Geology and Activity of the Utica-Point Pleasant of Ohio*

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Search and Discovery Article #10490 (2013)
Posted April 8, 2013

*Adapted from presentation at Tulsa Geological Society dinner meeting, March 5, 2013.
Editor's note: Please refer to the earlier posted, closely related article by the author and co-workers, as Search and Discovery Article #10409 (2012), adapted from a poster presentation at 2012 AAPG ACE.

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Abstract

Activity associated with the Ordovician Utica Shale-Point Pleasant Formation play continues to ramp up, and Ohio continues to be the primary focus of activity within this continuous reservoir system. This focus is mostly due to the drilling depths and the presence of natural gas liquids and oil within Ohio. The first horizontal exploration wells were drilled and completed in the Utica-Point Pleasant interval in early 2011. By the end of 2011, over 150 horizontal permits had been issued and 30 wells drilled. As of early January 2013 500 permits had been issued and 210 wells drilled. However, it still is early within this play and much remains to be defined.

Within Ohio, the Point Pleasant Formation lies directly above the Trenton Limestone and is, at least in part, equivalent with the thick deposits of the Trenton carbonate platform of northwestern Ohio, famous for the Lima-Indiana oil-and-gas trend, which was the first true giant field produced in North America, starting in 1884. As the carbonate-platform deposits of the Trenton thin, the interbedded, organic-rich carbonates and shales of the Point Pleasant thicken. The deposition of Trenton platform carbonates and contemporaneous interplatform shales represents major sedimentological and structural changes to the region as a direct result of the ensuing Taconic Orogeny. As the orogenic activity increased and the foreland basin deepened, the organic-rich Utica Shale transgressed the area overwhelming and drowning the carbonate environments. Thus in the deeper portions of the present-day basin, the Utica (and Antes) is, in part, laterally equivalent and overlies the Point Pleasant.

Even though most refer to this as the Utica Play, the Point Pleasant Formation is the primary target and producing interval. The Point Pleasant consists of interbedded light gray to black limestones, brown to black organic-rich calcareous shales, and, quite often, brachiopod coquina layers. The overlying Utica Shale is mostly light gray to black calcareous shales with few limestone layers and is, in general, more massive and denser than the Point Pleasant. In most wells analyzed, the Point Pleasant shales have higher source-rock potential than within the Utica. Clay

content of the Point Pleasant is fairly low (5-20%), while in the overlying Utica it can be 30-40%. Low water saturation is also prevalent (5-20%) and post-frac "soaking" periods appear to be working quite well.

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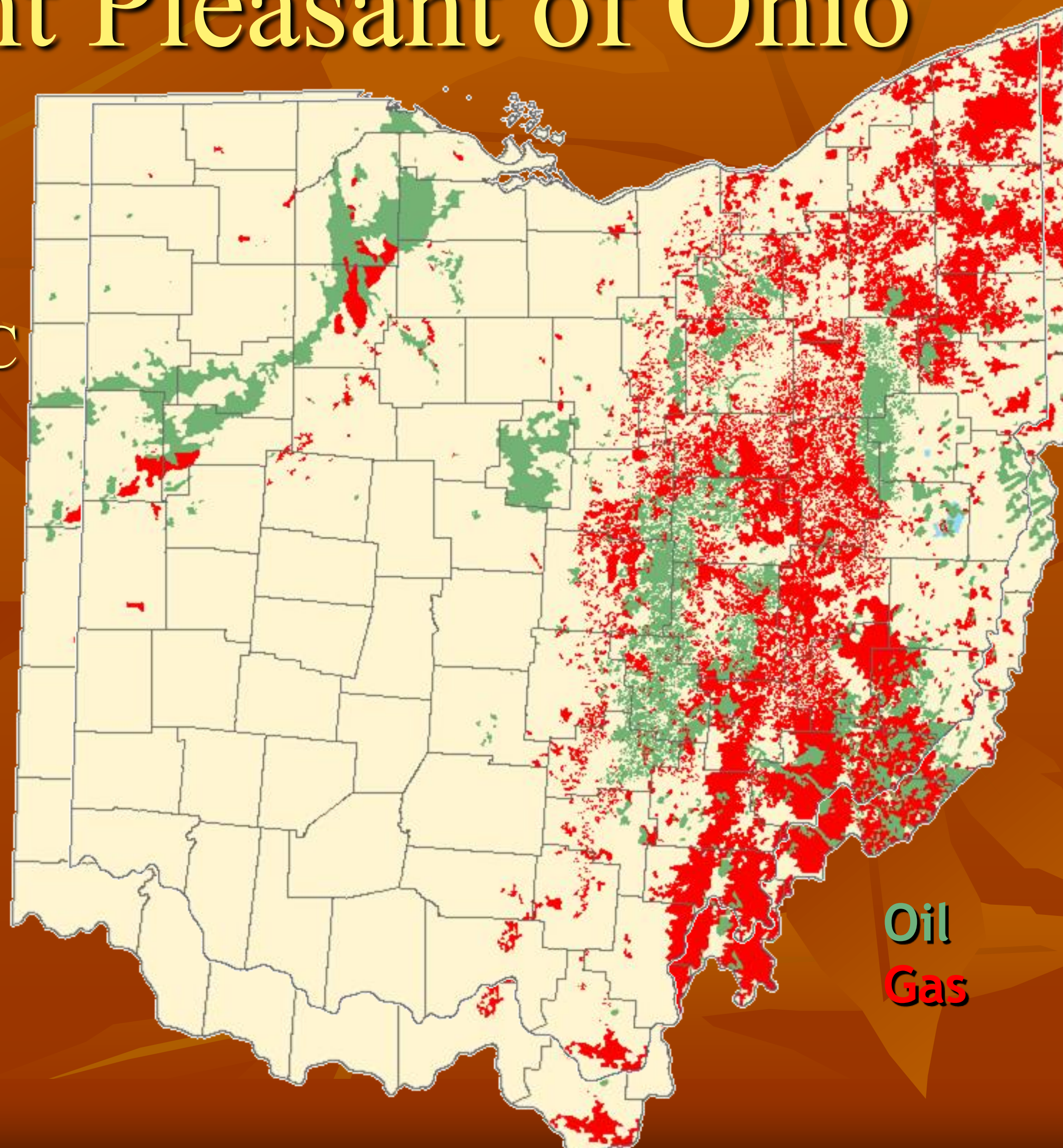


Tulsa Geological Society

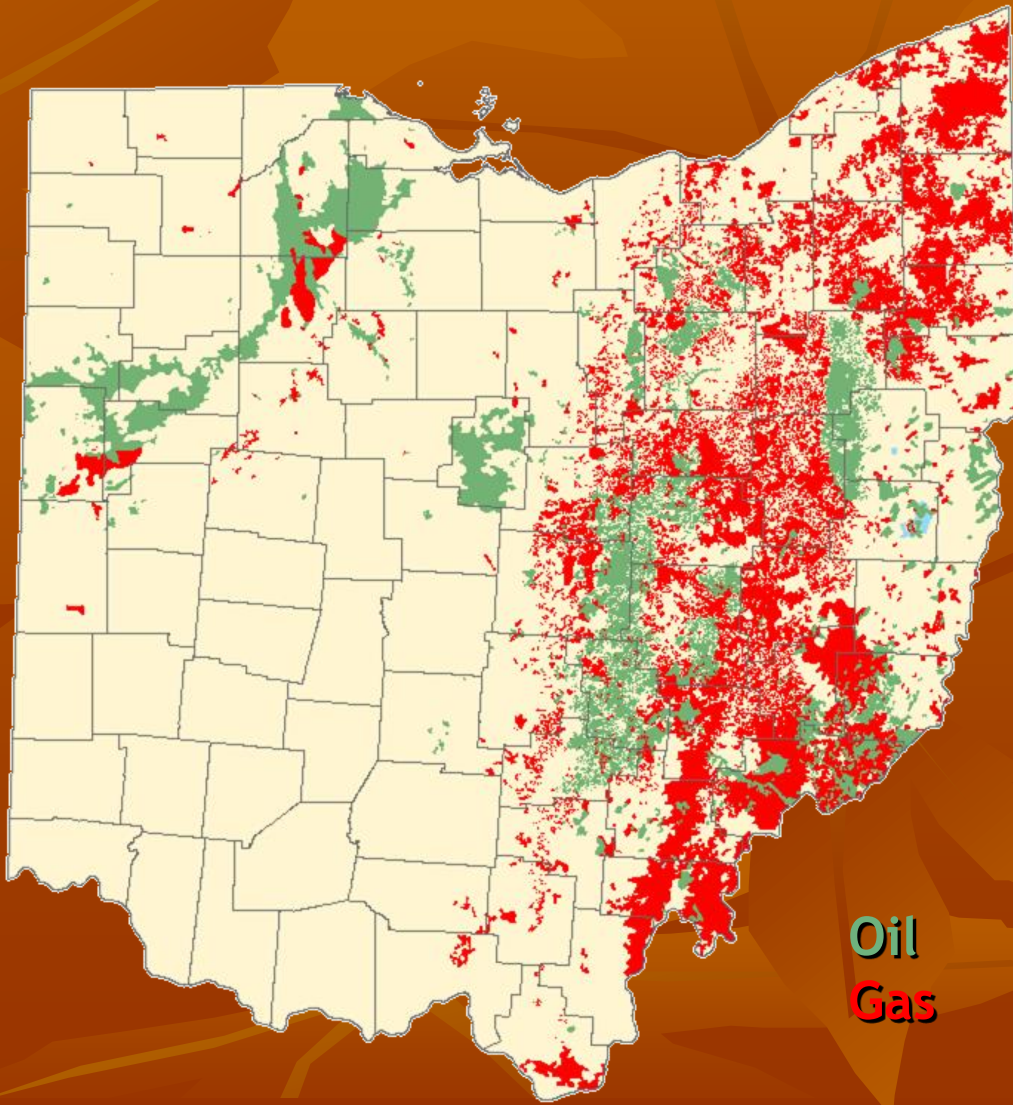
March 5, 2013

Overview

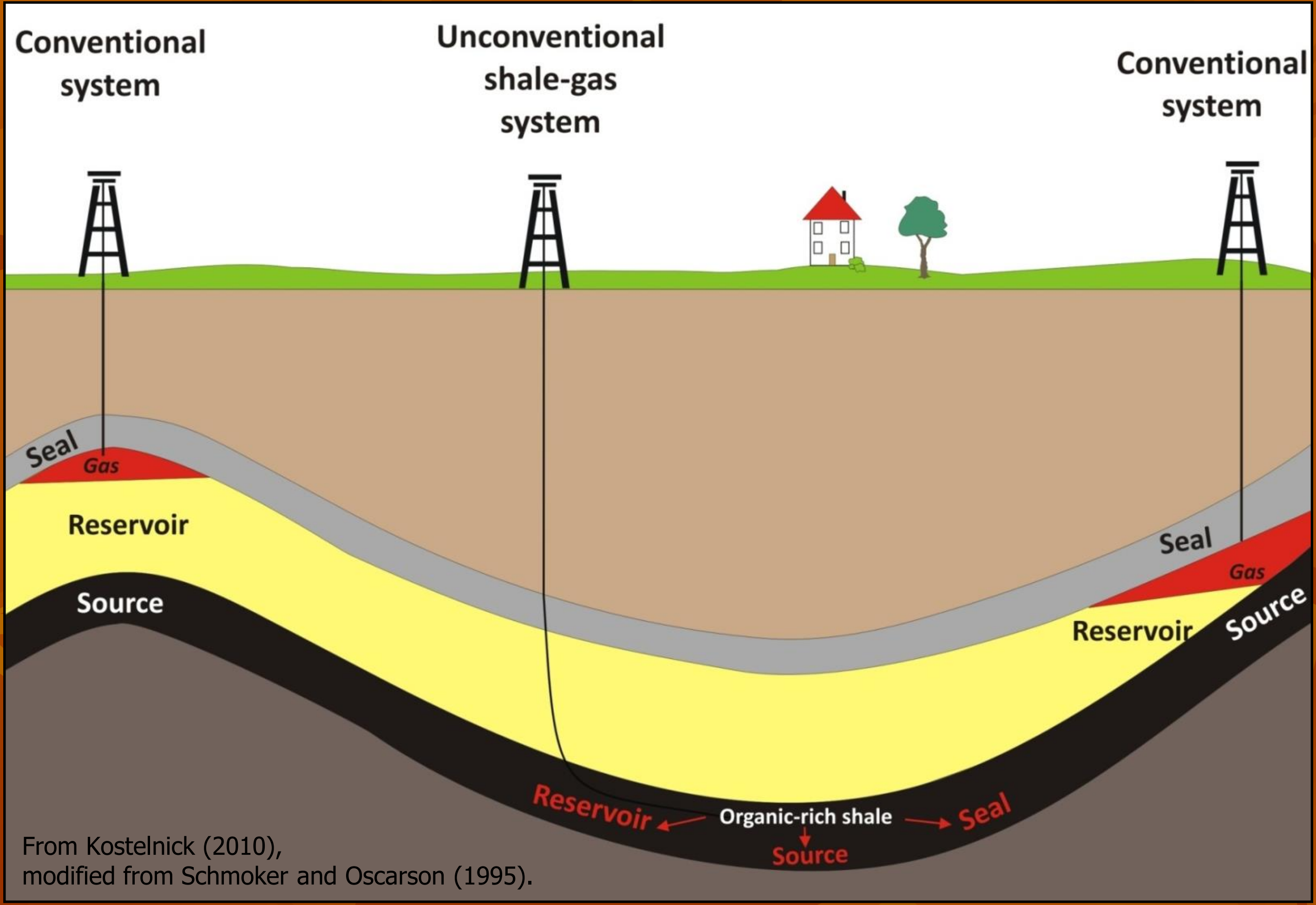
- Geology of the Point Pleasant Play
- Source Rock Geochemistry
  - Analyses and Pitfalls
- Activity Update
- Summary

Ohio Oil & Gas Fields

- Ohio currently has in excess of 63,000 producing oil & gas wells
- Historically, over 250,000 wells have been drilled
- Production has been established in 66 of our 88 Counties.
- The Lima-Indiana Trend of NW Ohio was one of the first true giant fields produced in the U.S. (1884-1934)
- Thus, oil & gas is not new to Ohio, especially in eastern half of state



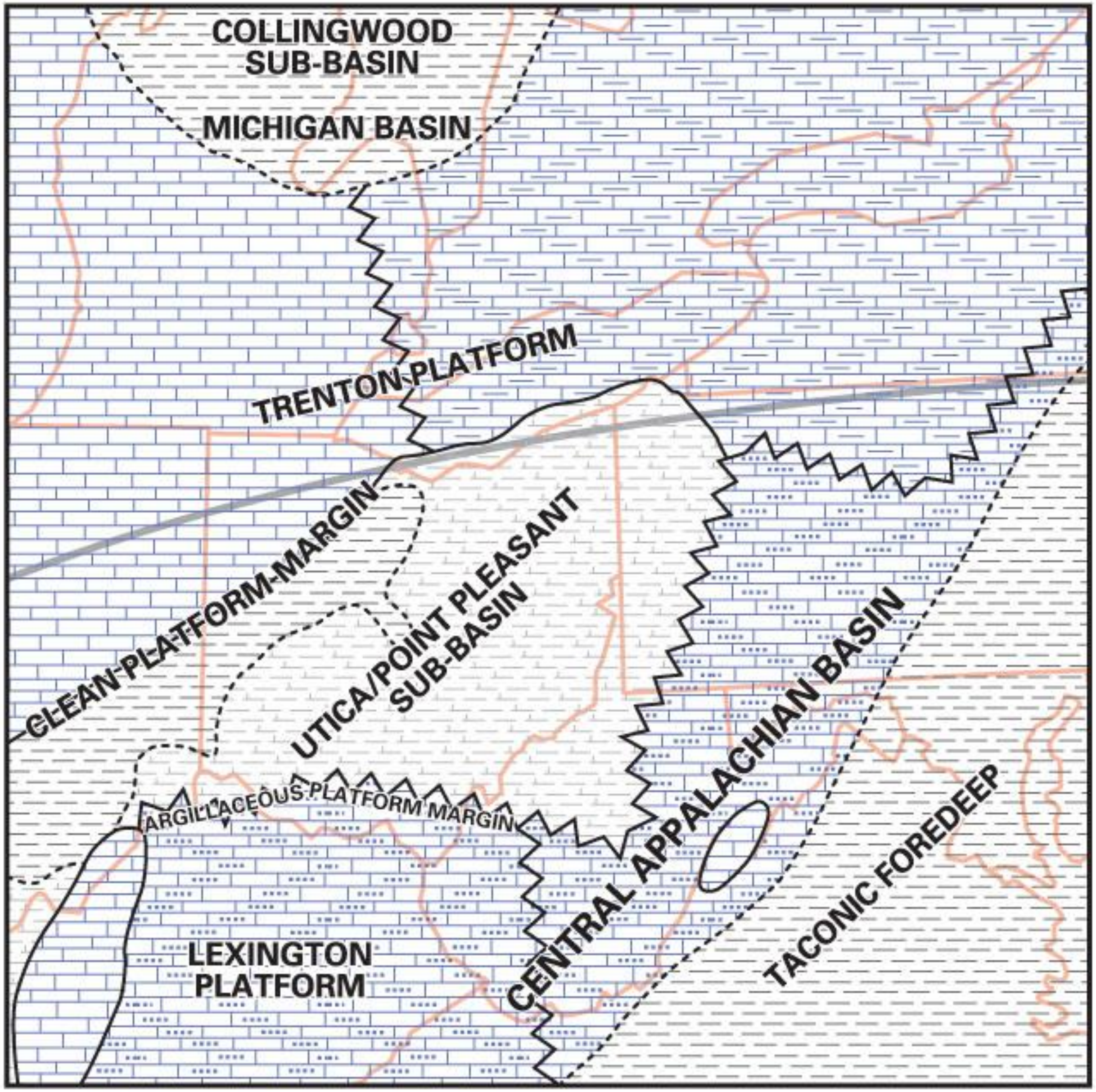
Drilling and producing from organic-rich shales represents a large paradigm shift for the oil and gas industry.



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.

Facies map of Trenton/Point Pleasant Time



Clean carbonate grainstones, packstones, and wackestones with sharp upper contact

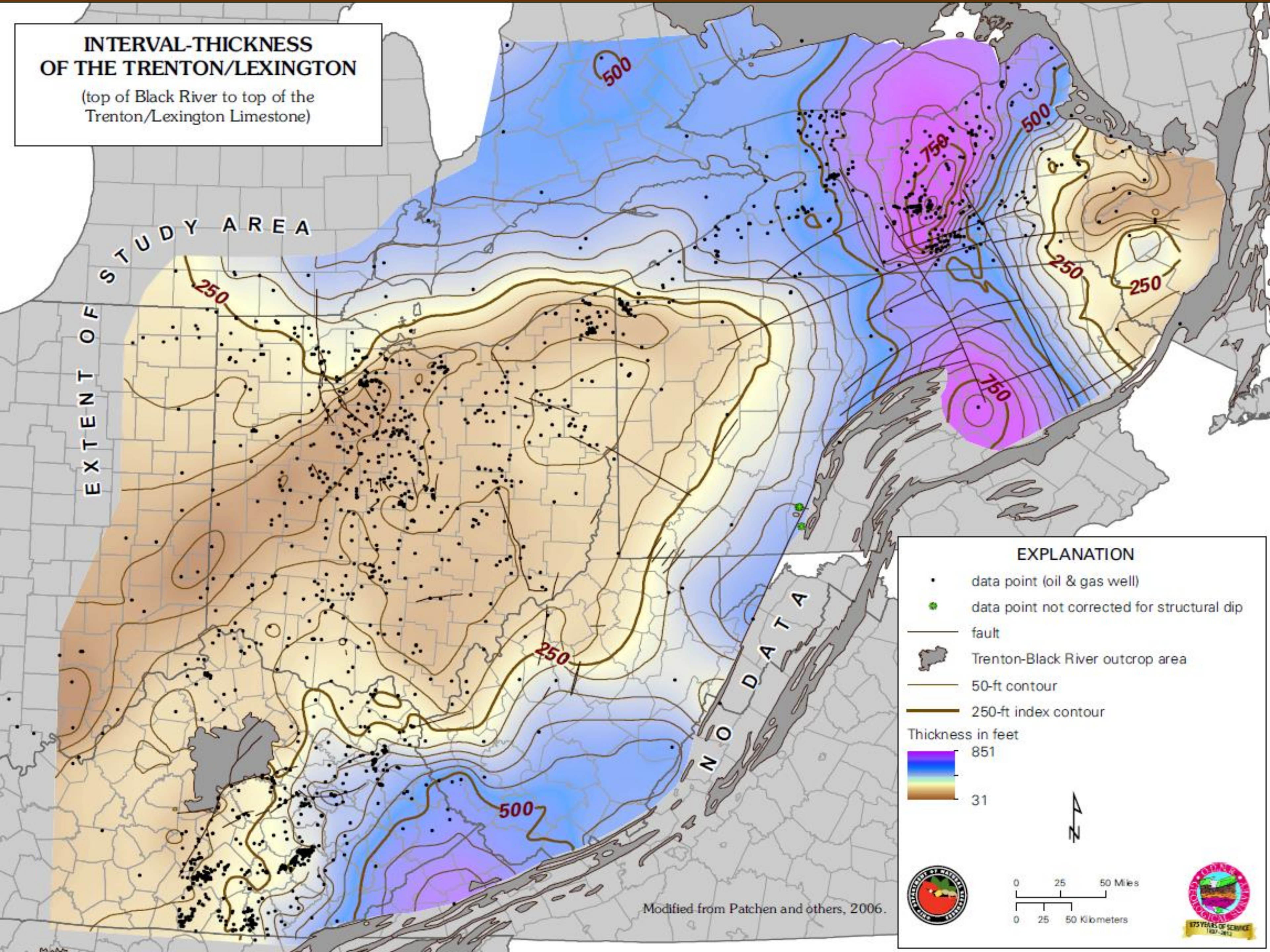
Argillaceous carbonate grainstones, packstones, and wackestones with sharp upper contact

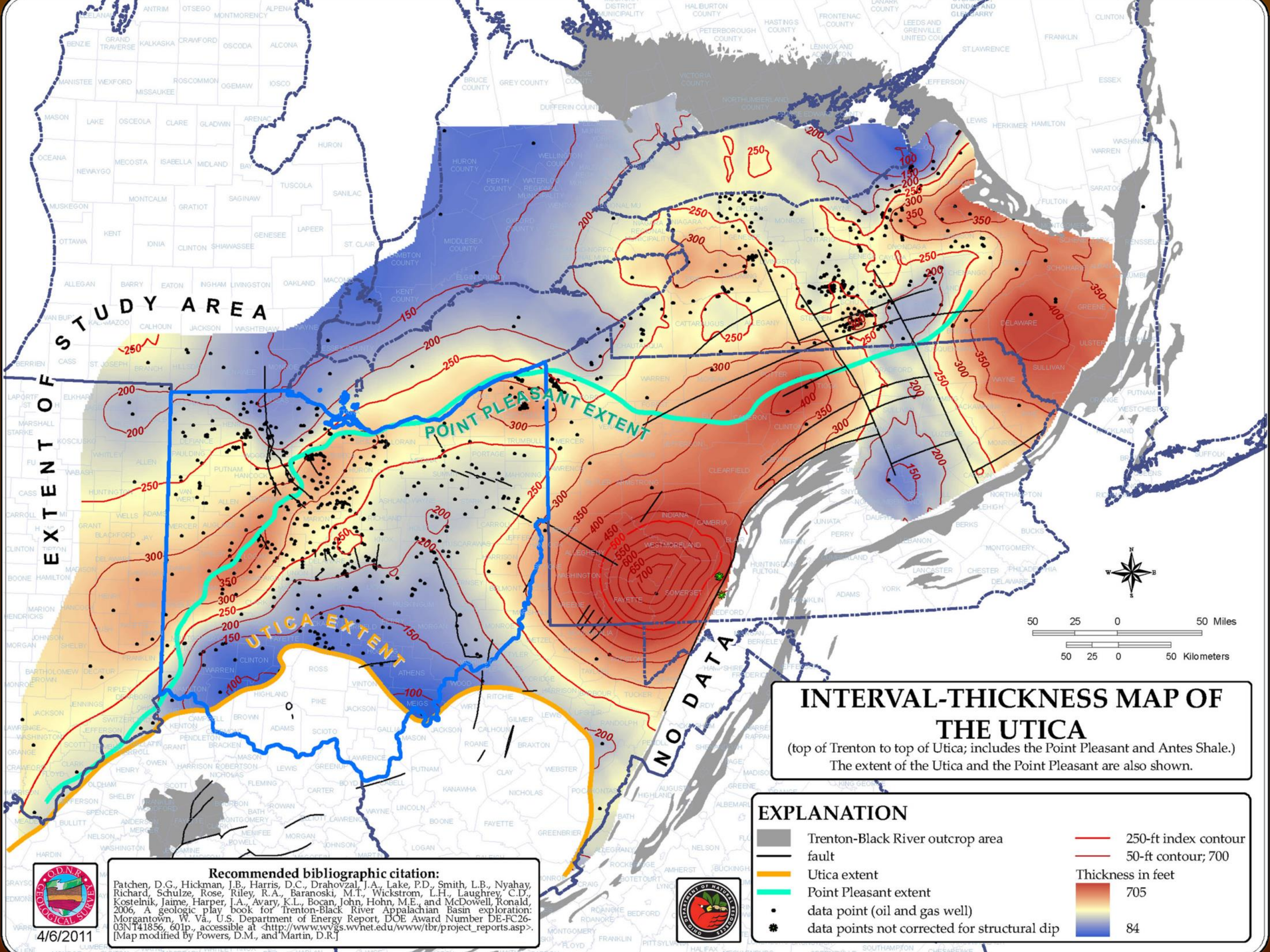
Argillaceous carbonate grainstones, packstones, and wackestones with gradational upper contact

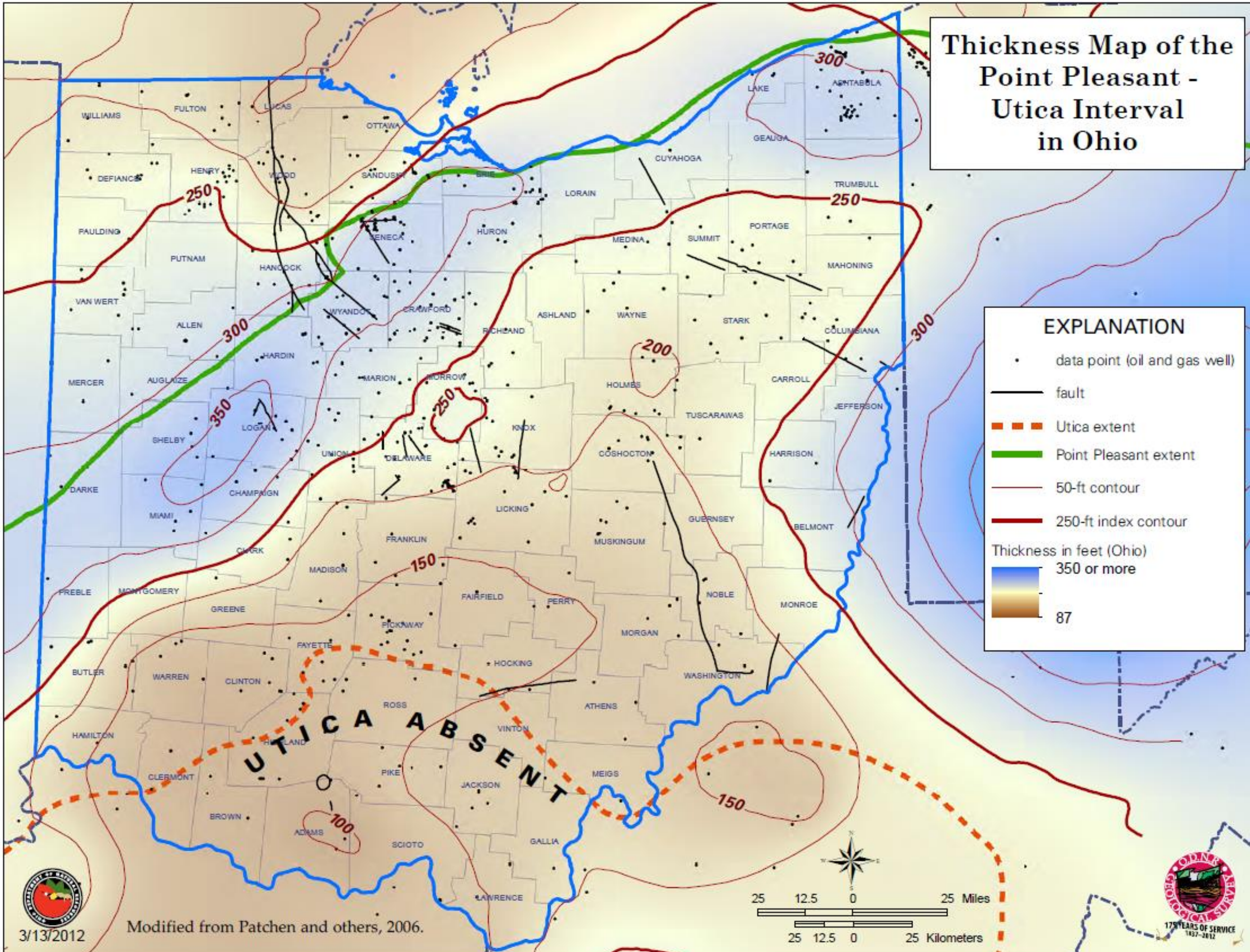
Shale

Calcareous shale and interbedded limestone

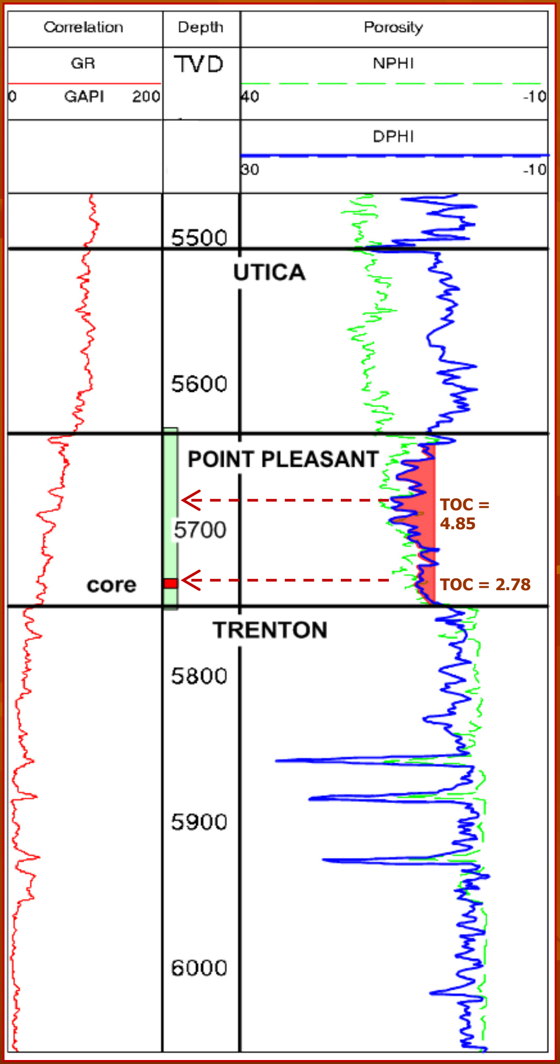
15° south Paleo latitude


INTERVAL-THICKNESS OF THE TRENTON/LEXINGTON
(top of Black River to top of the Trenton/Lexington Limestone)
EXTENT OF STUDY AREA
NO DATA
250
500
750
EXPLANATION
data point (oil & gas well)
data point not corrected for structural dip
fault
Trenton-Black River outcrop area
50-ft contour
250-ft index contour
Thickness in feet
851
31
0 25 50 Miles
0 25 50 Kilometers
Modified from Patchen and others, 2006.


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
EXTENT OF STUDY AREA
POINT PLEASANT EXTENT
UTICA EXTENT
NO DATA
50 25 0 50 Miles
50 25 0 50 Kilometers
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.]
O.D.N.R. GEOLOGICAL SURVEY
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 index contour
Thickness in feet (Ohio)
350 or more
87
UTICA ABSENT
WILLIAMS
FULTON
LUCAS
OTTAWA
SANDUSKY
ERIE
LORAIN
CUYAHOGA
LAKE
ASHTABULA
GEAUGA
TRUMBULL
DEFIANCE
HENRY
WOOD
HURON
MEDINA
SUMMIT
PORTAGE
MAHONING
PAULDING
PUTNAM
HANCOCK
SENECA
VAN WERT
ALLEN
WYANDOT
CRAWFORD
RICHLAND
ASHLAND
WAYNE
STARK
COLUMBIANA
HARDIN
MERCER
AUGLAIZE
MARION
MORROW
HOLMES
CARROLL
JEFFERSON
LOGAN
SHELBY
UNION
DELAWARE
KNOX
COSHOCTON
TUSCARAWAS
HARRISON
DARKE
CHAMPAIGN
MIAMI
LICKING
GUERNSEY
BELMONT
CLARK
FRANKLIN
MUSKINGUM
MADISON
PREBLE
MONTGOMERY
GREENE
FAIRFIELD
PERRY
NOBLE
MONROE
PICKAWAY
MORGAN
FAYETTE
HOCKING
BUTLER
WARREN
CLINTON
WASHINGTON
ROSS
ATHENS
VINTON
HAMILTON
HIGHLAND
CLERMONT
PIKE
JACKSON
MEIGS
BROWN
ADAMS
SCIOTO
GALLIA
LAWRENCE
100
150
200
250
300
350
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
175 YEARS OF SERVICE 1837–2012
3/13/2012
Modified from Patchen and others, 2006.

The presence, thickness, fracability, and source-rock richness, of the Point Pleasant Formation in Ohio are what make this state the center of this play.



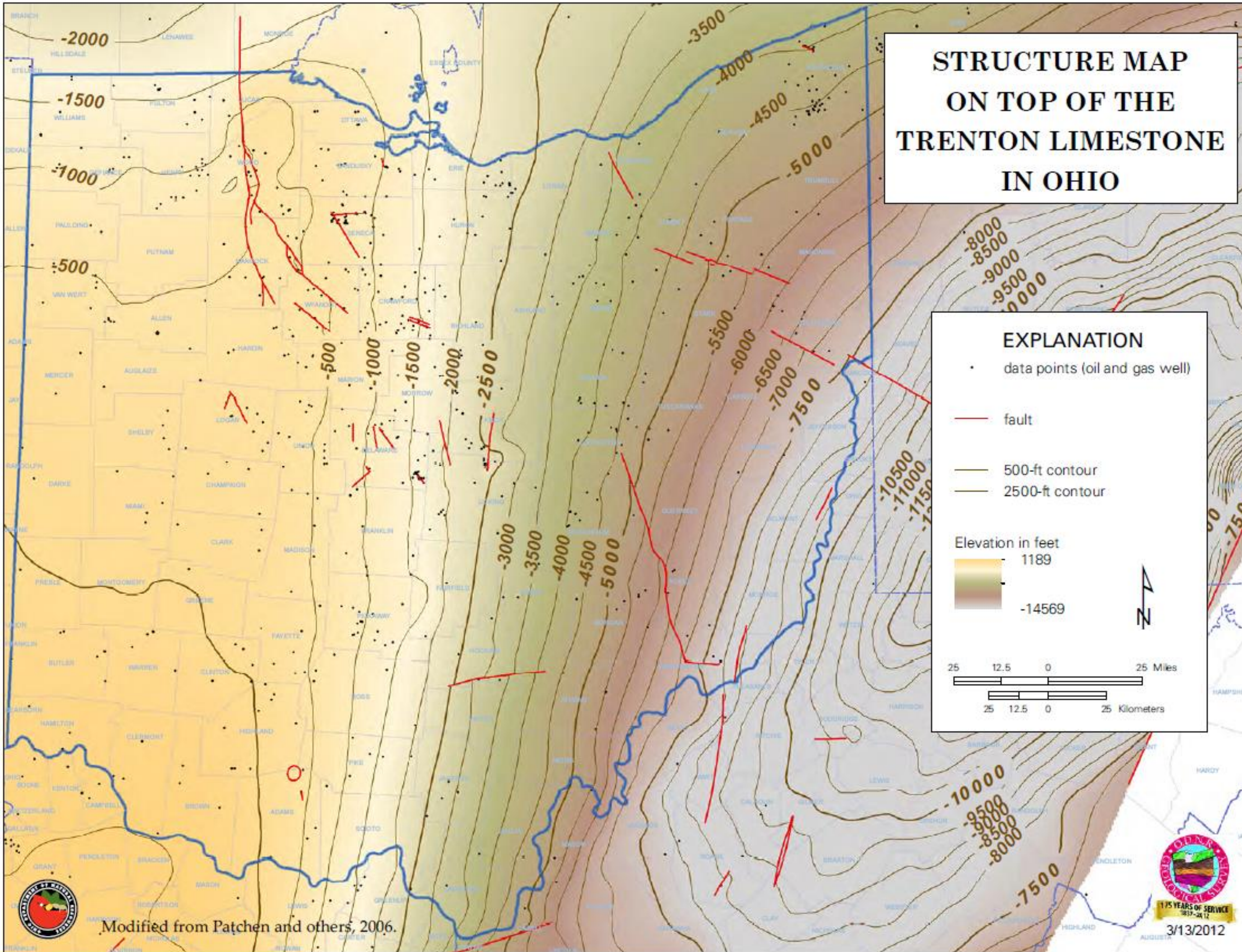
FRACABILITY
COSHOCTON COUNTY BARTH #3

- Low-density shale
- AVG TOC = 2.78
- High TOC = 7.3
- High carbonate %
- Responds to HCL
- Interbedded limestone and black shale

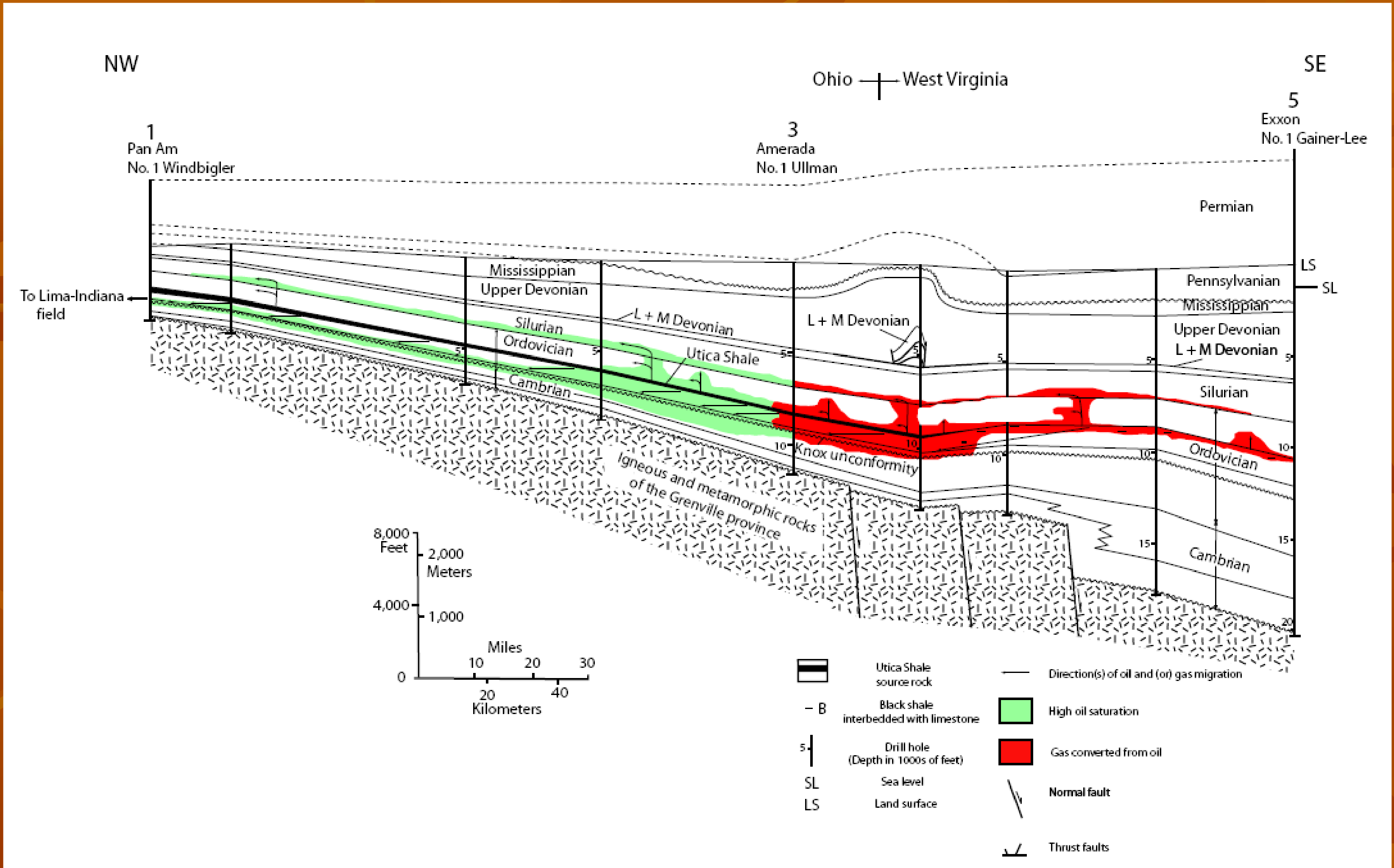
J. Wicks, 2011

Fine-Grained Reservoir Systems (modified from Bohacs, Passey and others, 2010)

SYSTEM TYPE	CHARACTERISTICS	SECONDARY MIGRATION	POROSITY AND PERMEABILITY COMPONENTS	EXAMPLES
Conventional Tight	Tight ss, sltst, carbonates interbedded with lean source rock or low TOC mudstones	Significant	INTERGRANULAR Intra-granular Fracture	Spraberry; Lewis Shale; Mancos; Mesaverde; Brallier Fm; Medina Group
Hybrid/Interbedded	Tight ss, sltst, carbonates interbedded with rich, mature source rock	Moderate	INTERGRANULAR INTRA-GRANULAR Fracture	Bakken; Bone Spring;, 2nd White Specs; Niobrara; Point Pleasant/Trenton
Porous Mudstone	Source rocks with significant inter/intra-grain porosity at oil to gas/condensate level of maturity	Minimal	INTERGRANULAR INTRA-GRANULAR FRACTURE	Eagle Ford; Haynesville; Wolfcamp; Woodford; Niobrara
Fractured Mudstone	Mature source rocks with significant fracture porosity	Minimal	INTERGRANULAR INTRA-GRANULAR FRACTURE	Monterey; Woodford; Mowry; Barnett; Marcellus; Utica


STRUCTURE MAP
ON TOP OF THE
TRENTON LIMESTONE
IN OHIO
EXPLANATION
data points (oil and gas well)
fault
500-ft contour
2500-ft contour
Elevation in feet
1189
-14569
N
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
-2000
-1500
-1000
-500
-3500
-4000
-4500
-5000
-8000
-8500
-9000
-9500
-500
-1000
-1500
-2000
-2500
-5500
-6000
-6500
-7000
-7500
-3000
-3500
-4000
-4500
-5000
-10500
-11000
-10000
-9500
-9000
-8500
-8000
-7500
175 YEARS OF SERVICE
Modified from Patchen and others, 2006.
3/13/2012

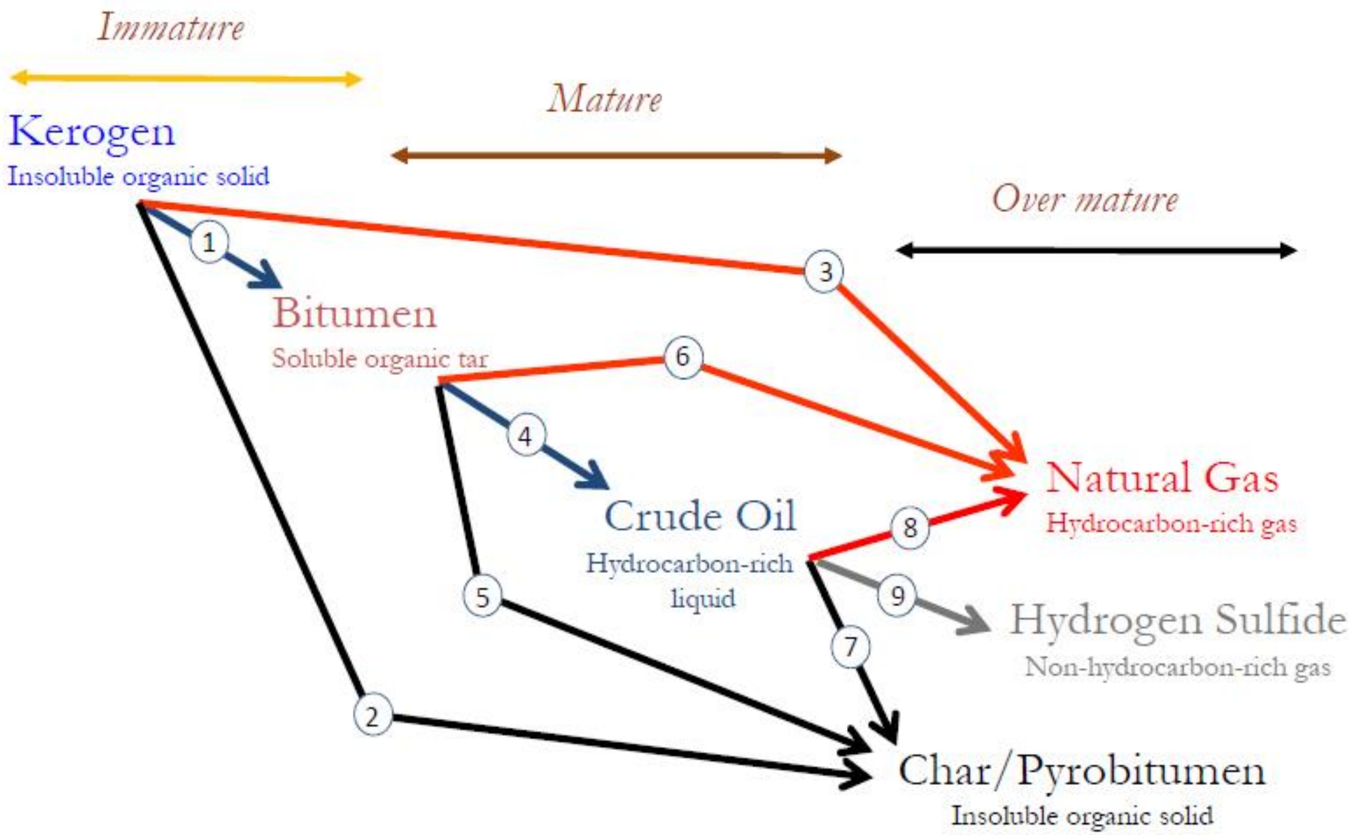
Why Ohio is the Focus of the Utica-Point Pleasant Play



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

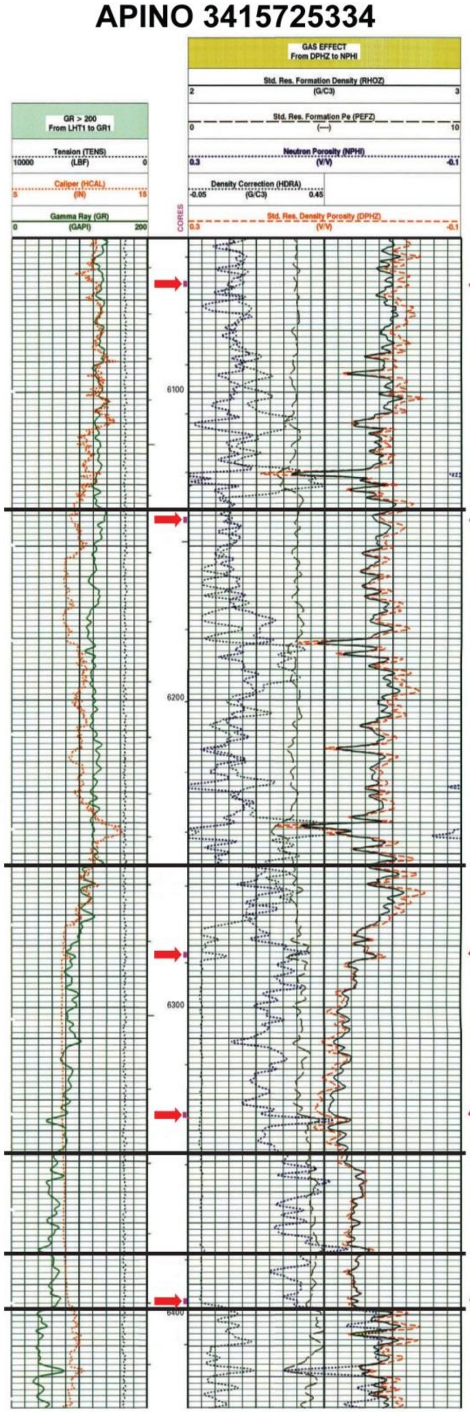
Source Rock Geochemistry

Petroleum Formation: Reactions and Processes



Courtesy Michael Lewan, USGS

A Utica-Point Pleasant Type Log for Eastern Ohio



Cincinnati gp

Utica Sh

Point Pleasant Fm

Lexington Ls Top
(Trenton Ls Top equivalent)

Logana Mbr

Curdsville Mbr

Ohio Geological Survey CO2 #1
Belden Brick Unit, Tuscarawas Co.

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

Basic Source-Rock Potential Definitions

Total Organic Carbon (TOC) is a measurement in weight percent of the quantity of organic carbon preserved in a rock sample and includes both kerogen and bitumen (Peters and Casa, 1994). A TOC of 0.5 percent is generally regarded as the minimum for defining a petroleum source rock, but most geochemists consider a TOC of greater than 1.0 percent as a good source rock for generating petroleum potential.

$\boldsymbol{S_1}$ is a measurement (mg HC/g of rock) of the free hydrocarbons already generated that are volatilized out of the rock without cracking the kerogen. An S_1 of greater than 1 is considered to be a good source rock.

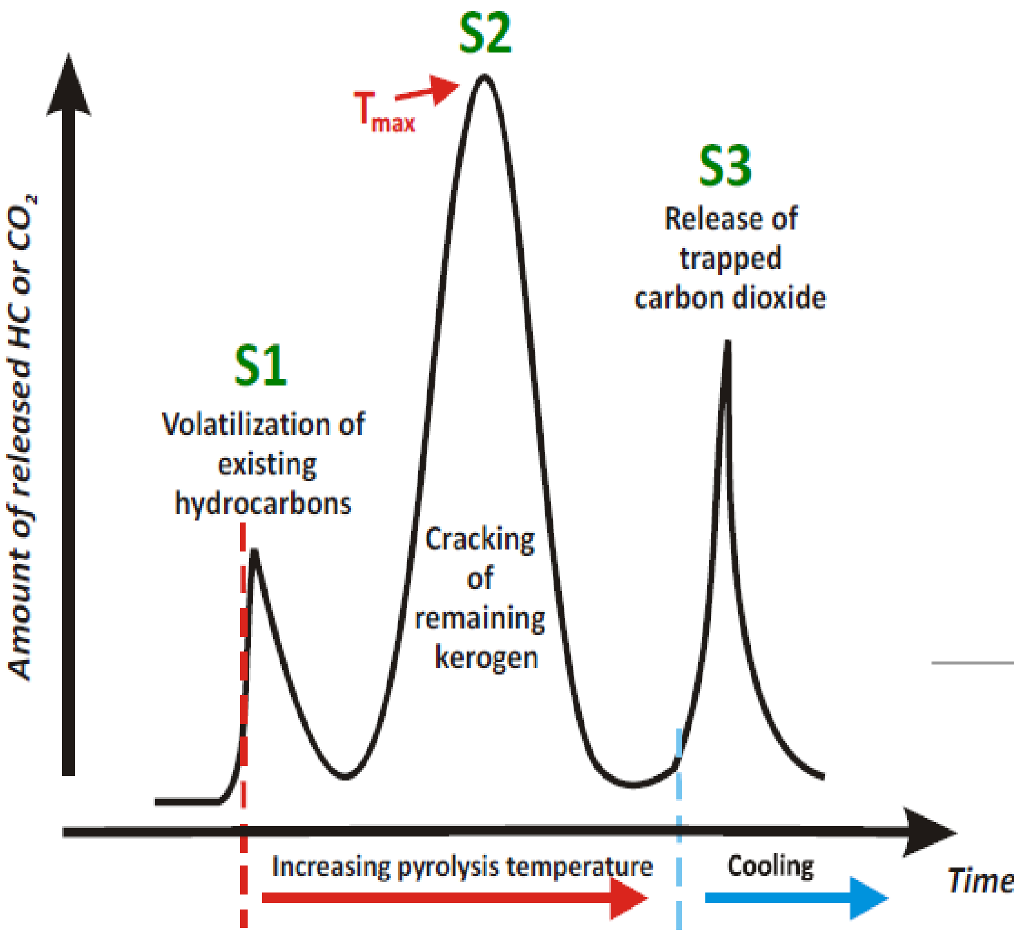
$\boldsymbol{S_2}$ is a measurement (mg HC/g of rock) of the amount of hydrocarbons generated through thermal cracking of kerogen and heavy hydrocarbons. It represents the existing potential of a rock to generate hydrocarbons and is a more realistic measure of source rock potential than TOC, which includes "dead carbon" incapable of generating hydrocarbons. An S_2 of greater than 5 is considered to have good source rock generative potential.

Diagrammatic Illustration of TOC for a given kerogen type, e.g., Type II

Oil/Bitumen-Free TOC (wt.%)

Generative Organic Carbon (wt.%)	Non-Generative Organic Carbon (wt.%)
• Responsible for generation of hydrocarbons • Accounts for development of organic porosity	• Does not generate any appreciable amount of petroleum • Does account for storage by adsorption

After: Jarvie et al., 2012



Source: *Pennsylvania Geology*, Spring 2010

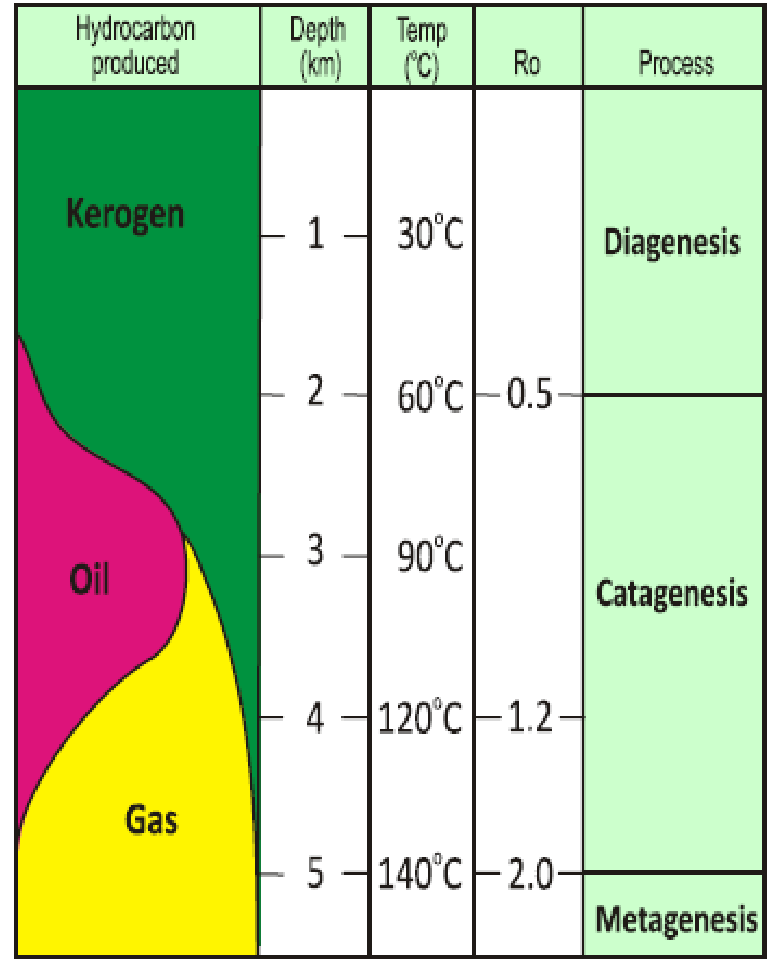
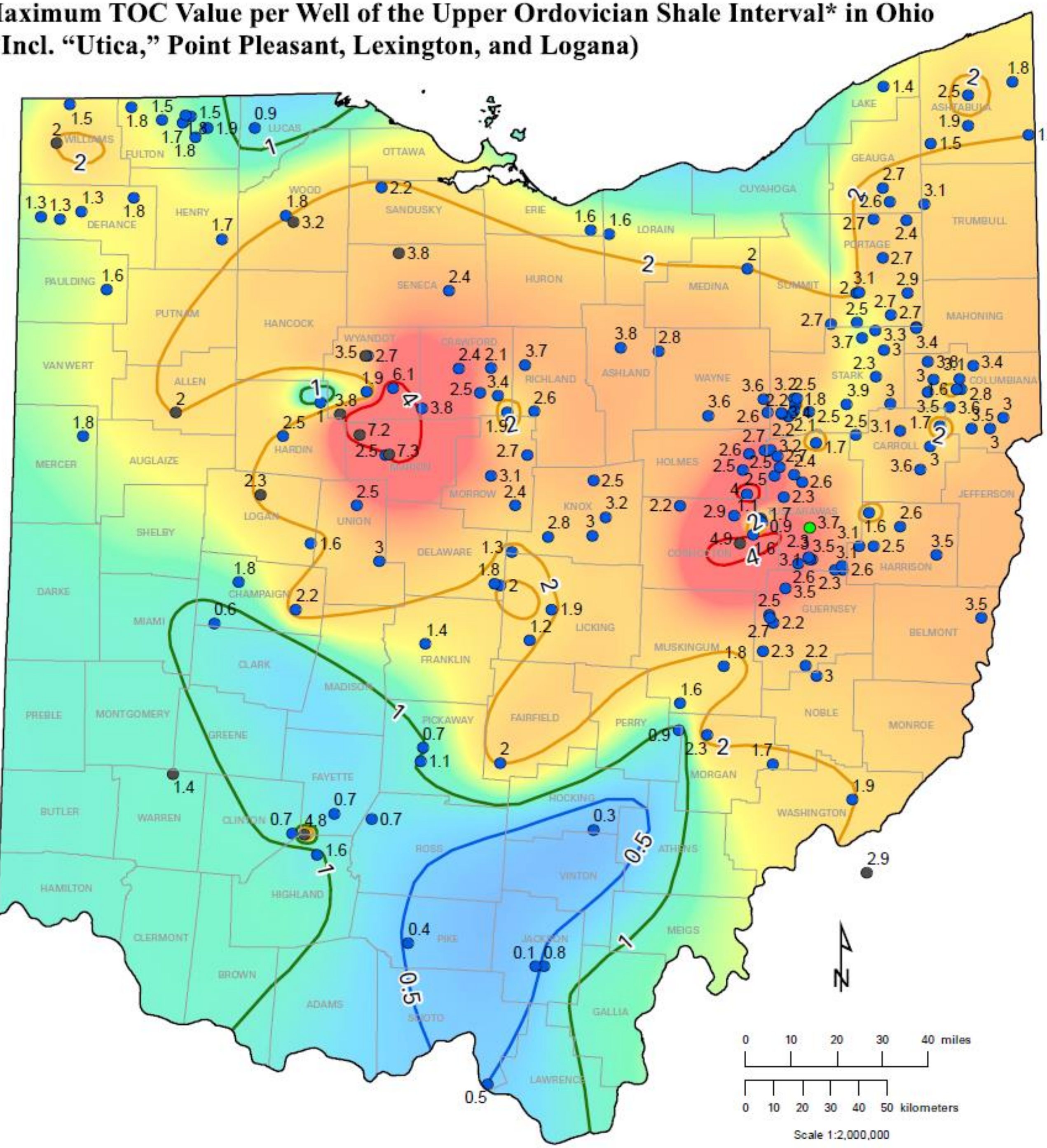


Figure 8. Graph of subsurface processes, depths, temperatures, and vitrinite reflectance values associated with the conversion of organic matter to hydrocarbons in petroleum source rocks. Modified from Tissot and Welte (1984).

Maximum TOC Value per Well of the Upper Ordovician Shale Interval* in Ohio (*Incl. "Utica," Point Pleasant, Lexington, and Logana)



EXPLANATION

TOC data source

- Core
- Cuttings
- Sidewall core/cuttings

TOC contours - weight %

- 4
- 2
- 1
- 0.5

TOC maximum - weight %

Excellent	>4
Very Good	2–4
Good	1–2
Fair	0.5–1
Poor	0–0.5

DISCLAIMER

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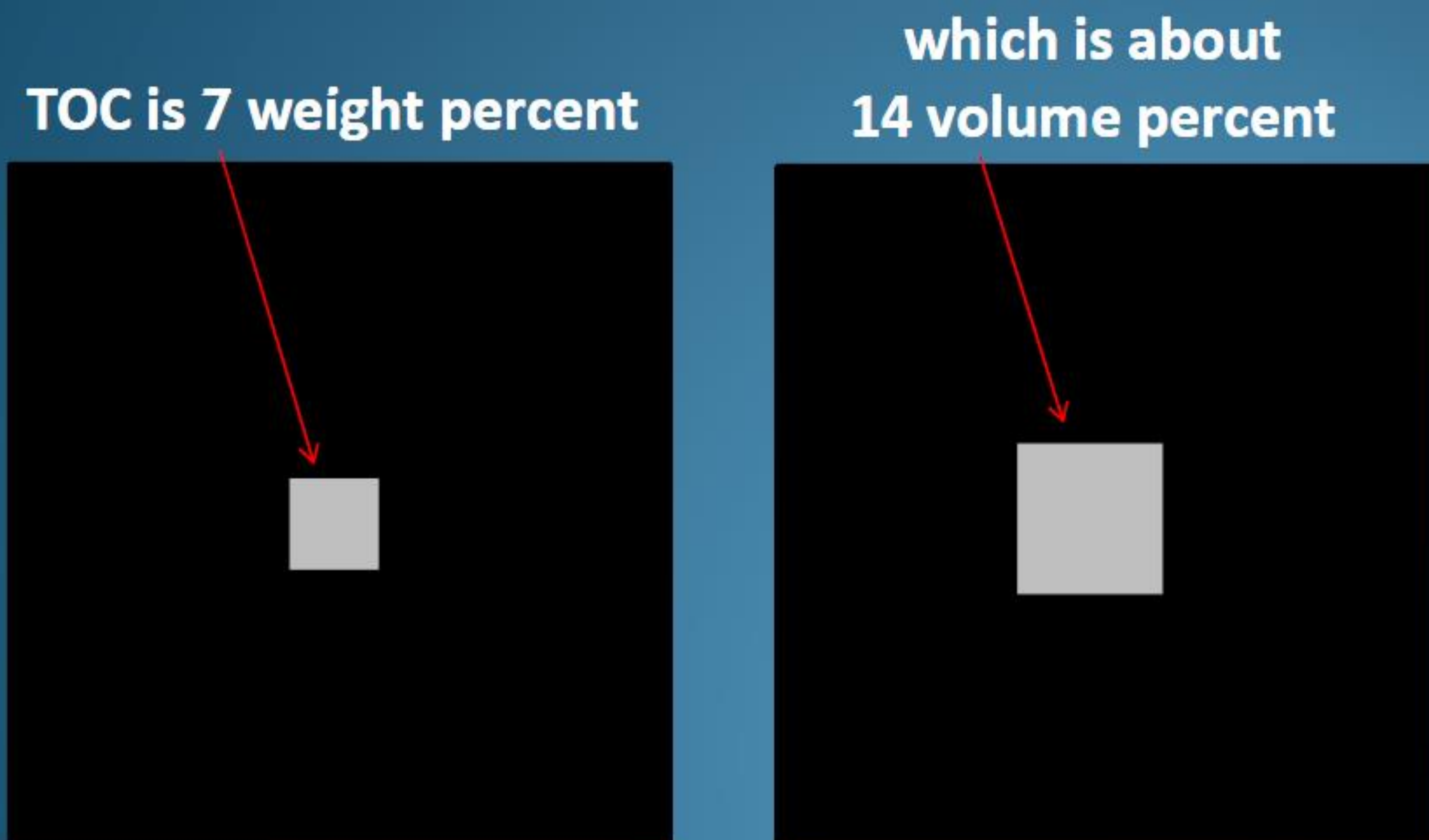
Why is TOC important ?

Porosity Increase due to Organic Carbon Decomposition



After: Jarvie et al., 2012

Formation of Organic Porosity from Generative Organic Carbon

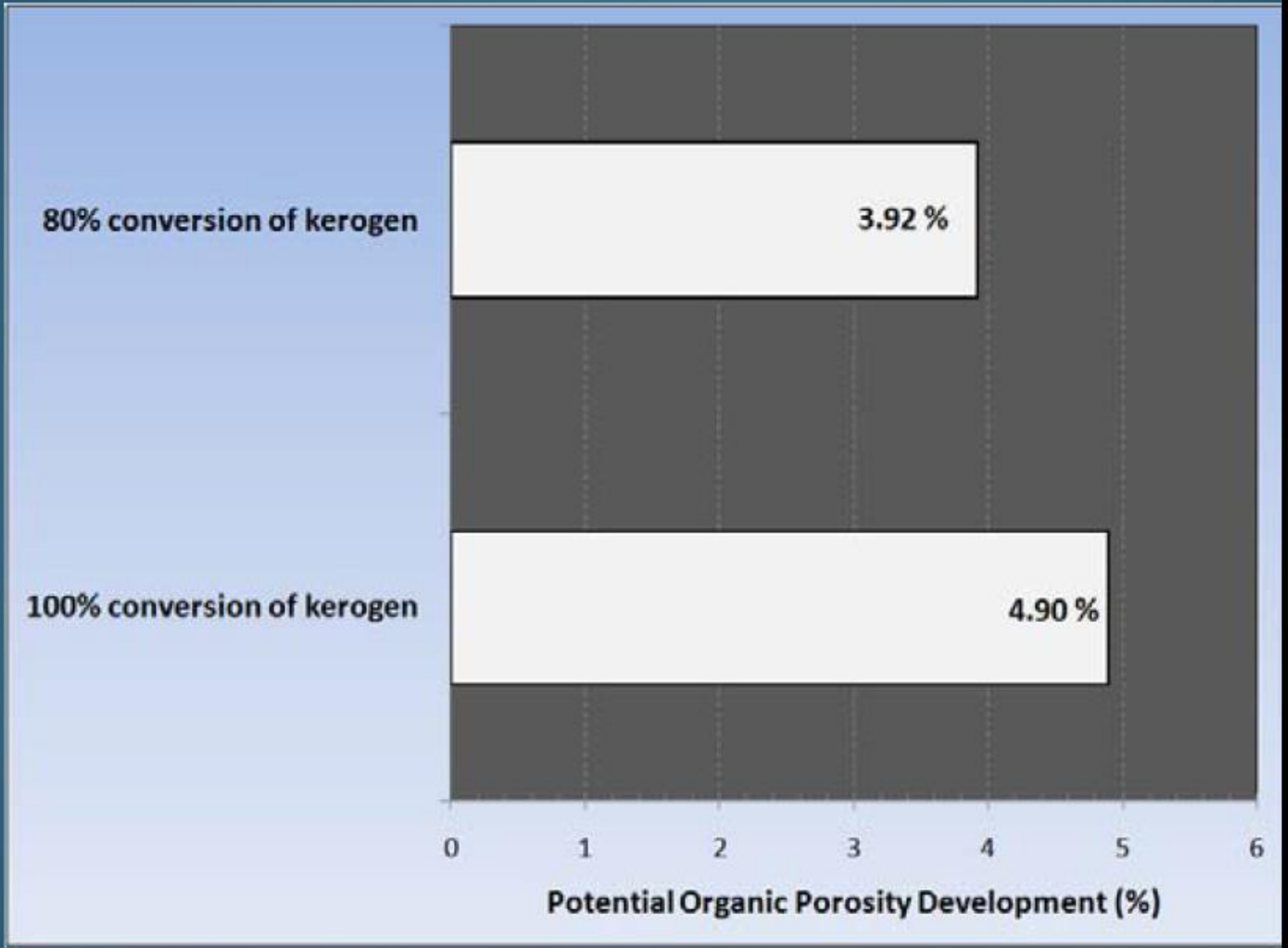
Assumptions:

7.00 wt.% TOC_o

14.00 vol.% TOC_o

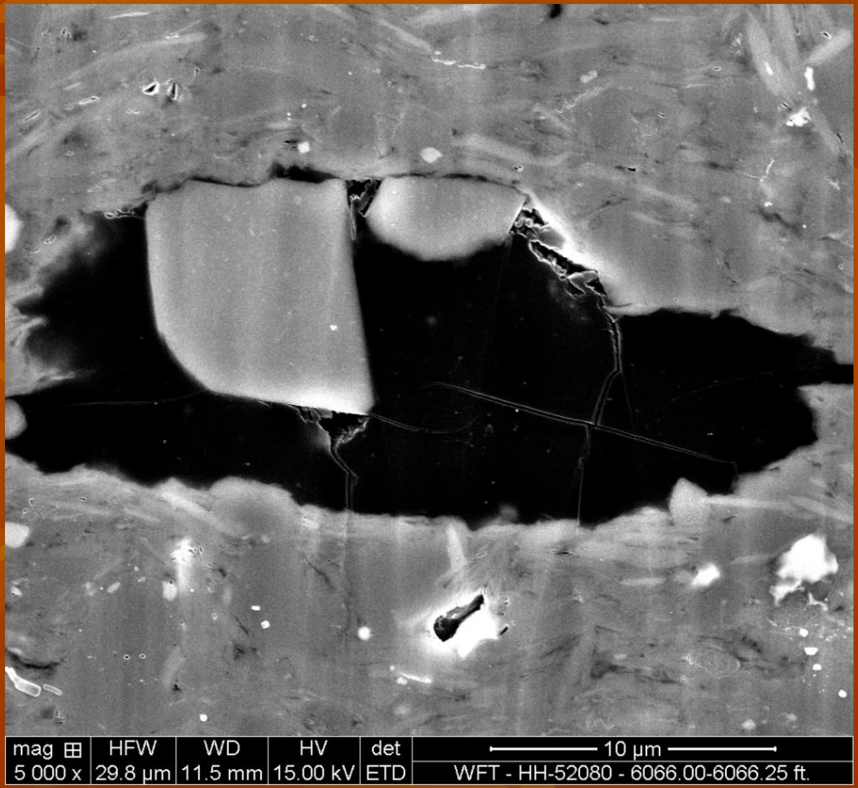
TOC_o is 37% GOC

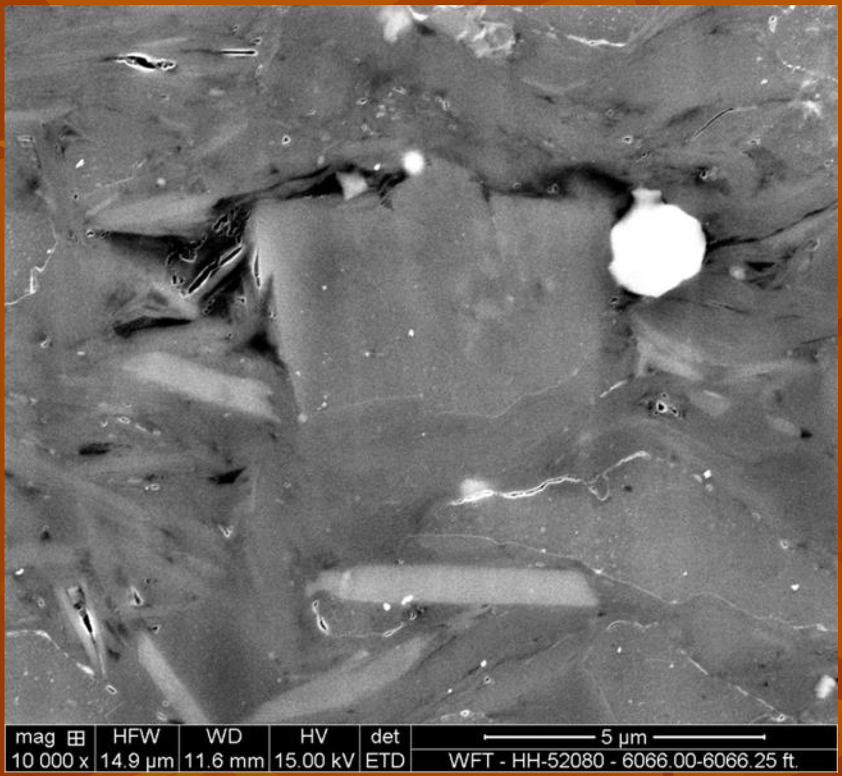
Kerogen density is:
1.1 g/cc GOC
1.4 g/cc NGOC



After: Jarvie et al., 2012

Point Pleasant Organic Porosity Examples

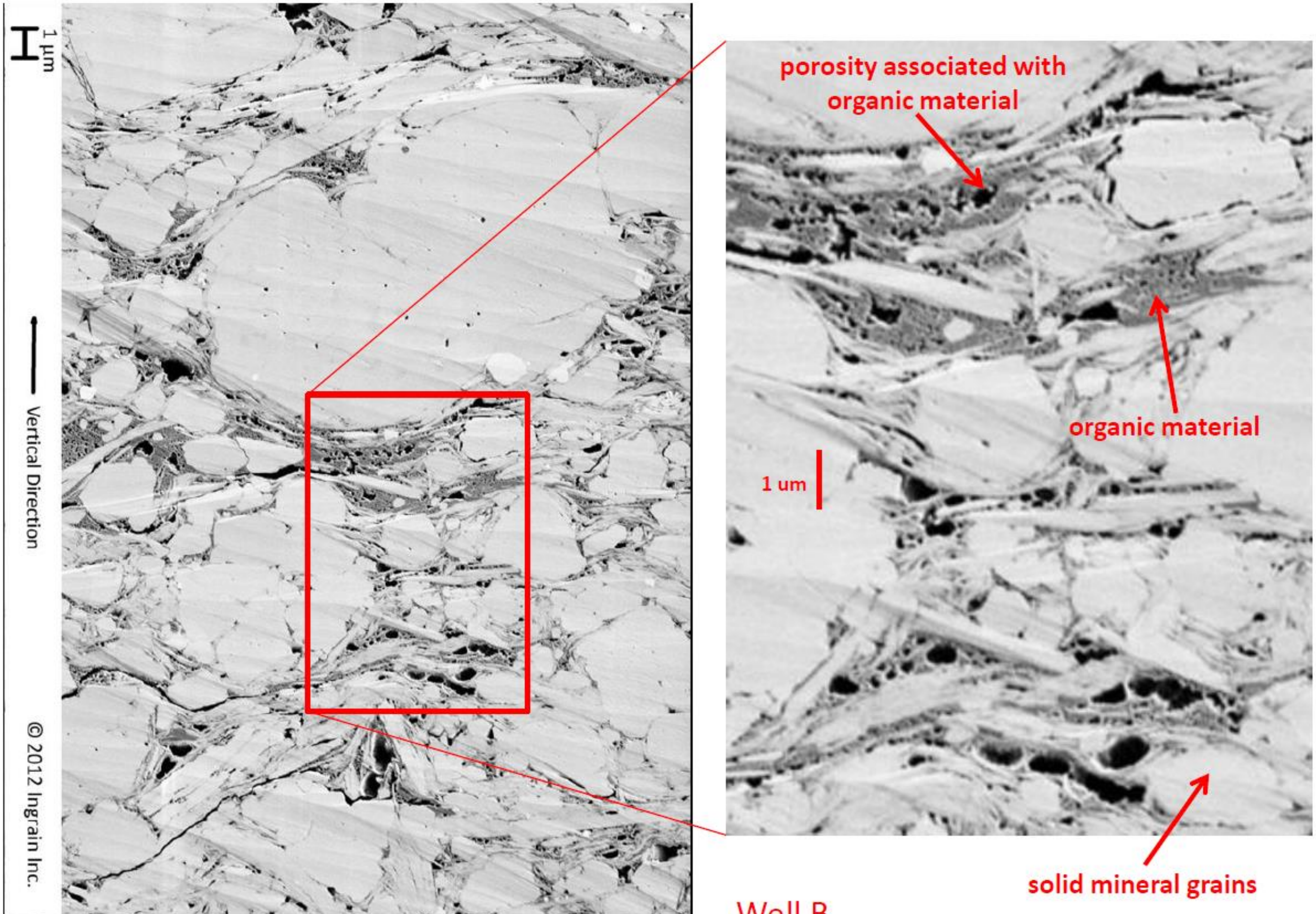




After: Laughrey et al., 2012

Shale Matrix Porosity

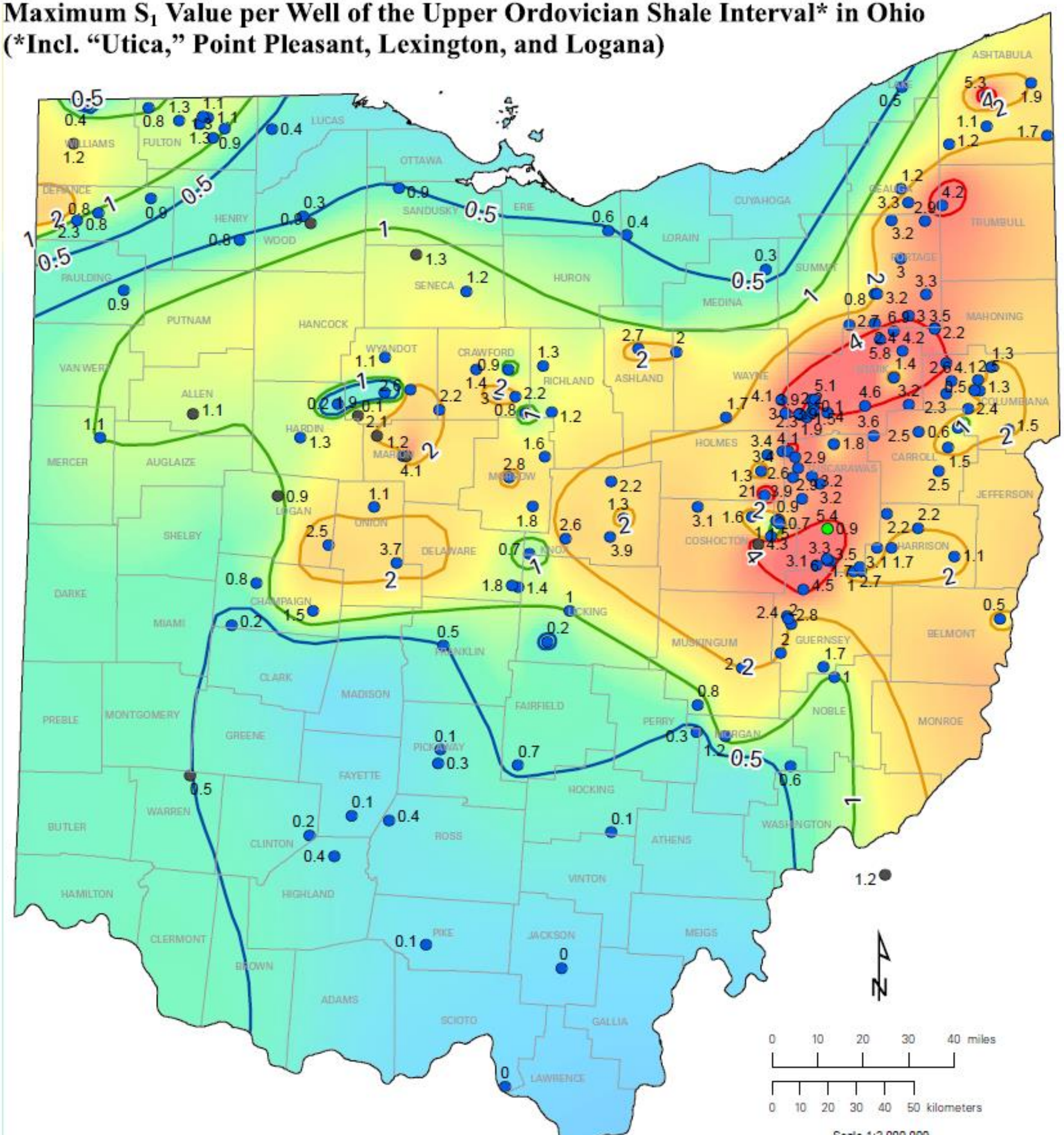
Extensive organic porosity development in Pt Pleasant fm.



www.ingrainrocks.com Well B

Joel Walls, DUG East, 2012

Maximum S_1 Value per Well of the Upper Ordovician Shale Interval* in Ohio
(*Incl. "Utica," Point Pleasant, Lexington, and Logana)



EXPLANATION

S_1 data source

- Core
- Cuttings
- Sidewall core/cuttings

S_1 contours - generative potential mg HC/g of rock

- 4
- 2
- 1
- 0.5

S_1 maximum - generative potential mg HC/g of rock

Excellent	>4
Very Good	2–4
Good	1–2
Fair	0.5–1
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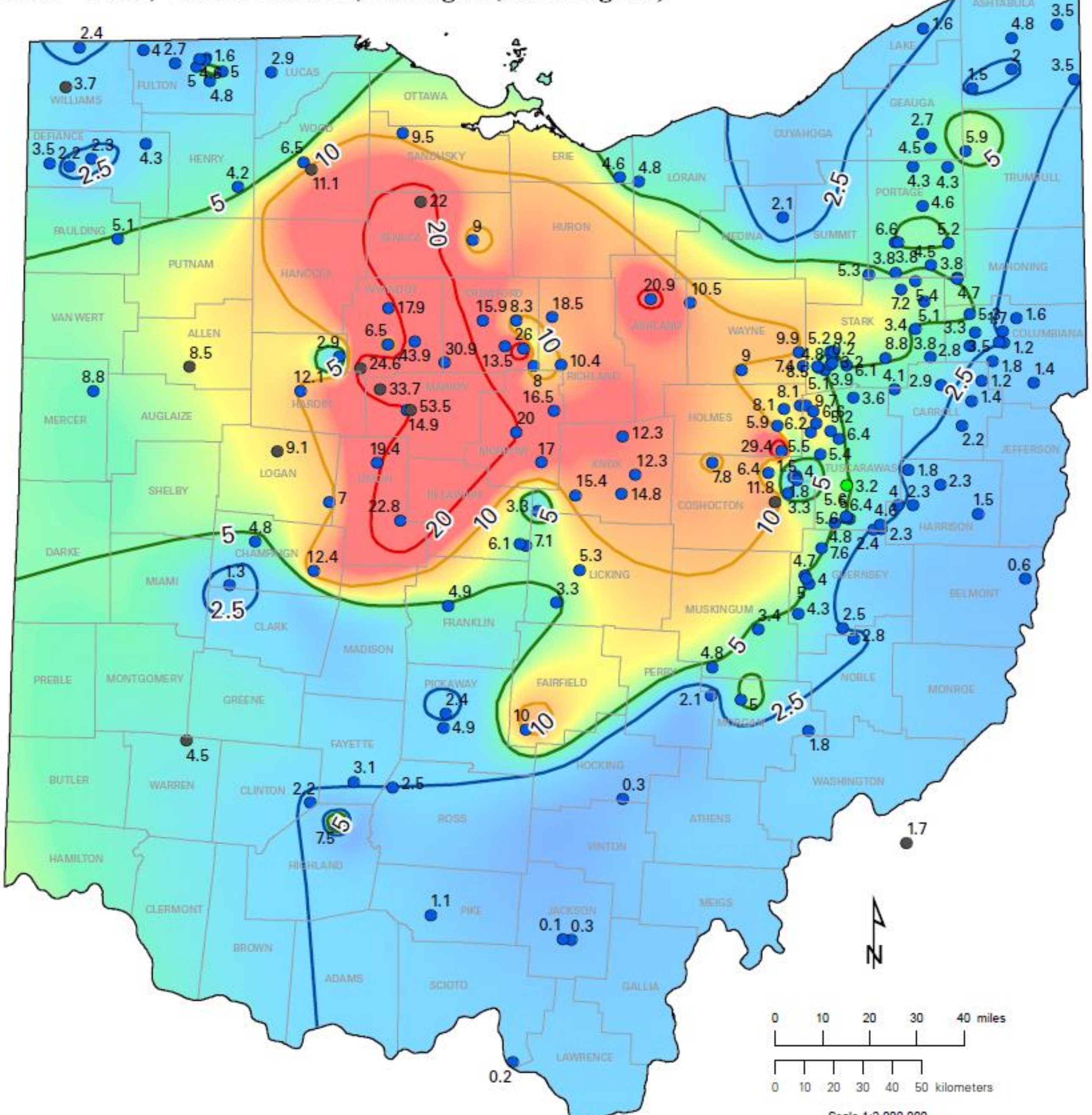
Maximum S_2 Value per Well of the Upper Ordovician Shale Interval* in Ohio
(*Incl. "Utica," Point Pleasant, Lexington, and Logana)



EXPLANATION

S_2 data source

- Core
- Cuttings
- Sidewall core/cuttings

S_2 contours - generative potential mg HC/g of rock

- 20
- 10
- 5
- 2.5

S_2 maximum - generative potential mg HC/g of rock

- >20
- 10–20
- 5–10
- 2.5–10
- 0–2.5

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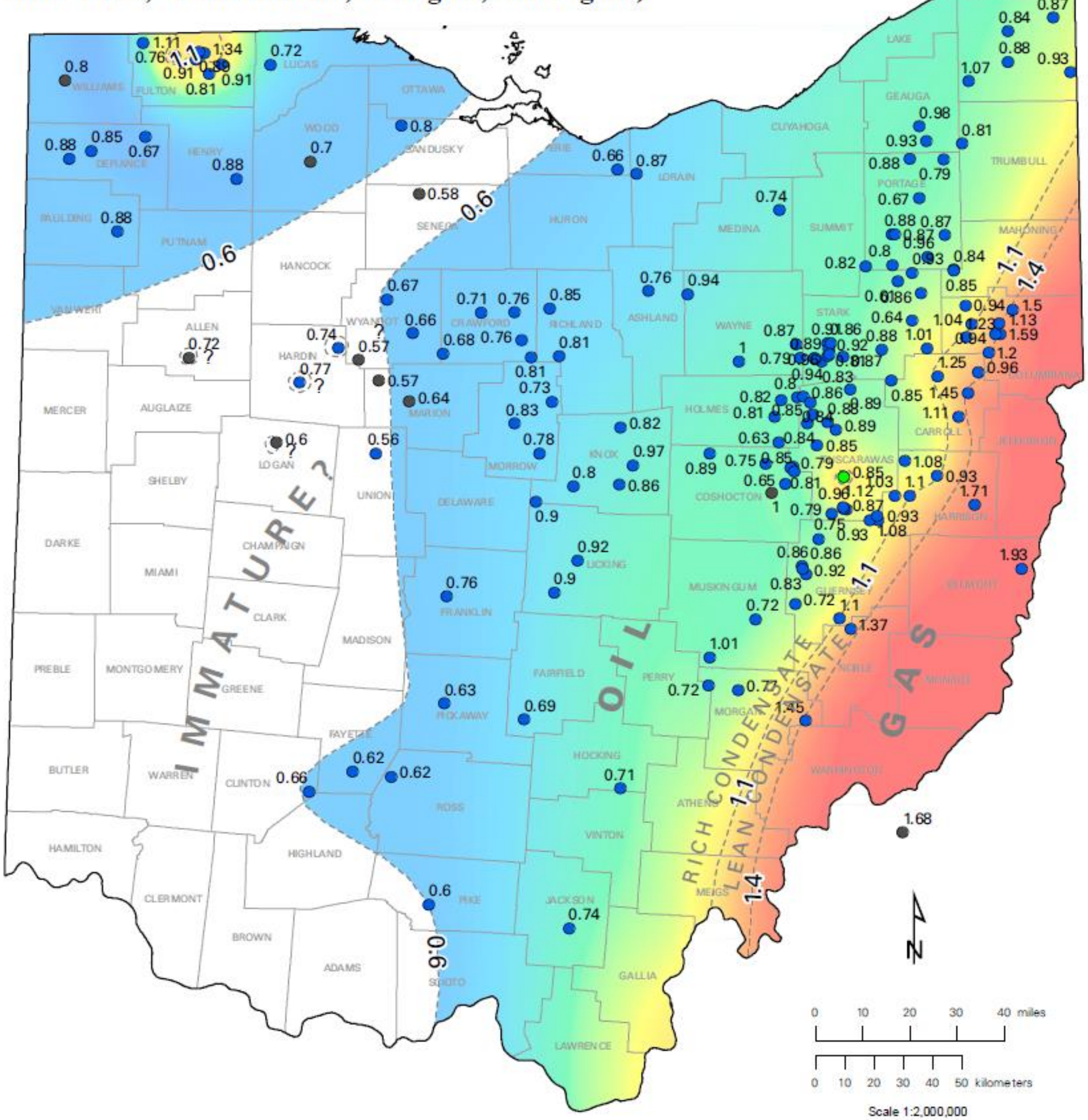
Basic Source-Rock Potential Definitions

- ***Vitrinite Reflectance (Ro)*** is a key diagnostic tool for assessing thermal maturity and is based on measuring the reflectivity (*R*) of vitrinite through a microscope. Vitrinite is a maceral (plant and animal remains) found in many kerogens. As temperature increases, vitrinite undergoes complex alterations that increase the reflectance. Reflectance measurements represent the percent of light reflected in oil, designated as *Ro*. The oil window generally falls within an Ro ranging from 0.6 to 1.4. Because vitrinite is only present in sediments with plants, and there was no plant life yet in the Ordovician, calculations and plots using Tmax and Hydrogen Index (HI), or other means of calibrating a given rock's Ro, are used. Conodont alteration indexing is perhaps the most reliable, but also the most difficult means of estimating maturity of these older sediments.

Calculated %R_o Average per Well of the Upper Ordovician Shale Interval* in Ohio (*Incl. "Utica," Point Pleasant, Lexington, and Logana)



EXPLANATION

% R_o data source

- Core
- Cuttings
- Sidewall core/cuttings

------ % R_o contour

% R_o average

MATURITY

DISCLAIMER

This map was prepared by the Ohio Department of Natural Resources, Division of Geological Survey. Contour lines are interpretive and may not reflect actual geologic conditions. These lines may be modified at a later date and should not be considered absolute or final. Dashed lines indicate a higher degree of uncertainty and reflect interpreted trends. Analyses of TOC, S1, S2 and other geochemical characteristics may not indicate recoverable hydrocarbons and should not be used for property valuation purposes. Neither the State of Ohio nor any of its agencies, nor any person acting on its behalf:
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Ohio Department of Natural Resources
Division of Geological Survey
11/23/2012

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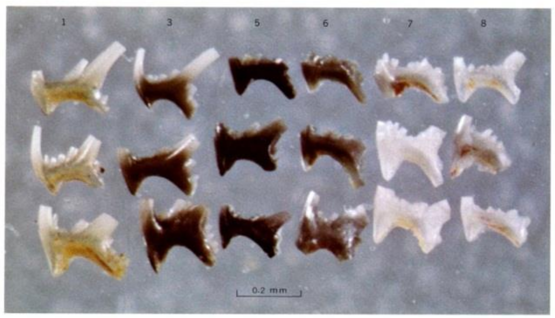
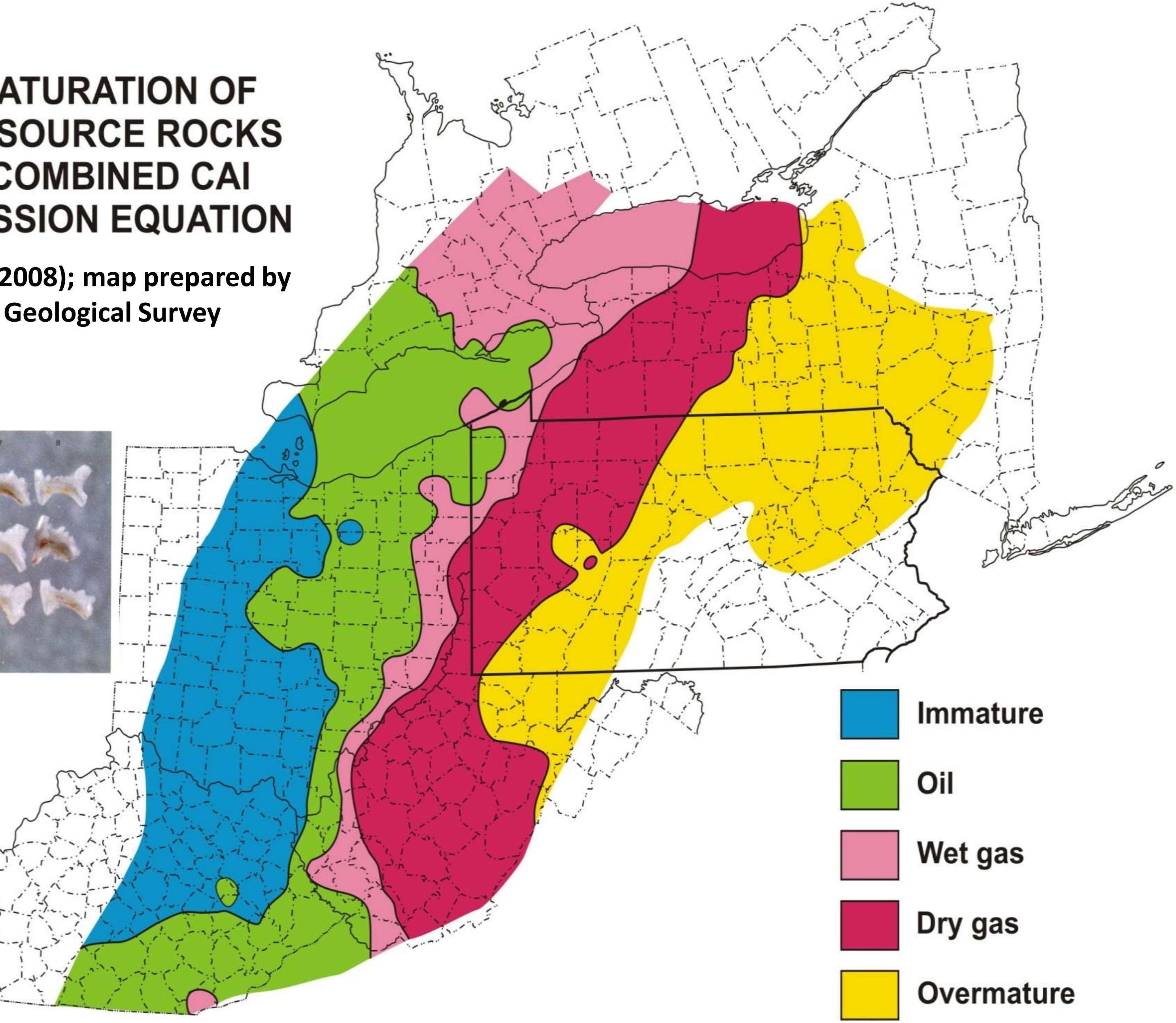
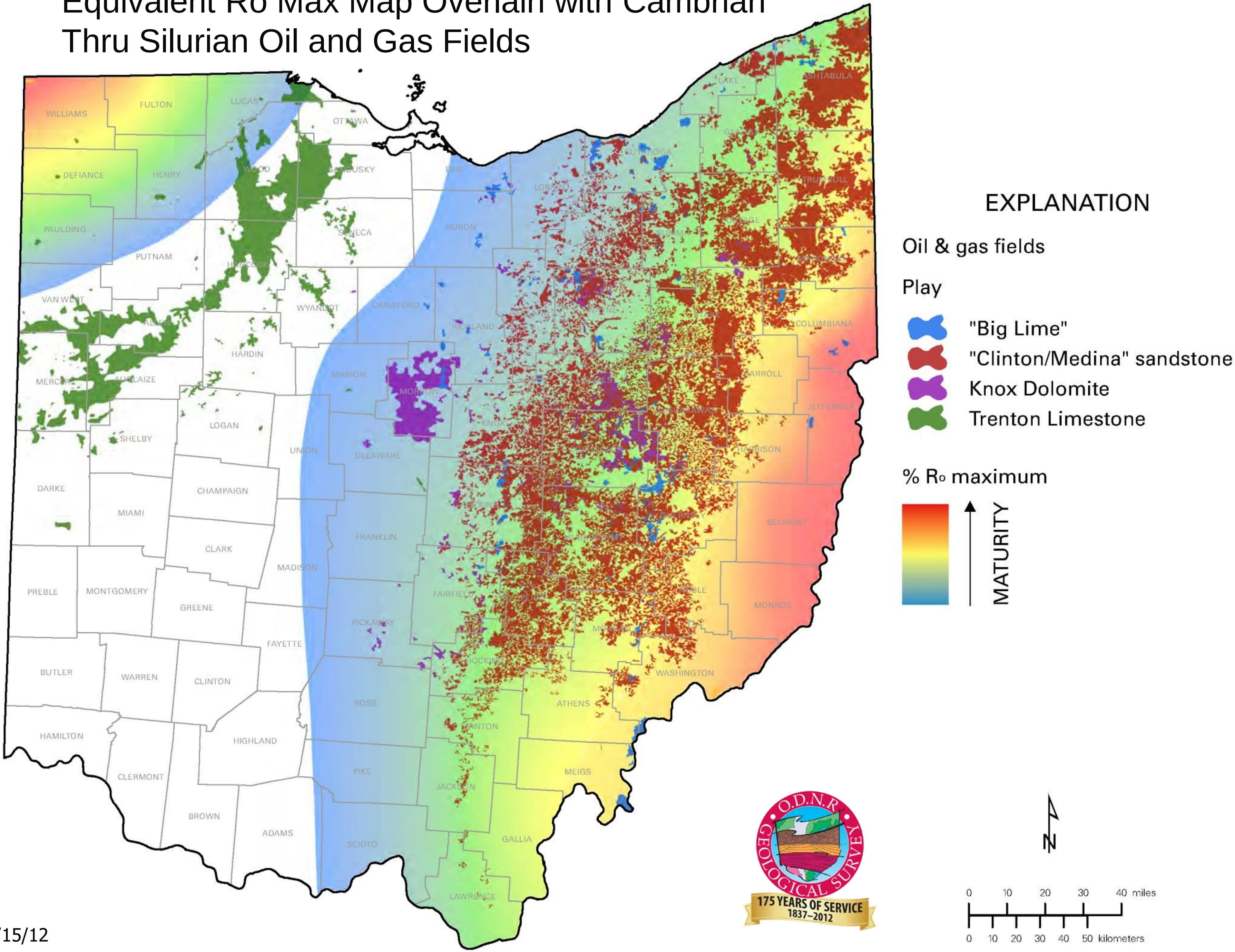
THERMAL MATURATION OF ORDOVICIAN SOURCE ROCKS BASED ON COMBINED CAI TO Ro REGRESSION EQUATION

From Repetski and others (2008); map prepared by John Harper, Pennsylvania Geological Survey





Equivalent Ro Max Map Overlain with Cambrian Thru Silurian Oil and Gas Fields



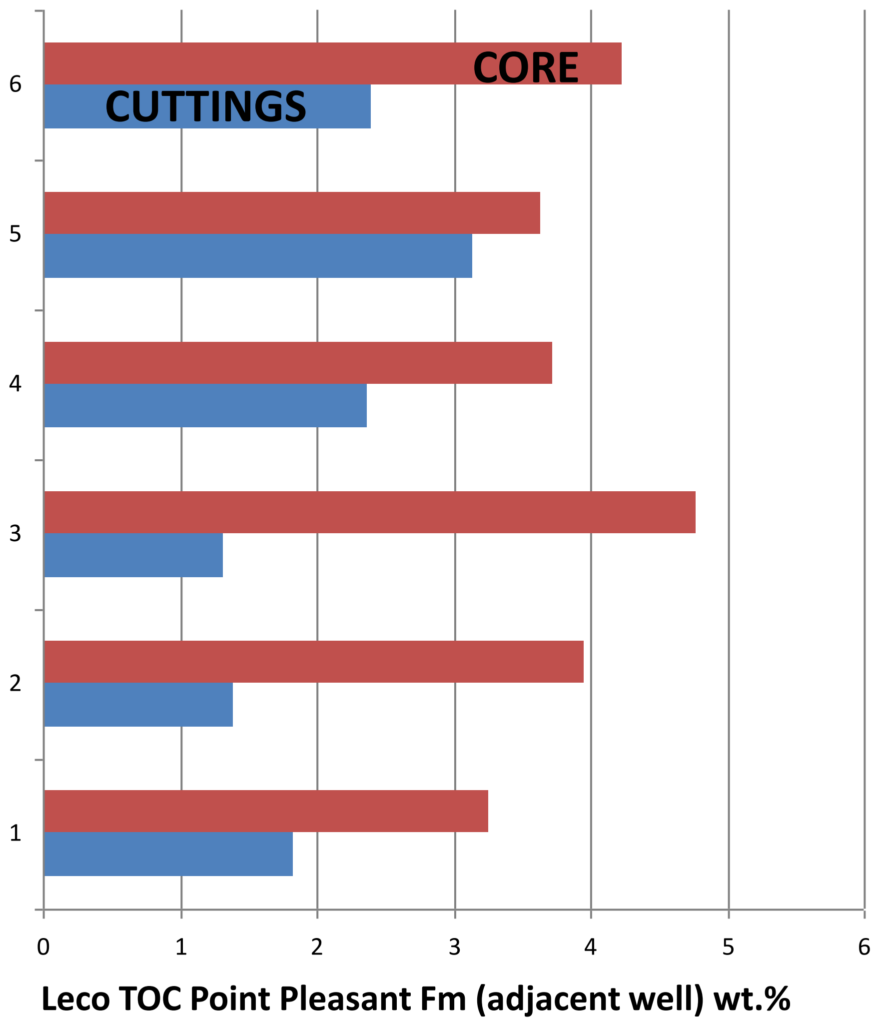
3/15/12

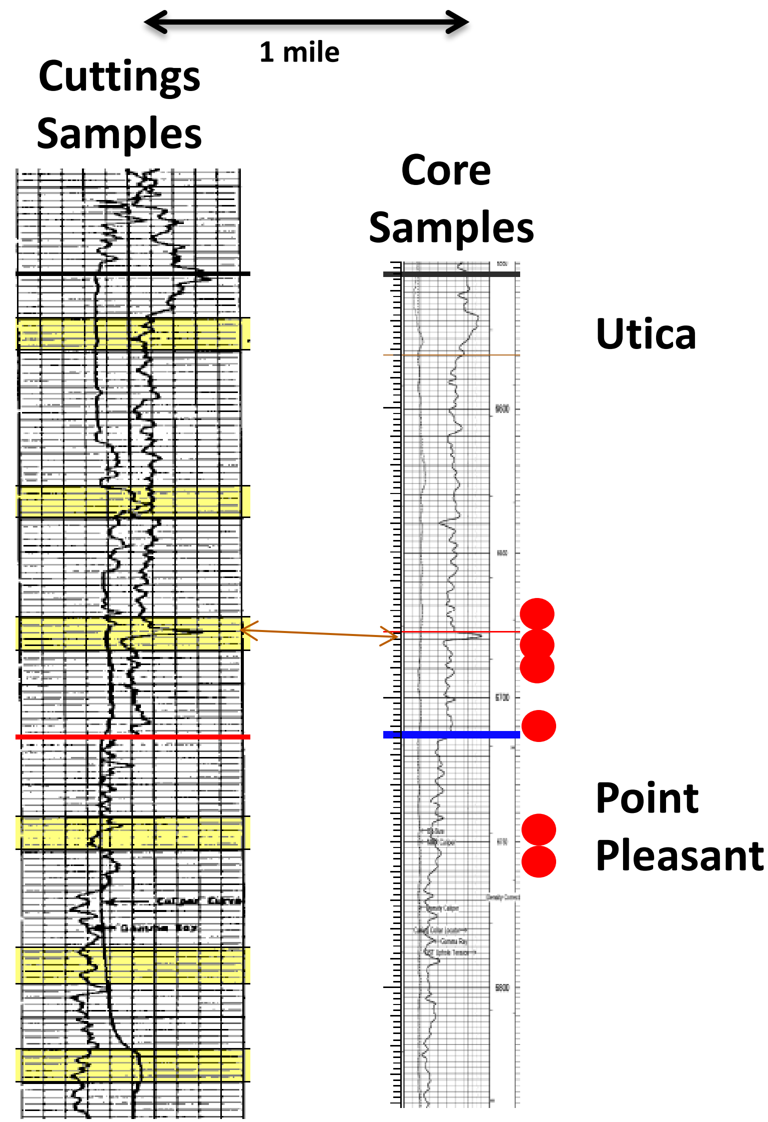
UTICA - POINT PLEASANT SOURCED CONVENTIONAL PRODUCTION IN OHIO

RESERVOIR	OIL (mmbo)	GAS (mmmcf)	BOE (mmbo)
• Trenton-Black River	380	1,000	546
• Clinton-Medina	180	5,000	1,013
• Knox Sands & Dolo	50	360	110
• TOTAL	610	6,360	1,669

J. Wicks, 2011

PITFALLS: Underestimation of Present Day TOC: Sample Dilution

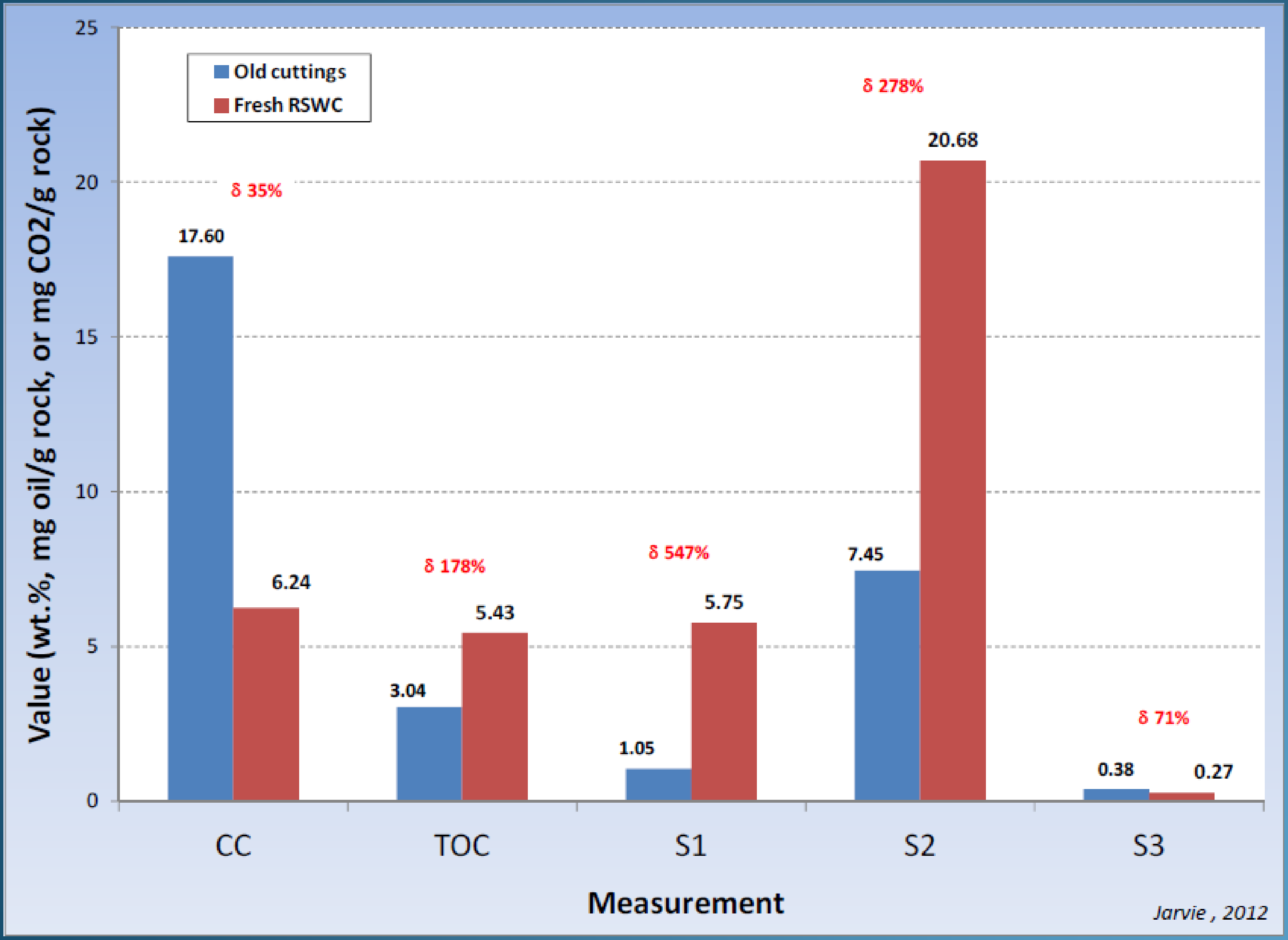




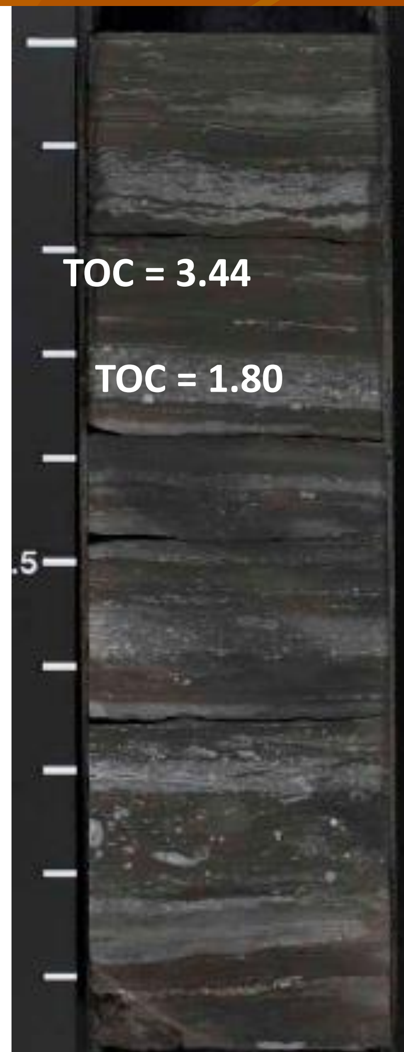
From: Laughrey et al., 2012

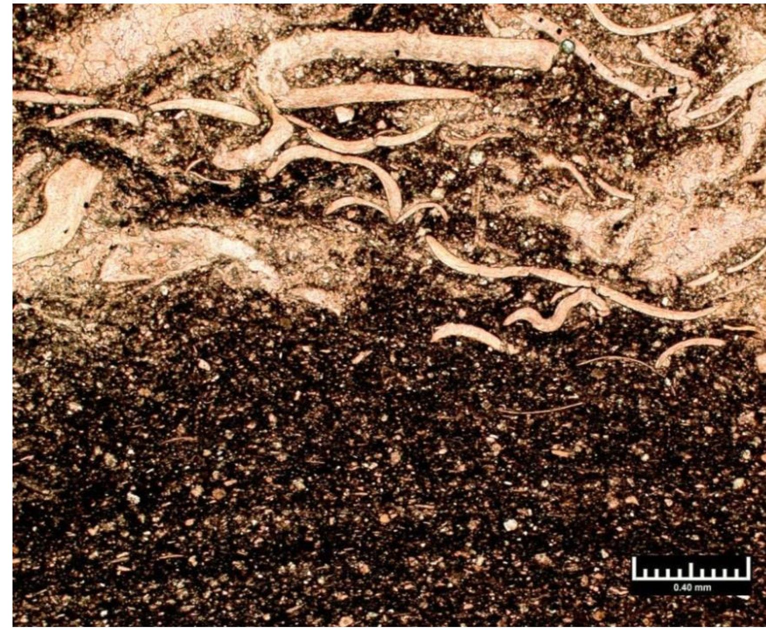
Change in Various Geochemical Measurements due to age, sample type

(data from 1980s well and new offset well)



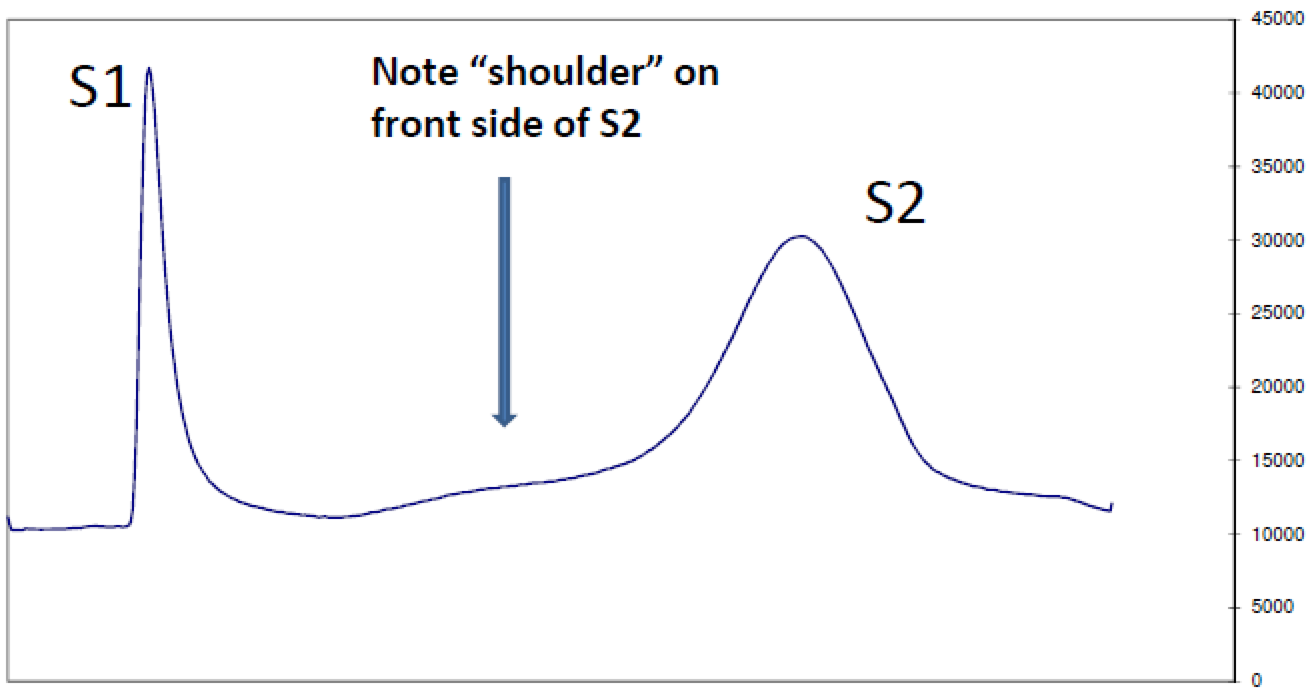
Underestimation of Present Day TOC





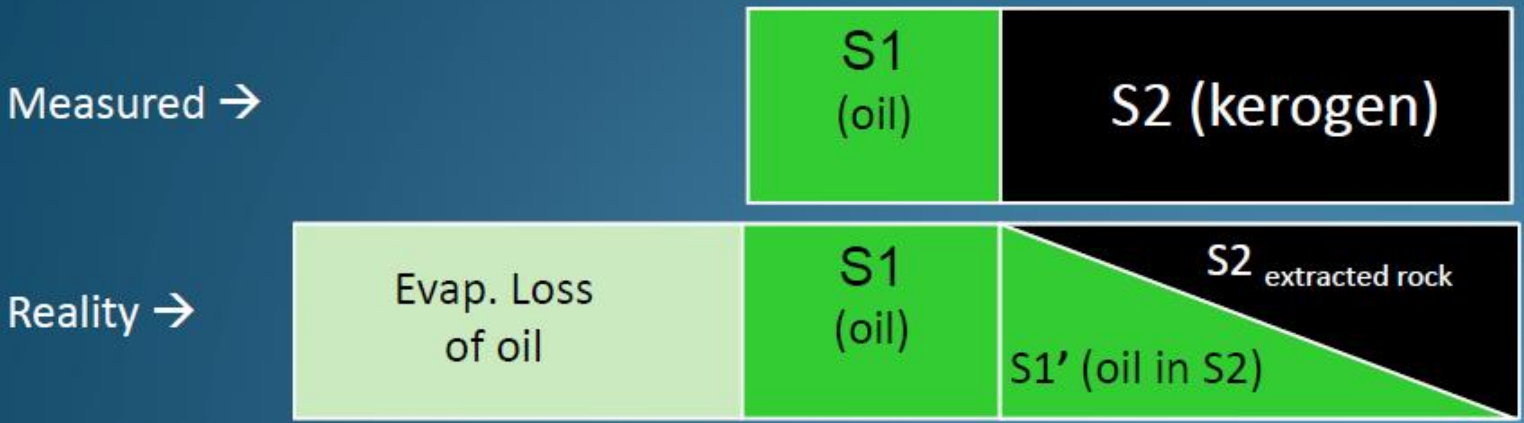
PITFALLS: Underestimation of S1, inflation of S2 & inaccurate Tmax

S1 Carry over: Inflates S2 value



2009 Weatherford Laboratories

Oil Content in Rock Sample as measured by thermal extraction



Overlap of free oil and oil carried over into S2
This is a function of oil type and isolated organic pores

Total Oil = $(S1_{WR} - S1_{\text{extracted rock}}) + (S2_{\text{whole rock}} - S2_{\text{extracted rock}}) + E.L.$

Evaporative Losses = S1 x (GC Fingerprint produced oil / GC Fingerprint of extracted oil)
This technique also allows prediction of GOR on <u>shale (rock) samples.</u>

After: Jarvie et al., 2012

A Respected Group of Geochemists Summarize the Source Rock Potential:

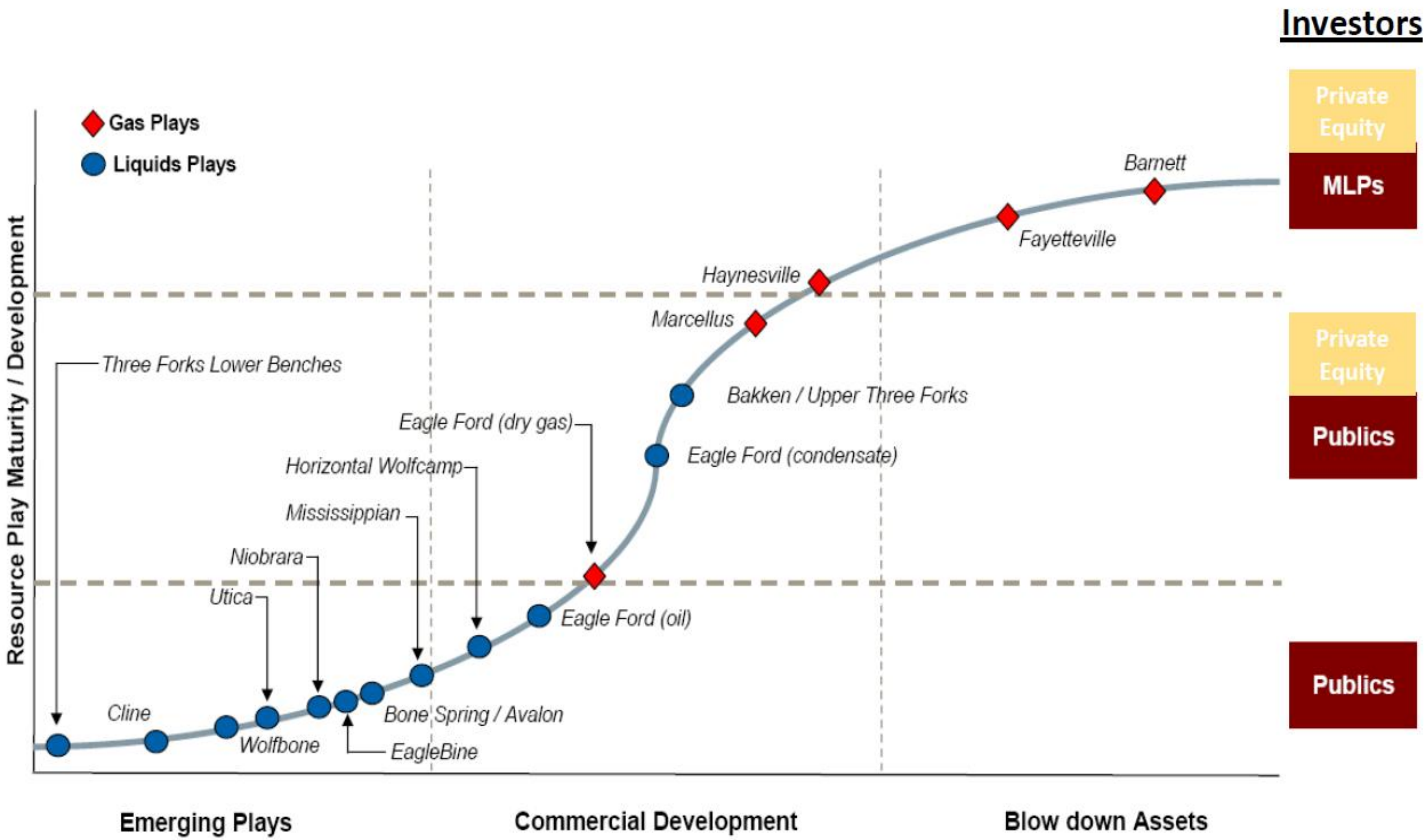
Utica-Point Pleasant

- Organic content in eastern Ohio is very high
- Organic matter is very rich and oil-prone
- The maturity ranges from dry gas in the east to early oil (westward) in the central part of the state over about 100-mile distance
- Significant hydrocarbon generation has occurred across the area and the hydrocarbon content is quite high
- The majority of the hydrocarbons are being generated in the Point Pleasant, but the overlying Utica is also prospective
- The high carbonate content of the entire section suggests fracing could be very effective for production

From: Reed, Brown, and Zumberge: DUG East, November 2011

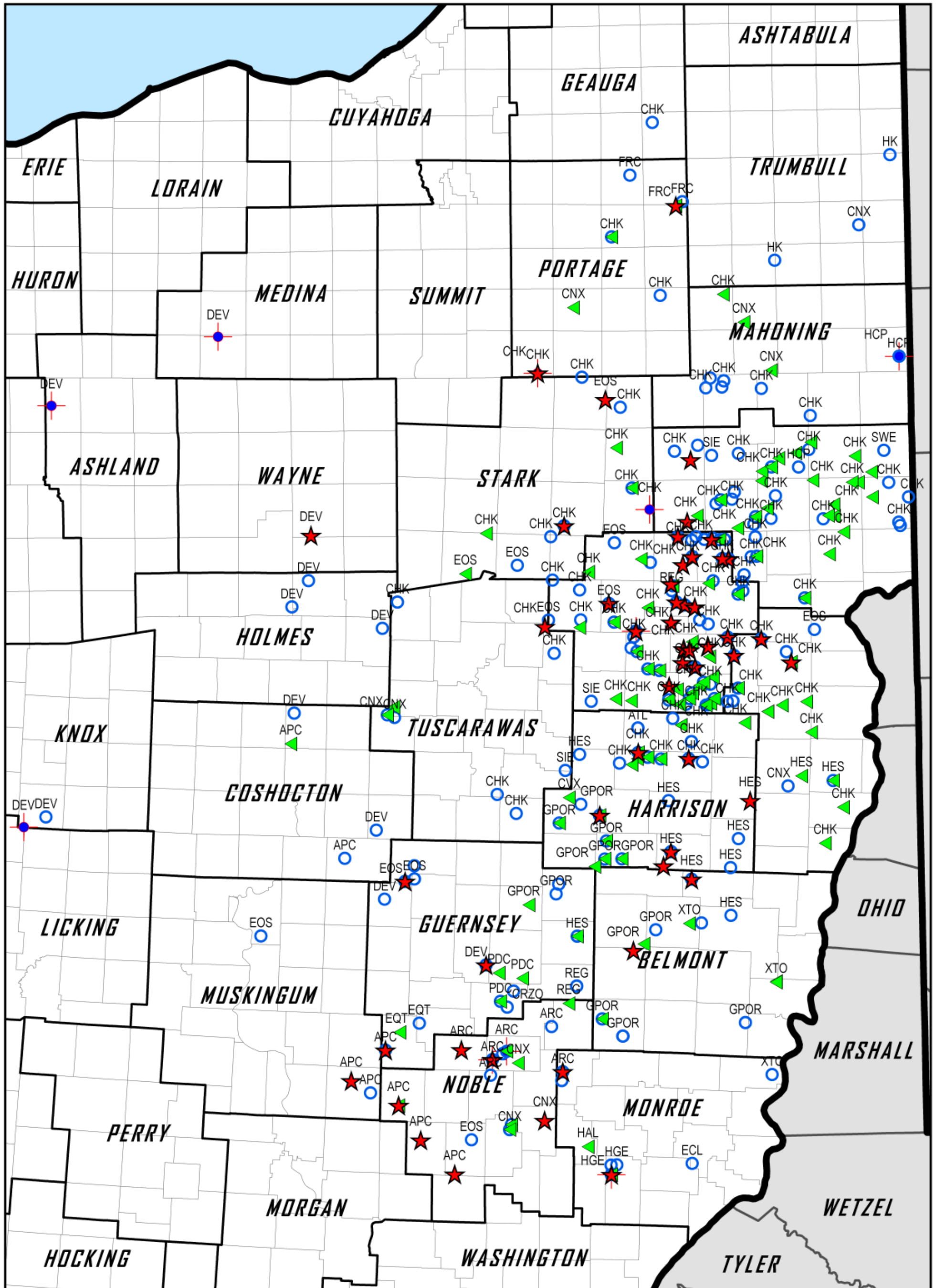
Activity Update

Stages of Resource Plays



Source: RBC Richardson Barr

UTICA HORIZONTAL WELL STATUS THROUGH 3/2/2013



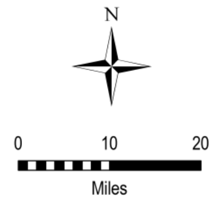
PERMITTED OR NOT DRILLED (286)

PRODUCING (73)

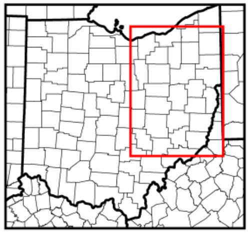
DRILLED, DRILLING OR INACTIVE (173)

PLUGGED (11)

OPERATOR	LBL	PROD	PMT	DRLG	DRLD	PLUG	INAC	NDRD	TOT
ANADARKO E & P ONSHORE LLC	APC	6	4	1	1	0	0	0	12
ANTERO RES APPALACHIAN CORP	ARC	3	11	1	1	2	0	0	18
ATLAS NOBLE LLC	ATL	0	5	0	0	0	0	0	5
CHEASPEAKE EXPLORATION LLC	CHK	49	162	2	125	3	1	4	346
CNX GAS COMPANY LLC	CNX	1	9	3	7	0	0	1	21
CARRIZO (UTICA) LLC	CRZO	0	2	0	0	0	0	0	2
CHEVRON APPALACHIA LLC	CVX	0	0	0	2	0	0	0	2
DEVON ENERGY PRODUCTION CO	DEV	2	6	0	0	3	0	2	13
ECLIPSE RESOURCES I LP	ECL	0	1	0	0	0	0	0	1
ENERVEST OPERATING LLC	EOS	3	12	0	1	0	0	0	16
EQT PRODUCTION COMPANY	EQT	0	2	0	1	0	0	0	3
MOUNTAINEER KEYSTONE LLC	FRC	1	5	0	1	0	0	0	7
GULFPORT ENERGY CORPOTATION	GPOR	3	18	4	5	0	0	1	31
HALL DRILLING LLC (OIL & GAS)	HAL	0	0	1	0	0	0	0	1
HILCORP ENERGY	HCP	0	2	0	0	1	0	0	3
HESS OHIO RESOURCES LLC	HES	3	13	1	2	0	0	0	19
HG ENERGY	HGE	1	10	1	0	2	2	0	16
HALCON OPERATING COMPANY	HK	0	2	0	0	0	0	0	2
PETROLEUM DEVELOPMENT CORP	PDC	0	1	1	2	0	0	0	4
R E GAS DEVELOPMENT LLC	REG	1	8	0	4	0	0	0	13
SIERRA RESOURCES LLC	SIE	0	3	0	0	0	0	0	3
SWEPI LP	SWE	0	1	0	0	0	0	0	1
XTO ENERGY INC.	XTO	0	1	1	2	0	0	0	4
	TOTALS	73	278	16	154	11	3	8	543



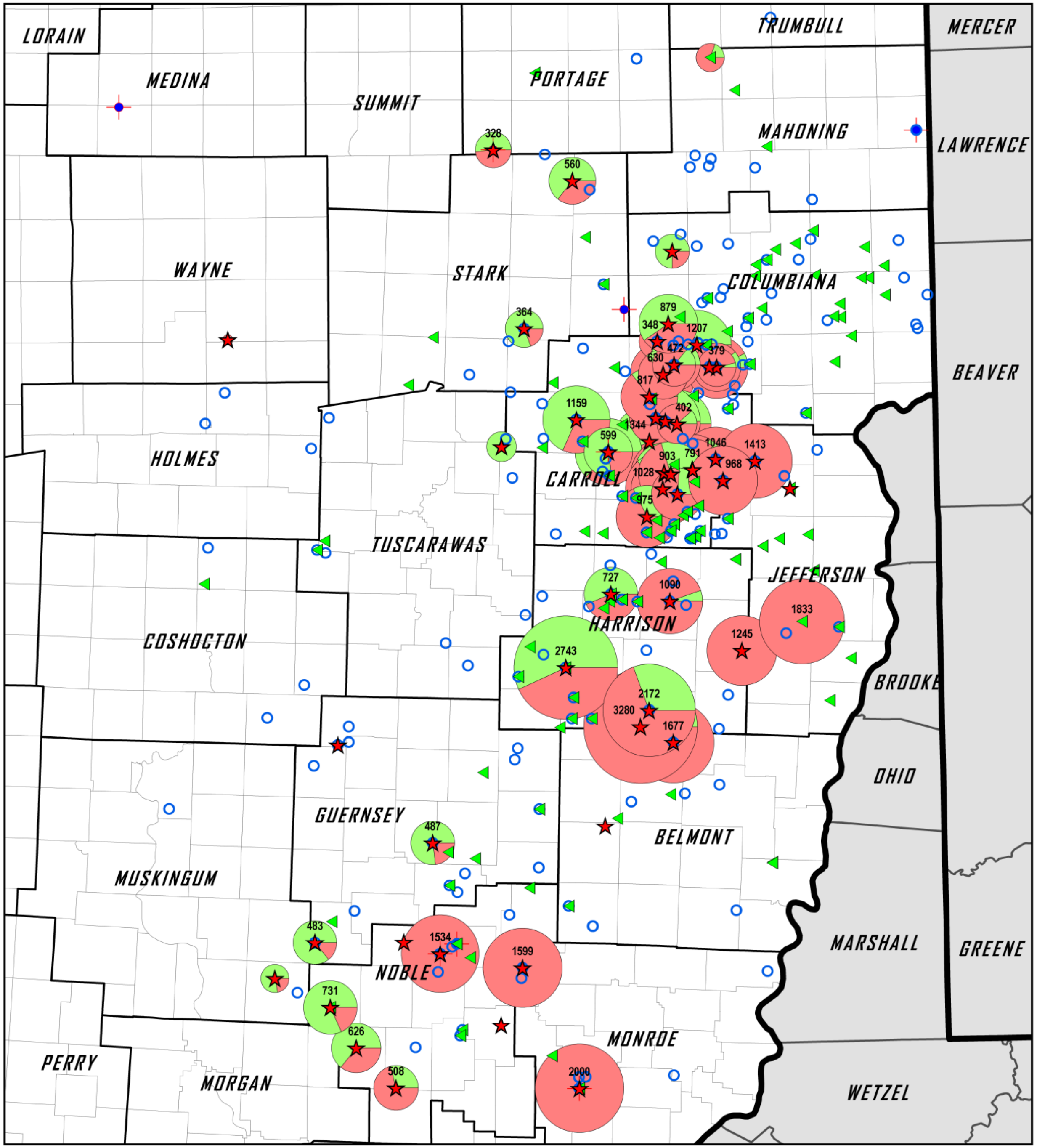
KEY	DESCRIPTION
DRLD	DRILLED
DRLG	DRILLING
INAC	INACTIVE
NDRD	NOT DRILLED
PMT	PERMITTED
PLUG	PLUGGED
PROD	PRODUCING



WICKSTROM GEOSCIENCE
(614) 301-6721

MacKenzie
Land & Exploration Ltd.
www.mackex.com
(614) 785-1682

UTICA HORIZONTAL WELL STATUS THROUGH 3/2/2013 REPORTED INITIAL PRODUCTION



- PERMITTED OR NOT DRILLED (286)
- PRODUCING (73)
- DRILLED, DRILLING OR INACTIVE (173)
- PLUGGED (11)

BBLS OIL EQUIVALENT PER DAY

1,000

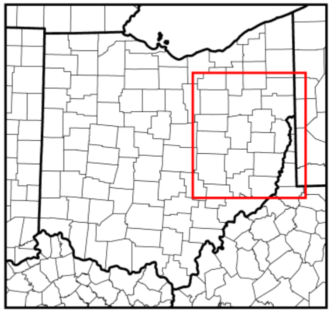
- PRODUCED AS OIL
- PRODUCED AS GAS

IP VALUES AS REPORTED TO THE STATE ON COMPLETION REPORTS. BARRELS OF OIL EQUIVALENT (BOE/D) CALCULATED AS 6 MCF NATURAL GAS PER DAY EQUALS 1 BOE/D. IP VALUES GREATER THAN 300 BOE/D ARE POSTED.

N

0 10 20

Miles



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Utica Shale – Summary of Wells Tested

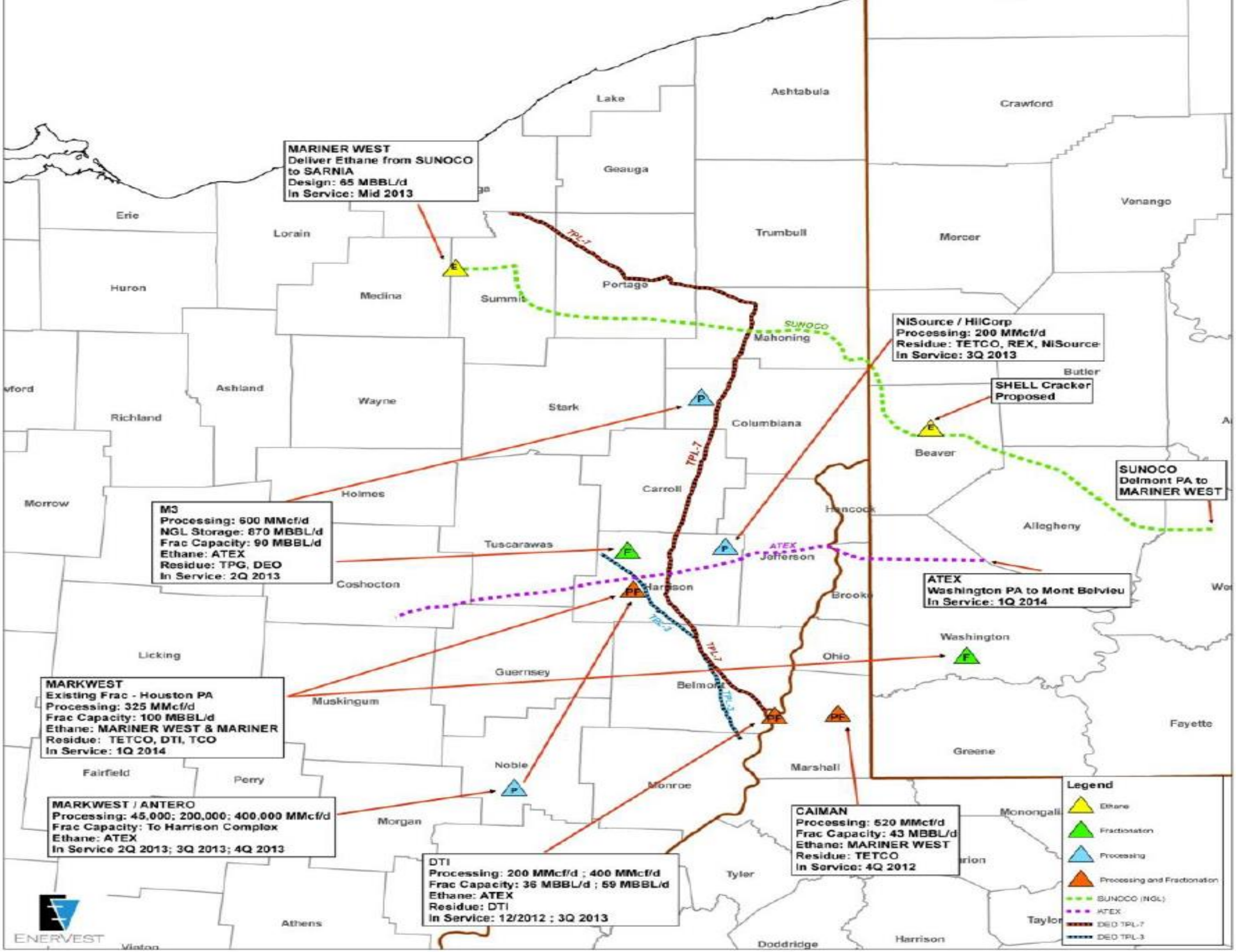
Well Name	County	Completion Date	Length of Lateral (feet)	Frac Stages	Peak IP Test (Boe/d) [1]	Production Mix: Oil	Gas	NGLs	Shrink Factor [1]
Wagner 1-28H	Harrison	5/28/12	8,143	28	4,650	9%	50%	40%	18%
Boy Scout 1-33H	Harrison	6/13/2012	7,974	22	3,456	45%	26%	29%	25%
Groh 1-12H	Guernsey	7/7/2012	5,414	16	1,935	61%	20%	19%	18%
Shugert 1-1H	Belmont	7/27/2012	5,758	16	4,911	3%	56%	41%	17%
Ryser 1-25H	Harrison	8/11/2012	8,291	23	2,914	51%	27%	22%	21%
BK Stephens 1-14H [2]	Harrison	9/19/2012	5,276	19	3,007	41%	34%	25%	11%

- First six wells averaged a peak rate of 1,006 barrels of condensate per day, 8.17 MMCF of natural gas per day and 1,111 barrels of NGLs, or 3,479 BOEPD [1]
  - Production mix of included approximately 29% condensate, 39% natural gas, and 32% natural gas liquids

Source: Company filings
(1) Assumes full ethane recovery

GULFPORT ENERGY CORPORATION

Infrastucture



MARINER WEST
Deliver Ethane from SUNOCO to SARNIA
Design: 65 MBBL/d
In Service: Mid 2013
Lake
Ashtabula
Crawford
Geauga
Venango
Erie
Lorain
Trumbull
Mercer
Huron
Medina
Summit
Portage
TPL-7
SUNOCO
Mahoning
NiSource / HilCorp
Processing: 200 MMcf/d
Residue: TETCO, REX, NiSource
In Service: 3Q 2013
Butler
SHELL Cracker
Proposed
Ashland
Wayne
Stark
Columbiana
Richland
Beaver
SUNOCO
Delmont PA to MARINER WEST
Holmes
Carroll
Morrow
Hancock
Allegheny
M3
Processing: 600 MMcf/d
NGL Storage: 870 MBBL/d
Frac Capacity: 90 MBBL/d
Ethane: ATEX
Residue: TPG, DEO
In Service: 2Q 2013
Tuscarawas
ATEX
Jefferson
Coshocton
Harrison
Brooke
ATEX
Washington PA to Mont Belvieu
In Service: 1Q 2014
TPL-3
Washington
Licking
Ohio
Guernsey
MARKWEST
Existing Frac - Houston PA
Processing: 325 MMcf/d
Frac Capacity: 100 MBBL/d
Ethane: MARINER WEST & MARINER
Residue: TETCO, DTI, TCO
In Service: 1Q 2014
Muskingum
Belmont
Fayette
Greene
Fairfield
Perry
Noble
Marshall
Monroe
MARKWEST / ANTERO
Processing: 45,000; 200,000; 400,000 MMcf/d
Frac Capacity: To Harrison Complex
Ethane: ATEX
In Service 2Q 2013; 3Q 2013; 4Q 2013
Morgan
CAIMAN
Processing: 520 MMcf/d
Frac Capacity: 43 MBBL/d
Ethane: MARINER WEST
Residue: TETCO
In Service: 4Q 2012
Monongalia
DTI
Processing: 200 MMcf/d ; 400 MMcf/d
Frac Capacity: 36 MBBL/d ; 59 MBBL/d
Ethane: ATEX
Residue: DTI
In Service: 12/2012 ; 3Q 2013
Tyler
Athens
Taylor
Doddridge
Harrison
Legend
Ethane
Fractionation
Processing
Processing and Fractionation
SUNOCO (NGL)
ATEX
DEO TPL-7
DEO TPL-3
ENERVEST

Summary

- Organic-rich mixed-carbonate/siliciclastic mudstones in the Upper Ordovician Utica, Point Pleasant, and Trenton formations are important source rocks in the northern Appalachian basin and are the target of tight-oil and shale-gas exploration and development, particularly in eastern Ohio.
- This activity is dictated by geology, and by geochemical screening parameters routinely employed to map and constrain the generative potential, kerogen type/expelled product, and thermal maturation of source rocks.

Summary

- Careful scrutiny of data derived from these screening methods, and comparisons with data from more advanced geochemical tools, such as stable isotope, light hydrocarbon, and biomarker analyses, reveal potential pitfalls in interpreting the geochemistry of these rocks. Caution must be applied when interpreting source rock data.

From: Laughrey et al,, 2012

Summary

- Permitting and drilling activity remain fairly high, but completions and production are lagging, due largely to inadequate infrastructure.
- Many pipeline and processing plant projects are underway or being planned. Between 1st QTR 2013 and 1st QTR 2014 we should see a number of these projects completed – if economics stay favorable...

Acknowledgments

- Many of the maps and slides were obtained from the Ohio Geological Survey and I thank them for their continued good work.
- Some material borrowed from a paper co-authored with Chris Laughrey and others at the 2012 Eastern Section AAPG meeting.
- Air photos courtesy of Tim Cox.