The Marcellus and Utica Shale Plays in Ohio

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Division of Geological Survey

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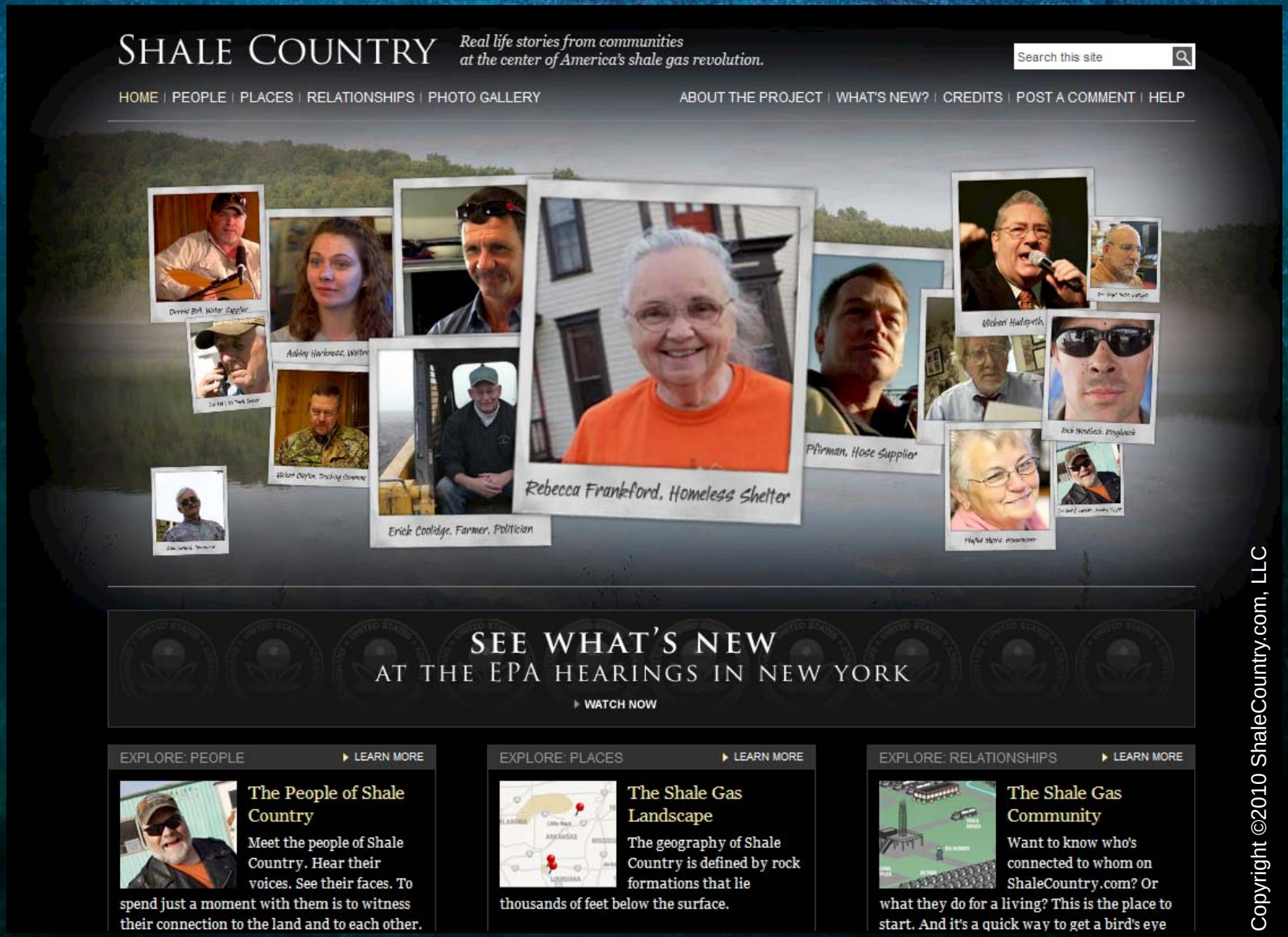
Acknowledgments

- USGS Open File Reports & Assessments
  - Bob Ryder
- ODNR Division of Geological Survey
  - Joe Wells, Donovan Powers



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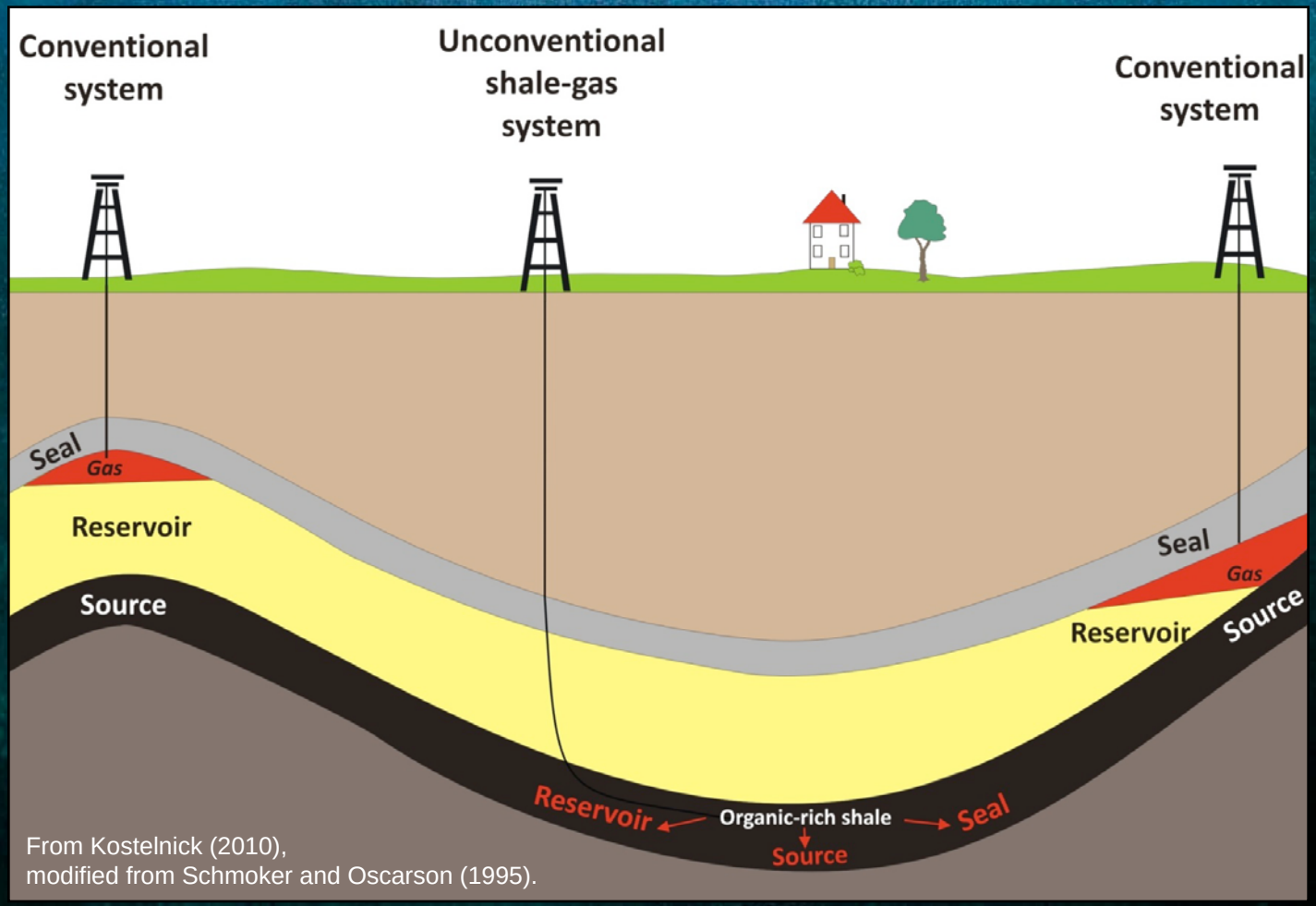
Like other parts of the country, “shale frenzy” has come to Ohio.

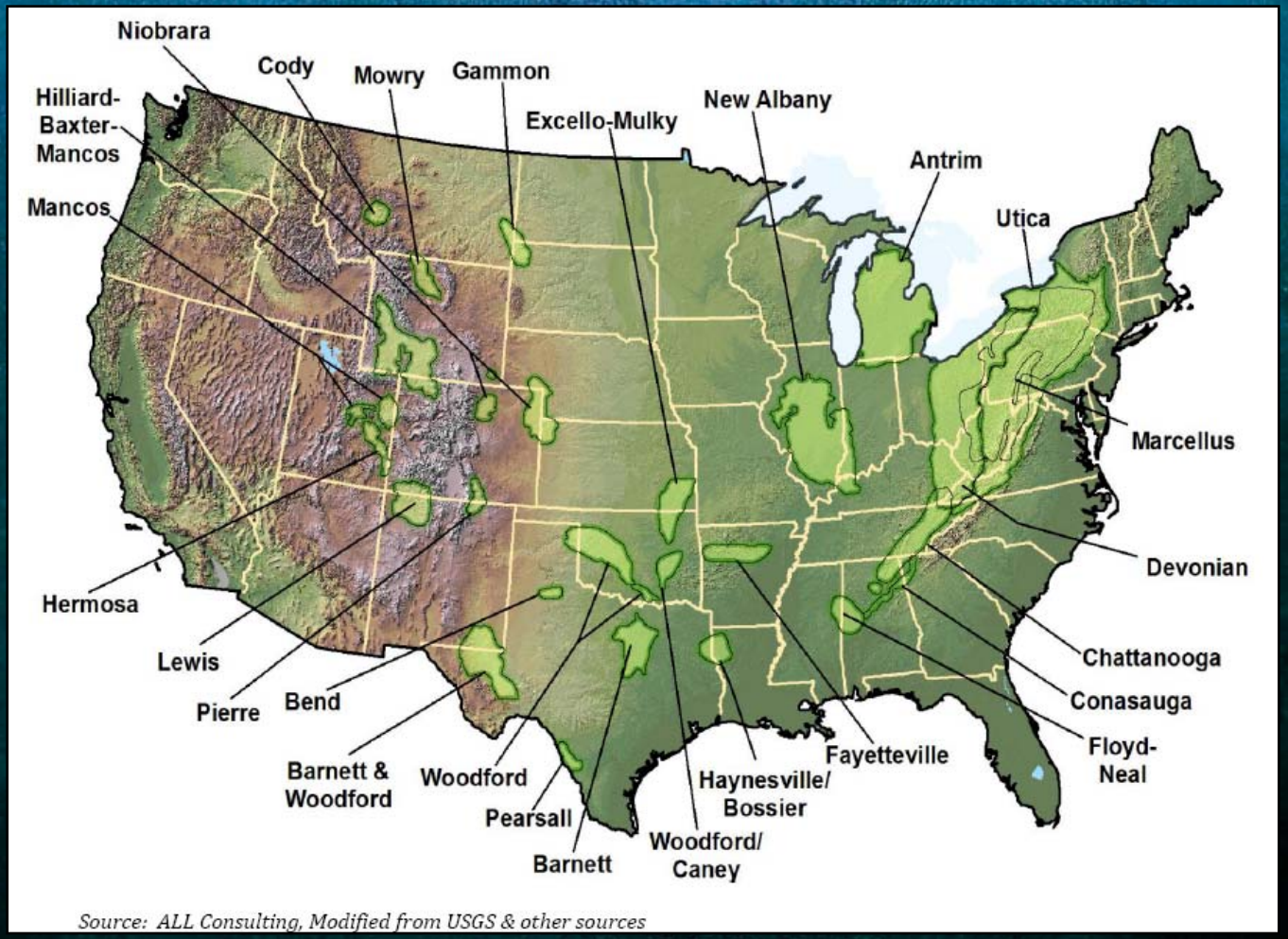
Drilling and producing from organic-rich shales represents a large paradigm shift for the oil and gas industry.



From Kostelnick (2010),
modified from Schmoker and Oscarson (1995).

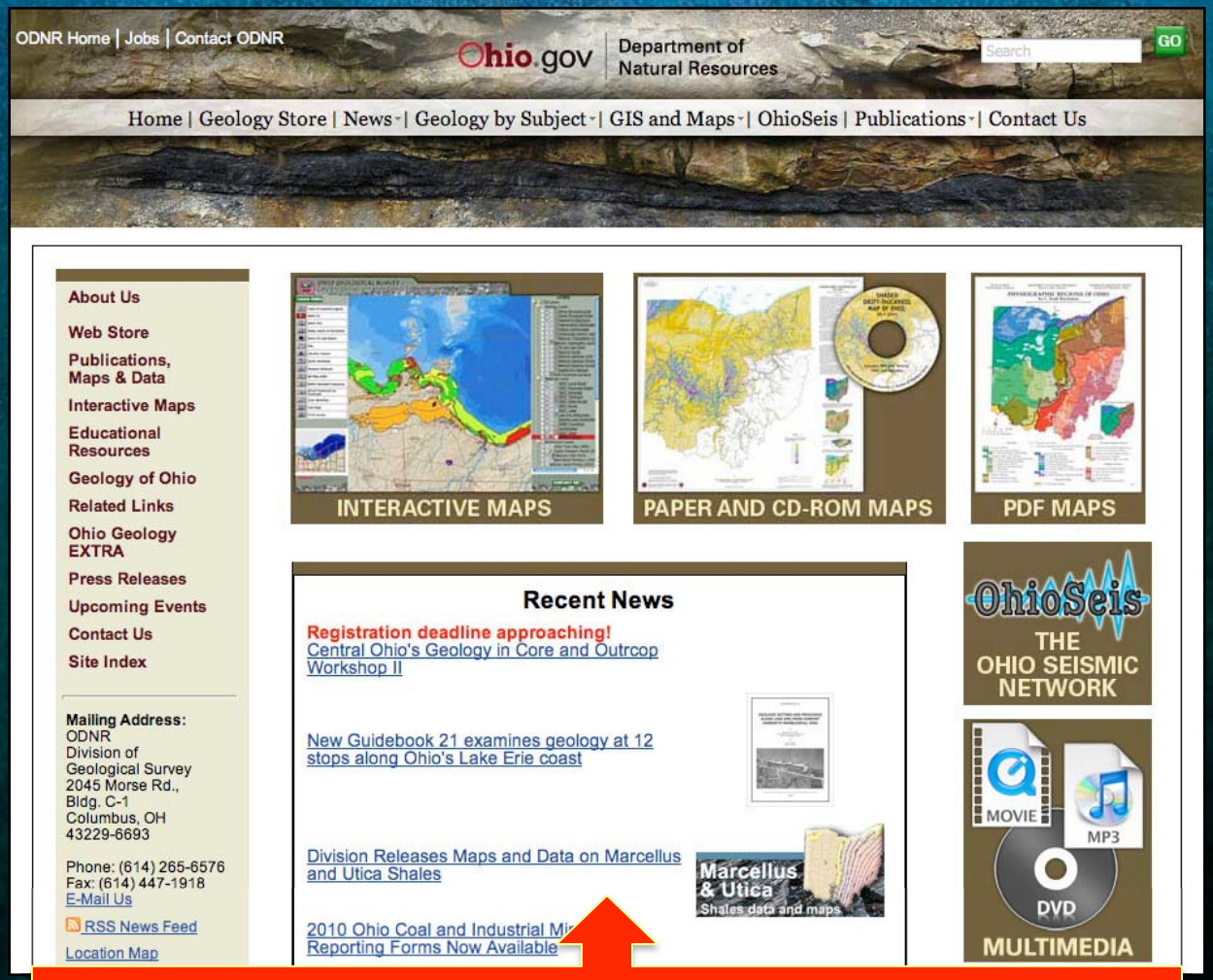
Prior to the late 1990s these shales were thought of principally as the source of oil and gas that would then migrate slowly over time into “conventional” reservoirs.

Ohio is not alone.



The advent of drilling long horizontal laterals combined with the ability to perform multiple stage hydraulic fracture treatments have allowed many shale gas plays to develop across the United States.

www.OhioGeology.com



The ODNR Division of Geological Survey is continually posting new information on the shale plays on its website.

www.OhioGeology.com

Marcellus Shale Files for Download

- *The Marcellus Shale Play: Geology, History, and Oil & Gas Potential in Ohio*, by Larry Wickstrom and Chris Perry [5 MB PDF]
- Isopach map of the Marcellus Shale in the Appalachian Basin [488 KB PDF]
- Stratigraphic cross sections illustrating the Devonian Shale interval in eastern Ohio and west-central West Virginia:
  - Northwest–southeast, along dip [6.1 MB PDF]
  - Southwest–northeast, along strike [8 MB PDF]
- Marcellus Shale Producing Wells in Ohio:
  - Map showing the locations of all Marcellus Shale producing wells in Ohio [629 KB PDF]
  - Data for Marcellus Shale producing wells [.xls]
- Structure map on the base of the Devonian Shale [1.9 MB PDF]

Utica Shale Files for Download

- Type log for eastern Ohio & TOC analyses from the CO_2 No. 1 Well in Tuscarawas County [2.2 MB PDF]
- Correlation chart for the Precambrian through Ordovician rocks in the Appalachian Basin [329 KB PDF]
- Regional stratigraphic cross sections in the Appalachian Basin showing the Cambrian–Ordovician interval [2.8 MB PDF]
- Utica Shale Producing Wells in Ohio:
  - Map showing locations of all Utica Shale producing wells in Ohio [1 MB PDF]
  - Data for Utica Shale producing wells [.xls]
- Structure map on top of the Ordovician Shale in the Appalachian Basin [2 MB PDF]
- Structure map on top of the Trenton Limestone in the Appalachian Basin [2 MB PDF]
- Isopach map of the Utica to Trenton interval in the Appalachian Basin [3.3 MB PDF]
- Source Rock Distribution and Total Organic Carbon Content:
  - Summary and regional maps [1.8 MB PDF]
  - Well header and source rock data [.xls] (Updated 02/02/2011)
  - Source rock well location map [1 MB PDF]

Additional Resources

- Ohio Geological Survey Digital Data File 6: *The Ohio Compilation of Devonian Shale Data and Investigations* (2007).
- *A Geologic Play Book for Trenton-Black River Appalachian Basin Exploration* (2006), CD-ROM available for free from the U.S. Department of Energy.
- Marcellus Shale Play: Boon or Burden? Penn State University, Earth and Environmental Systems Institute Spring 2009 EarthTalks – Marcellus Shale Series.
- Black Shale Source Rocks and Oil Generation in the Cambrian and Ordovician of the Central Appalachian Basin, USA, by R. T. Ryder, R. C. Burruss, and J. R. Hatch, AAPG Bulletin, v. 82, no. 3, p. 412–441, 1998. (Click here for abstract.)
- Update on Regional Assessment of Gas Potential in the Devonian Marcellus and Ordovician Utica Shales of New York, presentation by R. Nyahay, J. Leone, L. B. Smith, J. P. Martin, and D. J. Jarvie (adapted from presentation at 2007 AAPG Eastern Section Meeting, September 16–18, Lexington, KY).
- Marcellus Shale Research in Pennsylvania, Pennsylvania Geological Survey.
- Horizontal drilling/fracturing process for shale, Marcellus Shale Coalition (video).
- Special Report: The Great Shale Gas Rush, National Geographic.

Check back, as we will periodically add more resources.

Important Shale Characteristics
(Impact Recoverable Gas)

- Where and how much is present.
- How much organic matter it contains.
- Type of organic matter (gas- vs. oil-rich shale).
- Clay and other minerals it contains.
- How deeply it was buried & “cooked.”
- Its brittleness vs. ductility (break or bend).
- How fractured it is (natural fractures).

All of these characteristics can change in a shale formation across its area.

Devonian Depositional Environments

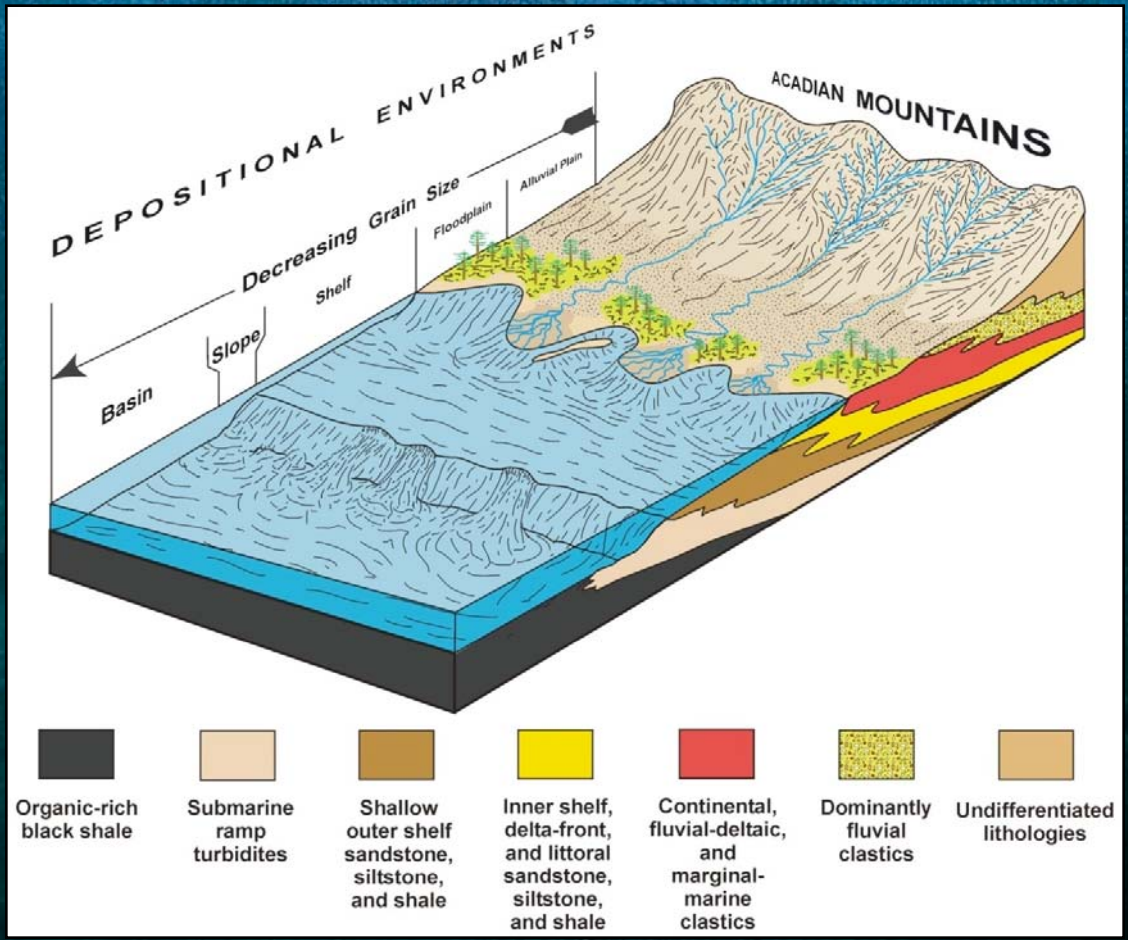
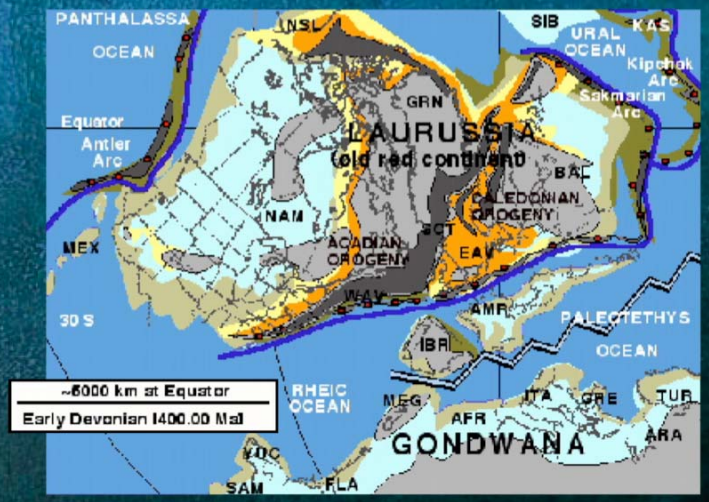
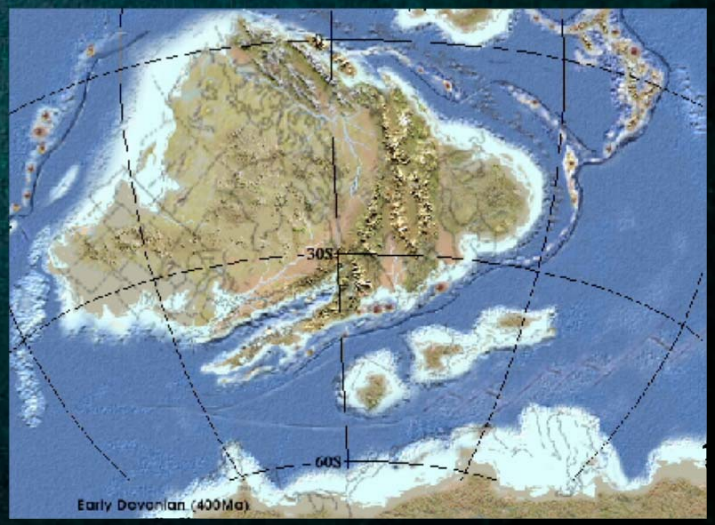


Figure attributed to Laughrey (2009) from Kostelnick (2010).

During the Acadian mountain-building event, sediments were shed from the highlands into a somewhat enclosed basin (resulting in lower amounts of oxygen available). The fine-grained sediments and organic remains that settled in the deeper part of this basin were later buried and became the gray and black Devonian shales we find today.

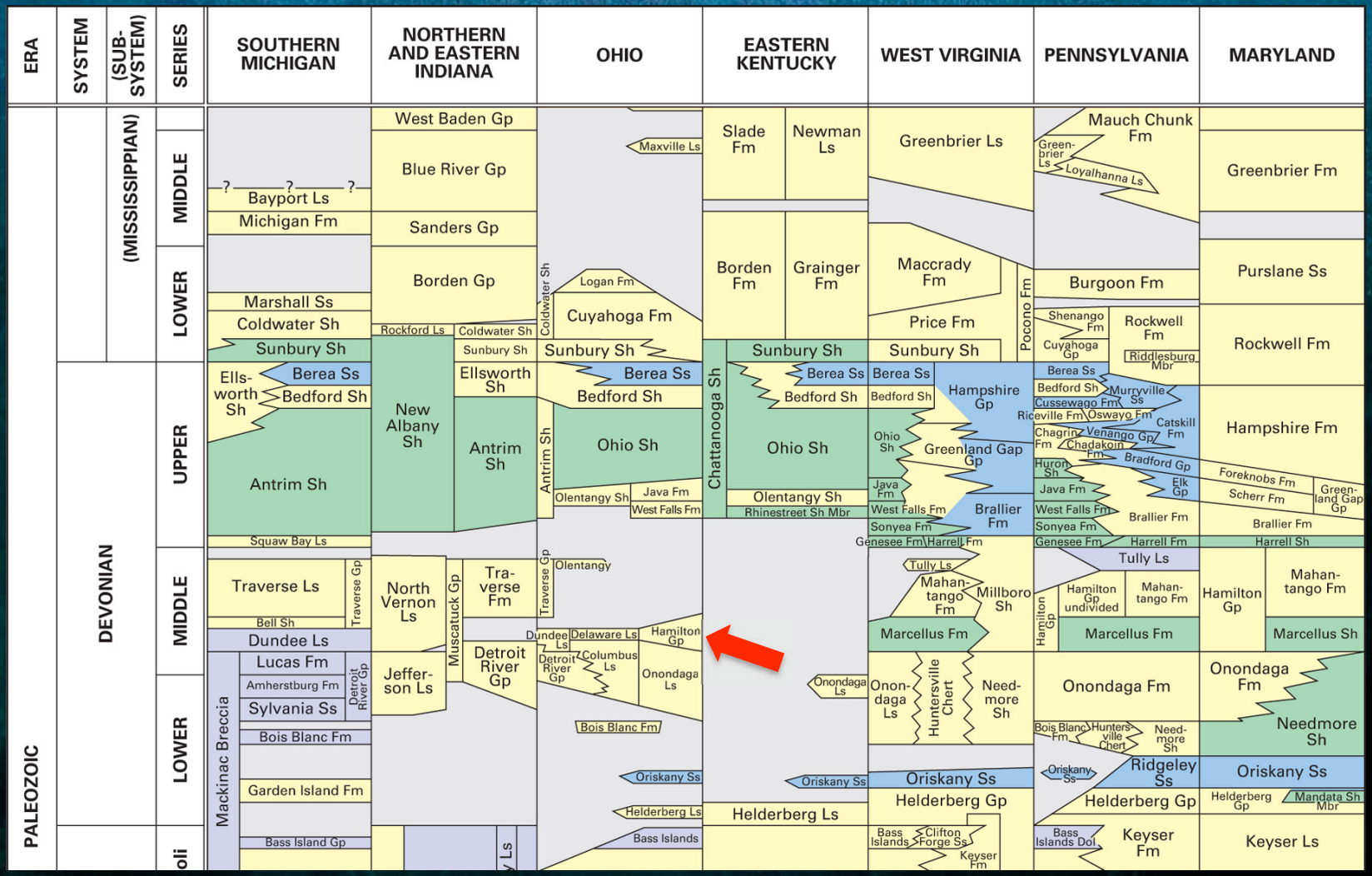
Middle Devonian (385 Ma) Paleogeography





Graphics modified from Blakey (2011a, 2011b).

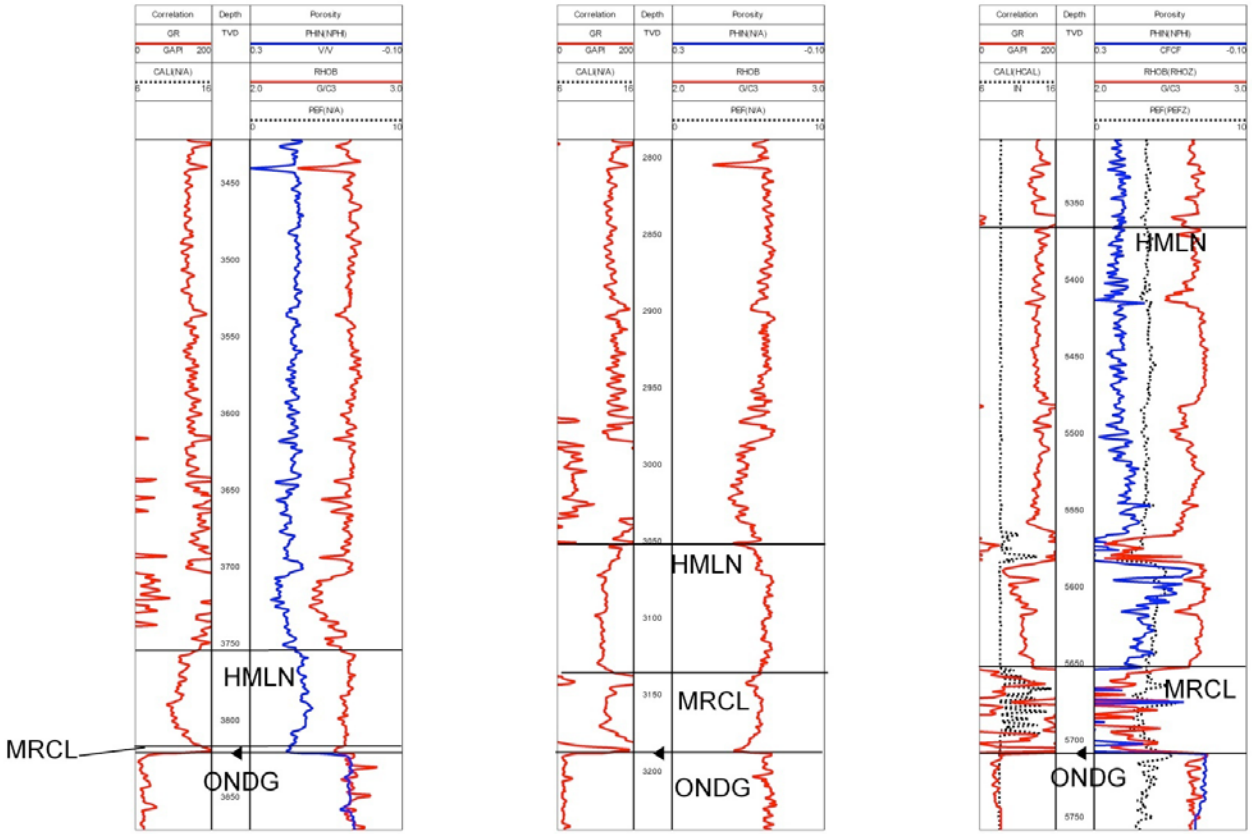
Multistate correlation chart showing the equivalent Devonian strata for the northern Appalachian Basin, Cincinnati Arch, and Michigan Basin.



Wickstrom and others, 2005

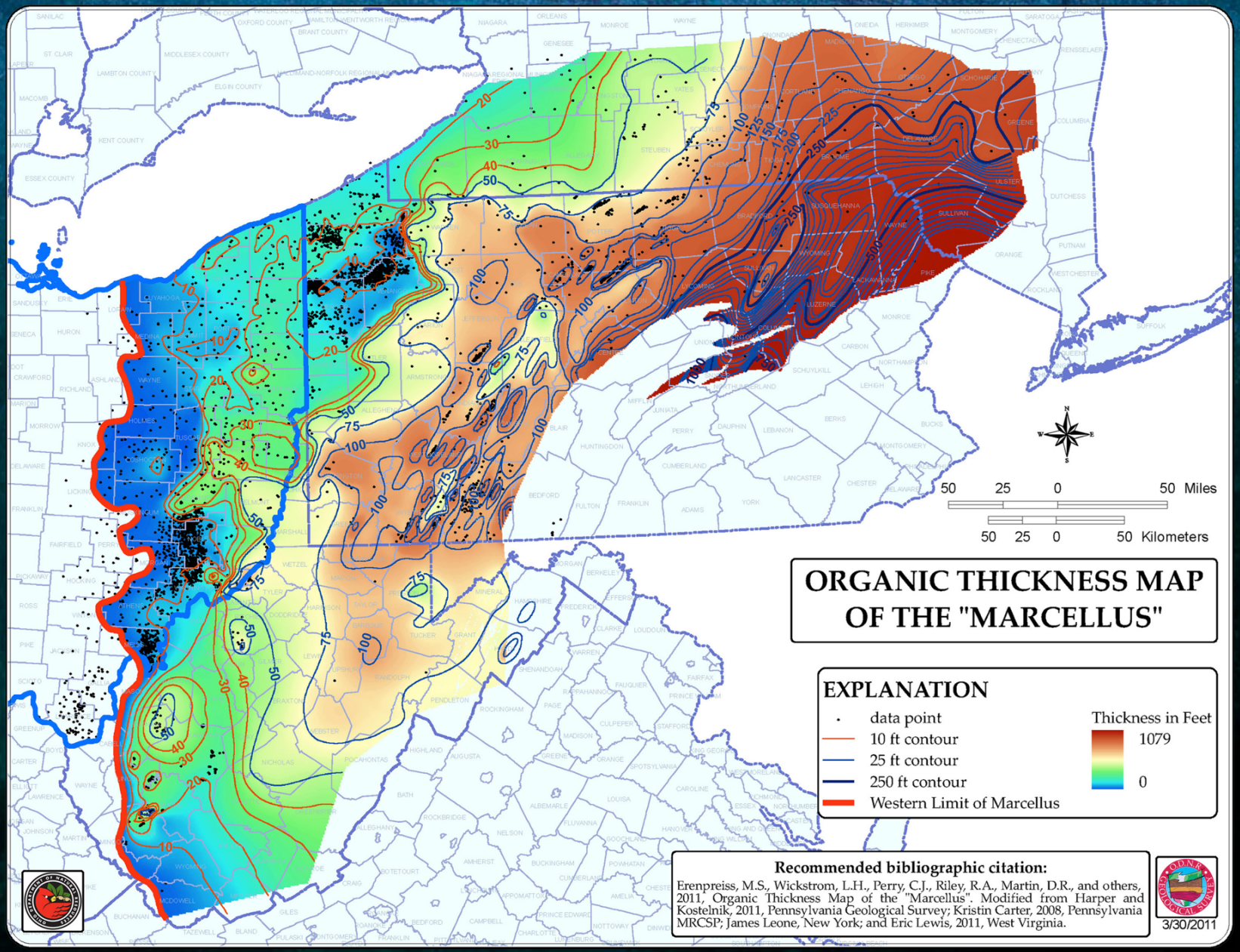
Marcellus thins as it enters Ohio. It is shown on this chart as part of the Hamilton Group.

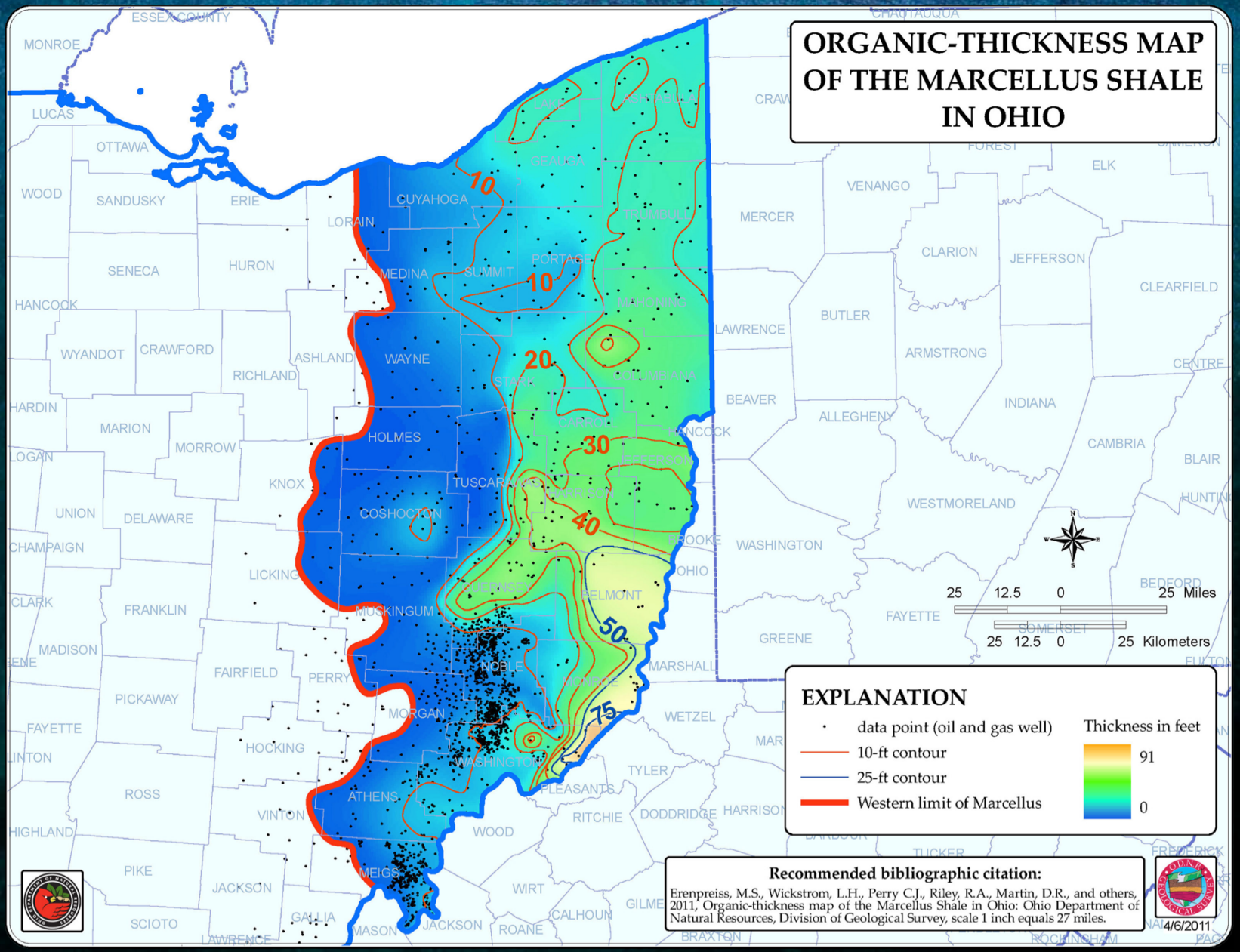
Noble Co.	Stark Co.	Belmont Co.
3412123096	3415122590	3401320586
CAVENDISH PETRO OF OH. INC. OHIO POWER CO.	POMINEX, INC. ECREMENT, R.	FIRST ENERGY GENERATION CORP MRCSP-FEGENCO
4 net ft 4 gross ft	18 net ft 52 gross ft	46 net ft 56 gross ft

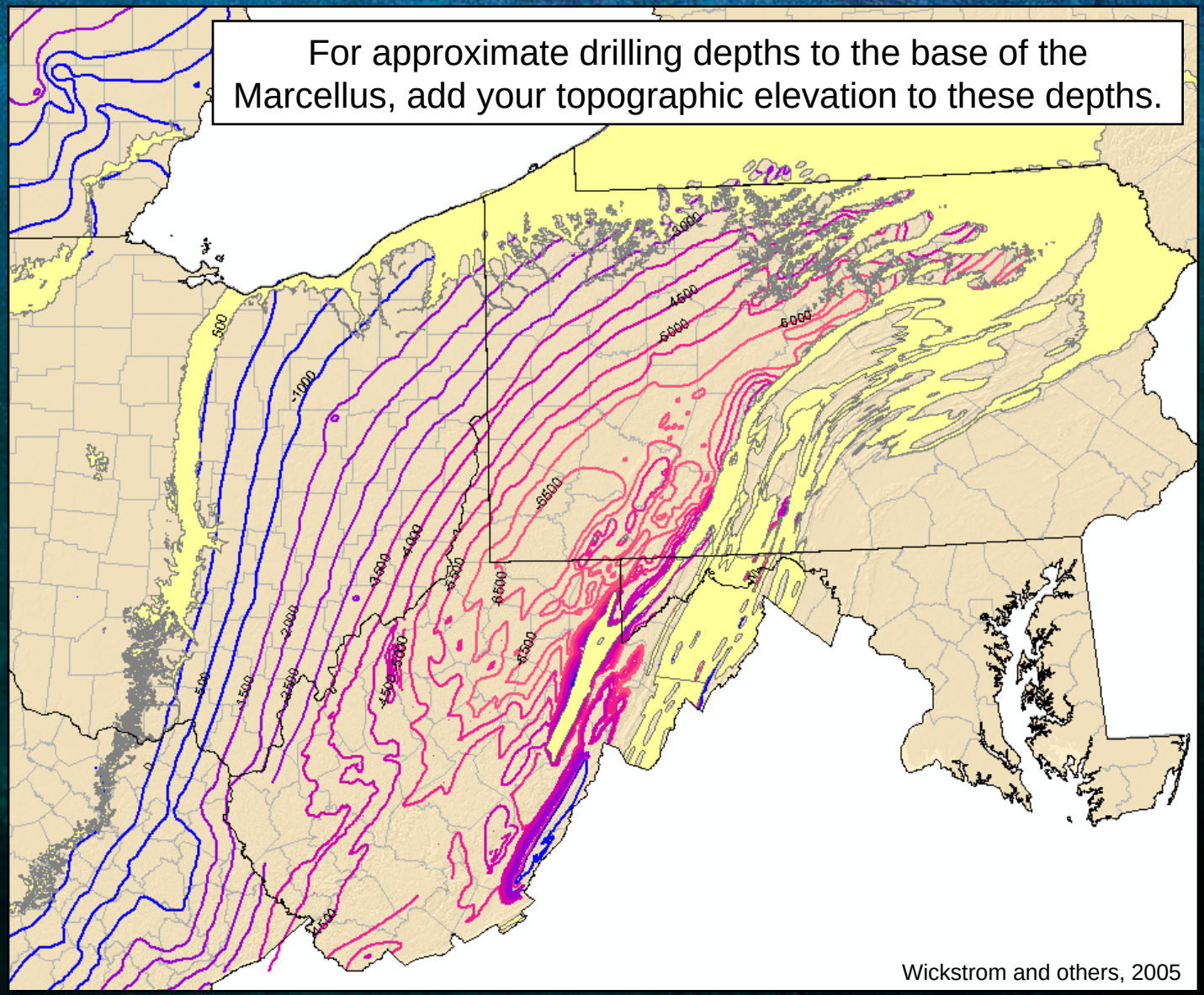


TD=5541 TD=5241 TD=8384

Logs from three Marcellus wells across eastern Ohio showing the varying nature of the unit.

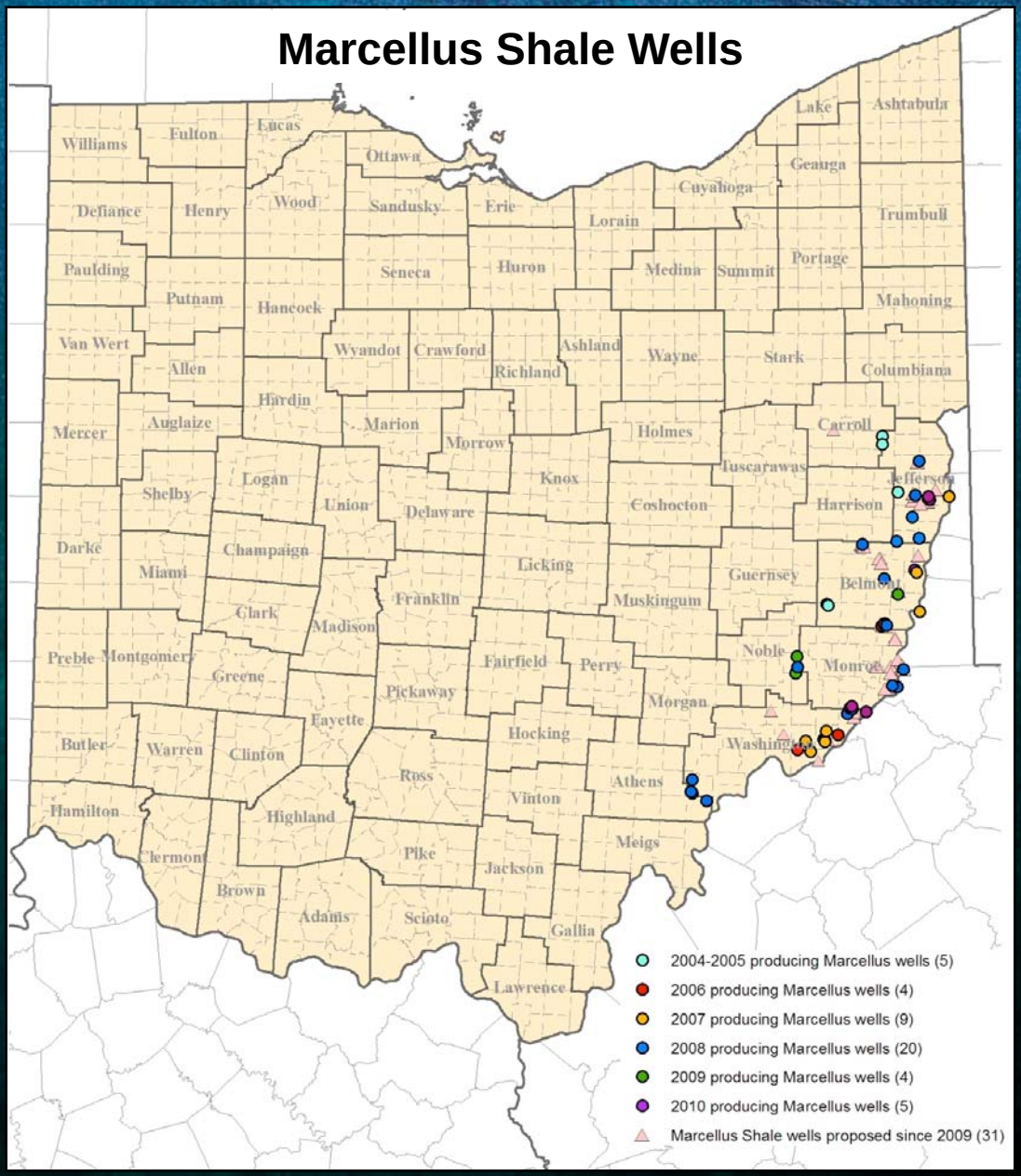

ORGANIC THICKNESS MAP OF THE "MARCELLUS"
EXPLANATION
data point
10 ft contour
25 ft contour
250 ft contour
Western Limit of Marcellus
Thickness in Feet
1079
0
50 25 0 50 Miles
50 25 0 50 Kilometers
Recommended bibliographic citation:
Erenpreiss, M.S., Wickstrom, L.H., Perry, C.J., Riley, R.A., Martin, D.R., and others, 2011, Organic Thickness Map of the "Marcellus". Modified from Harper and Kostelnik, 2011, Pennsylvania Geological Survey; Kristin Carter, 2008, Pennsylvania MRCSP; James Leone, New York; and Eric Lewis, 2011, West Virginia.
3/30/2011


ORGANIC-THICKNESS MAP OF THE MARCELLUS SHALE IN OHIO
EXPLANATION
data point (oil and gas well)
10-ft contour
25-ft contour
Western limit of Marcellus
Thickness in feet
91
0
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
10
10
20
30
40
50
75
Recommended bibliographic citation:
Erenpreiss, M.S., Wickstrom, L.H., Perry C.J., Riley, R.A., Martin, D.R., and others, 2011, Organic-thickness map of the Marcellus Shale in Ohio: Ohio Department of Natural Resources, Division of Geological Survey, scale 1 inch equals 27 miles.
4/6/2011
MONROE
LUCAS
OTTAWA
WOOD
SANDUSKY
ERIE
LORAIN
CUYAHOGA
SENECA
HURON
MEDINA
SUMMIT
PORTAGE
HANCOCK
WYANDOT
CRAWFORD
ASHLAND
WAYNE
RICHLAND
HARDIN
MARION
MORROW
HOLMES
LOGAN
KNOX
TUSCARAWAS
UNION
DELAWARE
COSHOCTON
CHAMPAIGN
LICKING
CLARK
FRANKLIN
MUSKINGUM
MADISON
FAIRFIELD
PERRY
NOBLE
PICKAWAY
MORGAN
FAYETTE
HOCKING
WASHINGTON
ROSS
ATHENS
VINTON
HIGHLAND
WOOD
PIKE
JACKSON
MEIGS
SCIOTO
GALLIA
MASON
JACKSON
ROANE
WIRT
CALHOUN
GILMER
BRAXTON
ROCKINGHAM
FREDERICK
TUCKER
HARRISON
DODDRIDGE
RITCHIE
PLEASANTS
TYLER
WETZEL
MARSHALL
BELMONT
JEFFERSON
CARROLL
STARK
COLUMBIANA
MAHONING
TRUMBULL
GEAUGA
LAKE
ASHTABULA
CRAWFORD
MERCER
VENANGO
FOREST
ELK
CLARION
JEFFERSON
CLEARFIELD
BUTLER
LAWRENCE
ARMSTRONG
CENTRE
BEAVER
ALLEGHENY
INDIANA
CAMBRIA
BLAIR
WESTMORELAND
WASHINGTON
BEDFORD
FAYETTE
GREENE
SOMERSET
FULTON
CHAUTAUQUA
ESSEX COUNTY



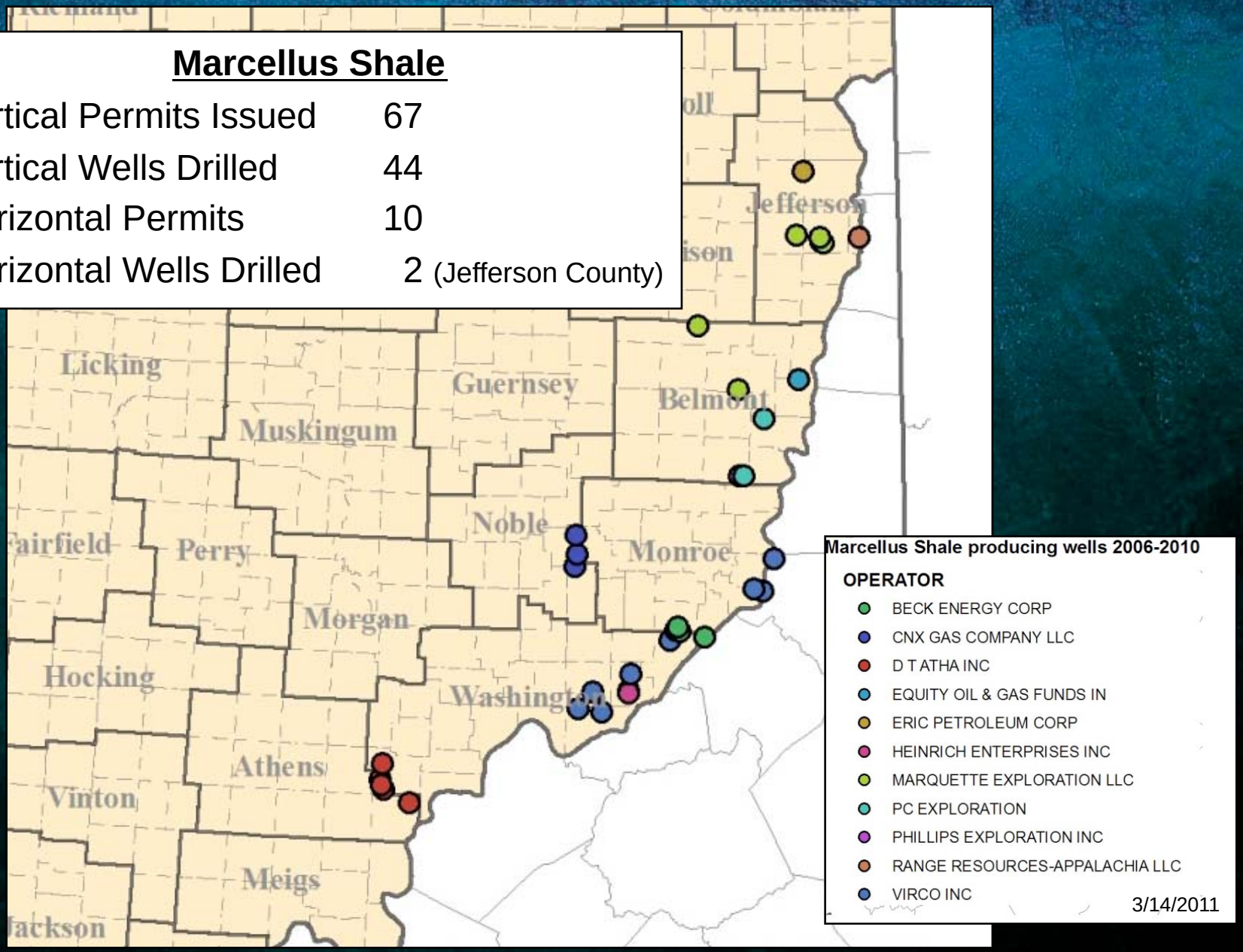
Devonian Shale Outcrop and Structure on the Onondaga Limestone (Big Lime of Ohio).

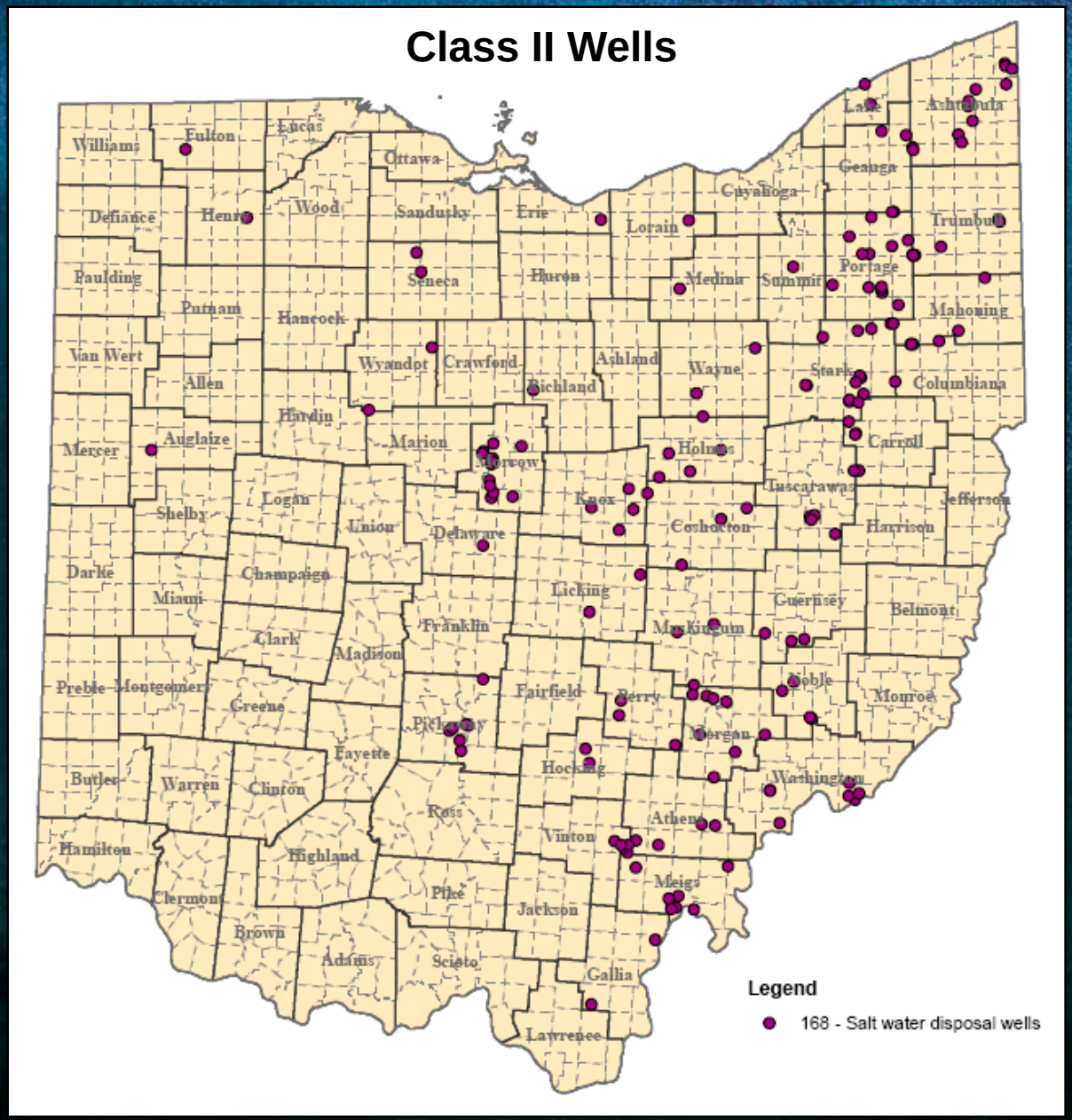
Marcellus Shale Wells



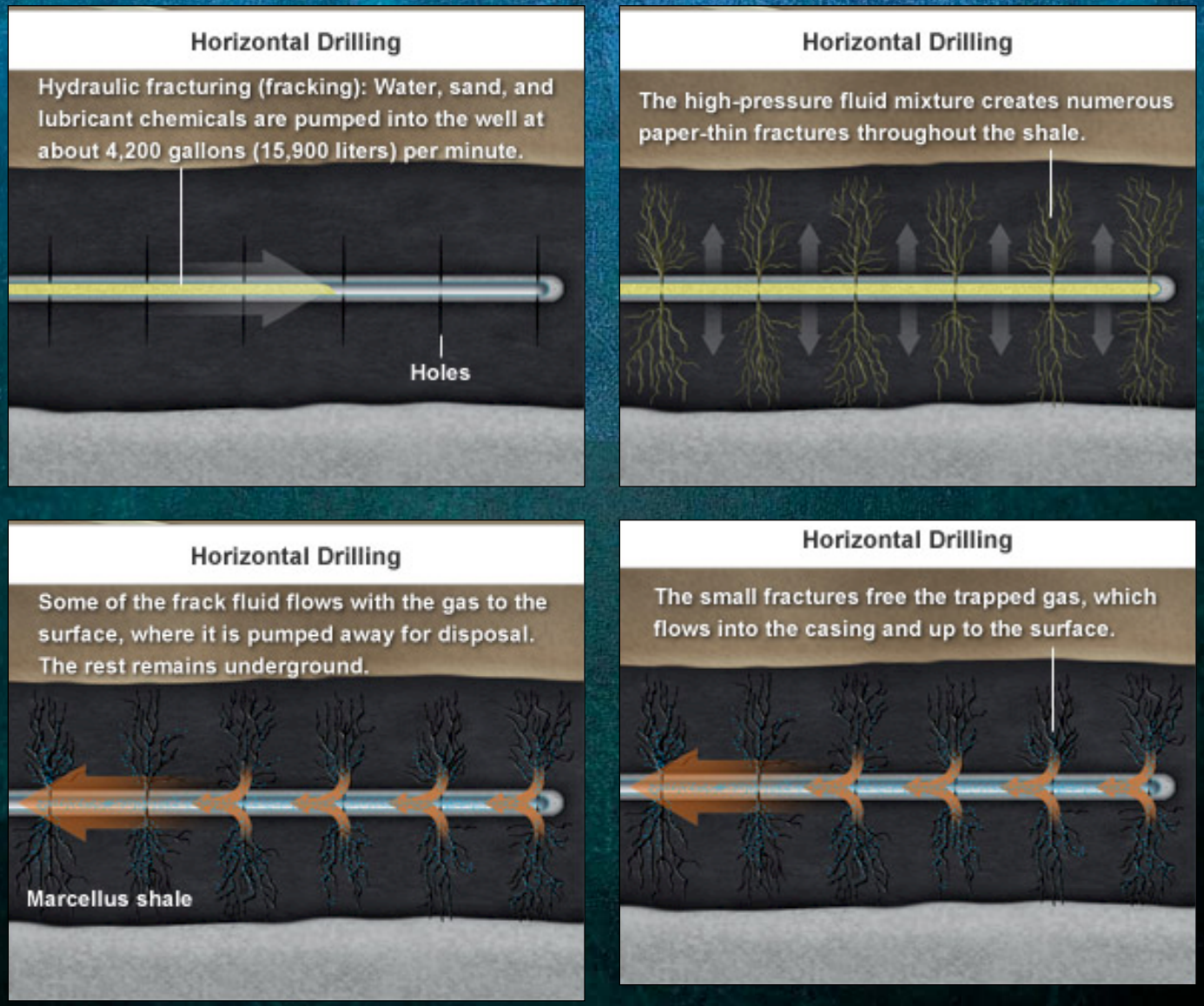
Marcellus Shale

Vertical Permits Issued	67
Vertical Wells Drilled	44
Horizontal Permits	10
Horizontal Wells Drilled	2 (Jefferson County)





Ohio has regulatory primacy of its brine injection wells; Pennsylvania does not.



Graphics from National Geographic (2010).

Fracture Treatment Validation via Microseismic Monitoring

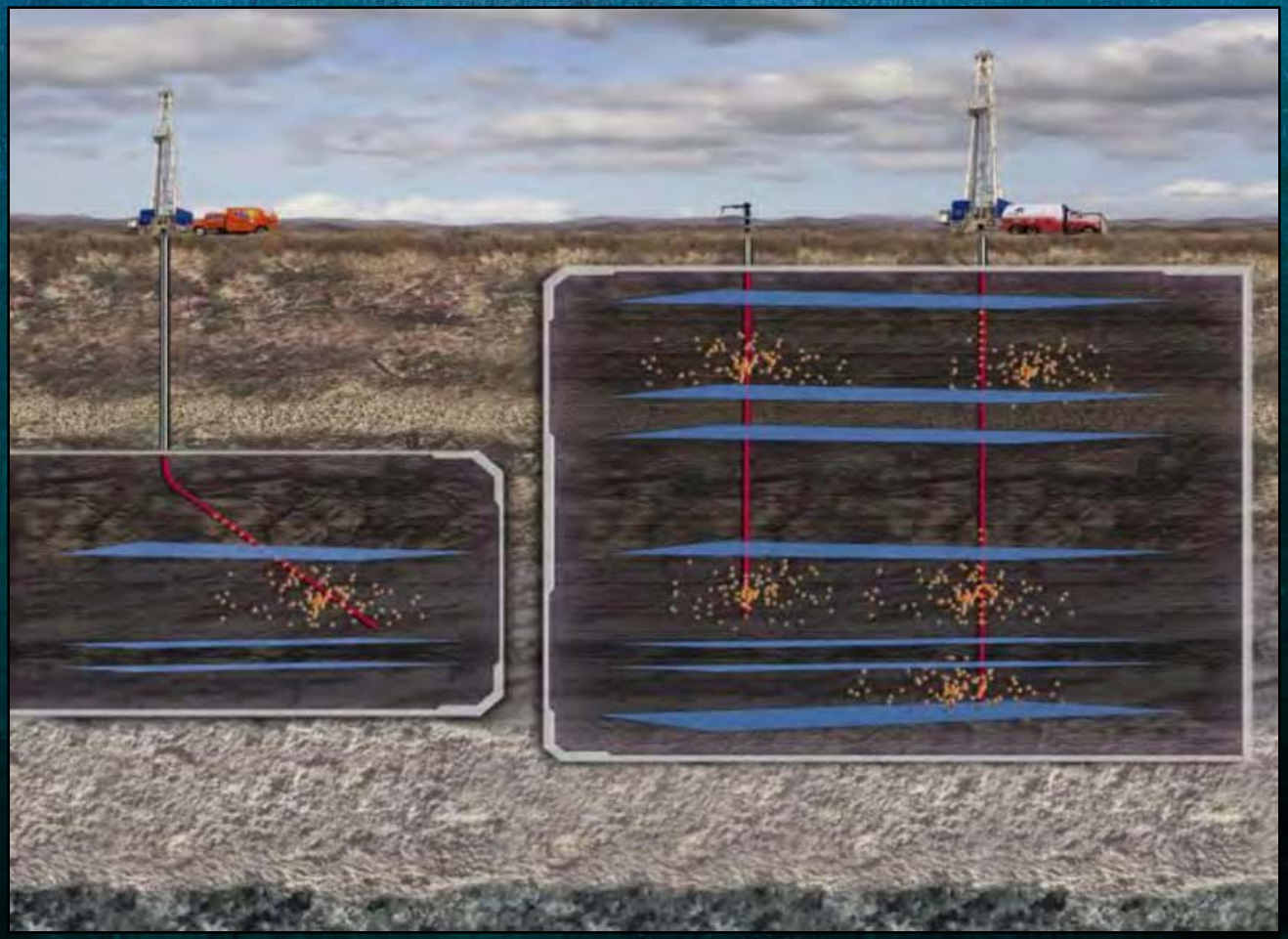
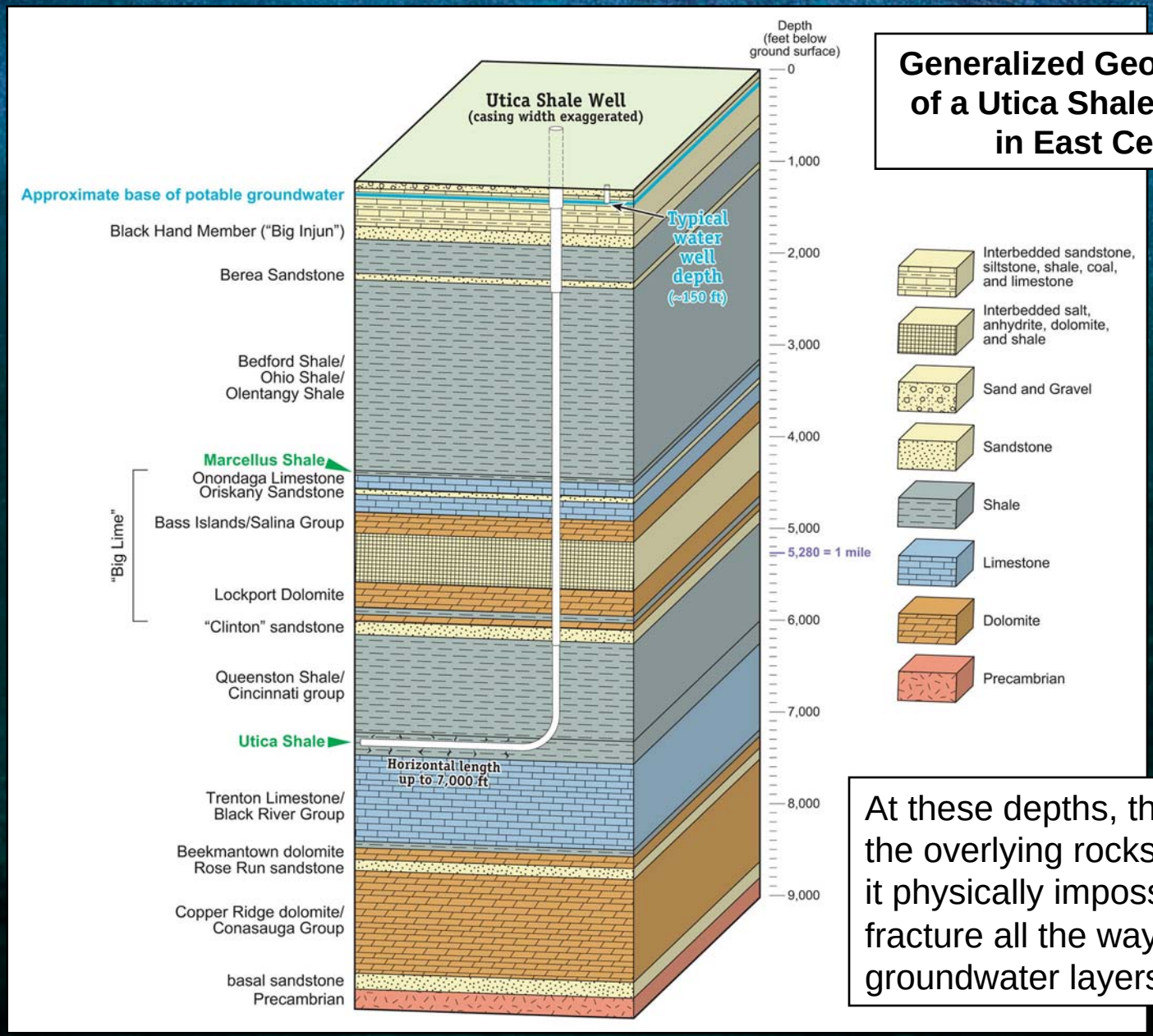


Image courtesy Steve Sadoskas, Baker Microseismic

Is the frac staying in zone vertically?
YES.

Pennsylvania: Aerial photo of a large Marcellus well frac job. Truck traffic, and associated potentially muddy roads, is a consideration.

Generalized Geology and Profile of a Utica Shale Well Prototype in East Central Ohio



At these depths, the pressure from the overlying rocks and fluids make it physically impossible to induce a fracture all the way up to the groundwater layers.

So, why is this a big deal?

- A "typical" conventional gas well in the Appalachian Basin produces 100–500,000 CF of gas per day and 200–500 MMCF in its life. (500 MMCF x $4/MCF* = $2M gross revenue.)

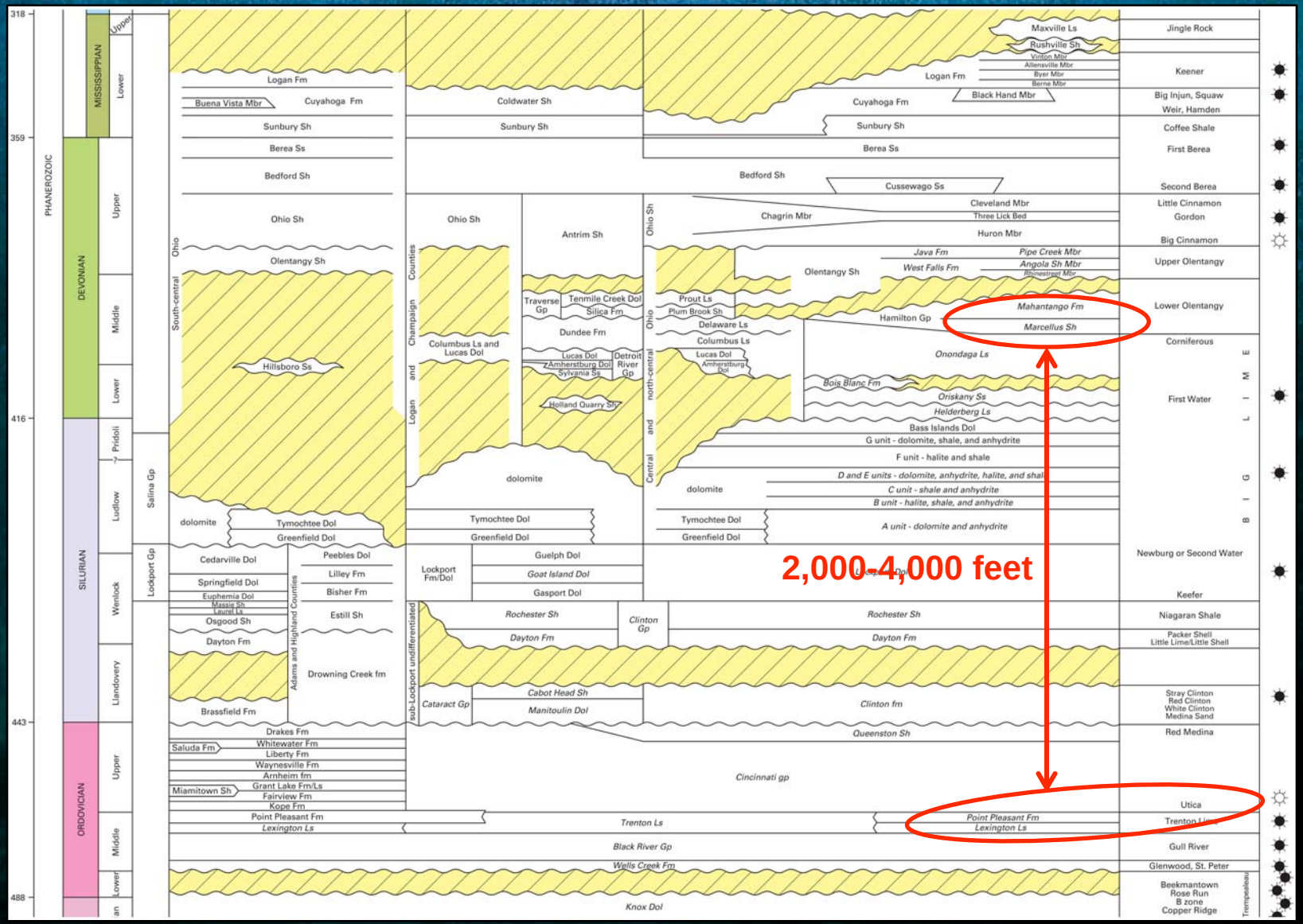
- Horizontal Marcellus (or Utica?) well may produce around 2–10 MMCF of gas per day and are projected to average around 4 BCF of gas over their life, per well. (4 BCF x $4/MCF* = $16M gross revenue.)

- These large gas production increases lessen our purchases of imported energy, create jobs, & retain wealth locally.

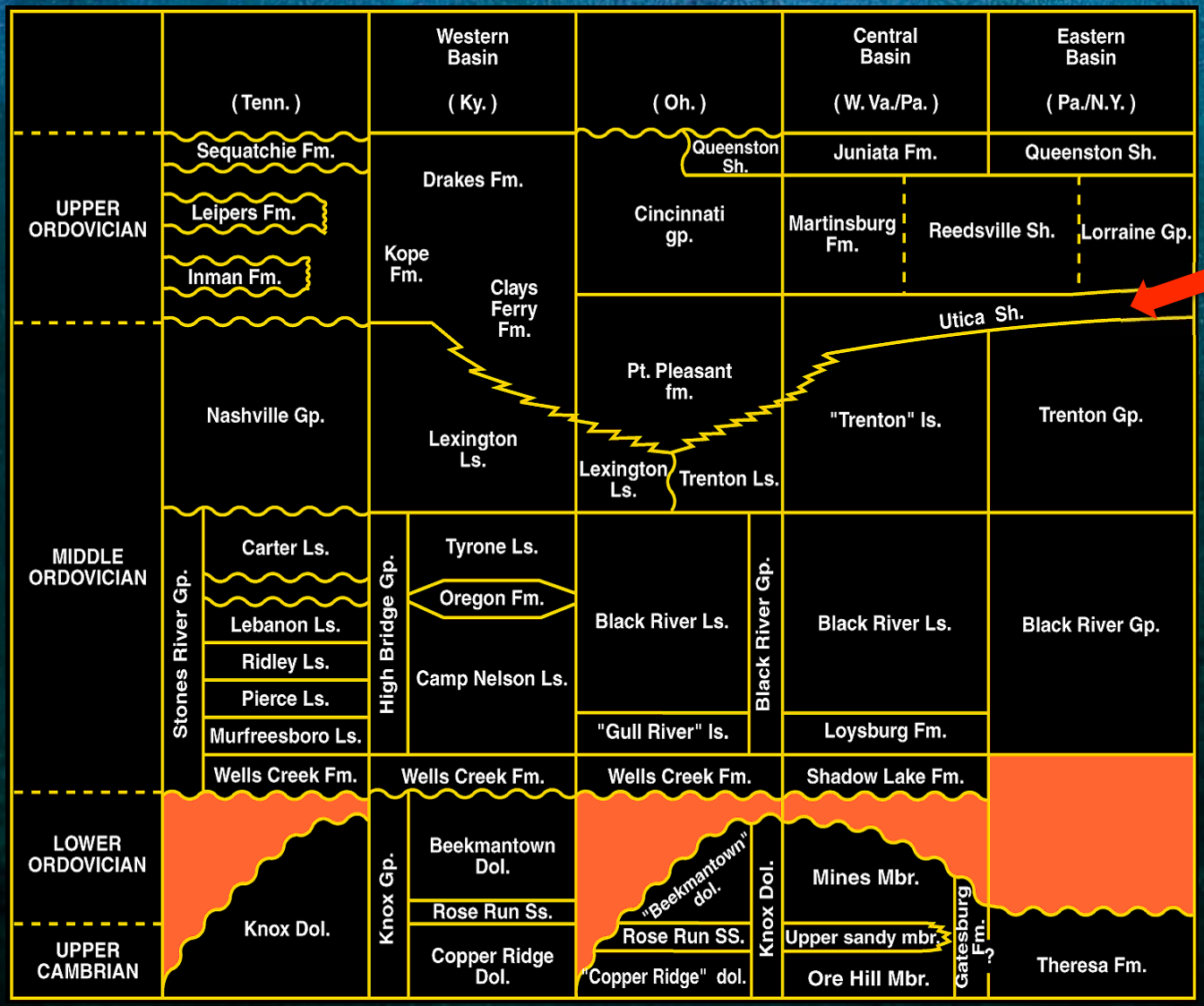
*Calculations show total gas sales for life of typical example wells, assuming sale price of $4 per MCF. Gas presently sells for $3.75 per MCF (10/28/10). Note that a typical horizontal well costs $3–5 million, and there are other significant costs to produce and transport gas to market.

KEY: M = million; MCF = thousand cubic feet; MMCF = million cubic feet (or 1,000 MCF); BCF = billion cubic feet

Ohio Stratigraphy from the Marcellus to the Utica-Point Pleasant



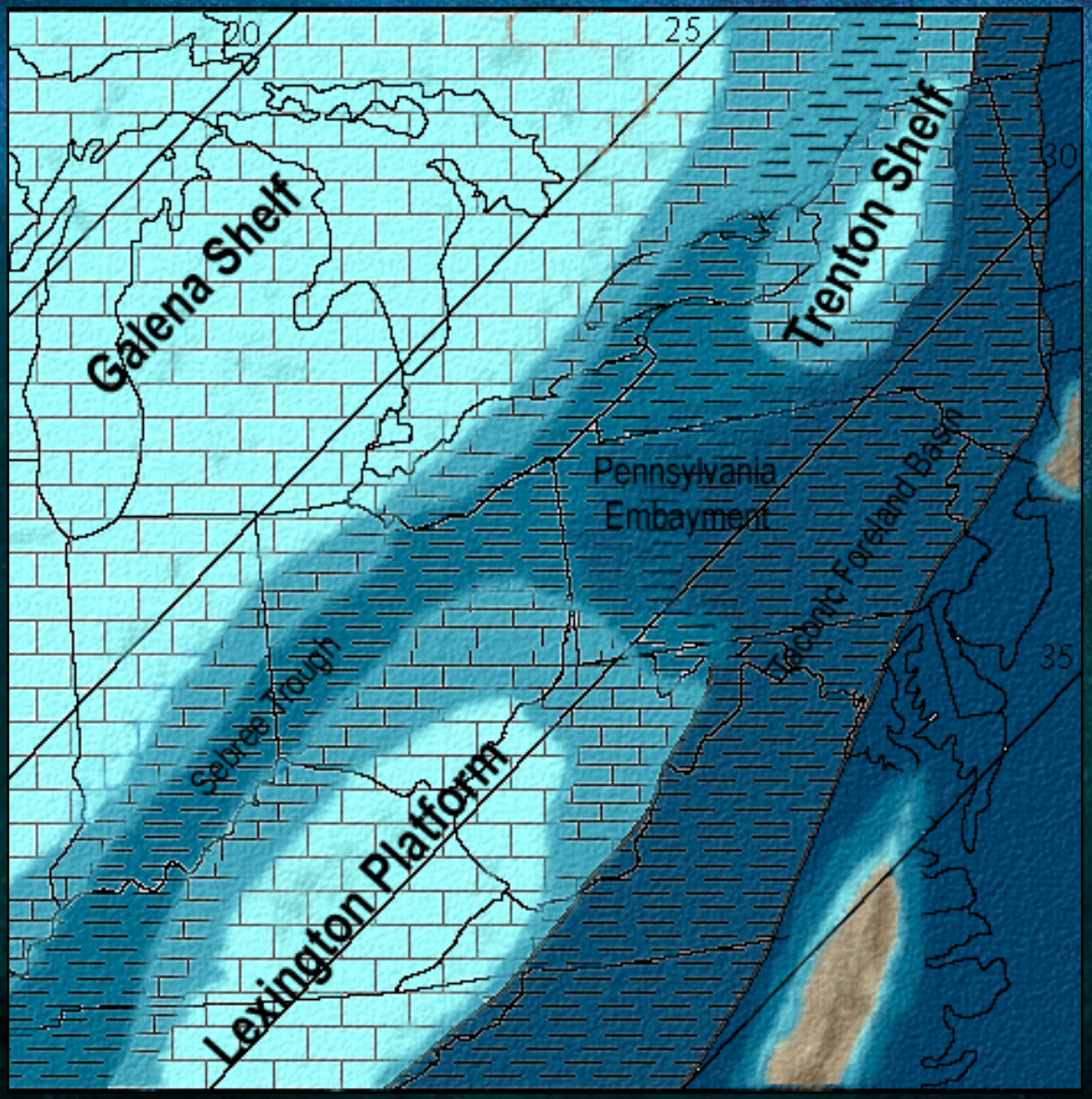
A Quick Look at Utica-Point Pleasant Geology



Wickstrom and others, 1992

The Point Pleasant is, in part, the lateral equivalent of the upper portion of the Trenton Limestone and is in a gradational relationship with the overlying Utica Shale. The Point Pleasant thins as one goes further east, while the Utica thickens eastward into the Appalachian Basin.

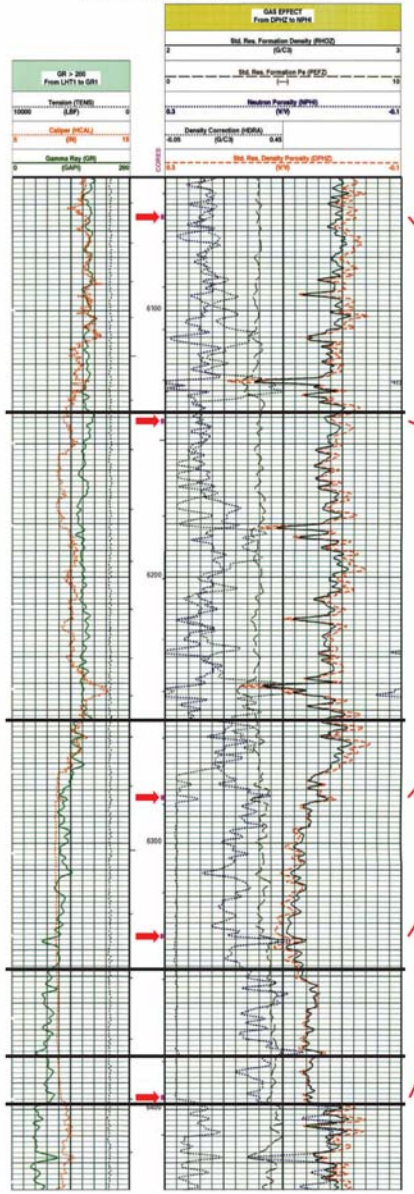
Point Pleasant Paleogeography



After Wickstrom and others, 1992 and Cornell, 2000
Image from http://www.mcz.harvard.edu/Departments/InvertPaleo/Trenton

A Utica-Point Pleasant Type Log for Eastern Ohio

APINO 3415725334



Cincinnati gp

Utica Sh

Point Pleasant Fm

Lexington Ls Top
(Trenton Ls Top equivalent)

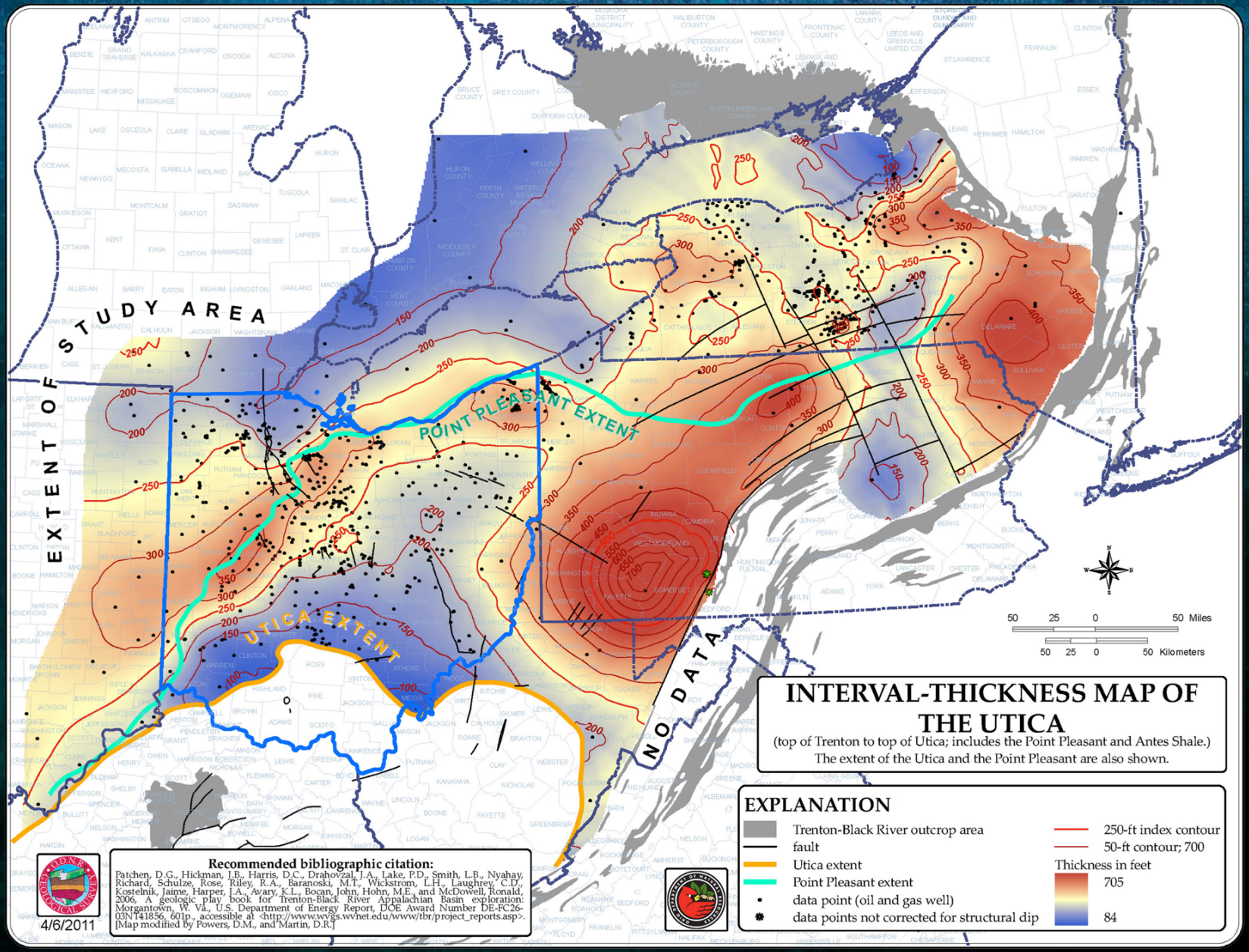
Logana Mbr

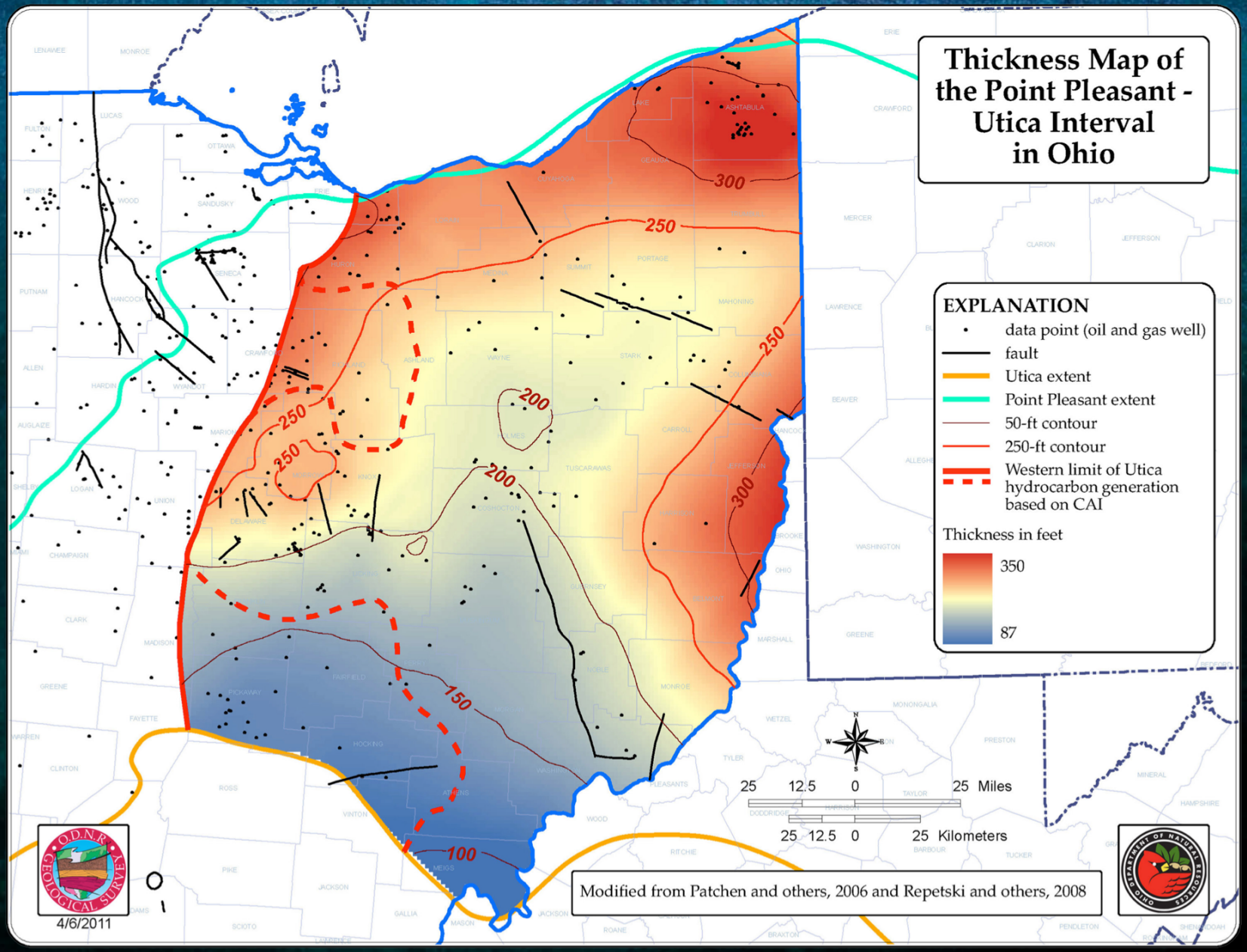
Curdsville Mbr

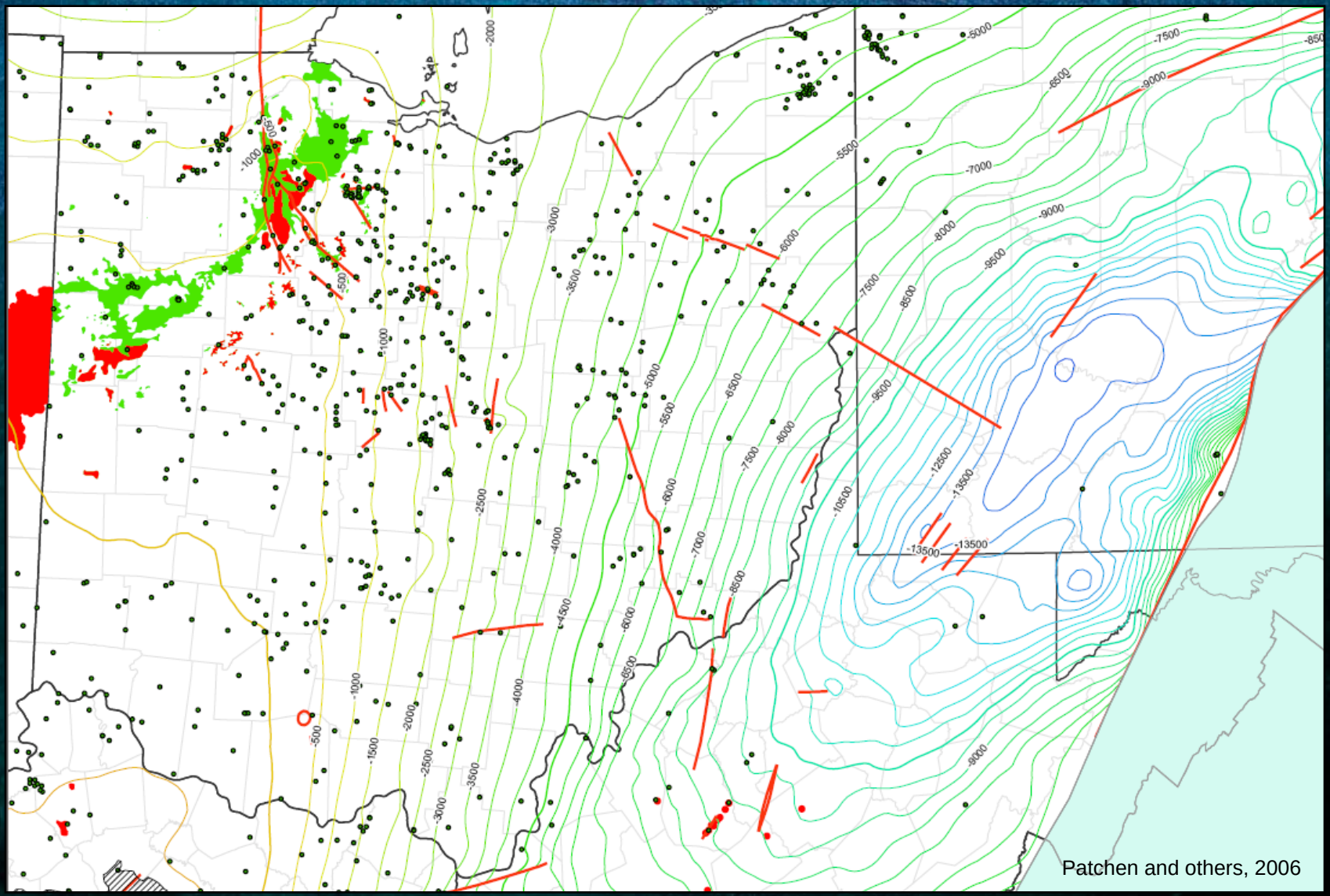
Source Rock Analyses

Depth (ft)	Sample Type	TOC	Rock Unit
6064	core	0.48	Cincinnati gp
6141	core	2.72	Utica Sh
6282	core	2.41	Point Pleasant Fm
6336	core	3.73	Point Pleasant Fm
6396	core	1.61	Logana Mbr
7192	core	0.11	Wells Creek Fm
7579	core	0.14	Copper Ridge dol
8274	core	0.23	Conasauga gp

Riley, 2010

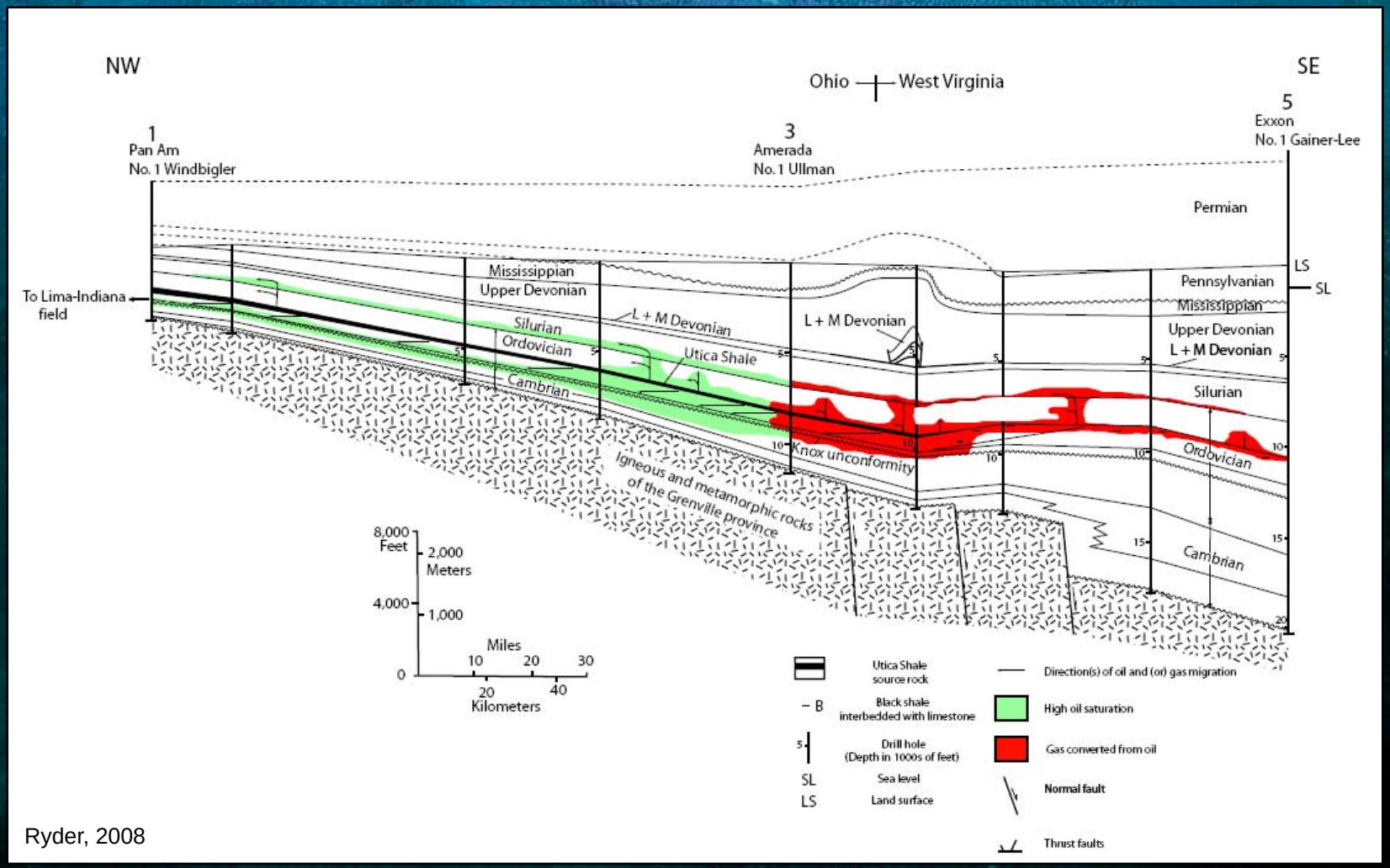

EXTENT OF STUDY AREA
POINT PLEASANT EXTENT
UTICA EXTENT
NO DATA
50 25 0 50 Miles
50 25 0 50 Kilometers
INTERVAL-THICKNESS MAP OF THE UTICA
(top of Trenton to top of Utica; includes the Point Pleasant and Antes Shale.)
The extent of the Utica and the Point Pleasant are also shown.
EXPLANATION
Trenton-Black River outcrop area
fault
Utica extent
Point Pleasant extent
data point (oil and gas well)
data points not corrected for structural dip
250-ft index contour
50-ft contour; 700
Thickness in feet
705
84
Recommended bibliographic citation:
Patchen, D.G., Hickman, J.B., Harris, D.C., Drahovzal, J.A., Lake, P.D., Smith, L.B., Nyahay, Richard, Schulze, Rose, Riley, R.A., Baranoski, M.T., Wickstrom, L.H., Laughrey, C.D., Kostelnik, Jaime, Harper, J.A., Avary, K.L., Bocan, John, Hohn, M.E., and McDowell, Ronald, 2006, A geologic play book for Trenton-Black River Appalachian Basin exploration: Morgantown, W. Va., U.S. Department of Energy Report, DOE Award Number DE-FC26-03NT41856, 601p., accessible at <http://www.wvgs.wvnet.edu/www/tbr/project_reports.asp>. [Map modified by Powers, D.M., and Martin, D.R.]
4/6/2011


Thickness Map of the Point Pleasant - Utica Interval in Ohio
EXPLANATION
data point (oil and gas well)
fault
Utica extent
Point Pleasant extent
50-ft contour
250-ft contour
Western limit of Utica hydrocarbon generation based on CAI
Thickness in feet
350
87
300
250
200
150
100
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Modified from Patchen and others, 2006 and Repetski and others, 2008
O.D.N.R. GEOLOGICAL SURVEY
4/6/2011



Structure on the Trenton Limestone. Add topographic elevation to derive approximate drilling depths through the Utica-Point Pleasant interval.

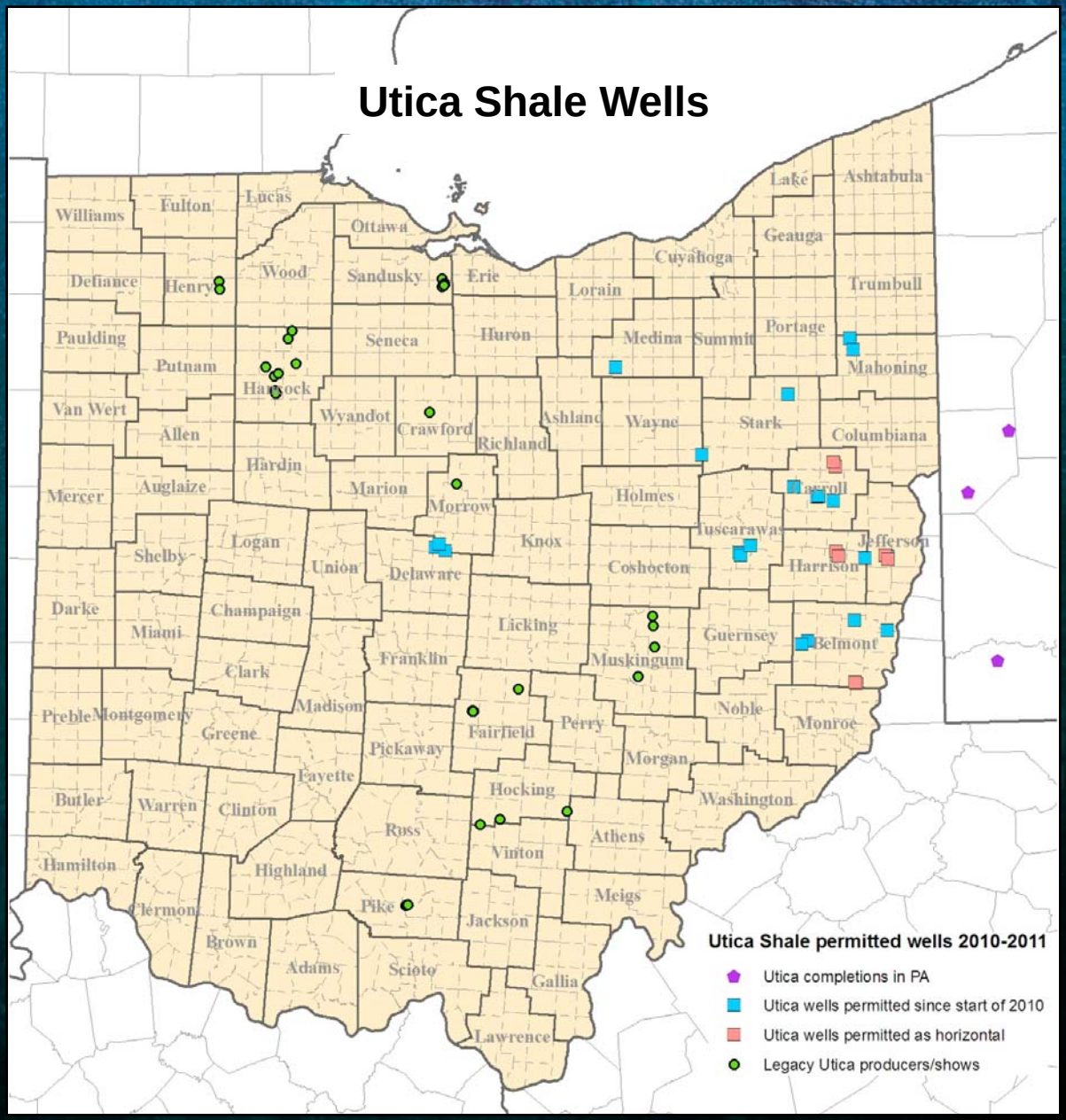
Why Ohio may be the Focus of the Utica-Point Pleasant Play



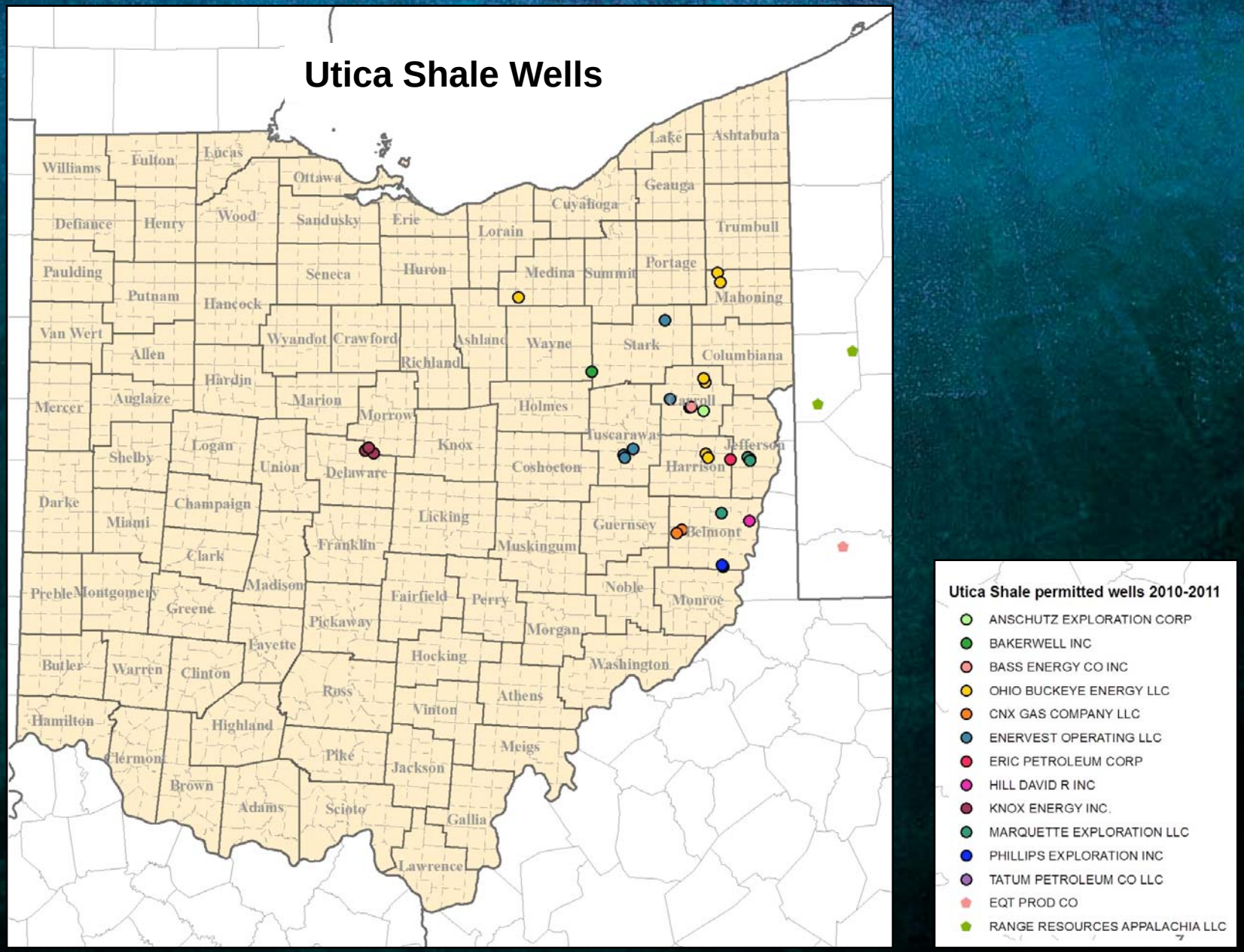
Ryder, 2008

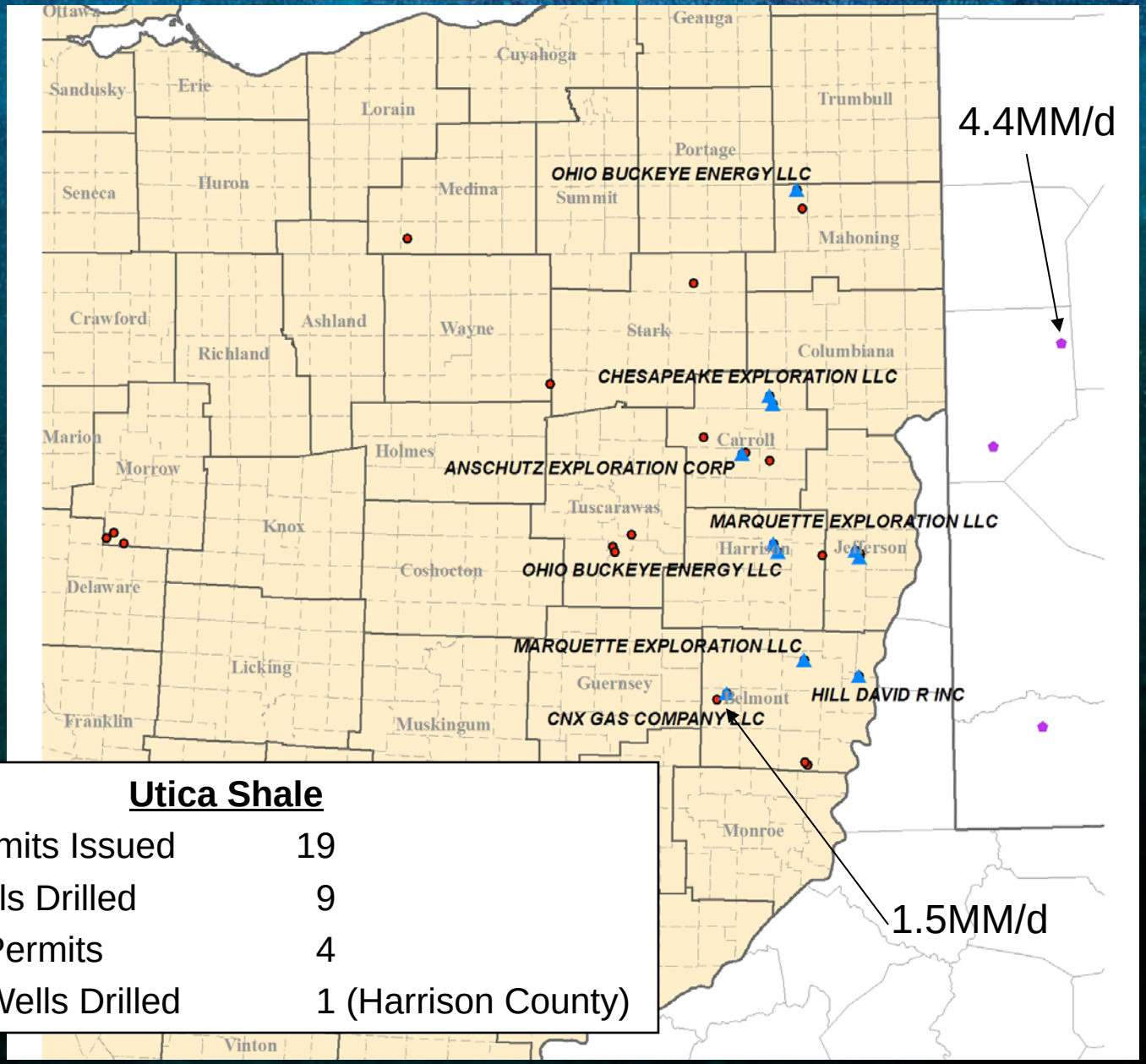
Gas-prone areas of Utica Shale will be in the deeper portion of the basin. Much of Ohio may contain appreciable amounts of oil within Utica Wells as illustrated by this NW–SE-oriented schematic cross section by Ryder illustrating the results of geochemical analyses of well samples.

Utica Shale Wells



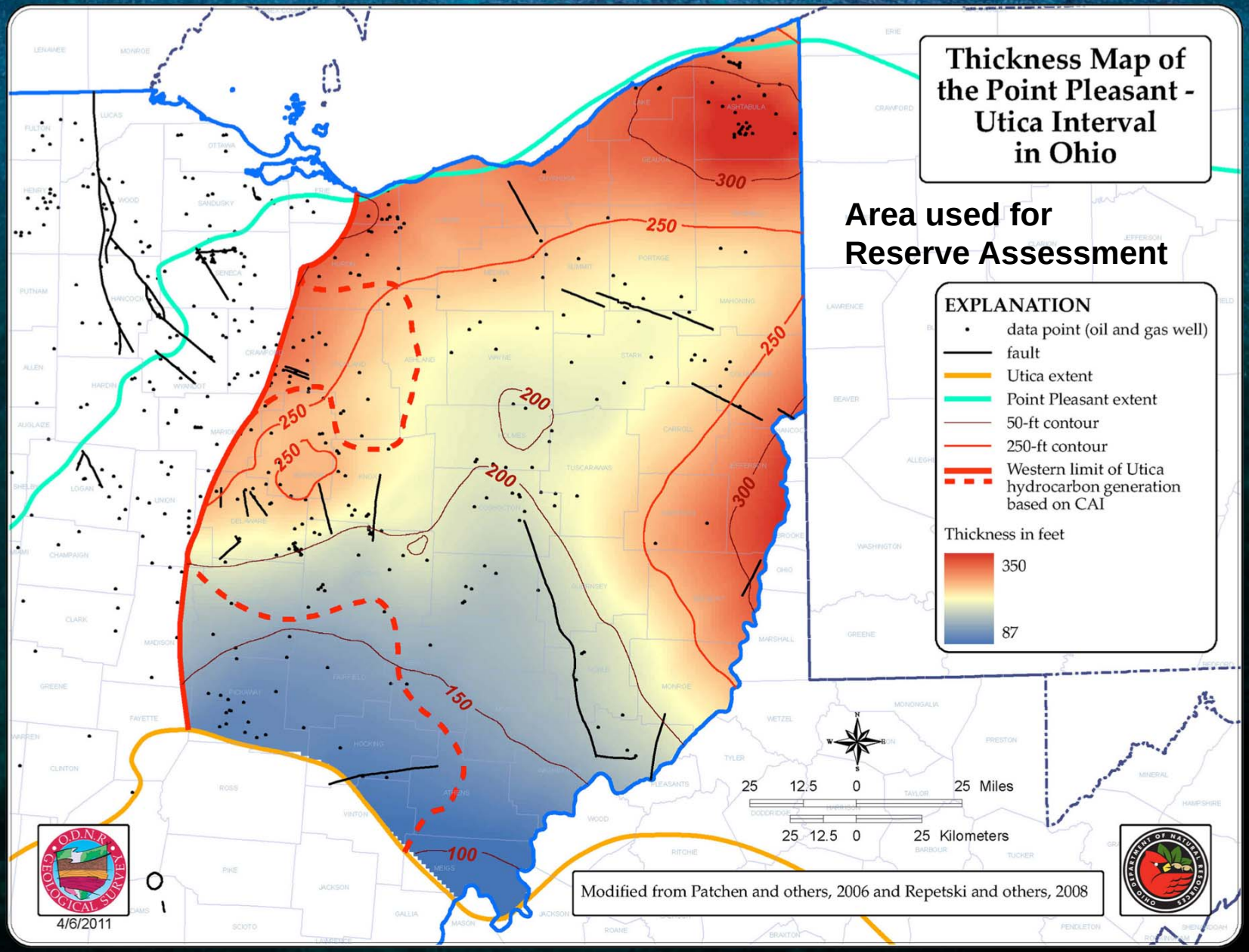
Utica Shale Wells





Utica Shale

Vertical Permits Issued	19
Vertical Wells Drilled	9
Horizontal Permits	4
Horizontal Wells Drilled	1 (Harrison County)


Thickness Map of the Point Pleasant - Utica Interval in Ohio
Area used for Reserve Assessment
EXPLANATION
data point (oil and gas well)
fault
Utica extent
Point Pleasant extent
50-ft contour
250-ft contour
Western limit of Utica hydrocarbon generation based on CAI
Thickness in feet
350
87
300
250
200
150
100
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Modified from Patchen and others, 2006 and Repetski and others, 2008
4/6/2011

Method for Calculating Utica Oil Resource Assessment

$$Q_t = V \times D \times TOC \times C \times \%R$$

where

Q_t = Quantity of hydrocarbons trapped (metric tons)

V = Volume of rock (cubic meters)

D = Rock density (kg /m)

TOC = Total organic content (percent)

C = Hydrocarbon conversion ratio (percent)

%R = Reservoir space with hydrocarbons (percent)

(Recoverable % from shale as reservoir)

Note: 1 metric ton = 7.1475 barrels

Wallace and Roen, 1989

Resource Assessment for the Utica-Point Pleasant in the Entire Appalachian Basin

D = 2.65 x 10^3 kg/m

TOC = 1.34 percent

C = 10 percent

%R = 3 percent

Qt = 13.26 billion barrels of oil migrated to conventional reservoirs

Wallace and Roen, 1989

Utica-Point Pleasant Recoverable Reserve Potential Estimate for Ohio

D = 2.70 x 10^3 kg/m^3
TOC = 2.50 percent
C = 10 percent
%R = 1.2 percent*—*recoverable from the interval*
Qt = 1.96 billion barrels of oil or equivalent

D = 2.70 x 10^3 kg/m^3
TOC = 2.50 percent
C = 10 percent
%R = 5 percent—*recoverable from the interval*
Qt = 8.2 billion barrels of oil or equivalent

*Value used for Bakken Oil Shale recoverability by Pollastro and others, 2008

Utica/Point Pleasant Recoverable Reserve Potential Estimate for Ohio

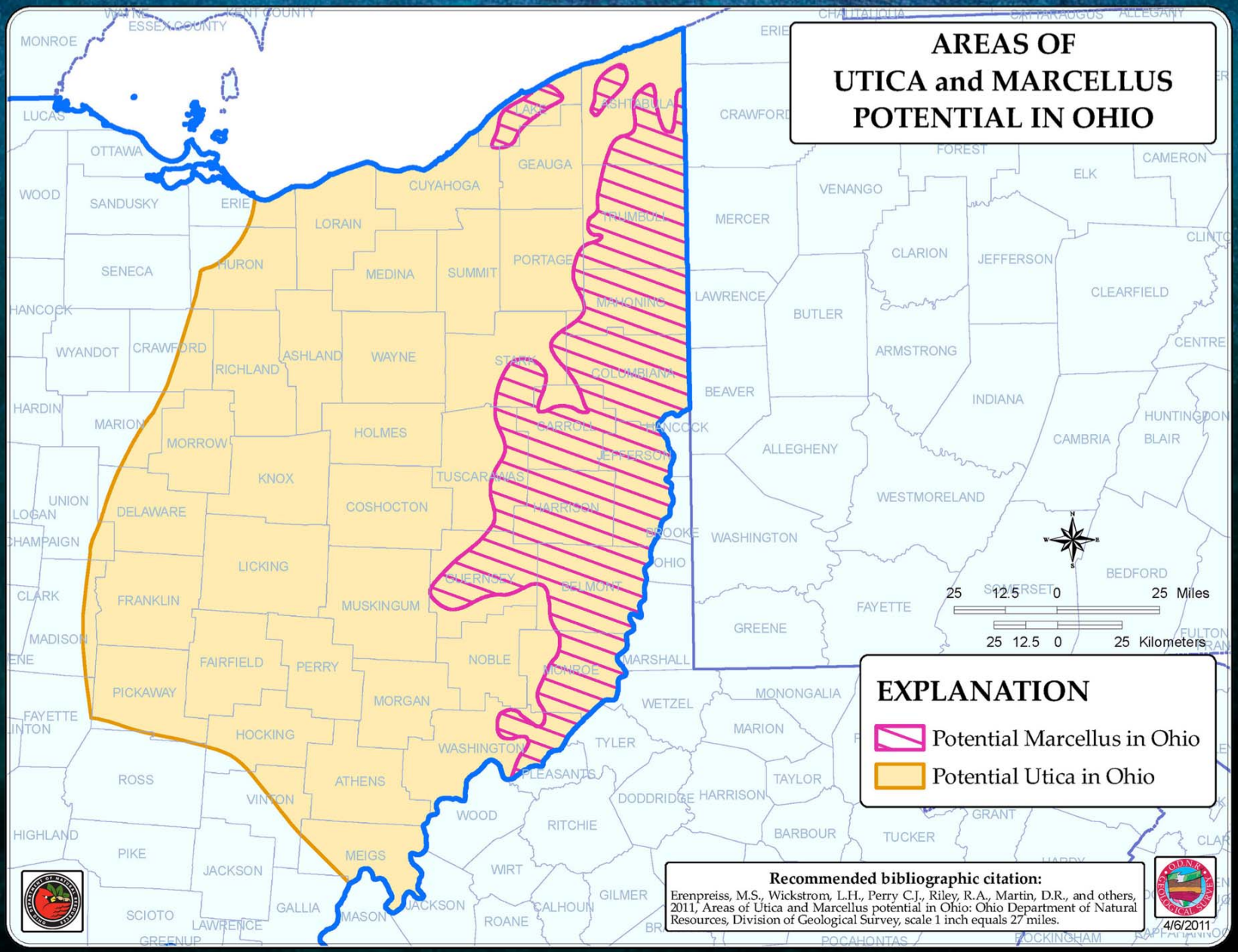
IF we assume $^{1}/_{3}$ of volume will be gas and $^{2}/_{3}$ is oil, then…

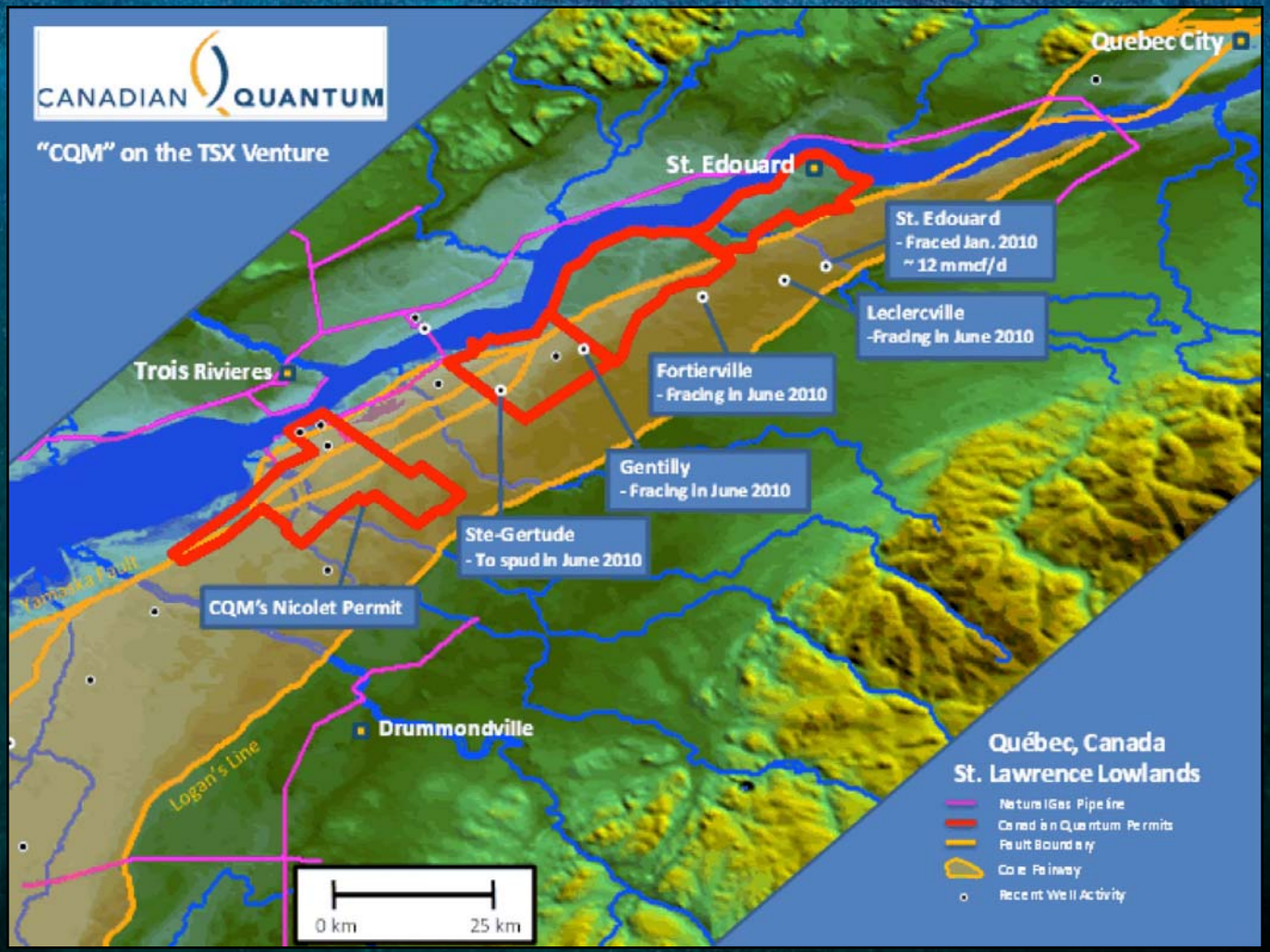
%R = 1.2 percent—*recoverable from the interval*
Qt = 1.96 billion barrels equivalent
= 3.75 TCF gas and 1.31 Billion barrels oil

%R = 5 percent—*recoverable from the interval*
Qt = 8.2 billion barrels equivalent
= 15.7 TCF and 5.5 Billion barrels oil

DISCLAIMER

- One of the mandates of the ODNR Division of Geological Survey is to "…collect, study, and interpret all available data pertaining to the origin, distribution, extent, use, and valuation of… natural resources such as… petroleum gas."
- Without actual production histories from existing Utica Shale wells, it is not possible to properly create a "probable" reserve estimate.
- This volumetric reserve calculation is only an educated guess as to the ultimate recoverable reserves from this interval. The ODNR Division of Geological Survey will continue to gather data and provide updated assessments when possible.


AREAS OF
UTICA and MARCELLUS
POTENTIAL IN OHIO
EXPLANATION
Potential Marcellus in Ohio
Potential Utica in Ohio
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Recommended bibliographic citation:
Erenpreiss, M.S., Wickstrom, L.H., Perry C.J., Riley, R.A., Martin, D.R., and others, 2011, Areas of Utica and Marcellus potential in Ohio: Ohio Department of Natural Resources, Division of Geological Survey, scale 1 inch equals 27 miles.
4/6/2011
MONROE
LUCAS
OTTAWA
WOOD
SANDUSKY
ERIE
LORAIN
CUYAHOGA
GEAUGA
LAKE
ASHTABULA
TRUMBULL
PORTAGE
SUMMIT
MEDINA
HURON
SENECA
HANCOCK
WYANDOT
CRAWFORD
RICHLAND
ASHLAND
WAYNE
STARK
MAHONING
COLUMBIANA
HARDIN
MARION
MORROW
HOLMES
CARROLL
HANCOCK
JEFFERSON
KNOX
TUSCARAWAS
UNION
LOGAN
DELAWARE
COSHOCTON
HARRISON
CHAMPAIGN
BROOKE
OHIO
LICKING
GUERNSEY
BELMONT
CLARK
FRANKLIN
MUSKINGUM
MADISON
FAIRFIELD
PERRY
NOBLE
MONROE
MARSHALL
PICKAWAY
MORGAN
FAYETTE
HOCKING
WASHINGTON
TYLER
ROSS
ATHENS
PLEASANTS
VINTON
WOOD
RITCHIE
HIGHLAND
PIKE
JACKSON
MEIGS
WIRT
SCIOTO
GALLIA
MASON
JACKSON
ROANE
CALHOUN
GILMER
LAWRENCE
GREENUP
ERIE
CHAUTAUQUA
CATTARAUGUS
ALLEGANY
CRAWFORD
FOREST
CAMERON
ELK
VENANGO
MERCER
CLARION
JEFFERSON
CLINTON
LAWRENCE
BUTLER
CLEARFIELD
ARMSTRONG
CENTRE
BEAVER
INDIANA
HUNTINGDON
CAMBRIA
BLAIR
ALLEGHENY
WESTMORELAND
WASHINGTON
BEDFORD
SOMERSET
FAYETTE
GREENE
FULTON
MONONGALIA
WETZEL
MARION
TAYLOR
DODDRIDGE
HARRISON
GRANT
BARBOUR
TUCKER
POCAHONTAS
ROCKINGHAM



Source: www.marketoracle.co.uk

The Utica Play may extend throughout much of the northern Appalachian Basin and on the other side of the Adirondack Mountains within the St. Lawrence River lowlands. The Utica Play in Quebec has been unfolding since at least 2007 with wells testing as high as 12 million cubic feet of gas/day.

Location of Quebec Utica Play
Michigan
Maine
Vermont
New York
New Hampshire
Massachusetts
Connecticut
Rhode Island
Pennsylvania
Ohio
New Jersey
Maryland
Delaware
West Virginia
Kentucky
Google Earth

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