MARCELLUS SHALE

GEOLOGIC CONTROLS ON PRODUCTION

By Gregory Wrightstone, Texas Keystone, Inc.

PRESENTED February 26, 2009

AT THE WINTER MEETING OF THE IOGAWV

In Charleston, WV

MARCELLUS SHALE

GEOLOGIC CONTROLS ON PRODUCTION

Texas Keystone INCORPORATED

Wrightstone 2008

Thanks to Texas Keystone, Inc.

GEOLOGIC FACTORS CONTROLLING SHALE PROJECT SUCCESS*

1. THICKNESS
2. MATURITY
3. GAS CONTENT/ROCK PROPERTIES
4. AREAL EXTENT
5. DEPTH
6. STRUCTURAL COMPLEXITY
7. LATERAL CONTINUITY

*Creties Jenkins 2007

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*After Creties Jenkins 2007

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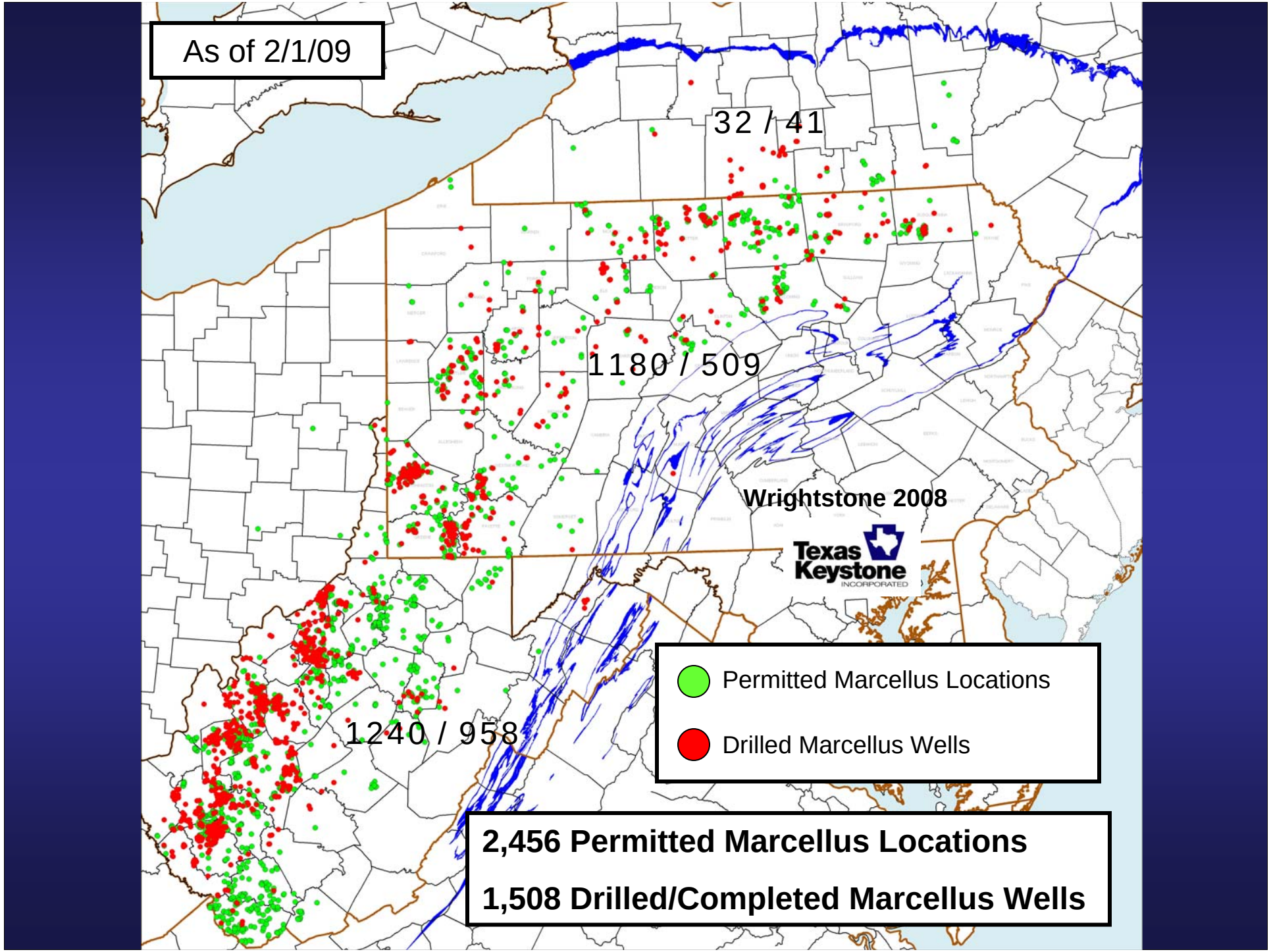
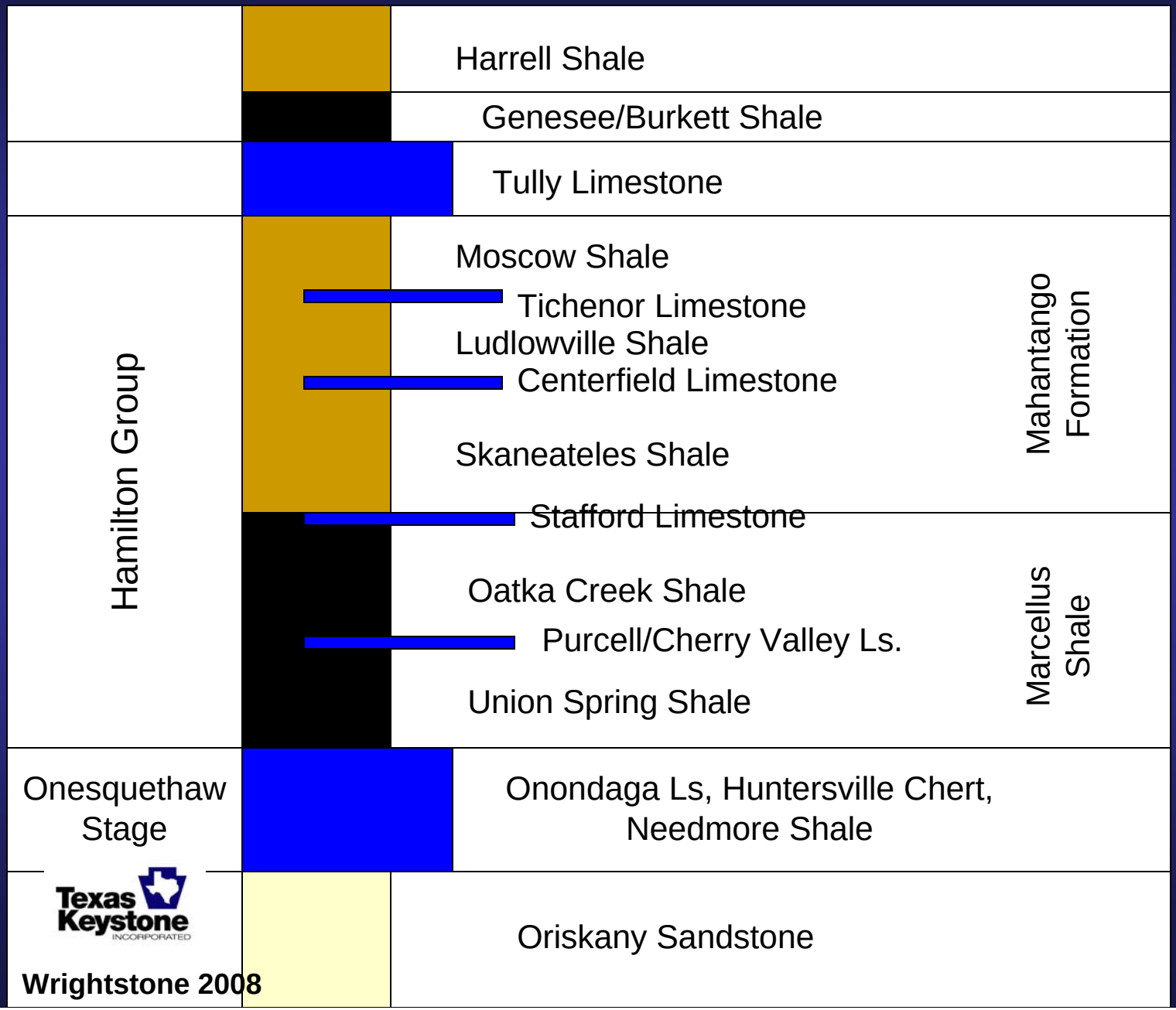

As of 2/1/09
32 / 41
1180 / 509
1240 / 958
Wrightstone 2008
Texas Keystone INCORPORATED
Permitted Marcellus Locations
Drilled Marcellus Wells
2,456 Permitted Marcellus Locations
1,508 Drilled/Completed Marcellus Wells

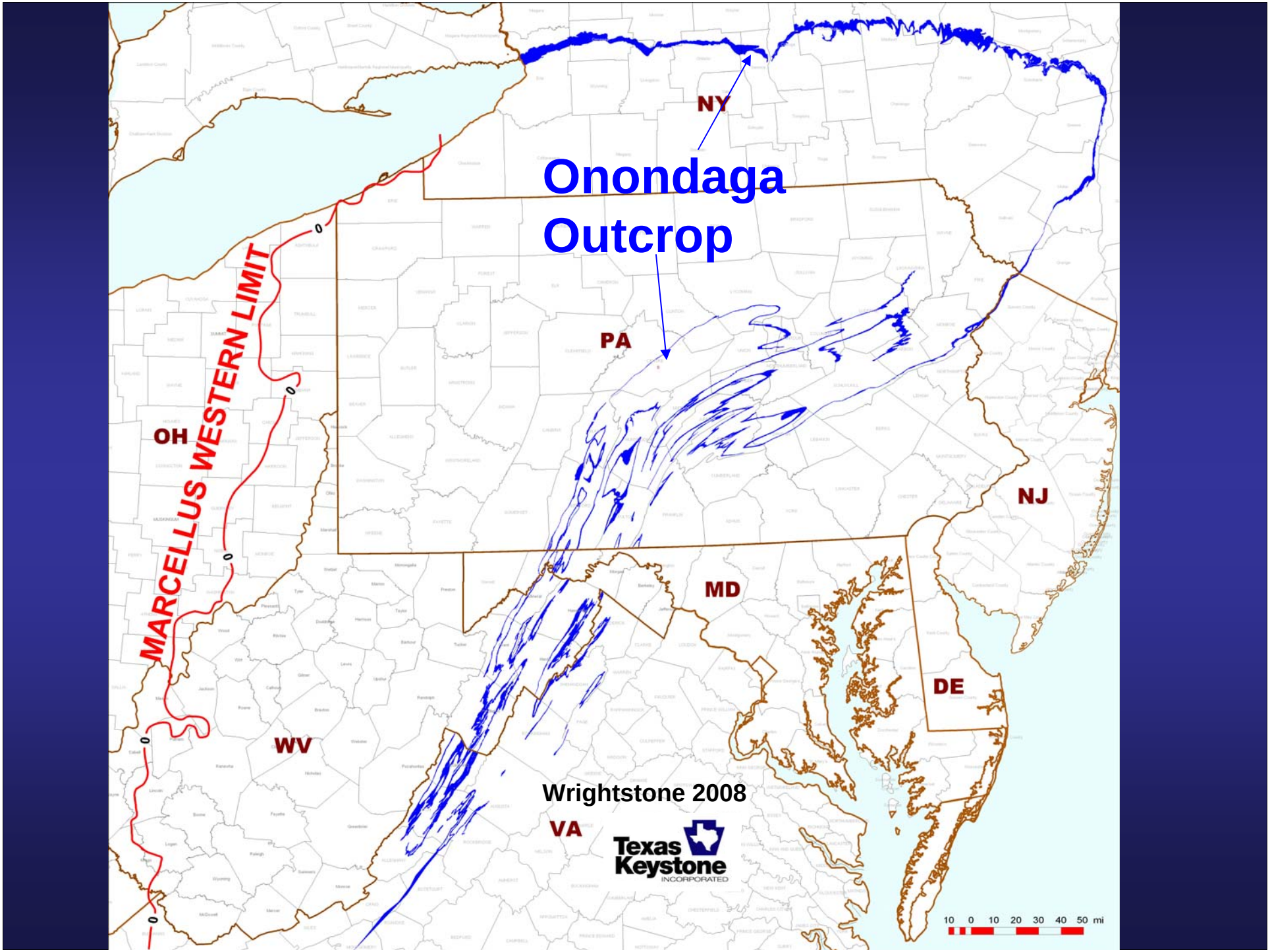
STRATIGRAPHY – LOWER & MIDDLE DEVONIAN

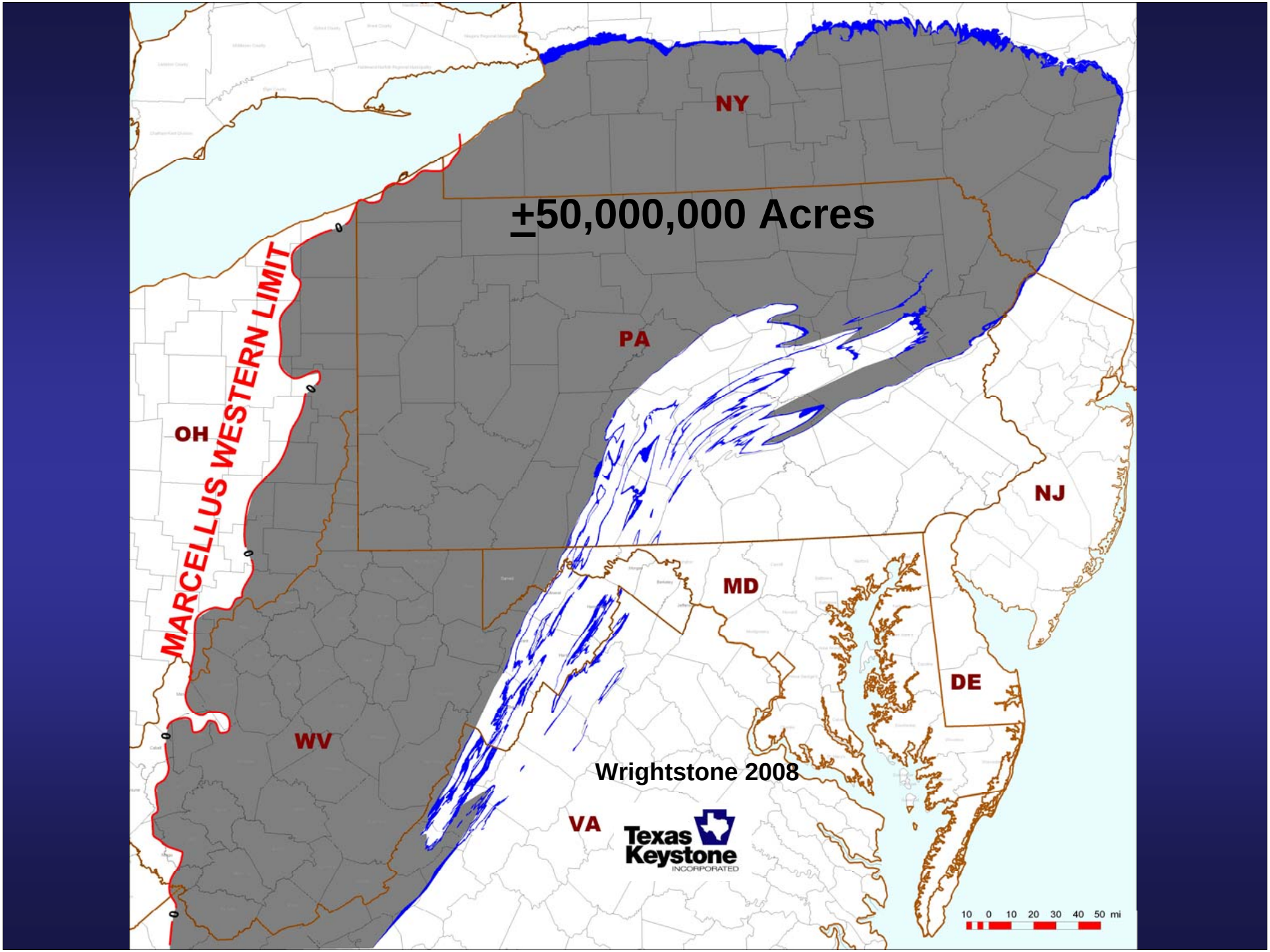


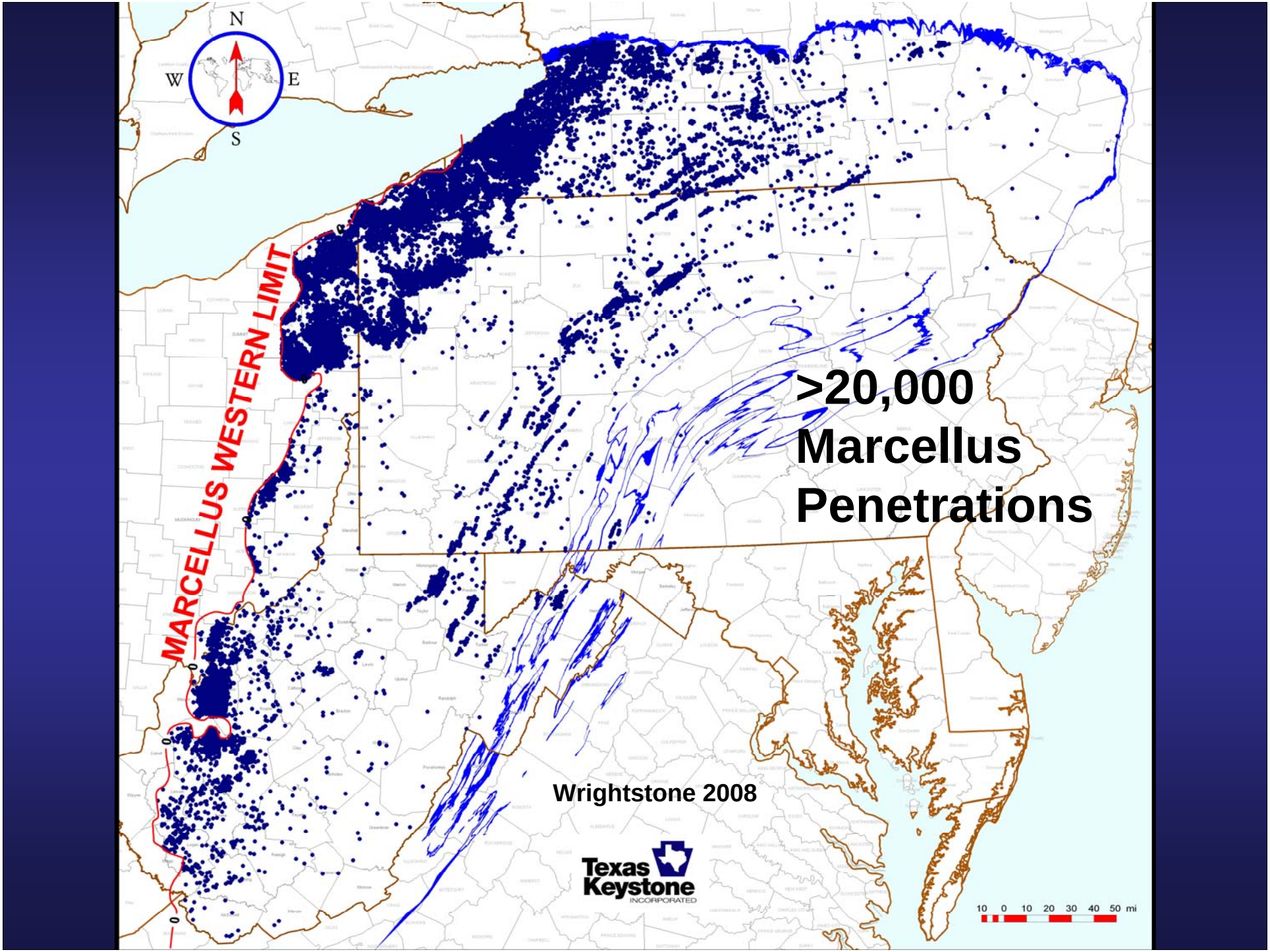
Texas Keystone INCORPORATED

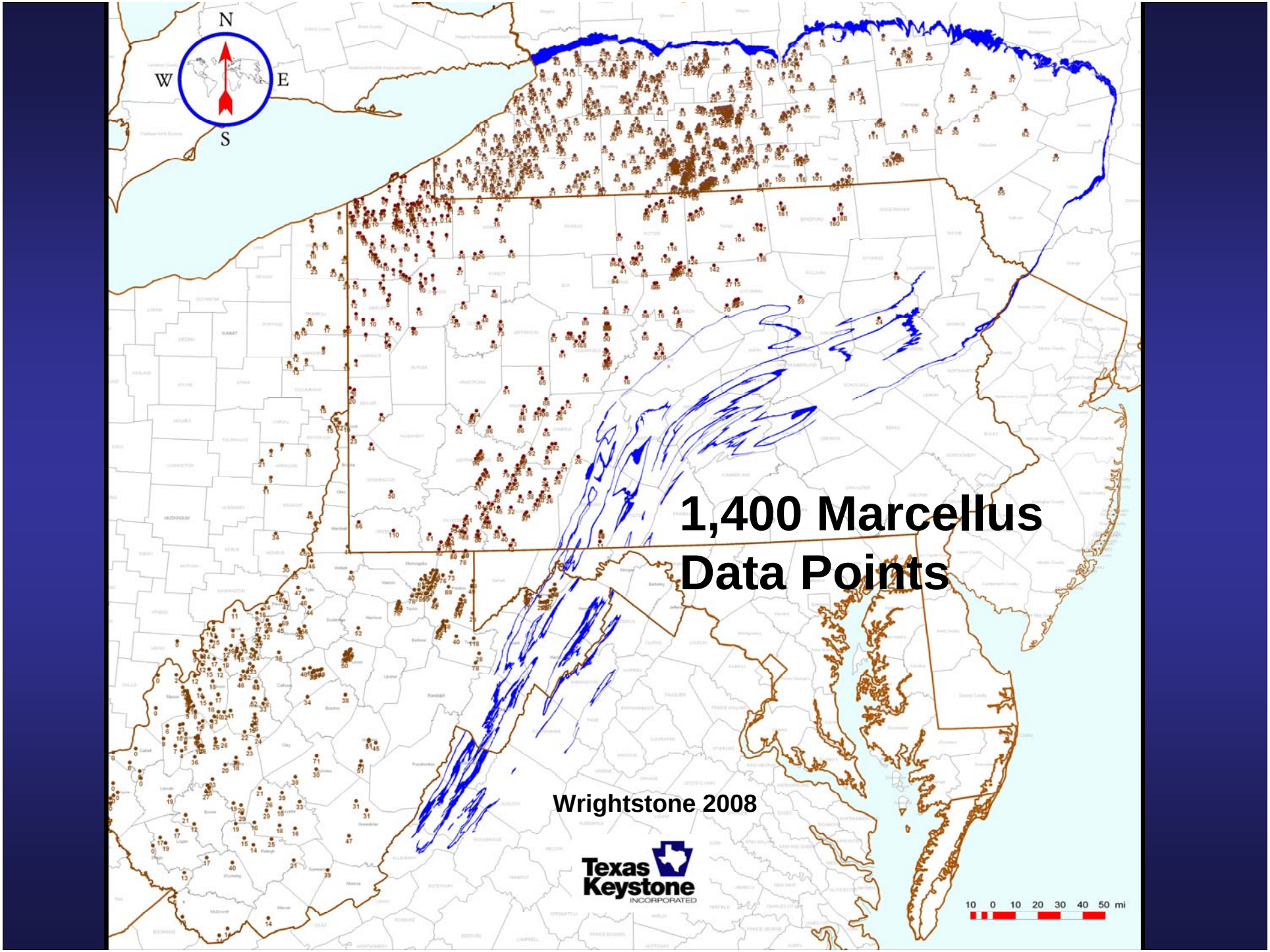
Wrightstone 2008

After Lash, 2007


Onondaga
Outcrop
NY
PA
OH
WV
VA
MD
DE
NJ
MARCELLUS WESTERN LIMIT
0
0
0
0
Wrightstone 2008
Texas Keystone
INCORPORATED
10 0 10 20 30 40 50 mi


NY
±50,000,000 Acres
PA
OH
MARCELLUS WESTERN LIMIT
NJ
MD
DE
WV
Wrightstone 2008
VA
Texas Keystone
INCORPORATED
10 0 10 20 30 40 50 mi


N
W
E
S
MARCELLUS WESTERN LIMIT
>20,000
Marcellus
Penetrations
Wrightstone 2008
Texas
Keystone
INCORPORATED
10 0 10 20 30 40 50 mi


N
W
E
S
1,400 Marcellus
Data Points
Wrightstone 2008
Texas
Keystone
INCORPORATED
10 0 10 20 30 40 50 mi

GEOLOGIC FACTORS CONTROLLING SHALE PROJECT SUCCESS*

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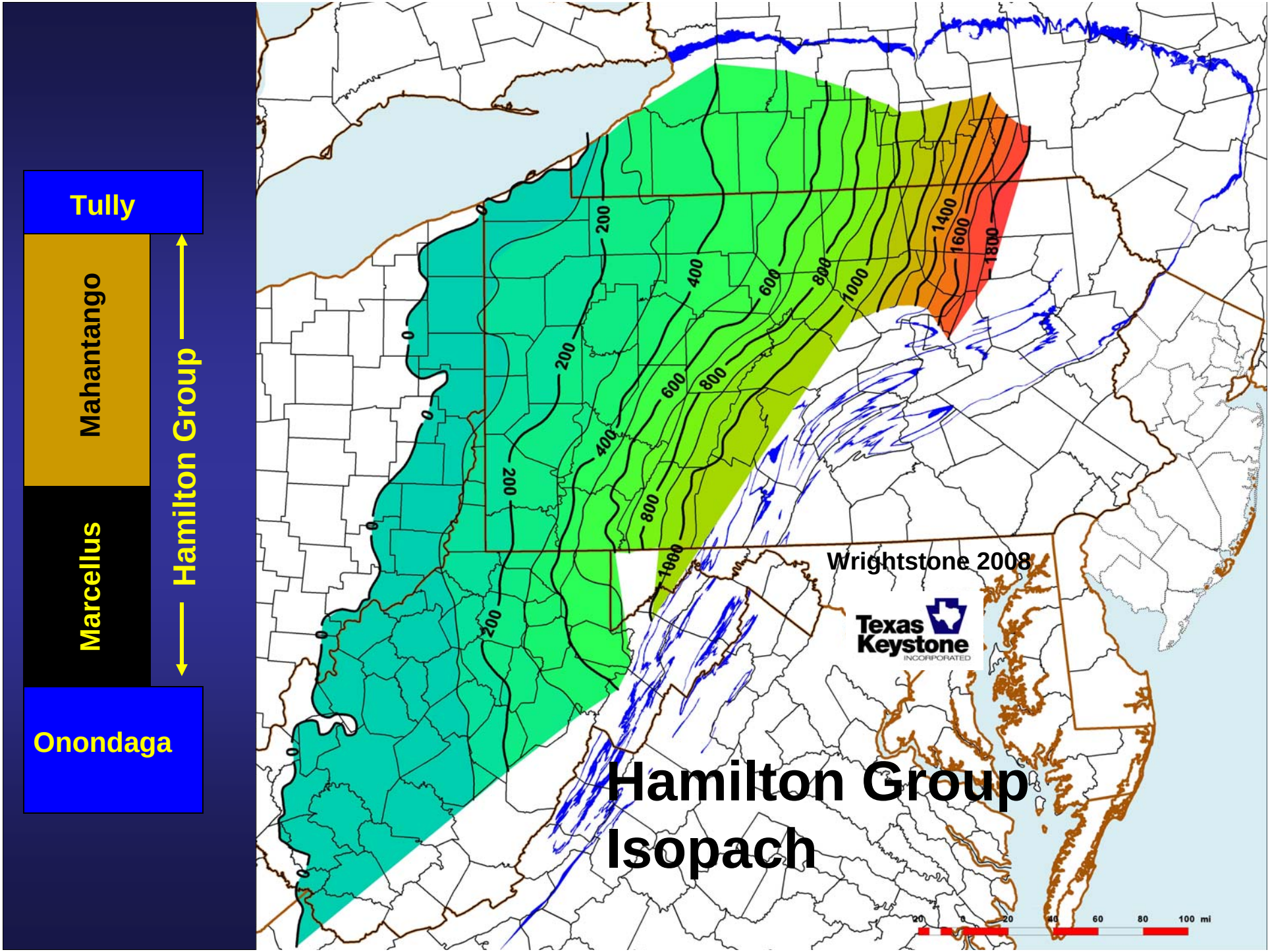
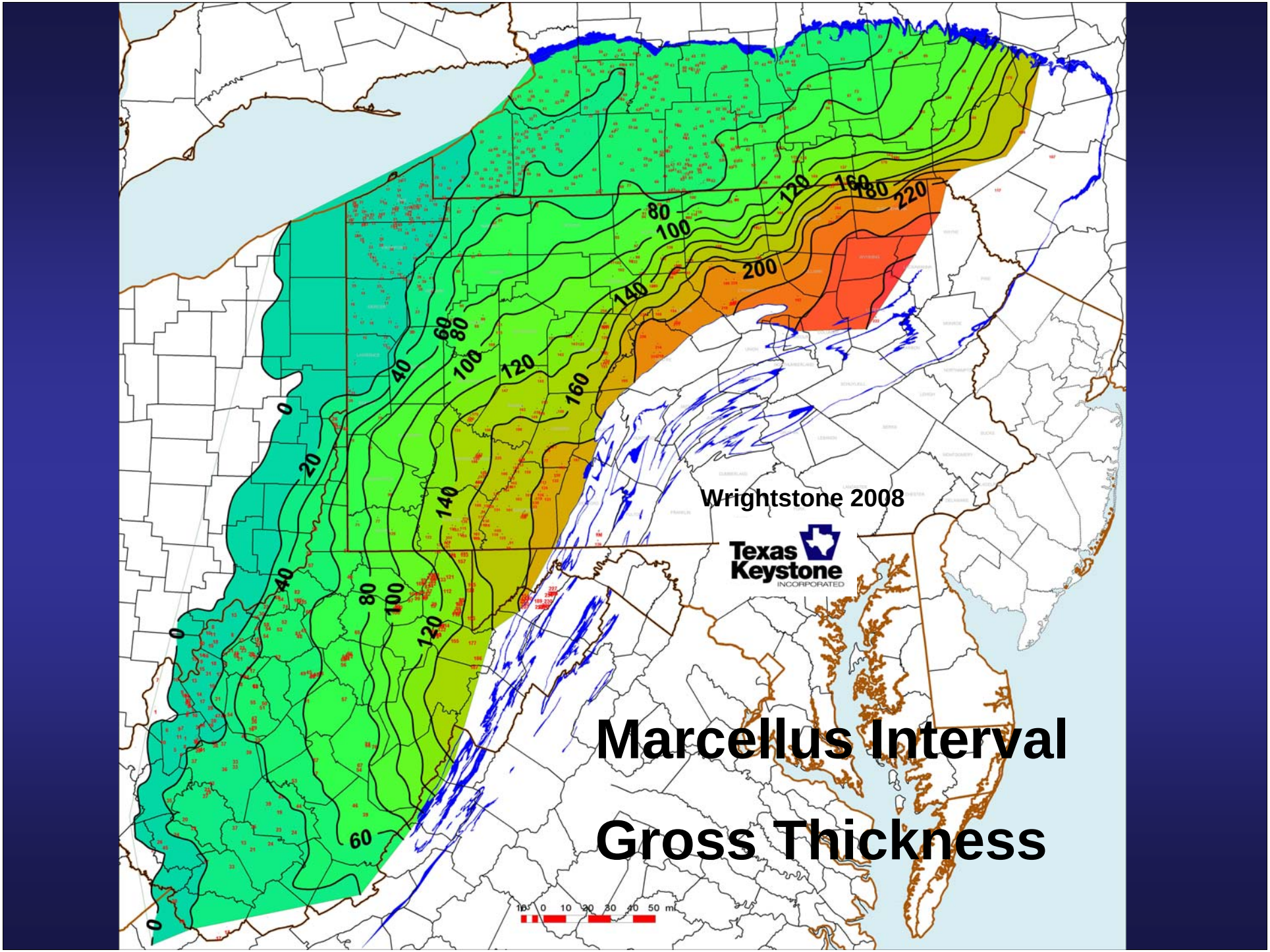
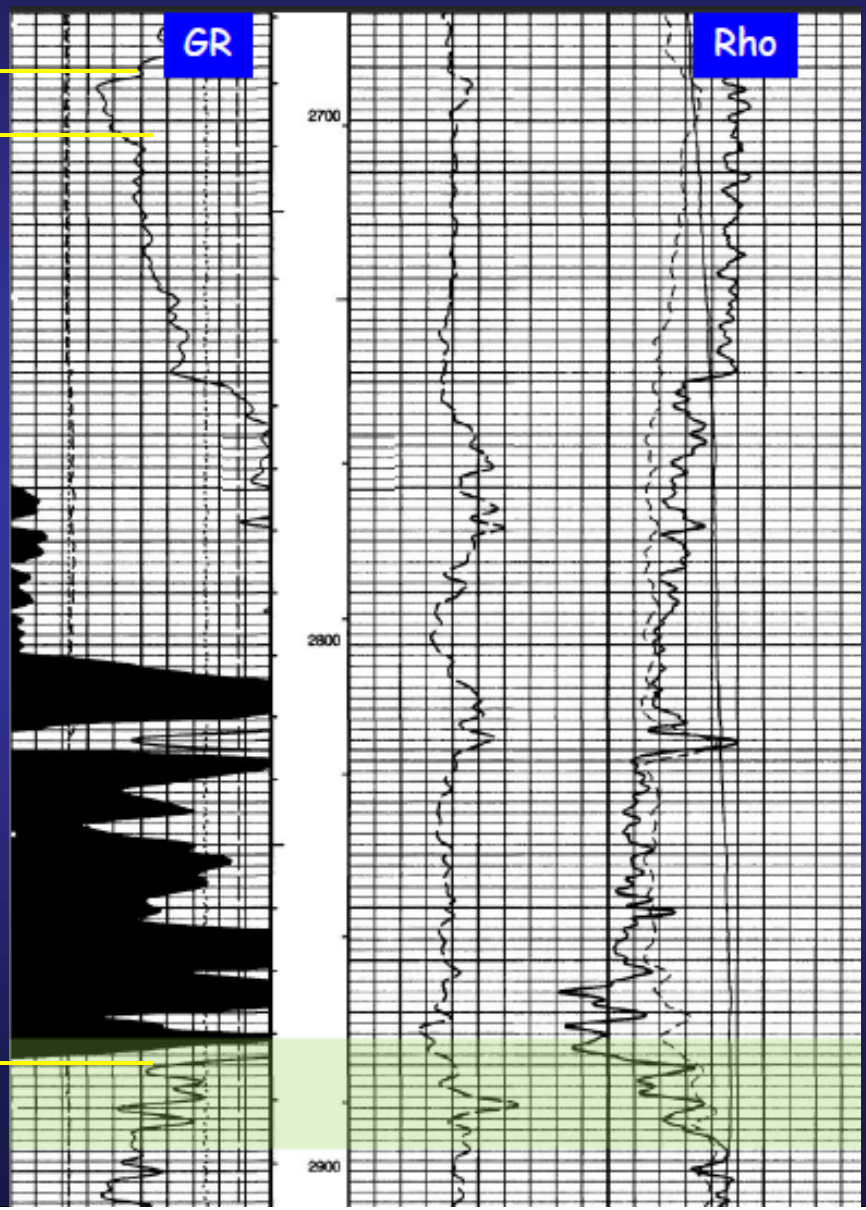
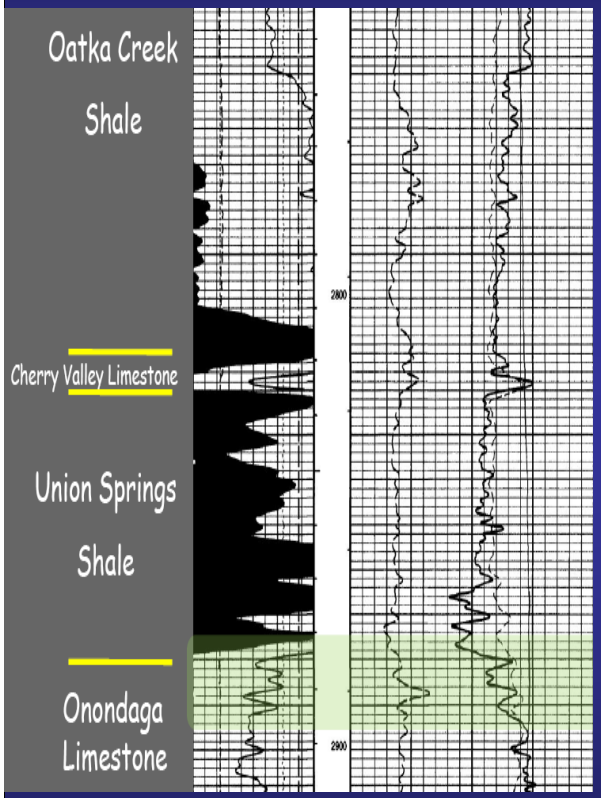

Tully
Mahantango
Marcellus
Onondaga
Hamilton Group
0
200
400
600
800
1000
1400
1600
1800
Wrightstone 2008
Texas Keystone
INCORPORATED
Hamilton Group
Isopach
20
0
20
40
60
80
100 mi

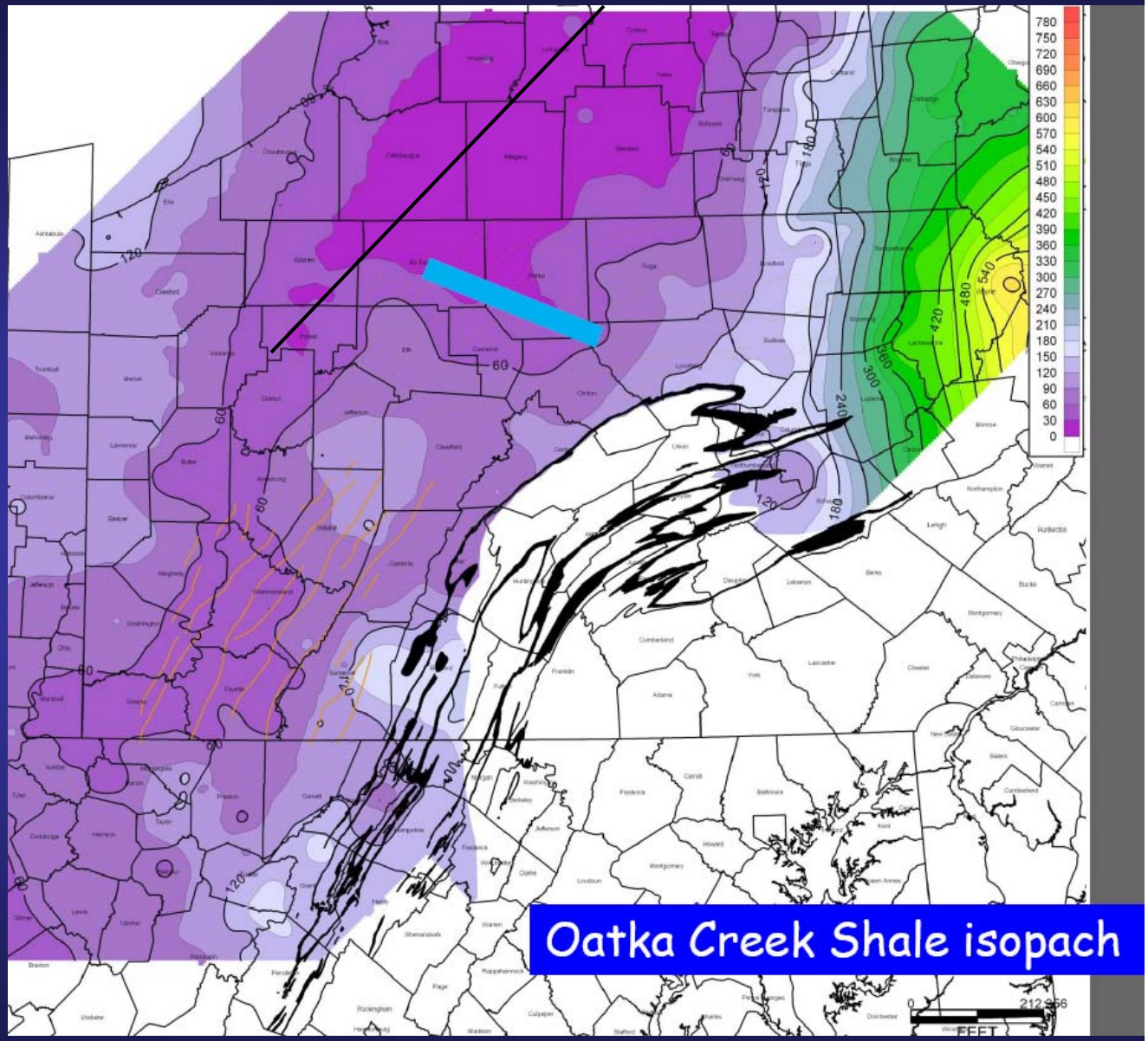

Wrightstone 2008
Texas Keystone INCORPORATED
Marcellus Interval
Gross Thickness

Wrightstone Correlations & Terminology	Lash Correlations & Terminology
Stafford Limestone	Stafford Limestone
Undifferentiated Gray Shale	Oatka Creek Shale
Upper Marcellus	
Purcell Ls.	Cherry Valley Ls.
Lower Marcellus	Union Springs Shale

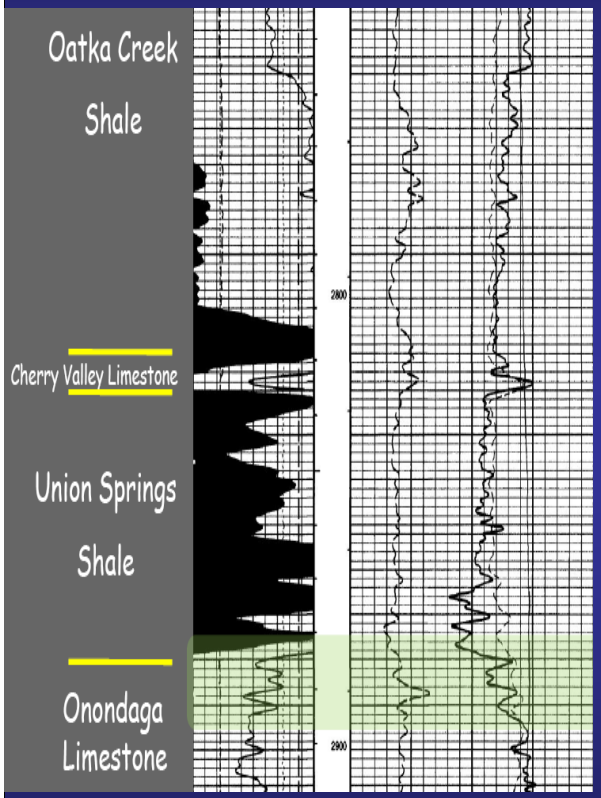


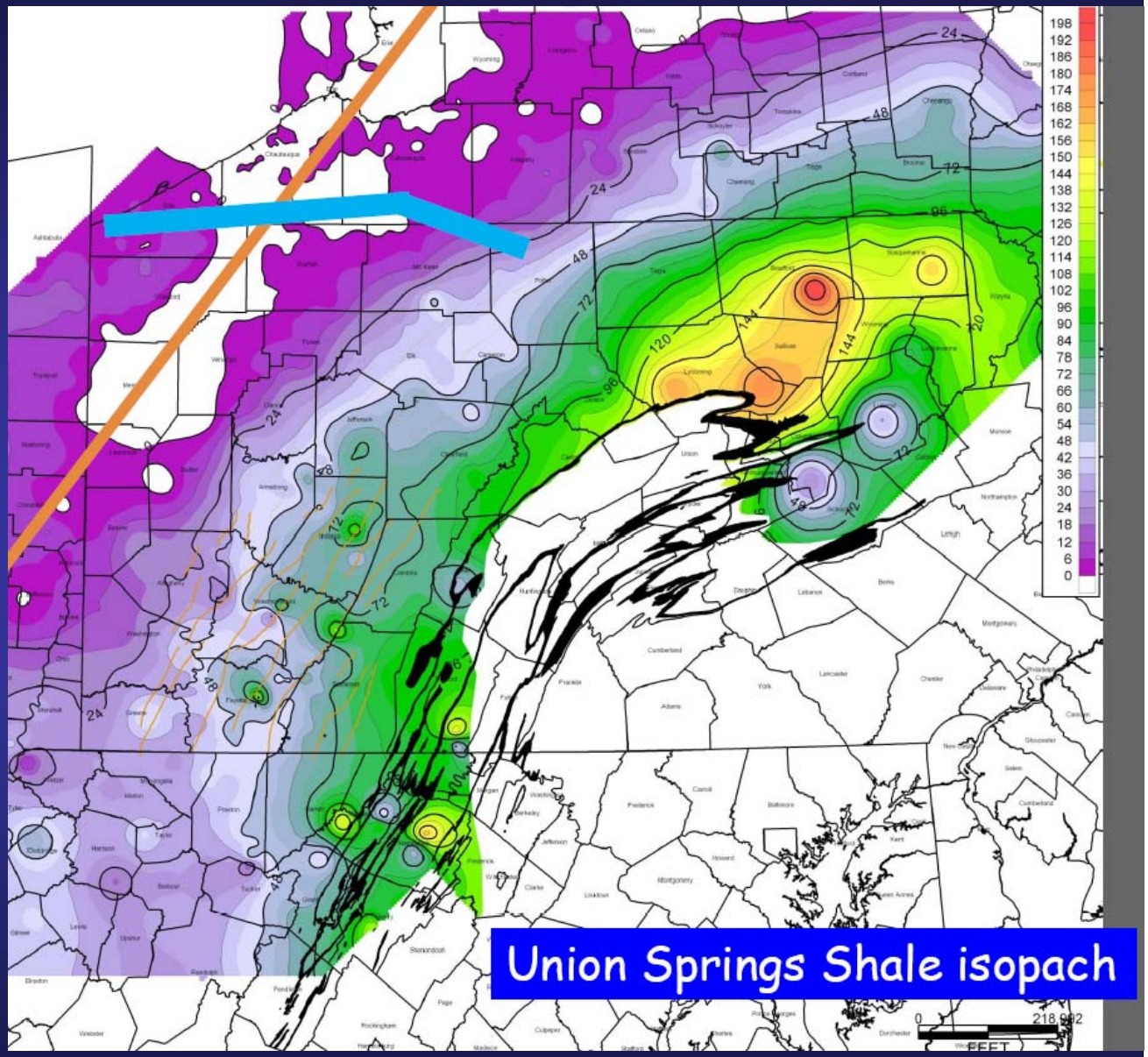
Texas Keystone INCORPORATED





From Lash and Engelder 2008





From Lash and Engelder 2008

MARCELLUS SHALE SUBSURFACE STRATIGRAPHY AND THICKNESS TRENDS: EASTERN NEW YORK TO NORTHEASTERN WEST VIRGINIA

Gary G. Lash
Dept. of Geosciences
SUNY-Fredonia
Fredonia, NY 14063

Terry Engelder
Dept. of Geosciences
The Pennsylvania State University
University Park, PA 16802

Presented at 2008 AAPG Eastern Section Meeting - Pittsburgh

For pdf of Lash's presentation go to:

papgrocks.org/publications

THIS SLIDE LEFT BLANK

Marcellus Net Thickness of "Hot Shale"

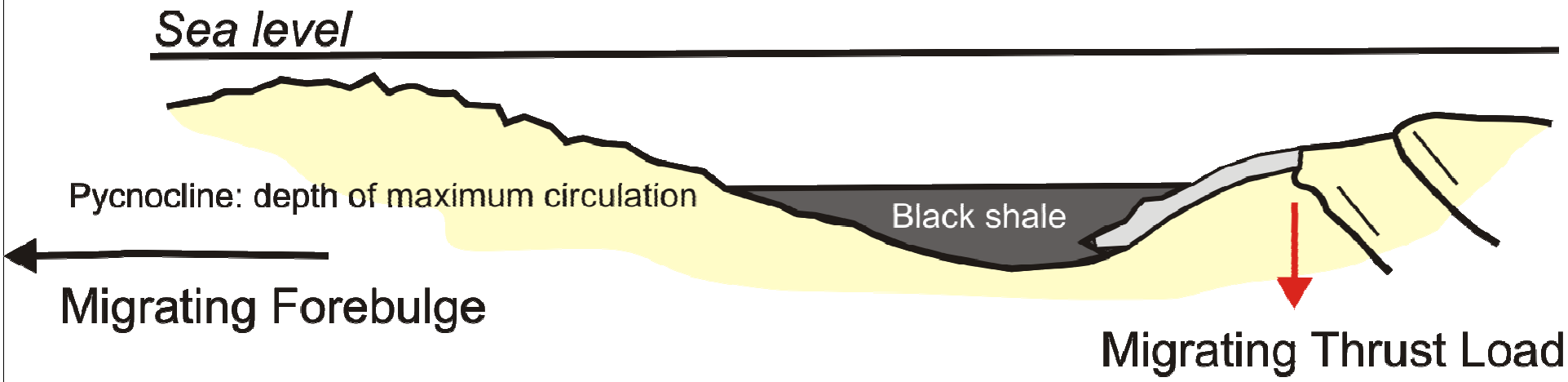
60 API ≥ Shale Base Line

2nd Tectophase of Frank Ettensohn

Foreland Basin

Or

Proximal Trough



Wrightstone 2008

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After Ettensohn 2004

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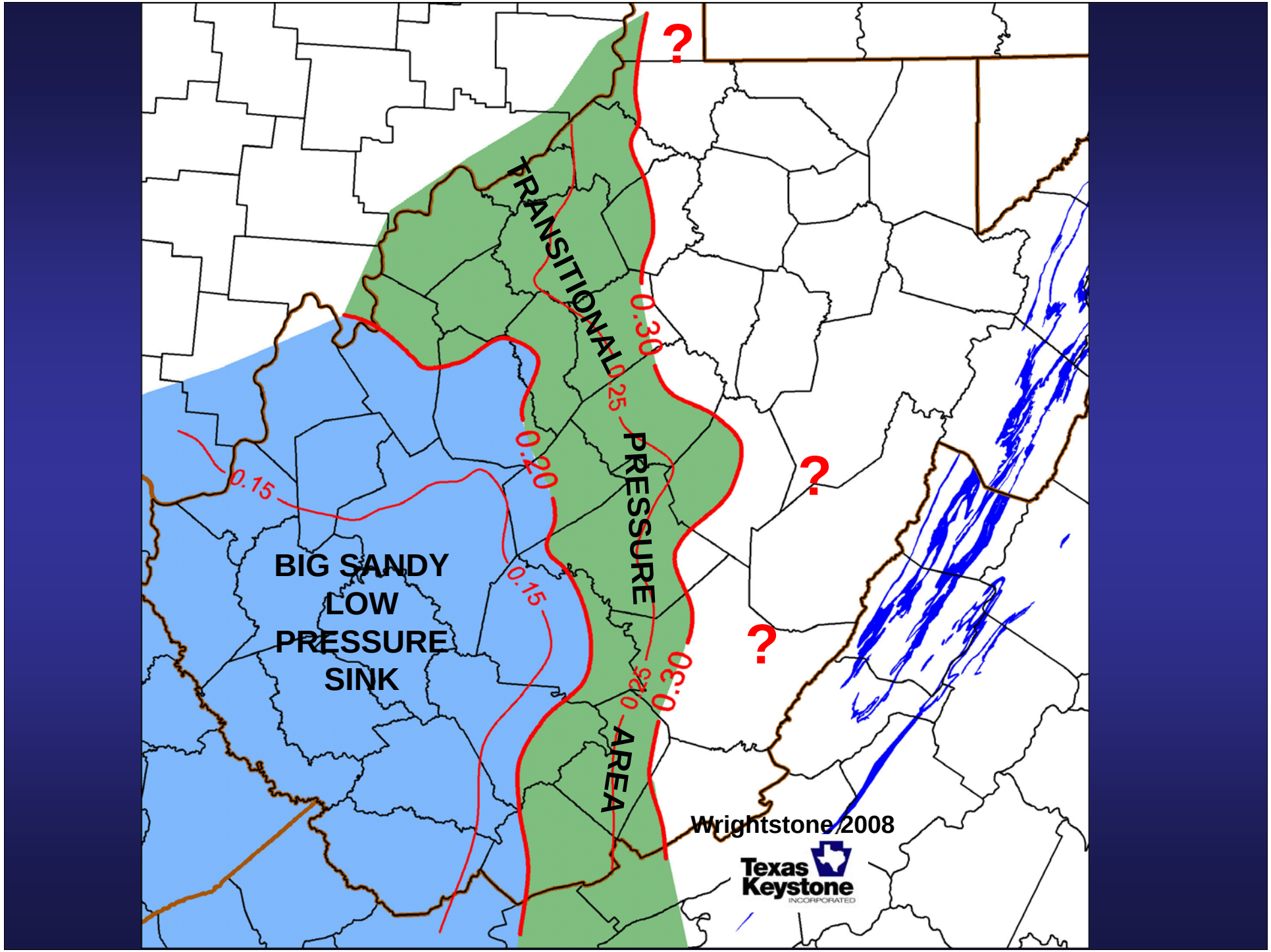
*After Creties Jenkins 2007


?
TRANSITIONAL
PRESSURE
AREA
0.30
0.25
0.20
0.15
0.15
0.20
0.30
?
?
BIG SANDY
LOW
PRESSURE
SINK
Wrightstone 2008
Texas
Keystone
INCORPORATED

BIG SANDY LOW PRESSURE SINK - RESERVES

Chesapeake Reserves - Boone, Lincoln & Logan Cos., WV

Before the WV OGCC 6/7/2007

EXAMINATION

BY CHAIRMAN LAY:

Q I only have one question. Do you have any quantitative number you can share with us with regards to the amount of reserves that are going to be left in the ground if we reduce the spacing requirements to three thousand to fifteen hundred feet or a thousand feet, for that matter, at your request?

A Pertaining to the Marcellus, right now, we don't know what the drainage area is per well. I mean, we're drilling on fifteen hundred feet. Our typical, recoverable reserves from the Marcellus alone, we estimate at about seventy-five million.

Low Pressure Gradient = Low Reserves

75 MMCF EUR

40 Acre Spacing

Marcellus Only

Most wells are commingled with shallower zones for higher total EUR

Wrightstone 2008

Texas Keystone INCORPORATED

Transitional Pressure Area Production

Review of Marcellus Non-commingled Wells

Ritchie & Pleasants Counties, WV

38 Water Frac Wells:

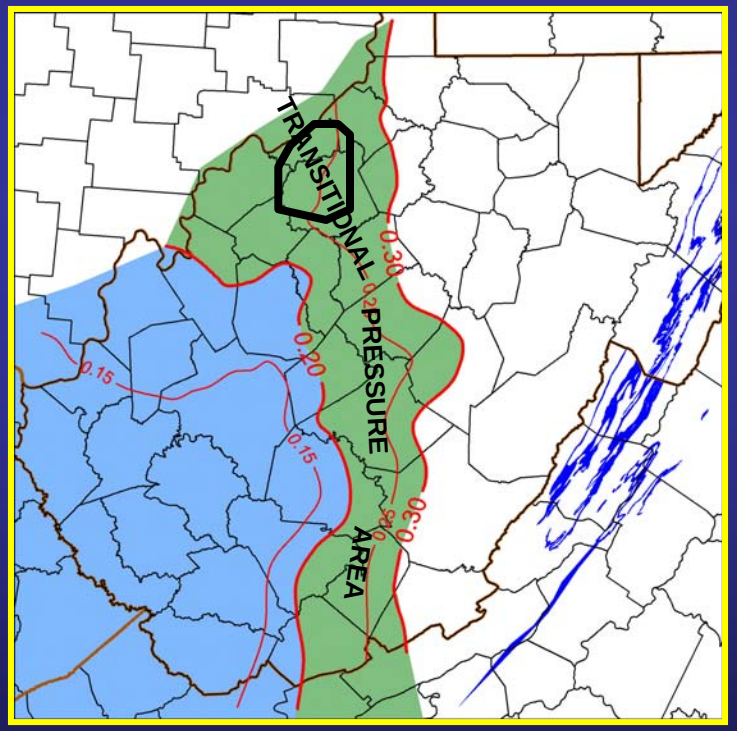
17,961 MCF 1st Year Production

48 MCFPD

29 Foam Frac Wells:

15,235 MCF 1st Year Production

42 MCFPD



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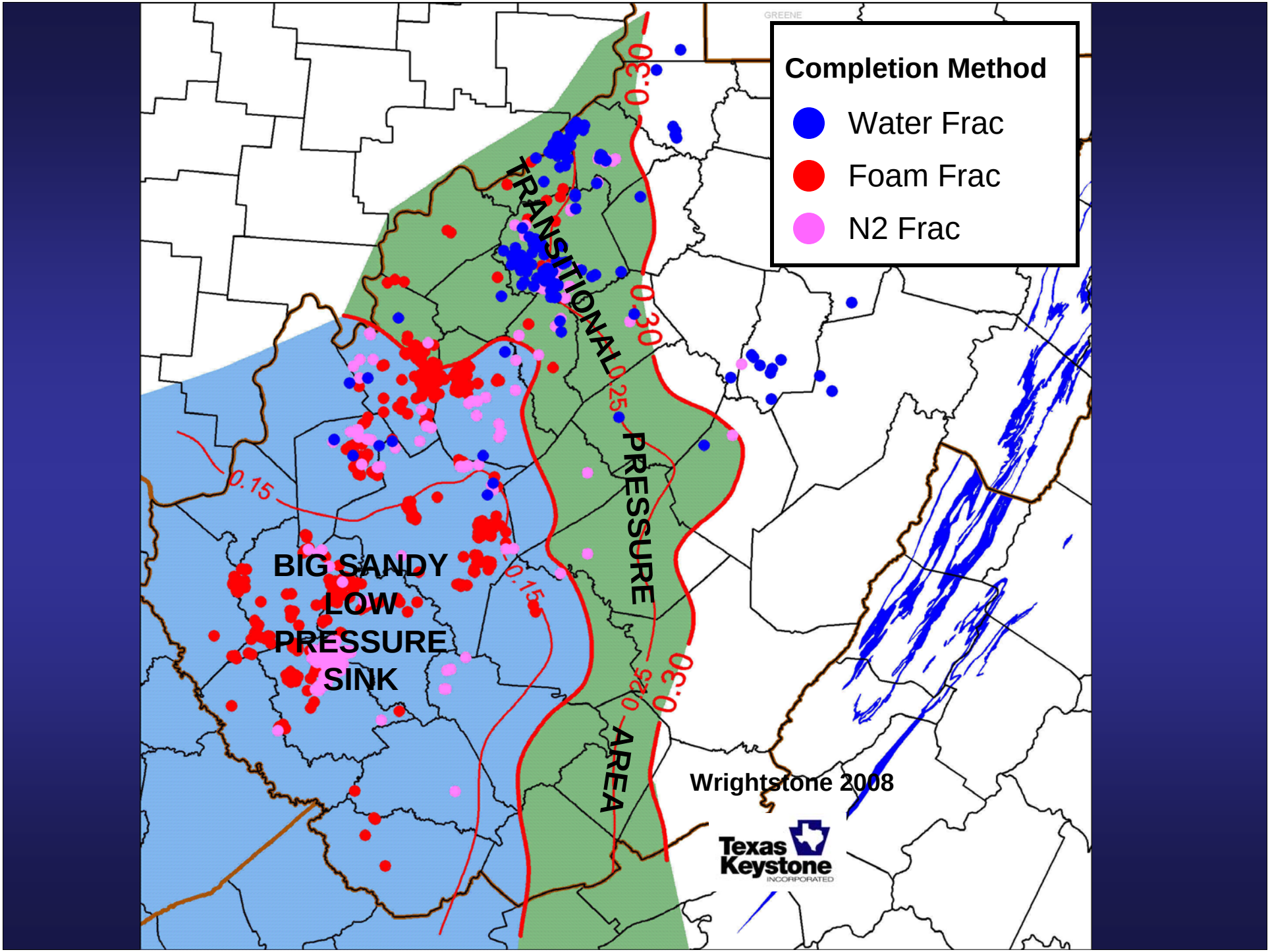
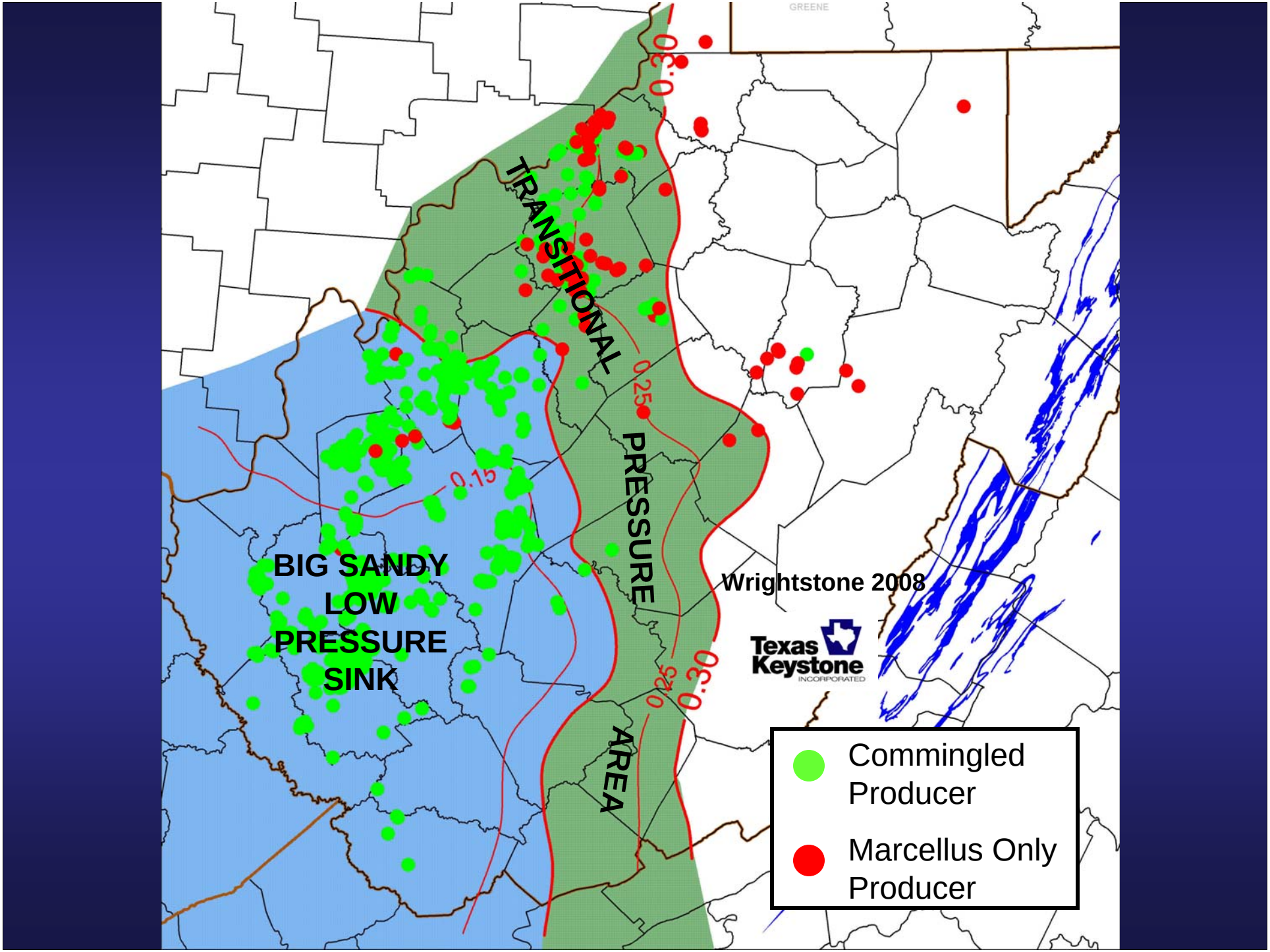

Completion Method
Water Frac
Foam Frac
N2 Frac
0.30
0.25
0.20
0.15
0.15
BIG SANDY
LOW
PRESSURE
SINK
TRANSITIONAL
PRESSURE
AREA
Wrightstone 2008
Texas
Keystone
INCORPORATED


GREENE
0.30
0.25
0.15
0.25
0.30
TRANSITIONAL
PRESSURE
AREA
BIG SANDY
LOW
PRESSURE
SINK
Wrightstone 2008
Texas Keystone INCORPORATED
Commingled Producer
Marcellus Only Producer

RESOURCE SHALE PLAYS

PRESSURE GRADIENT COMPARISONS

		Gradient	Pressure	Depth
MARCELLUS	Big Sandy Low Pressure	.1 - .2	900#	4,500’
	Transitional Pressure	.2 - .35	1,800#	6,000’
	Core Areas	.4 - >.60?	4,000#	7,550’
	BARNETT	.53	4,000#	7,550’
	FAYETTEVILLE	.43	1,000#	2,400’
	WOODFORD	.44	3,270#	7,500’
	HAYNESVILLE	.92	12,500#	13,500’

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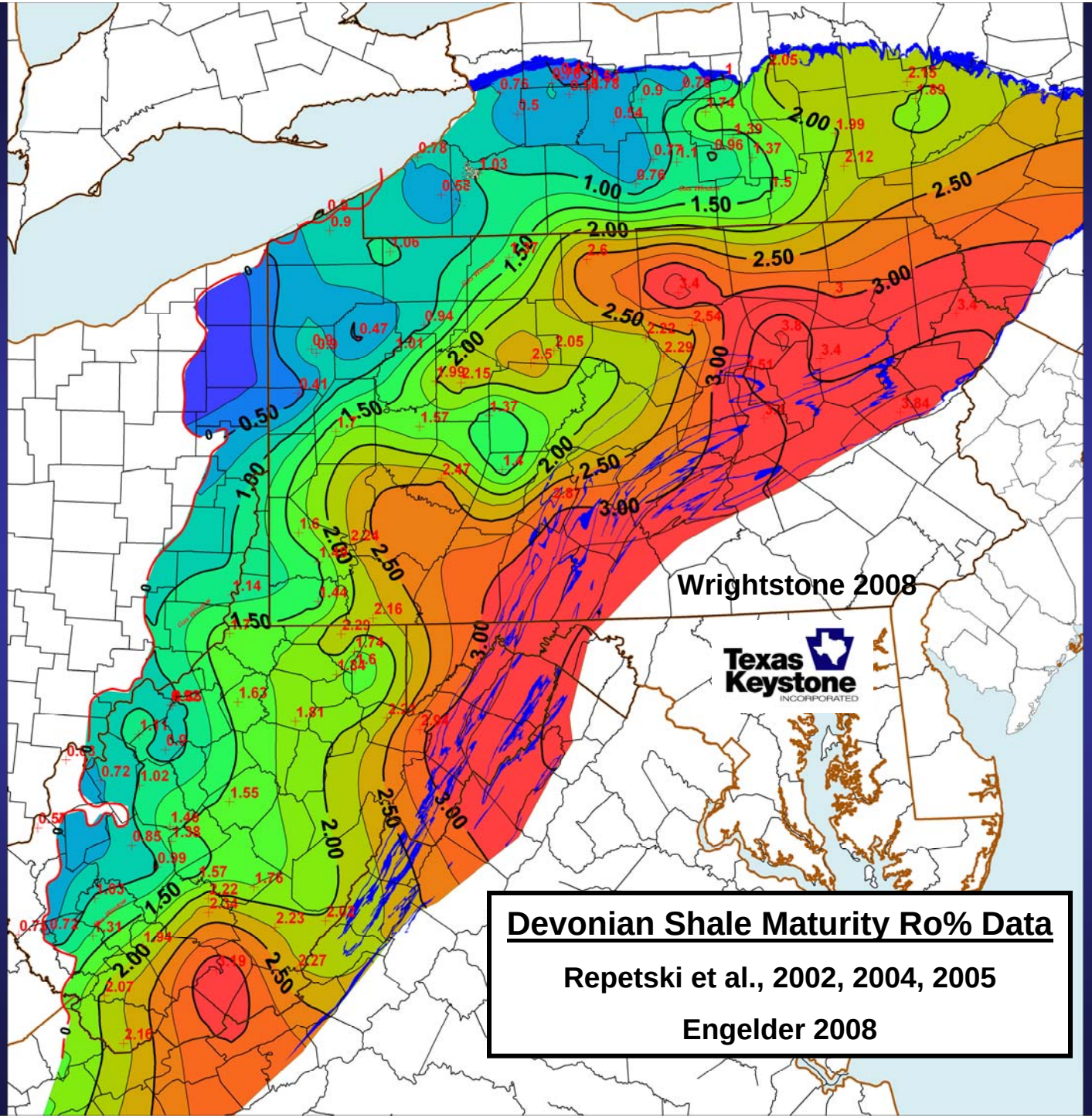
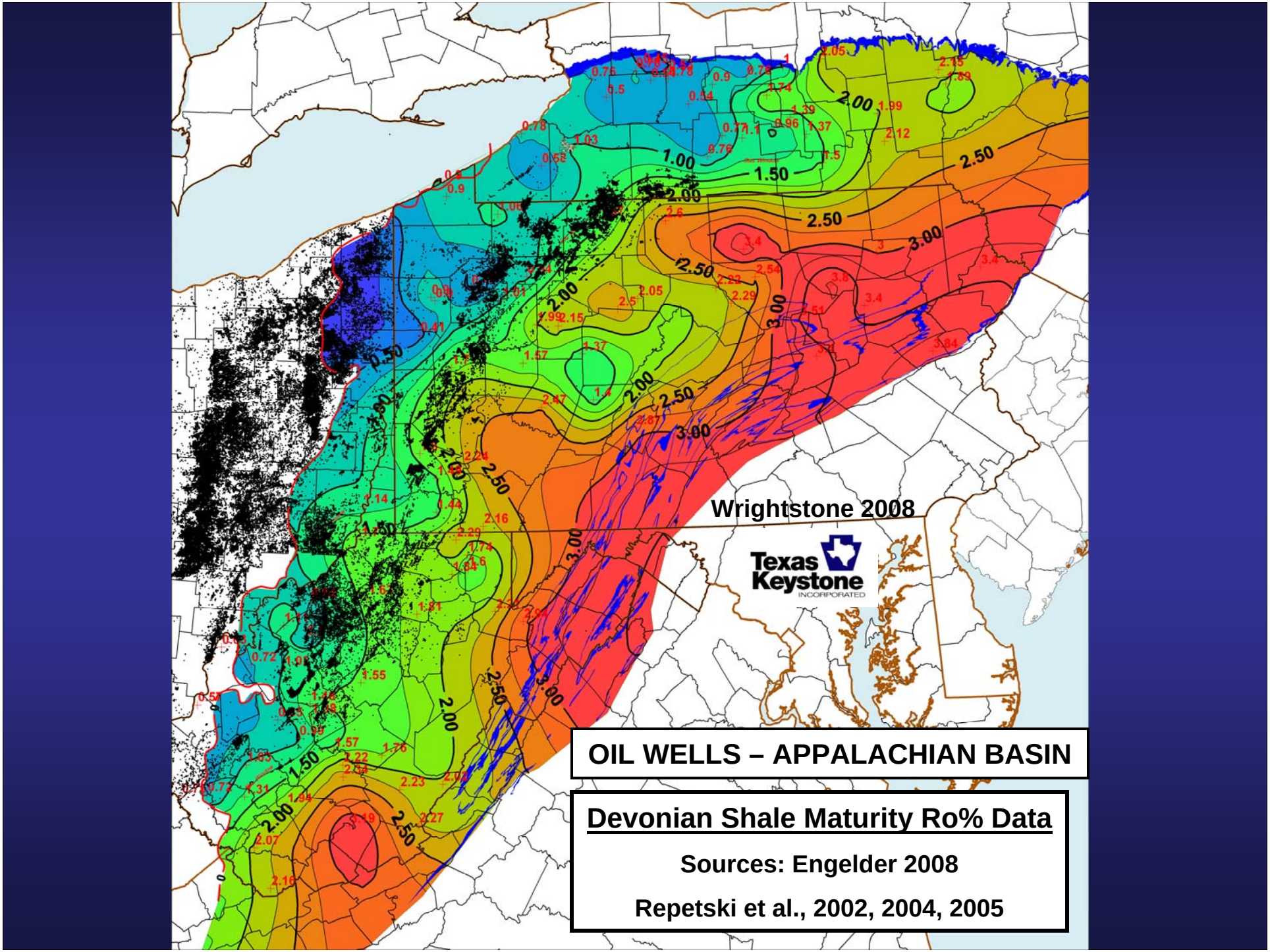

Wrightstone 2008
Texas Keystone INCORPORATED
Devonian Shale Maturity Ro% Data
Repetski et al., 2002, 2004, 2005
Engelder 2008


Wrightstone 2008
Texas Keystone INCORPORATED
OIL WELLS – APPALACHIAN BASIN
Devonian Shale Maturity Ro% Data
Sources: Engelder 2008
Repetski et al., 2002, 2004, 2005

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*After Creties Jenkins 2007

MARCELLUS PROPERTIES VS. OTHER SHALES

	Marcellus	Barnett (Core)	Barnett (SW)	Fayetteville	Arkoma Woodford
Avg. TOC	2 - 10%	3.5 - 8%	3.5 - 5%	4 - 9.5%	3 - 10%
Avg. Total Porosity	6%	4 - 6%	3 - 4.8%	2 - 8%	6 - 8%
GIP, BCF/Section	70 - 150	50 - 200	50 - 125	25 - 65	40 - 120
Silica Content	40 - 60%	40 - 60%		20 - 60%	60 - 80%

Limited public data available. Two large consortiums of core data:

Core Lab

Omni/Weatherford

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Source: Deutsche Bank 2008

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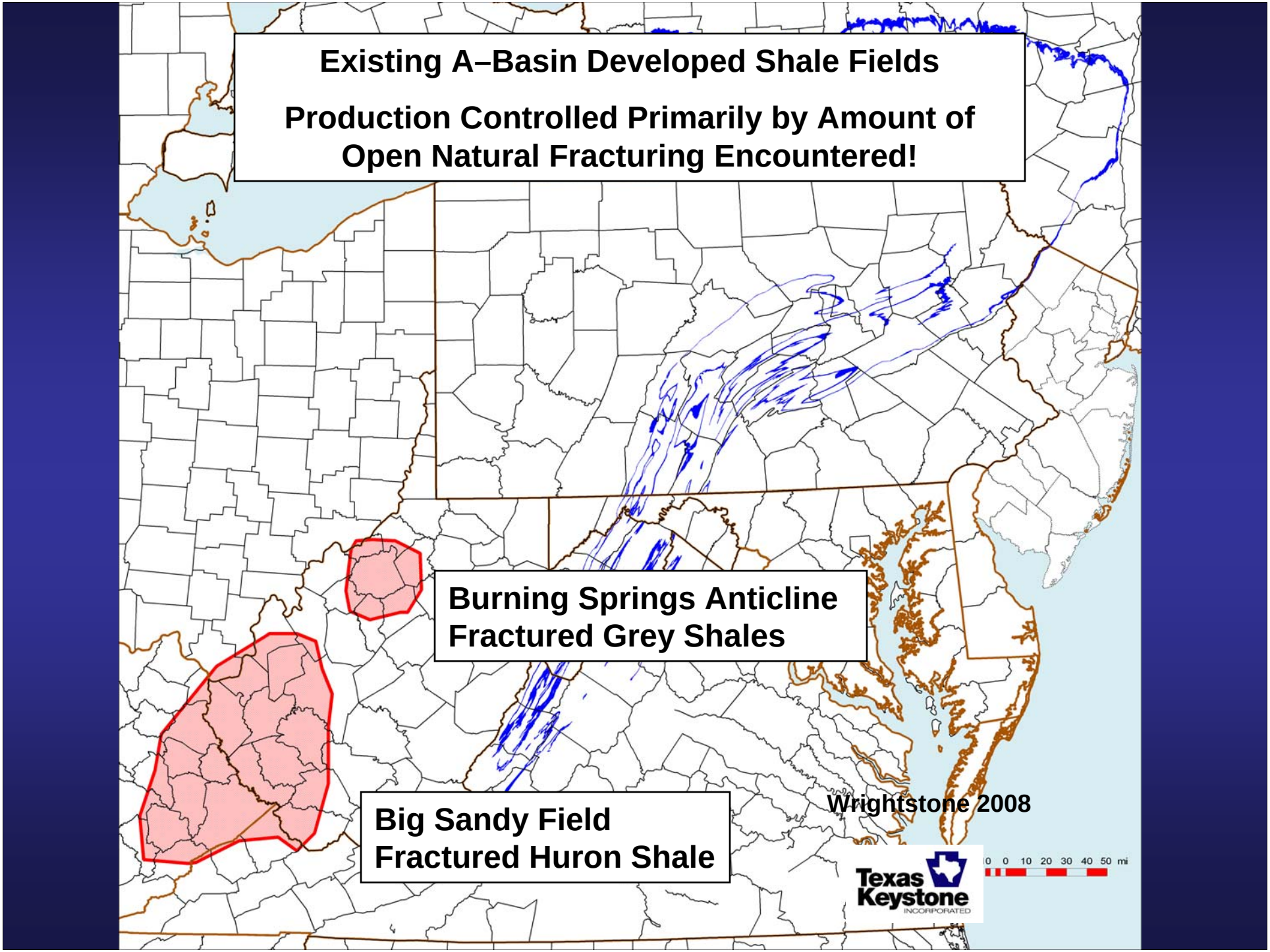
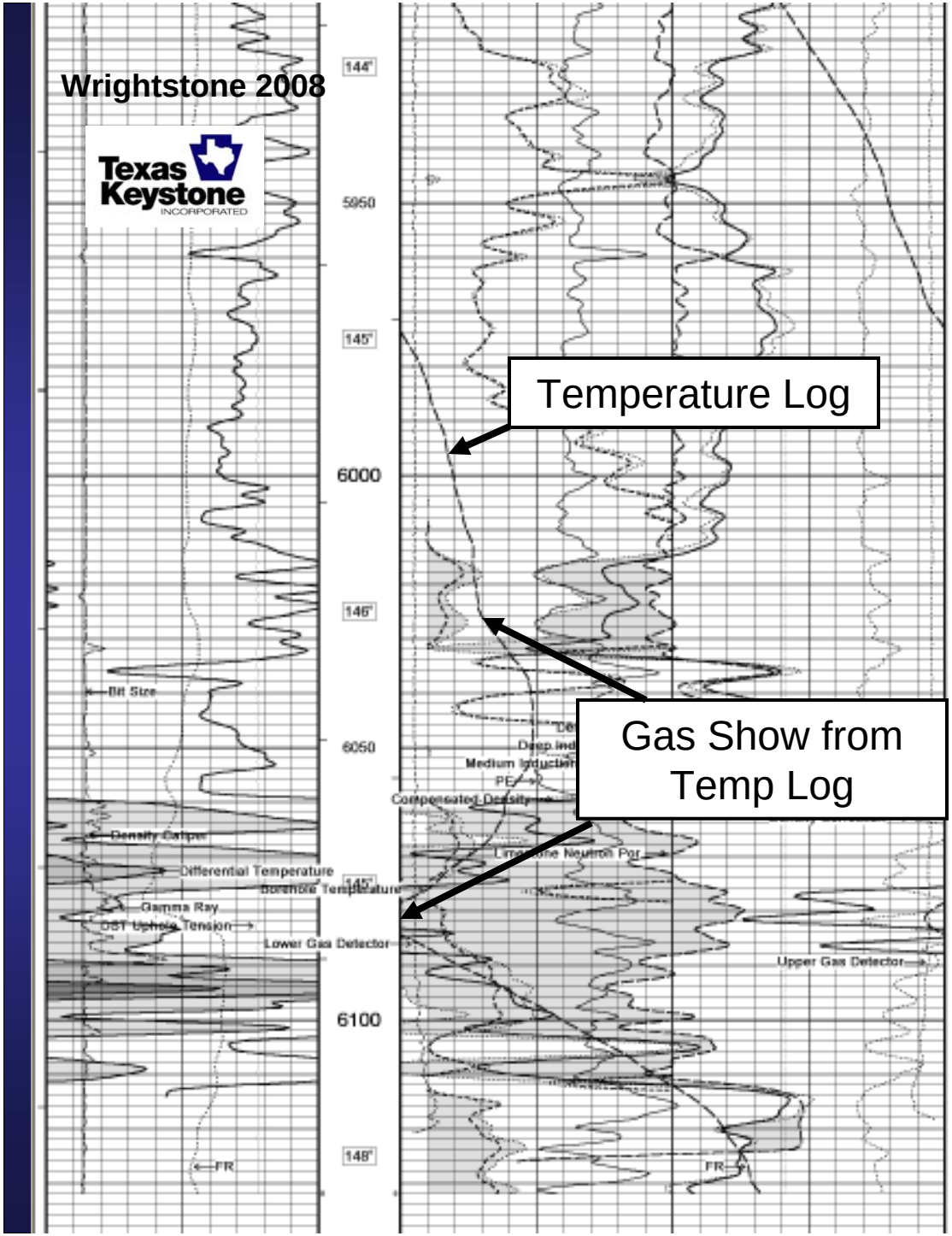

Existing A–Basin Developed Shale Fields
Production Controlled Primarily by Amount of Open Natural Fracturing Encountered!
Burning Springs Anticline
Fractured Grey Shales
Big Sandy Field
Fractured Huron Shale
Wrightstone 2008
Texas Keystone
INCORPORATED
0 0 10 20 30 40 50 mi



Nearly all Marcellus Penetrations have been Air Drilled

Many Marcellus Penetrations Report Natural Flows of Gas from the Marcellus or Shows of Gas from Temperature Logs

Indication of Natural Fracturing

From Cabot O & G Press Release Feb. 13, 2008

CONCERNING INITIAL WELLS DRILLED IN NE PA

This shale is sparsely drilled, both vertically and geographically, it is normal to over-pressured in contrast to the shallower pays in the basin, and **it appears to be extensively fractured**. Also, the rocks are at the optimum maturation level, with the rock mechanical properties appropriate for maximum stimulation effectiveness

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Dave Boyer 12/2007


Wrightstone 2008
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Plumose Fracture Morphology
J 2 Fracture

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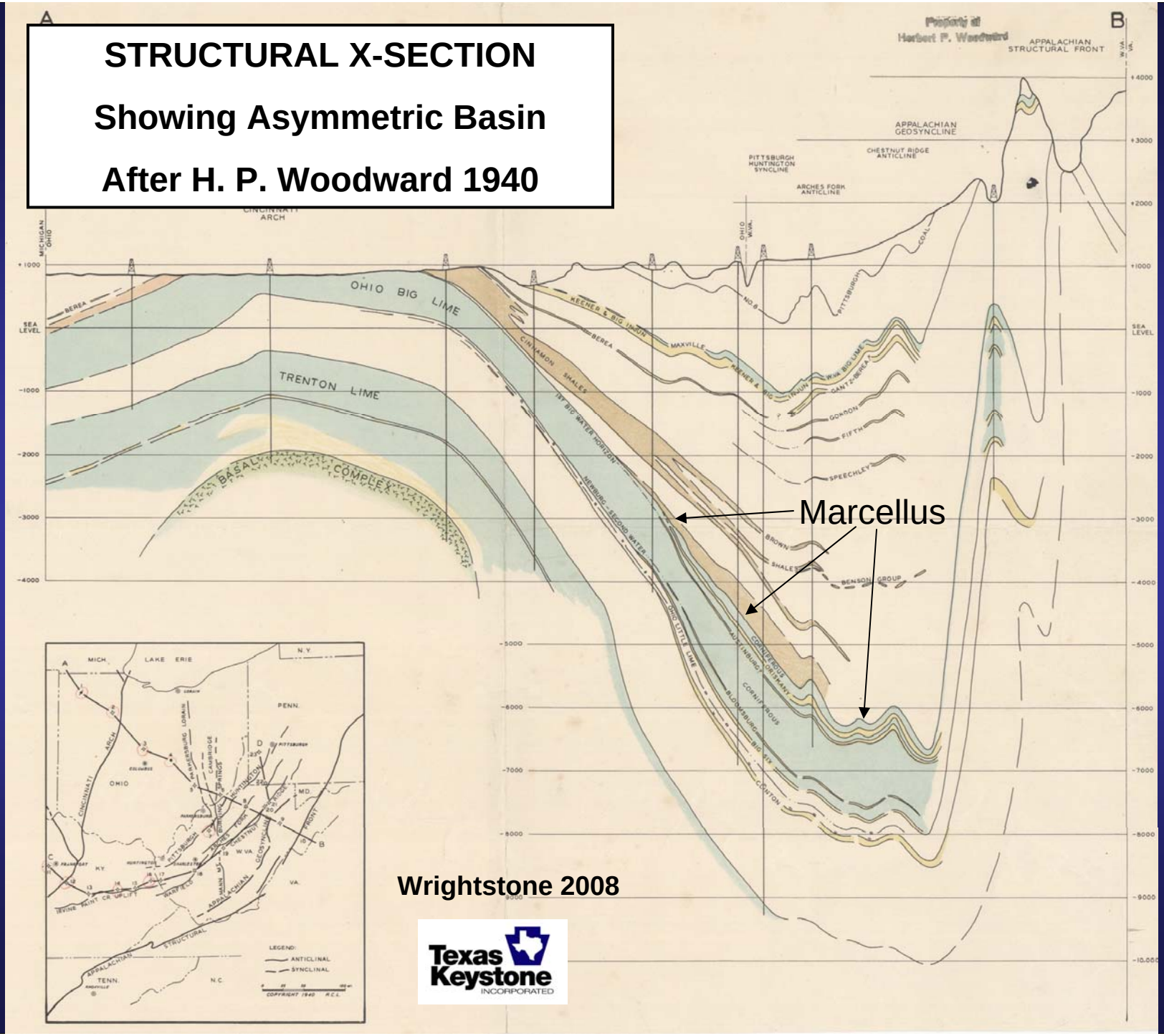
*After Creties Jenkins 2007

STRUCTURAL X-SECTION

Showing Asymmetric Basin

After H. P. Woodward 1940



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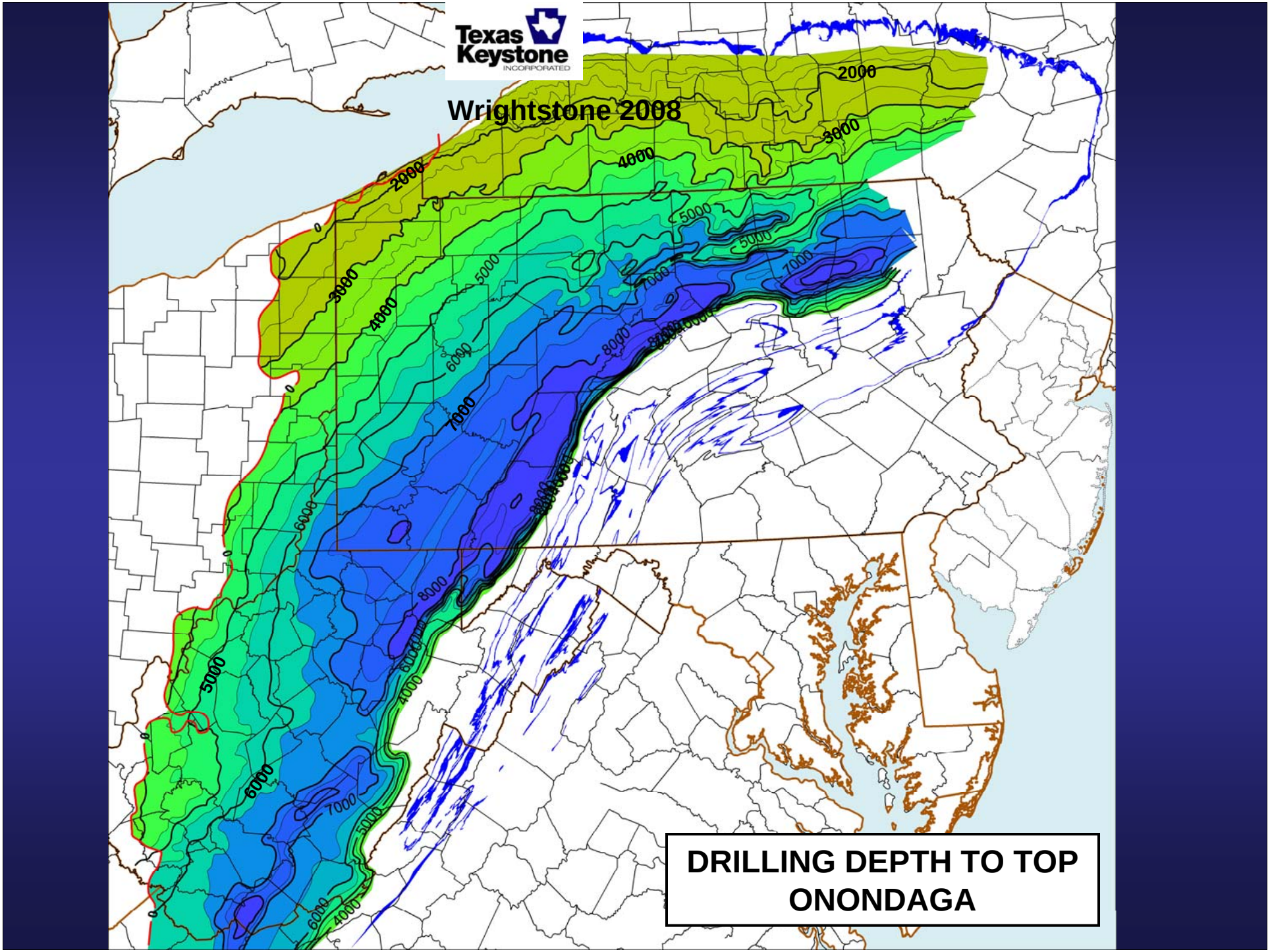
Texas Keystone
INCORPORATED
Wrightstone 2008
DRILLING DEPTH TO TOP ONONDAGA

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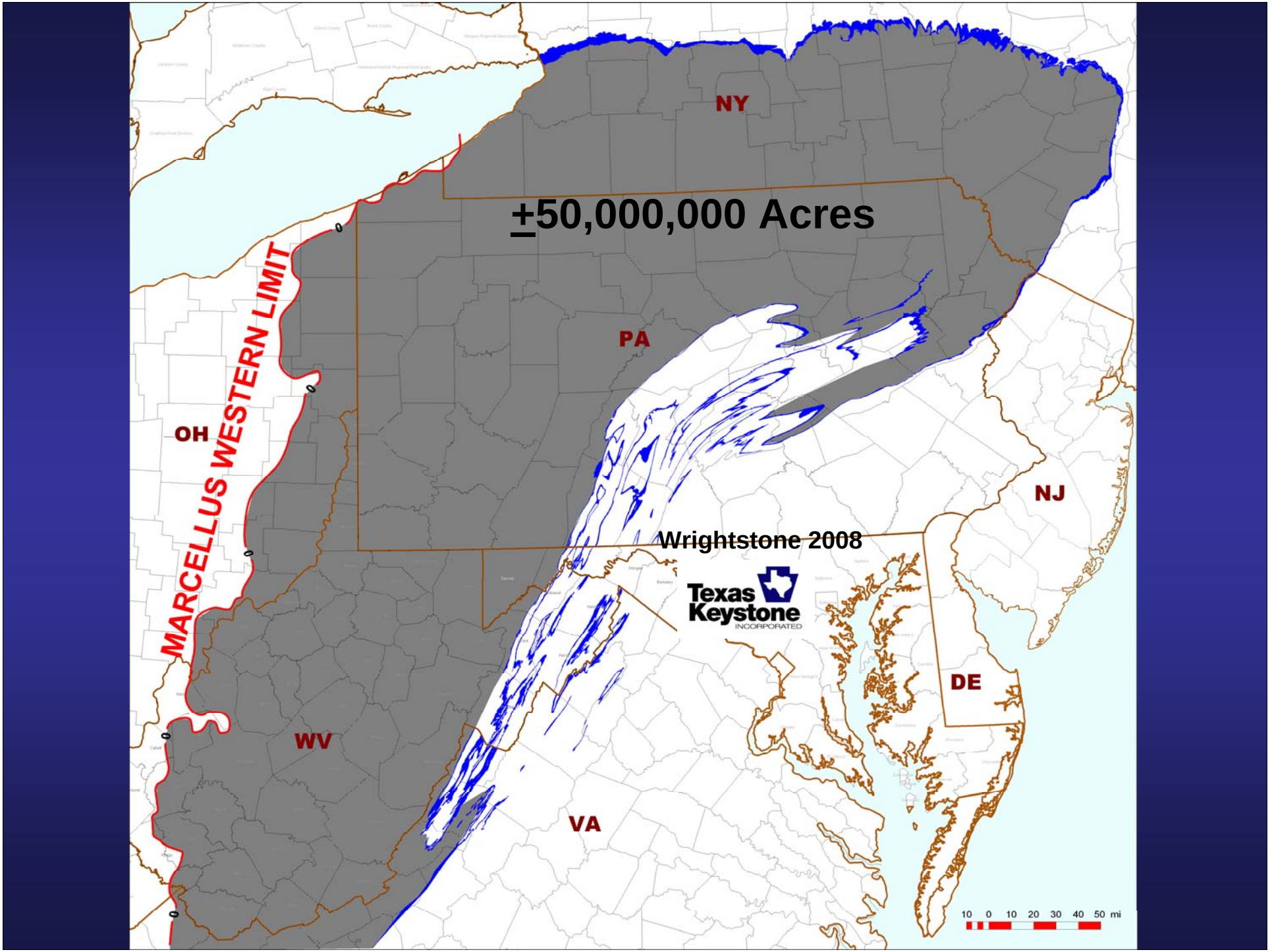
NY
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PA
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OH
NJ
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INCORPORATED
DE
WV
VA
10 0 10 20 30 40 50 mi

GEOLOGIC HAZARDS

1. No Upper Frac Boundary
2. No Lower Frac Boundary
    a. Water below in Oriskany/Chert?
    b. Gas Productive below?
3. Fracture migration along Faults
    a. Migrate Downward into Water
    b. Migrate Upward Out of Zone
4. Horizontal Hole Failures – Lost Holes due to Collapse

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GEOLOGIC HAZARDS

FAULTS ARE BAD

STRATIGRAPHY – LOWER & MIDDLE DEVONIAN

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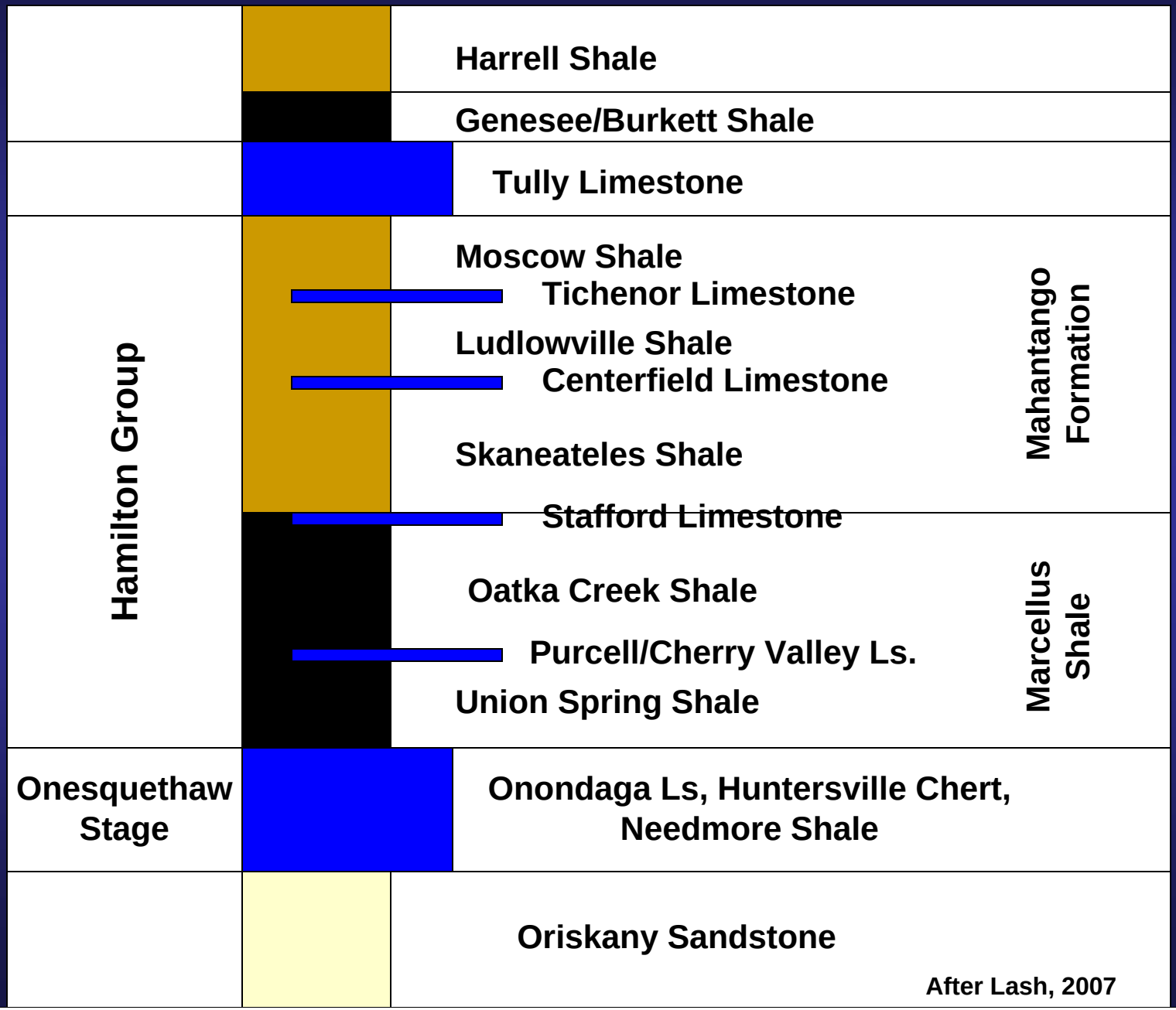
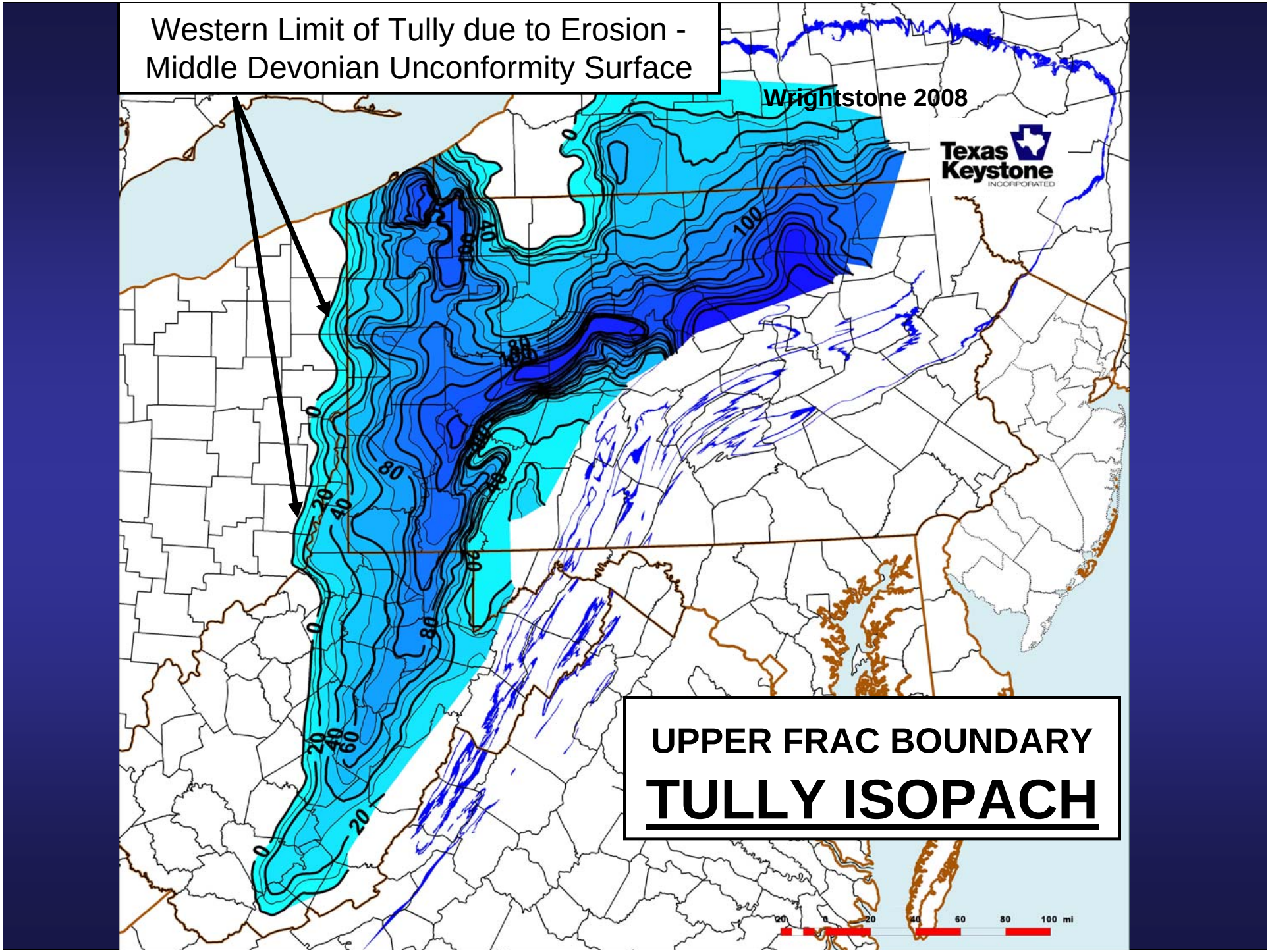
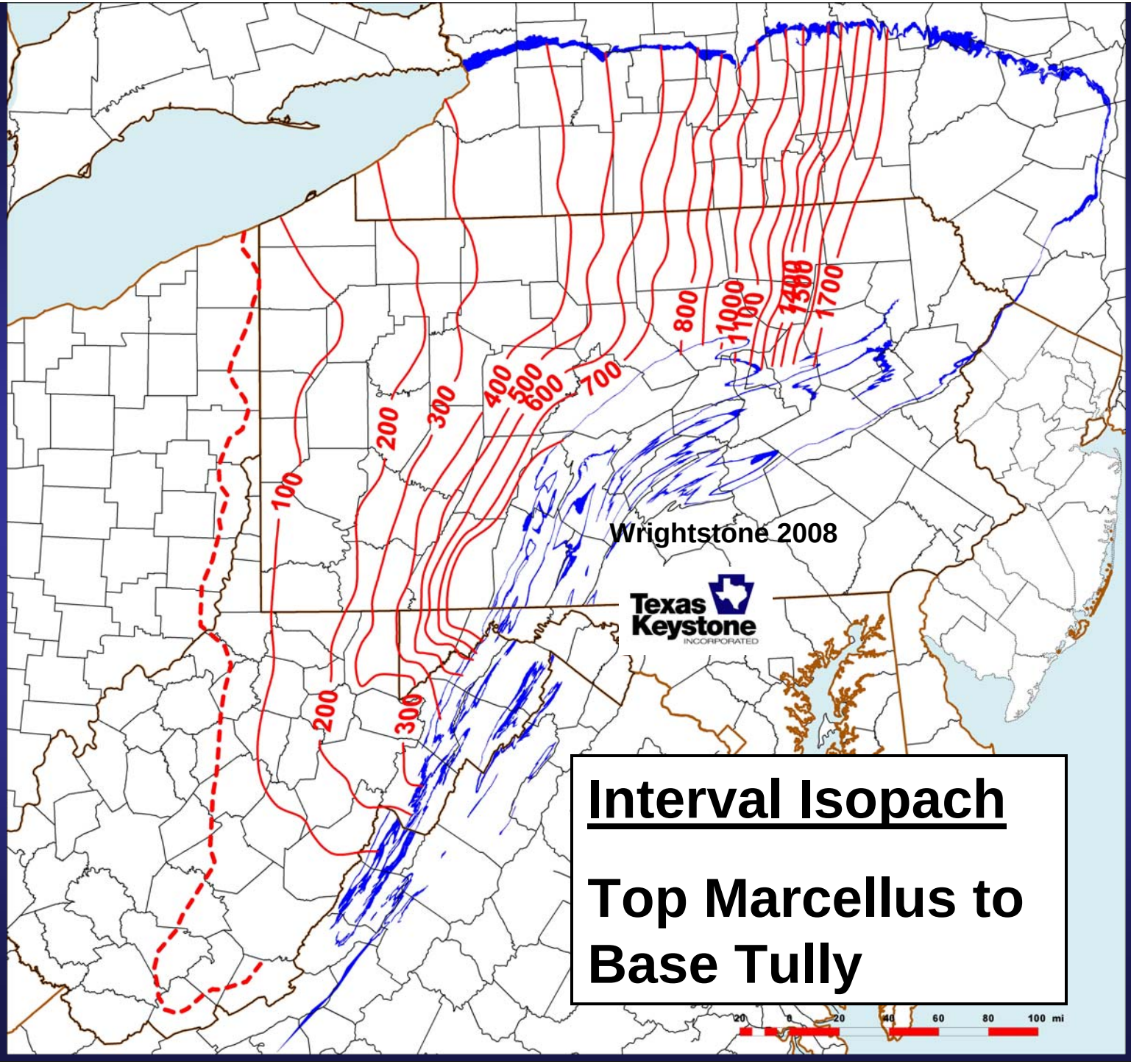
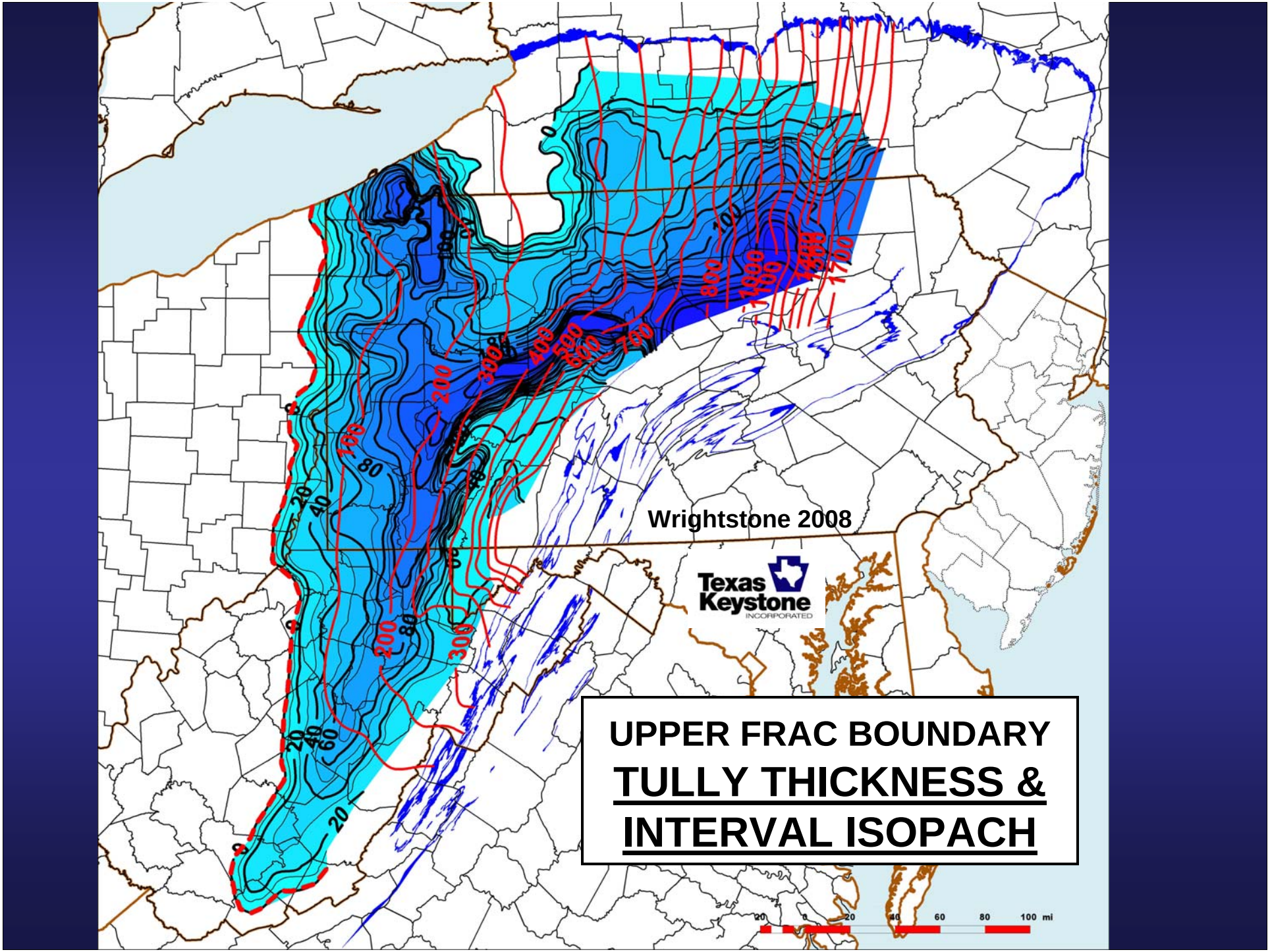
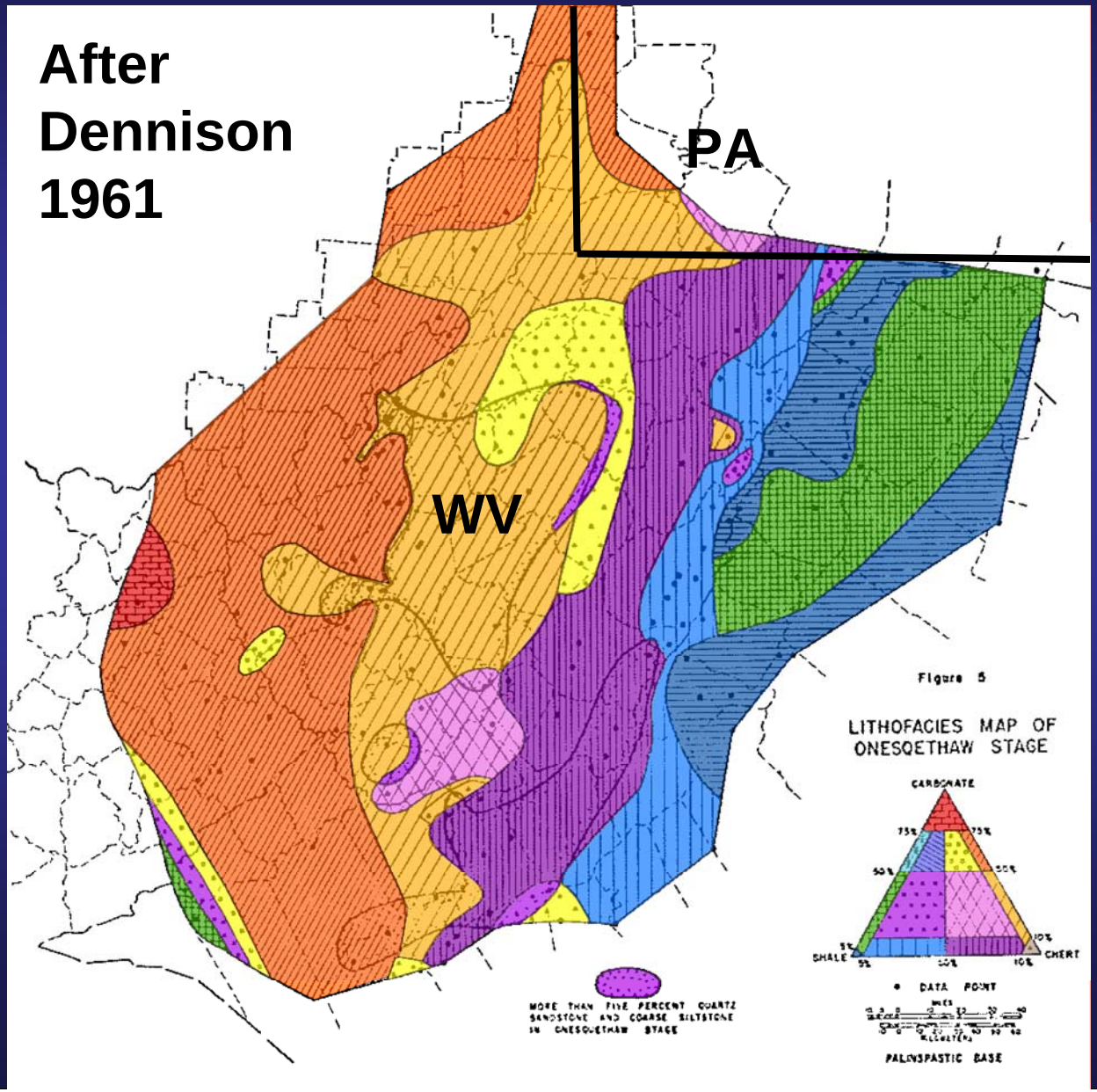



Western Limit of Tully due to Erosion -
Middle Devonian Unconformity Surface
Wrightstone 2008
Texas Keystone
INCORPORATED
UPPER FRAC BOUNDARY
TULLY ISOPACH
0
20
40
60
80
100
120
140
160
180
20
0
20
40
60
80
100 mi


100
200
300
400
500
600
700
800
1000
1100
1500
1700
Wrightstone 2008
Texas Keystone
INCORPORATED
Interval Isopach
Top Marcellus to Base Tully
20 0 20 40 60 80 100 mi


Wrightstone 2008
Texas Keystone INCORPORATED
UPPER FRAC BOUNDARY
TULLY THICKNESS &
INTERVAL ISOPACH
20 0 20 40 60 80 100 mi

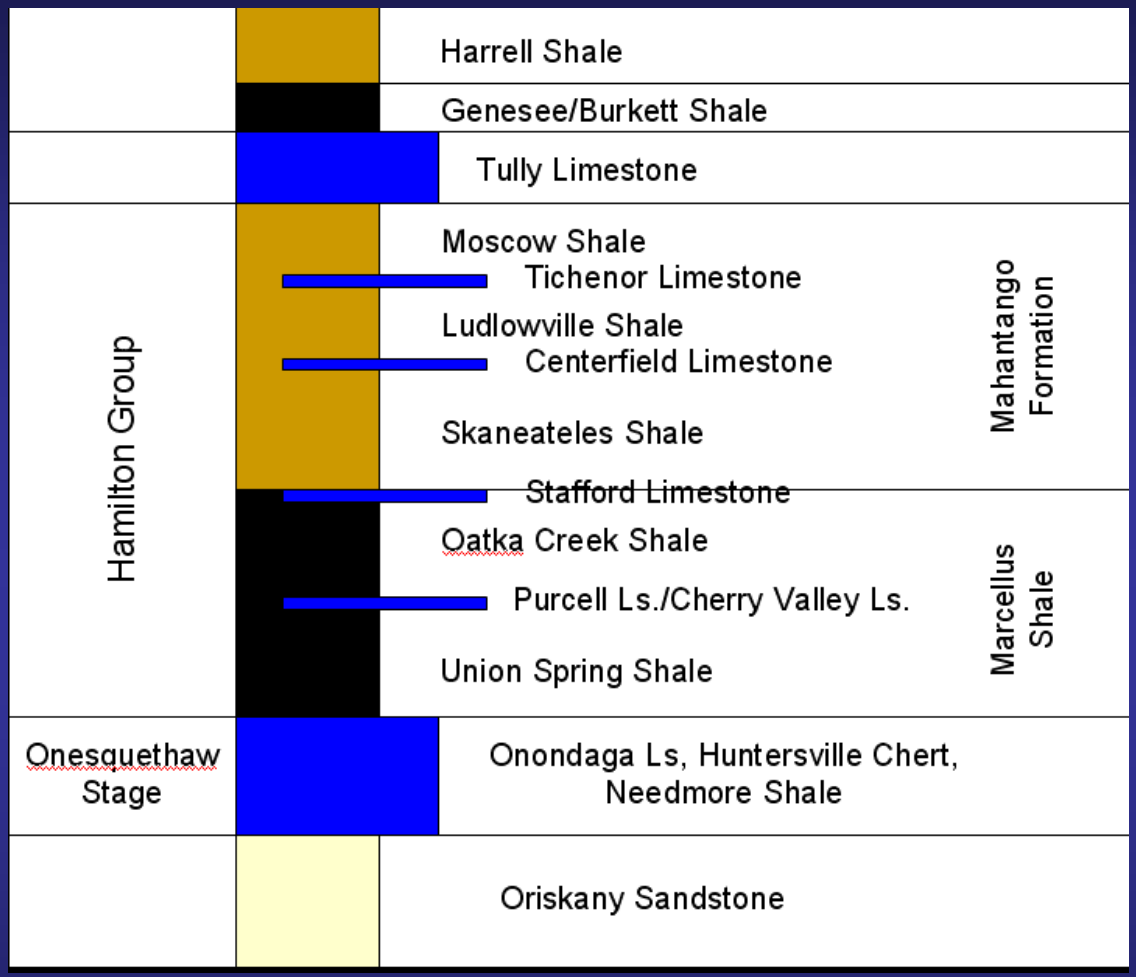
Lower Frac Boundary – Onesquethaw Stage Lithofacies Map
After Dennison 1961

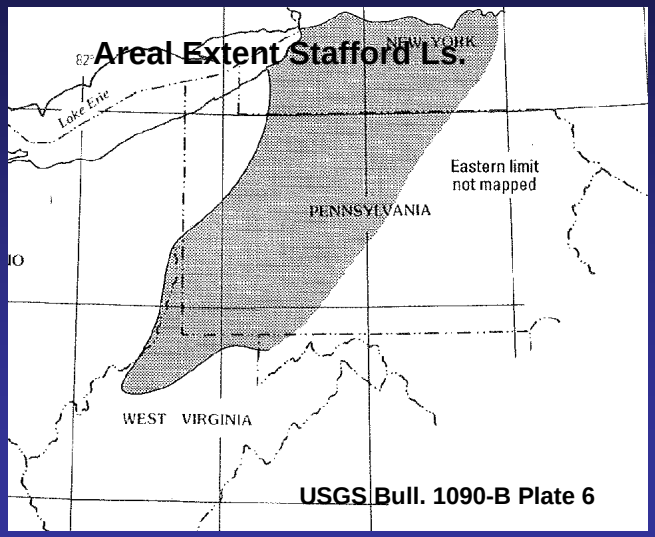


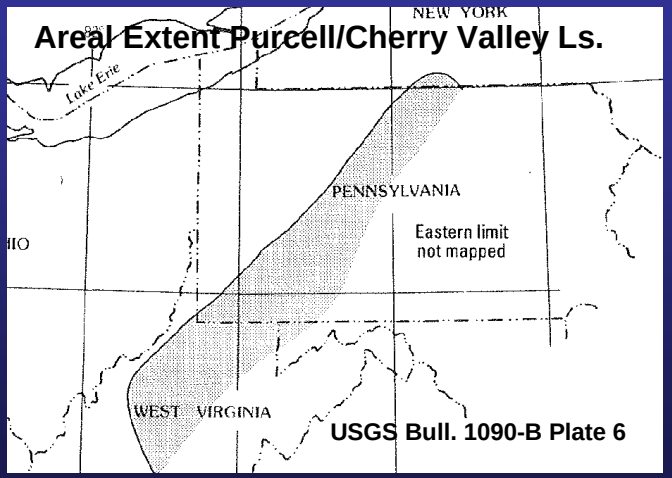
Wrightstone 2008

Texas Keystone INCORPORATED

Additional Possible Frac Boundaries







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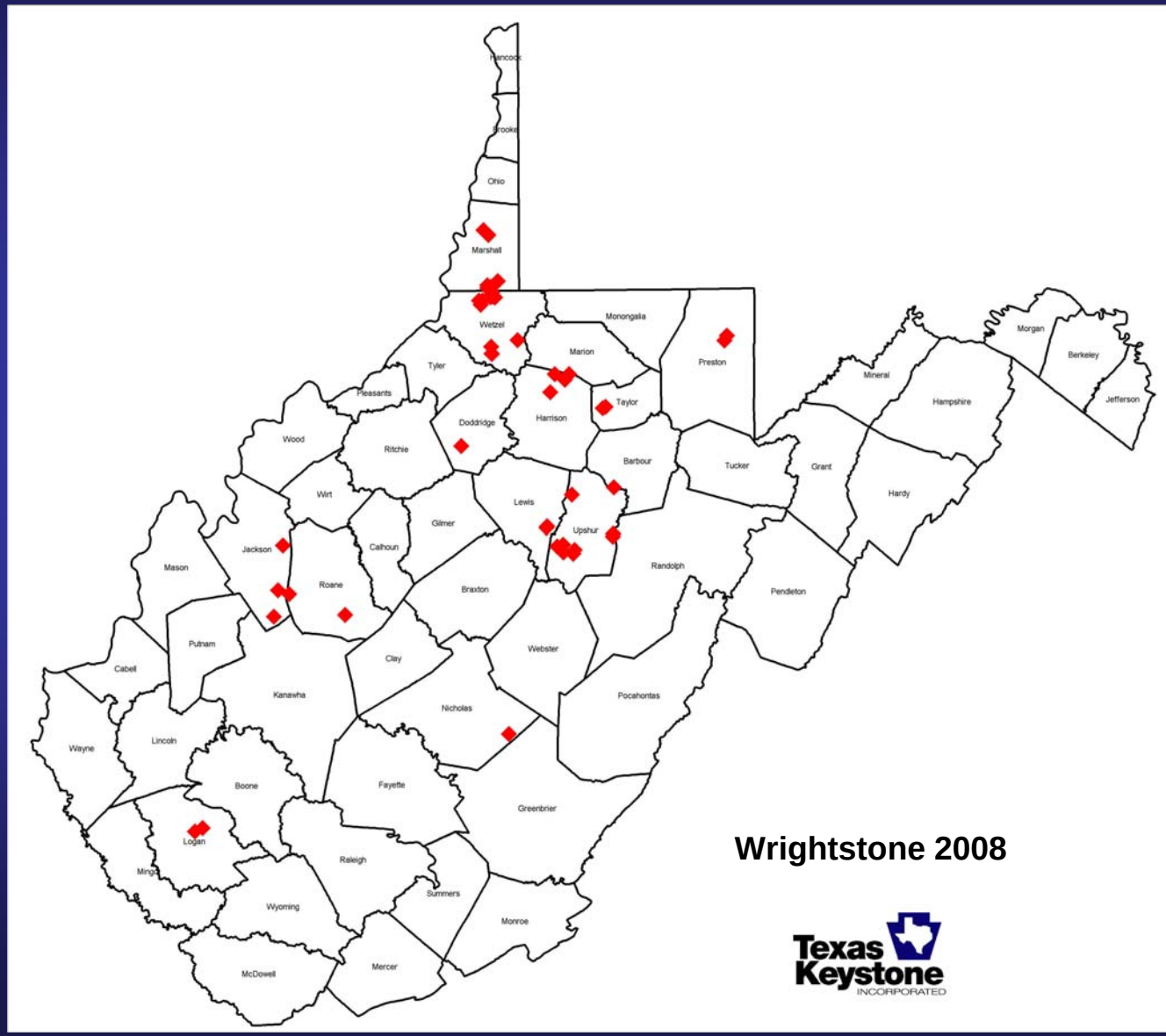
HORIZONTAL DRILLING

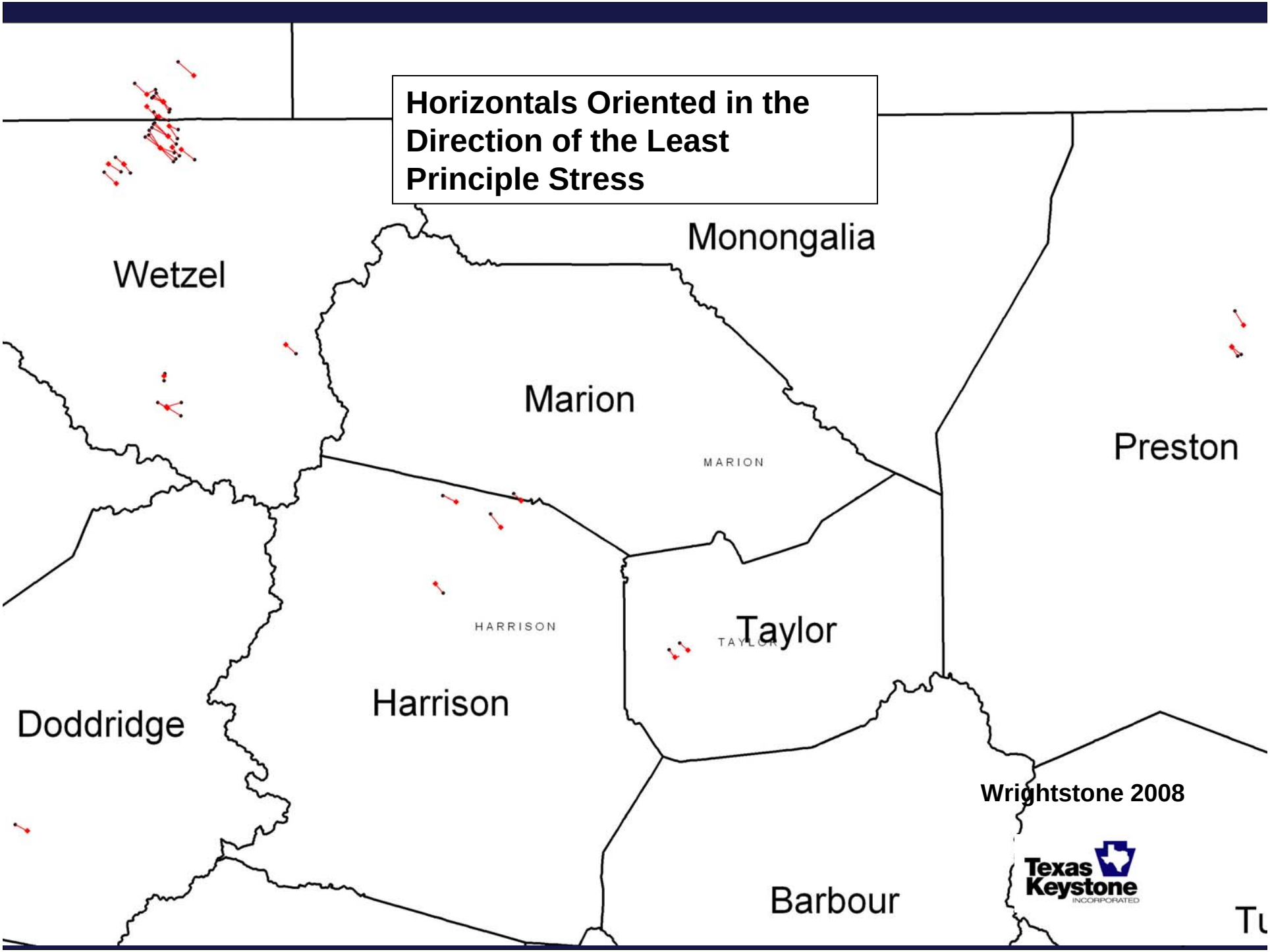
IN

WEST VIRGINIA

Dave Boyer 12/2007

71 Permitted Horizontal Marcellus Wells in WV (as of 2/1/09)




Horizontals Oriented in the Direction of the Least Principle Stress
Monongalia
Wetzel
Marion
MARION
Preston
HARRISON
Taylor
TAYLOR
Harrison
Doddridge
Barbour
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WEST VIRGINIA

MARCELLUS

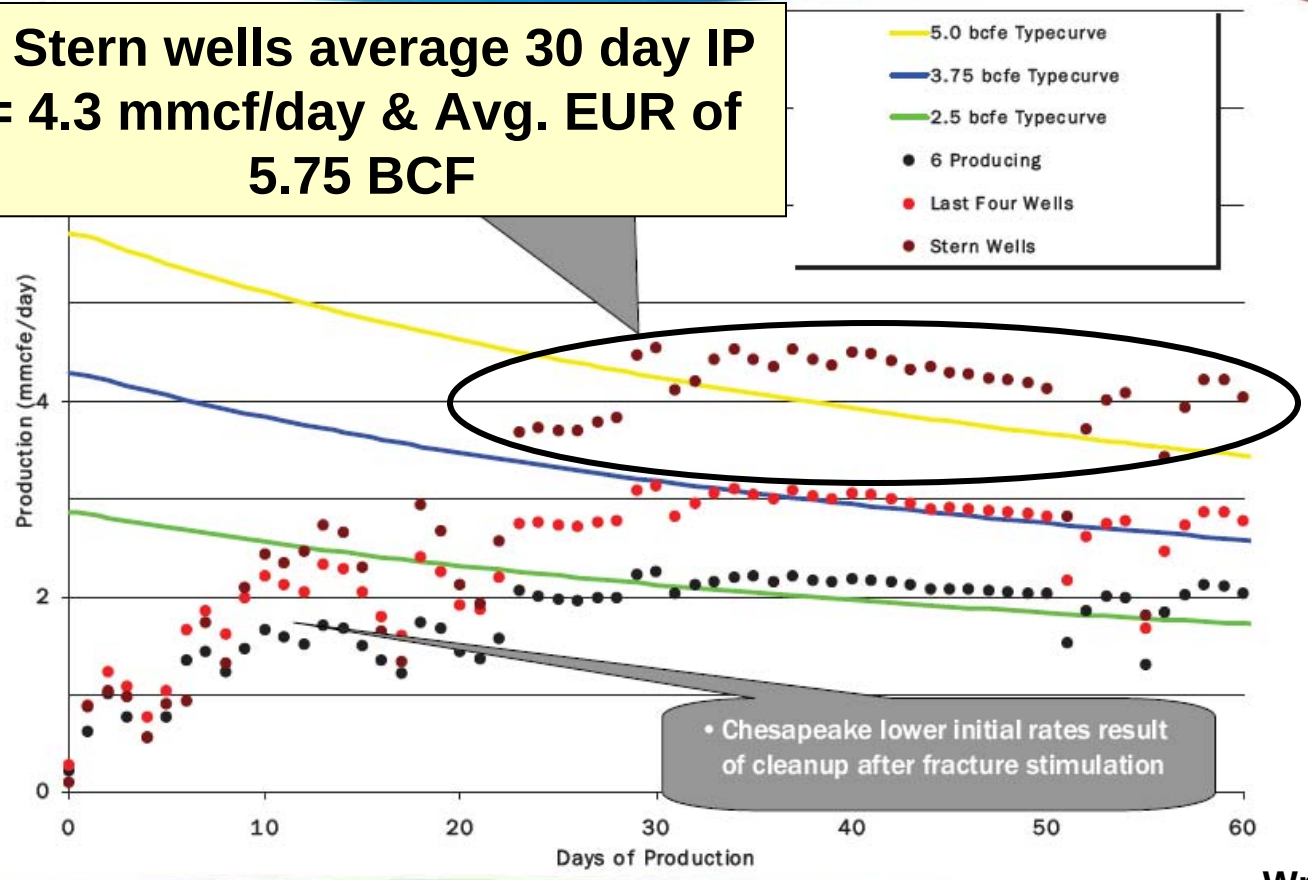
RESERVES & PRODUCTION

Dave Boyer 12/2007

2008 Investor and Analyst Meeting

Marcellus Shale – Horizontal Well Performance

2 Stern wells average 30 day IP = 4.3 mmcf/day & Avg. EUR of 5.75 BCF



Wrightstone 2008

Chesapeake ENERGY

• Risk disclosure regarding unproved reserve estimates appears on page ii of the meeting presentation package

Texas Keystone INCORPORATED

ON LINE: 11/2007
DEC '07: 66,893 MCF

WR-35

DATE: December 17, 2007
API #: 47-9703398

State of West Virginia
Division of Environmental Protection
Section of Oil and Gas

Well Operator's Report of Well Work

Farm name: BECKWITH LUMBER COMPANY Operator Well No.: 626349

LOCATION: Elevation: 2,114 Quadrangle: ROCK CAVE 7 1/2

District: BANKS County: UPSHUR

Latitude: 10,950 Feet South of 39 Deg. 50 Min. 00 Sec.
Longitude 9,200 Feet West of 80 Deg. 15 Min. 00 Sec.

Company: CHESAPEAKE APPALACHIA, L.L.C.

	Casing & Tubing	Used in Drilling	Left in well	Cement fill up Cu. Ft.
Address: Post Office Box 6070				
Charleston, WV 25362-0070				
Agent: Michael John				
Inspector: Craig Duckworth	16"	44'	44'	
Date Permit Issued: 05/24/2007	11 ¾"	170'	170'	Cts
Date Well Work Commenced: 09/30/2007	8 5/8"	975'	975'	215 sks
Date Well Work Completed: 11/15/2007	5 ½"	7285'	7285'	255 sks
Verbal Plugging:				
Date Permission granted on:				
Rotary XX Cable Rig				
Total Depth (feet): 7283				
Fresh Water depths (ft):				
Salt water depths (ft):				
Is coal being mined in area (Y/N)? NO				
Coal Depths (ft):				

RECEIVED
Office of Oil & Gas
JUL 10 2008
WV Department of
Environmental Protection

OPEN FLOW DATA

Producing formation Marcellus Pay zone depth (ft) 7154-7194 / 7198-7234

X Gas: Initial open flow ____ MCF/d Oil: Initial open flow ____ Bbl/d
Final open flow 1500 MCF/d Final open flow 4 Bbl/d
Time of open flow between initial and final tests ____ Hours
Static rock Pressure 2600 psig (surface pressure) after 72 Hours

Second producing formation ____ Pay zone depth (ft) ____
Gas: Initial open flow ____ MCF/d Oil: Initial open flow ____ Bbl/d
Final open flow ____ MCF/d Final open flow ____ Bbl/d
Time of open flow between initial and final tests ____ Hours
Static rock Pressure ____ psig (surface pressure) after ____ Hours

NOTE: ON BACK OF THIS FORM PUT THE FOLLOWING: 1). DETAILS OF PERFORATED INTERVALS, FRACTURING OR STIMULATING, PHYSICAL CHANGE, ETC. 2). THE WELL LOG WHICH IS A SYSTEMATIC DETAILED GEOLOGICAL RECORD OF ALL FORMATIONS, INCLUDING COAL ENCOUNTERED BY THE WELLBORE.

Signed: ____, Chesapeake Appalachia, L.L.C.
By: Mark Watkins, District Manager
Date: 7/09/08

upsh 03396

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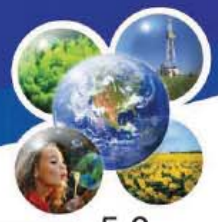
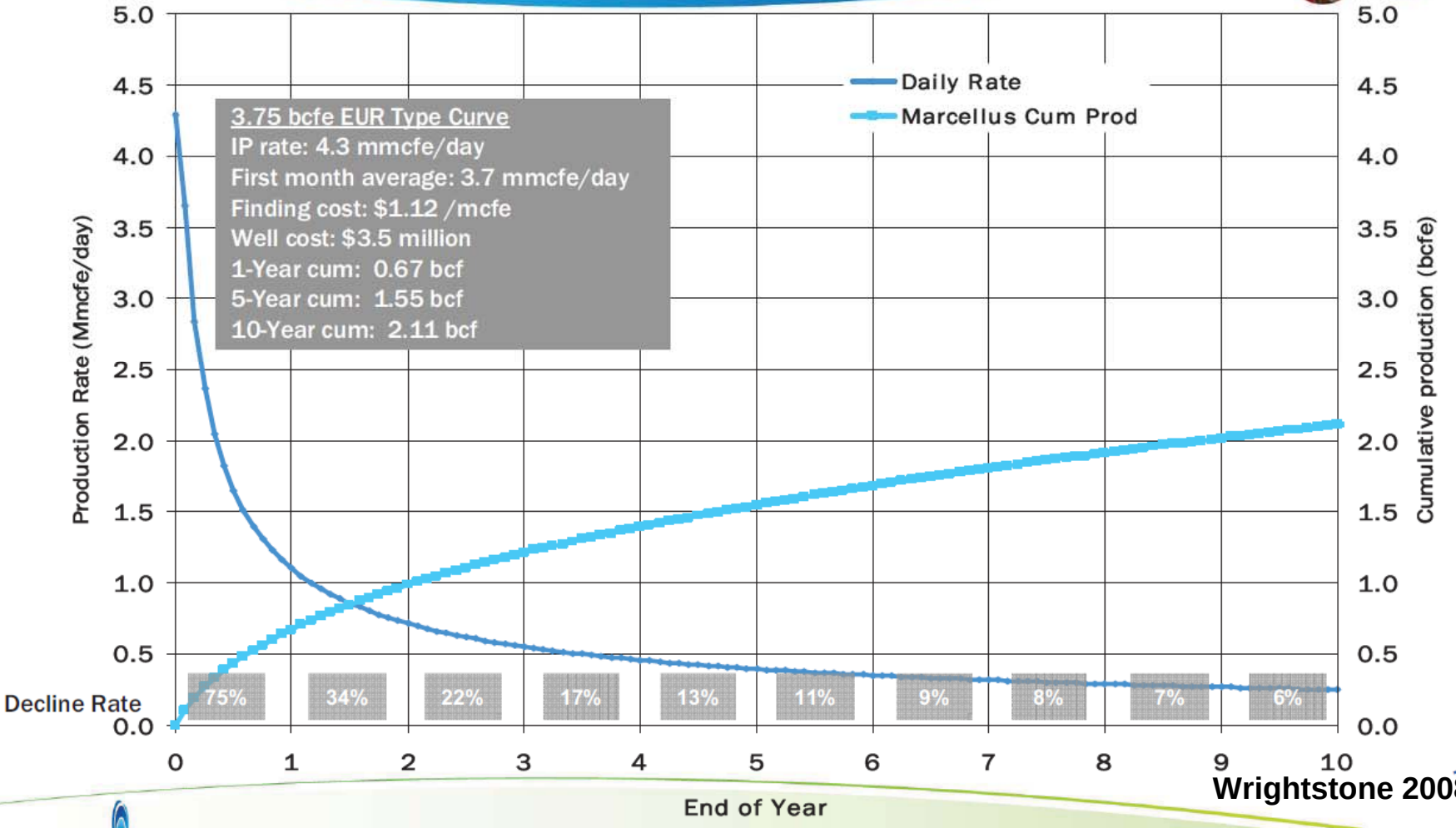
Marcellus Shale – Pro Forma Horizontal Well Profile





Wrightstone 2008

Chesapeake ENERGY

• Risk disclosure regarding unproved reserve estimates appears on page ii of the meeting presentation package

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Chesapeake Reserves - Boone, Lincoln & Logan Cos., WV

Before the WV OGCC 6/7/2007

EXAMINATION

BY CHAIRMAN LAY:

Q I only have one question. Do you have any quantitative number you can share with us with regards to the amount of reserves that are going to be left in the ground if we reduce the spacing requirements to three thousand to fifteen hundred feet or a thousand feet, for that matter, at your request?

A Pertaining to the Marcellus, right now, we don't know what the drainage area is per well. I mean, we're drilling on fifteen hundred feet. Our typical, recoverable reserves from the Marcellus alone, we estimate at about seventy-five million.

75 MMCF Chesapeake EUR

Triple Pressure Gradient

Double Depth of Production

Triple Thickness of Pay

Yields ~ 1.35 BCF/well

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QUESTIONS?

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