

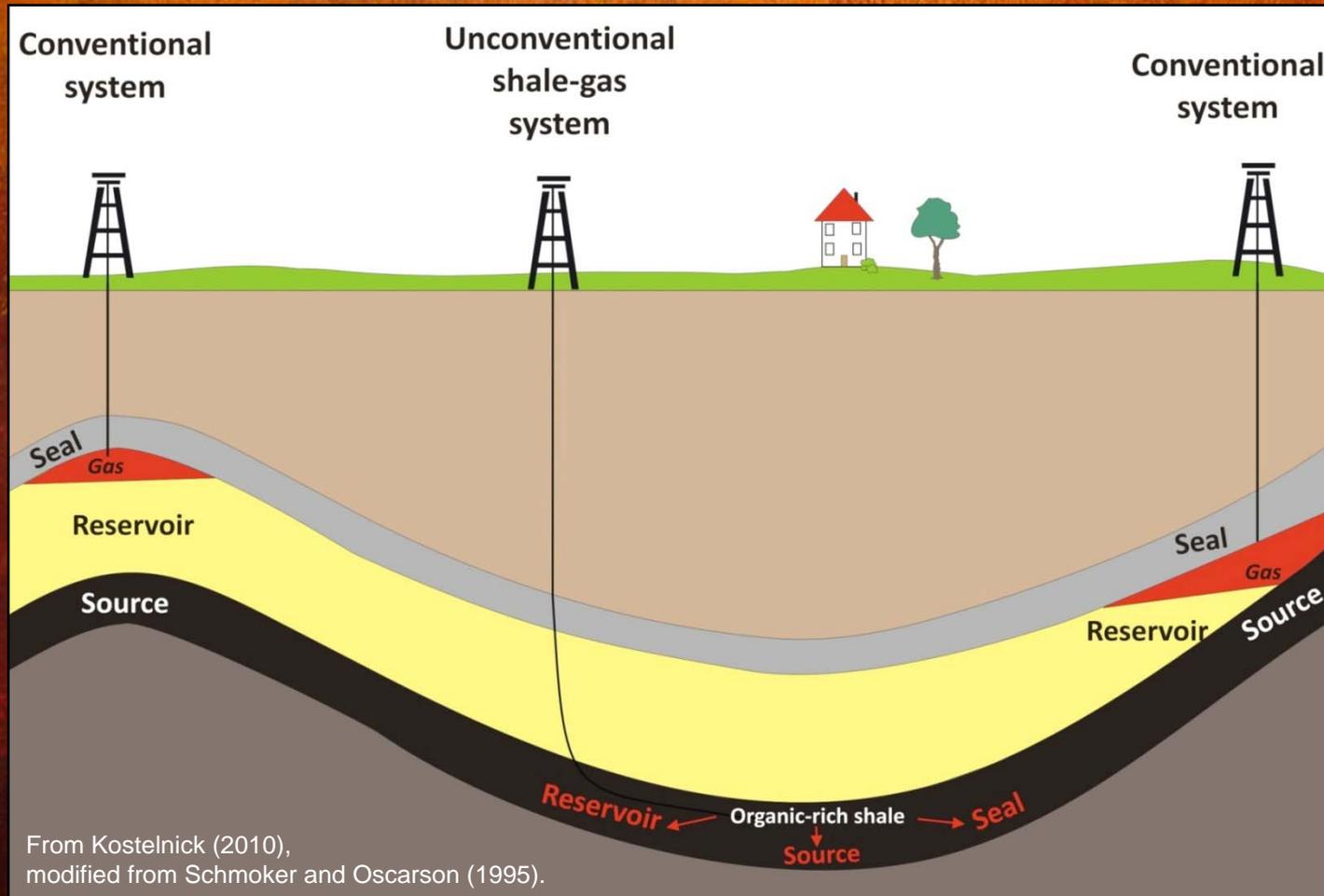
Geology and Activity Update of the Ohio Utica-Point Pleasant Play

Larry Wickstrom, Matt Erenpreis,
Ron Riley, Chris Perry,
and Dean Martin

Ohio Department of Natural Resources
Division of Geological Survey

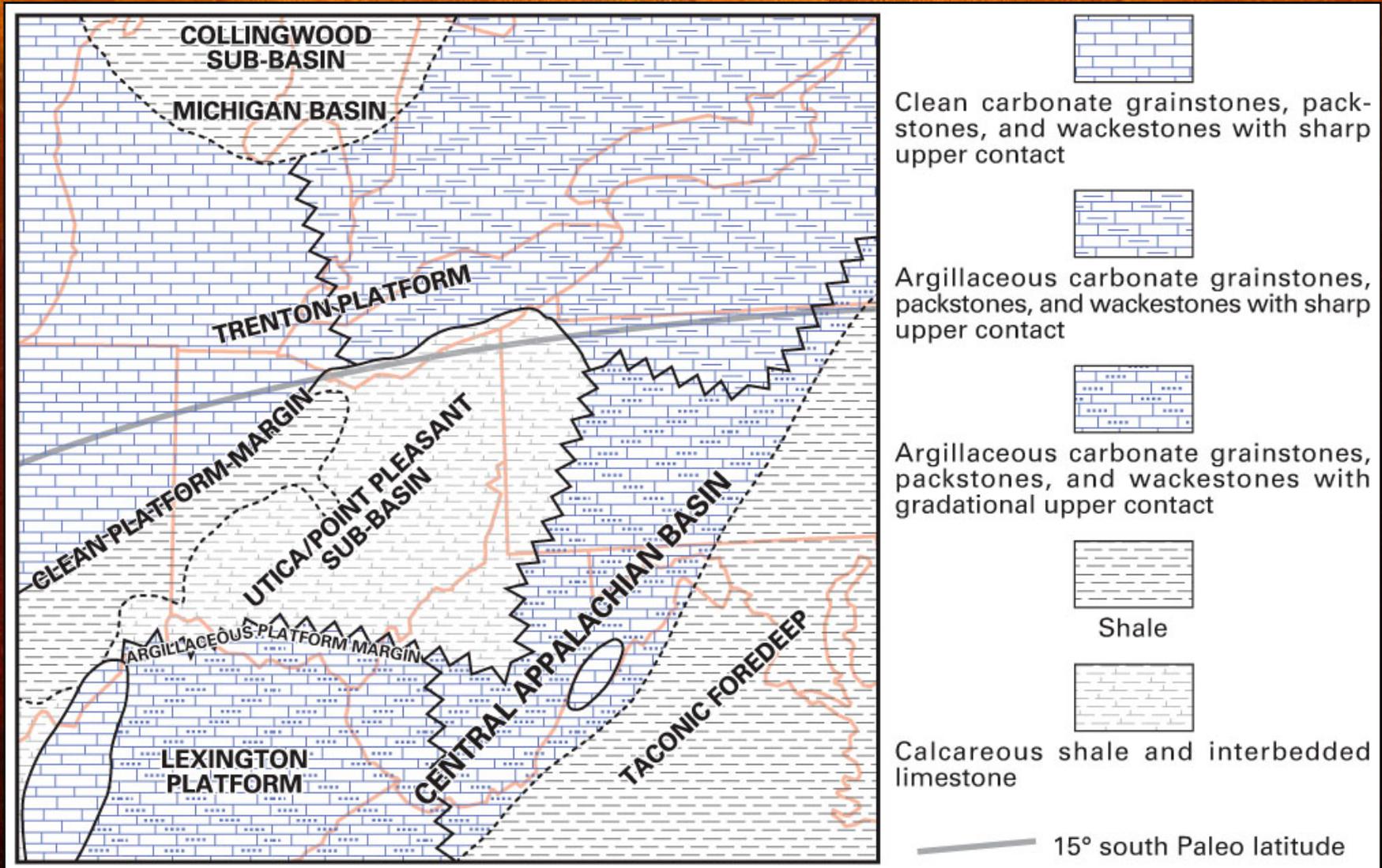


Drilling and producing from organic-rich shales represents a large paradigm shift for the oil-and-gas industry.

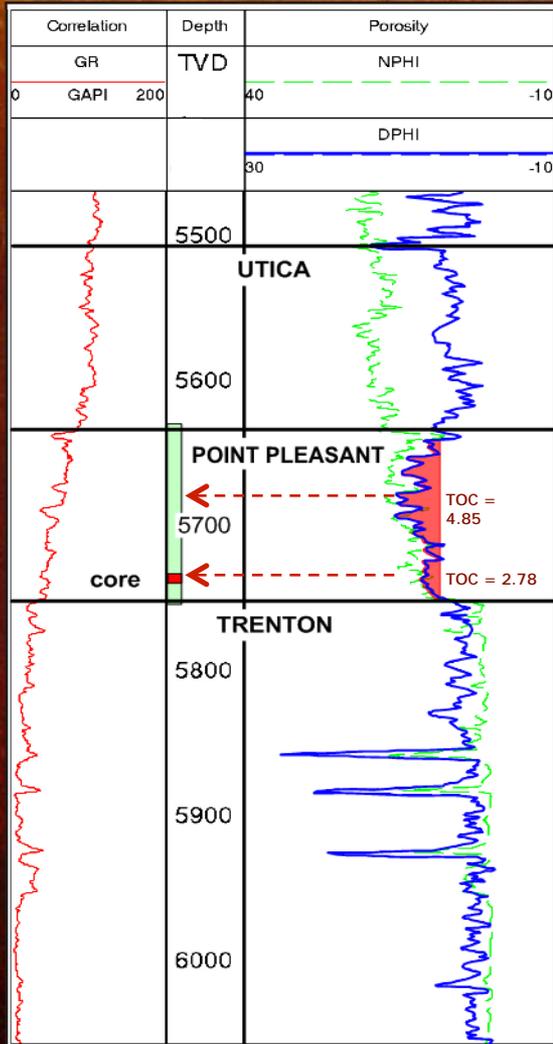


Prior to the late 1990s these shales were thought of principally as the source of oil and gas that would then migrate slowly over time into “conventional” reservoirs.

Facies map of Trenton/Point Pleasant Time



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.

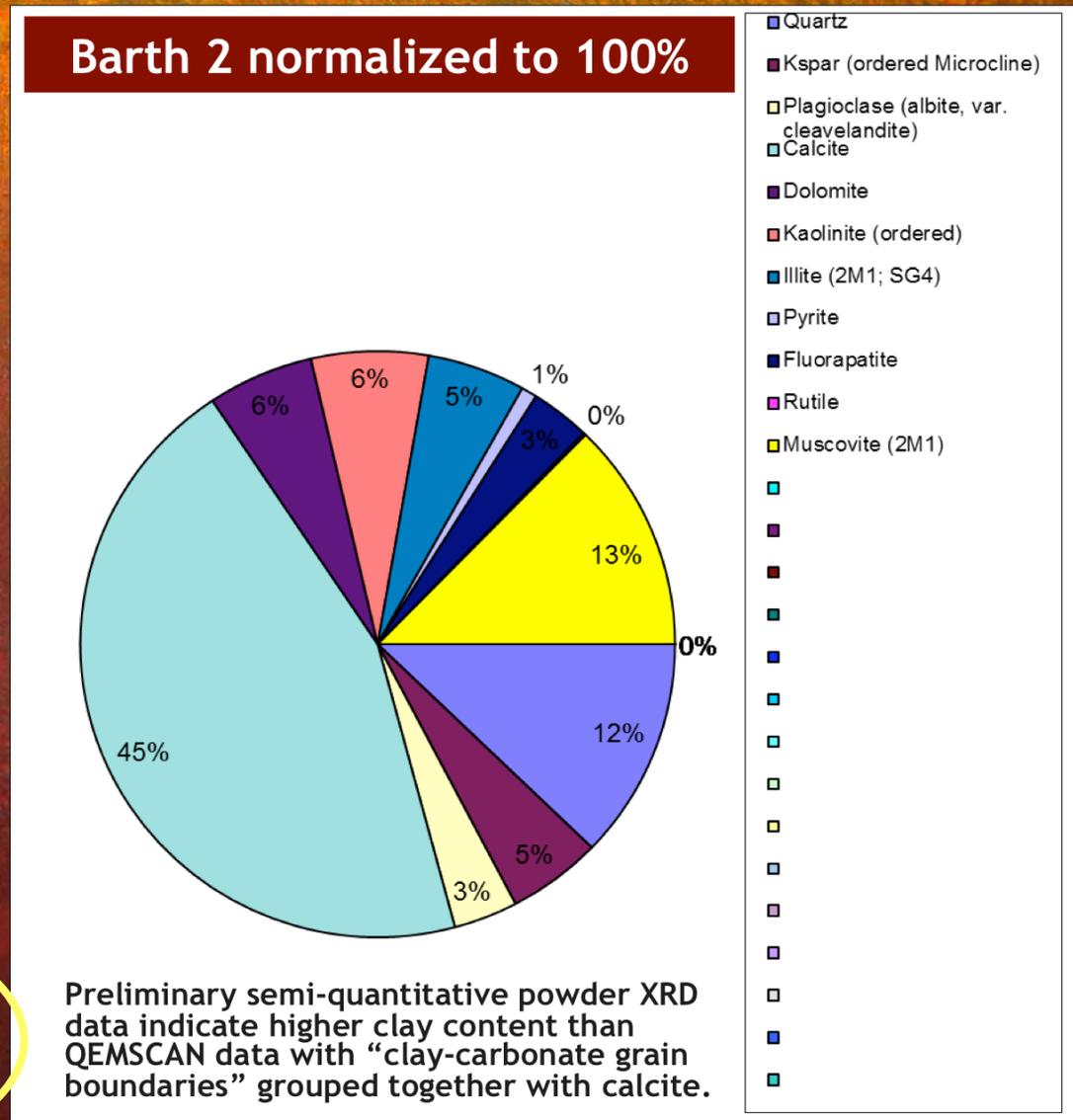


FRACABILITY COSHOCKTON COUNTY BARTH #3

- Low density shale
- AVG TOC = 2.78
- High TOC = 4.85
- High carbonate %
- Responds to HCL
- Interbedded limestone and black shale

- Barth 2 randomly-oriented powder mount with corundum as internal standard.
- Mineral modes estimated using computer program RockJock.
- Low totals may indicate presence of amorphous material.

Mineral	Weight %
NON-CLAYS	
Quartz	10.5
Kspar (ordered Microcline)	4.4
Plagioclase (albite, var. cleavelandite)	3.0
Calcite	38.5
Dolomite	5.0
Pyrite	0.7
Fluorapatite	2.8
Rutile	0.1
Total non-clays	65.0
CLAYS	
Kaolinite (ordered)	5.5
Illite (2M1; SG4)	4.6
Muscovite (2M1)	10.9
Total clays	20.9
TOTAL	85.9



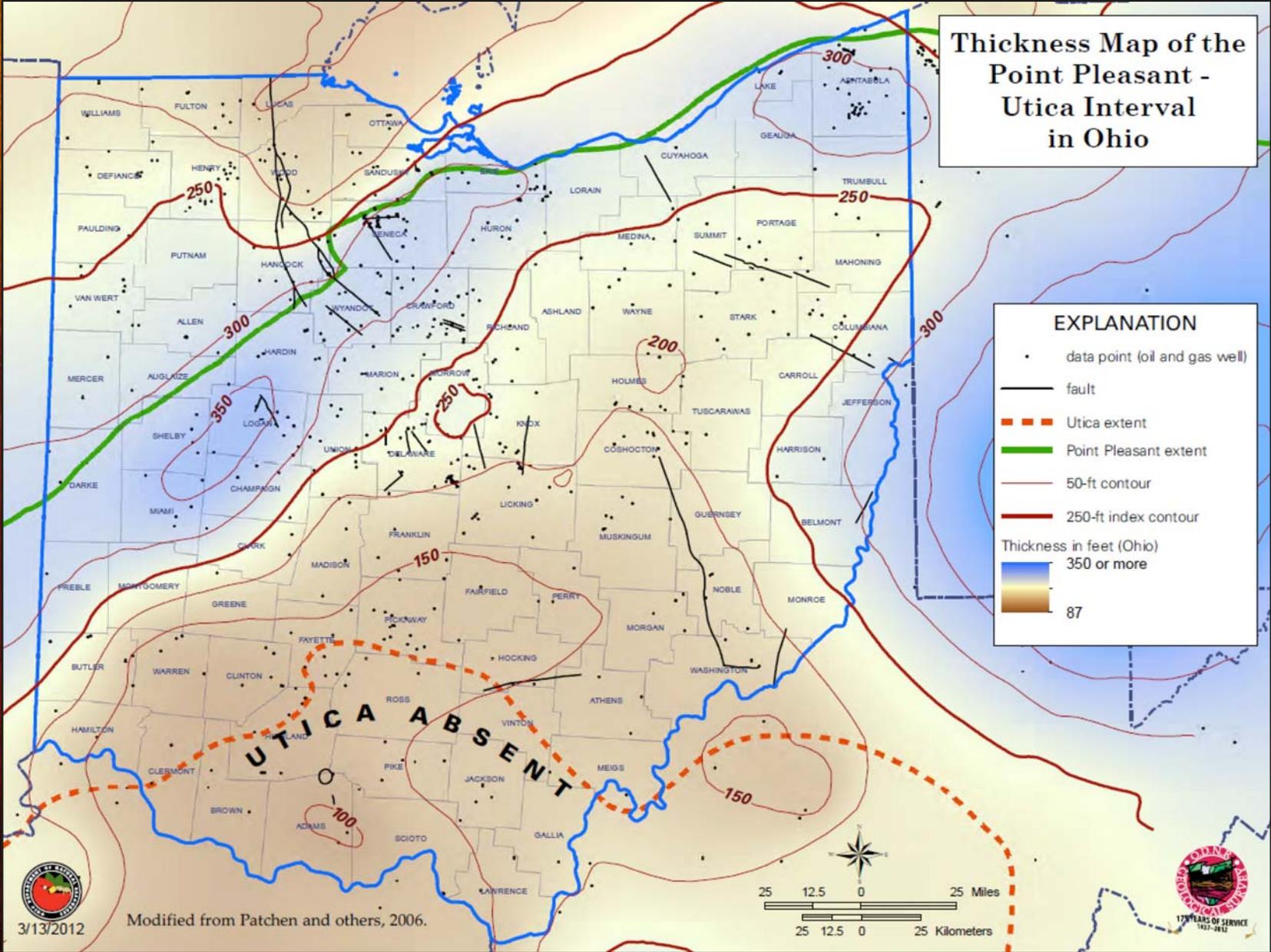
Thickness Map of the Point Pleasant - Utica Interval in Ohio

EXPLANATION

- data point (oil and gas well)
- fault
- - - Utica extent
- Point Pleasant extent
- 50-ft contour
- 250-ft index contour

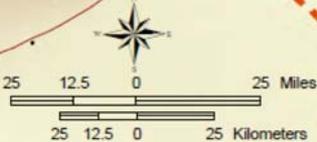
Thickness in feet (Ohio)

350 or more
87



3/13/2012

Modified from Patchen and others, 2006.

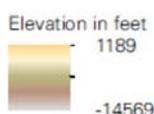


STRUCTURE MAP ON TOP OF THE TRENTON LIMESTONE IN OHIO

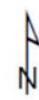
EXPLANATION

- data points (oil and gas well)
- fault
- 500-ft contour
- 2500-ft contour

Elevation in feet

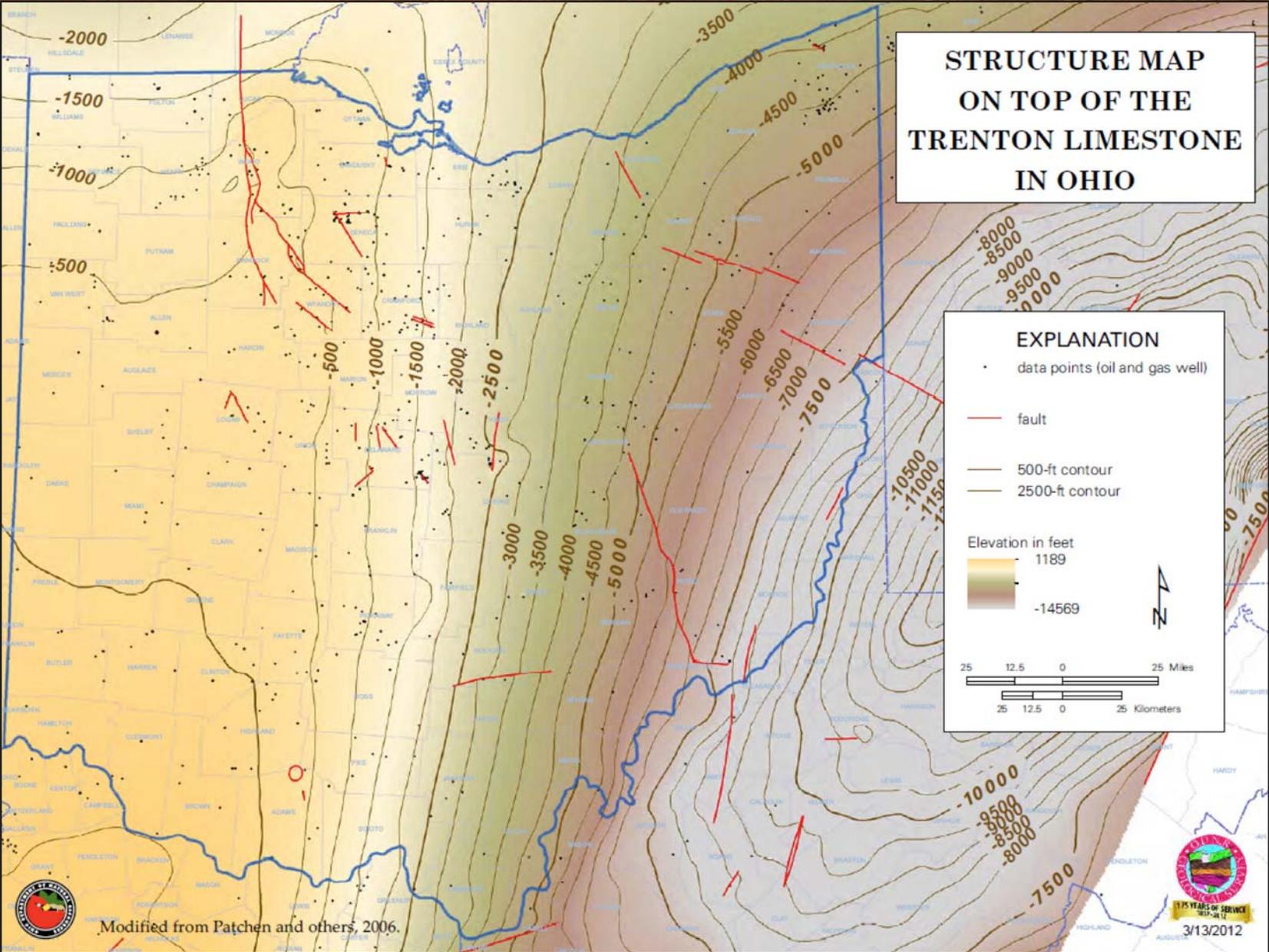


1189
-14569



25 12.5 0 25 Miles

25 12.5 0 25 Kilometers



Modified from Patchen and others, 2006.



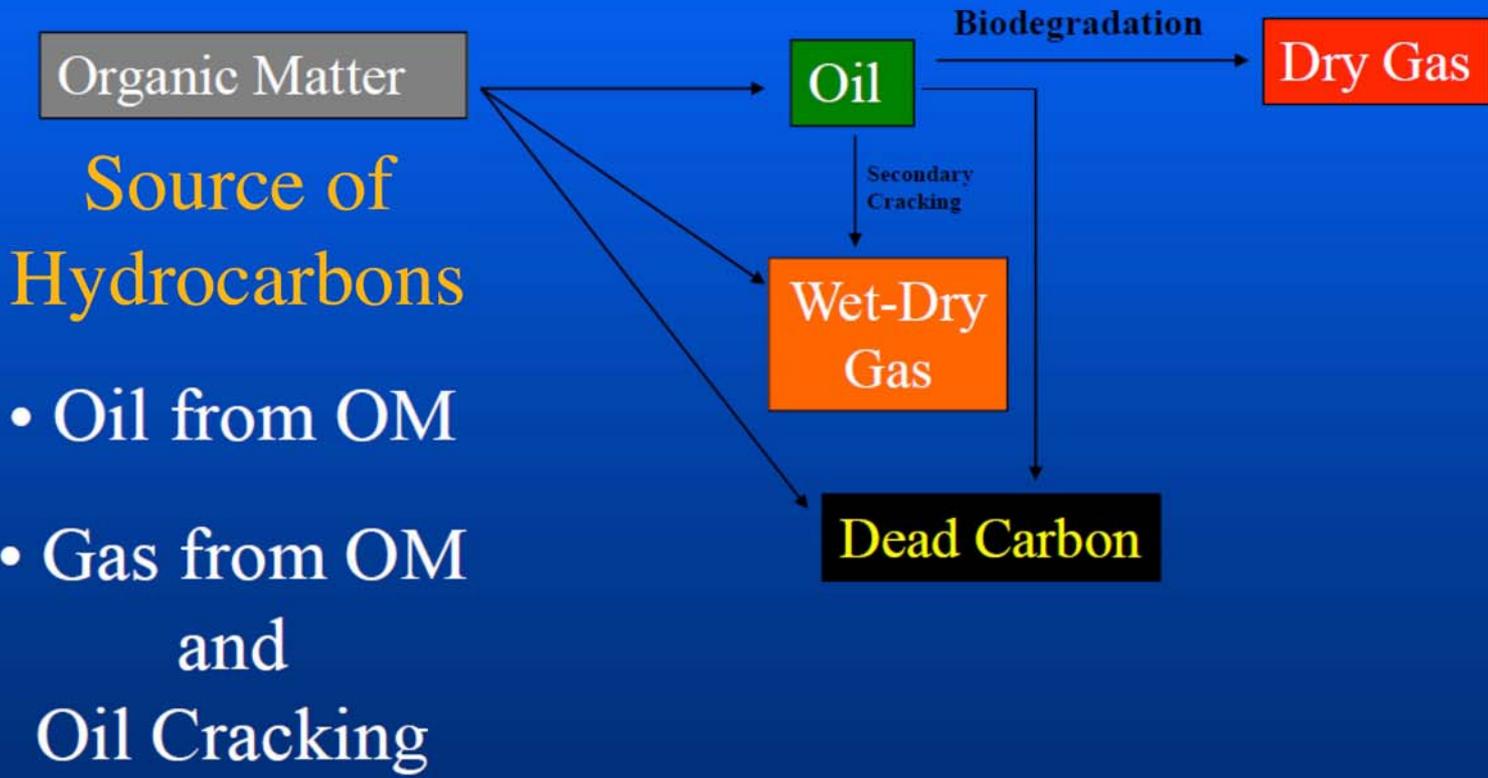
3/13/2012

We have known for years that the Utica-Point Pleasant was the primary source for most Cambrian-Silurian conventional reservoirs in Ohio

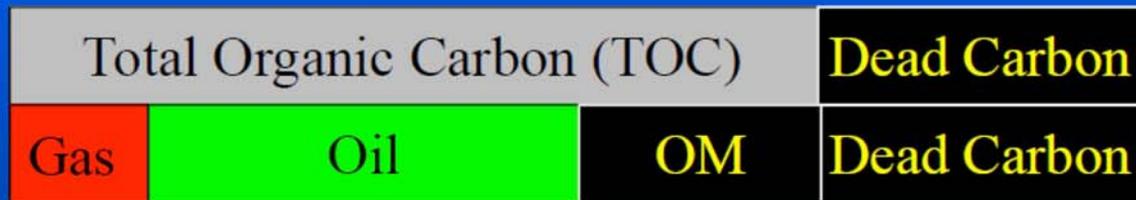
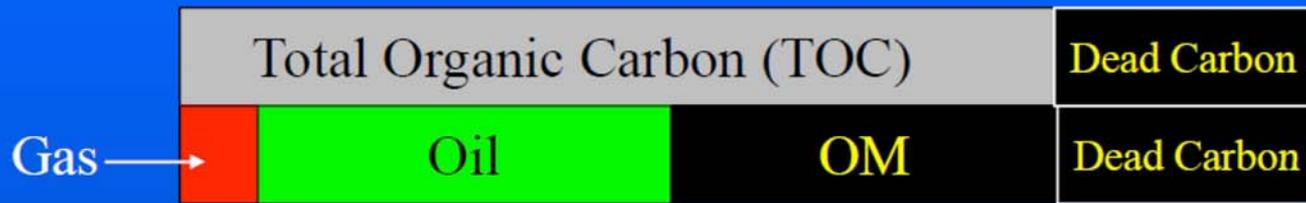
RESERVOIR	OIL (mmbo)	GAS (mmcf)	BOE (mmbo)
Trenton-Black River	380	1,000	546
Clinton-Medina	180	5,000	1,013
Knox Sands & Dol	50	360	110
TOTAL	610	6,360	1,669

So, we know it has already produced lots of hydrocarbons. Now the question remains—how much is in this source/reservoir to produce?

Generation of Oil and Gas



But episodic expulsion also changes the mix



Generation fracture



Expulsion

Residual oil, OM, and DC in rock



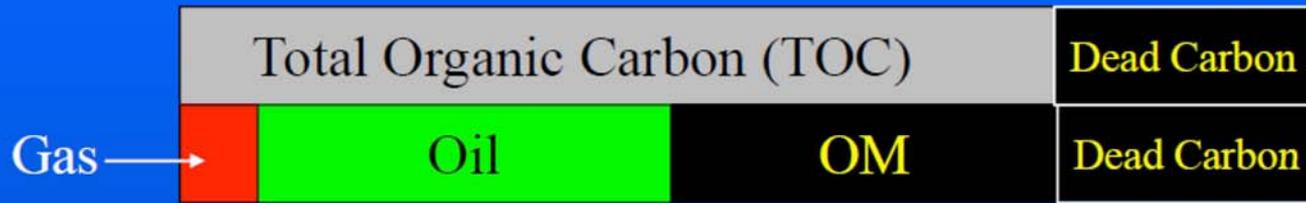
Basic Source Rock Potential Definitions

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.

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.

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.

But episodic expulsion also changes the mix



Generation fracture



Expulsion

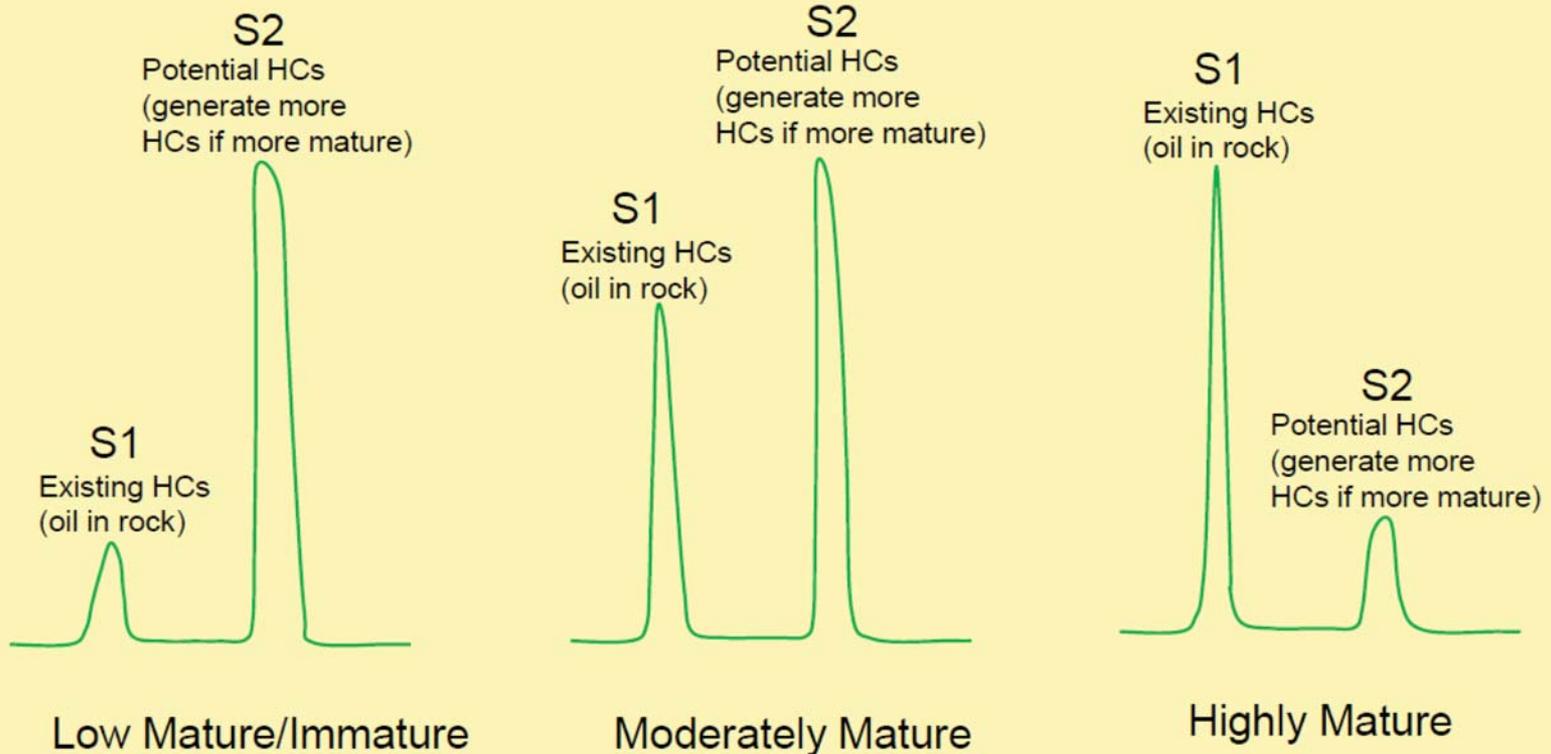
Residual oil, OM, and DC in rock



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 equipped with an oil-immersion objective lens and photometer. 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 T_{\max} and Hydrogen Index (HI), or other means of calibrating a given rock's Ro , are used.

Hydrocarbons in Sediment Rock-Eval Data



$$(S1/TOC)*100=Hydrocarbon Content (HC)$$

$$(S2/TOC)*100=Hydrogen Index (HI)$$

A Respected Group of Geochemists Summarize the Source Rock Potential

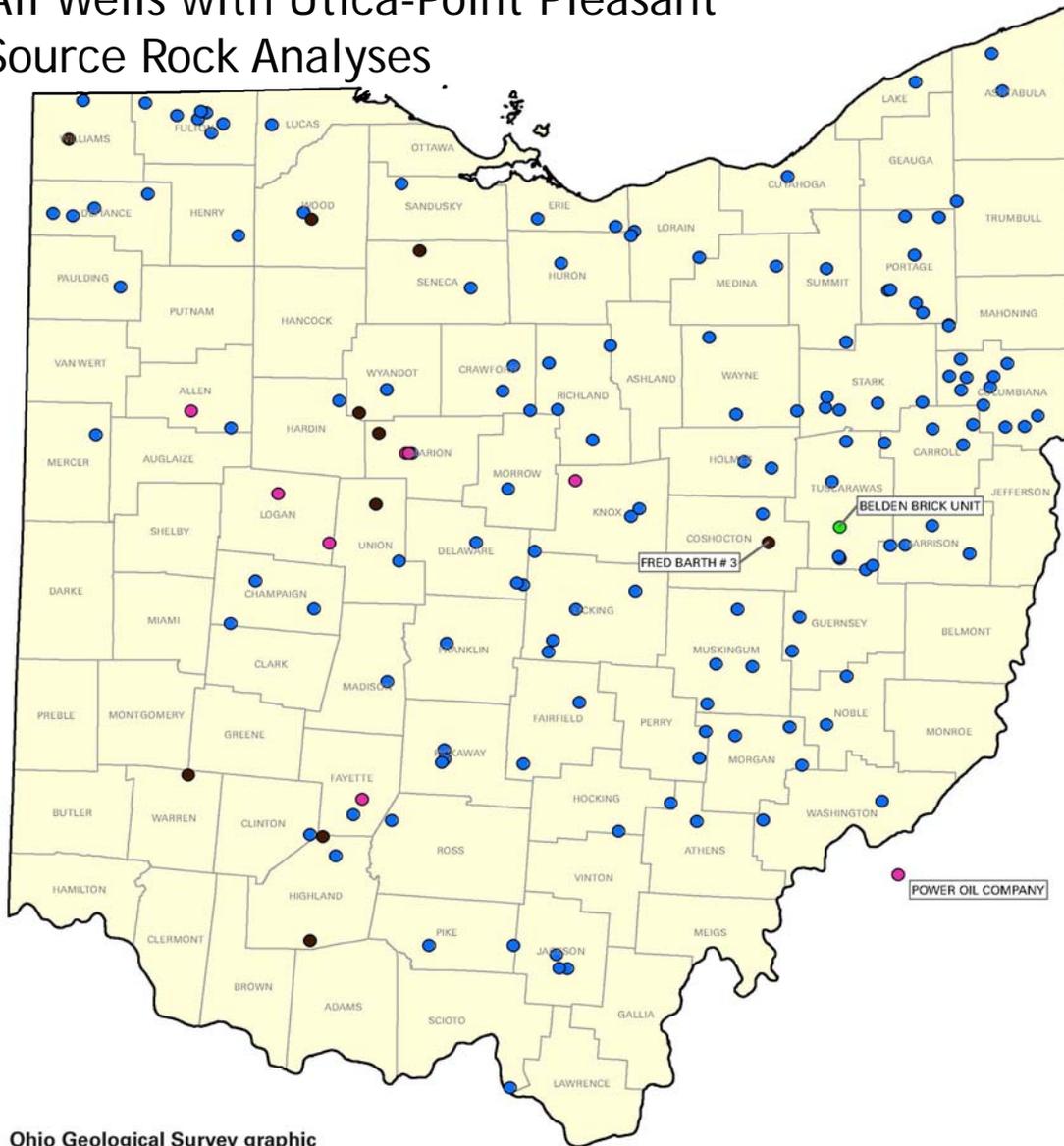
Utica-Point Pleasant

- 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 west, to 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 fracturing could be very effective for production

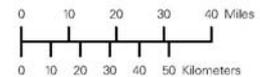
Ohio Geological Survey Core and Sample Repository

- Visitors using the sample repository:
 - 2006 - 124
 - 2007 - 169
 - 2008 - 110
 - 2009 - 439 (Utica-PP sampling began)
 - 2010 - 456
 - 2011 - 472
 - 2012 - 91 (as of March 15)
- Total wells with cuttings sampled = 183
 - Total samples analyzed = 4,143
- Total cores examined and sampled = 20
 - Total core samples analyzed = 586
- Companies/individuals are given a one year proprietary status (from date of sampling) on analyses.

All Wells with Utica-Point Pleasant Source Rock Analyses



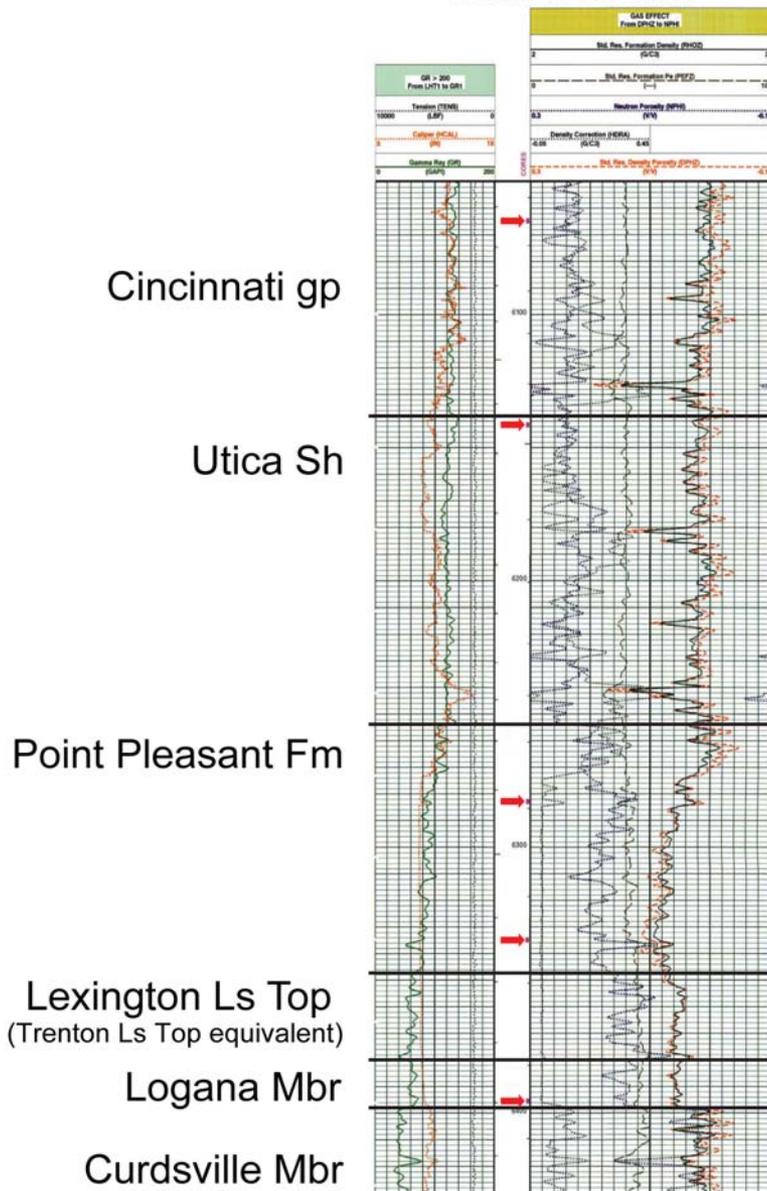
- EXPLANATION**
- Wells sampled
- Core
 - Core / Cuttings
 - Cuttings
 - Sidewall core / Cuttings



APINO 3415725334

A Utica-Point Pleasant Type Log for Eastern Ohio

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



Source Rock Analyses

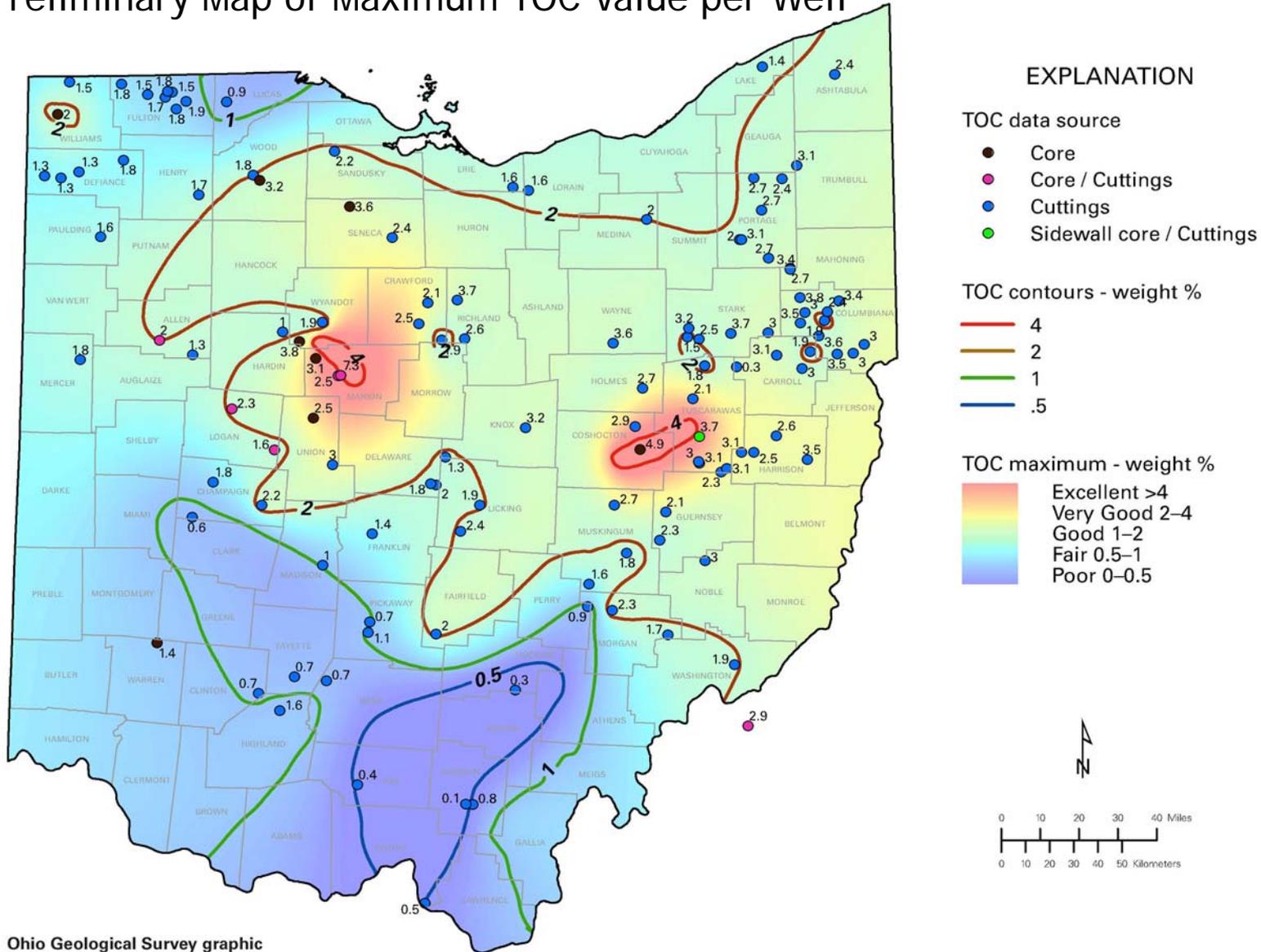
Depth (ft)	Sample Type	TOC	Rock Unit
6064	core	0.48	Cincinnati gp
6141	core	2.72	Utica Sh
6282	core	2.41	Point Pleasant Fm
6336	core	3.73	Point Pleasant Fm
6396	core	1.61	Logana Mbr
7192	core	0.11	Wells Creek Fm
7579	core	0.14	Copper Ridge dol
8274	core	0.23	Conasauga gp

The following maps are based on the maximum value, per parameter, per well.

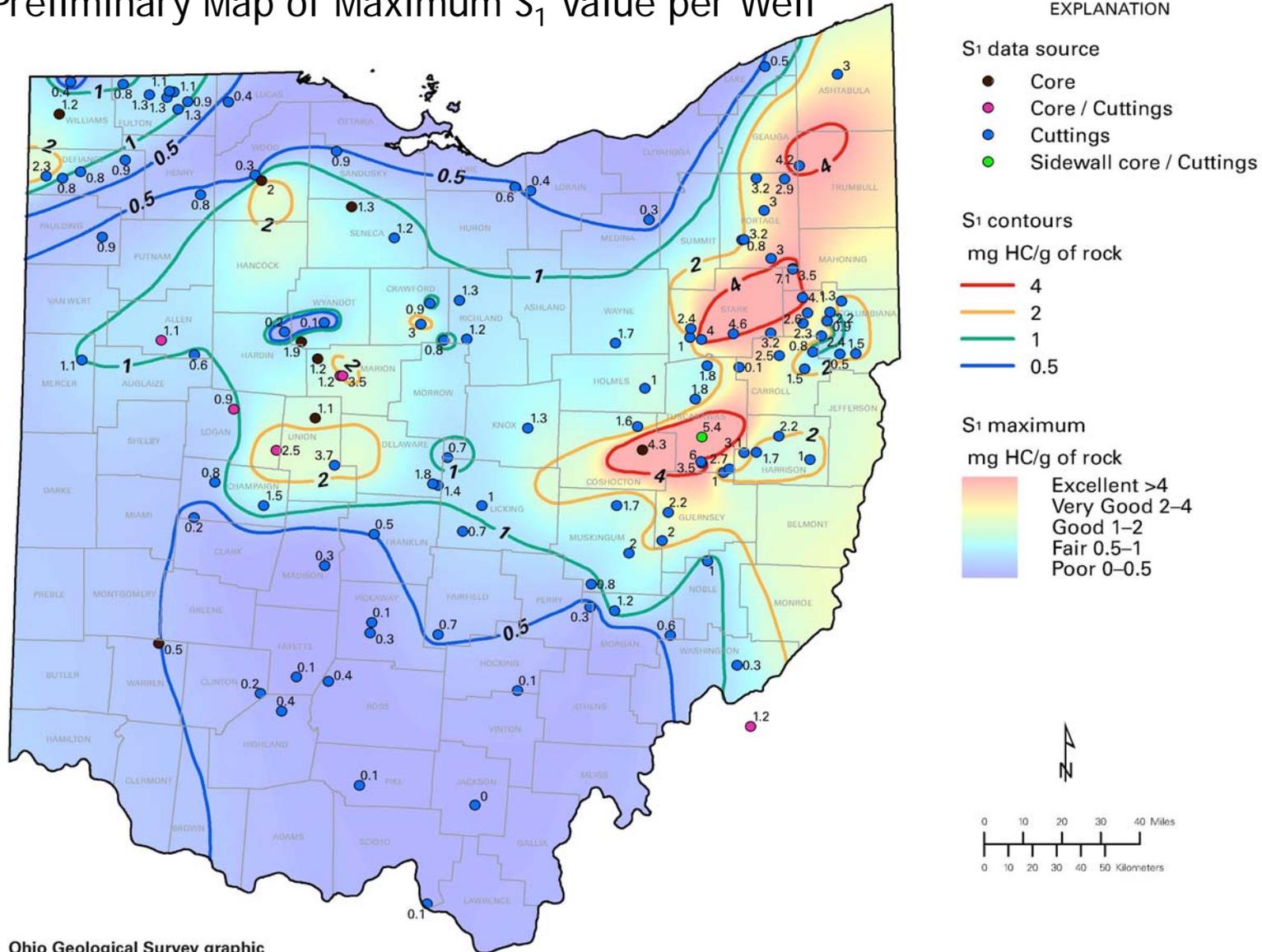
Please Note

- 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.
- The maps presented here are based on presently available data. As such, they are preliminary. As additional wells are drilled and analyses conducted, the maps will be updated. No lines on the maps should be considered absolute or final.
- While a particular area may fall “outside” the preliminary “core” play area, this does not mean that said area may not be productive. Conversely, there will good areas and bad “inside” the “core.” Only drilling in those areas can determine the productive capacity of any area—inside or outside the “core” area.

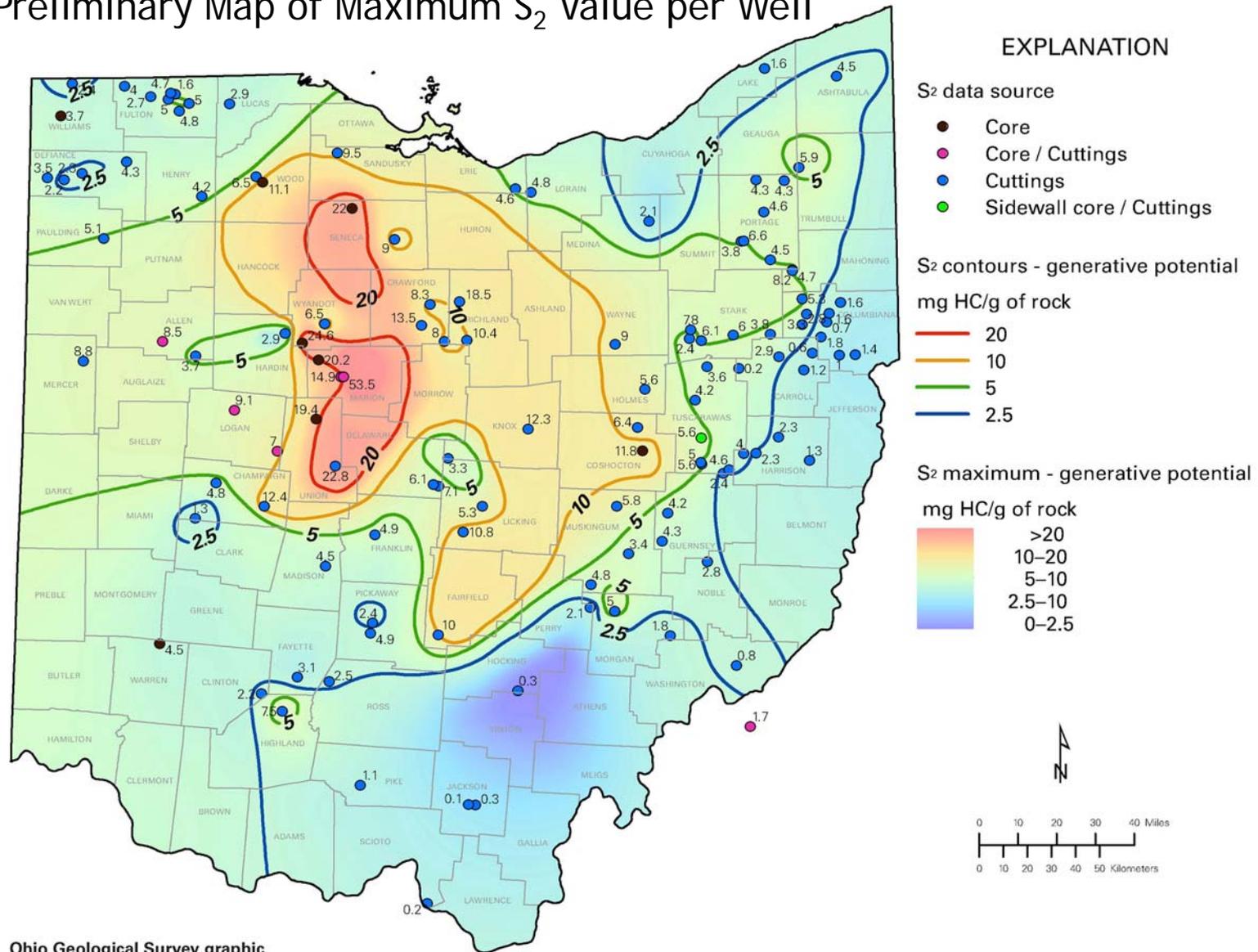
Preliminary Map of Maximum TOC Value per Well



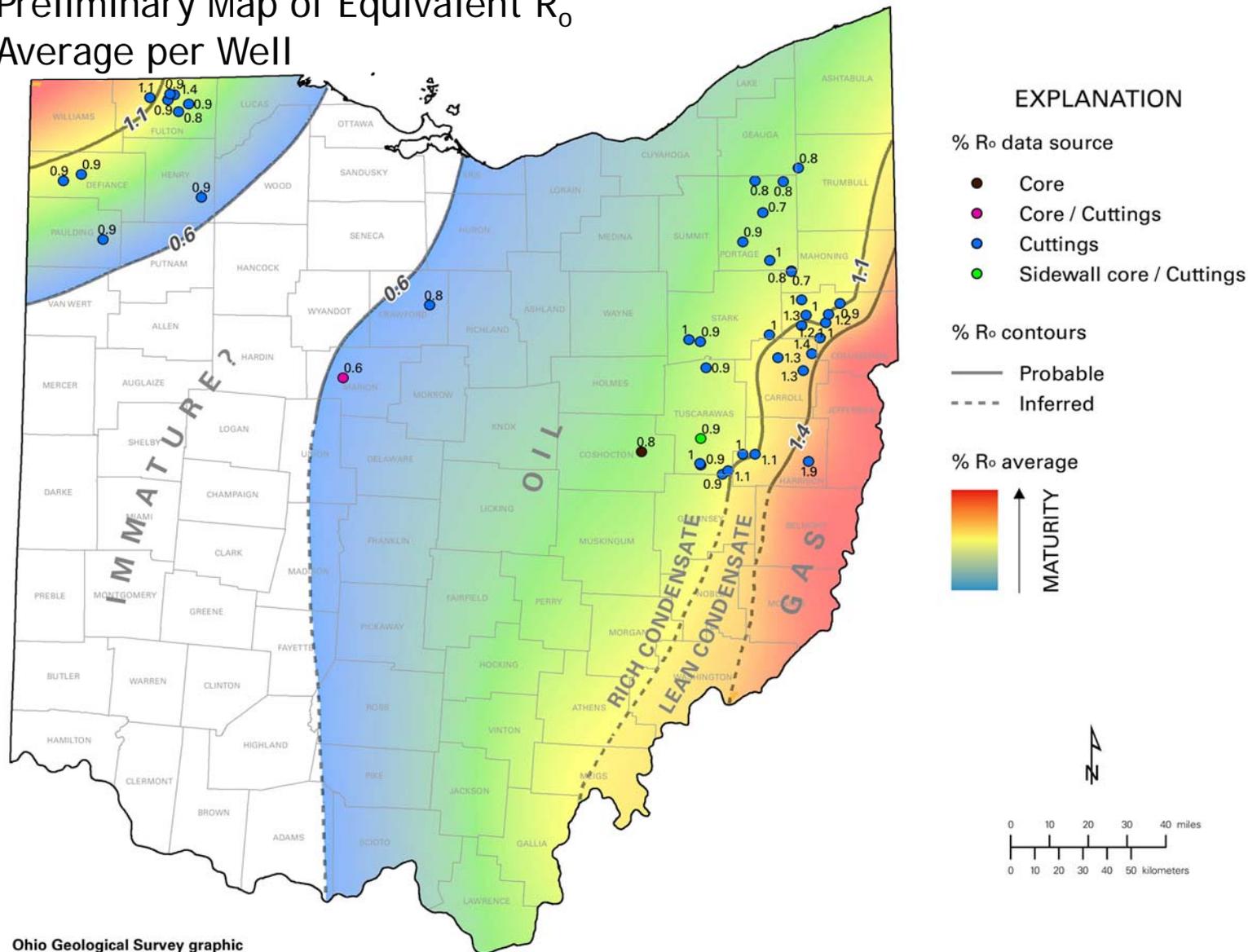
Preliminary Map of Maximum S₁ Value per Well



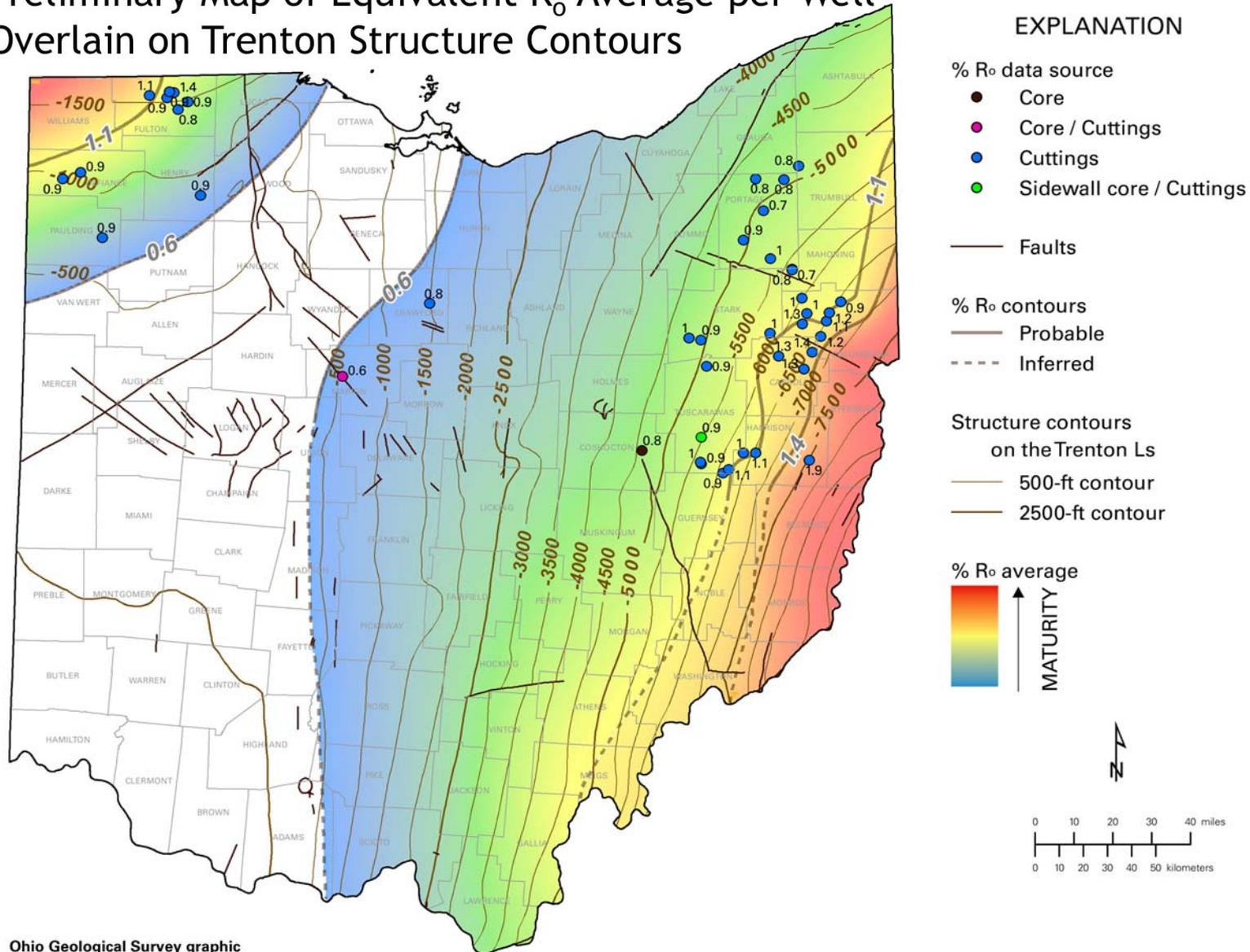
Preliminary Map of Maximum S₂ Value per Well



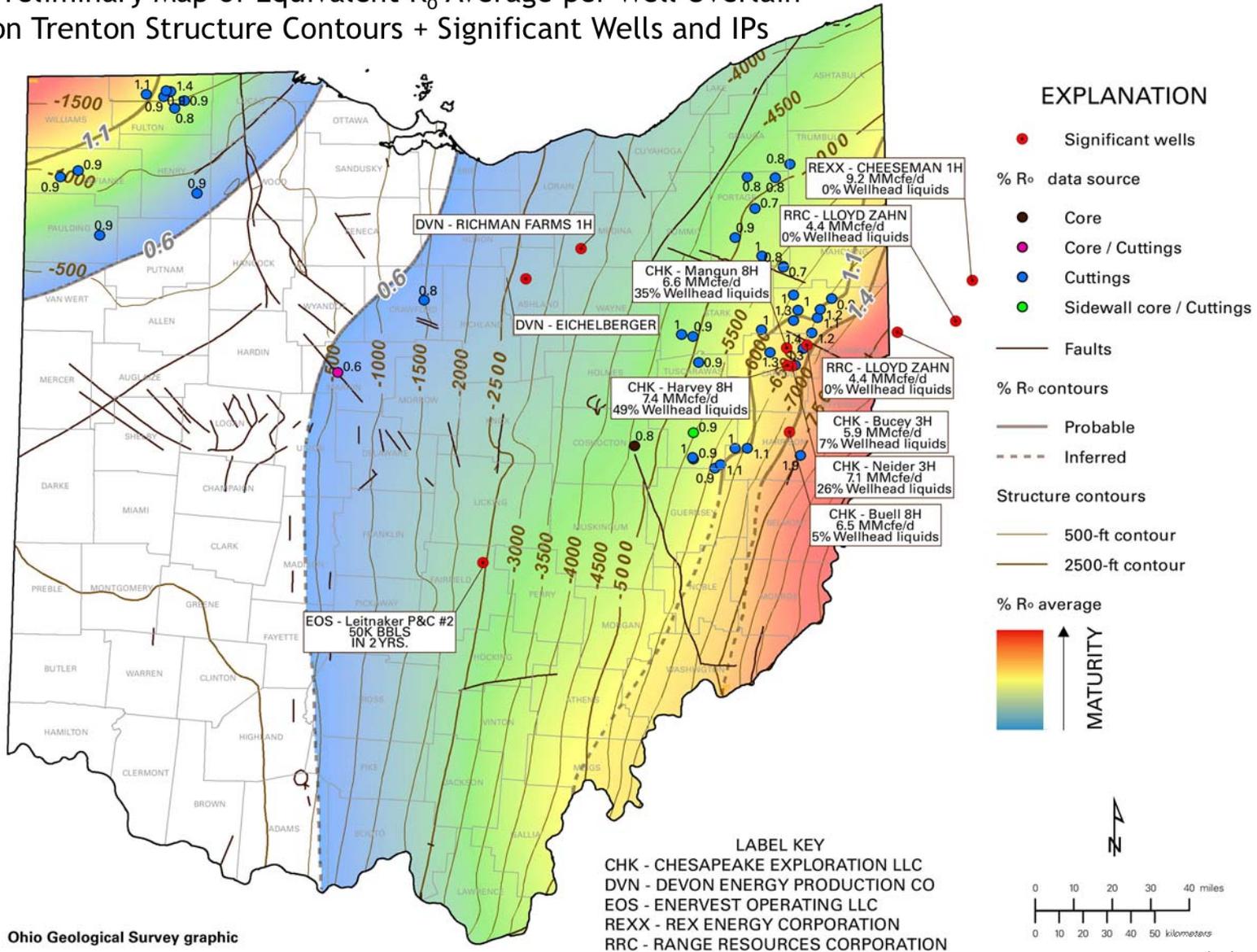
Preliminary Map of Equivalent R_o Average per Well



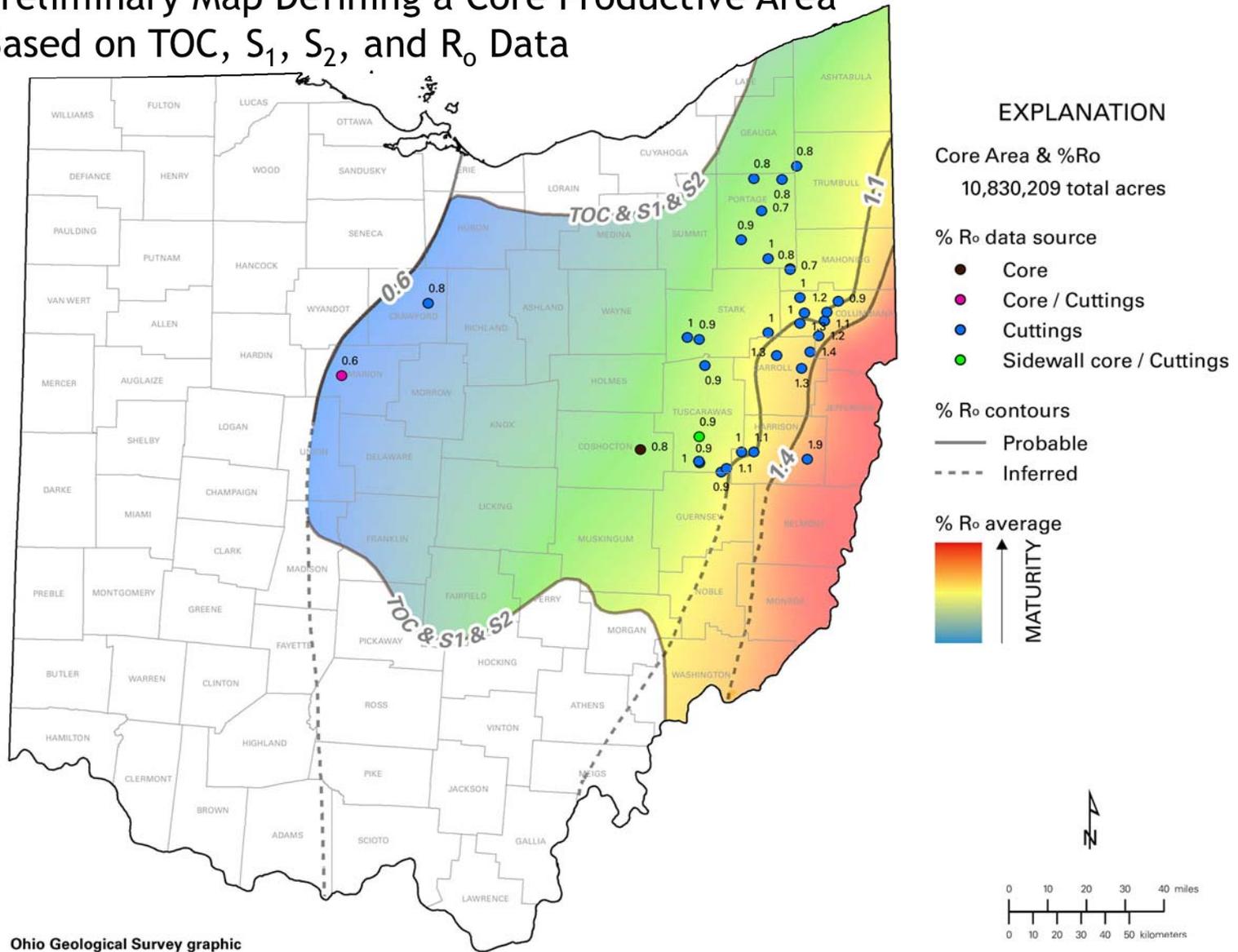
Preliminary Map of Equivalent R_o Average per Well Overlain on Trenton Structure Contours



Preliminary Map of Equivalent R_o Average per Well Overlain on Trenton Structure Contours + Significant Wells and IPs



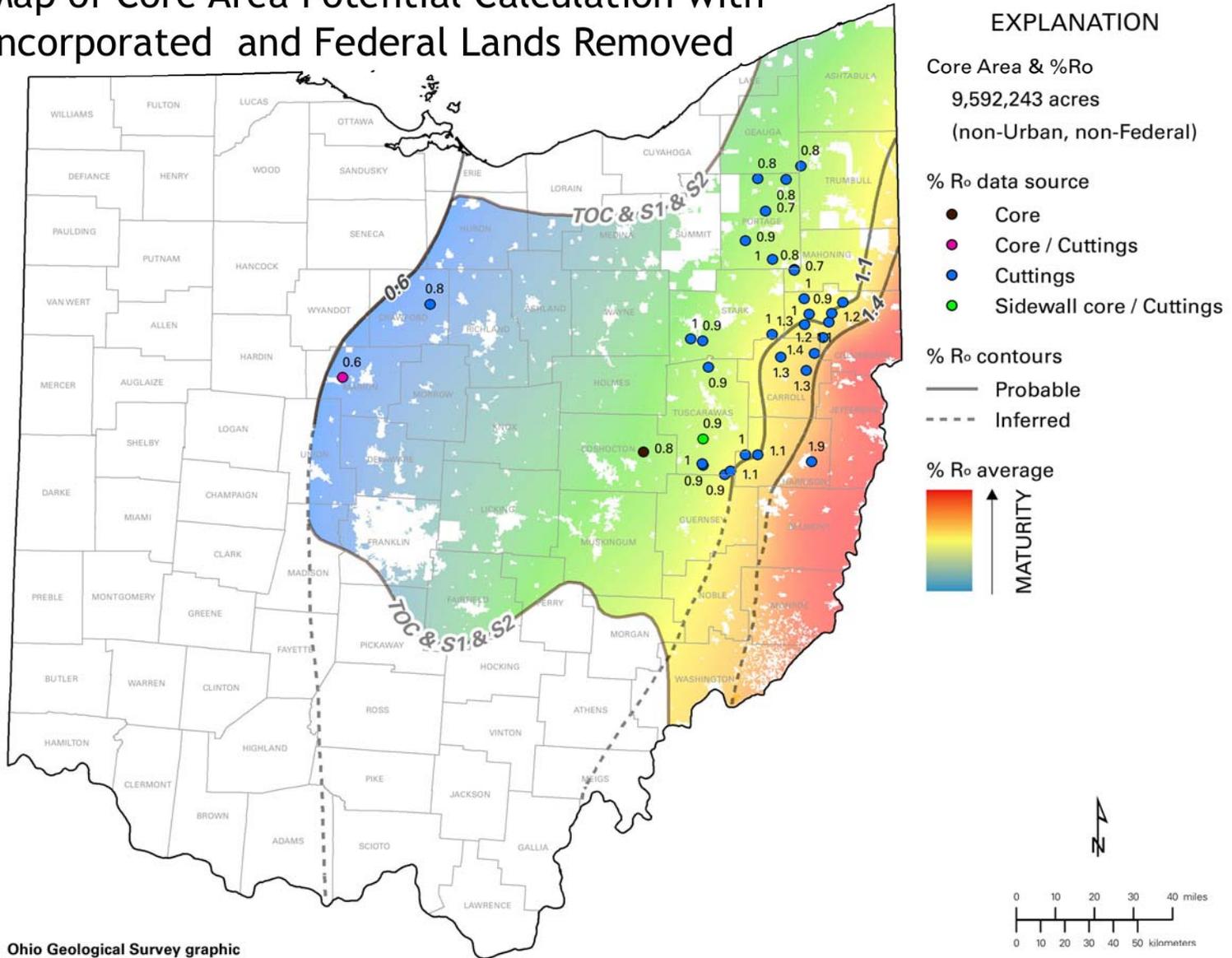
Preliminary Map Defining a Core Productive Area Based on TOC, S₁, S₂, and R_o Data



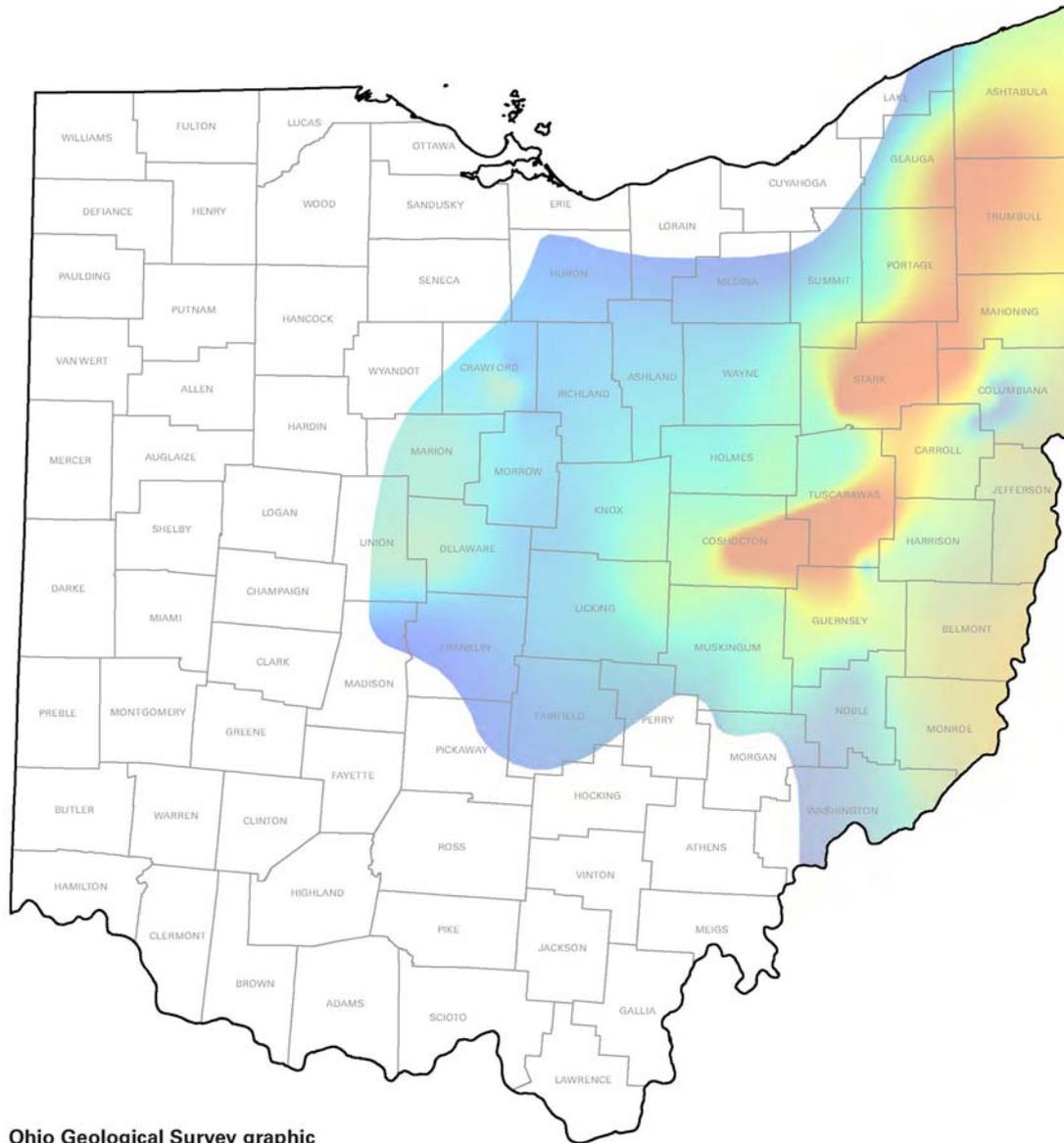
Ohio Geological Survey graphic

4/2/12

Map of Core Area Potential Calculation with Incorporated and Federal Lands Removed



Utica-Point Pleasant Core Play Area in Ohio with S₁ Maximum Color Ramp Superimposed



EXPLANATION

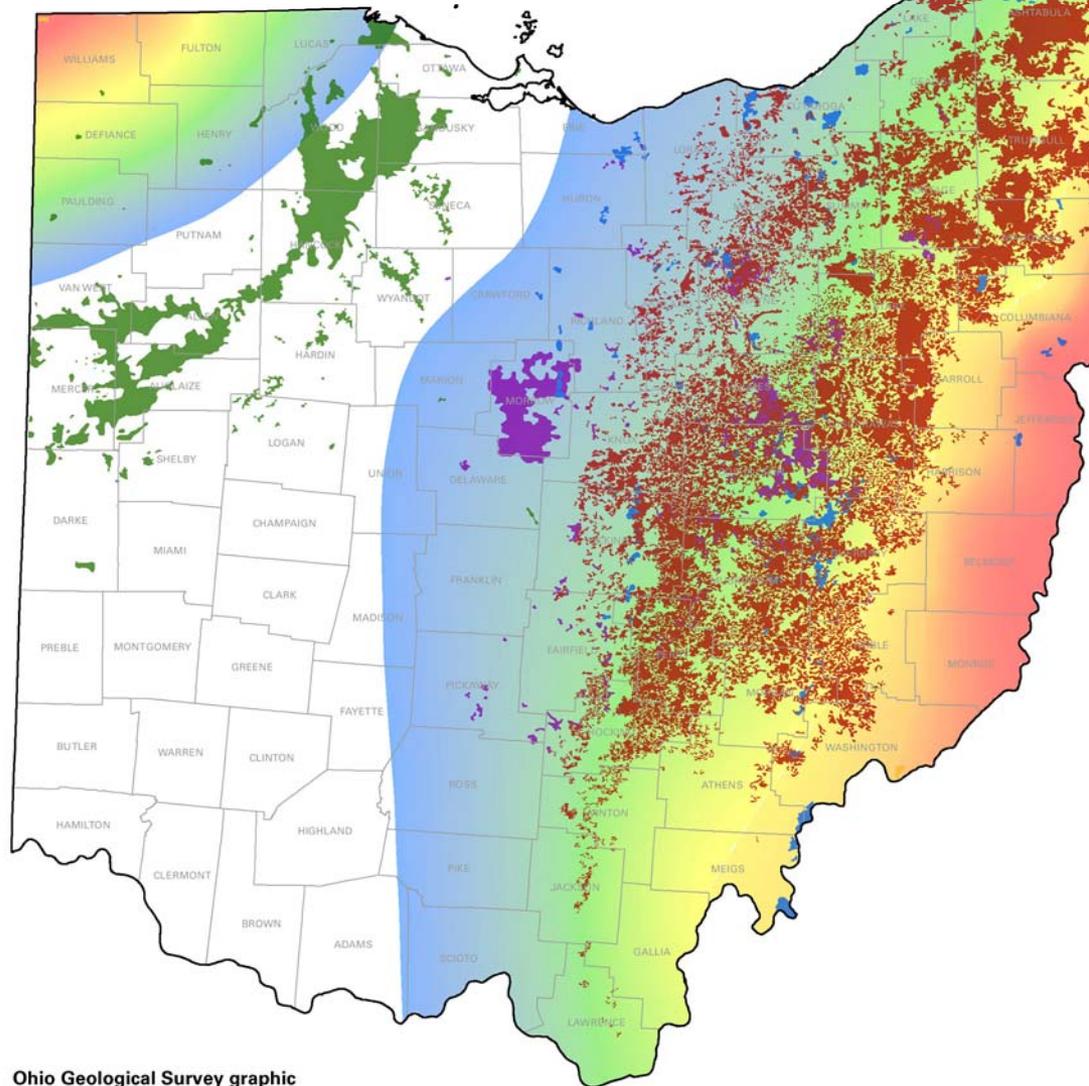
Play core area defined by TOC, S₁, S₂, and R_o

S₁ maximum

mg HC/g of rock



Map of Equivalent R_o Average Overlain with Cambrian through Silurian Oil and Gas Fields



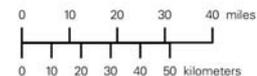
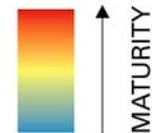
EXPLANATION

Oil & gas fields

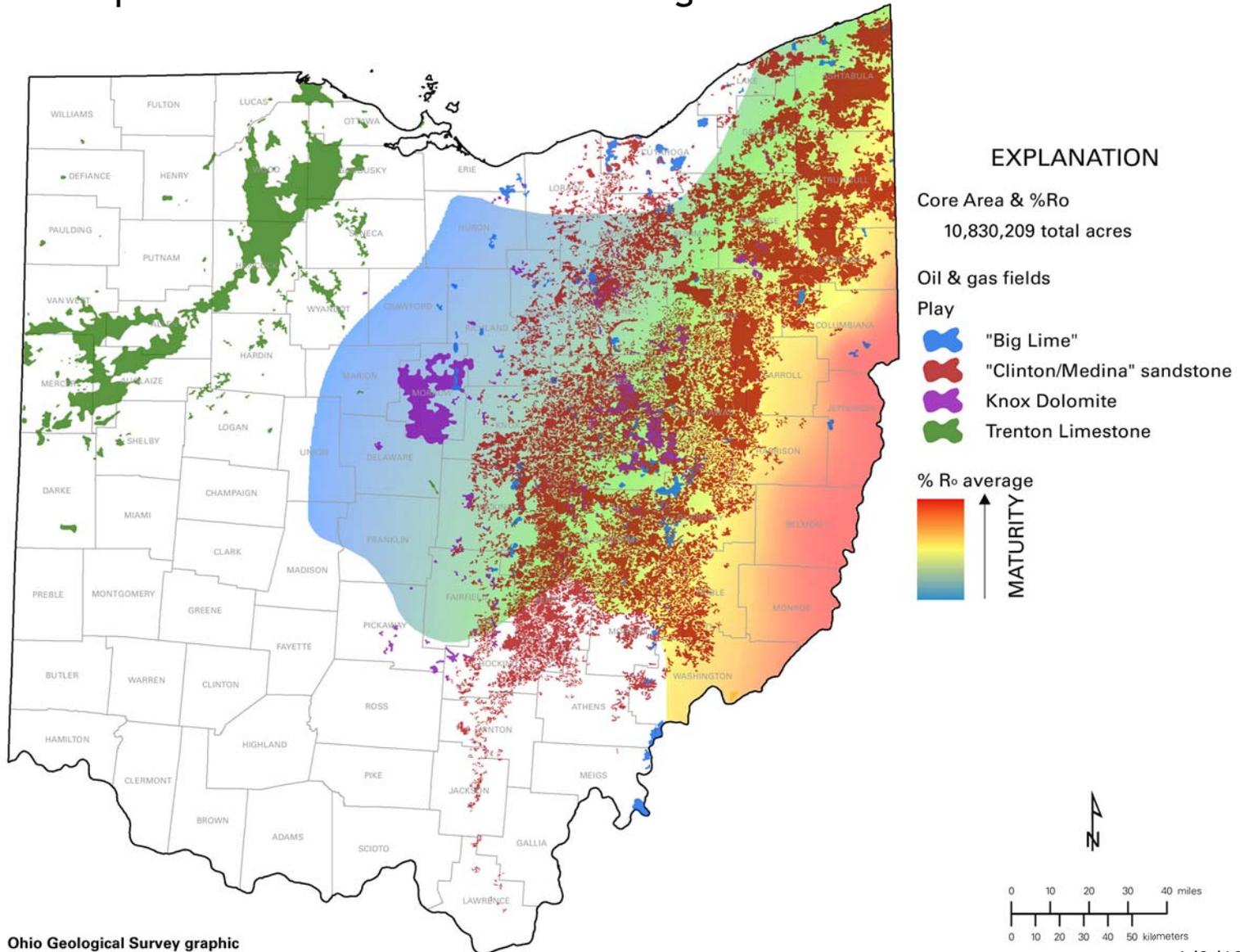
Play

-  "Big Lime"
-  "Clinton/Medina" sandstone
-  Knox Dolomite
-  Trenton Limestone

% R_o average

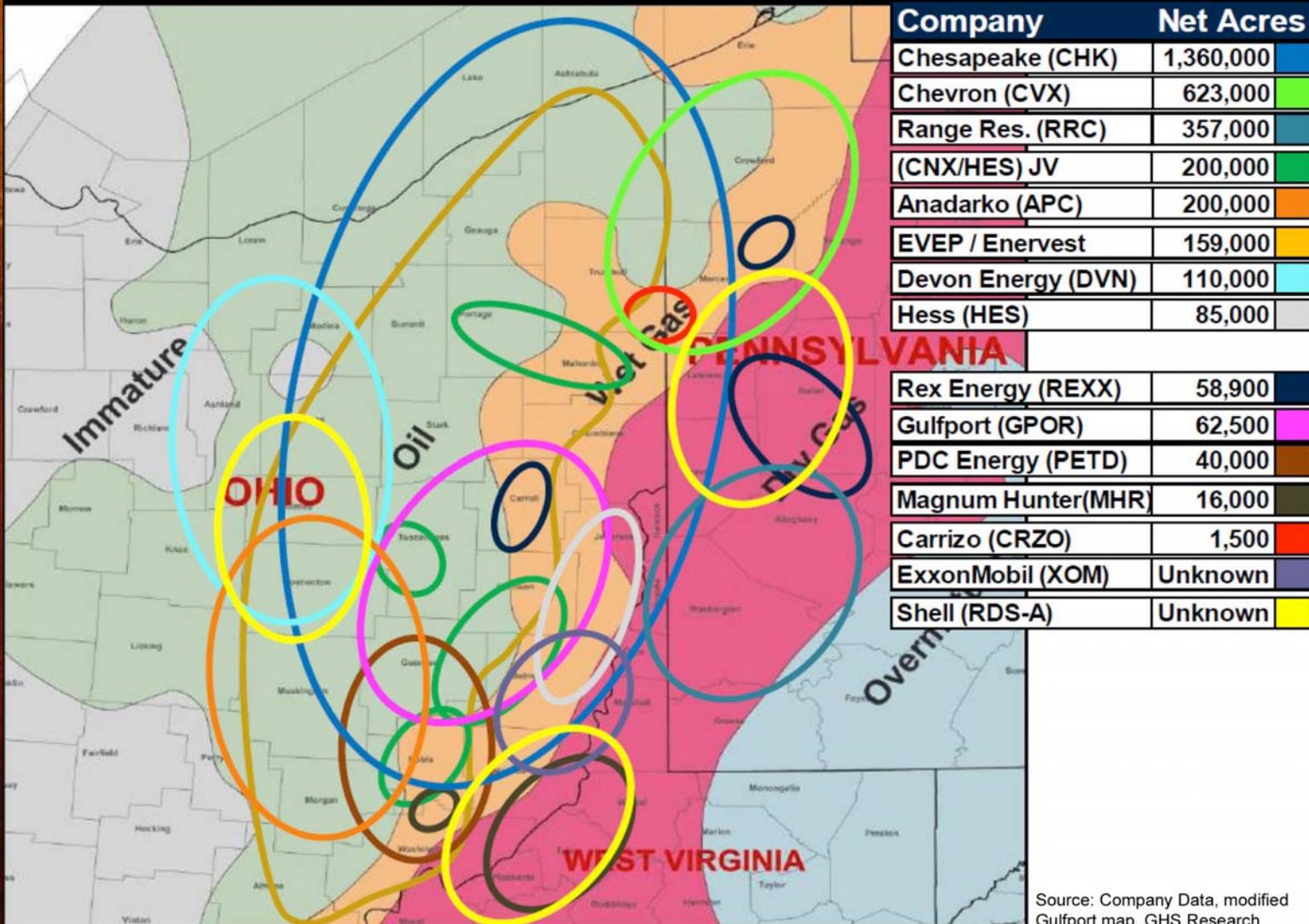


Utica-Point Pleasant Play Core Area—Equivalent R_o Average Color Ramp Overlain with Cambrian through Silurian Oil and Gas Fields



Activity

Acreage Positions



Source: Company Data, modified Gulfport map, GHS Research

Modified from M. Bodino, November 2011, DUG East presentation

HORIZONTAL UTICA-POINT PLEASANT WELL ACTIVITY IN OHIO

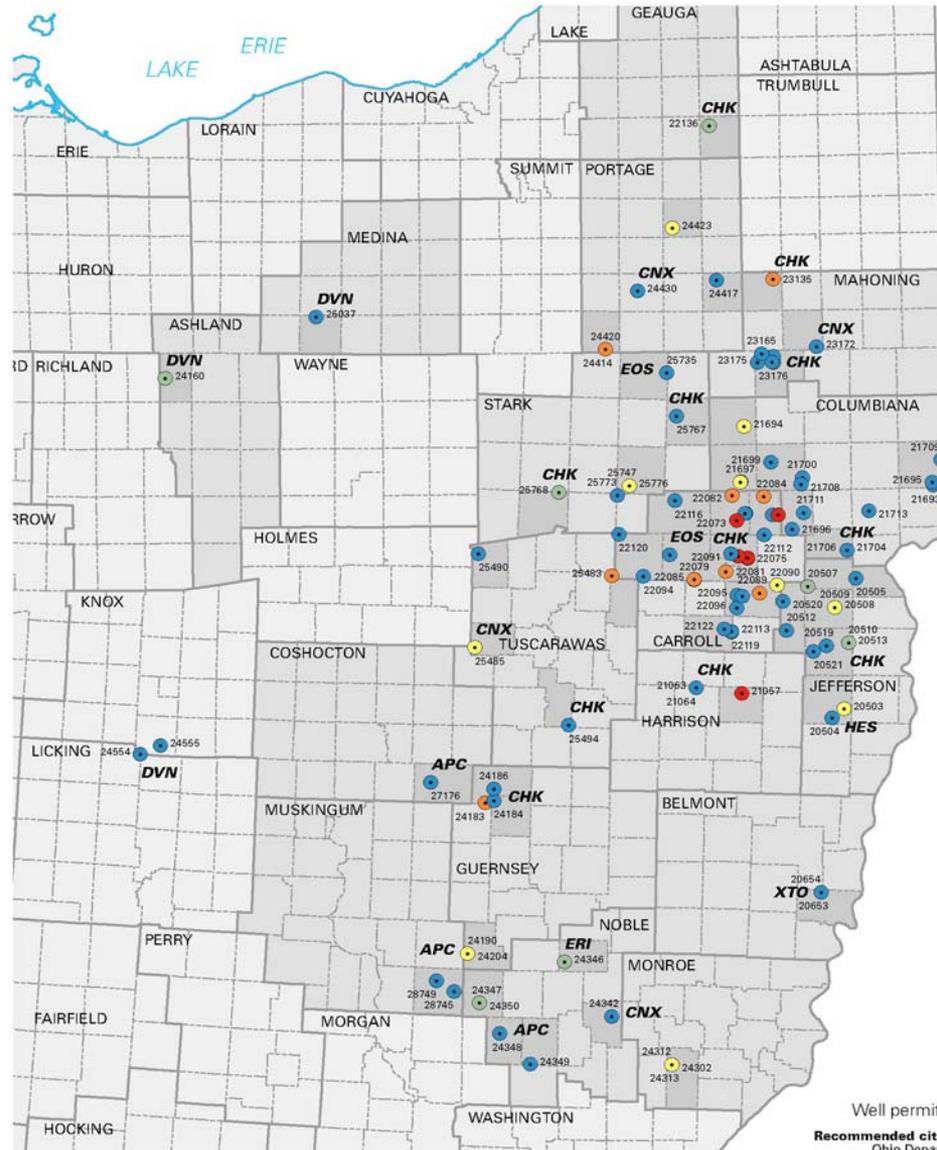
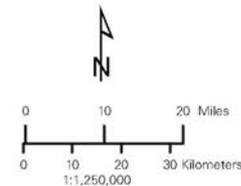
EXPLANATION

Horizontal well status

Showing wells permitted 2010–Present

- Permitted
- Drilling
- Drilled
- Completed
- Producing

OPERATOR NAME	MAP LABEL	COUNT
ANADARKO E & P COMPANY LP	APC	10
CHESAPEAKE EXPLORATION LLC	CHK	103
CNX GAS COMPANY LLC	CNX	5
DEVON ENERGY PRODUCTION CO	DVN	4
ECLIPSE RESOURCES I LP	ERI	1
ENERVEST OPERATING L	EOS	7
HESS OHIO RESOURCES LLC	HES	1
HG ENERGY LLC	HGE	5
XTO ENERGY INC.	XTO	2
		138

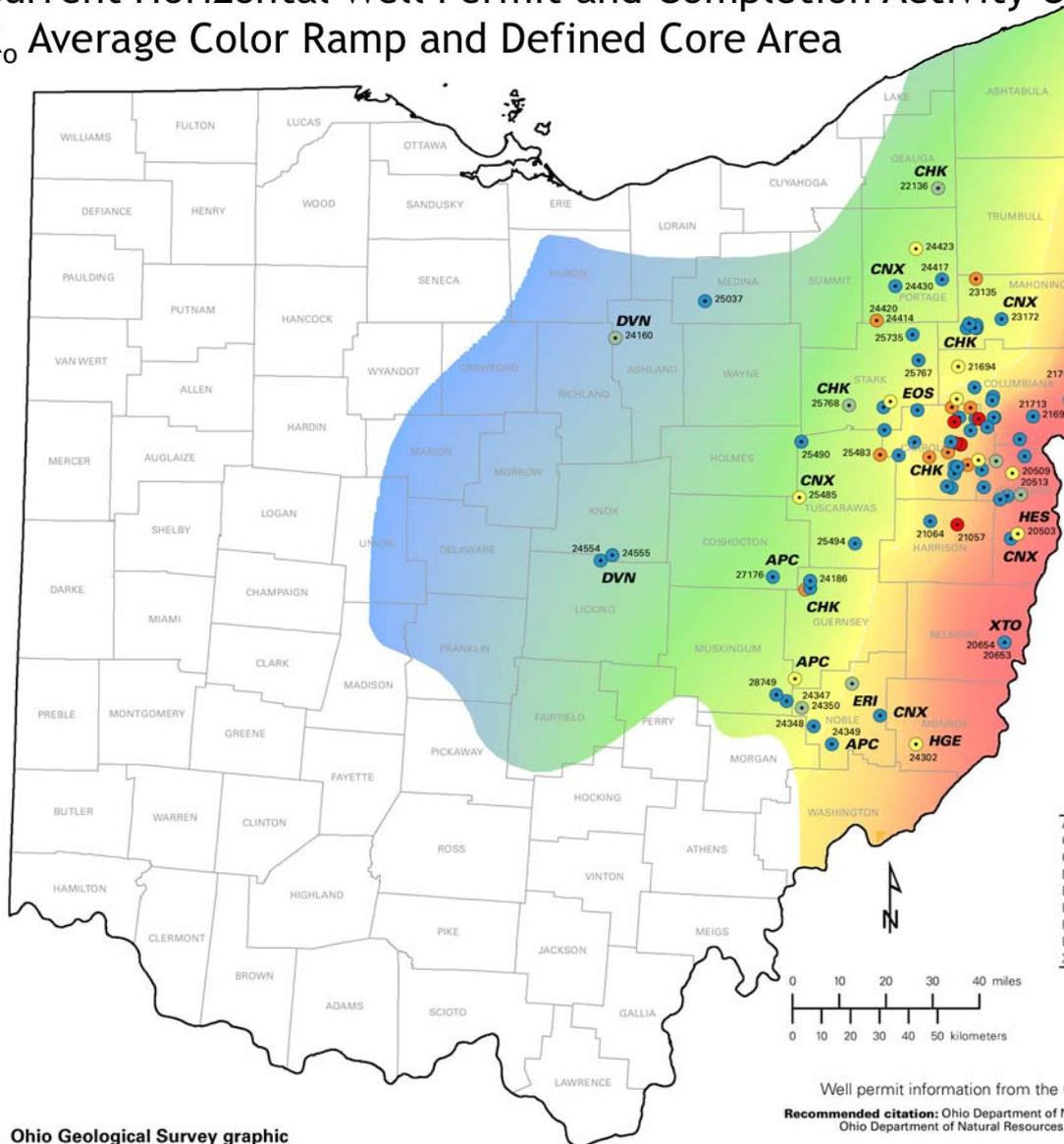


Well permit information from the ODNR Division of Oil and Gas Resources Management

Recommended citation: Ohio Department of Natural Resources, 2012, Horizontal Utica-Point Pleasant Well Activity in Ohio: Ohio Department of Natural Resources, Division of Geological Survey, scale 1:1,250,000, revised 2/27/2012.

Activity through 2-27-12

Current Horizontal Well Permit and Completion Activity Overlain on Equivalent R_o Average Color Ramp and Defined Core Area



EXPLANATION

Core Area & % R_o

10,830,209 total acres

Horizontal well status

Showing wells permitted 2010–Present

● Permitted

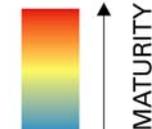
● Drilling

● Drilled

● Completed

● Producing

% R_o average



OPERATOR NAME	MAP LABEL	COUNT
ANADARKO E & P COMPANY LP	APC	10
CHESAPEAKE EXPLORATION LLC	CHK	103
CNX GAS COMPANY LLC	CNX	5
DEVON ENERGY PRODUCTION CO	DVN	4
ECLIPSE RESOURCES I LP	ERI	1
ENERVEST OPERATING L	EOS	7
HESS OHIO RESOURCES LLC	HES	1
HG ENERGY LLC	HGE	5
XTO ENERGY INC.	XTO	2
		138

Well permit information from the ODNR Division of Oil and Gas Resources Management

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Chesapeake News Release, October 2011

9.5 MMCFG per day.

1,425 bbl per day of natural gas liquids and oil.

First Ohio Utica-PP well in production. Annual production report due to ODNR by March 31.

Gas Show @ 8,250 ft in Utica.

Lateral length ~6,400 ft.

ISIP 6,287 psi.

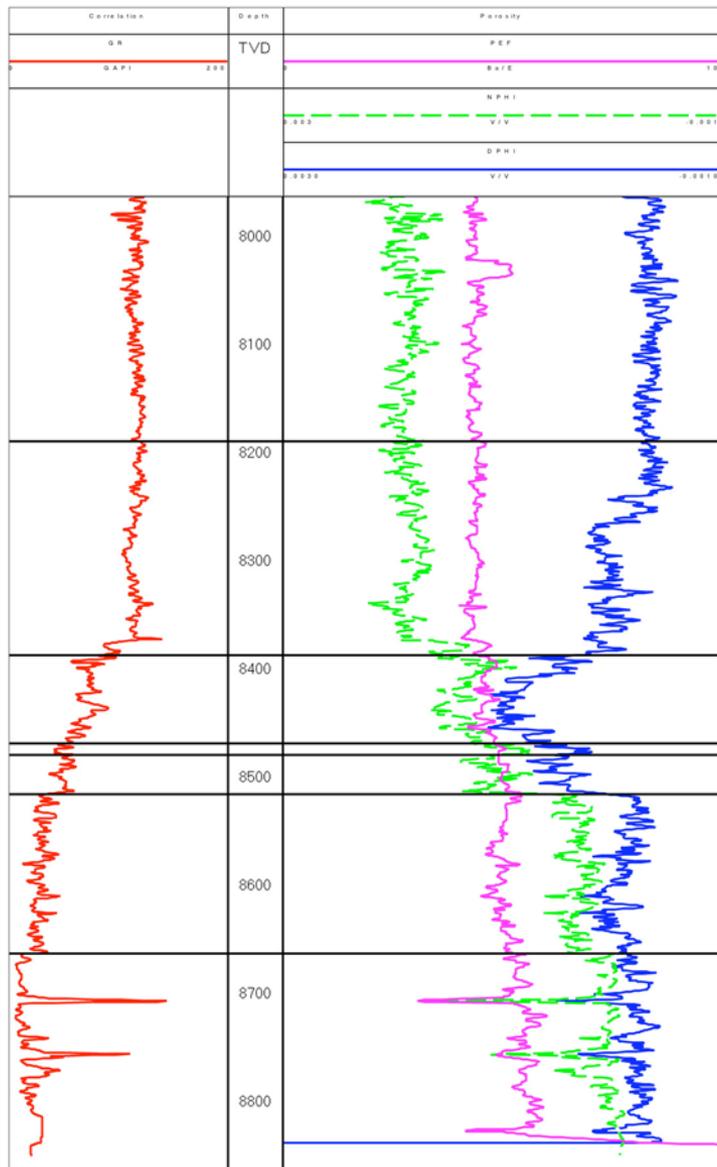
18 stage frac.

649,479 bbl injected.

Logs and completion data now available.

34067210570100

Chesapeake
Buell #8H



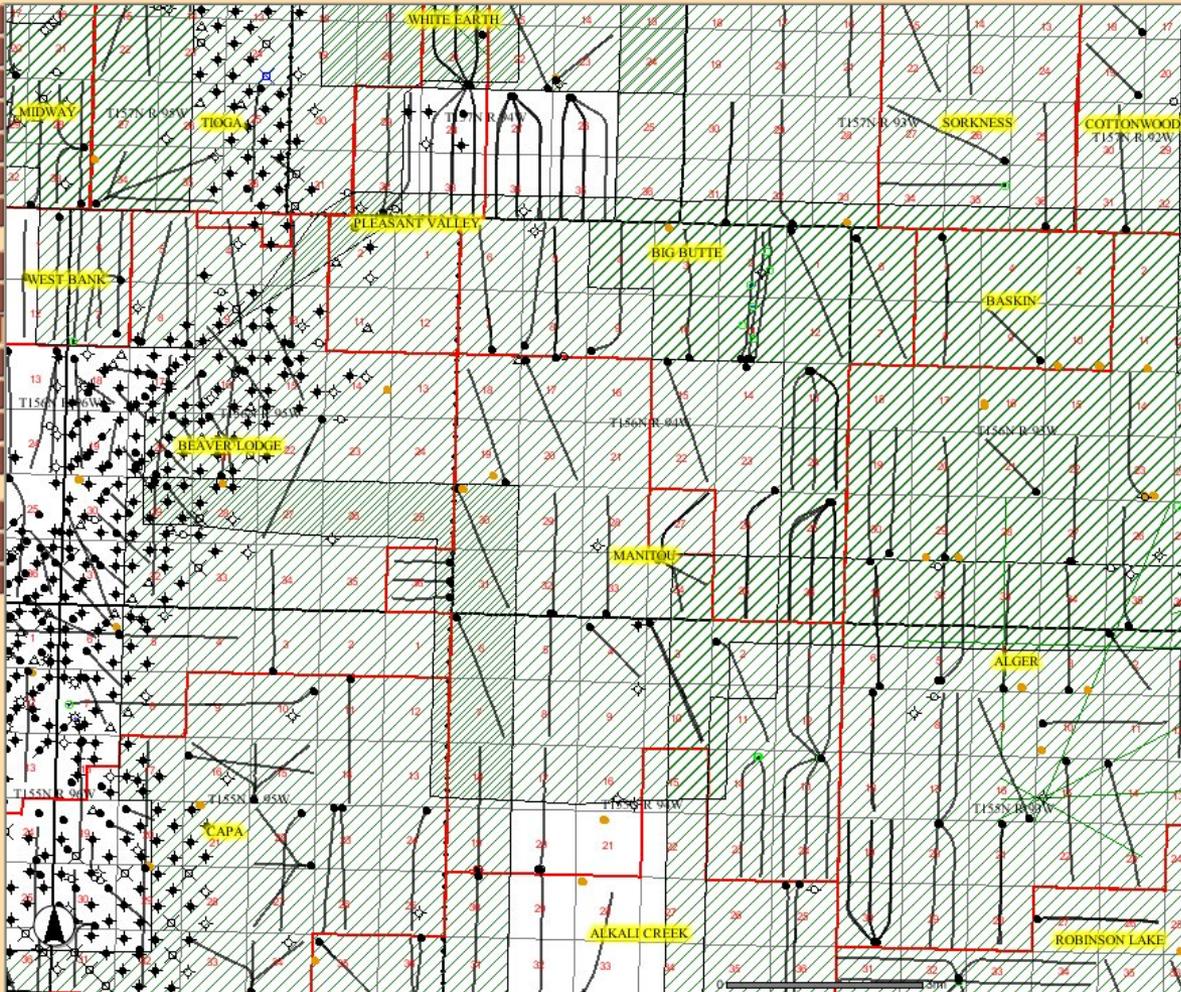
TD=8863

Oil and Gas : ArcIMS Viewer

Download Shape Files

- Legend / Layers
- Overview Map
- View Entire State
- Previous View
- Clear Selection
- Search
- Generate PDF

- Zoom In
- Zoom Out
- Pan
- Rect Identify
- Select Object
- Buffer
- Distance
- Find Well
- Find Field/Unit
- Find Section



- ### ND OIL & GAS LAYERS
- Oil and Gas
 - Wells
 - Rig Location
 - Directional Surveys
 - Directional Legs
 - Horizontal Surveys
 - Horizontal Legs
 - Cases Docketed
 - Oil Fields
 - Unit Boundaries
 - Inspector Areas
 - Drilling / Spacing
 - Seismic
 - Gas Plants
 - Other
 - Imagery
 - Topo/DRG 250k
 - Topo/DRG 100k
 - NAIP 2009
- Refresh Map
- Auto Refresh

- Help:
- A closed group, click to open.
 - An open group, click to close.
 - A map layer.
 - A hidden group/layer, click to make visible.
 - A visible group/layer, click to hide.
 - A visible layer, but not at this scale.
 - A partially visible group, click to make visible.
 - An inactive layer, click to make active.
 - The active layer.

Wells is now the Active Layer

Source: North Dakota Industrial Commission, Oil and Gas Division.

Pan

Map Data Last Updated : 2/22/2012

View of a portion of the Bakken horizontal drilling intensity.



OHIO GEOLOGICAL SURVEY OIL & GAS INTERACTIVE WEB MAP

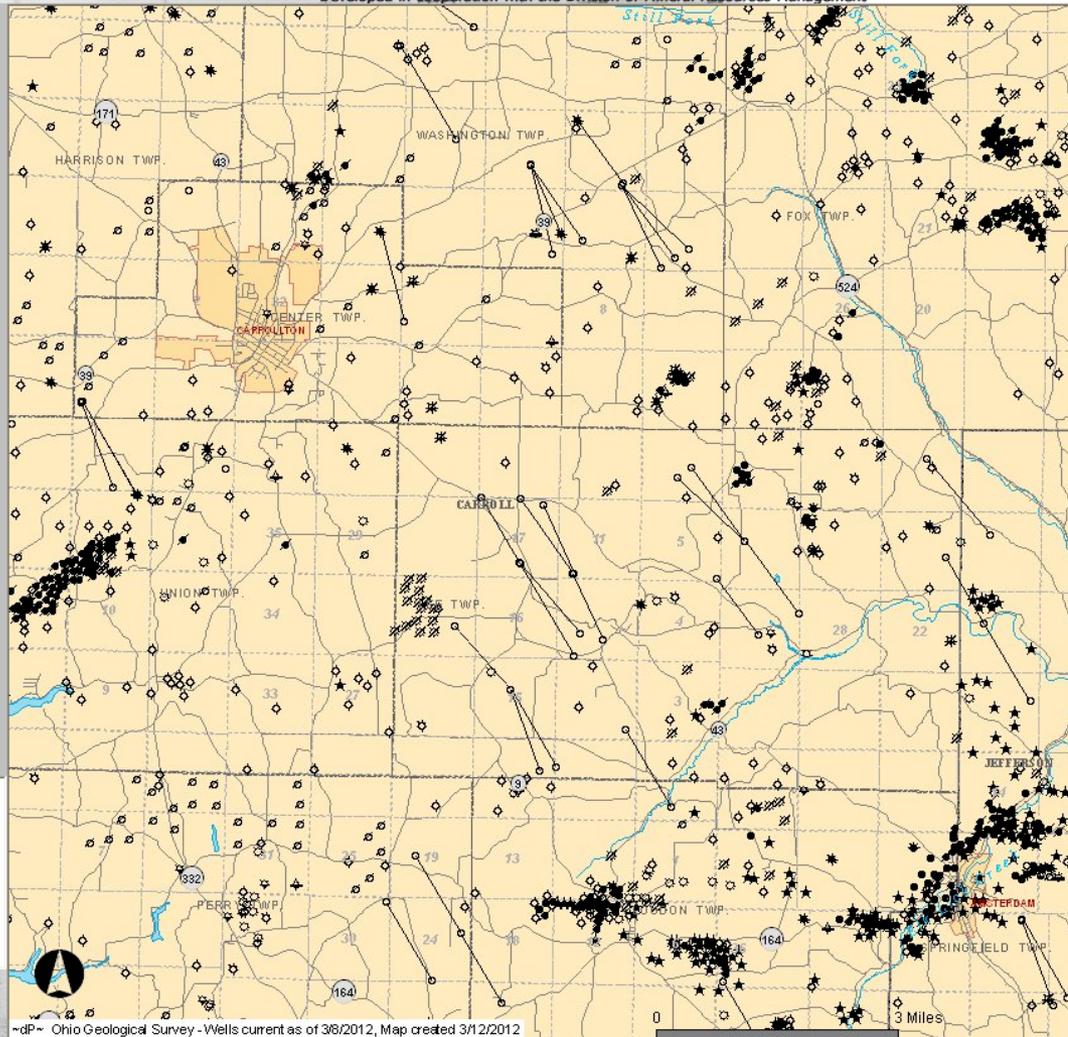


Developed in cooperation with the Division of Mineral Resources Management

Locate Address

Zoom to County

- Table of Content/Legend
- Zoom In
- Zoom Out
- Reset, Zoom to Full Extent
- Zoom To Last Extent
- Pan
- Hotlink-View Well Card
- Identify Feature
- Query Database
- Measure Distance
- Set Map Units
- Buffer Selected Feature(s)
- Select Feature(s) by Rectangle
- Clear Selection
- Tool Help
- Print Layout



- ### LAYERS
- All Layers
 - Oil and Gas Layers
 - Wells
 - Directional Drill Wellbore
 - Core Holdings
 - Oil and Gas Fields
 - Basemap Layers
 - Map Background(choose 1)
 - USGS Topo Map (DRG)
 - Color Aerial Photos (2005)

Refresh Map

Auto Refresh

Help:

Note: Layers are scale dependent. This means you must be zoomed in to certain scales to view some layers.

- A closed group, click to open.
- An open group, click to close.
- A map layer.
- A hidden group/layer, click to make visible.
- A visible group/layer, click to hide.
- A visible layer, but not at this scale.
- A partially visible group, click to make visible.
- An inactive layer, click to make active.
- The active layer.
- Layer's detailed legend (hidden), click to open.
- Layer's detailed legend (open), click to hide it.
- Layername - A layer with Metadata, click to view it.
- Layername - A standard layer with no Metadata.

Formation Codes

CONTACT US

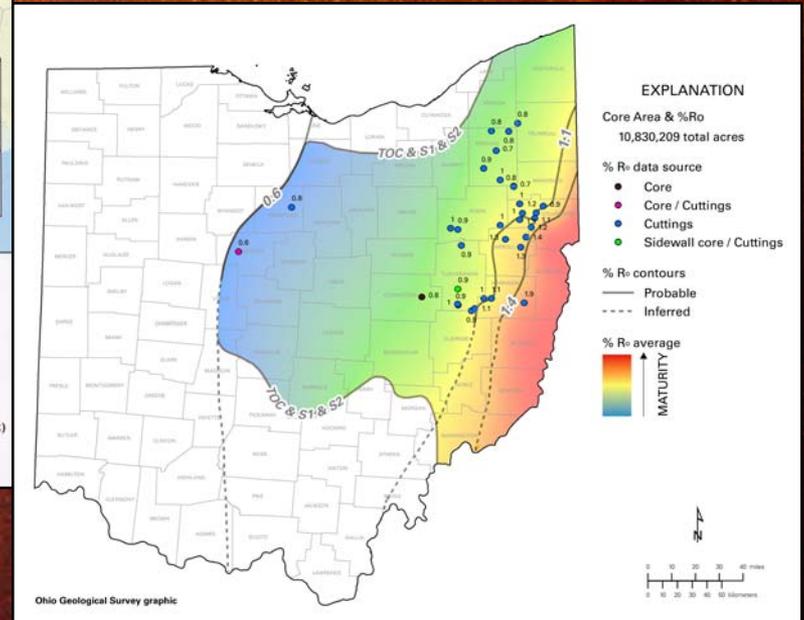
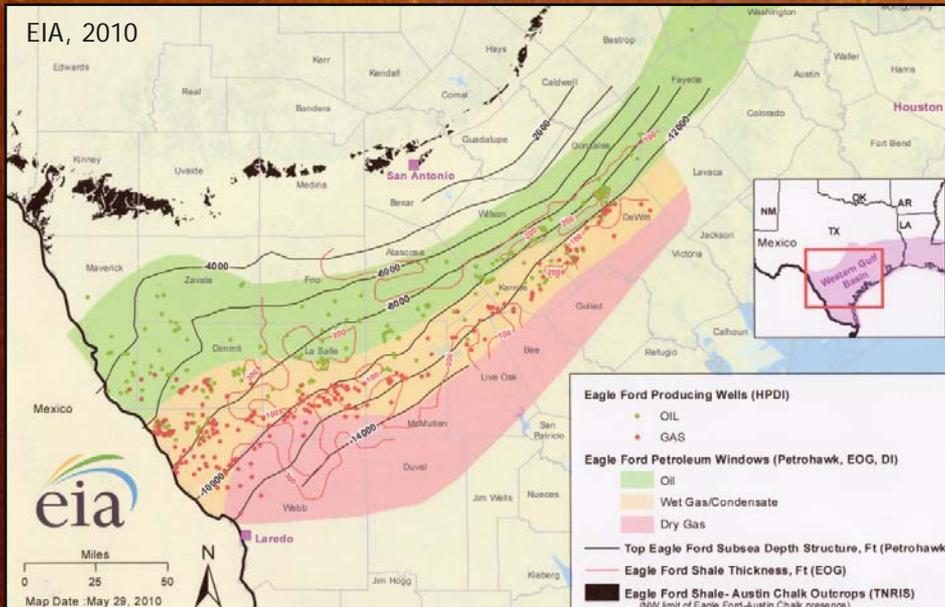


Pan

Ohio Geological Survey - Wells current as of 3/6/2012, Map created 3/12/2012

View of current horizontal permits in a portion of Carroll & Jefferson Counties, from Ohio Geological Survey Oil and Gas Interactive Web Map.

Eagle Ford and Utica-Point Pleasant Comparison



Estimated area of the Eagle Ford is about 20,000 square miles, equating to about 12.8 million acres.

(UTSA, 2011)

Estimated area of the Utica-Point Pleasant core play area is about 17,000 square miles, equating to about 11 million acres.

Recent Industrial Investments in Ohio as a Result of the Utica and Marcellus Shale Plays

V&M Star, Youngstown - \$650 million+

U.S. Steel, Lorain - \$240 million

Timken, Canton - \$225 million

Chesapeake, M3 Midstream, & EV Energy Partners, Columbiana County - \$900 million

Halliburton, Muskingum County - \$150 million & 300 jobs

MarkWest, Harrison & Monroe Counties - \$500 million & 700+ construction jobs

Exterran, Columbiana County - \$13 million & about 100 jobs

Baker Hughes, Stark County - \$64 million & 700 jobs

Select Energy Services, Carroll County- \$10 million & 185 jobs

TOTAL INVESTMENT = \$2.75 BILLION

and counting, NOT including lease and royalty payments, operations, etc.!

Acknowledgments

- Greg Schumacher, Joe Wells, Lisa Van Doren, and Chuck Salmons—Ohio Geological Survey
- Jackie Reed—Reed Geochemical Consulting
- Bob Ryder, Sue Tewalt, Bob Milici, and Jingle Rupert—USGS

References Cited

Bodino, Michael, 2011, Got Utica? A Utipedia of Producers' Acreage and Drilling Plans: Developing Unconventional Gas East Annual Conference, 3rd, Pittsburgh, Pa., Nov. 15-17, 2011 [Proceedings].

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