

An Overview of Marcellus and other Devonian Shale Production in West Virginia*

Eric Lewis¹, Mary Behling¹, and Susan Pool¹

Search and Discovery Article #10372 (2011)

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*Adapted from oral presentation at AAPG Eastern Section meeting, Washington, DC, September, 25-27, 2011

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Abstract

The Middle Devonian Marcellus Shale Play has put the Appalachian Basin at the center of a national debate concerning America's future energy supply. Although it has been received in the region with mixed reviews, this highly organic shale formation has secured itself as a major contributor to the natural gas supply of West Virginia and other states in the Basin. As production continues throughout West Virginia, areas of high production continue to emerge; however, it appears that some of these "sweet spots" may not actually be within the "Marcellus" per se, but rather, in other, overlying Devonian shales. Various aspects of shale production will be explored including vertical versus horizontal completions.

An Overview of Marcellus Shale Production in West Virginia

Eric Lewis
Mary Behling
Sue Pool

Tuesday, September 27, 2011

AAPG-ES Washington, D.C.

www.wvgs.wvnet.edu

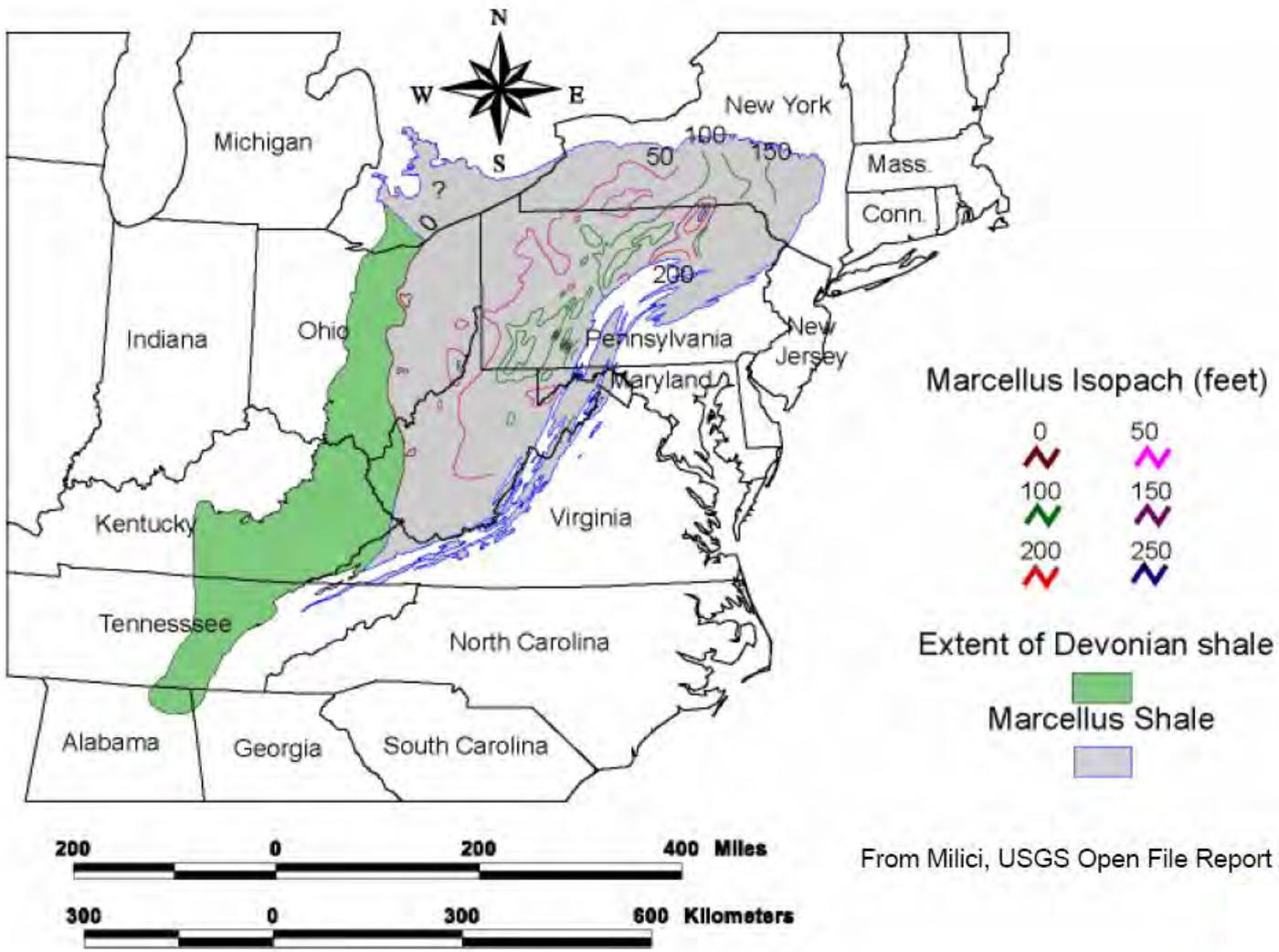


OUTLINE

- Regional geology
- Units of interest
 - L. Huron
 - Rhinestreet
 - Marcellus
- Marcellus in detail
- Current and future work
 - Bruner's work
 - Bilgesu's work
 - Pool's work – resource assessment

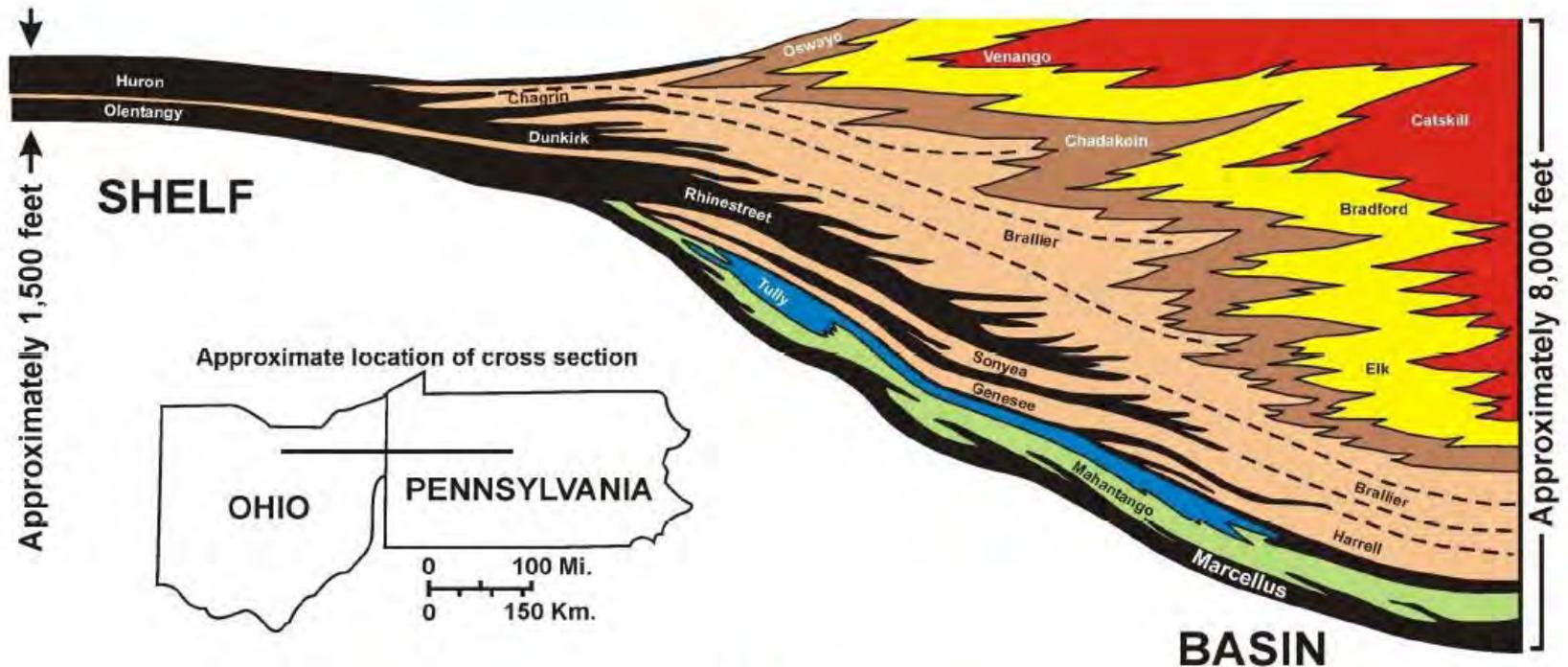
Regional geology

Marcellus Shale

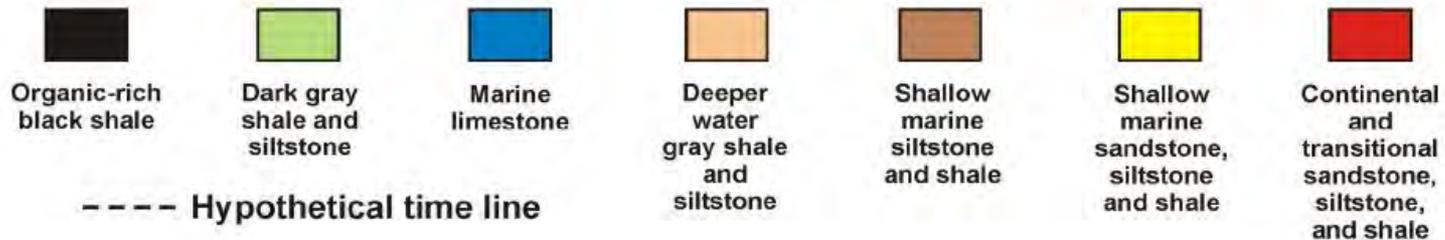


From Milici, USGS Open File Report 2005-1268

THE CATSKILL CLASTIC WEDGE



LEGEND



Modified from Harper, 1999

Southwest

KENTUCKY | WEST VIRGINIA

Northeast

B

A

Sea Level

Price Formation

Pycnocline

Borden Formation

Sunbury Shale

Berea-Bedford

Chagrin Shale

Ohio Shale

Upper Part Huron Member

Chattanooga Shale

Ohio Shale

Middle Part Huron Member

Lower Part Huron Member

Portwood Member

Upper Oolite Shale

Hanover-Angola shales

Rhinestreet Shale

Cashaqua/Sonyea shales

Middlesex Shale Member

Tully Limestone

Cratonic Basin

Foreland Basin

KENTUCKY
WEST VIRGINIA

West River-Penn Yan Shales

Mahantango Formation

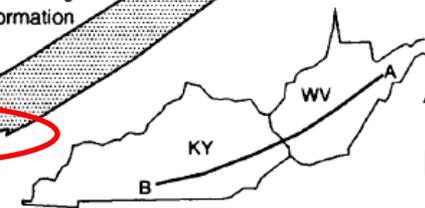
Genesee shales

Lower Oolite Shale

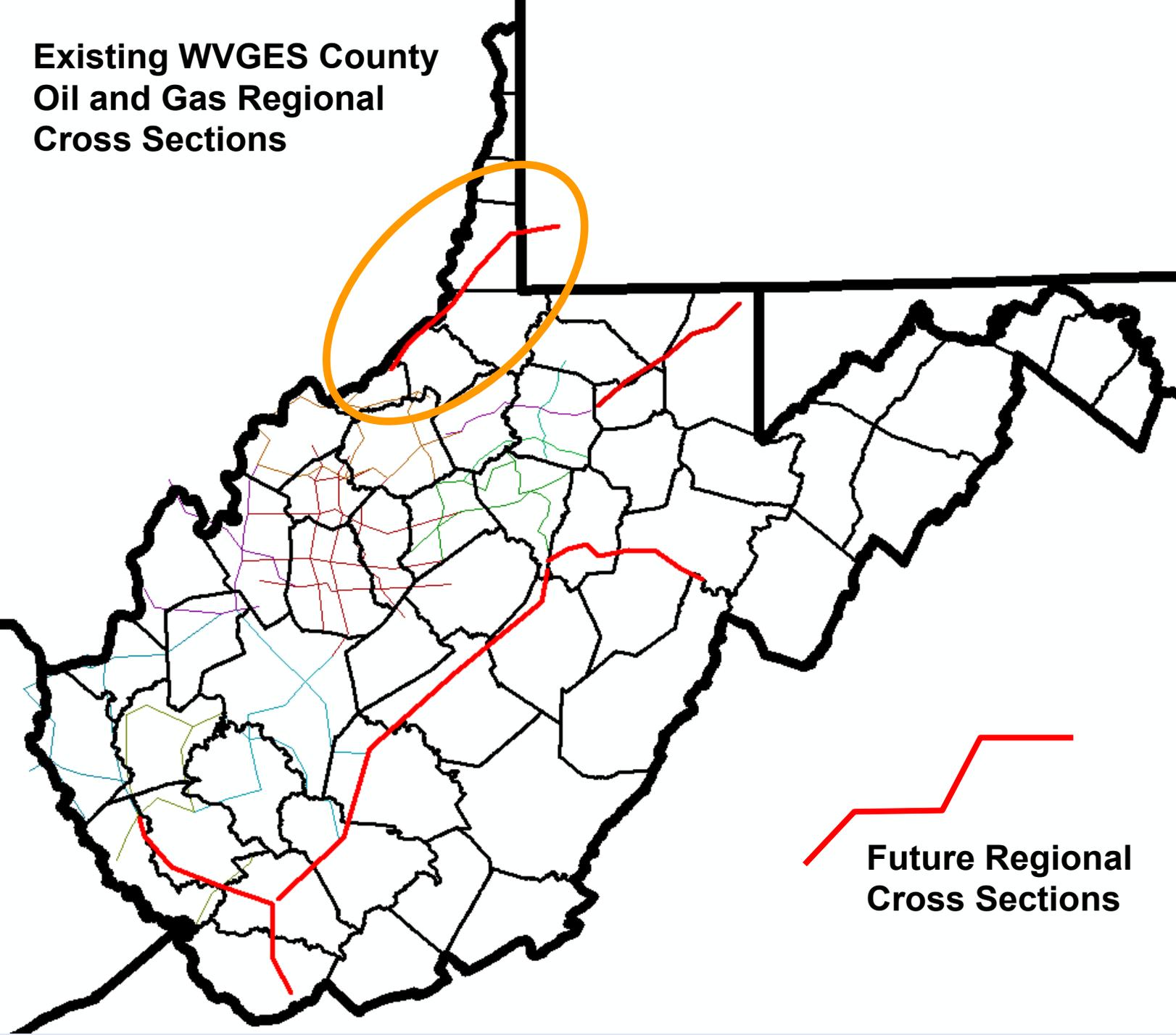
Marcellus Shale

LEGEND

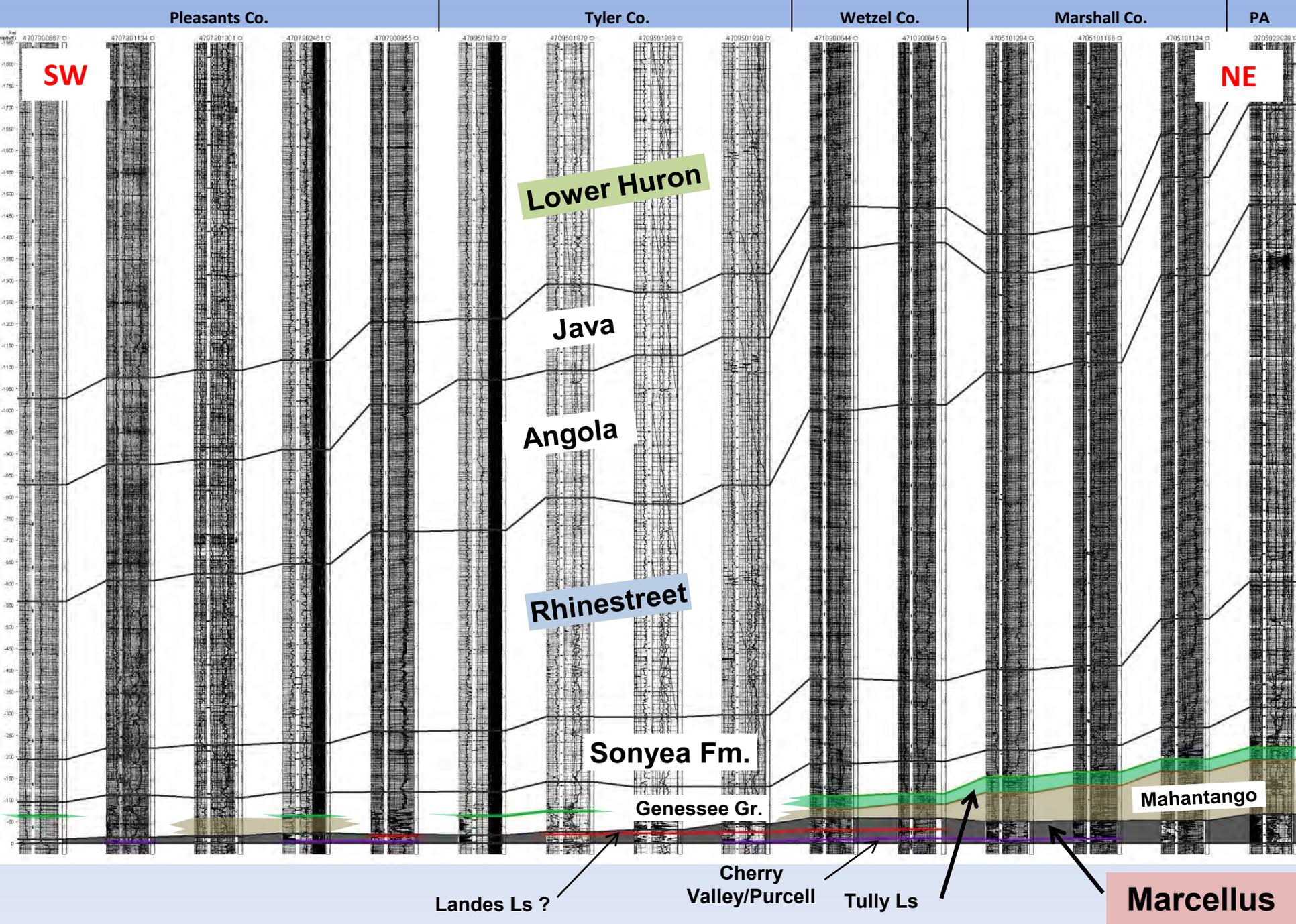
-  Transgressive Black Shales
-  Regressive Shales
-  Lighter Colored Clastic Sediments
-  Carbonate-Rich Black Shales
- BB Borden Black-Shale Equivalents
- TL Three Lick Bed
-  Disconformity



**Existing WVGES County
Oil and Gas Regional
Cross Sections**



**Future Regional
Cross Sections**



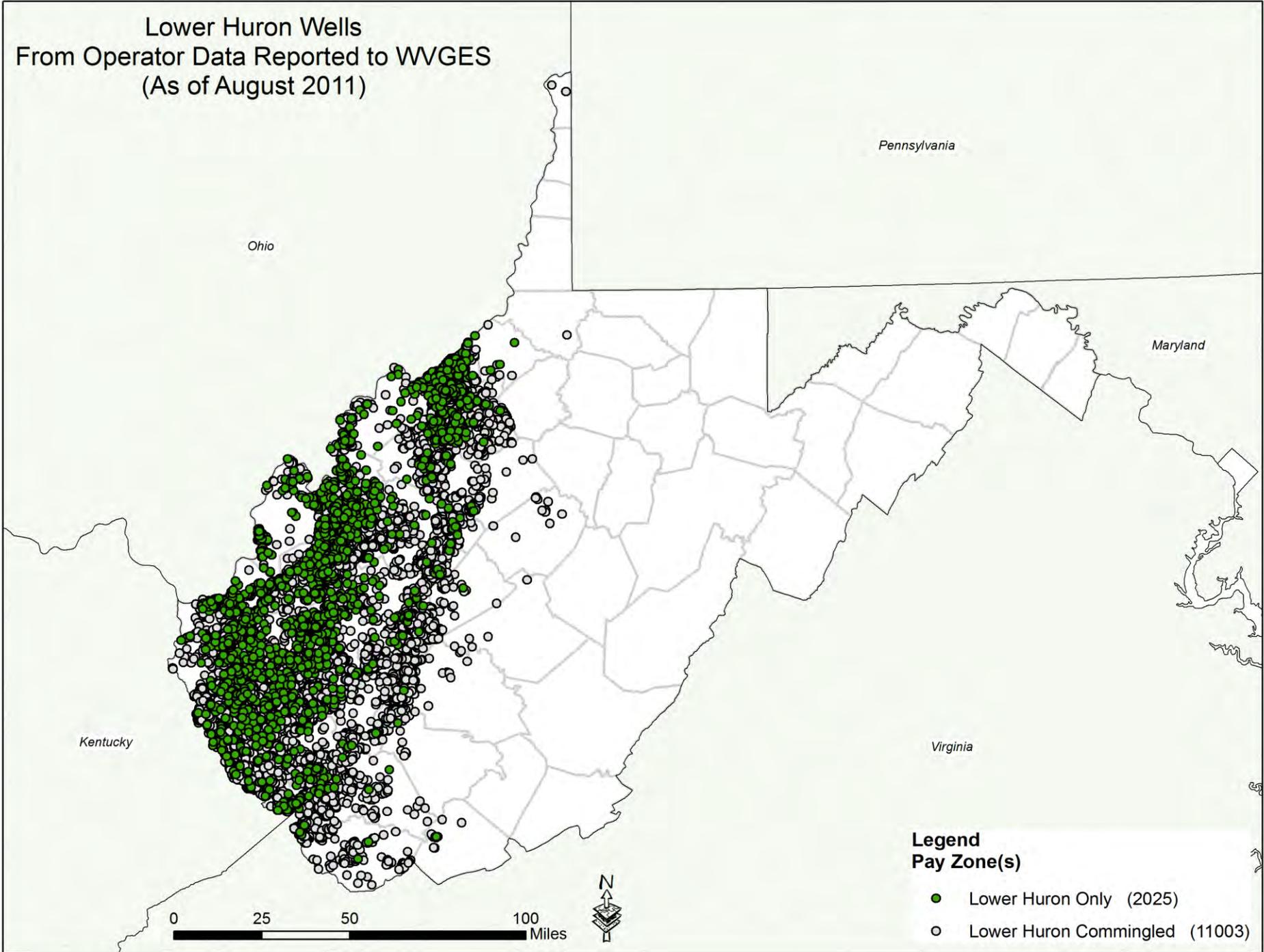
Datum: Onondaga Ls

Lower Huron

Rhinestreet

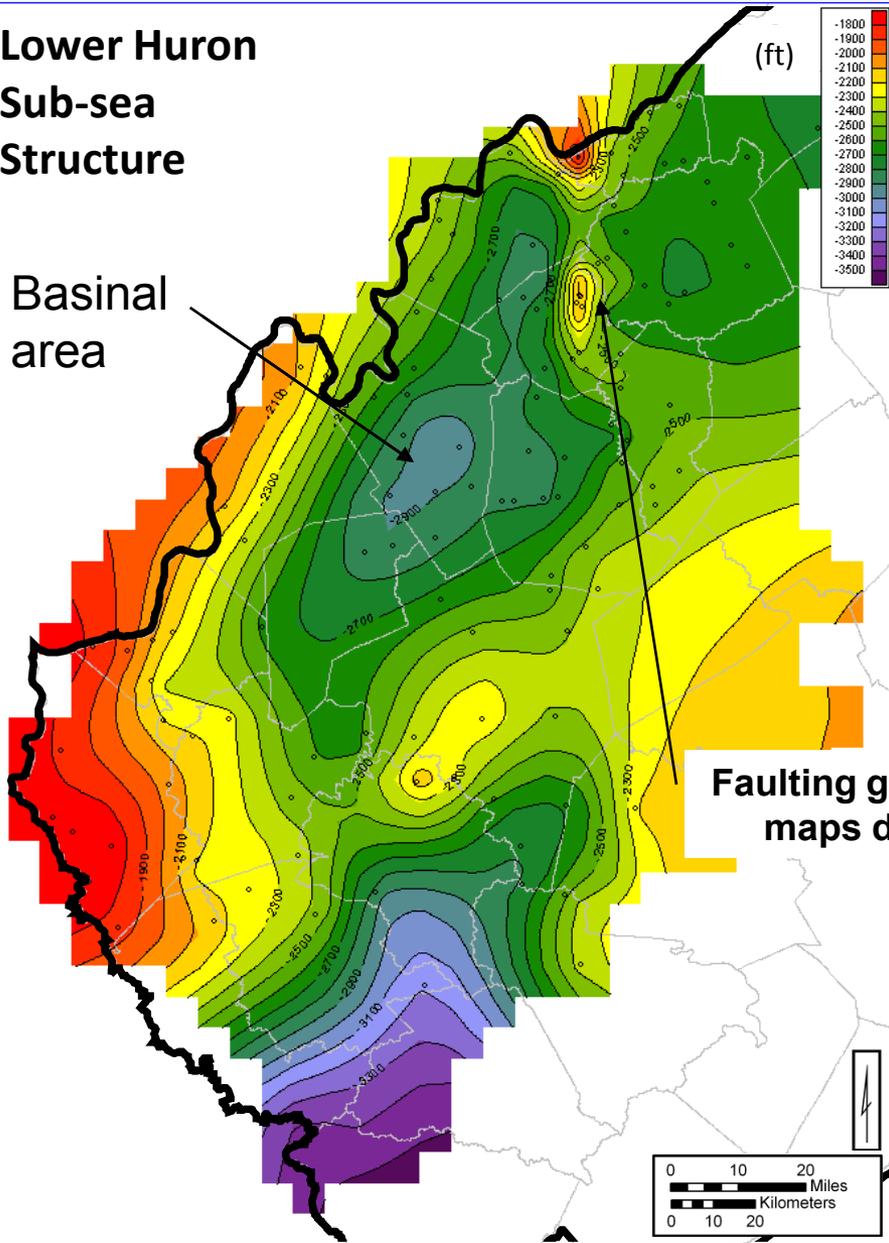
Marcellus

Lower Huron Wells From Operator Data Reported to WVGES (As of August 2011)



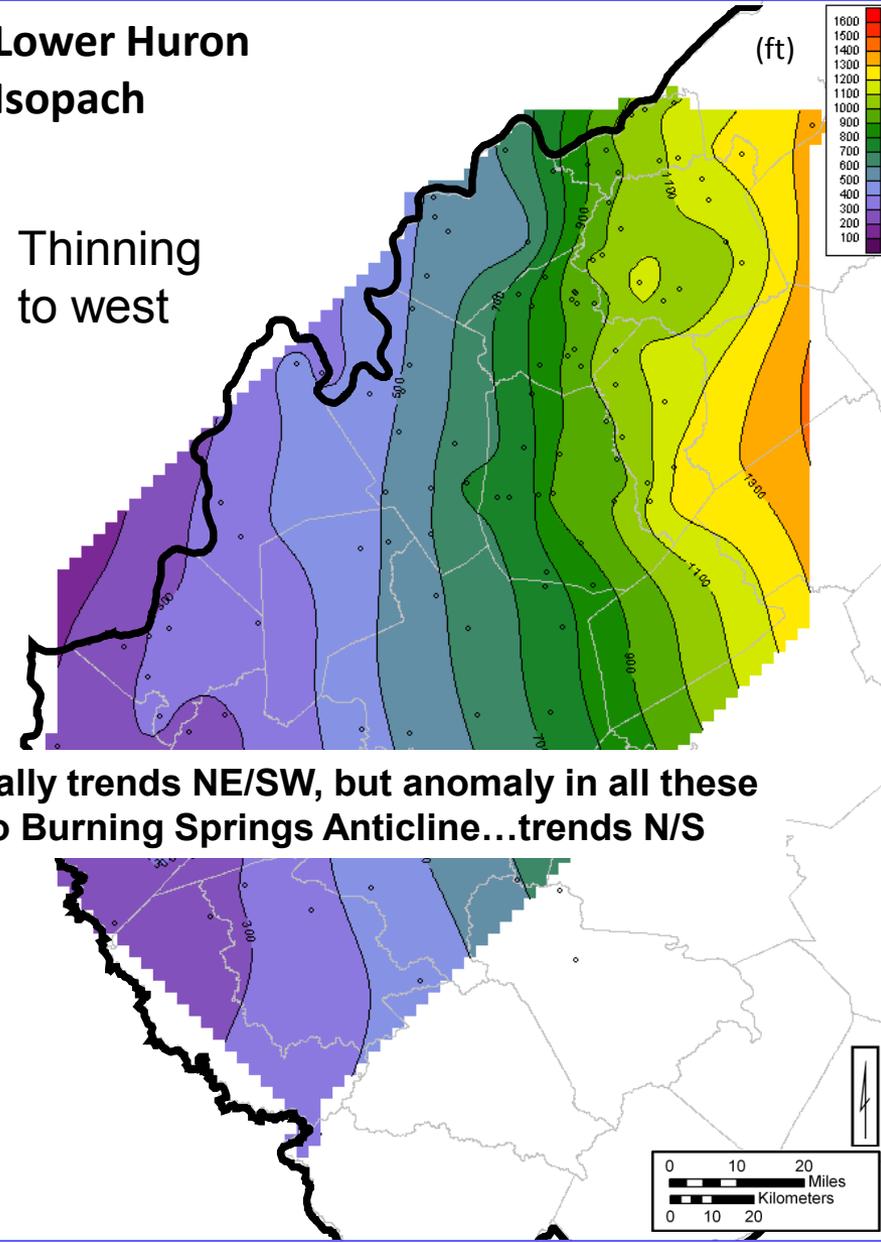
Lower Huron Sub-sea Structure

Basinal
area



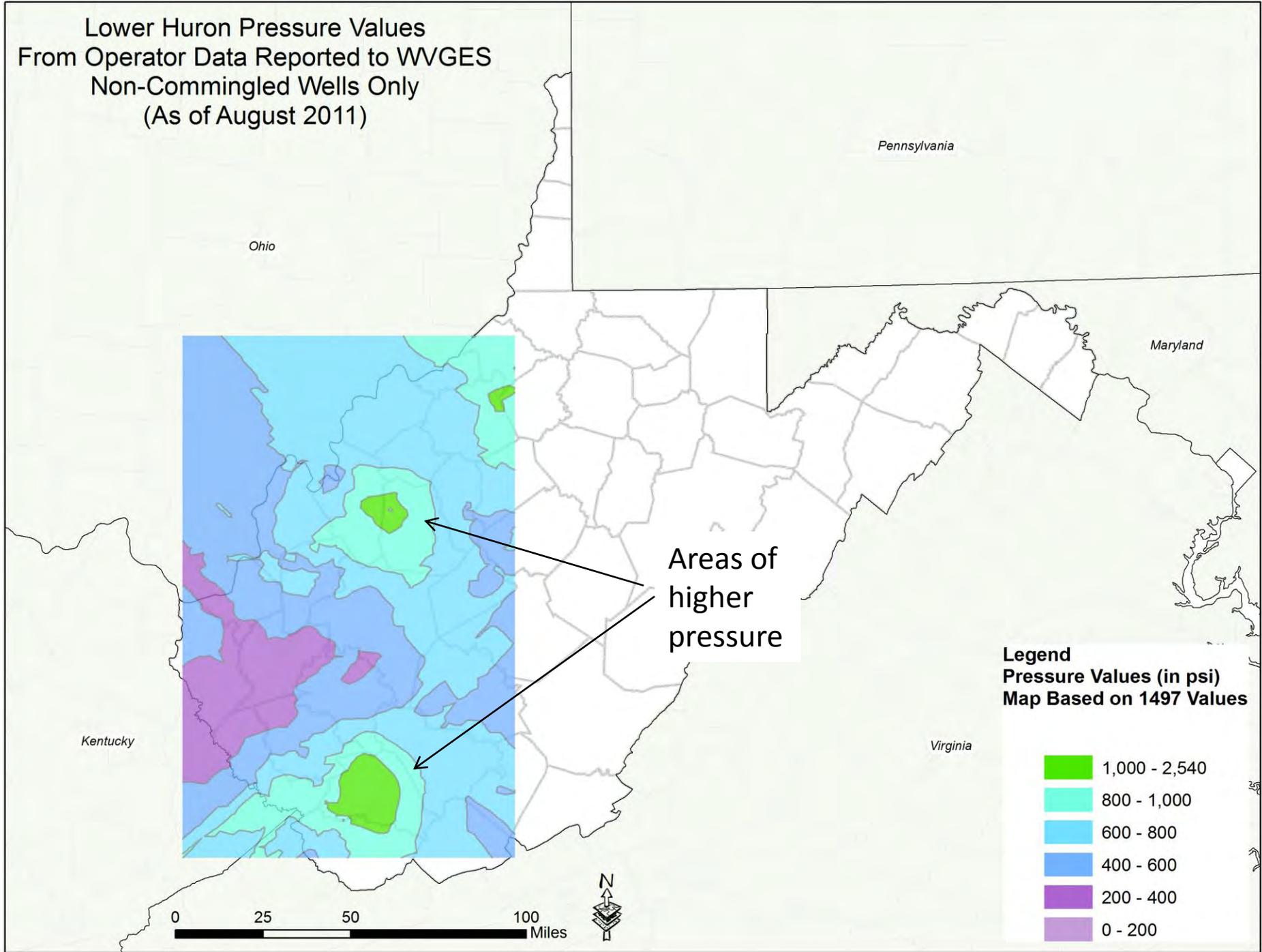
Lower Huron Isopach

Thinning
to west

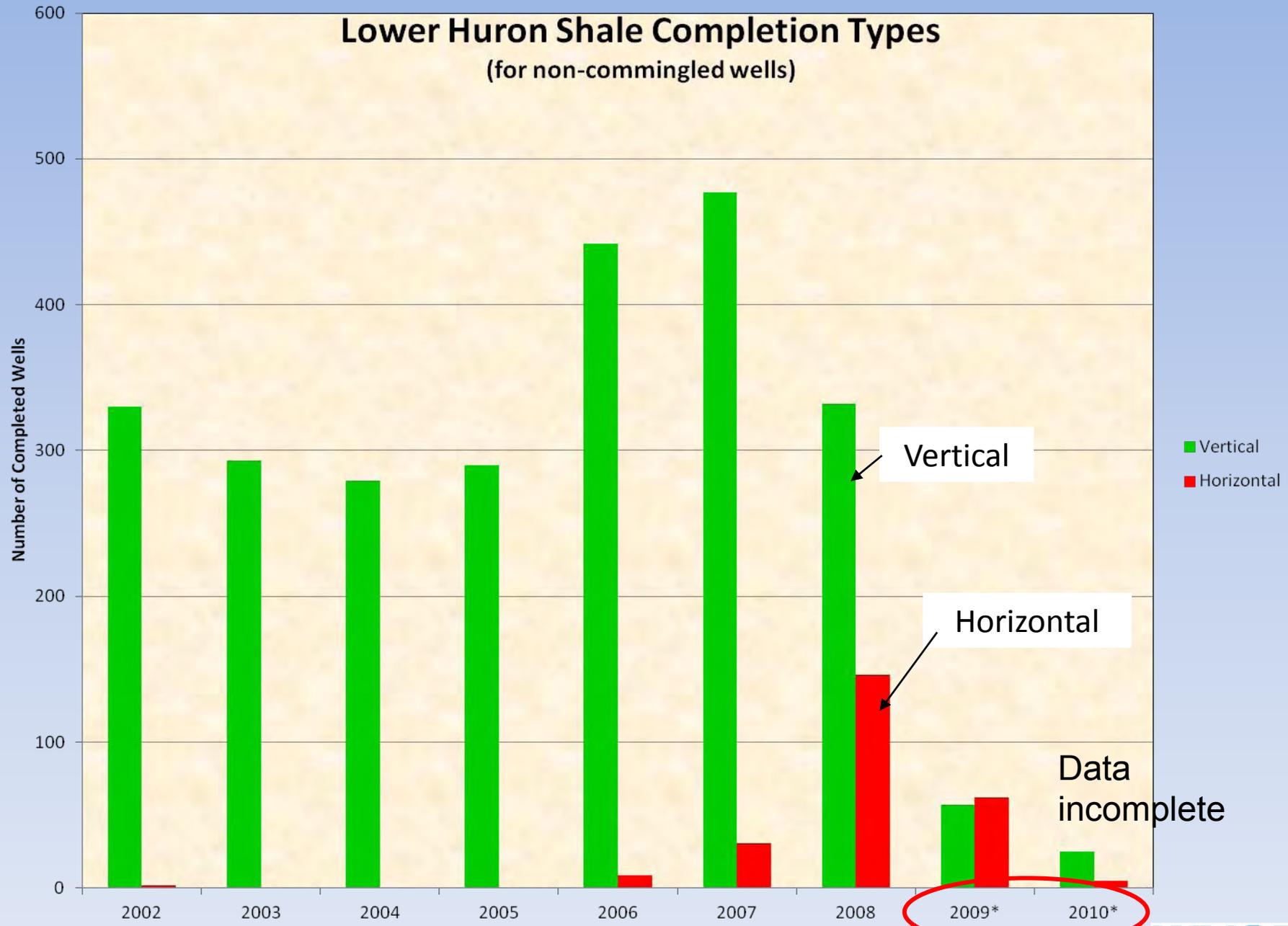


Faulting generally trends NE/SW, but anomaly in all these maps due to Burning Springs Anticline...trends N/S

Lower Huron Pressure Values
From Operator Data Reported to WVGES
Non-Commingled Wells Only
(As of August 2011)

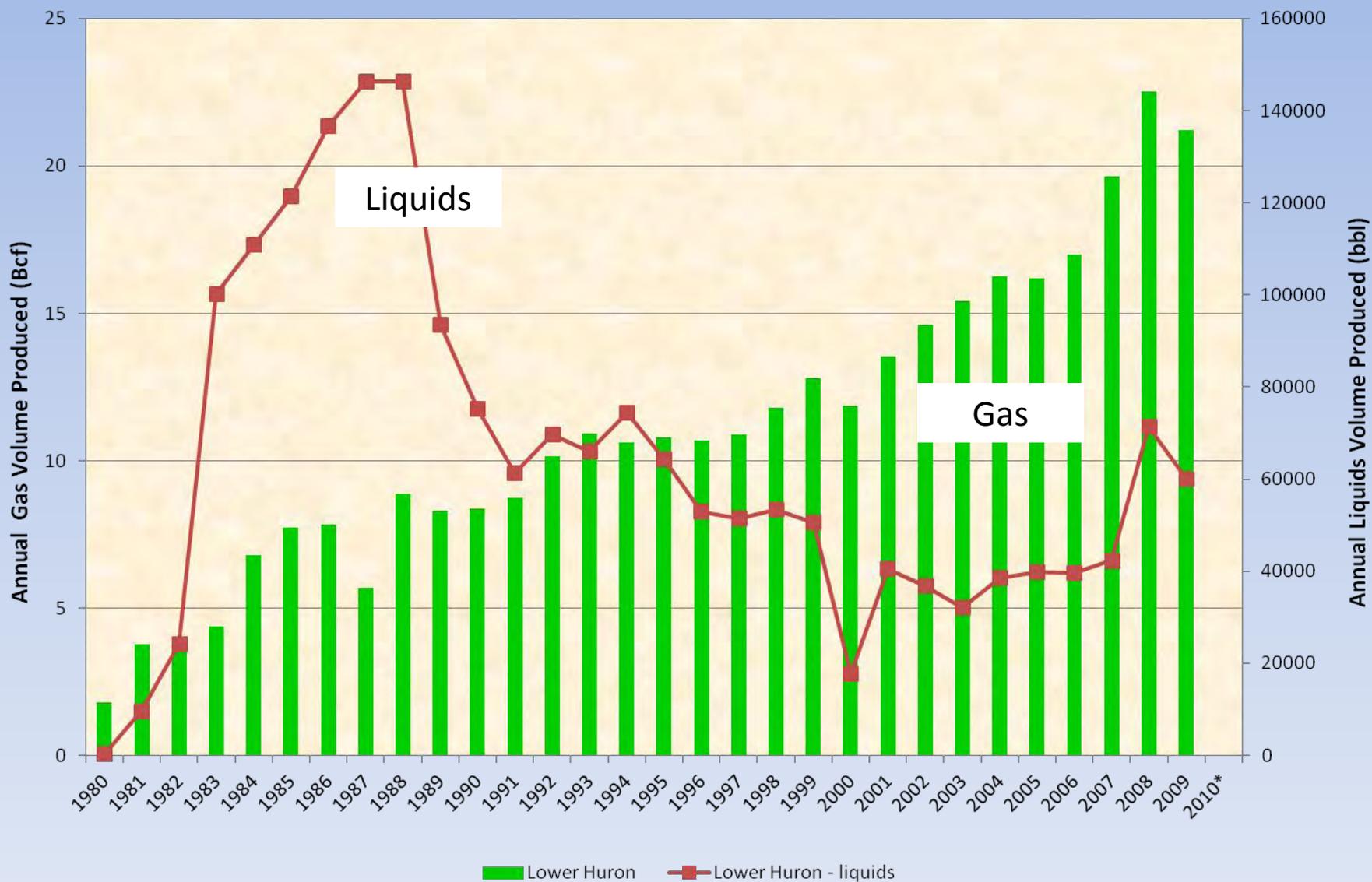


Lower Huron Shale Completion Types (for non-commingled wells)



Lower Huron Shale Production

(from non-commingled wells)



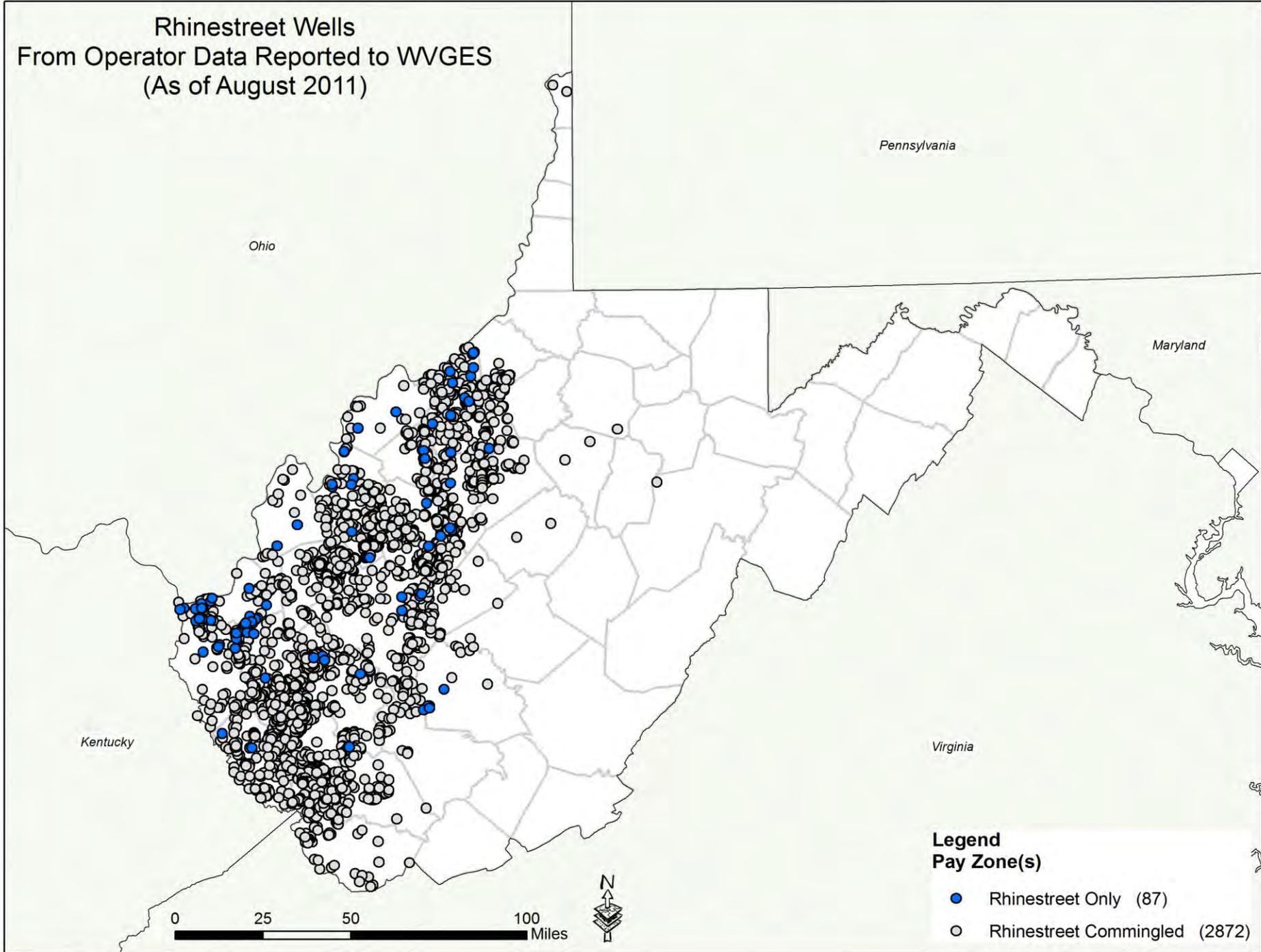
Lower Huron

Rhinstreet

Marcellus

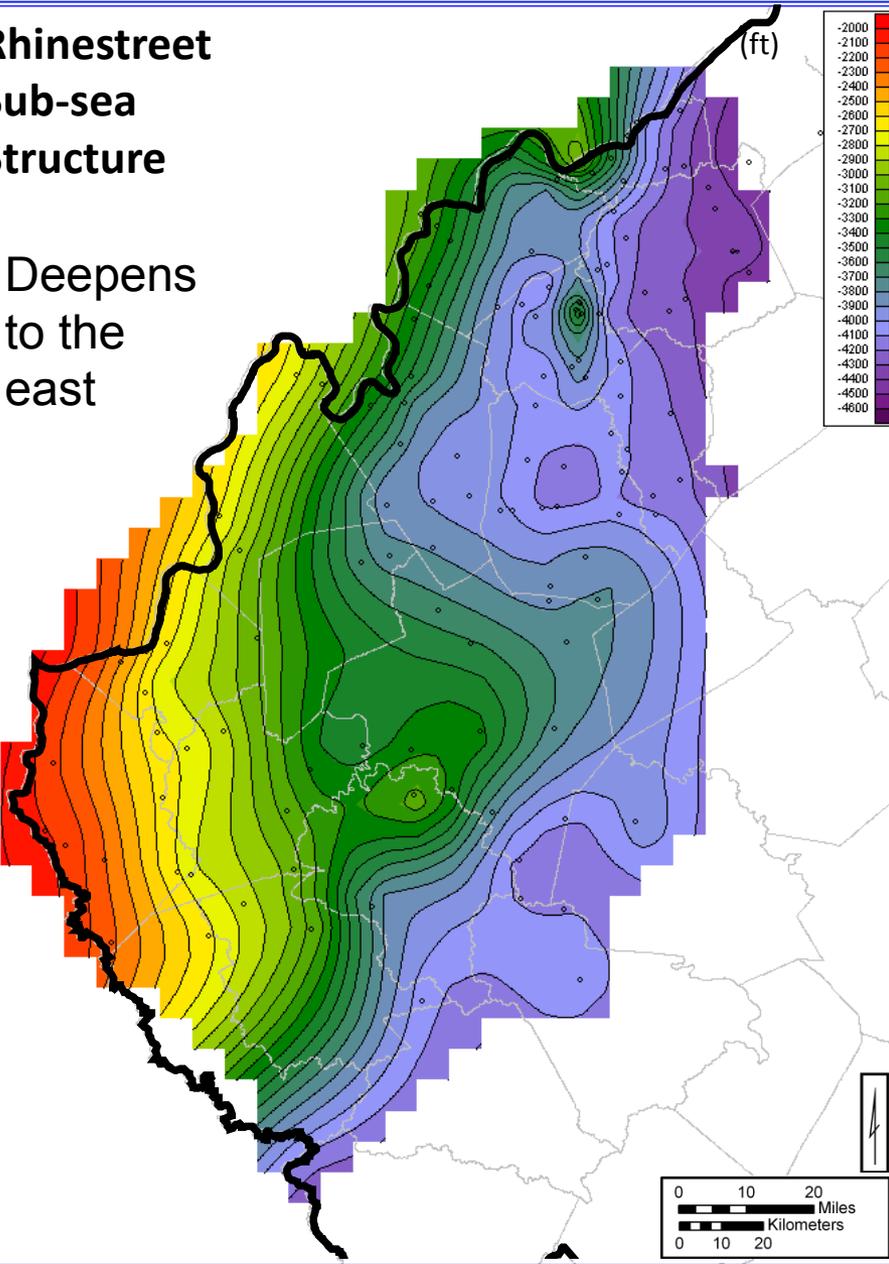
Rhinestreet Wells

From Operator Data Reported to WVGES
(As of August 2011)



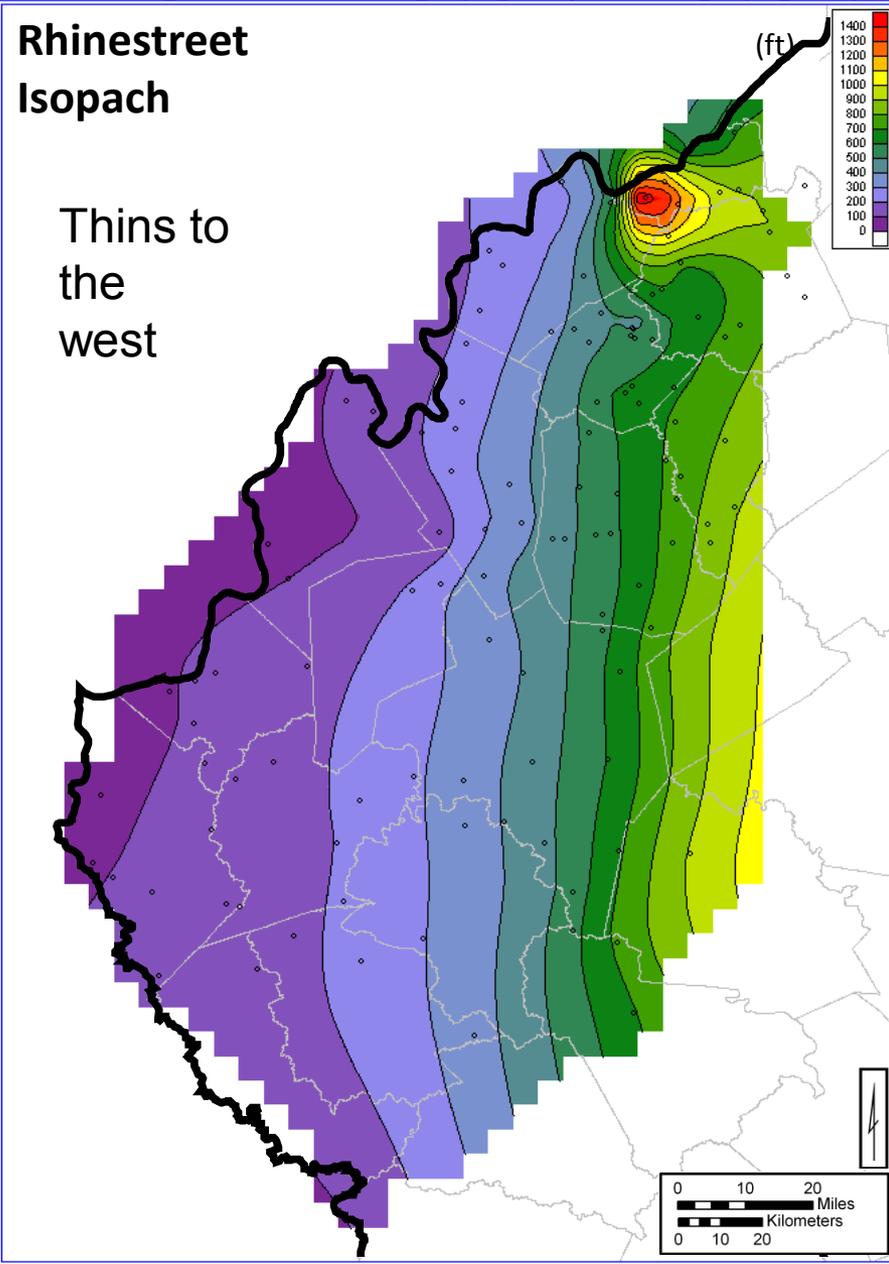
Rhinestreet Sub-sea Structure

Deepens
to the
east

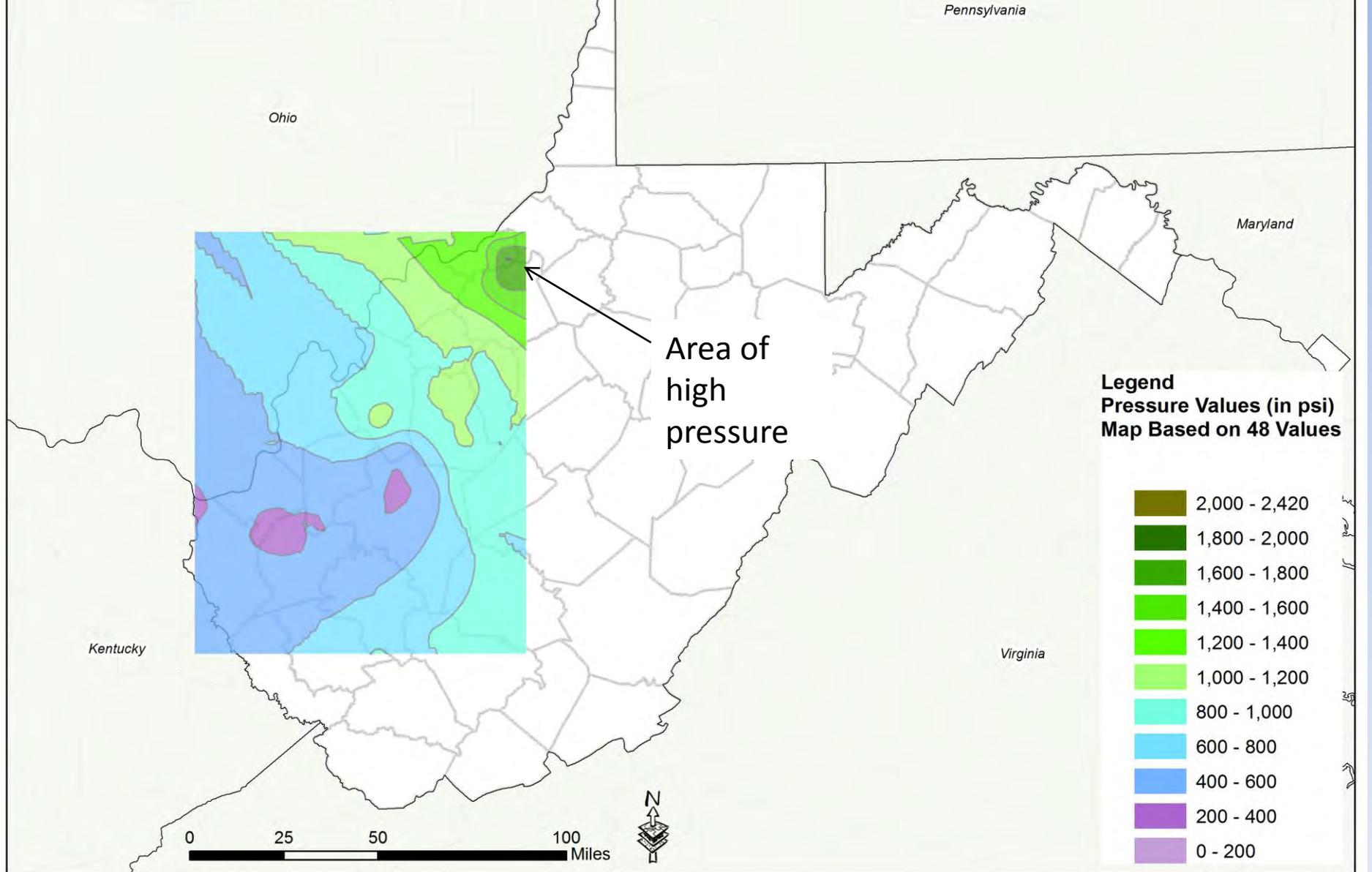


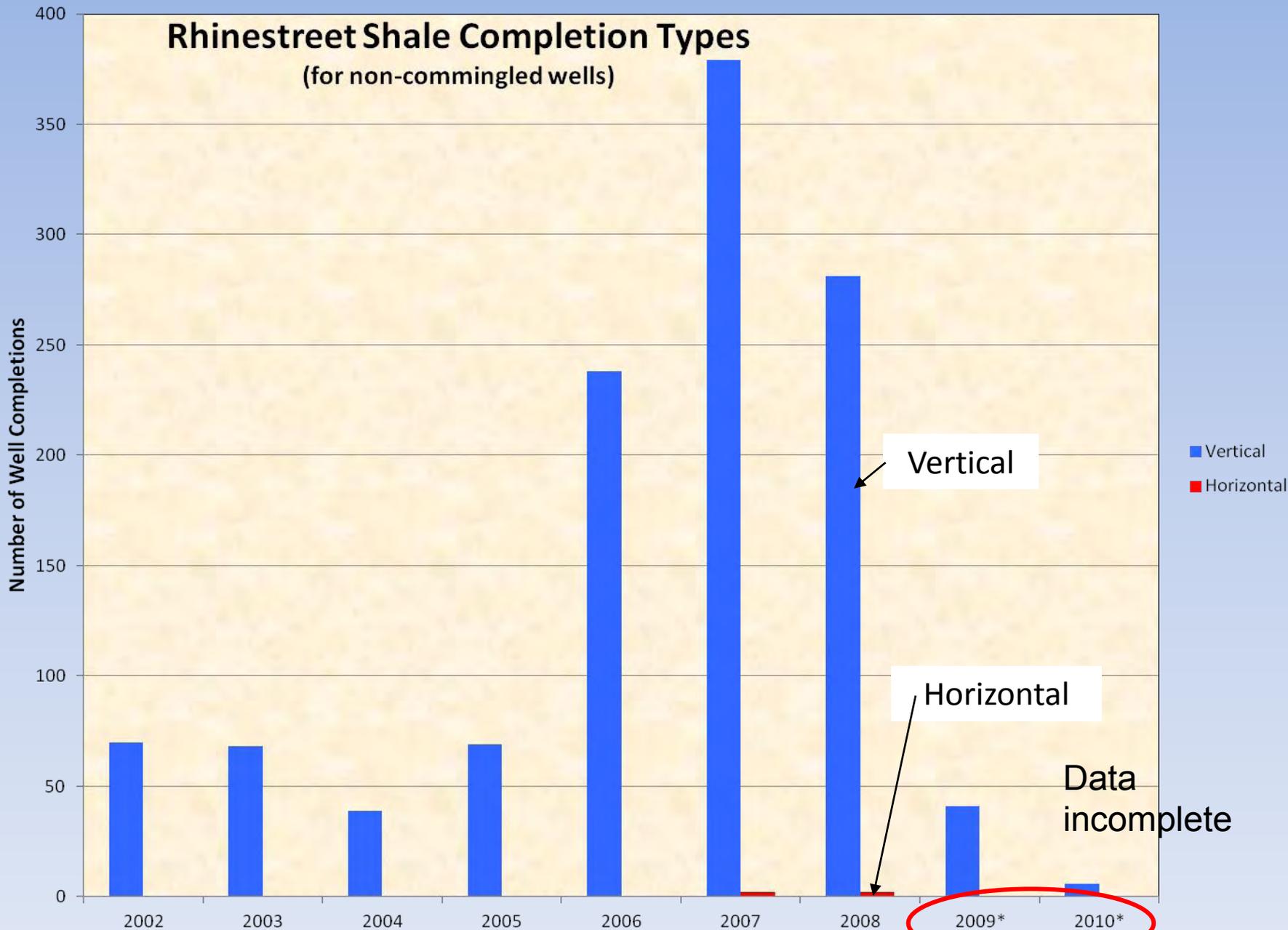
Rhinestreet Isopach

Thins to
the
west

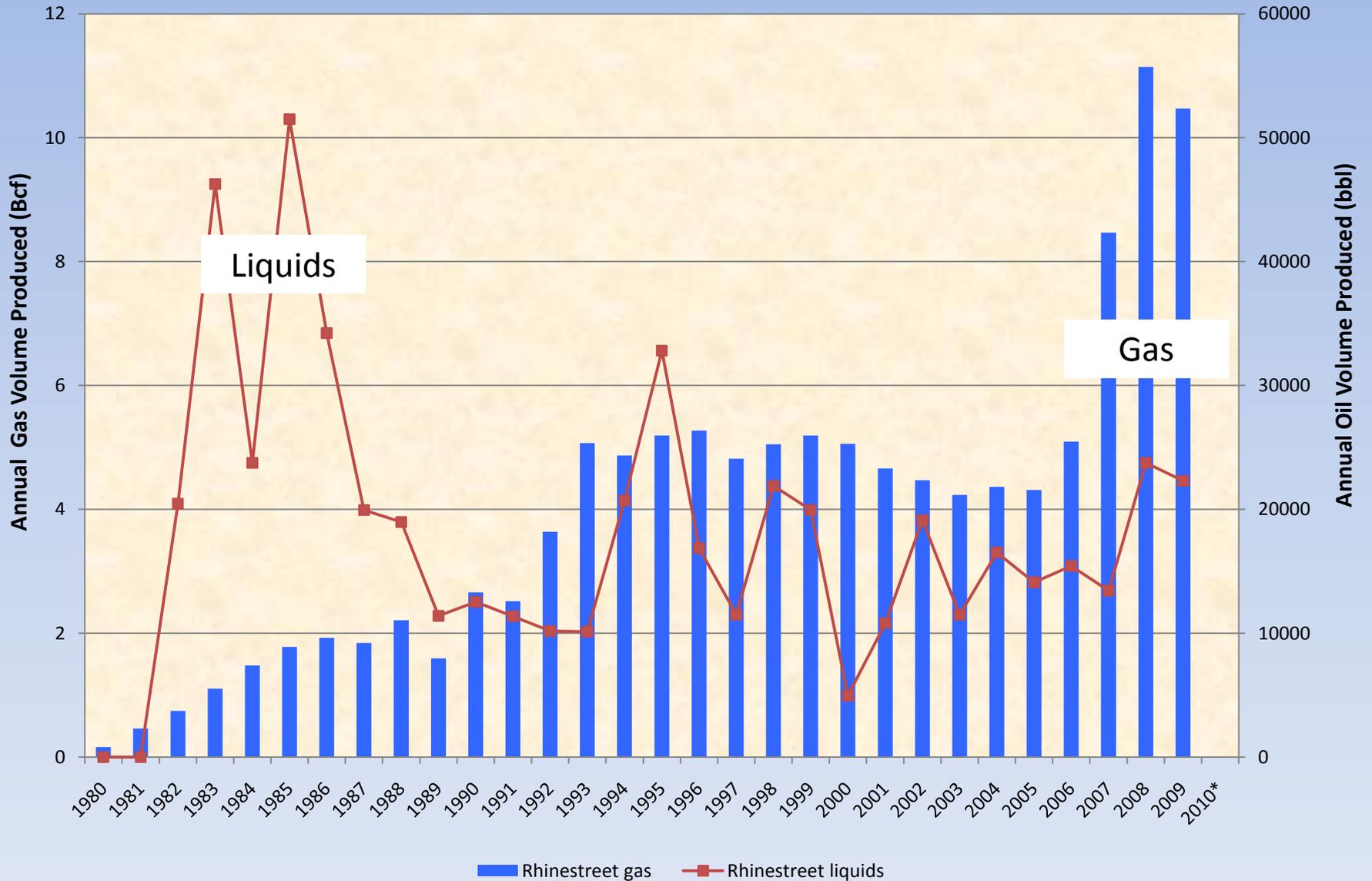


Rhinestreet Pressure Values
From Operator Data Reported to WVGES
Non-Commingled Wells Only
(As of August 2011)





Rhinestreet Shale Production (from non-commingled wells)



Lower Huron

Rhinestreet

Marcellus



Some information we receive is inconsistent and incomplete

Publications Policy:

This publication represents interpretations of best available data made by professional geologists. As in all research work, professional interpretations may vary, and can change with advancements in both technology and data quality. This publication is offered as a service of the State of West Virginia; proper use of the information herein is the sole responsibility of the user.

Marcellus "zero" line

Geological and Economic Survey.

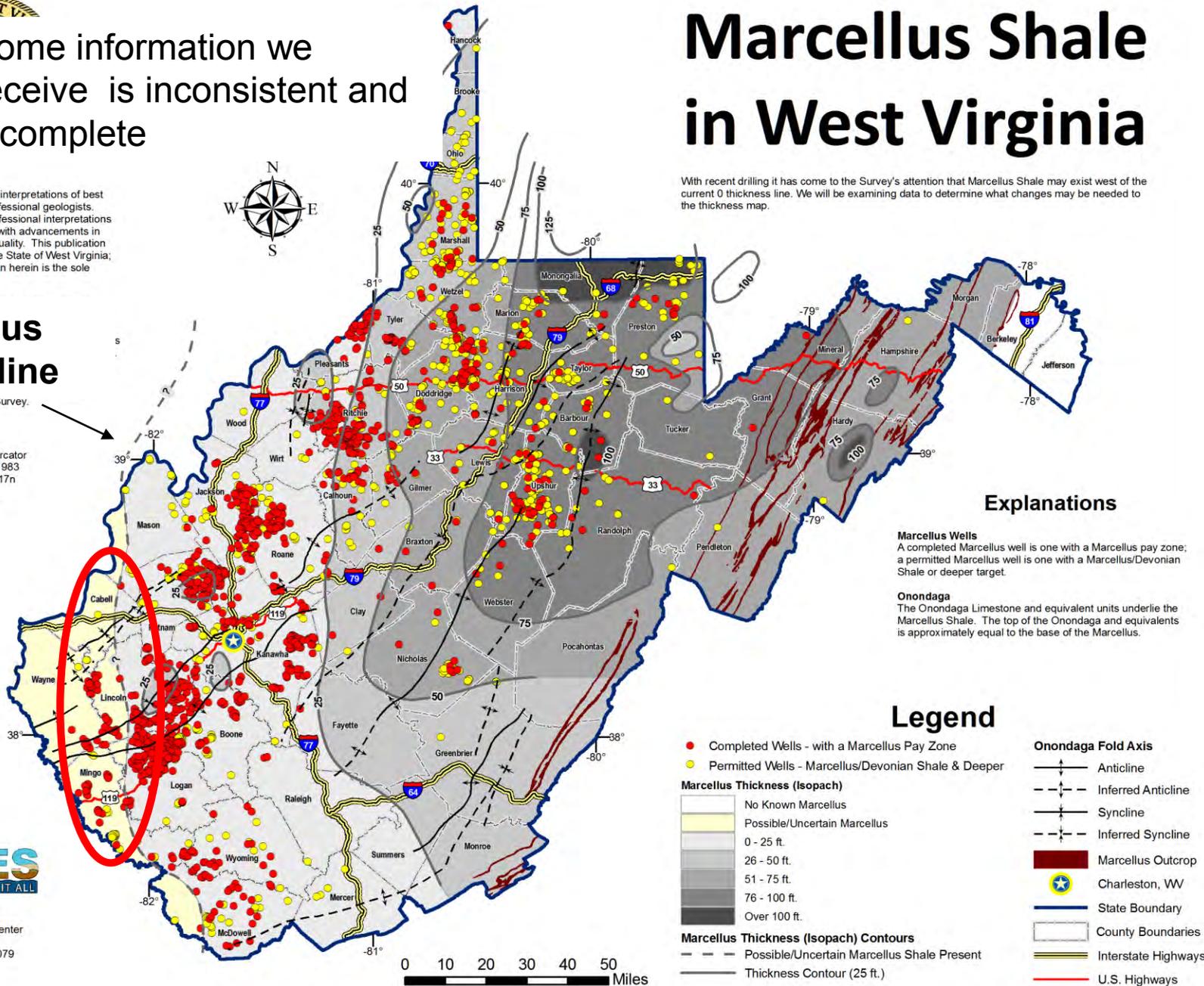
Map Date: April 28, 2011
 Projection: Transverse Mercator
 Horizontal Datum: NAD 1983
 Coordinate System: UTMz17n
 Map Scale: 1:2,000,000
 (for full 8.5" x 11" display)



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Marcellus Shale in West Virginia

With recent drilling it has come to the Survey's attention that Marcellus Shale may exist west of the current 0 thickness line. We will be examining data to determine what changes may be needed to the thickness map.



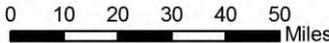
Explanations

Marcellus Wells
 A completed Marcellus well is one with a Marcellus pay zone; a permitted Marcellus well is one with a Marcellus/Devonian Shale or deeper target.

Onondaga
 The Onondaga Limestone and equivalent units underlie the Marcellus Shale. The top of the Onondaga and equivalents is approximately equal to the base of the Marcellus.

Legend

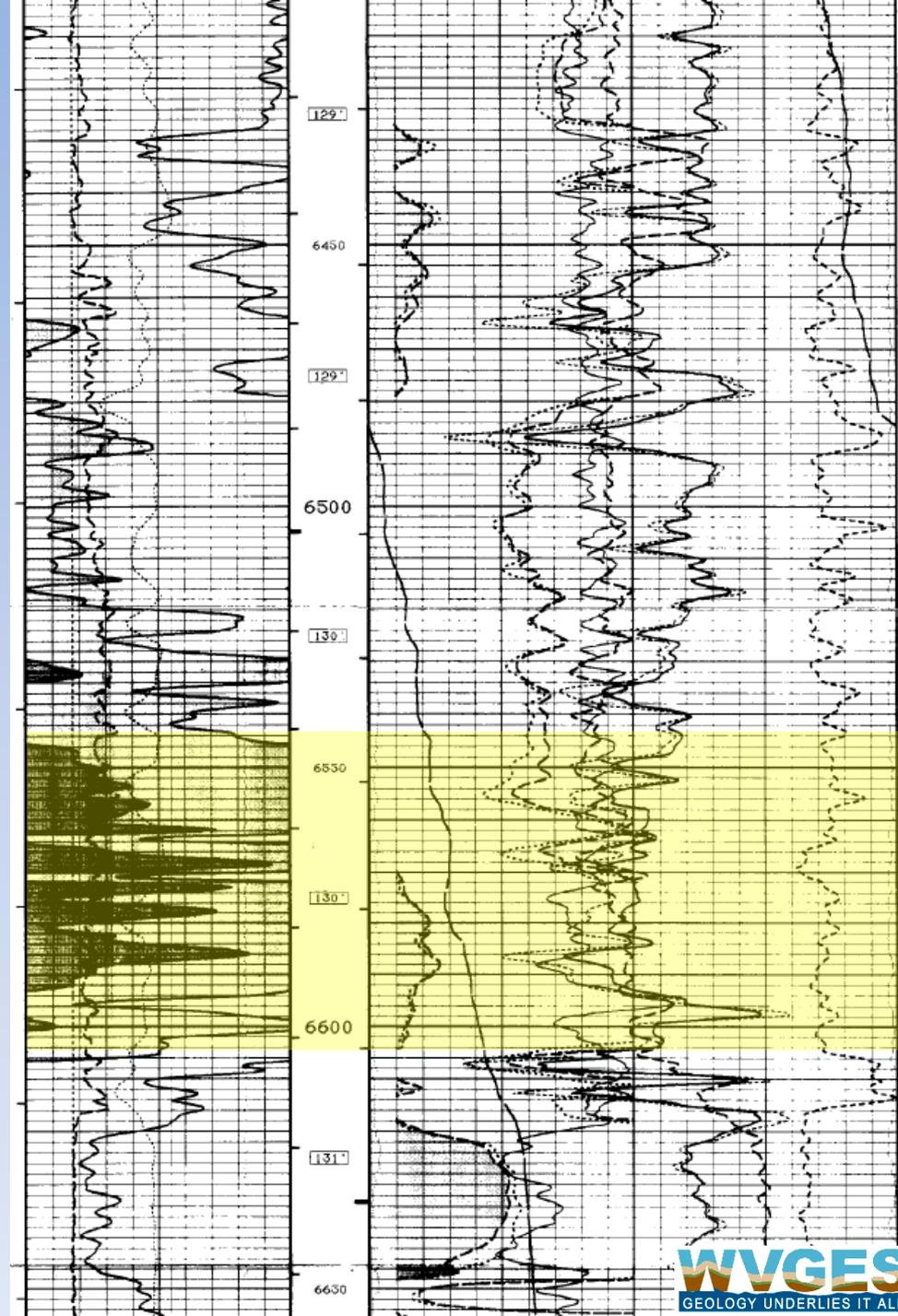
- Completed Wells - with a Marcellus Pay Zone
- Permitted Wells - Marcellus/Devonian Shale & Deeper
- Marcellus Thickness (Isopach)**
 - No Known Marcellus
 - Possible/Uncertain Marcellus
 - 0 - 25 ft.
 - 26 - 50 ft.
 - 51 - 75 ft.
 - 76 - 100 ft.
 - Over 100 ft.
- Marcellus Thickness (Isopach) Contours**
 - - - Possible/Uncertain Marcellus Shale Present
 - Thickness Contour (25 ft.)
- Onondaga Fold Axis**
 - Anticline
 - - - Inferred Anticline
 - Syncline
 - - - Inferred Syncline
 - Marcellus Outcrop
 - ★ Charleston, WV
 - State Boundary
 - County Boundaries
 - Interstate Highways
 - U.S. Highways



Well in south-eastern

Operator reported
1,560' of Marcellus

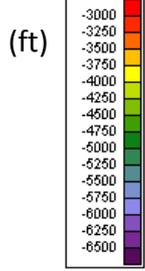
Marcellus pay zone



Base of Marcellus Sub-sea Structure (top of Onondaga)

OH

PA



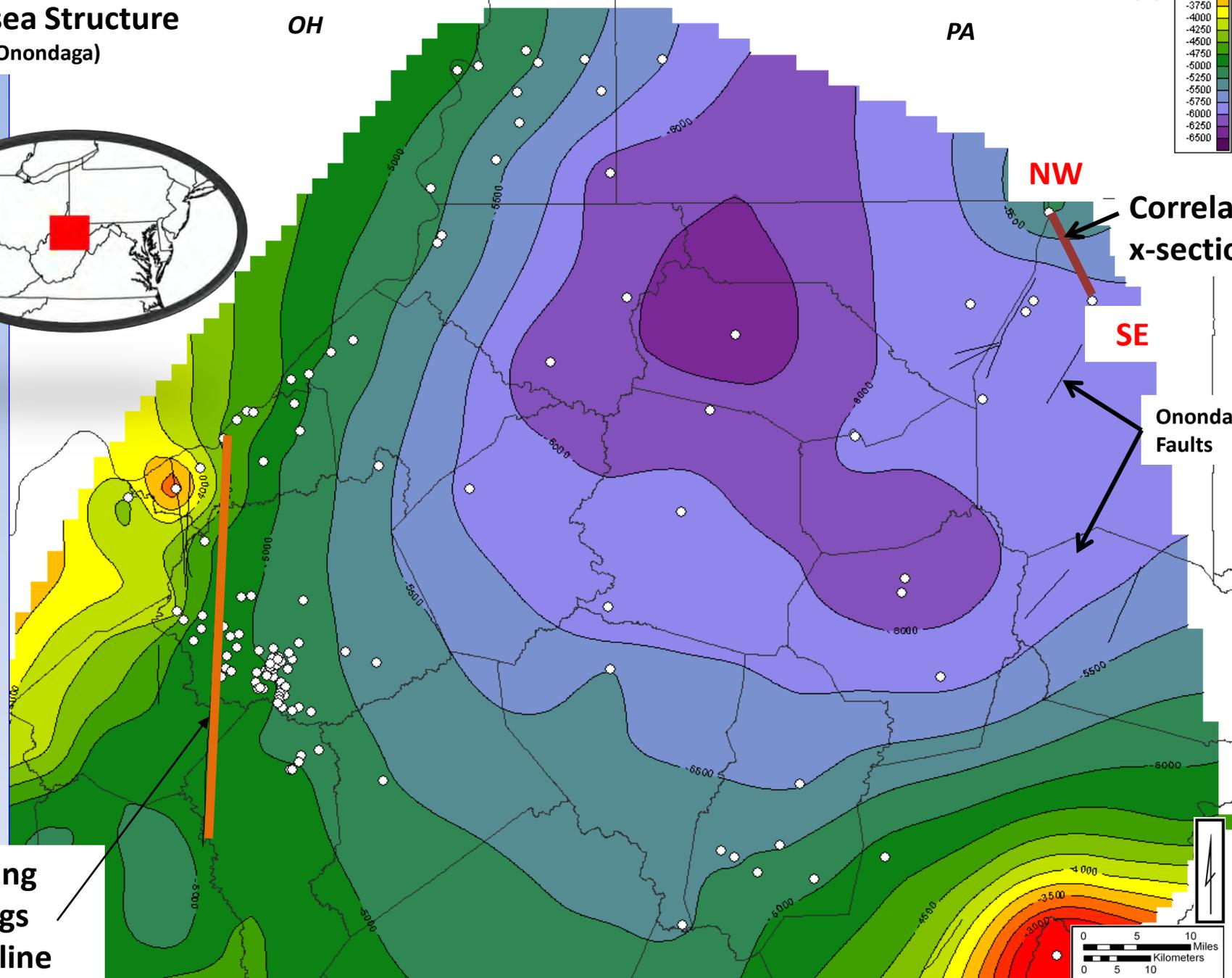
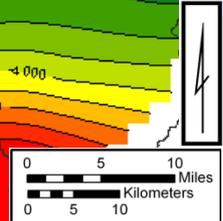
NW

Correlation
x-section

SE

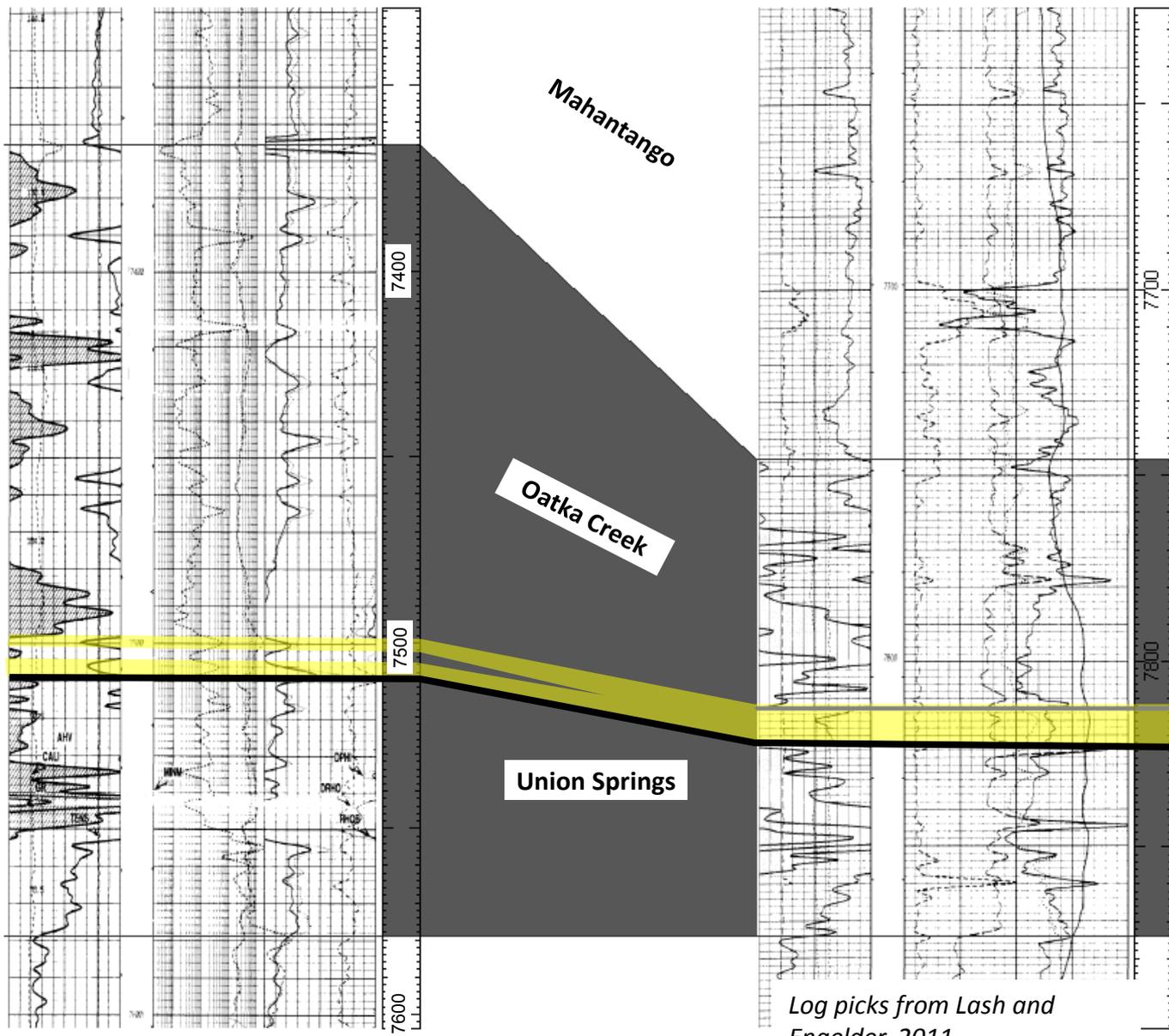
Onondaga
Faults

Burning
Springs
Anticline



4707700284 ○

4707700320 ○



Marcellus

Mahantango

Oatka Creek

Union Springs

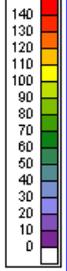
Cherry Vly/Purcell Ls

Log picks from Lash and Engelder, 2011

Datum: Onondaga Ls

Marcellus Isopach

(ft)

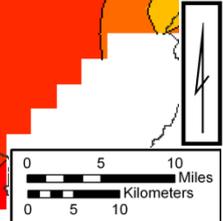
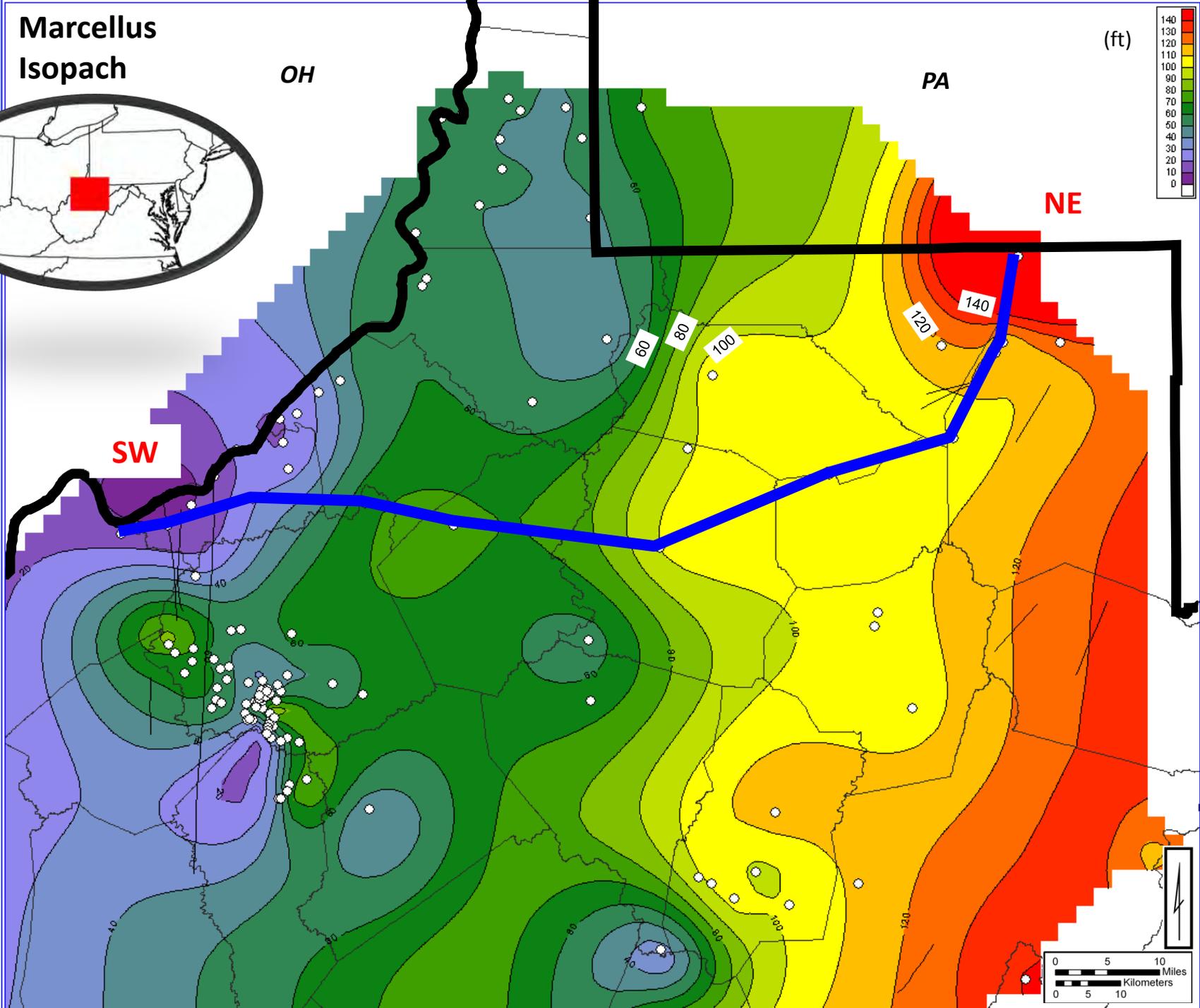


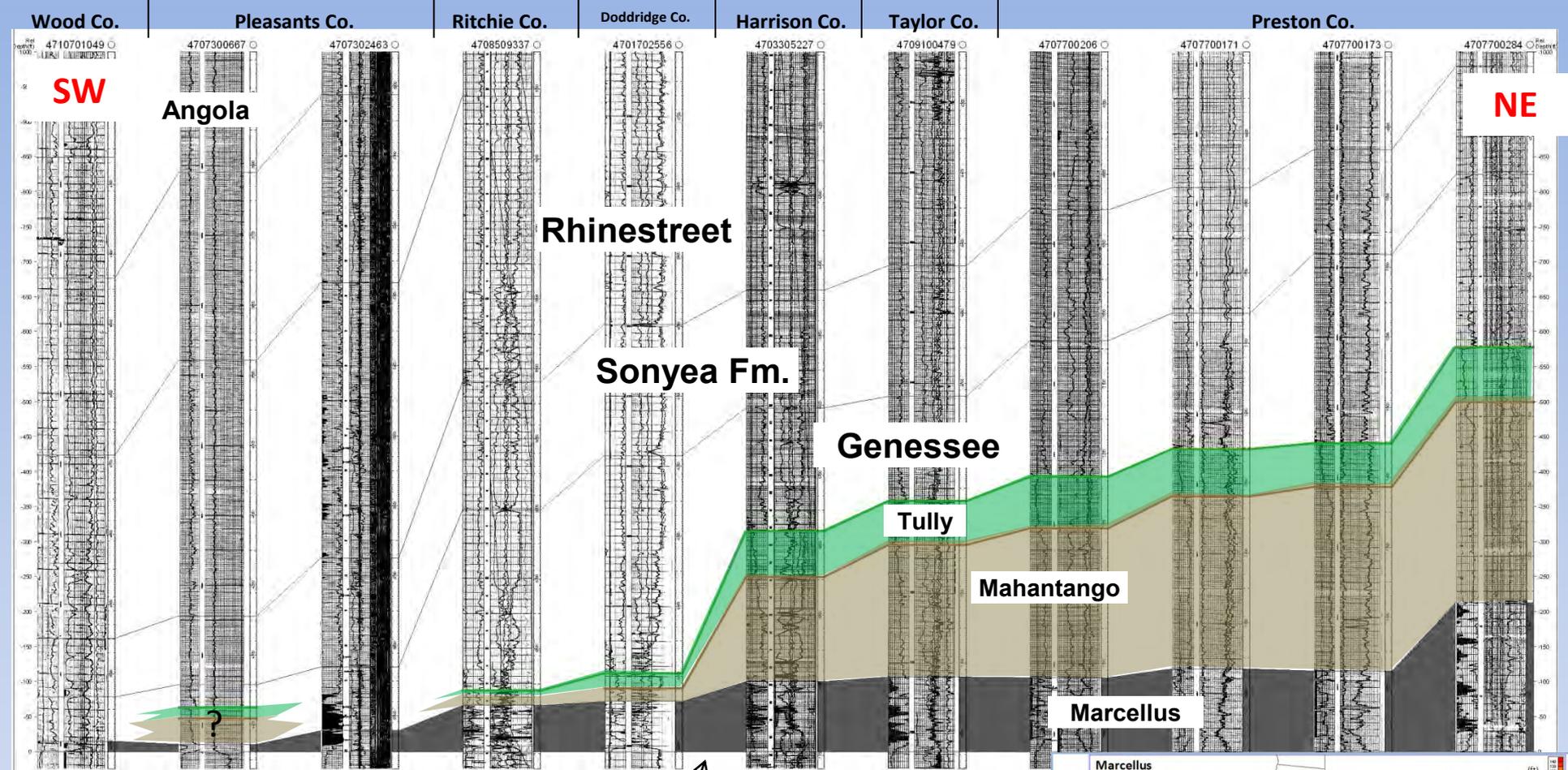
OH

PA

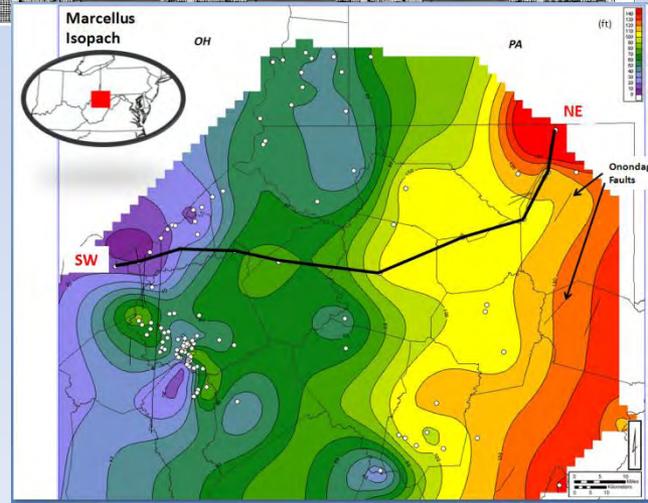
NE

SW





Mahantango thinning coincides with area of high production



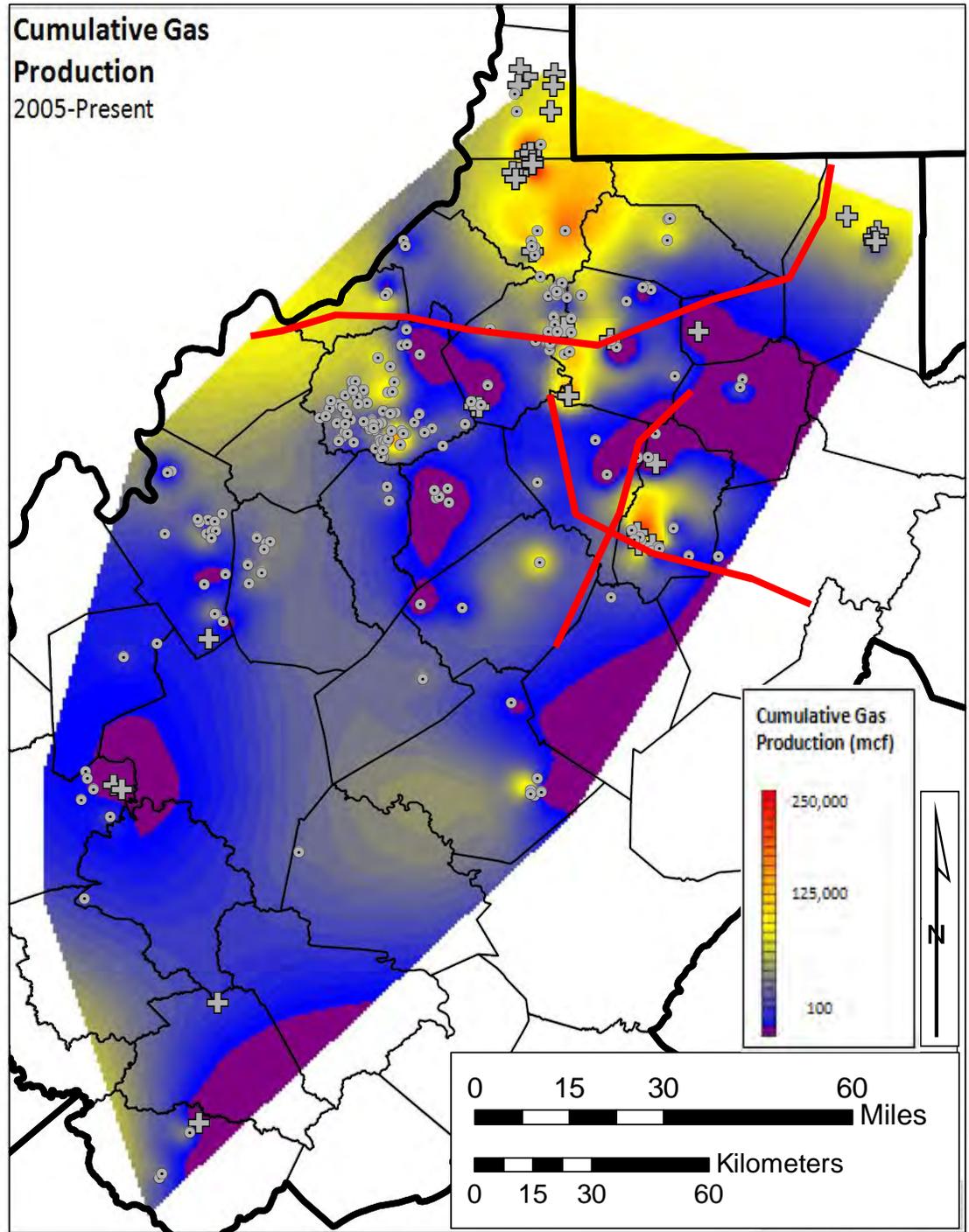
Marcellus Shale

(commingled wells excluded)

259 total wells (212 vertical - 47 horizontal)

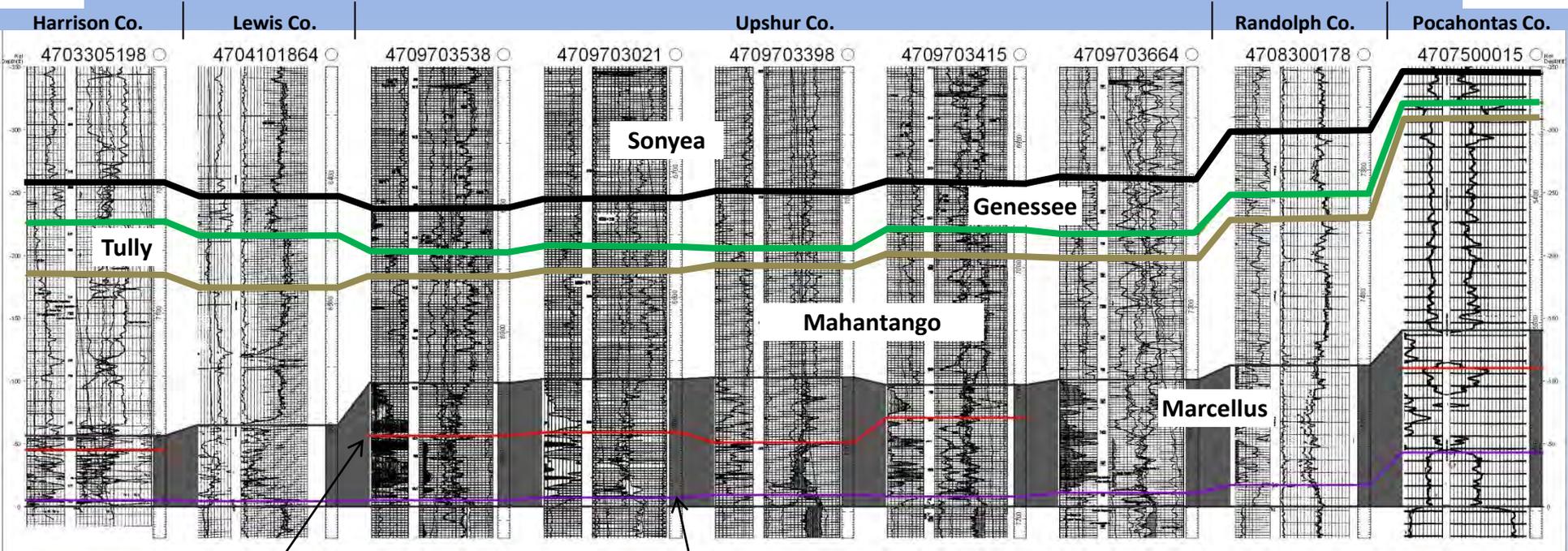
(Permits reported to WVGES up to April 1, 2010)

Cumulative Gas Production 2005-Present



NW

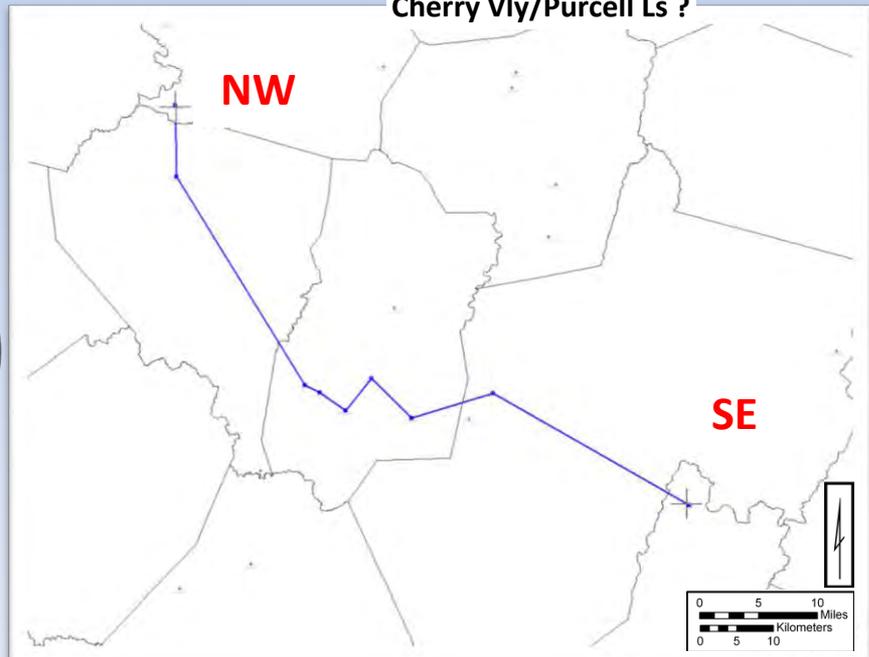
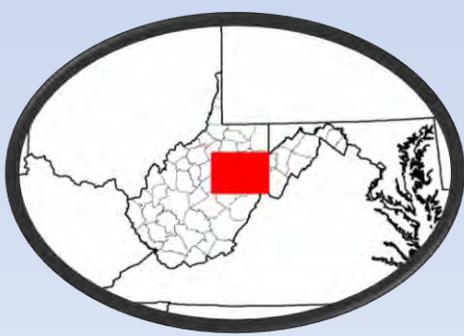
SE



Landes Ls ?

Cherry Vly/Purcell Ls ?

Datum: Onondaga Ls



Not much change in thickness across strike...a couple of consistent Ls beds

SW

NE

Webster Co.

Upshur Co.

Barbour Co.

4710100102

4710100097

4709703398

4709703415

4709703515

4700103028

4700103072

4700102985

Sonyea

Genessee

Tully

Mahantango

Marcellus

Landes Ls ?

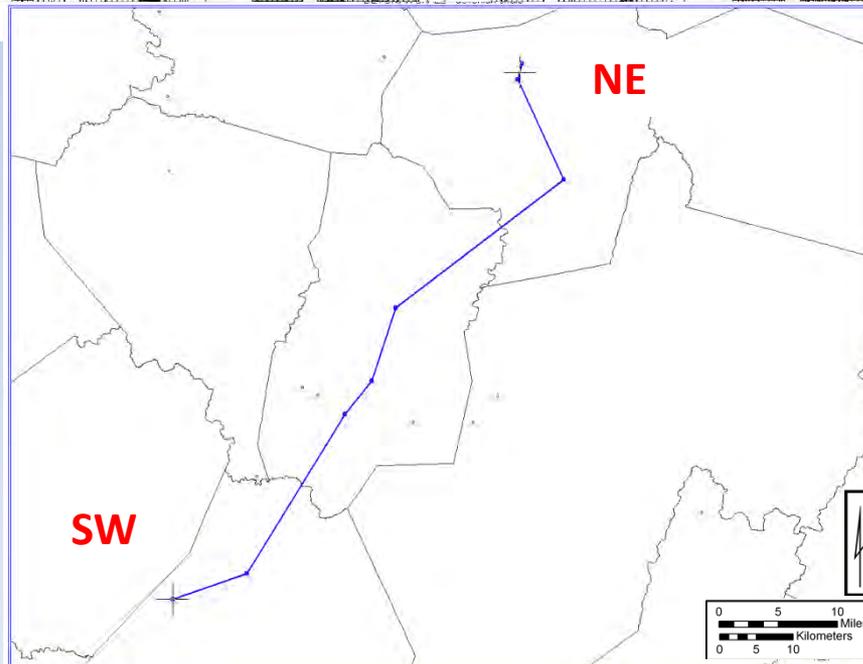
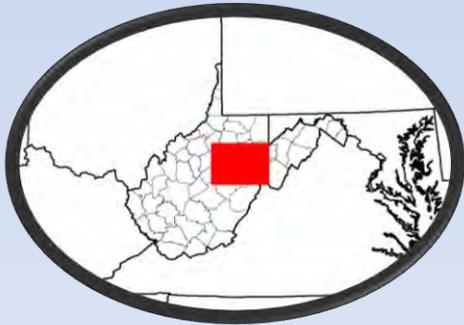
Cherry Vly/Purcell Ls ?

NE

SW

Datum: Onondaga Ls

Significant thinning of Mahantango along strike to the SW as you enter Upshur Co.



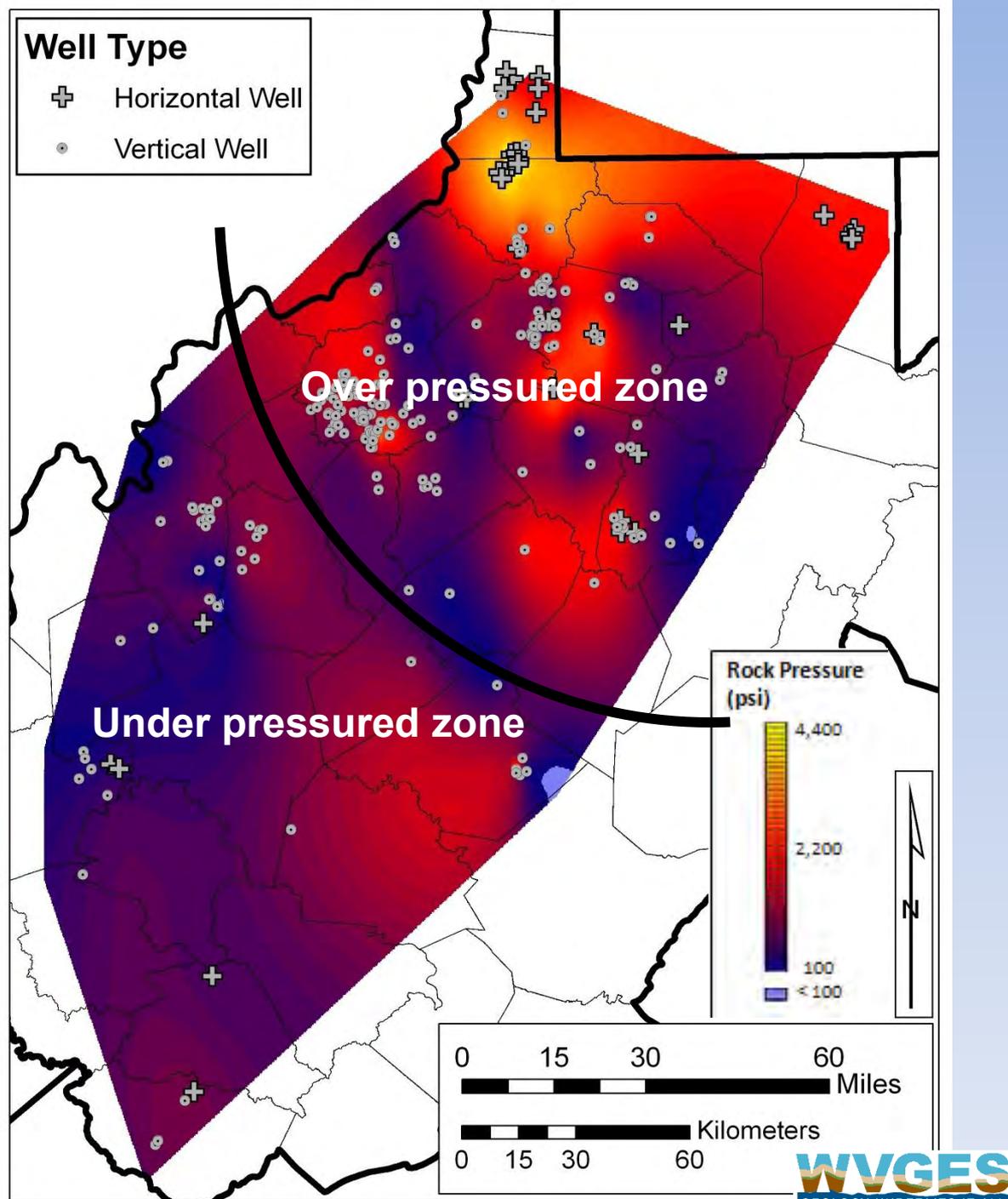
Marcellus Shale

(Comingled wells excluded)

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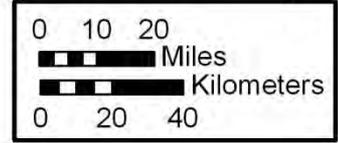
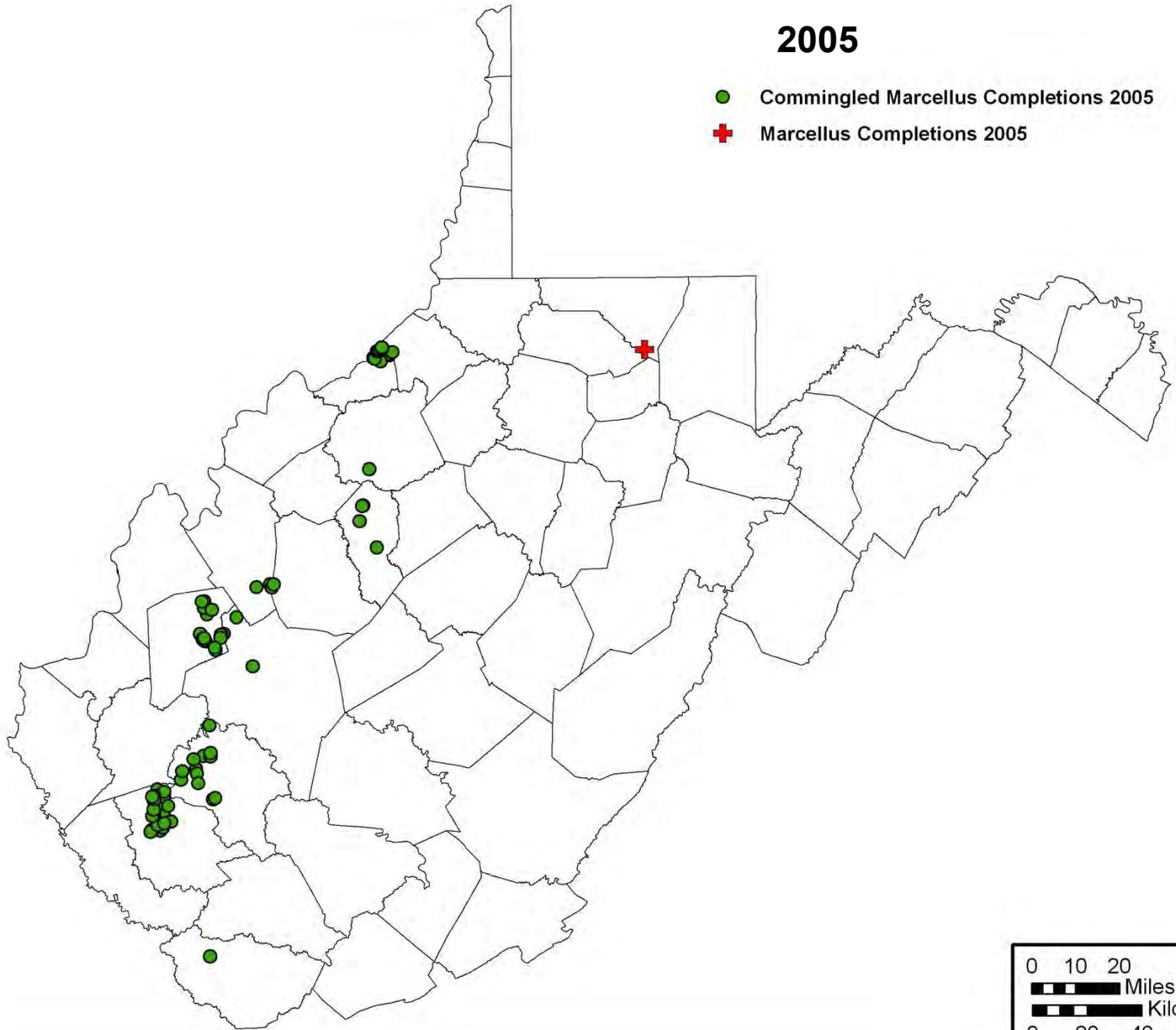
(Permits reported to WVGES up to April 1, 2010)

Rock Pressure



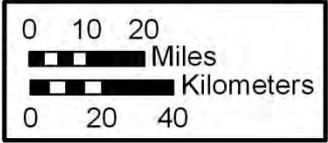
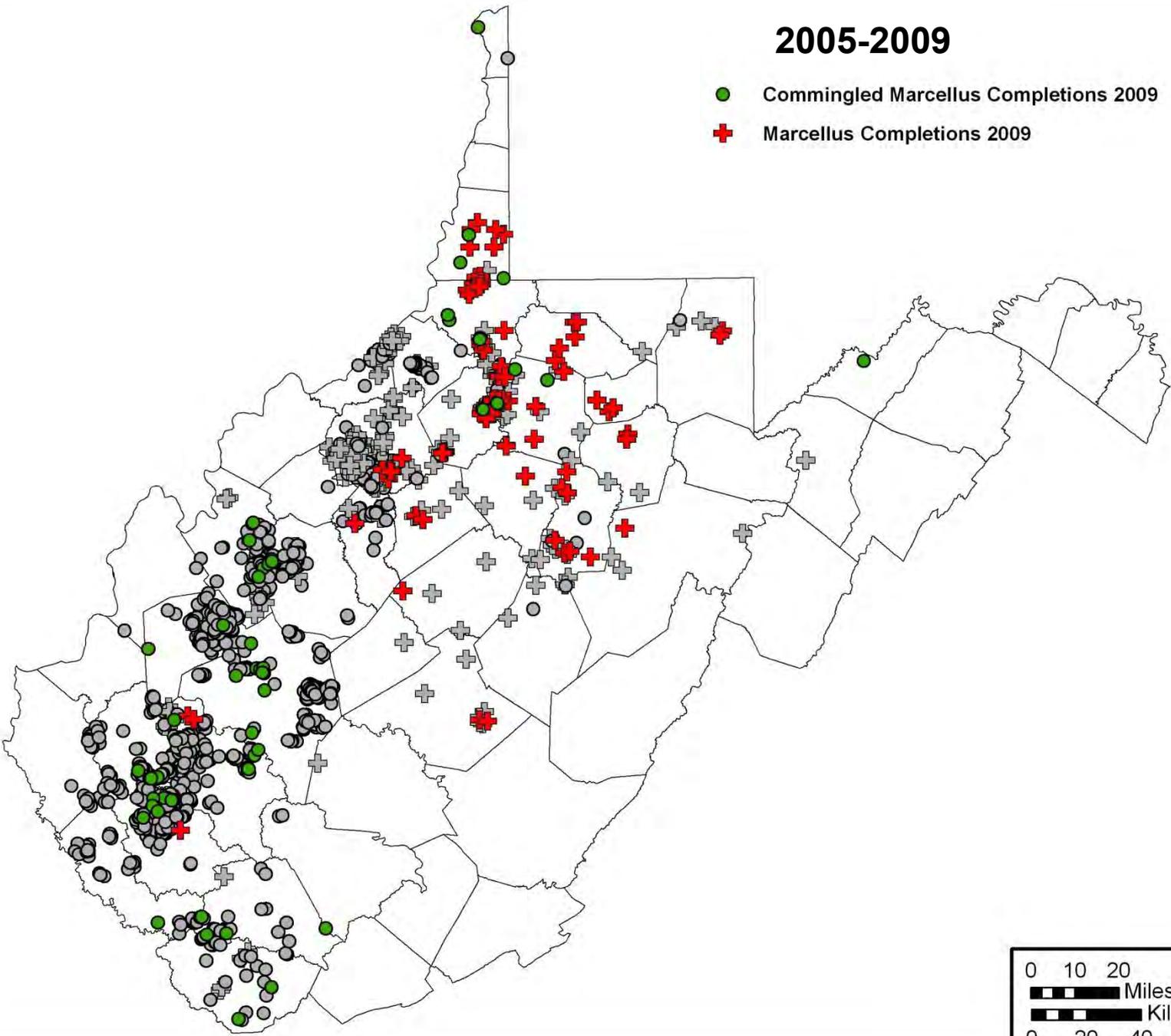
2005

- Commingled Marcellus Completions 2005
- ✚ Marcellus Completions 2005



2005-2009

- Commingled Marcellus Completions 2009
- ✚ Marcellus Completions 2009



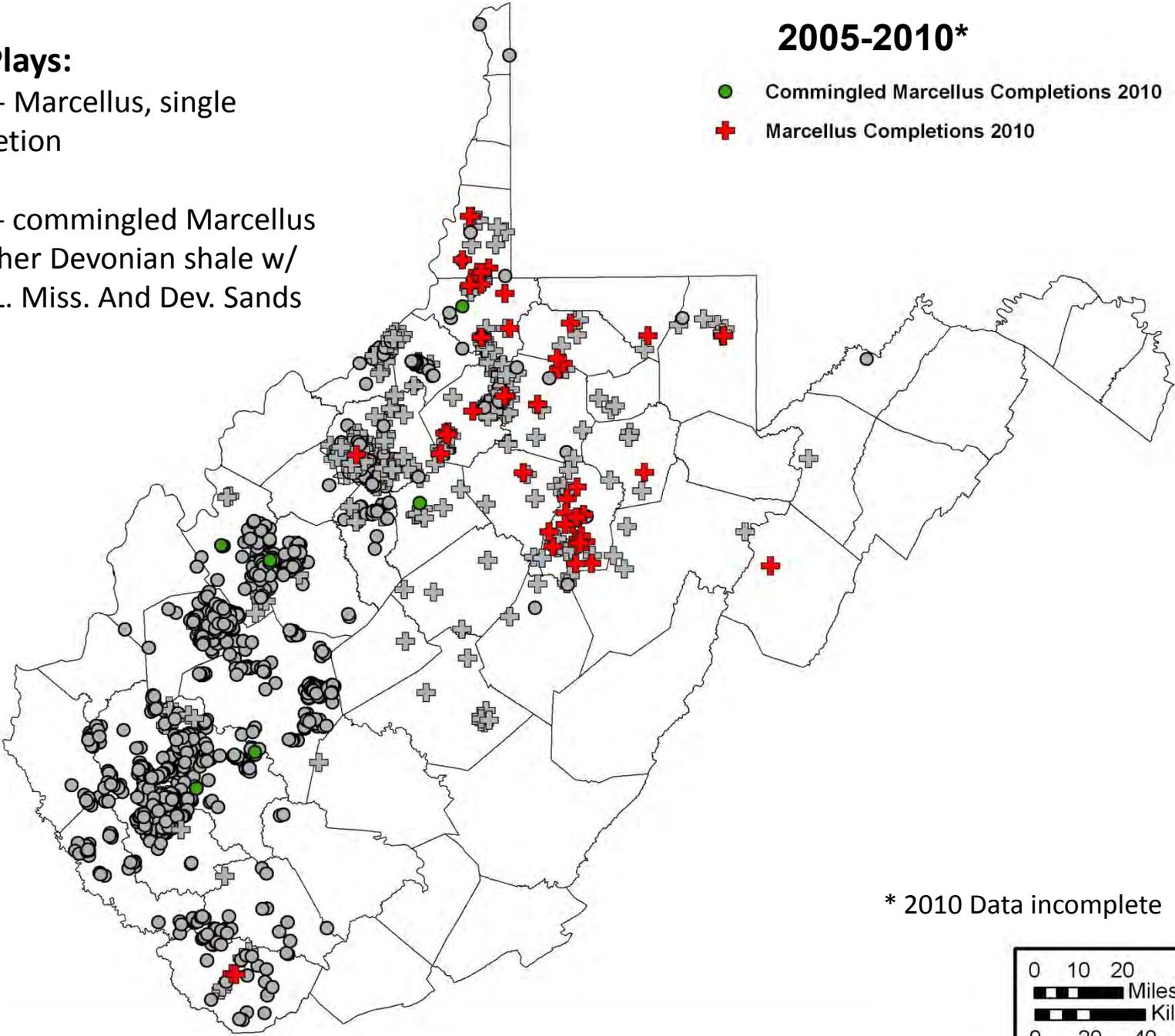
2005-2010*

Two Plays:

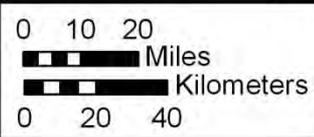
North - Marcellus, single completion

South - commingled Marcellus and other Devonian shale w/ some L. Miss. And Dev. Sands

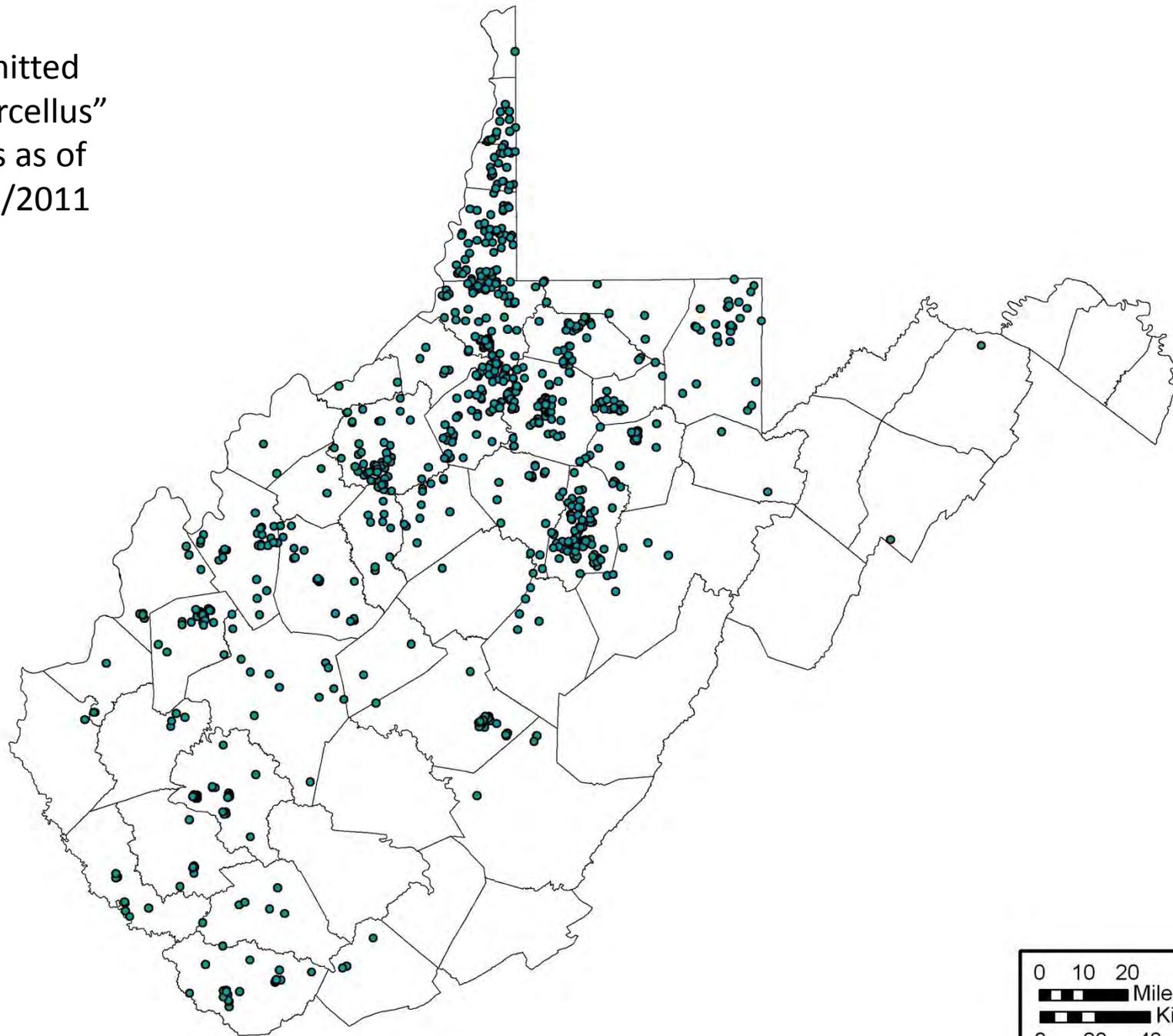
- Commingled Marcellus Completions 2010
- ✚ Marcellus Completions 2010



* 2010 Data incomplete

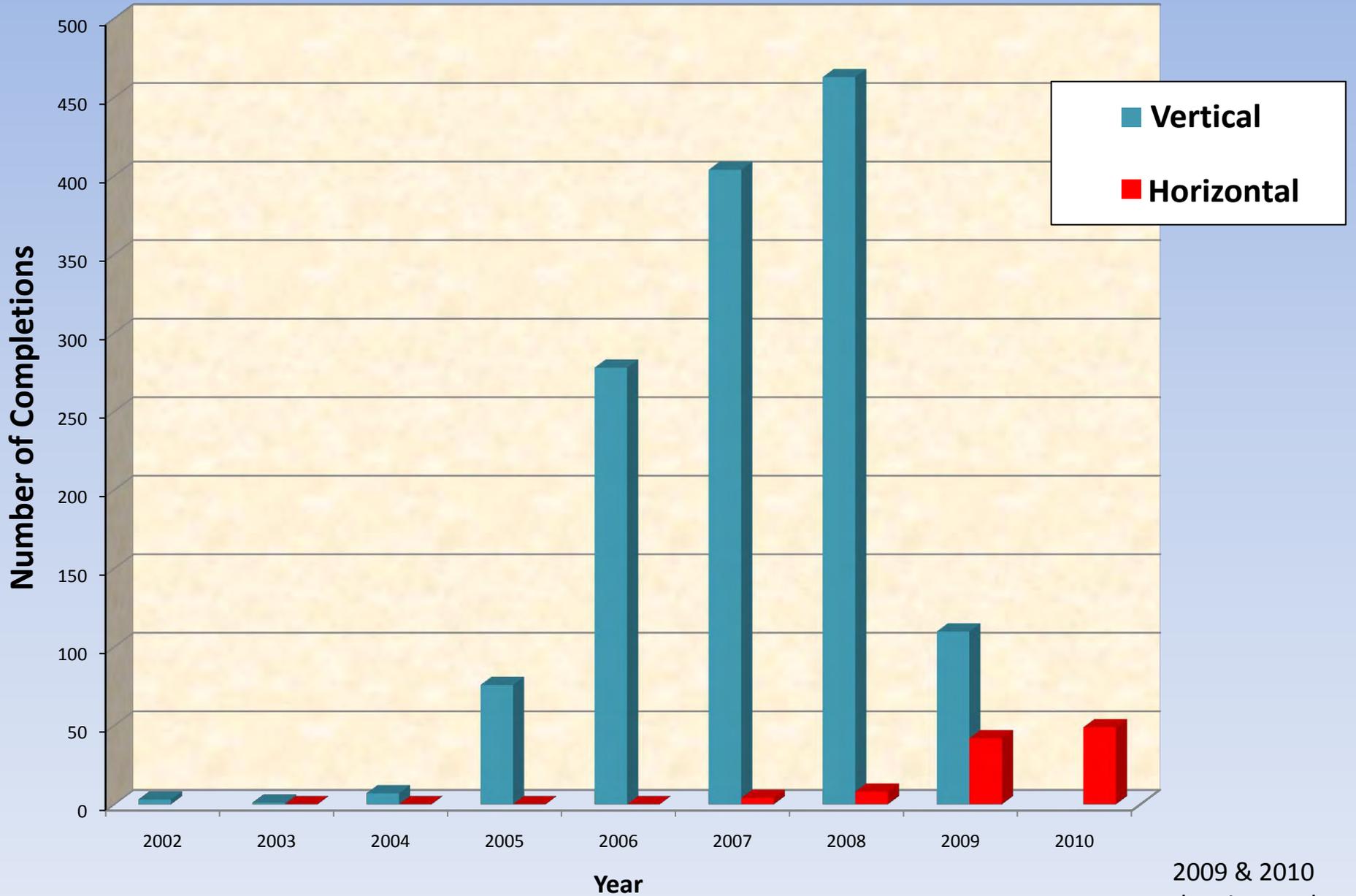


Permitted
"Marcellus"
wells as of
8/25/2011



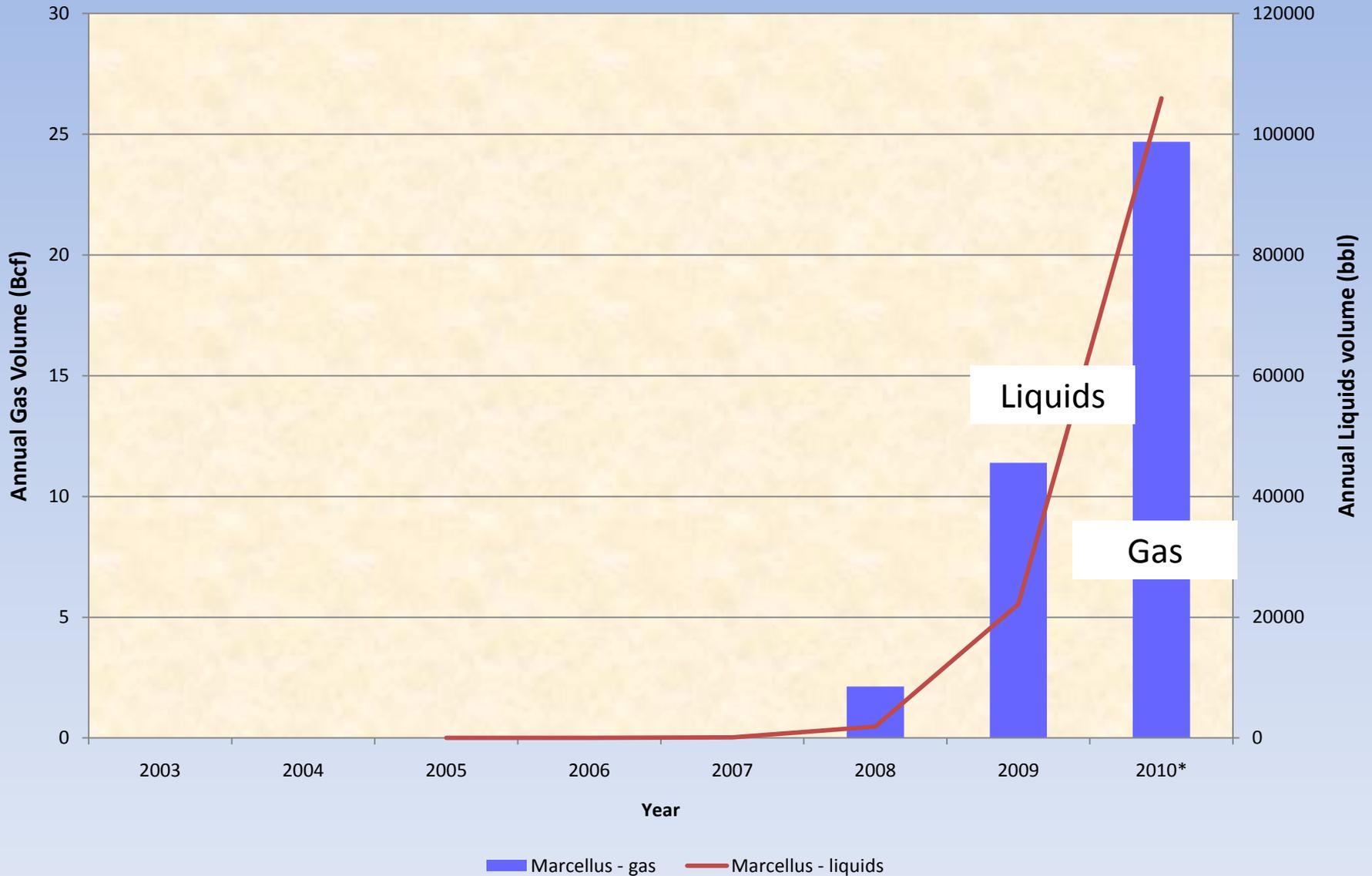
Marcellus Wells: Vertical vs. Horizontal Completions

(all completions; 2002 - 2010)



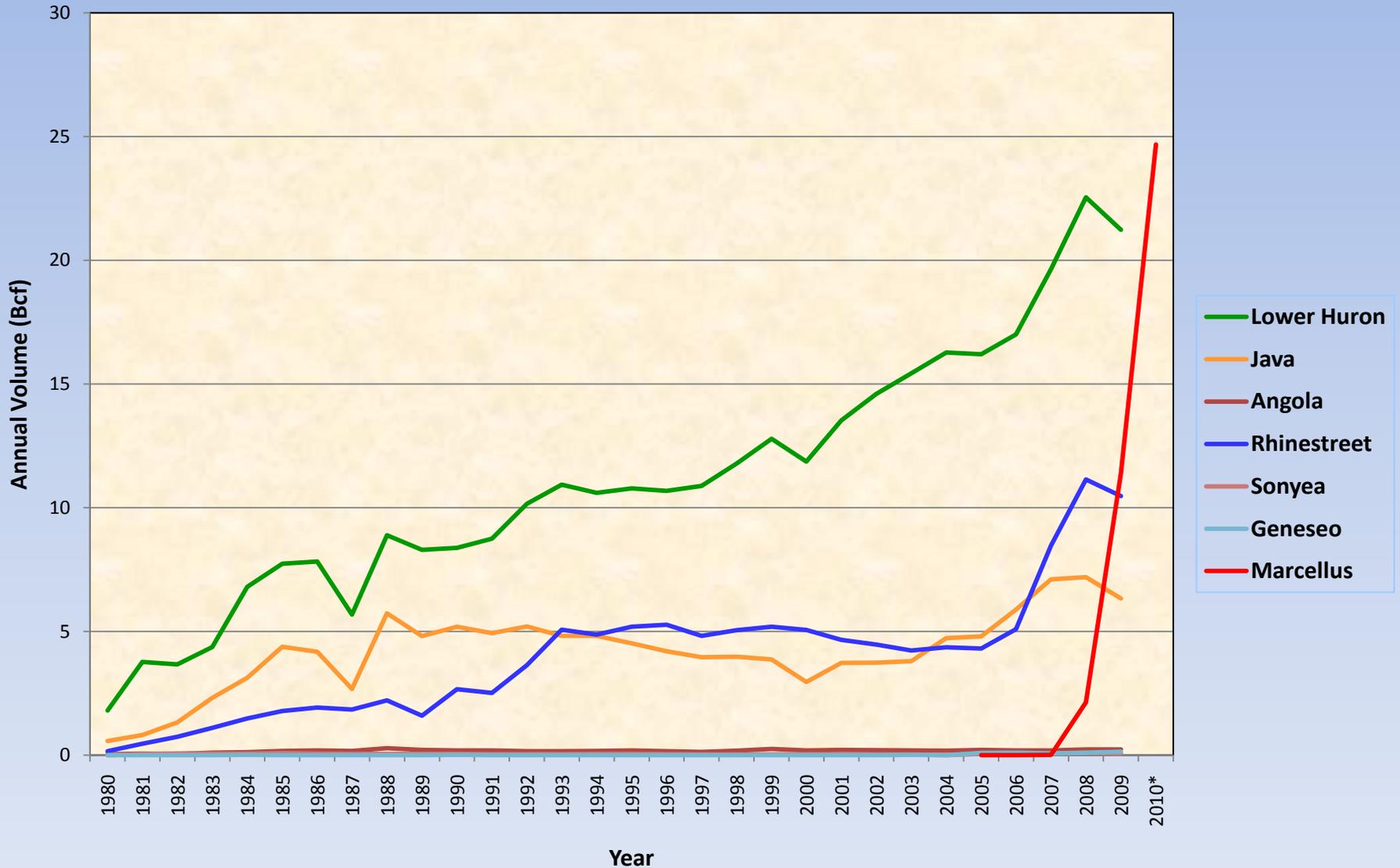
Marcellus Shale Production

(from non-commingled wells)



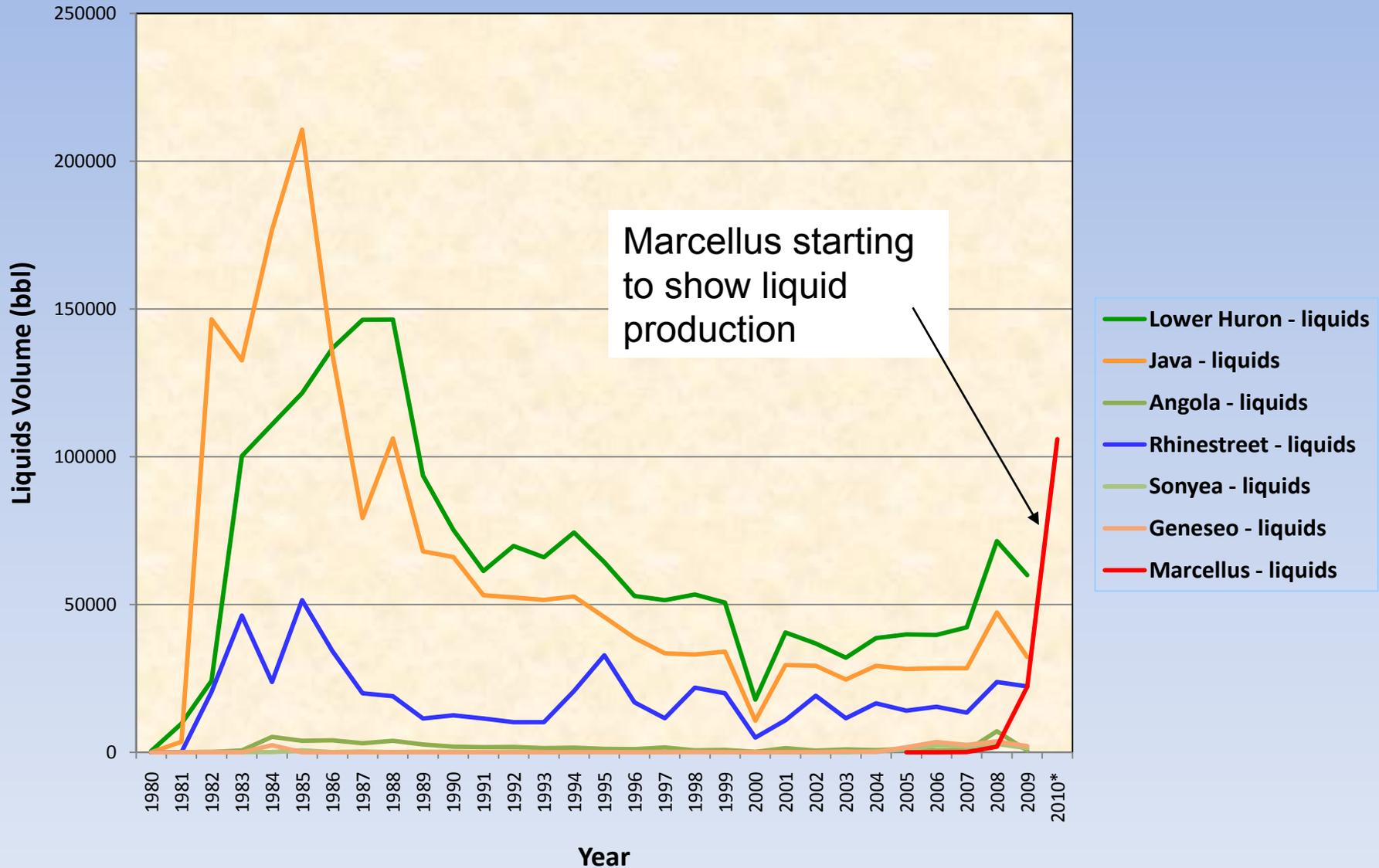
Gas Production from West Virginia Devonian Shales

(production not commingled; 1980 - 2010)

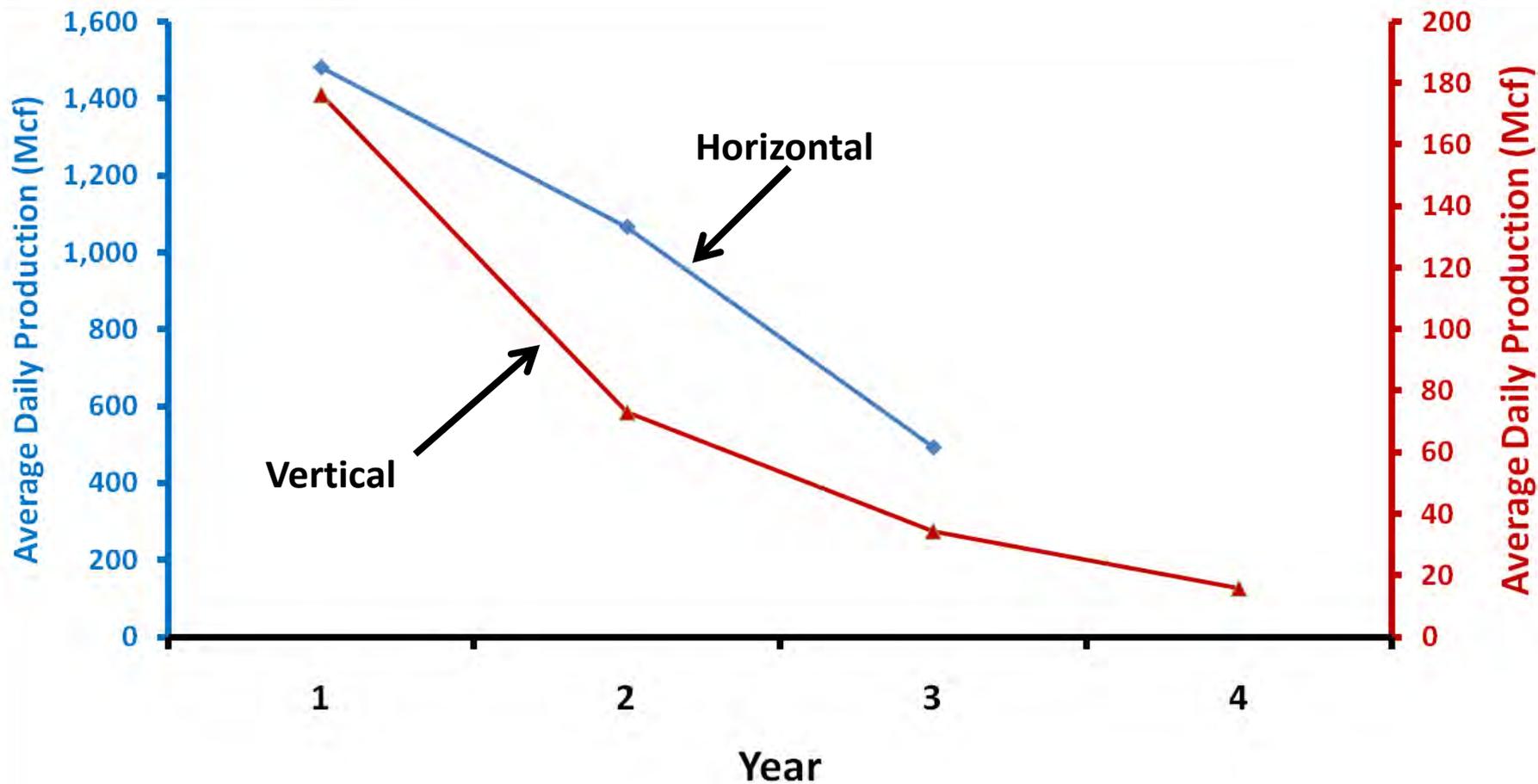


Liquids Production from West Virginia Devonian Shales

(production not commingled; 1980 - 2010)



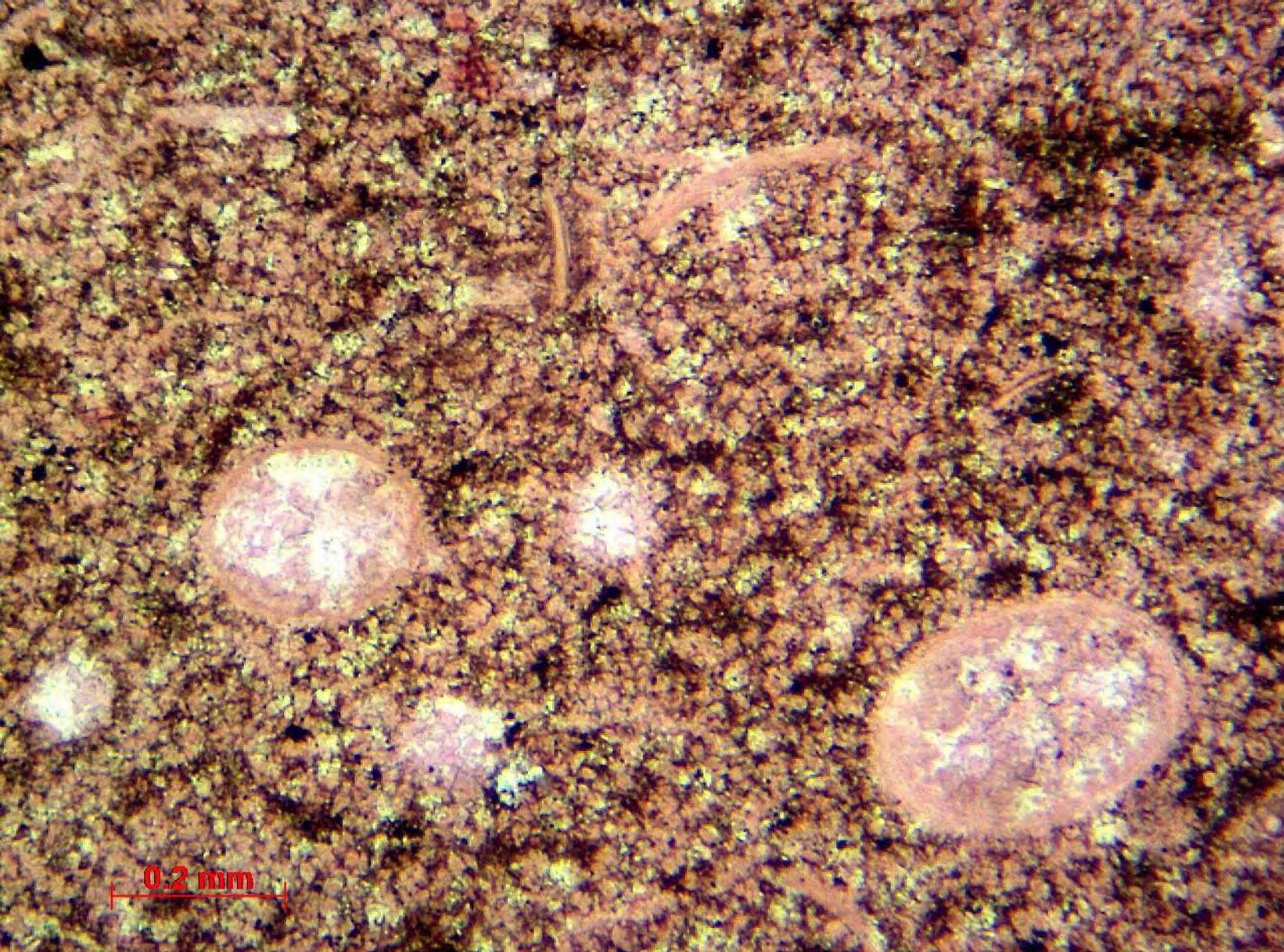
Average Daily Production Marcellus Wells in WV



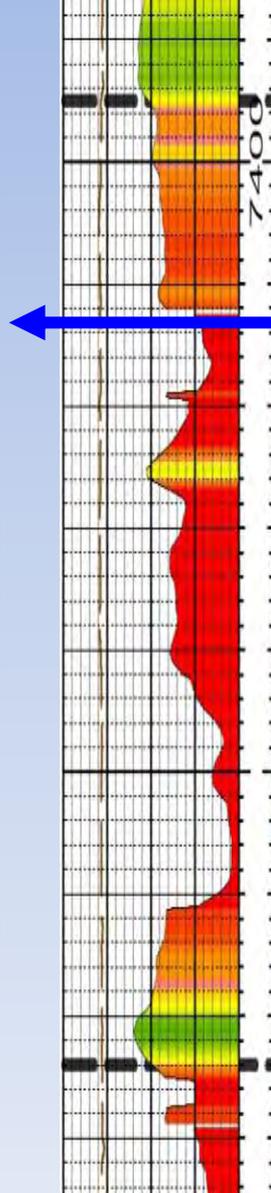
Horizontal/Vertical = 8/1

Current and future work

- Kathy Bruner (DOE) – detailed work on our core
- Stratigraphic Framework - \approx 3,000 e-logs into the “Marcellus”
- Sue Pool (WVGES) – resource assessment
- Ilken Bilgesu (WVU Petroleum Eng.) – SEM analysis on our core

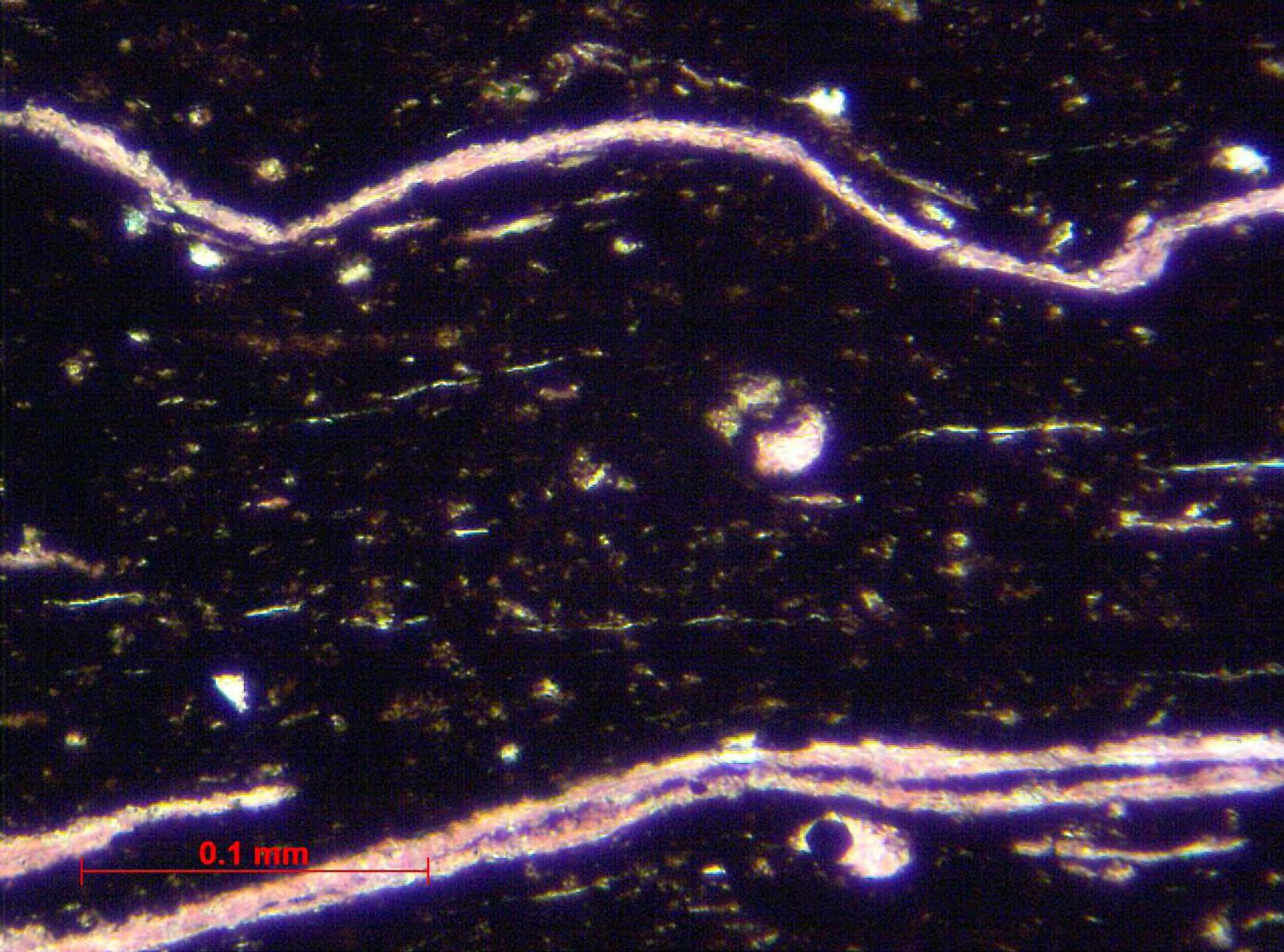


Mon. Co.
Core

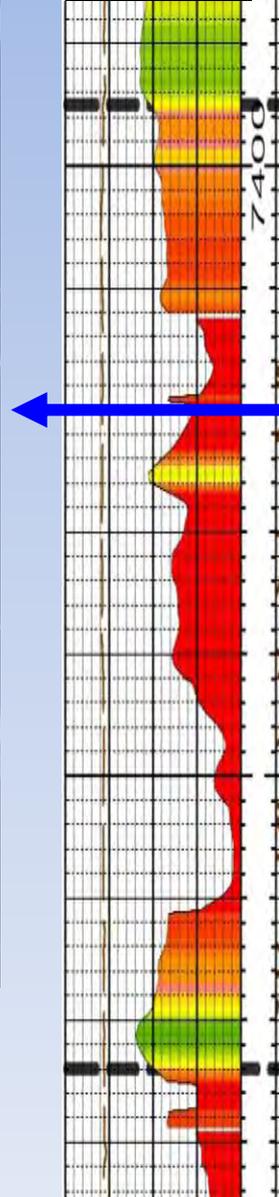


7413' - concretion, stylolites (shell wall), green is actually tan and it's dolomite?, most of this is calcite microspar, minor OM

Pics and descriptions, Bruner

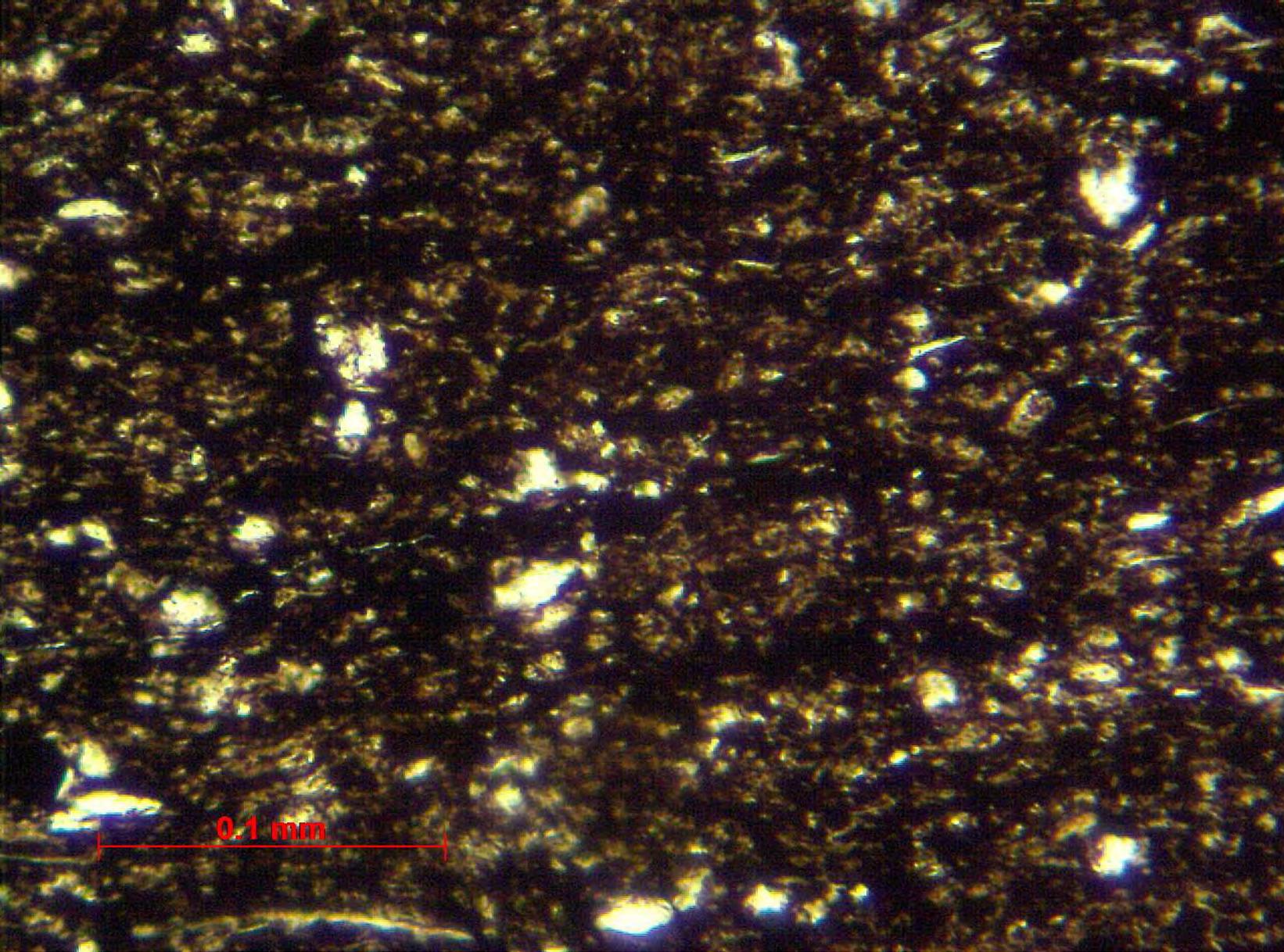


Mon. Co.
Core

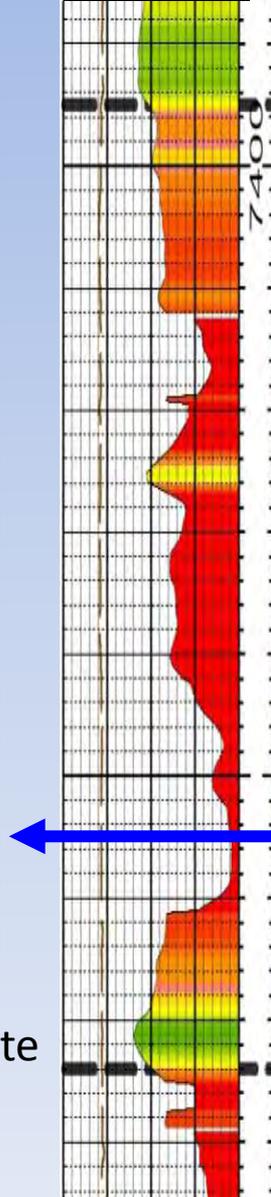


7420.8' - Organic shales have fossils in them...washed in? or environment not as anoxic as previously thought...Fossil frags brachs, styliolinids, Iron dolomite, micas

Pics and descriptions, Bruner



Mon. Co.
Core



7455.2' – “pay zone”, high OM, laminations are OM, large white calcite, smaller white specs are quartz, mica “sticks”

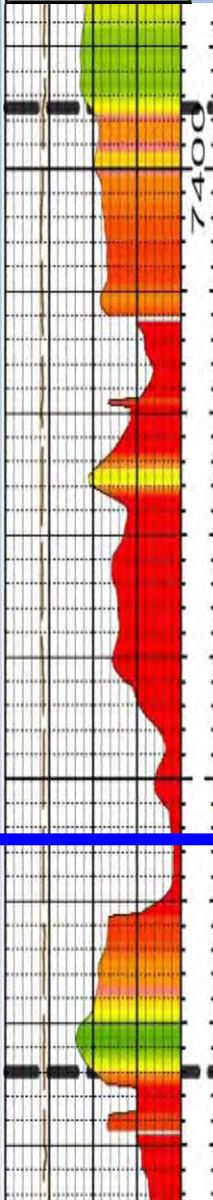
Pics and descriptions, Bruner

Mon. Co.
Core



Basically, no porosity,
lots of OM, shell
material

0.2 mm



7455.2' - crushed styliolinids w/ quartz replacement, pyrite lamination, OM throughout, clays are brown, pyrite crystals at base of lower styliolinid

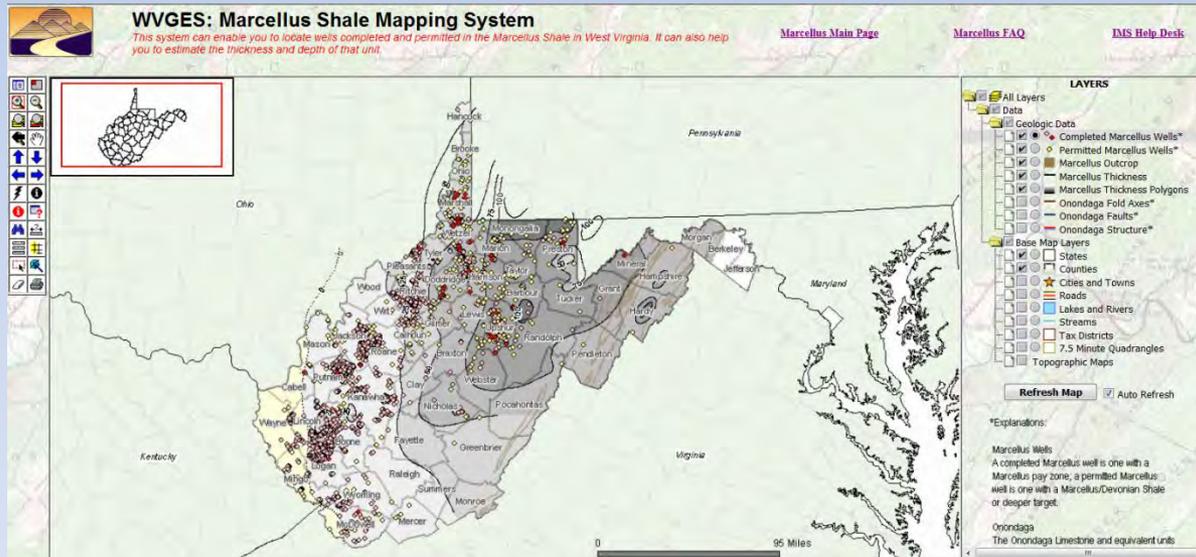
Pics and descriptions, Bruner

Current Research--Overview

Preliminary Natural Gas Resource Assessment of the Marcellus Shale using Basic Geologic Data and GIS

The *purpose of the project* is to:

collect basic geologic data, conduct a natural gas resource assessment, and make data available through the web and a web-based GIS-driven interface.



A preliminary version of an interactive mapping system has been developed already and is publicly accessible

First resource assessment specifically of the Marcellus shale in WV.



QUESTIONS?

J. Eric Lewis
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