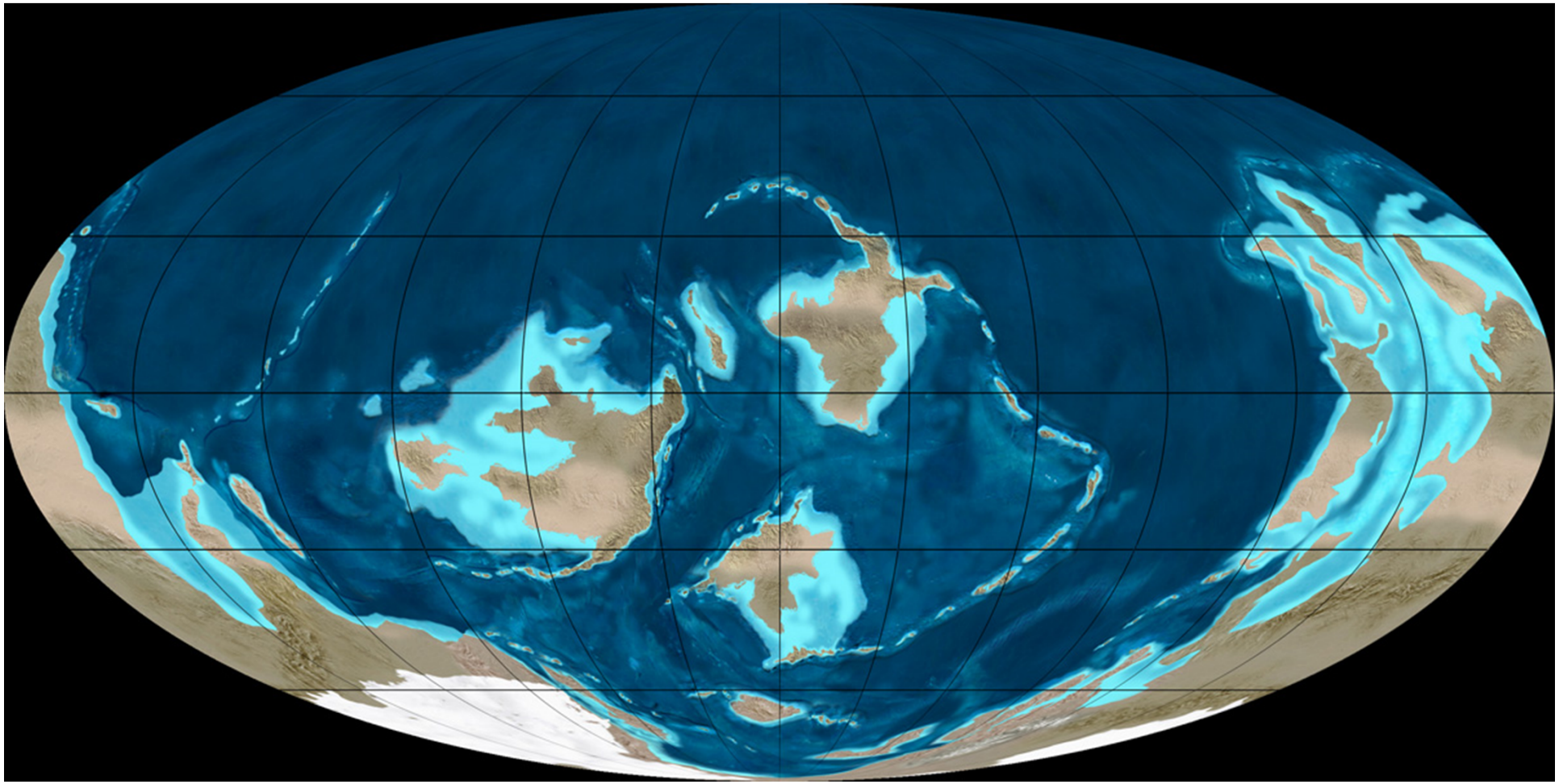
STATE OF OHIO • DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

BEDROCK GEOLOGIC MAP OF OHIO

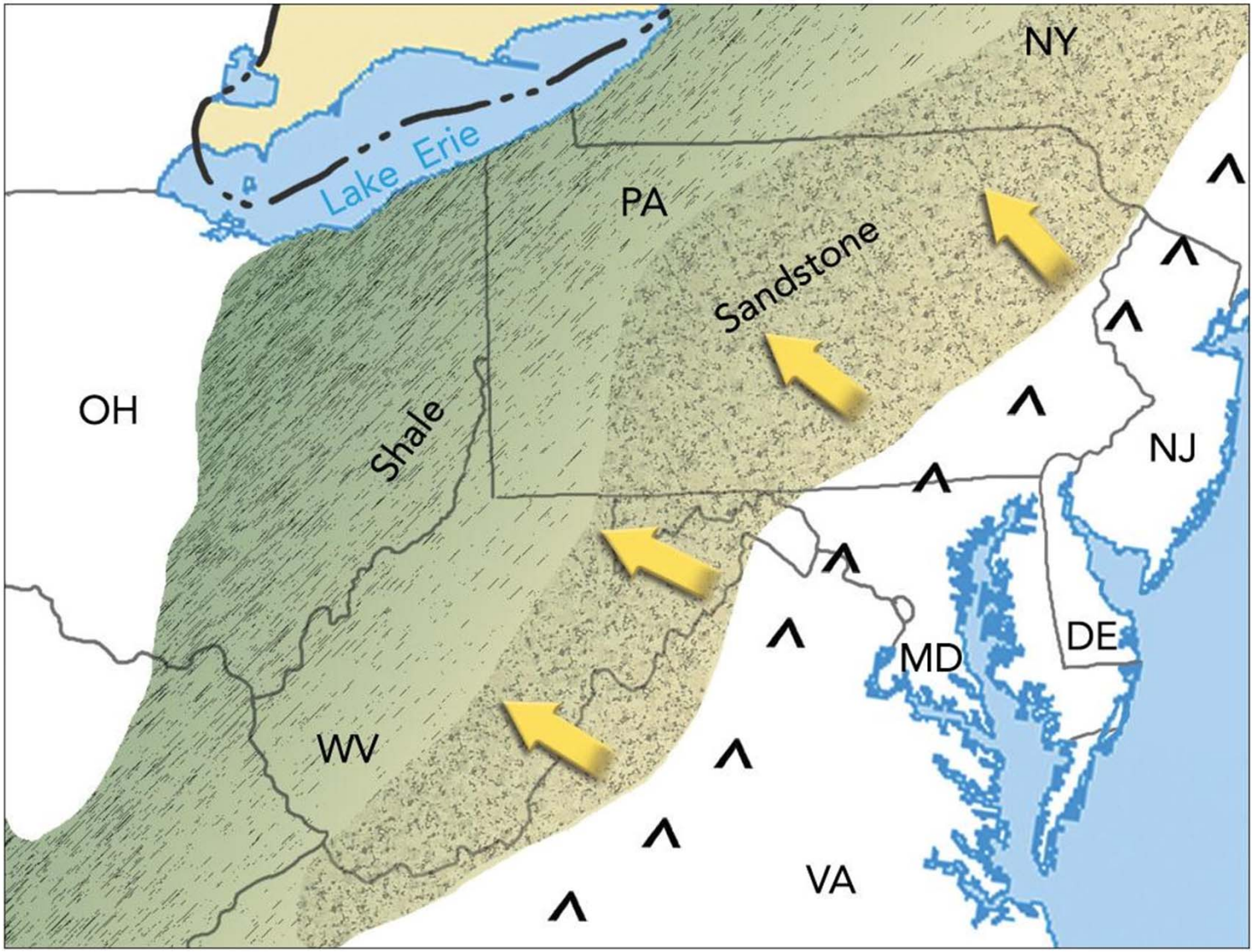


Recommended citation: Ohio Division of Geological Survey, 2006, Bedrock geologic map of Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map BG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

Ordovician Period



Deposition of Utica Shale



Source: Exploring Geology Reynolds et al

Induced Seismicity

Can Fracking Cause Earthquakes?

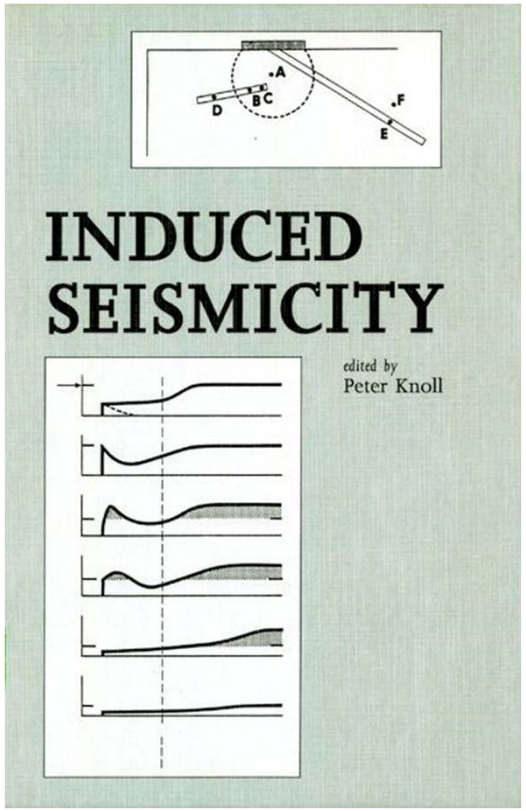
Induced Seismicity

Can Fracking Cause Earthquakes?

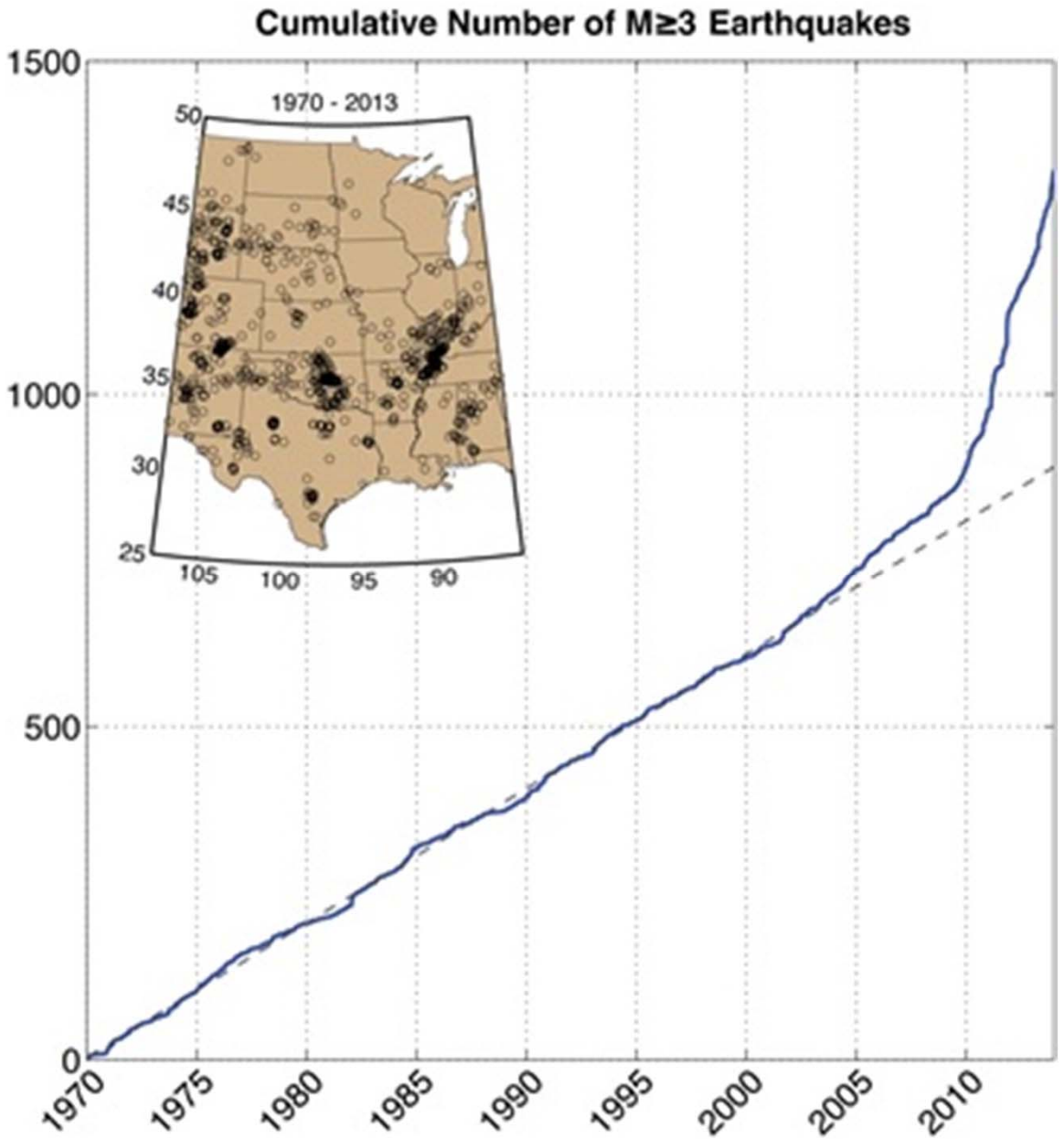
Yes & Yes

Induced Seismicity

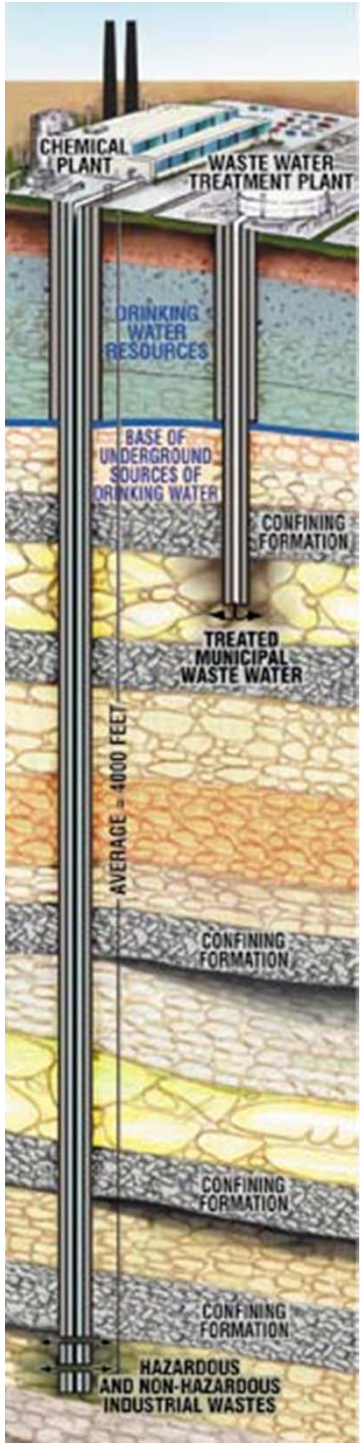
Human Activity Causes Earthquakes



- Reservoir
- Mining
- Fluid Injection
  - Liquids
  - Gas (CO_2 sequestration)
- Fluid Withdrawal
  - Geothermal
  - Hydrocarbon
- Scientific Experiments



http://www.usgs.gov/blogs/features/usgs_top_story/man-made-earthquakes/



I Hazardous Waste Deep

II Oil & Gas Waste

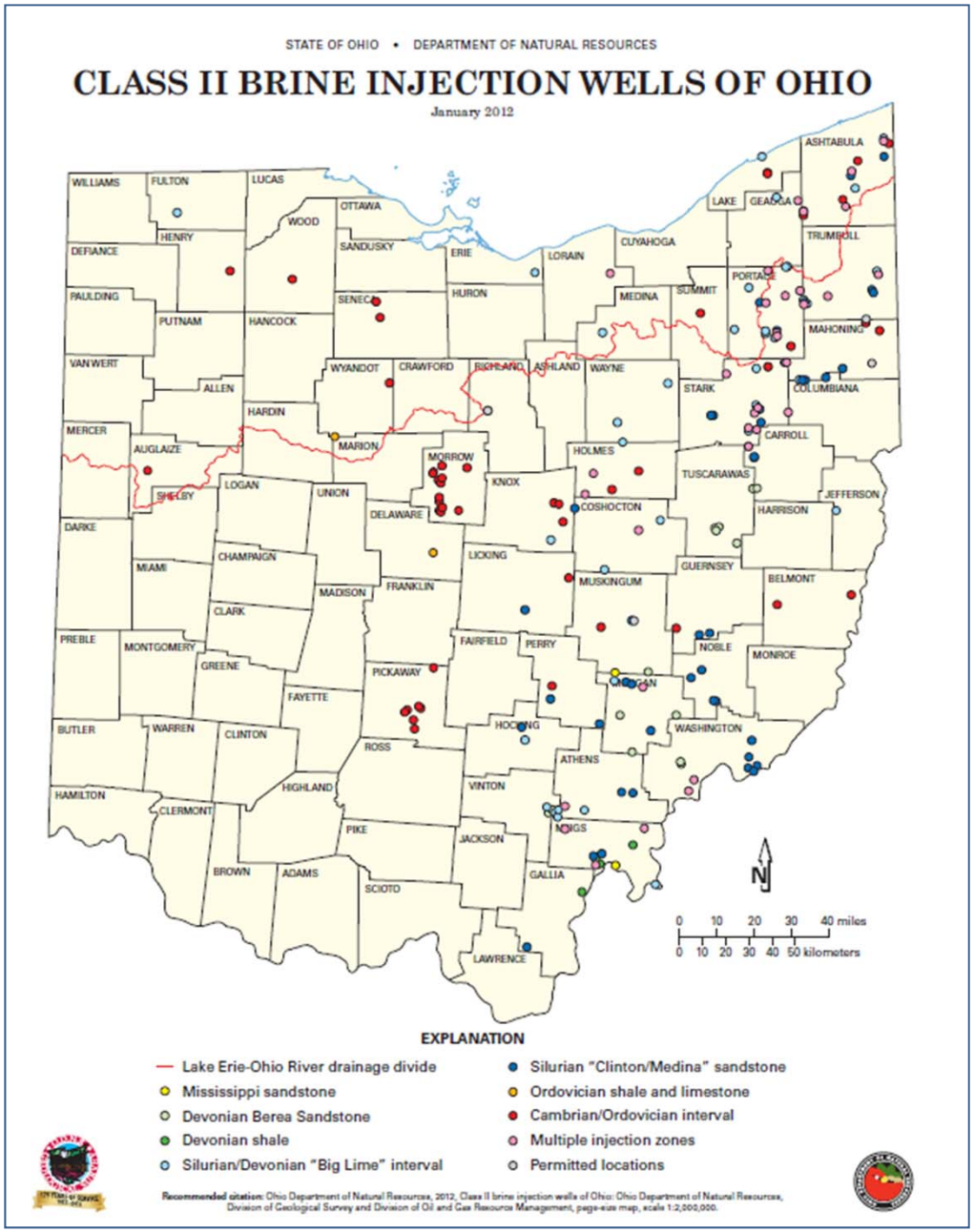
III Liquid injected to dissolve minerals

IV ~~Hazardous Waste Shallow~~

V Non-Hazardous Shallow

VI CO_2 Carbon Sequestration

Ohio EPA



ODNR Oil and Gas Resources Management, 2012

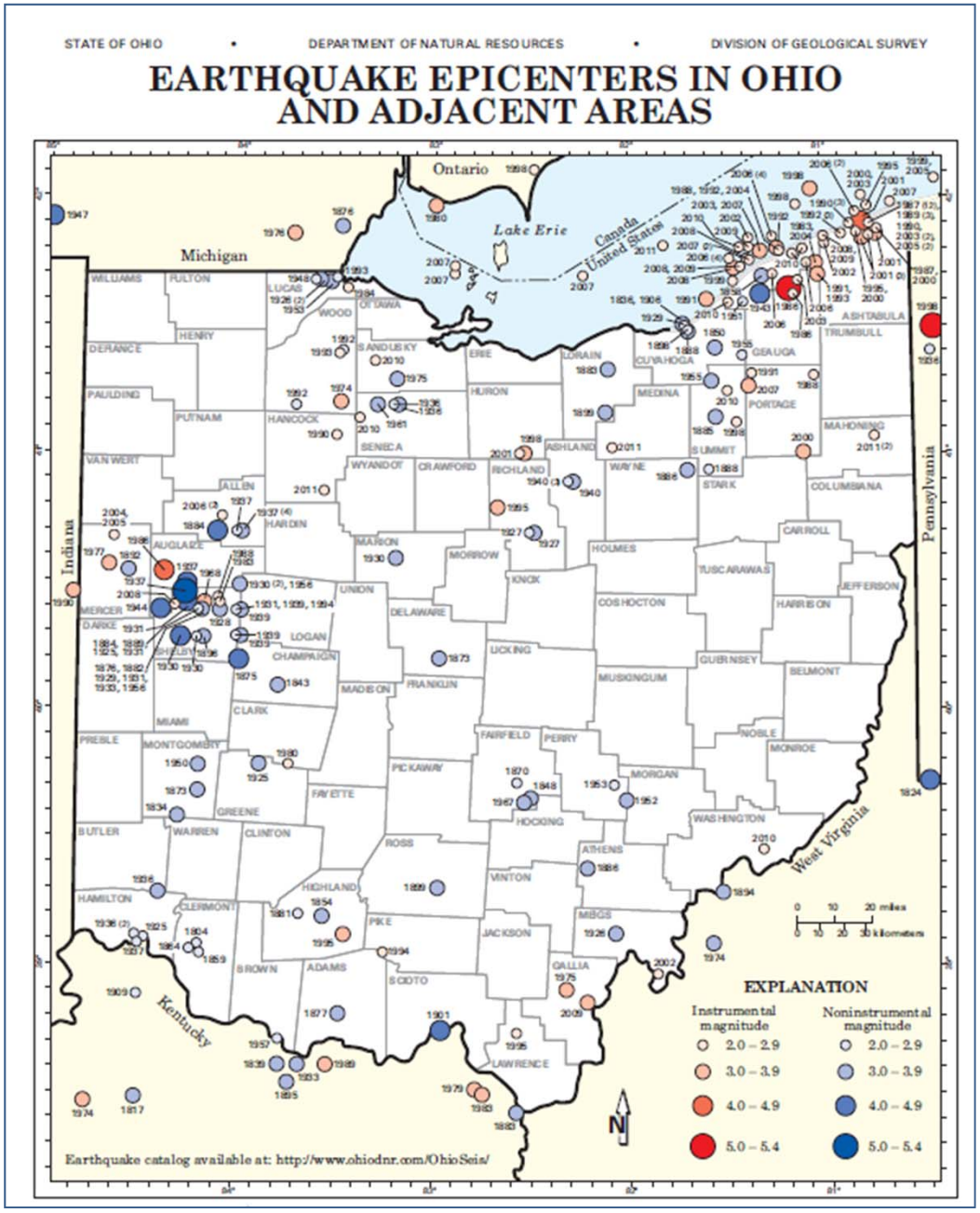

McDonald
Warren Youngstown Rd
80
Martin Luther King Jr Blvd
Wirt St
422
289
W Rayen Av
711
193
NORTH STAR WELL
Sept 2
M = 2.2
Jan 13
M = 2.1
March 17
M = 2.6
Oct 20
M = 2.3
March 17
M = 2.1
August 22
M = 2.2
Nov 25
M = 2.2
August 25
M = 2.4
Sept 26
M = 2.6
Sept 30
M = 2.7
Dec 24
M = 2.7
Dec 31
M = 4.0

OhioSeis

Ohio's earthquake monitoring network

Recent Ohio/Regional Earthquakes

- Youngstown, Mahoning County, December 31, 2011
- Youngstown, Mahoning County, December 24, 2011
- Youngstown, Mahoning County, November 25, 2011
- Youngstown, Mahoning County, October 20, 2011
- Youngstown, Mahoning County, September 30, 2011
- Youngstown, Mahoning County, September 26, 2011
- Marietta, Washington County, September 04, 2011
- Youngstown, Mahoning County, September 02, 2011
- Marietta, Washington County, August 31, 2011
- Marietta, Washington County, August 31, 2011
- Youngstown, Mahoning County, August 25, 2011
- *Virginia Earthquake, August 23, 2011*
- Youngstown, Mahoning County, August 22, 2011
- Offshore Lake Erie, Ohio-Canada Border Region, August 13, 2011
- Offshore Lake Erie (Cuyahoga County, Ohio), June 15, 2011
- Medina County, Ohio, June 5, 2011
- Delaware Township, Hancock County, April 26, 2011
- Youngstown, Mahoning County, March 17, 2011 (10:53)
- Youngstown, Mahoning County, March 17, 2011 (10:42)



ODNR Geological Survey, 2011

LOCALLY OWNED SINCE 1869
Vindy.com
The Vindicator
SUNDAY
OCTOBER 30, 2011
$1.50

Did brine well trigger 6 Valley earthquakes?

By KARL HENKEL
khenkel@vindy.com

YOUNGSTOWN The Mahoning Valley has experienced seven minor earthquakes since March — the only quakes ever recorded with epicenters in the Valley.

The sudden occurrences have experts now examining a brine-water injection well near Salt Springs Road and state Route 711.

The Ohio Department of Natural Resources is looking into the correlation between the 18-month-old well and the earthquakes.

Injection wells are a back-end process in the hydraulic-fracking industry. In the fracking process, water, chemicals and sand are blasted through pipes into rocks thousands of feet below the ground to unlock natural gas and oil. That liquid is returned to the surface as brine wastewater, which ultimately is flushed underground by injection wells.

Some wells, such as the one in Youngstown, go 9,000 feet below the earth's surface.

Of the seven earthquakes, six had epicenters near the injection well on Youngstown's West Side, just off the Salt Springs Road exit and Ohio Works Drive.

See QUAKES, A14

QUAKE & WELL LOCATIONS

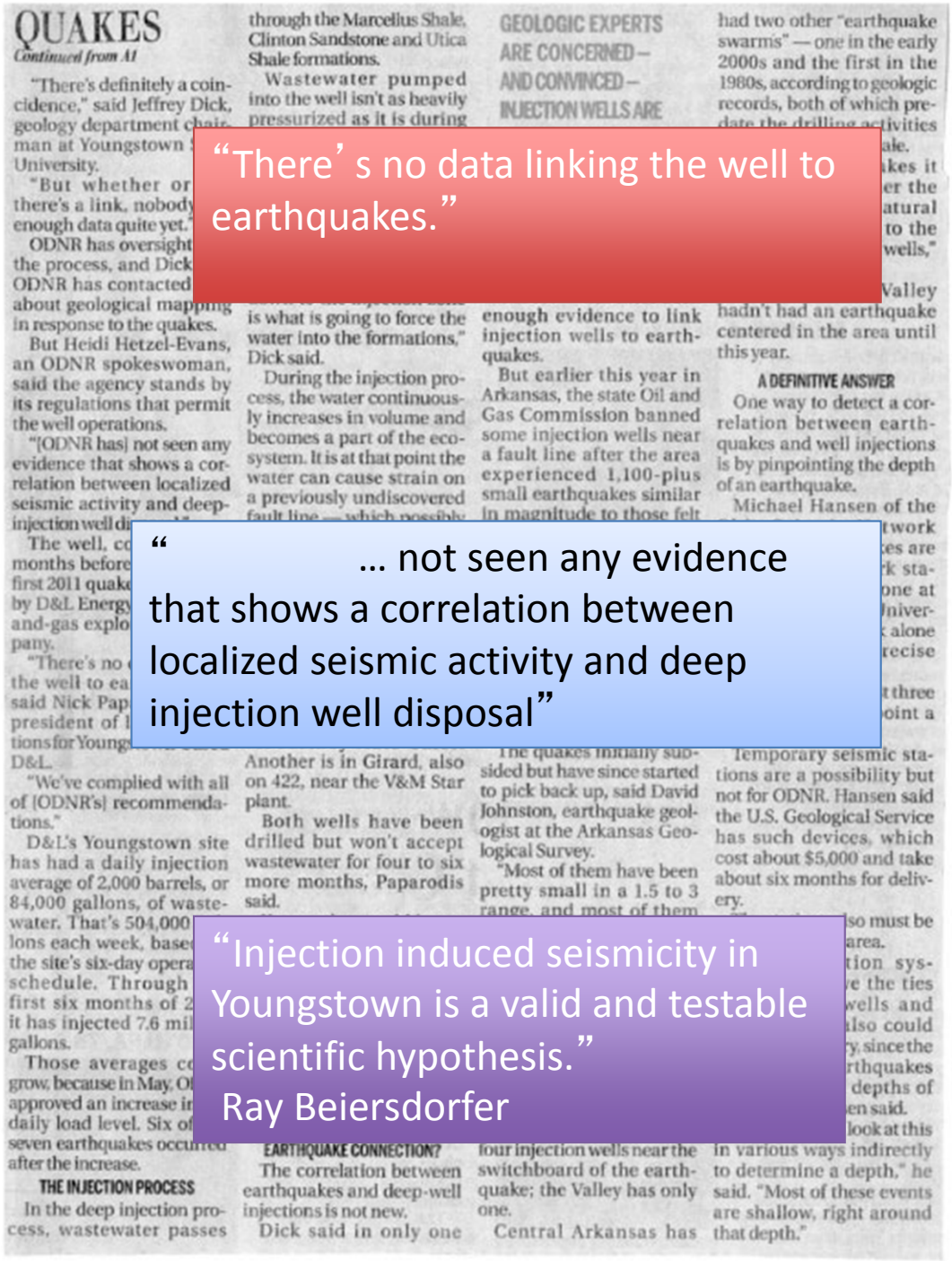
AREA EARTHQUAKES
1. **March 17:** magnitude 2.6
2. **Aug. 22:** magnitude 2.2
3. **Aug. 25:** magnitude 2.4 (near Decamp Rd. in Austintown)
4. **Sept. 2:** magnitude 2.2
5. **Sept. 25:** magnitude 2.6
6. **Sept. 29:** magnitude 2.7
7. **Oct. 20:** magnitude 2.3

Sources: ODNR, U.S. Geological Survey

The epicenter of six of the seven earthquakes this year coincidentally is near a brine injection well on Ohio Works Drive.

Injection Started
December 2010

First Earthquakes
March 2011



QUAKES

Continued from A1

"There's definitely a coincidence," said Jeffrey Dick, geology department chairman at Youngstown State University.

"But whether or not there's a link, nobody has enough data quite yet."

ODNR has oversight of the process, and Dick said ODNR has contacted D&L about geological mapping in response to the quakes.

But Heidi Hetzel-Evans, an ODNR spokeswoman, said the agency stands by its regulations that permit the well operations.

"[ODNR has] not seen any evidence that shows a correlation between localized seismic activity and deep-injection well disposal."

The well, completed months before the first 2011 quake, is owned by D&L Energy, an oil-and-gas exploration company.

"There's no data linking the well to earthquakes," said Nick Paparodis, president of D&L Operations for Youngstown D&L.

"We've complied with all of [ODNR's] recommendations."

D&L's Youngstown site has had a daily injection average of 2,000 barrels, or 84,000 gallons, of wastewater. That's 504,000 gallons each week, based on the site's six-day operating schedule. Through the first six months of 2011, it has injected 7.6 million gallons.

Those averages could grow, because in May ODNR approved an increase in the daily load level. Six of the seven earthquakes occurred after the increase.

THE INJECTION PROCESS

In the deep injection process, wastewater passes through the Marcellus Shale, Clinton Sandstone and Utica Shale formations.

Wastewater pumped into the well isn't as heavily pressurized as it is during [illegible] is what is going to force the water into the formations," Dick said.

During the injection process, the water continuously increases in volume and becomes a part of the ecosystem. It is at that point the water can cause strain on a previously undiscovered fault line — which possibly

Another is in Girard, also on 422, near the V&M Star plant.

Both wells have been drilled but won't accept wastewater for four to six more months, Paparodis said.

EARTHQUAKE CONNECTION?

The correlation between earthquakes and deep-well injections is not new.

Dick said in only one

GEOLOGIC EXPERTS ARE CONCERNED — AND CONVINCED — INJECTION WELLS ARE

enough evidence to link injection wells to earthquakes.

But earlier this year in Arkansas, the state Oil and Gas Commission banned some injection wells near a fault line after the area experienced 1,100-plus small earthquakes similar in magnitude to those felt

The quakes initially subsided but have since started to pick back up, said David Johnston, earthquake geologist at the Arkansas Geological Survey.

"Most of them have been pretty small in a 1.5 to 3 range, and most of them

four injection wells near the switchboard of the earthquake; the Valley has only one.

Central Arkansas has

had two other "earthquake swarms" — one in the early 2000s and the first in the 1980s, according to geologic records, both of which predate the drilling activities

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A DEFINITIVE ANSWER

One way to detect a correlation between earthquakes and well injections is by pinpointing the depth of an earthquake.

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Temporary seismic stations are a possibility but not for ODNR, Hansen said the U.S. Geological Service has such devices, which cost about $5,000 and take about six months for delivery.

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"Injection induced seismicity in Youngstown is a valid and testable scientific hypothesis."
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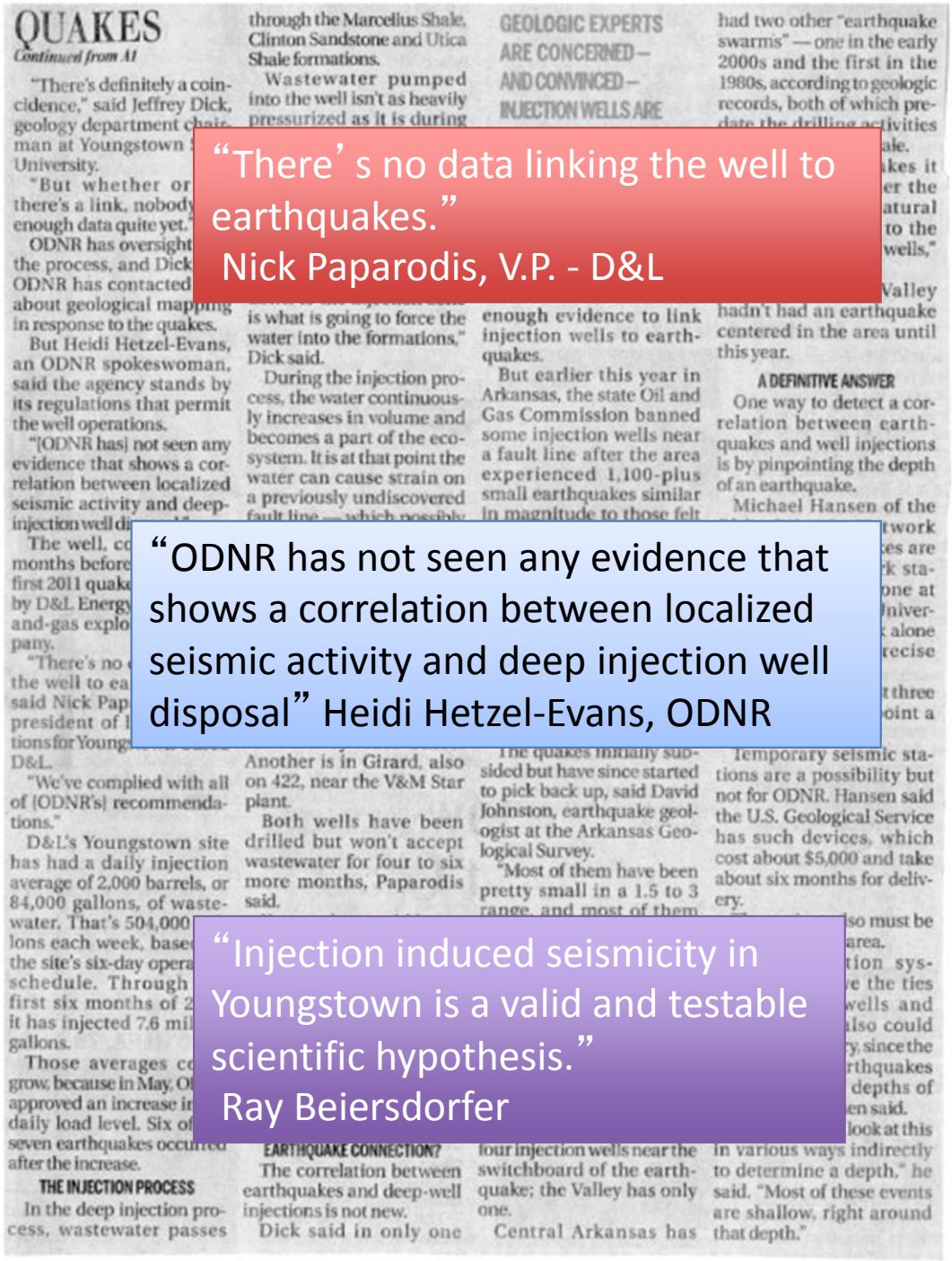

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Fears that 'fracking' causes Ohio earthquakes
by AlJazeeraEnglish
WELCOME TO THE COVELLI CENTRE
ALJAZEERA
C BEATS WORLD NUMBER EIGHT MARDY FISH IN KOOYONG CLASSIC FINA
YouTube
1:23 / 2:28
360p

ALJAZEERA

North Star #10 Construction Details

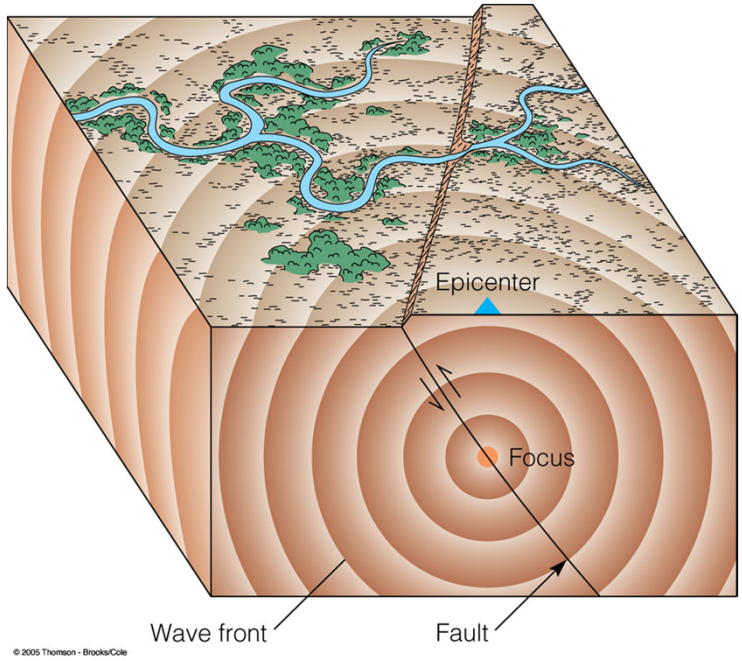
- 9,192 feet Deep
- 204 foot "rat hole" into Precambrian basement rocks (1.2 BYO igneous and metamorphic)
- Casing depth = 8,215 feet
- "Open hole" completion; no casing from 8,215' to 9,192' (977 feet total)
- Injection Formations: Cooper Ridge Dolomite, Conasauga Fm, Rome Fm, Mt. Simon Sandstone and Precambrian Basement
- Commenced injection December 2010

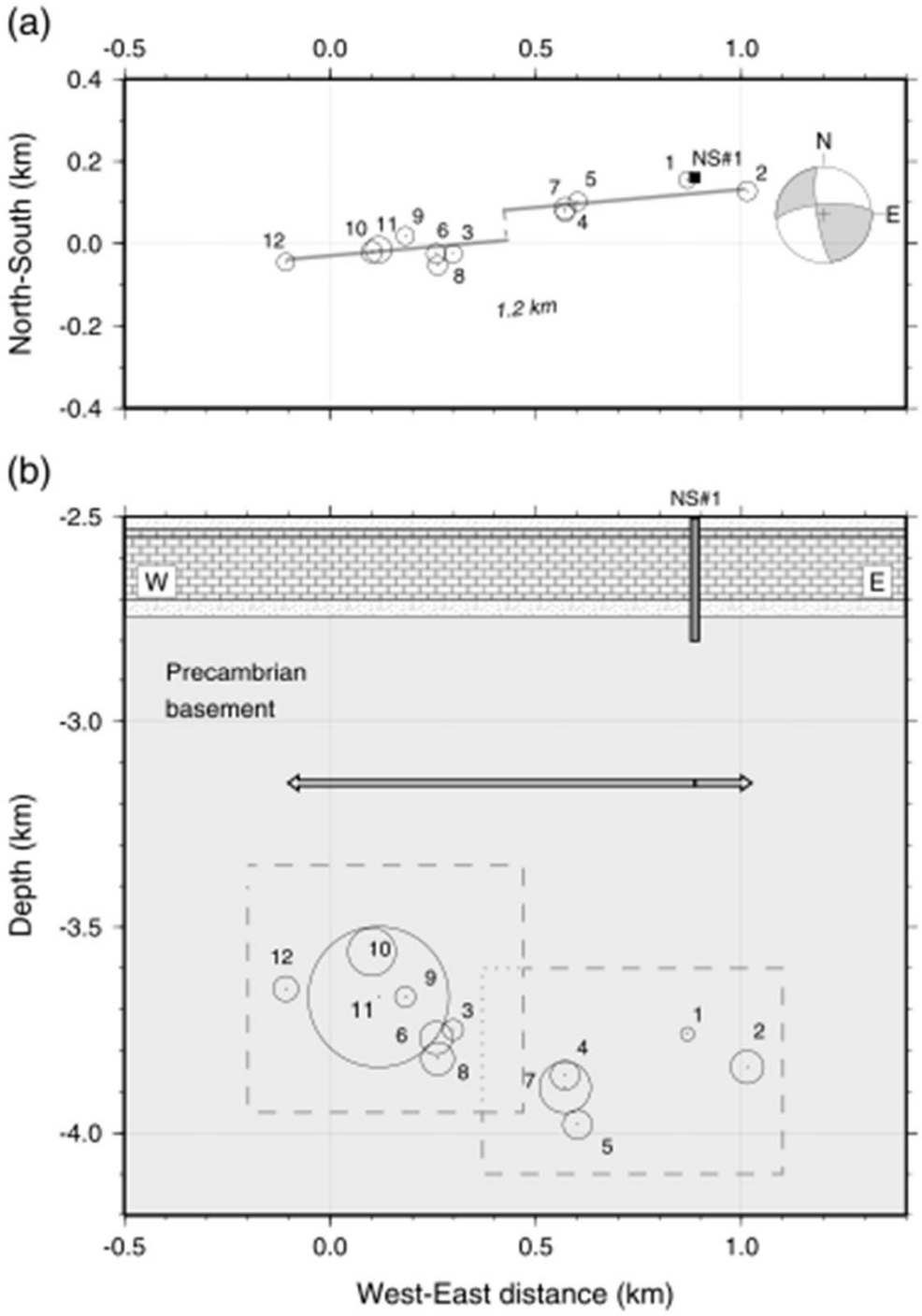
ODNR Report March 2012

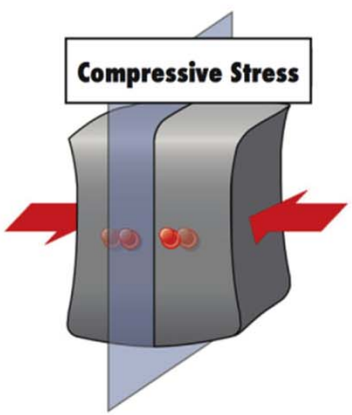
Injected 495,622 barrels (over 20 million gallons)

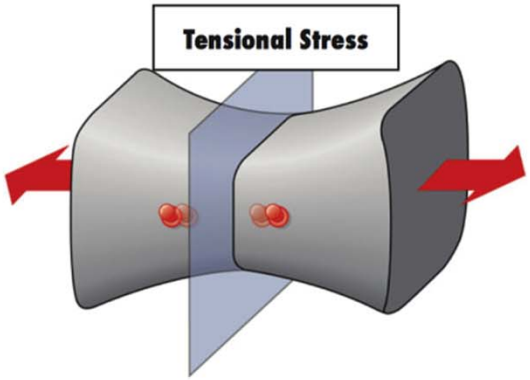
Fault is around 2.2 to 2.3 miles below the surface.

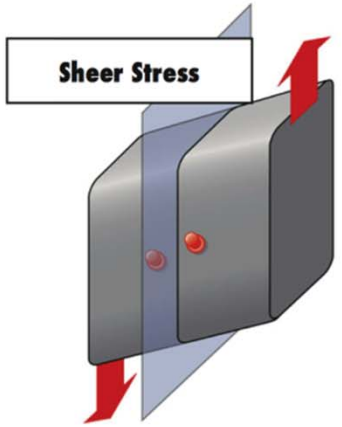
Foci of the earthquakes are around
4,000 ft laterally
2,500 feet below
the bottom of the well.

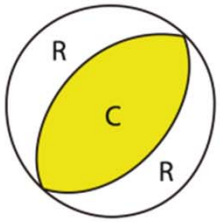



(a)
-0.5
0.0
0.5
1.0
0.4
0.2
0.0
-0.2
-0.4
North-South (km)
NS#1
1
2
3
4
5
6
7
8
9
10
11
12
1.2 km
N
E
(b)
NS#1
W
E
Precambrian
basement
-2.5
-3.0
-3.5
-4.0
Depth (km)
-0.5
0.0
0.5
1.0
West-East distance (km)

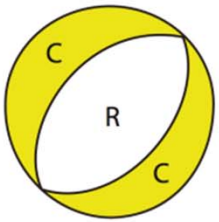




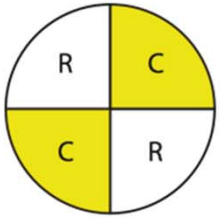




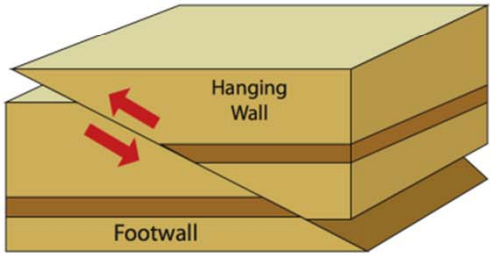
Thrust Fault

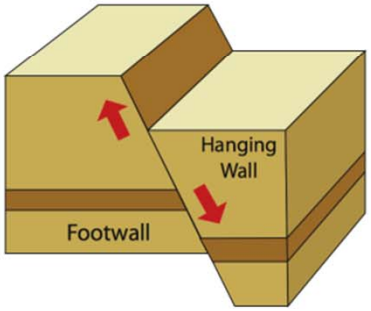


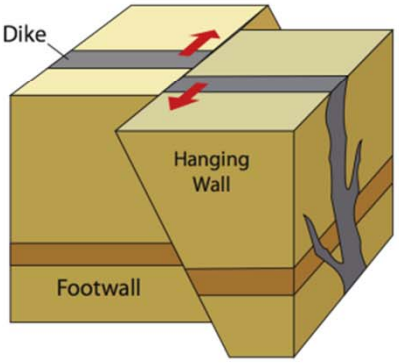
Normal Fault

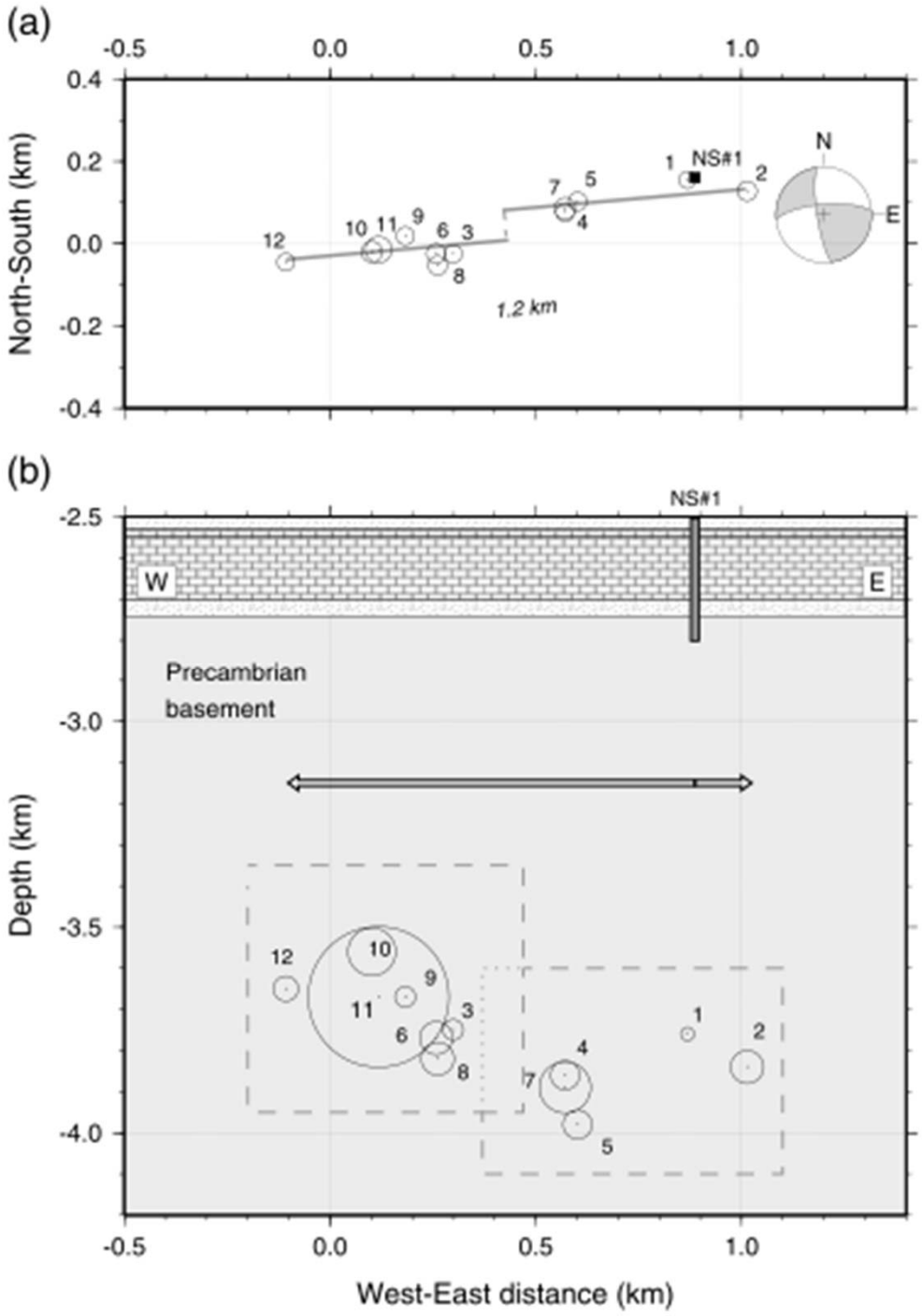


Strike-slip Fault








(a)
-0.5
0.0
0.5
1.0
0.4
0.2
0.0
-0.2
-0.4
North-South (km)
NS#1
1
2
3
4
5
6
7
8
9
10
11
12
1.2 km
N
E
(b)
NS#1
W
E
Precambrian
basement
-2.5
-3.0
-3.5
-4.0
Depth (km)
-0.5
0.0
0.5
1.0
West-East distance (km)

ODNR Report March 2012

2011 Timeline

March 14th Request Increase in Pressure

March 16th Get Permission Granted

March 17th Two Earthquakes

March 19th They Increase the Pressure

The Vindicator

NOTICE OF CITATION | OhioEPA

residue material was intentional discharged to storm sewer by company employee under direction of Ben Lupo - owner

February 6, 2013

Documents: CEO directed illegal dump

ROBERT K. YOSAY | THE VINDICATOR

State Rep. Bob Hagan of Youngstown, D-60th, stands in front of D&L Energy on Tuesday after speaking with representatives about the dumping of substances including oil. Below, workers hook up hoses to the tanks and trucks in the area of the dump on D&L Energy property.

By JAMISON COCKLIN | *jcocklin@vindy.com*

YOUNGSTOWN

Documents released by state regulators Tuesday show that Ben W. Lupo, a partner in several companies that share an address at Salt Springs Road, directed employees there to dump up to 20,000 gallons of wastewater down a storm drain.

The revelation comes five days after the incident, which occurred at Hard Rock Excavating's headquarters, where a large storage tank, capable of holding up to 20,000 gallons of waste — including oil and brine — was being cleaned by an employee of the company.

According to business records filed with the Ohio Secretary of State's Office, D&L Energy is listed as the owner of the company. Lupo, D&L's chief executive, is listed on those records as Hard Rock's only authorized representative.

He also is affiliated with several other companies that share an address at 2761 Salt Springs Road where the dumping incident occurred.

Both the Ohio Department of Natural Resources and the Ohio Environmental Protection Agency received an anonymous tip late

See **DUMPING, A4**

ONLINE VIDEO

See video, documents for this story at vindy.com

MORE INSIDE

- **Retired YSU** professor bemoans news of crude oil and brine being dumped into a storm drain that empties into the Mahoning River. **A4**
- **Dumping was** a criminal assault on environment and should be treated as such. Editorial, **A12**

Youngstown man admits dumping toxic fracking waste into Mahoning River

By James F. McCarty, The Plain Dealer
Email the author | Follow on Twitter
on August 29, 2013 at 12:30 PM, updated August 29, 2013 at 2:28 PM

Print

CLEVELAND, Ohio -- An employee of a Youngstown company that stored, treated and disposed of oil and gas drilling liquids admitted this morning to dumping tens of thousands of gallons of fracking waste on at least 24 occasions into a tributary of the Mahoning

Vindy.com
The Valley's Homepage

Lupo brine dumping trial set for April 8

Clean Water Act violation alleged

Saturday, February 8, 2014

By Peter H. Milliken

Although Lupo and Hardrock have pleaded not guilty, Guesman says in his written plea agreement that he dumped brine and drilling mud down a storm drain from 20,000-gallon storage tanks on Salt Springs Road in Youngstown at Lupo's direction on 24 nights beginning Dec. 12, 2012.

The investigation of the case was triggered by a Jan. 31, 2013, discharge that resulted in a massive cleanup of the unnamed tributary and of the Mahoning River, used specialized contractors and cost more than $1 million.

Vindy.com
The Valley's Homepage

Ben Lupo pleads guilty in brine dumping

Businessman who ordered illegal dumping could get prison term or probation

By William K. Alcorn

Tuesday, March 25, 2014

By Peter H. Milliken

milliken@vindy.com


02/03/2013


02/03/2013


02/03/2013


02/03/2013

THIS TIME, NO INJECTION WELLS NEAR QUAKE EPICENTERS, BUT THE SITE CONTAINS HORIZONTAL DRILLING WELLS

VALLEY IS SHAKEN AGAIN

ROBERT K. YOSAY | THE VINDICATOR

The Ohio Department of Natural Resources shut down all activity at Hilcorp Energy Co.'s fracking well on Moore Road in Poland Township, after a series of earthquakes occurred in Mahoning County on Monday.

By TOM MCPARLAND
tmcparland@vindy.com

POLAND

A state agency and local leaders again find themselves looking for answers as to why seismic tremors shook up part of the Valley for the first time in two years.

> "SOMETHING'S GOING ON. I DON'T KNOW IF IT'S GEOLOGICAL OR IF IT'S FRACKING, BUT IT'S STRANGE."
>
> TIM SICAFUSE, *Poland Village mayor*

Police in Boardman and Poland said they fielded calls Monday from people who felt the early-morning tremors, but no injuries or property damage were reported.

The Ohio Department of Natural Resources and Hilcorp Energy Co. say it's too soon to determine the cause of four earthquakes in Poland Township.

Citing an abundance of caution, however, ODNR ordered Hilcorp to halt all activity at two well pads at the Carbon Limestone Landfill "until further assessment can take place."

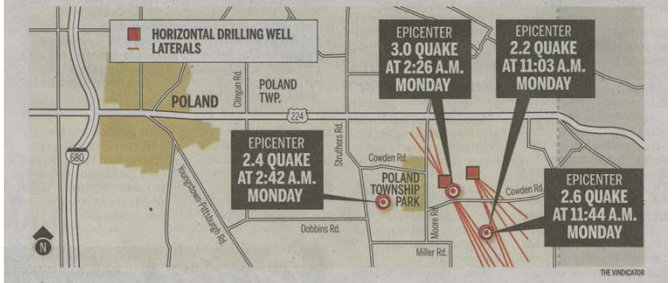
Hilcorp said it complied, shutting down seven wells at the site including one that was actively producing oil and gas.

"It is far too early in the process to know exactly what happened, and we are not aware of any evidence to connect our operations to these events," the company said in a statement. "We would also like

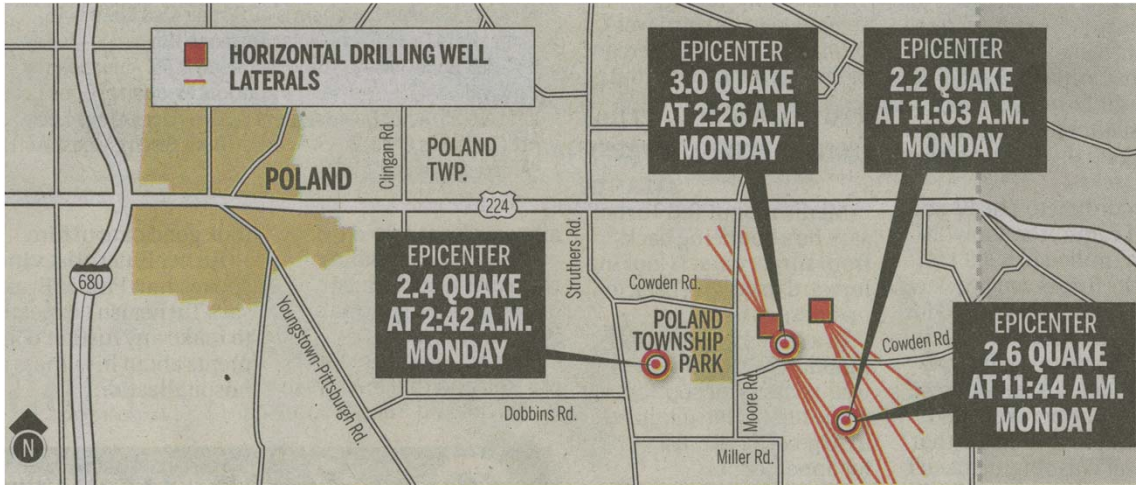
See QUAKES, A4

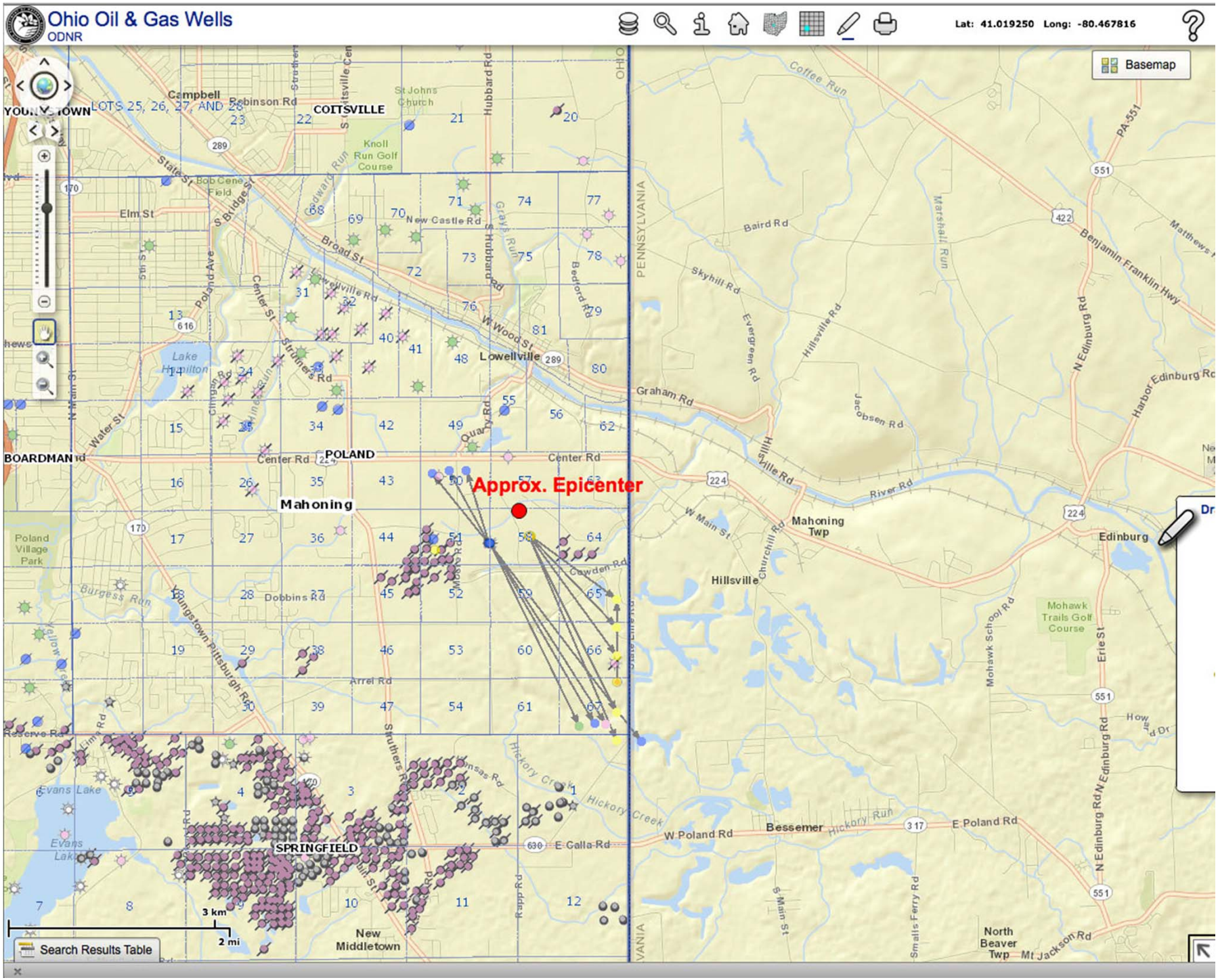
INSIDE ON C3

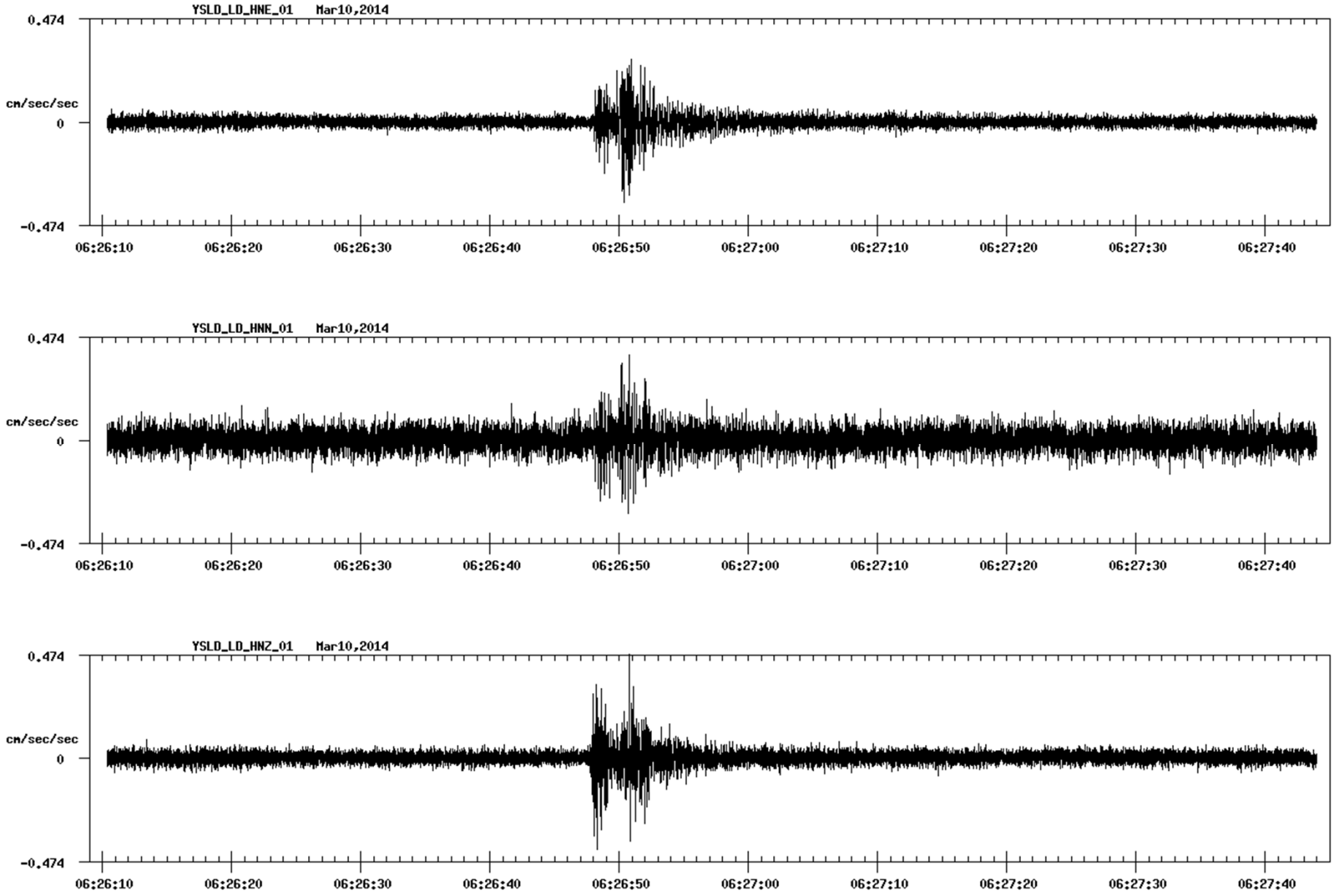
The Youngstown State University art department is sponsoring a series of free and public events called the Marcellus Shale Documentary Project.



The Vindicator




Ohio Oil & Gas Wells
ODNR
Lat: 41.019250 Long: -80.467816
Basemap
Approx. Epicenter
Mahoning
POLAND
COITSVILLE
Campbell
BOARDMAN
Lowellville
Mahoning Twp
Hillsville
Edinburg
Bessemer
SPRINGFIELD
New Middletown
North Beaver Twp
PENNSYLVANIA
Search Results Table
3 km
2 mi


YSLD_LD_HNE_01 Mar10,2014
0.474
cm/sec/sec
0
-0.474
06:26:10
06:26:20
06:26:30
06:26:40
06:26:50
06:27:00
06:27:10
06:27:20
06:27:30
06:27:40
YSLD_LD_HNN_01 Mar10,2014
0.474
cm/sec/sec
0
-0.474
06:26:10
06:26:20
06:26:30
06:26:40
06:26:50
06:27:00
06:27:10
06:27:20
06:27:30
06:27:40
YSLD_LD_HNZ_01 Mar10,2014
0.474
cm/sec/sec
0
-0.474
06:26:10
06:26:20
06:26:30
06:26:40
06:26:50
06:27:00
06:27:10
06:27:20
06:27:30
06:27:40

USGS

7 Days, All Magnitudes Worldwide

1375 earthquakes - Download

Updated: 2014-03-12 06:35:06 UTC-04:00

Showing event times using Local System Time (UTC-04:00)

5 earthquakes in map area

2.1	3km S of Lowellville, Ohio 2014-03-11 03:01:13 UTC-04:00	5.2 km
2.6	2km S of Lowellville, Ohio 2014-03-10 11:44:06 UTC-04:00	5.0 km
2.2	2km S of Lowellville, Ohio 2014-03-10 11:03:47 UTC-04:00	5.0 km
2.4	3km SSW of Lowellville, Ohio 2014-03-10 02:42:44 UTC-04:00	5.0 km
3.0	2km S of Lowellville, Ohio 2014-03-10 02:26:45 UTC-04:00	2.5 km

Didn't find what you were looking for?

Change your "Settings" to view more earthquakes.

Which earthquakes are included on the map and list?

Felt something not shown – report it here.

5 USGS and Lamont-Doherty Cooperative Seismographic Network (LCSN) reported events

Date (year/mo/dy)	Time (hh:mm:sec)	Latitude (ºN)	Longitude (ºW)	Depth (km)	Magnitude	Location
2014/03/10	06:26:45.9	41.010	80.543	2.5	3.0	31 km (19 mi) SSE of Youngstown,OH
2014/03/10	06:42:44.1	41.009	80.555	5.0	2.4	31 km (19 mi) SSE of Youngstown,OH
2014/03/10	15:03:47.7	41.010	80.530	5.0	2.2	31 km (19 mi) SSE of Youngstown,OH
2014/03/10	15:44:06.8	41.009	80.532	5.0	2.6	32 km (20 mi) SSE of Youngstown,OH
2014/03/11	07:01:13.0	41.002	80.534	5.2	2.1	32 km (20 mi) SSE of Youngstown,OH

Additional 7 shocks are detected by detailed analysis of seismic records around the epicentral area. Events are detected based on their waveform similarity with the reference event on 03/10/2014 06:26:45.9 (M 3.0), so locations are fixed to the reference event. These shocks are quite small (M 1.2 – 2.2) and are not felt by residents.

Date (year/mo/dy)	Time (hh:mm:sec)	Location & depth fixed to shock on 2014/03/10 06:26:45			Magnitude
2014/03/04	23:14:01.10	41.010	80.543	2.54	1.36
2014/03/05	03:05:19.18	41.010	80.543	2.54	2.24
2014/03/05	06:12:15.08	41.010	80.543	2.54	1.47
2014/03/06	15:31:03.70	41.010	80.543	2.54	1.58
2014/03/10	06:12:35.65	41.010	80.543	2.54	1.18
2014/03/10	06:23:10.68	41.010	80.543	2.54	1.44
2014/03/10	14:41:17.03	41.010	80.543	2.54	1.52

2.5 km = 8,200 feet

March 13, 2014

Won-Young Kim, Lamont-Doherty Cooperative Seismographic Network (LCSN)
Lamont-Doherty Earth Observatory of Columbia University

Four Earthquakes, Lowellville, Mahoning County, March 10, 2014

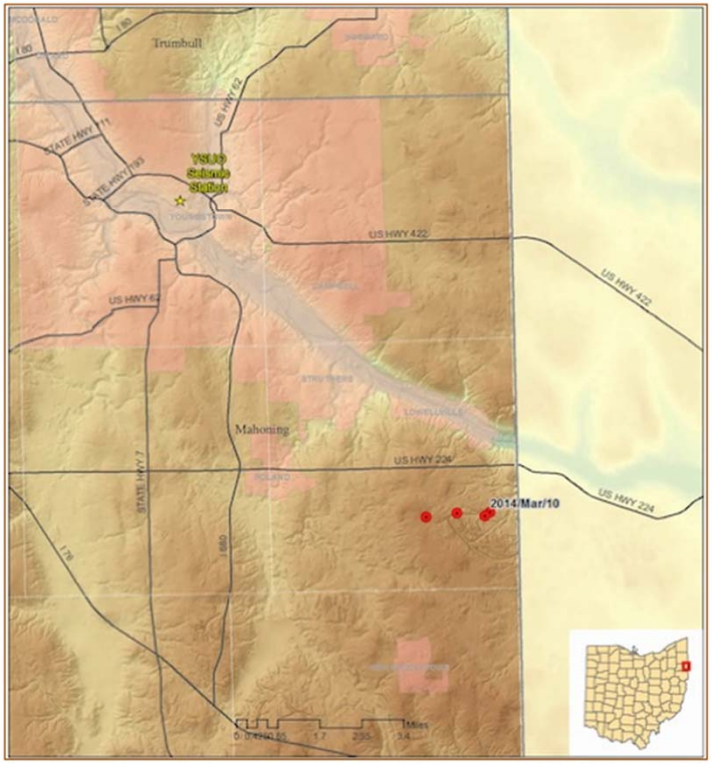
Origin Time:
10 March, 2014, 06:26:45 UTC
Location:
41.010 North -80.543 West
Magnitude: 3.0
Depth: 5 km (fixed)

Origin Time:
10 March, 2014, 06:42:44 UTC
Location:
41.009 North -80.555 West
Magnitude: 2.4
Depth: 5 km (fixed)

Origin Time:
10 March, 2014, 15:03:47 UTC
Location:
41.010 North -80.530 West
Magnitude: 2.2
Depth: 5 km (fixed)

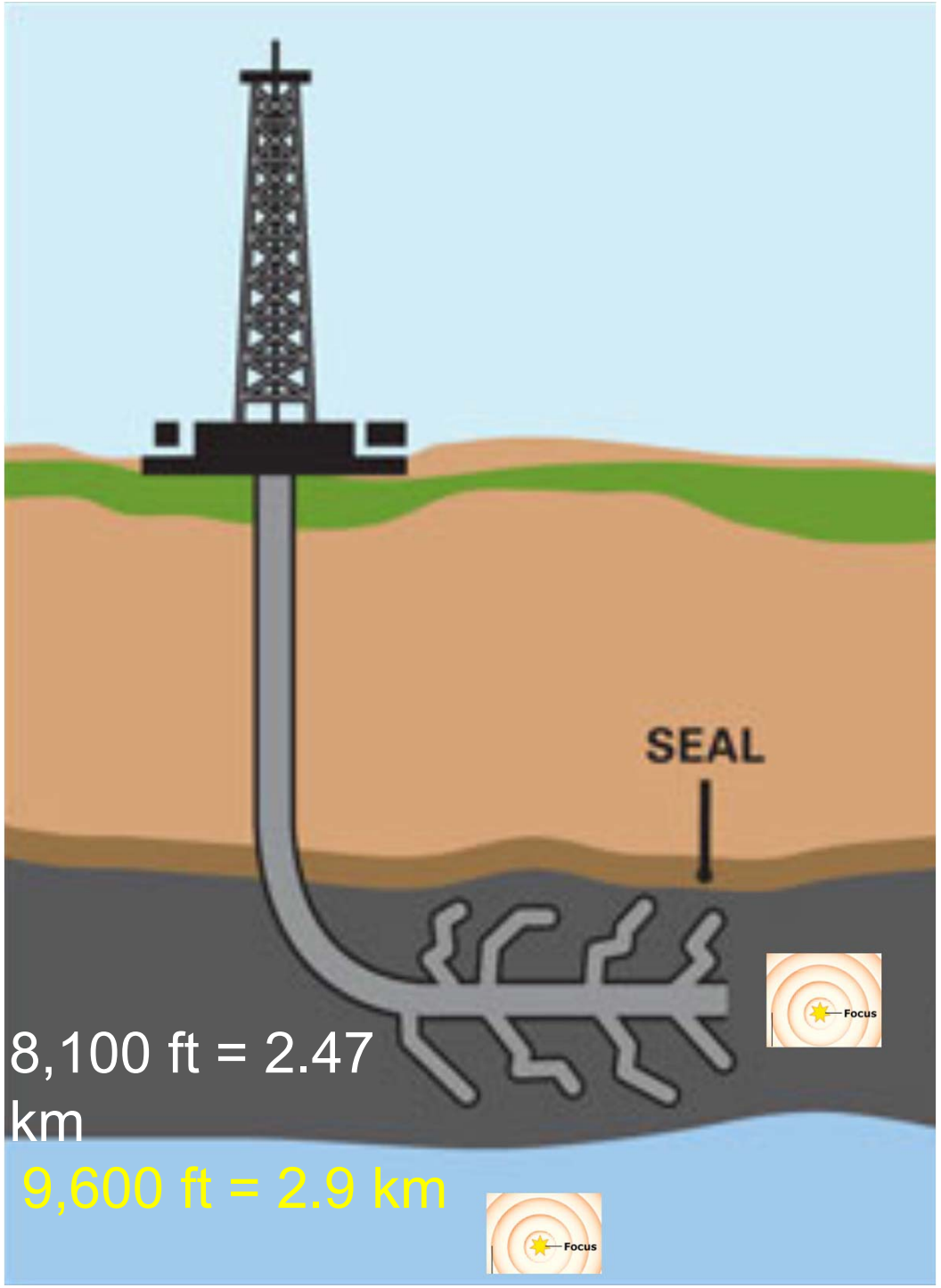
Origin Time:
10 March, 2014, 15:44:06 UTC
Location:
41.009 North -80.532 West
Magnitude: 2.6
Depth: 5 km (fixed)

5 km = 16,000 feet



Four small earthquakes above 2.0 magnitude were recorded about 2.8 kilometers (1.75 miles) south of Lowellville, Poland Township, Mahoning County, at 2:26 a.m EDT, 2:42 a.m. EDT, 11:03 a.m. EDT, and 11:44 a.m. EDT. Felt reports were received for the 2:26, 11:03, and 11:44 events. There were no damages from these minor earthquakes. Individuals who felt this event are encouraged to submit a report or email: ohioseis@dnr.state.oh.us. Please include a description of what you felt and your street address in your email message.

Where did the earthquakes occur?

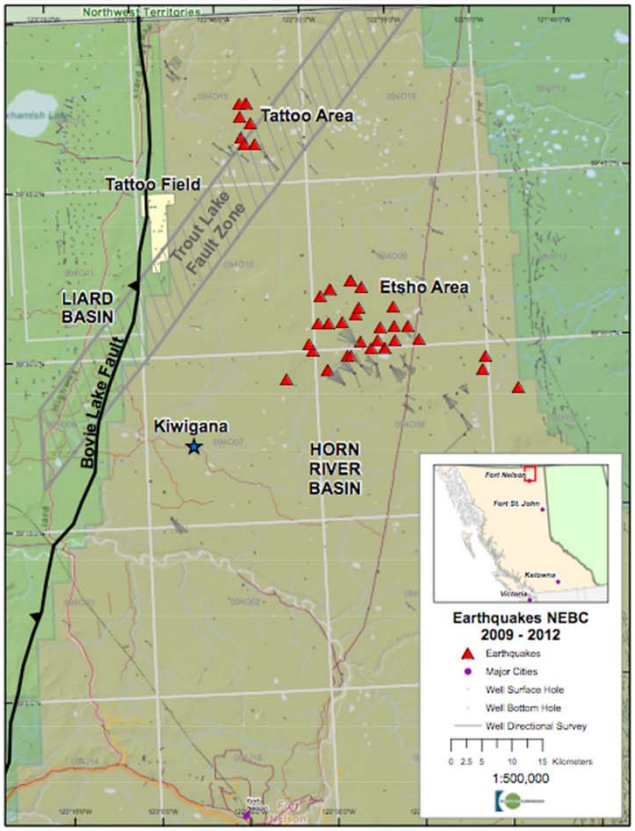


CBS NEWS / *May 14, 2014, 5:31 PM*

Fracking linked to Ohio earthquakes, officials say

Investigation of Observed Seismicity in the Horn River Basin

BC Oil and Gas Commission - August 2012



The investigation has concluded that the events observed within remote and isolated areas of the Horn River Basin between 2009 and 2011 were caused by fluid injection during hydraulic fracturing in proximity to pre-existing faults.

Two instances of wellbore deformation along horizontal sections were reported by one operator.

BC Oil & Gas COMMISSION

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

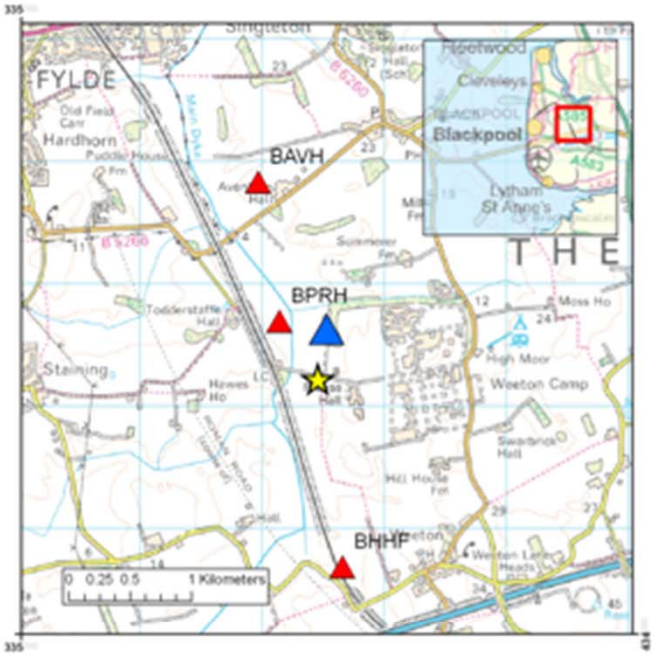
England 2011

Fracking and Earthquake Hazard

A REPORT PUBLISHED BY DECC that includes a BGS co-author concludes that the earthquakes near Blackpool in April and May 2011 were induced by hydraulic fracture treatments at the Preese Hall well (PH1), operated by CUADRILLA RESOURCES LTD. The report also concludes that further small earthquakes cannot be ruled out, however the risk from these earthquakes is low, and structural damage is extremely unlikely.

The report also recommends a number of measures to reduce the likelihood of earthquakes associated with hydraulic fracturing in future. These include :

- Less fluid should be injected during future hydraulic fracture treatments. Since, the number of earthquakes should increase roughly proportionally to the injected volume, injecting less fluid should reduce the probability of larger earthquakes. Also,the fluid should be allowed to 'flow back' out of the formation after the hydraulic fracture forms, to minimise the probability of fluids percolating.
- Earthquake activity should be carefully monitoring before, during and after fracture treatments. If any earthquakes above a certain magnitude threshold occur, the operations should be temporarily suspended. A magnitude of 0.5 ML is suggested as an appropriate threshold. Such a TRAFFIC LIGHT SYSTEM is based on extensive experience in Enhanced Geothermal Systems (EGS)
- Detailed MICROSEISMIC MONITORING should be carried out for the next hydraulic fracture treatment in the Bowland shale. Microseismic is routinely used in the oil and gas industry to image fracture networks and estimate stimulated volumes. This should improve understanding of fracture growth and the hazards associated with this.

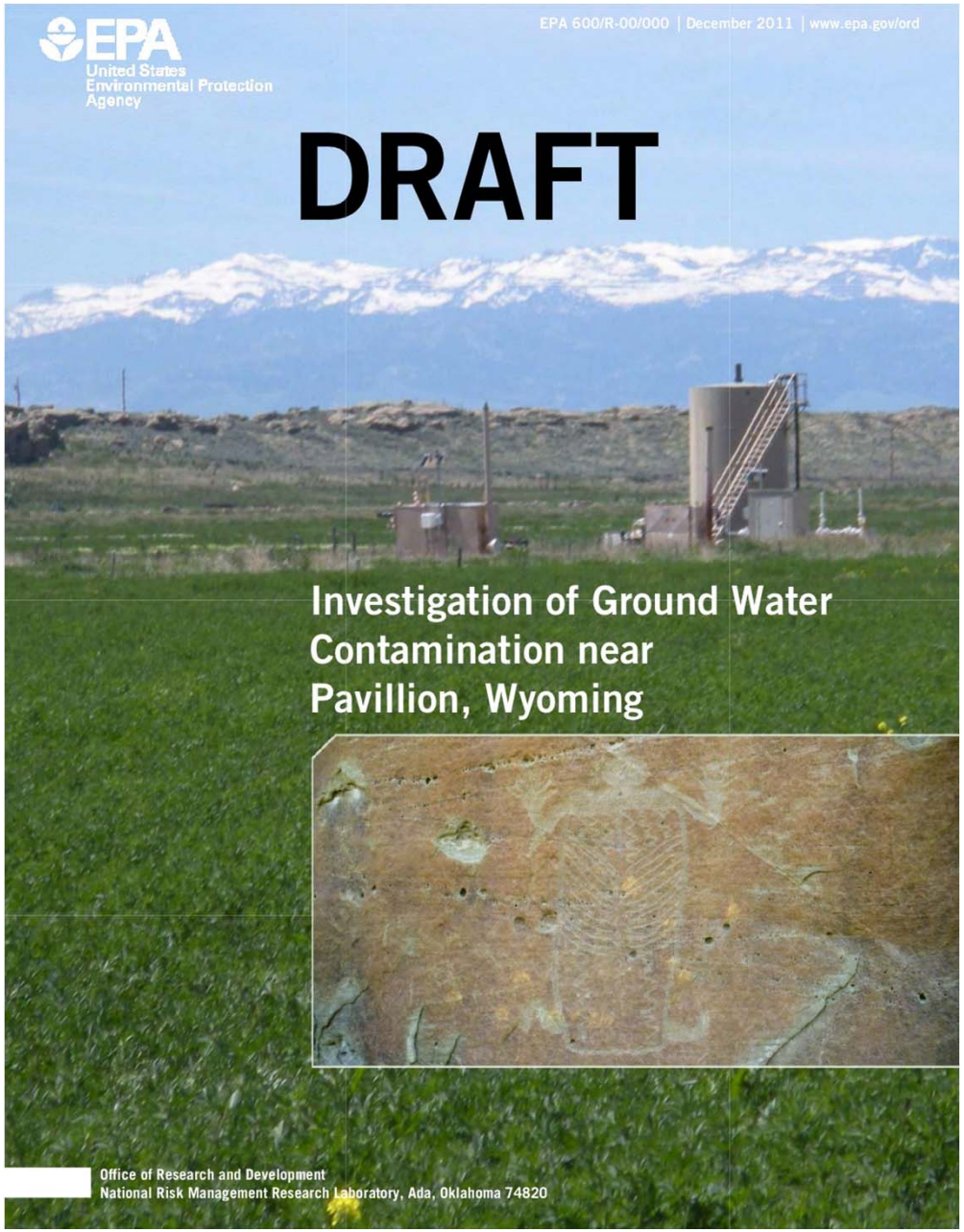


Epicentres of Blackpool earthquakes (yellow star). The location of the Preese Hall drill site is shown by the blue triangle. The red triangles show in locations of temporary monitoring stations installed by BGS. CLICK TO ENLARGE

Less fluid should be injected during future hydraulic fracture treatments.

Earthquake activity should be carefully monitoring before, during and after fracture treatments. If any earthquakes above a certain magnitude threshold occur, the operations should be temporarily suspended. A magnitude of 0.5 M_L is suggested as an appropriate threshold.

Detailed microseismic monitoring should be carried out for the next hydraulic fracture treatment



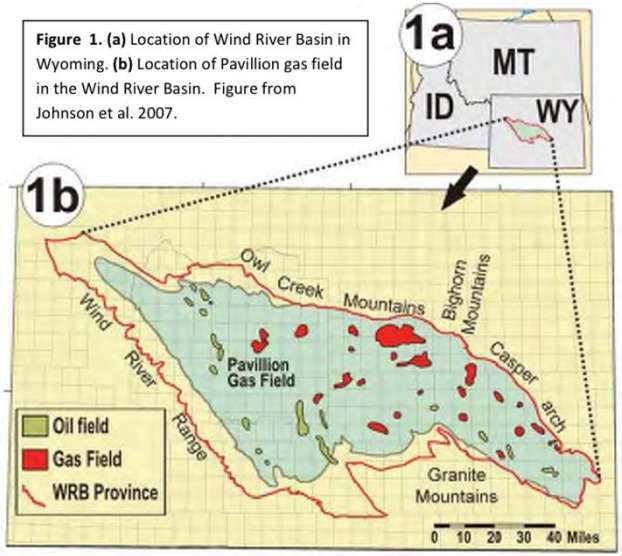


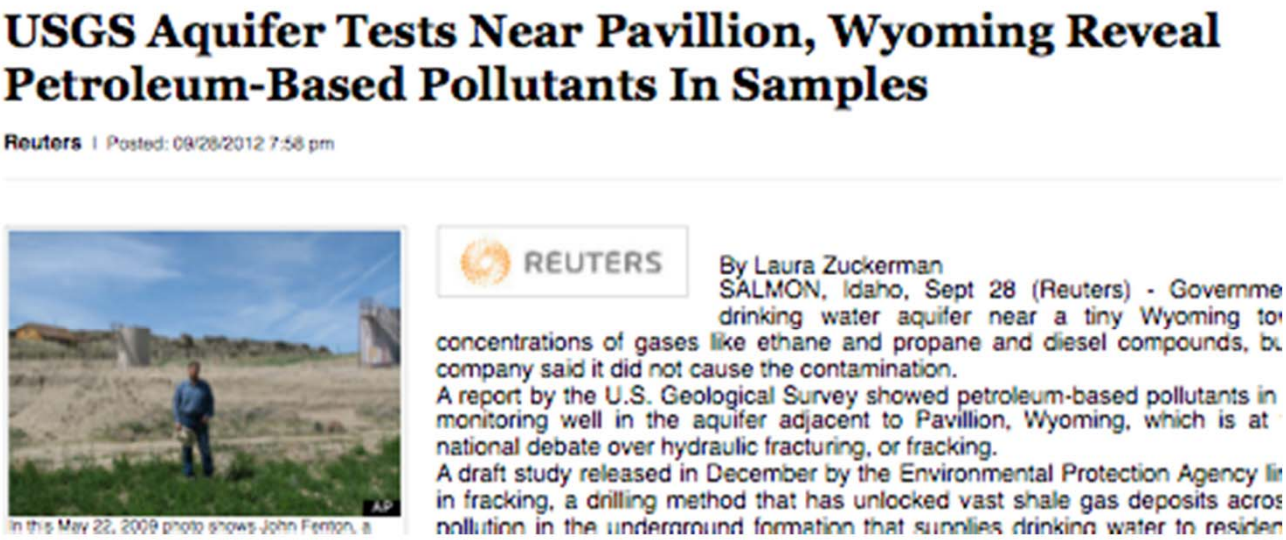
Figure 1. (a) Location of Wind River Basin in Wyoming. **(b)** Location of Pavillion gas field in the Wind River Basin. Figure from Johnson et al. 2007.

Found evidence of contamination

USGS
science for a changing world

In cooperation with the Wyoming Department of Environmental Quality

Groundwater-Quality and Quality-Control Data for Two Monitoring Wells near Pavillion, Wyoming, April and May 2012



USGS Aquifer Tests Near Pavillion, Wyoming Reveal Petroleum-Based Pollutants In Samples

Reuters | Posted: 09/28/2012 7:58 pm

In this May 22, 2009 photo shows John Fenton, a

REUTERS

By Laura Zuckerman
SALMON, Idaho, Sept 28 (Reuters) - Governme
drinking water aquifer near a tiny Wyoming to
concentrations of gases like ethane and propane and diesel compounds, bu
company said it did not cause the contamination.
A report by the U.S. Geological Survey showed petroleum-based pollutants in
monitoring well in the aquifer adjacent to Pavillion, Wyoming, which is at
national debate over hydraulic fracturing, or fracking.
A draft study released in December by the Environmental Protection Agency li
in fracking, a drilling method that has unlocked vast shale gas deposits acros
pollution in the underground formation that supplies drinking water to residen

Data Series 718

U.S. Department of the Interior
U.S. Geological Survey

01.10.12 - 11:09 PM

Fracking Dimock, Again

by Abby Zimet

The all-suffering residents of Dimock, PA. - population 1,368 and enough Cabot gas and oil fracking sites to have poisoned their wells over the last three years - got screwed again this weekend when the federal E.P.A. **said** they'd bring them safe water, and then abruptly **changed** their minds. More here and here on Dimock's woeful history.

> "These agencies were developed to help us, and they don't," said Jean Carter, whose home is 326 feet from a Cabot well. "We just keep getting hurt all the way around, as if we weren't hurt enough."

Source: commondreams.org

latimes.com/news/nationworld/nation/la-na-epa-dimock-20130728,0,4847442.story

latimes.com

Internal EPA report highlights disputes over fracking and well water

An EPA staff report suggests methane from hydraulic fracturing, or fracking, contaminated wells near Dimock, Pa., but the agency says the water's safe to drink.

By Neela Banerjee

8:00 PM PDT, July 27, 2013

WASHINGTON — One year ago, the Environmental Protection Agency finished testing drinking water in Dimock, Pa., after years of complaints by residents who suspected that nearby natural gas production had fouled their wells. The EPA said that for nearly all the 64 homes whose wells it sampled, the water was safe to drink.

Yet as the regulator moved to close its investigation, the staff at the mid-Atlantic EPA office in Philadelphia, which had been sampling the Dimock water, argued for continuing the assessment.

In an internal EPA PowerPoint presentation obtained by the Tribune/Los Angeles Times Washington Bureau, staff members warned their superiors that several wells had been contaminated with methane and substances such as manganese and arsenic, most likely because of local natural gas production.

EPA changed course after oil company protested

AP **RAMIT PLUSHNICK-MASTI** January 16, 2013

WEATHERFORD, Texas (AP) — When a man in a Fort Worth suburb reported his family's drinking water had begun bubbling like champagne, the federal government sounded an alarm: An oil company may have tainted their wells while drilling for natural gas.

At first, the Environmental Protection Agency believed the situation was so serious that it issued a rare emergency order in late 2010 that said at least two homeowners were in immediate danger from a well saturated with flammable methane. More than a year later, the agency rescinded its mandate and refused to explain why.

Now a confidential report obtained by The Associated Press and interviews with company representatives show that the

ENVIRONMENTAL WORKING GROUP

Cracks in the Façade

25 Years Ago, EPA Linked "Fracking" to Water Contamination

Dusty Horwitt, Senior Counsel, Environmental Working Group

August 3, 2011

www.ewg.org/gas-drilling-and-fracking

EPA Traced Pollution of Underground Water Supply to Hydraulic Fracturing

In 1982, Kaiser Gas Co. drilled and hydraulically fractured a natural gas well on the property of James Parsons in Jackson County, W. Va. The EPA concluded in a 1987 report to Congress that the process contaminated Parsons' water well with fracturing fluid. It is unclear how the "fracking" fluids may have entered the water well, but four old natural gas wells nearby could have been the conduits for contamination.

Old Well
Drilled 1941-42

New Well
Drilled 1982

Jackson County, WV

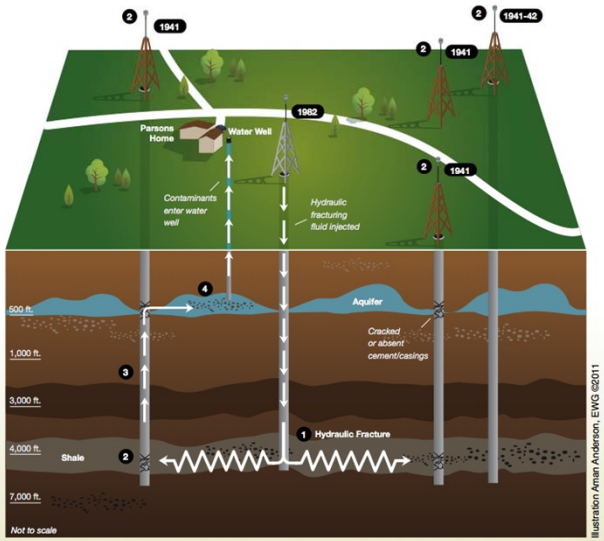


Illustration Aman Anderson, EWG ©2011

1 Hydraulic Fractures
According to industry studies, hydraulic fractures can extend up to 2,500 feet horizontally, well within range of old natural gas wells near Parsons' property. Studies found that fractures have broken into nearby oil and gas wells and that fracking fluid has migrated up old wells to the surface.

2 1940s Wells Nearby
Four old natural gas wells were located within 1,700 feet of the gas well drilled on James Parsons' property. Each of the wells was "shot," an early fracturing process in which companies detonated explosives inside a well to help access gas or oil deposits.

3 Fluid Migration
Government studies have found that oil and natural gas waste fluids injected underground can migrate up old oil and natural gas wells.

4 Breakout into Aquifer
These fluids can break into aquifers near the surface if the old wells have deteriorated casings, lack cement plugs or contain cracked cement. This phenomenon is known as "salt water breakout." It is possible that hydraulic fracturing fluids migrated in a similar way into Parsons' water well.

Published on Tuesday, January 17, 2012 by Common Dreams

Well Blowout, Toxic Water: Fracking Disasters on the Rise

Oil well blowout in Alberta, explosive water in Ohio put drilling technique under scrutiny

- Common Dreams staff

The process of hydraulic fracturing, known as fracking, has recently been linked to earthquakes in Ohio, and fracking chemicals were confirmed in Wyoming groundwater just a month ago.

With news today out of Alberta and Ohio, the controversial project may be under even further scrutiny.

photo: Alberta Surface Rights Group

On Friday afternoon, The ***Calgary Herald*** reports, fracking at one oil well in Alberta caused a blowout at another oil well a kilometer away.

> Fluids blasted deep into the earth under high pressure appear to have intersected underground with the second well, forcing oil up through the well bore at explosive rates.

By Ruth McDermott-Levy, PhD, RN,
Nina Kaktins, MSN, RN, and
Barbara Sattler, DrPH, RN

AJN ▼ June 2013 ▼ Vol. 113, No. 6

Fracking, the Environment, and Health

New energy practices may threaten public health.

Evidence of the negative human and ecologic health effects of fracking are emerging, and it should be noted that sufficient evidence has been presented to the ANA, the American Public Health Association, and the American Medical Association's Resident and Fellow Section to result in a call for a moratorium on the issuance of new fracking permits nationally. Nurses' voices in our communities, in state legislatures, in Congress, and with the EPA can help to keep health issues front and center as we address national energy needs and policies. ▼

Oil Yield and Uranium Content of Black Shales

Over 100 times greater than other sedimentary rocks

By VERNON E. SWANSON

URANIUM IN CARBONACEOUS ROCKS

GEOLOGICAL SURVEY PROFESSIONAL PAPER 356-A

This report concerns work done on behalf of the U.S. Atomic Energy Commission and is published with the permission of the Commission

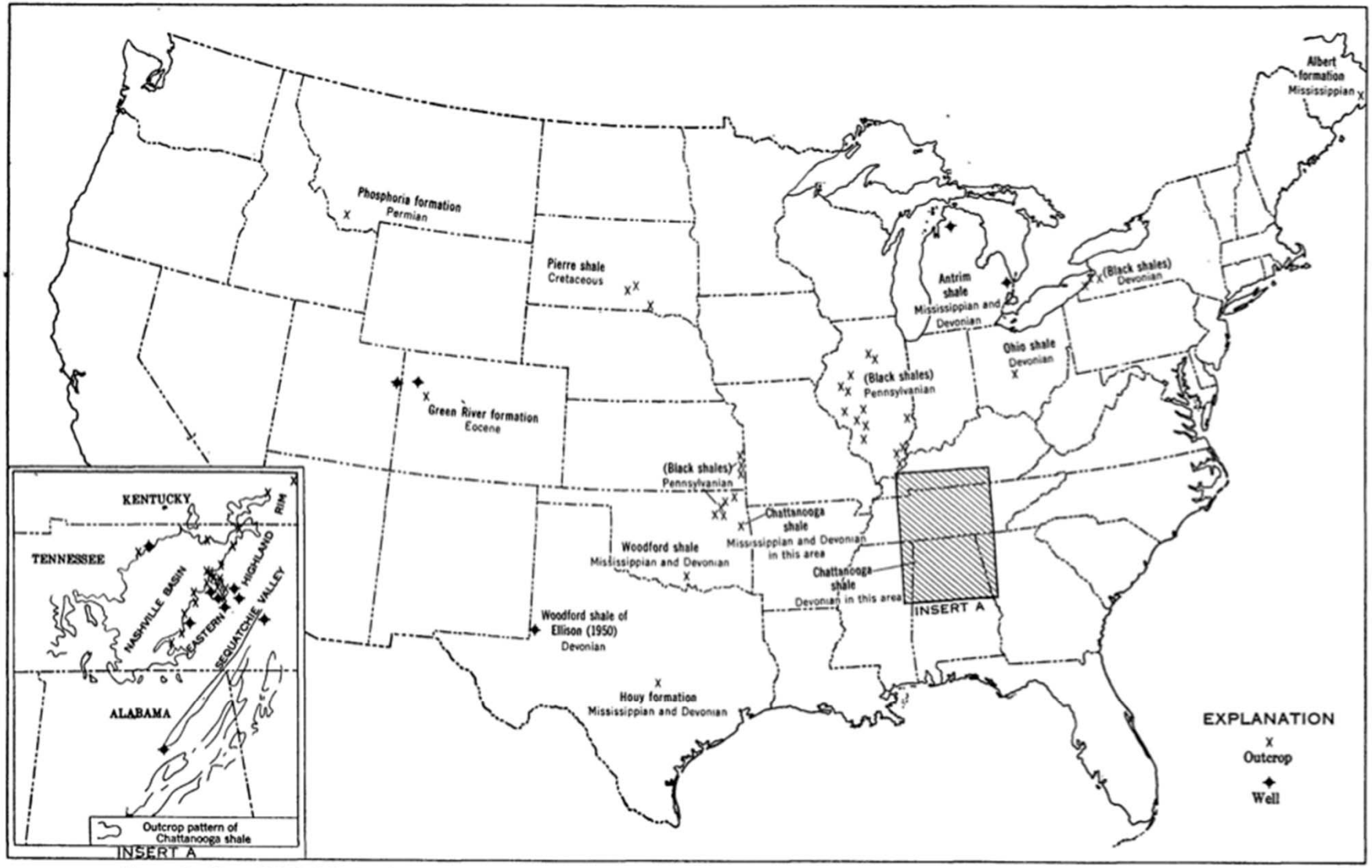


FIGURE 1.—Map of United States showing localities of samples and of black shales for which oil yield and uranium content have been determined.

Environmental Science & Technology

October 2013

Article

pubs.acs.org/est

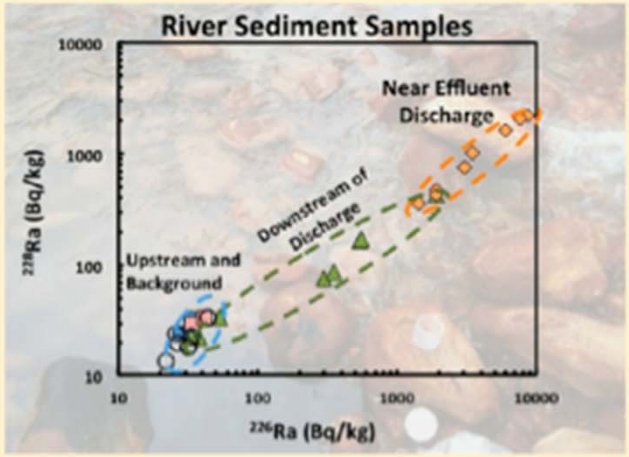
Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania

Nathaniel R. Warner,*[,†] Cidney A. Christie, Robert B. Jackson, and Avner Vengosh*

Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, North Carolina 27708, United States

Supporting Information

ABSTRACT: The safe disposal of liquid wastes associated with oil and gas production in the United States is a major challenge given their large volumes and typically high levels of contaminants. In Pennsylvania, oil and gas wastewater is sometimes treated at brine treatment facilities and discharged to local streams. This study examined the water quality and isotopic compositions of discharged effluents, surface waters, and stream sediments associated with a treatment facility site in western Pennsylvania. The elevated levels of chloride and bromide, combined with the strontium, radium, oxygen, and hydrogen isotopic compositions of the effluents reflect the composition of Marcellus Shale produced waters. The discharge of the effluent from the treatment facility increased downstream concentrations of chloride and bromide above background levels. Barium and radium were substantially (>90%) reduced in the treated effluents compared to concentrations in Marcellus Shale produced waters. Nonetheless, ^{226}Ra levels in stream sediments (544−8759 Bq/kg) at the point of discharge were ~200 times greater than upstream and background sediments (22−44 Bq/kg) and above radioactive waste disposal threshold regulations, posing potential environmental risks of radium bioaccumulation in localized areas of shale gas wastewater disposal.



Company Gets Permit to Handle Radioactive Waste

Monday, April 21, 2014

By Dan O'Brien

YOUNGSTOWN, Ohio -- Activists in Ohio are concerned that a local company may soon be handling waste from the oil and gas industry that they say is just too hot to handle. But a principal of the operation says that the objective of his company is to protect the environment and to ensure safety, especially when it comes to "hot" radioactive material generated from drilling operations in the Utica and Marcellus shale plays.

"I understand their concerns," says Pat Horkman, principal and Ohio field manager for Austin Masters Services, based in Pottsville, Pa. "But they should be happy we're here."

Ohio has licensed Austin Masters Services to handle radioactive material and the firm would be conducting tests and analyses on materials moving through Industrial Waste Disposal/Ground Tech Inc.'s site at 240 Sinter Court.

The Journal

Activists Raise Concerns about Handling of Radioactive Waste

Thursday, April 24, 2014

YOUNGSTOWN, Ohio -- Residents here have lodged an appeal with the Ohio Department of Natural Resources, asking that the agency revoke a permit they say would allow a local operation to process radioactive waste.

"We need to have local control over what goes on in our communities and neighborhoods," said Susie Beiersdorfer, a member of Frack Free Mahoning. "We cannot let the Ohio Department of Natural Resources bureaucrats in Columbus make public health and safety decisions for our local community."

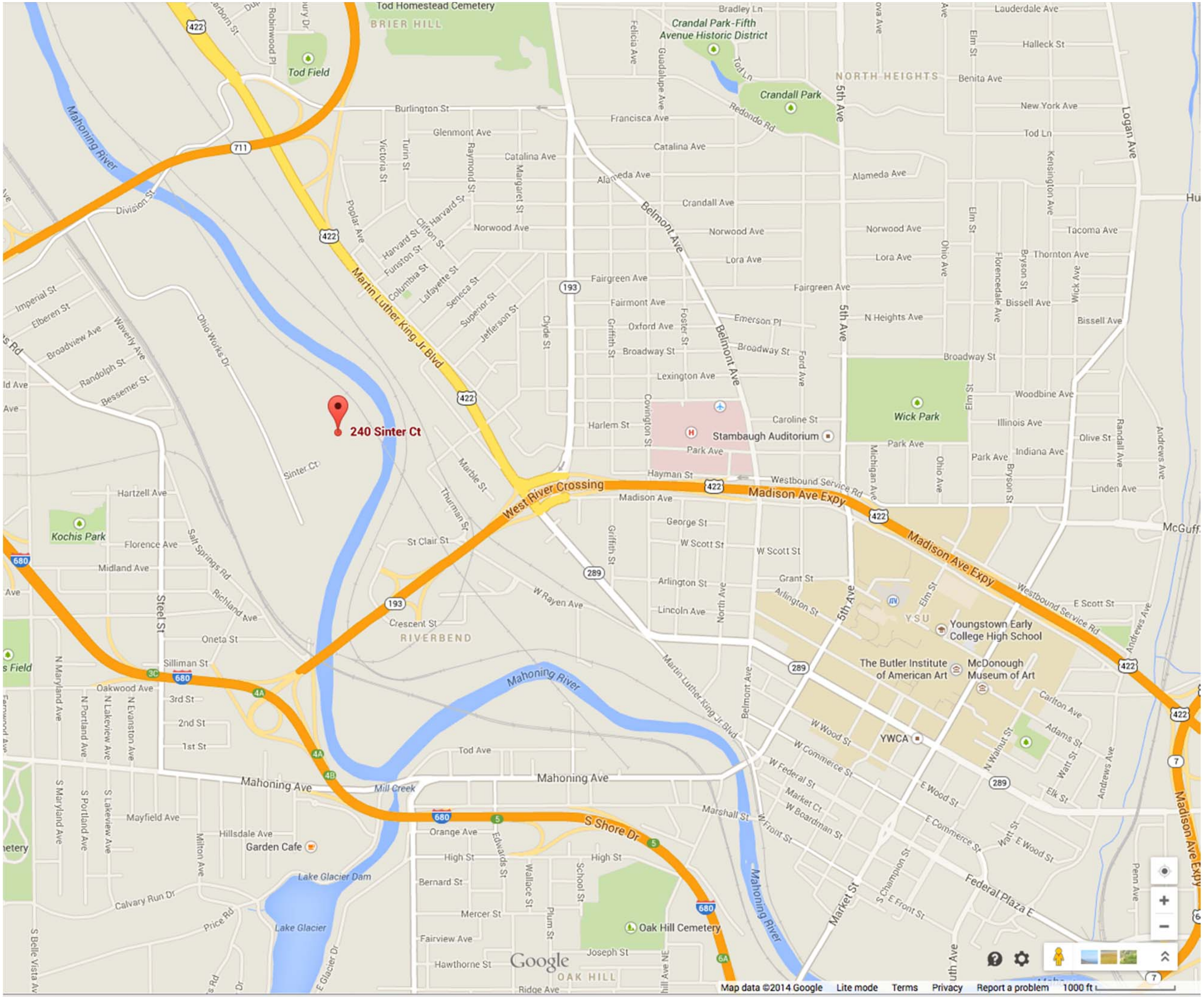
The group wants the oil and gas commission to vacate a decision by ODNR oil and gas division chief Richard Simmers that approved a permit for Industrial Waste Control Inc., 240 Sinter Court. According to the permit, the company would use a third party to handle and test waste generated from drilling operations to determine whether the material is radioactive.

On Monday, The Business Journal reported that Industrial Waste had obtained the permit and would use Pennsylvania-based Austin Master Services LLC to conduct tests on incoming waste to determine the levels, if any, of radioactivity.

Pat Horkman, principal and Ohio field manager of Austin Masters, told The Business Journal that the operation would use new technology to test waste moving through the area on trucks without the material ever being exposed.

"We have the ability to test the entire contents of a container without it ever coming out of the box," he said. "We're policing the industry."

Beiersdorfer contends that ODNR placed the permit on the fast track and didn't adequately inform the community about the prospect of an operation that could handle radioactive waste in the heart of the city. The group learned of the permit through a public records request that another organization filed in Columbus.


240 Sinter Ct
Sinter Ct
Tod Homestead Cemetery
BRIER HILL
Tod Field
Crandal Park-Fifth Avenue Historic District
Crandall Park
NORTH HEIGHTS
Bradley Ln
Lauderdale Ave
Halleck St
Benita Ave
New York Ave
Tod Ln
Logan Ave
Burlington St
Glenmont Ave
Catalina Ave
Francisca Ave
Redondo Rd
Alameda Ave
Crandall Ave
Norwood Ave
Lora Ave
Tacoma Ave
Thornton Ave
Fairgreen Ave
Fairmont Ave
Oxford Ave
Broadway St
Lexington Ave
Emerson Pl
N Heights Ave
Bissell Ave
Woodbine Ave
Illinois Ave
Indiana Ave
Olive St
Linden Ave
Caroline St
Park Ave
Harlem St
Hayman St
Stambaugh Auditorium
Wick Park
Belmont Ave
5th Ave
Elm St
Ohio Ave
Mahoning River
Division St
Imperial St
Elberen St
Broadview Ave
Waverly Ave
Randolph St
Bessemer St
Ohio Works Dr
Martin Luther King Jr Blvd
Marble St
Thurman St
West River Crossing
Madison Ave
Madison Ave Expy
Westbound Service Rd
George St
W Scott St
Grant St
Arlington St
Lincoln Ave
E Scott St
McGuffey
Hartzell Ave
Kochis Park
Florence Ave
Midland Ave
Salt Springs Rd
Richland Ave
Steel St
Oneta St
Silliman St
Oakwood Ave
3rd St
2nd St
1st St
St Clair St
Crescent St
RIVERBEND
W Rayen Ave
YSU
Youngstown Early College High School
The Butler Institute of American Art
McDonough Museum of Art
YWCA
W Wood St
W Commerce St
W Federal St
W Boardman St
W Front St
E Wood St
E Commerce St
Federal Plaza E
Carlton Ave
Adams St
Elk St
Walnut St
Tod Ave
Mahoning Ave
Mill Creek
S Shore Dr
Marshall St
Orange Ave
High St
Bernard St
Mercer St
Fairview Ave
Hawthorne St
Ridge Ave
Joseph St
Oak Hill Cemetery
OAK HILL
Mayfield Ave
Hillsdale Ave
Garden Cafe
Lake Glacier Dam
Lake Glacier
Calvary Run Dr
Price Rd
Market St
Google
Map data ©2014 Google
Lite mode
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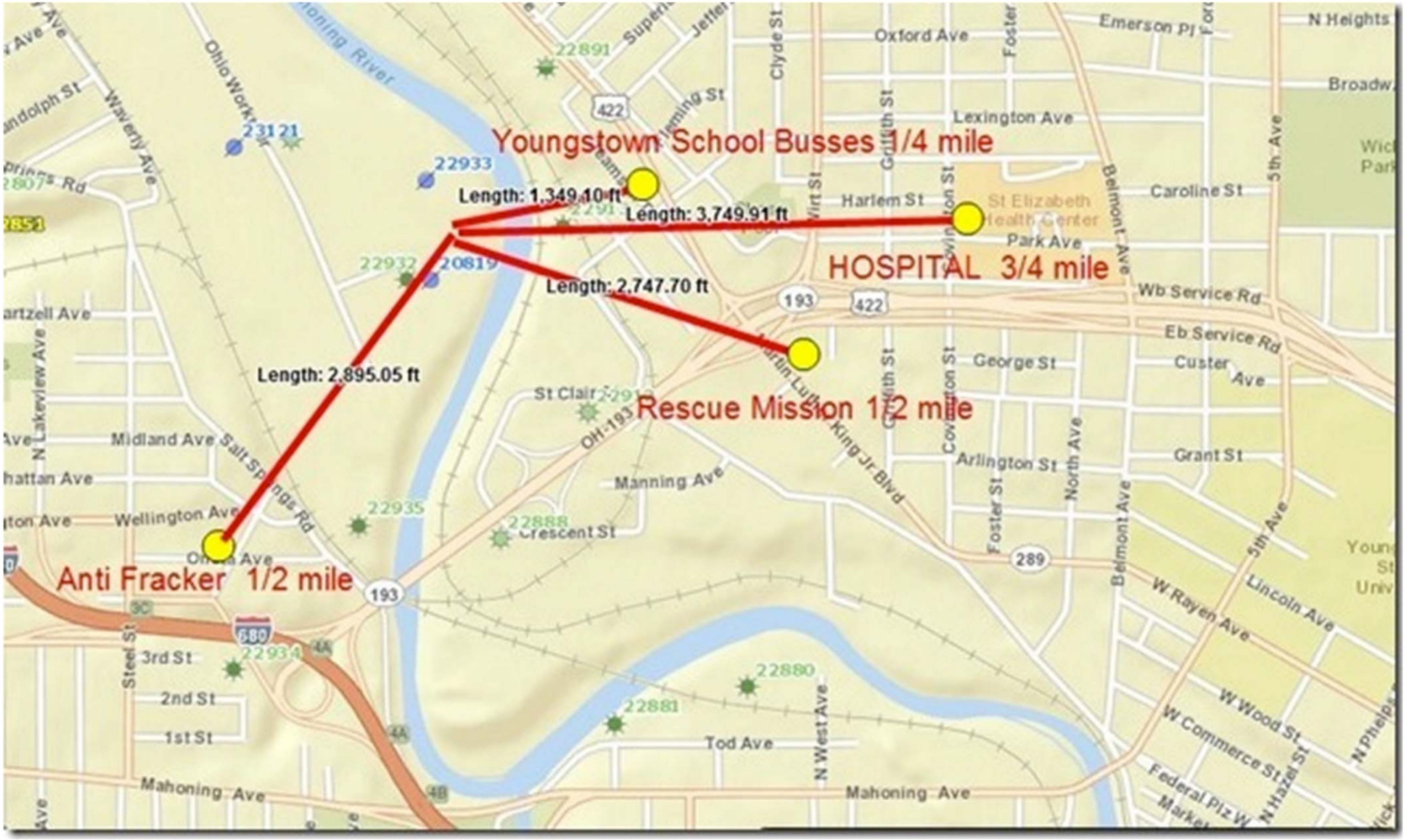
Privacy
Report a problem
1000 ft


Youngstown School Busses 1/4 mile
HOSPITAL 3/4 mile
Rescue Mission 1/2 mile
Anti Fracker 1/2 mile
Length: 1,349.10 ft
Length: 3,749.91 ft
Length: 2,747.70 ft
Length: 2,895.05 ft
St Elizabeth Health Center
Mahoning River
Oxford Ave
Lexington Ave
Harlem St
Caroline St
Park Ave
Wb Service Rd
Eb Service Rd
George St
Custer Ave
Arlington St
Grant St
Manning Ave
Crescent St
Midland Ave
Wellington Ave
Salt Springs Rd
3rd St
2nd St
1st St
Mahoning Ave
Tod Ave
N West Ave
Belmont Ave
5th Ave
W Rayen Ave
Lincoln Ave
W Wood St
W Commerce St
Federal Plz W
N Hazel St
N Phelps
Emerson Pl
N Heights
Steel St
Wick Park

The application for the Youngstown Facility was received by ODNR on Feb. 7, 2014

Public Records request for all applications under 1509.22 was made on Feb. 11, 2014.

The application for the Youngstown facility was not included in ODNR response to Feb. 11 request.

March 3, 2014, ODNR responded they would send a CD with the information requested.

March 6, 2014, ODNR issued the "order".

March 10, 2014, sent ODNR email stating the CD was not yet received.

March 11, 2014, ODNR email stating CD was sent the day before.

March 28, 2014, sent request again asking for all applications.

April 5, 2014, Sent "did you receive" email because ODNR had not acknowledged receiving second request.

April 7, 2014, ODNR did acknowledge receiving.

April 10, 2014, Received CD which did finally include the Youngstown facility.

Source: Teresa Mills, Center for Health, Environment & Justice

Two more drilling sites found with Marcellus Shale sludge radioactivity in Washington County; DEP sees no threat

May 27, 2014 11:34 PM

By Don Hopey / Pittsburgh Post-Gazette

Range Resources has confirmed that Marcellus Shale drilling sludge with radioactivity content too high for normal landfill disposal is stored at two more of its drilling pads in Washington County.

Waste containing higher radioactivity levels is being temporarily held by Range at the Malinky pad and the MCC pad in Smith, near Mount Pleasant. Earlier this month, drilling sludge from Range Resources' Carter drill pad and impoundment in Mount Pleasant was also found to have higher radioactivity readings.

Related Media:

West Virginia won't accept additional drilling waste tainted with radioactivity

State Department of Environmental Protection spokesman John Poister said the stored waste doesn't present a health threat to nearby workers or residents.

West Virginia won't accept additional drilling waste tainted with radioactivity

May 29, 2014 2:15 PM

By Don Hopey / Pittsburgh Post-Gazette

Range Resources shipped 12 tons of drilling sludge containing higher than normal radioactivity 100 miles to a West Virginia landfill Tuesday afternoon, but for now won't be able to use it to dispose of similar waste stored on well pads in Washington County.

Kelly Gillenwater, a West Virginia Department of Environmental Protection spokeswoman, said Thursday that Waste Management's Meadowfill Landfill in Bridgeport, just west of Clarksburg, W.Va., has been ordered to stop accepting drilling waste containing radioactivity while the department investigates the shipment.

Related Media:

Two more drilling sites found with Marcellus Shale sludge radioactivity in Washington County; DEP sees no threat

FrackFree Sets Town Hall on Fracking Waste Plant

Saturday, May 31, 2014

YOUNGSTOWN, Ohio -- FrackFree Mahoning Valley will hold a town hall-style meeting June 5 to address concerns and questions related to a new plant to store and treat potentially radioactive waste from hydraulic fracturing. The event is scheduled for 7-9 p.m. at the First Unitarian Universalist Church of Youngstown, 1105 Elm St.

In February, Industrial Waste Control/Ground Tech Inc., was awarded a permit to perform "radiological waste characterization, tank cleaning and decontamination, waste solidification, brine storage, and preparation for disposal operations." Ohio has licensed Austin Masters Services to handle radioactive material and this company would be conducting tests and analyses on materials moving through Industrial Waste Disposal/Ground Tech Inc.'s site at 240 Sinter Court. (READ STORY)

Pat Horkman, principal and Ohio field manager of Austin Masters, told The Business Journal in April that the operation would use new technology to test waste moving through the area on trucks without the material ever being exposed.

"We have the ability to test the entire contents of a container without it ever coming out of the box," he said. "We're policing the industry."

The citizens group, which opposes fracking, says it received “disconcerting documents” earlier this week showing that Austin Masters Services is claiming “trade secret protections” regarding the method the company plans to use to determine levels of radioactive materials, specifically technologically enhanced naturally occurring radioactive material, or TENORM.

The citizens group, which opposes fracking, says it received “disconcerting documents” earlier this week showing that Austin Masters Services is claiming **“trade secret protections”** regarding the method the company plans to use to determine levels of radioactive materials, specifically technologically enhanced naturally occurring radioactive material, or TENORM.

ehp ENVIRONMENTAL HEALTH PERSPECTIVES
http://www.ehponline.org

Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado

Lisa M. McKenzie, Ruixin Guo, Roxana Z. Witter, David A. Savitz, Lee S. Newman, and John L. Adgate

http://dx.doi.org/10.1289/ehp.1306722

Received: 27 February 2013
Accepted: 28 January 2014
Advance Publication: 28 January 2014

Background: Birth defects are a leading cause of neonatal mortality. Natural gas development (NGD) emits several potential teratogens and US production is expanding.

Objectives: We examined associations between maternal residential proximity to NGD and birth outcomes in a retrospective cohort study of 124,842 births between 1996 and 2009 in rural Colorado.

Congenital Heart Defects (CHDs) Neural Tube Defects (NTDs)

Results: Prevalence of CHDs increased with exposure tertile, with an odds ratio (OR) of 1.3 for the highest tertile (95% CI: 1.2, 1.5) and NTD prevalence was associated with the highest tertile of exposure (OR = 2.0, 95% CI: 1.0, 3.9, based on 59 cases), compared to no gas wells within a 10-mile radius. Exposure was negatively associated with preterm birth and positively associated with fetal growth, though the magnitude of association was small. No association was found between exposure and oral clefts.

Science of the Total Environment 424 (2012) 79–87

Contents lists available at SciVerse ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Human health risk assessment of air emissions from development of unconventional natural gas resources☆,☆☆

Lisa M. McKenzie *, Roxana Z. Witter, Lee S. Newman, John L. Adgate

Colorado School of Public Health, University of Colorado, Anschutz Medical Campus, Aurora, Colorado, USA

Residents living ≤½ mile from wells are at greater risk for health effects from Natural Gas Development.

Subchronic exposures to air pollutants during well completion activities present the greatest potential for health effects.

The subchronic non-cancer hazard is driven primarily by exposure to trimethylbenzenes, xyl enes, and aliphatic hydrocarbons.

Cumulative cancer risks were 10 in a million and 6 in a million for residents living ≤½ mile and >½ mile from wells, respectively

Benzene as the major contributor to the risk.

Fracking Boom Spews Toxic Air Emissions on Texas Residents

Eight-month investigation reveals that the Texas State Legislature is more intent on protecting the industry than protecting residents' health.

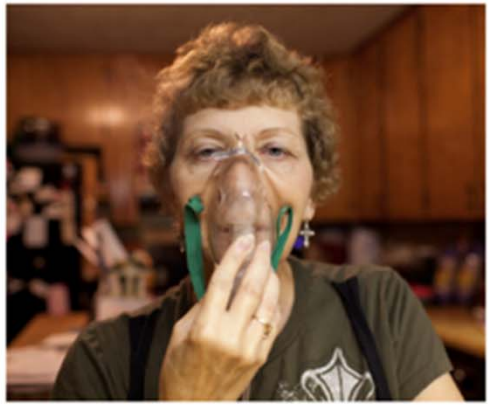
Lisa Song, Jim Morris and David Hasemyer

Feb 18, 2014

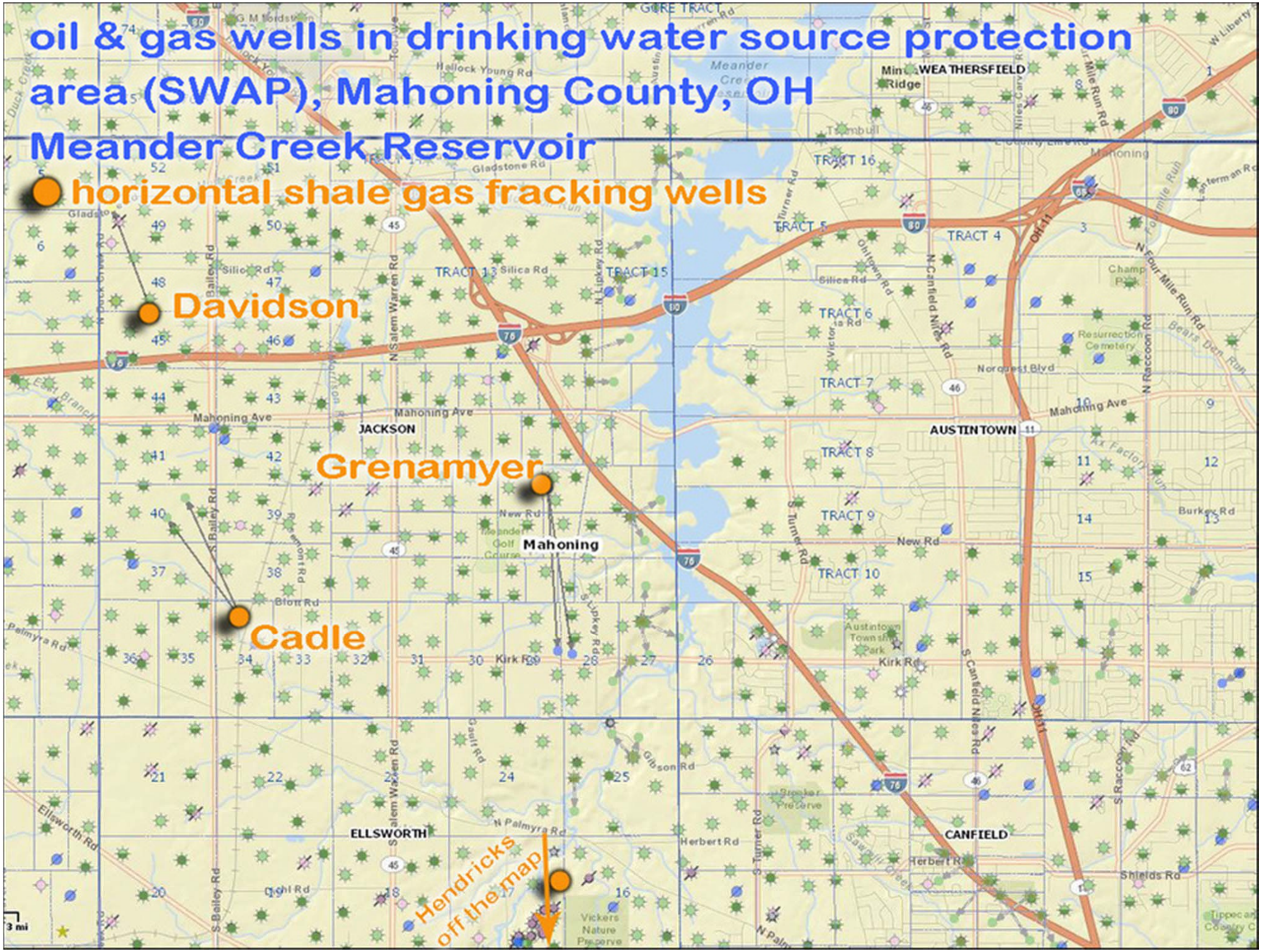
Lynn Buehring in her home in Karnes County, Texas, shows the mask and medicine mist that she relies on for breathing. Sept. 25, 2013. Credit: Lance Rosenfield/Prime

KARNES CITY, Texas—When Lynn Buehring leaves her doctor's office in San Antonio she makes sure her inhaler is on the seat beside her, then steers her red GMC pickup truck southeast on U.S. 181, toward her home on the South Texas prairie.

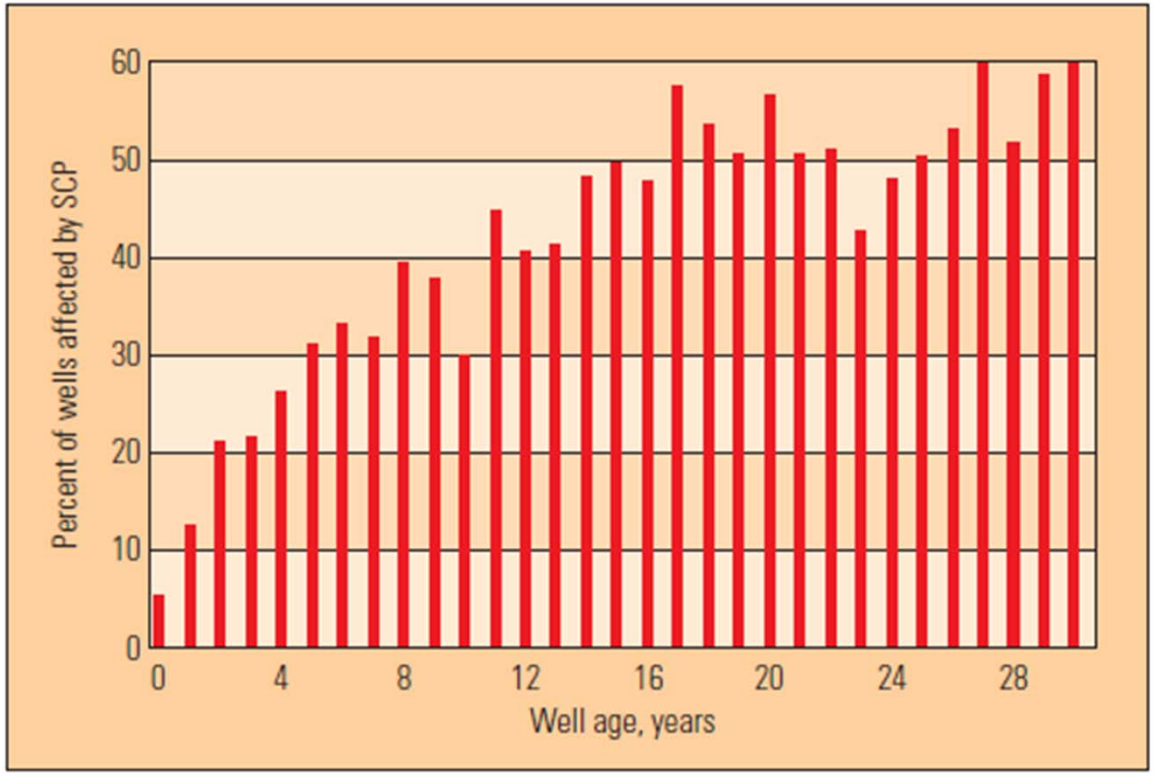
SOMETHING'S FOUL IN THE EAGLE FORD



See the Multimedia Investigation
Big Oil & Bad Air on the Texas Prairie


oil & gas wells in drinking water source protection area (SWAP), Mahoning County, OH
Meander Creek Reservoir
horizontal shale gas fracking wells
Davidson
Grenamyer
Cadle
Hendricks off the map
JACKSON
AUSTINTOWN
Mahoning
ELLSWORTH
CANFIELD

“Since the earliest gas wells, uncontrolled migration of hydrocarbons to the surface has challenged the oil and gas industry”



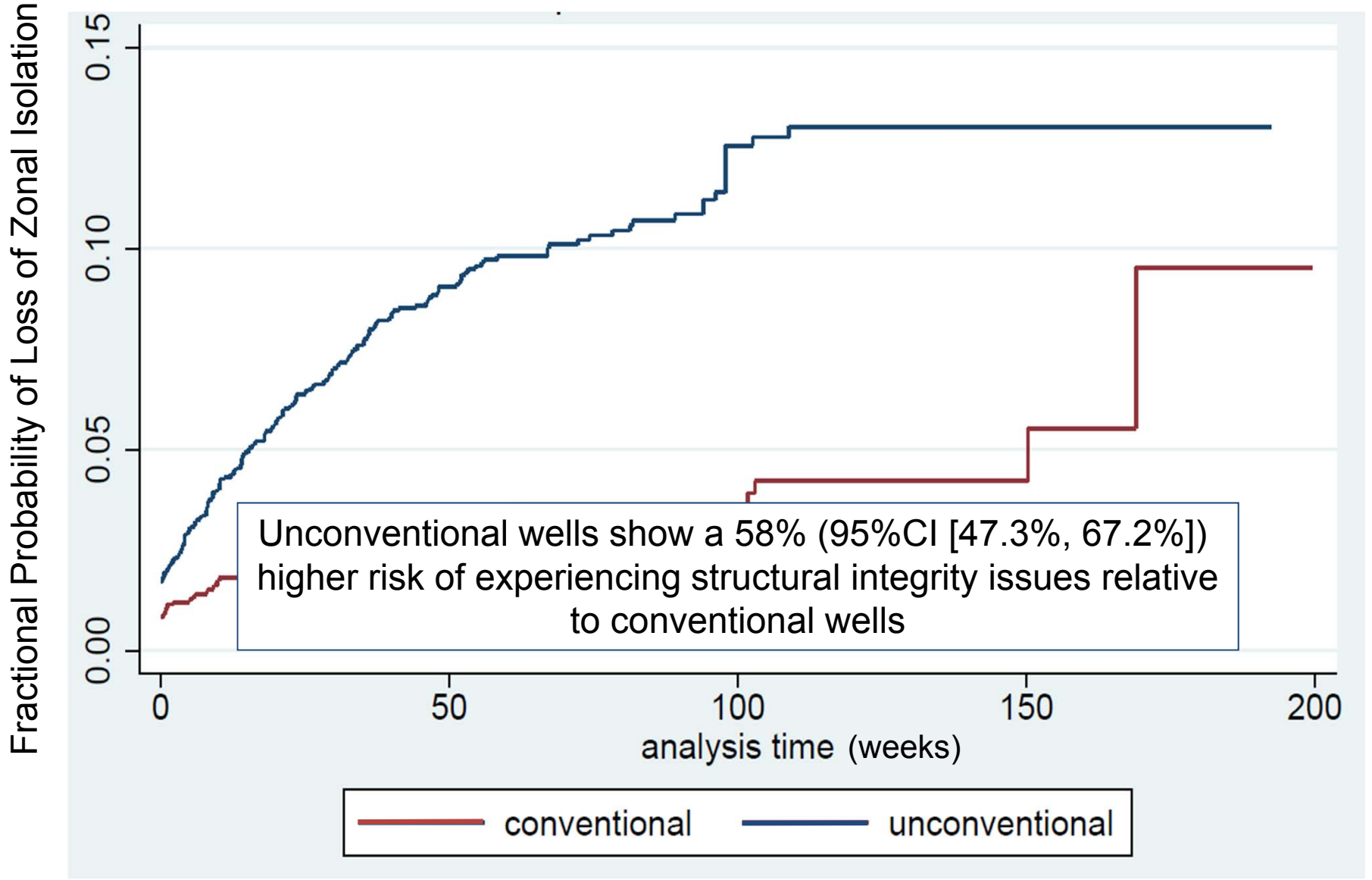
^ Wells with SCP by age. Statistics from the United States Mineral Management Service (MMS) show the percentage of wells with SCP for wells in the outer continental shelf (OCS) area of the Gulf of Mexico, grouped by age of the wells. These data do not include wells in state waters or land locations.

SCP=Sustained Casing Pressure. Also called sustained annular pressure in one or more of the casing annuli.

Brufatto *et al*., *Oilfield Review*, Schlumberger, Autumn, 2003

Source: Dr. A Ingraffea

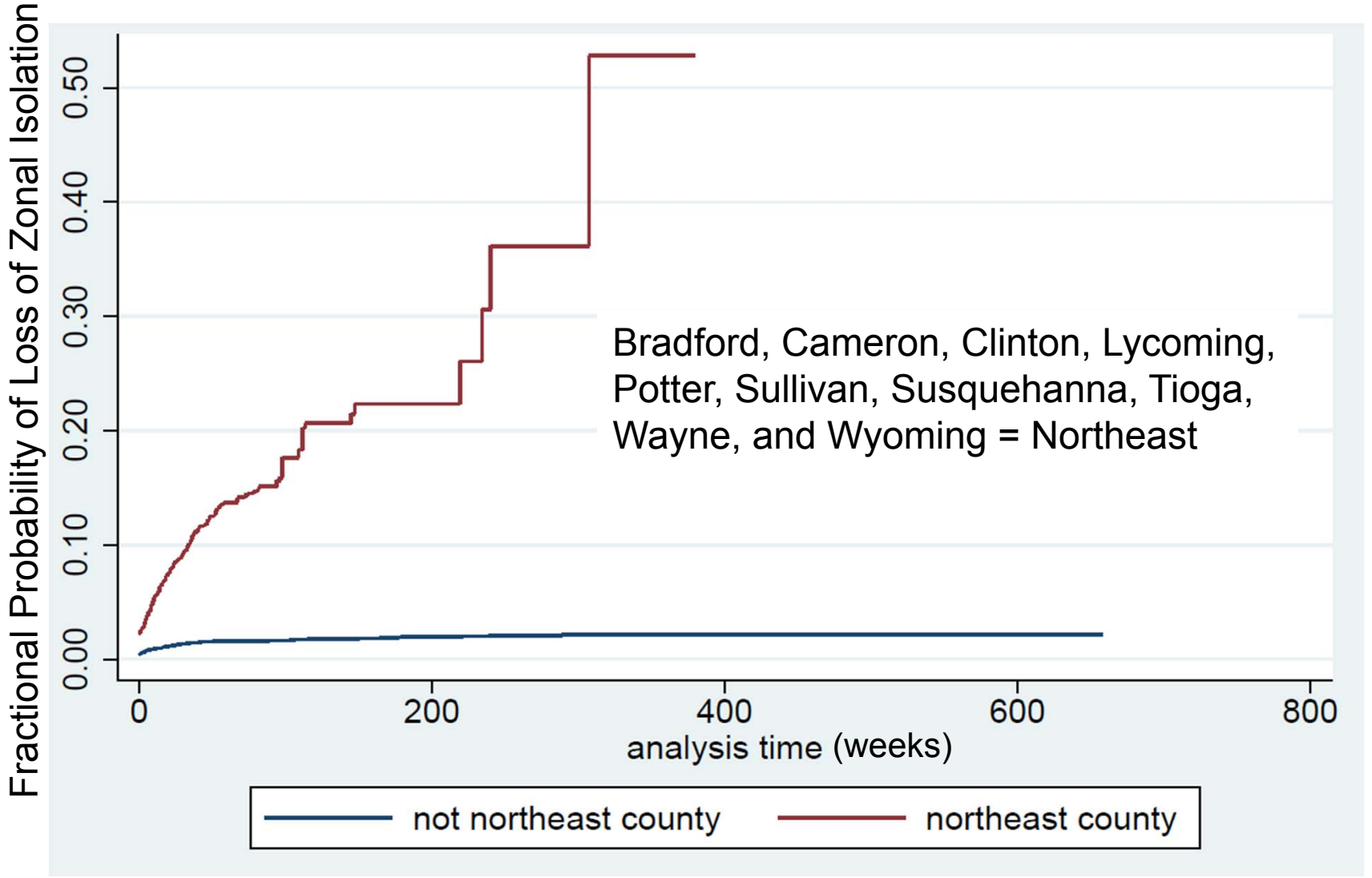
Hazard Prediction for Conventional and Unconventional Wells: Statewide, Post-2009 Data



27,455 wells and 75,505 inspections

Source: Dr. A Ingraffea

Hazard Prediction for Northeast and Non-Northeast Counties: All Wells



Source: Dr. A Ingraffea

OSC On-Scene Coordinator

United States Environmental Protection Agency EPA

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profile Navigate epa osc

Bearkamp Orphan Well Plug

Ellsworth, OH - EPA Region V

Site Contact:
Lori Muller
On-Scene Coordinator
muller.lori@epa.gov

5303 Gault Road
Ellsworth, OH 44406
www.epaosc.org/BearkampWell
Latitude: 41.0366171
Longitude: -80.8383793

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Documents
None for this site.
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Contacts
None for this site.
Links
None for this site.

In October 2011, the ODNR, Division of Meral Resources Management requested assistance with the evaluation of and potential funding for plugging a leaking orphan oil well discharging crude oil to Meander Creek. The orphan well is located within three feet of the bank of the creek and in the near floodplain. Meander Creek flows into the Meander Creek Reservoir.

Source: www.epaosc.org/site/site_profile.aspx?site_id=8063