# Activity and Potential of the Utica Shale in Pennsylvania

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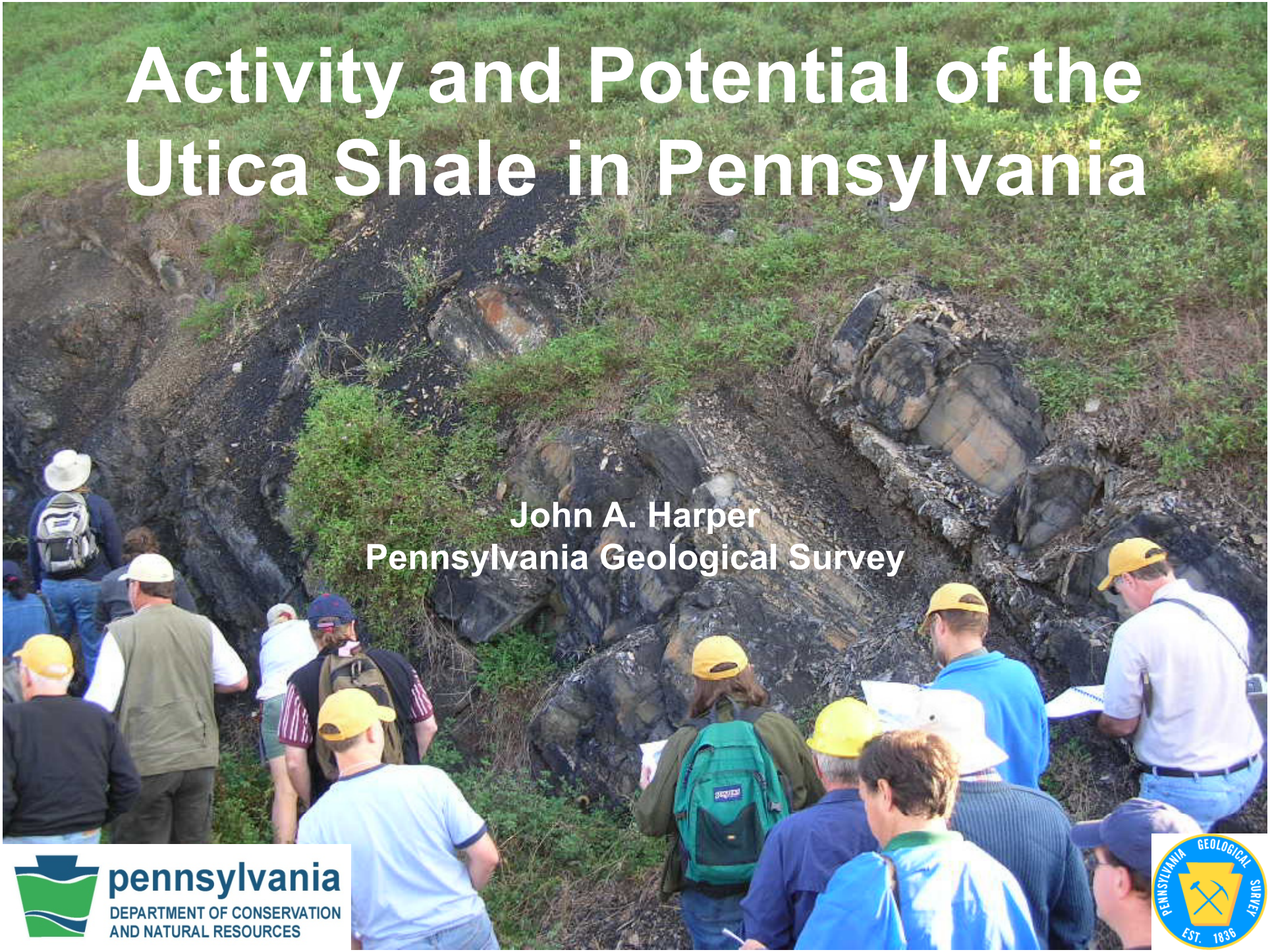
Pennsylvania Geological Survey



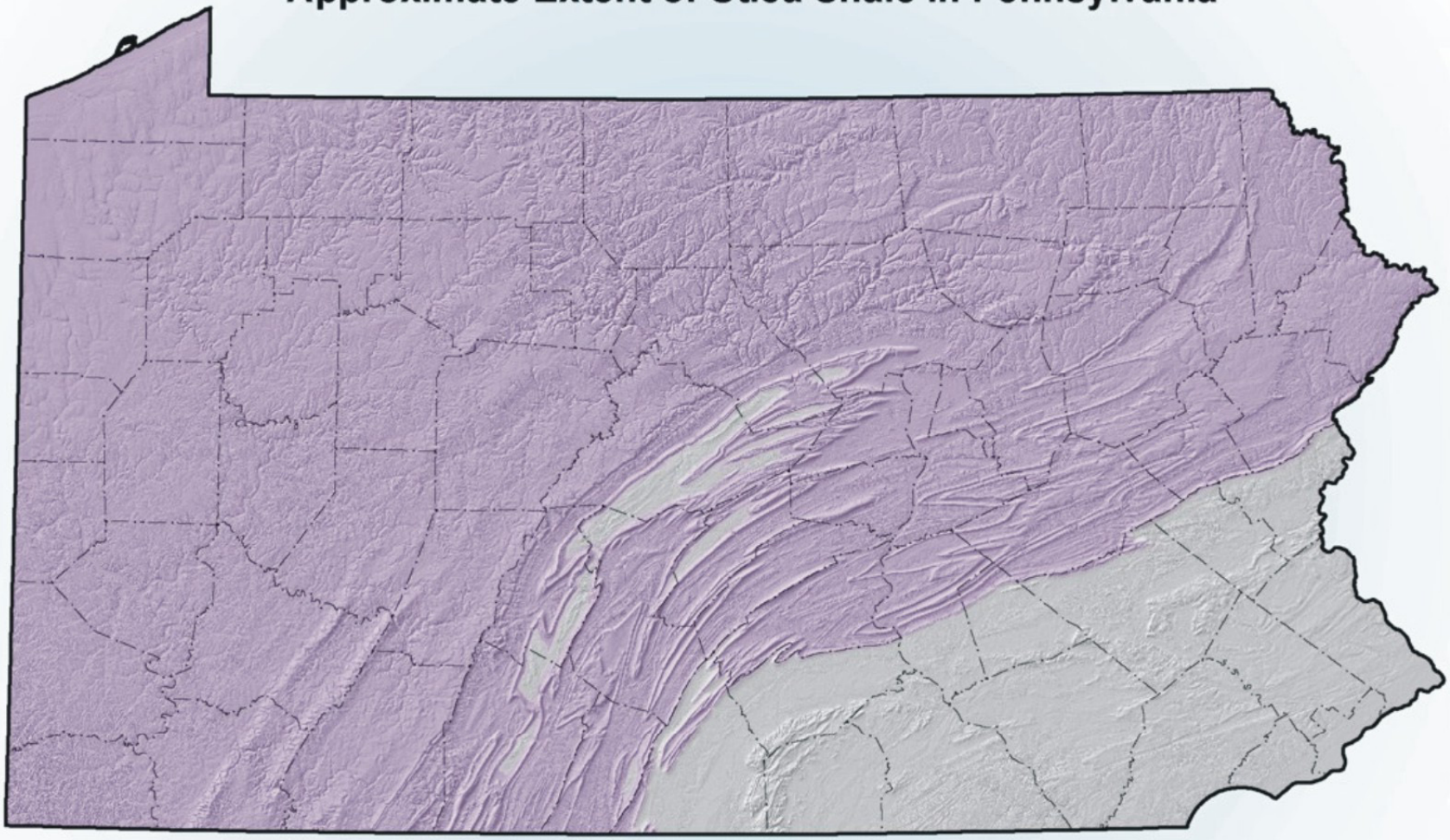
pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

PENNSYLVANIA GEOLOGICAL SURVEY EST. 1836

# THE UTICA SHALE PLAY IN THE APPALACHIAN BASIN

- The Utica Shale play extends from KY into WV, OH, PA, and NY, and even northward at least as far as Quebec
- The Utica and Point Pleasant formations produce liquids in eastern OH and may have the potential to do so in KY and WV as well
- The Utica and Point Pleasant formations have the potential to produce gas in all five states
- Recent well results in PA are very promising
- This is an emerging play, so much needs to be done to reduce geologic risk and help better understand this complex reservoir interval

# Approximate Extent of Utica Shale in Pennsylvania



Utica Shale occurs
in subsurface or outcrop

April 5, 2011

N
W E
S

0 50
Miles

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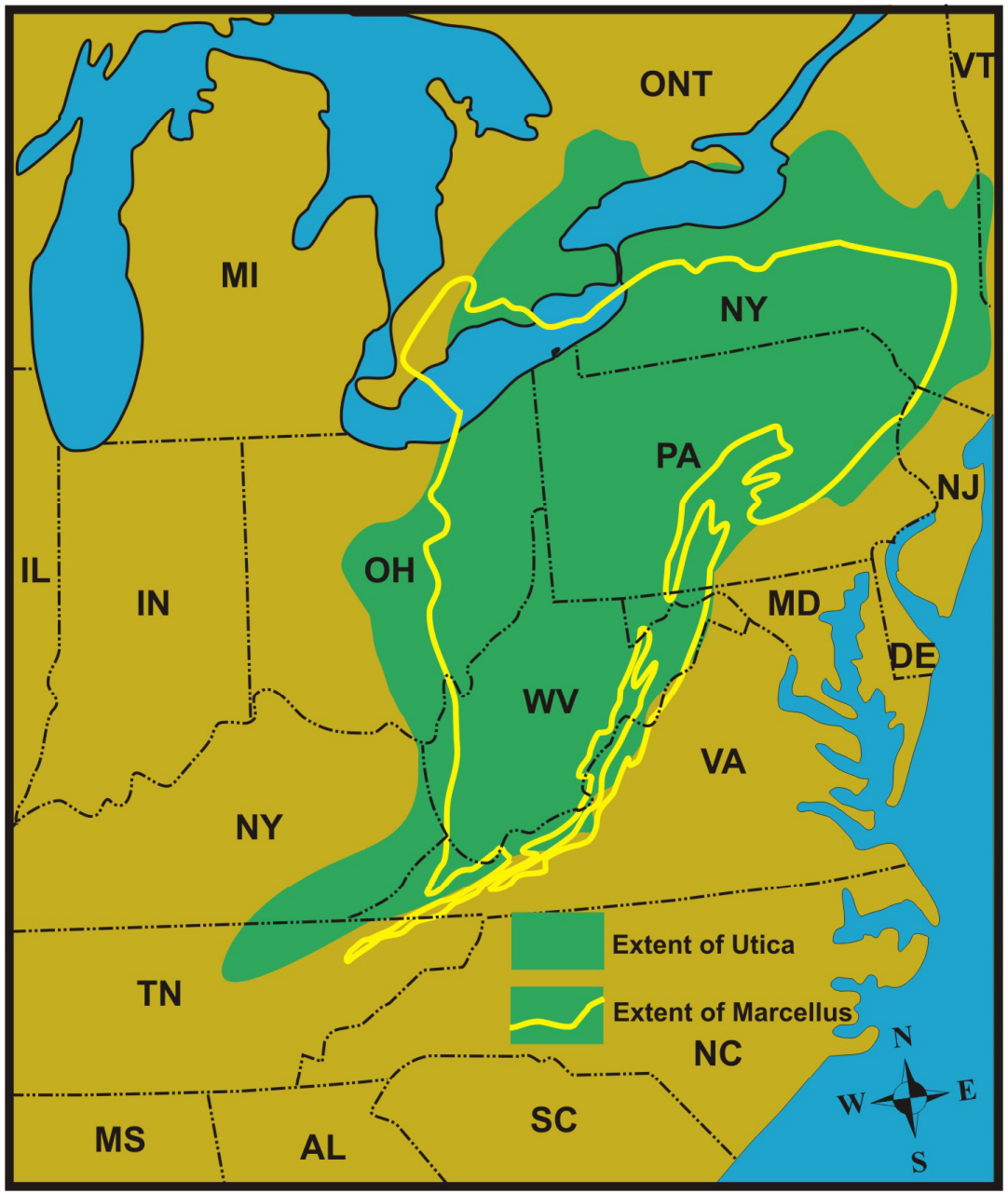
PaGS, 2011b

UTICA SHALE IN OUTCROP,
CENTRAL PENNSYLVANIA
TRENTON
UTICA
M.P.H.




# EXTENT OF THE UTICA SHALE GAS PLAY

Although the Utica Shale has less total organic carbon (TOC) than the Marcellus shale, the area of the play is larger.

Modified from Geology.com, 2011

# THE "UTICA SHALE" PLAY IS A MISNOMER

- Taury Smith (NY State Geological Survey) says the Utica Shale play is more appropriately called the "*Utica Shale and associated organic-rich calcareous shale and interbedded limestone and shale play*"
- Throughout their interval, the organic-rich strata of the Utica play are both time-equivalent to and younger than the Trenton Limestone
- Some Utica shale is organic-rich, but much of it appears to be non-organic rich gray shale
- It appears that the underlying Point Pleasant Formation might have higher organic-richness and, therefore, be a higher-potential target than the Utica Shale proper

**Utica Shale**
(Indian Castle of New York)

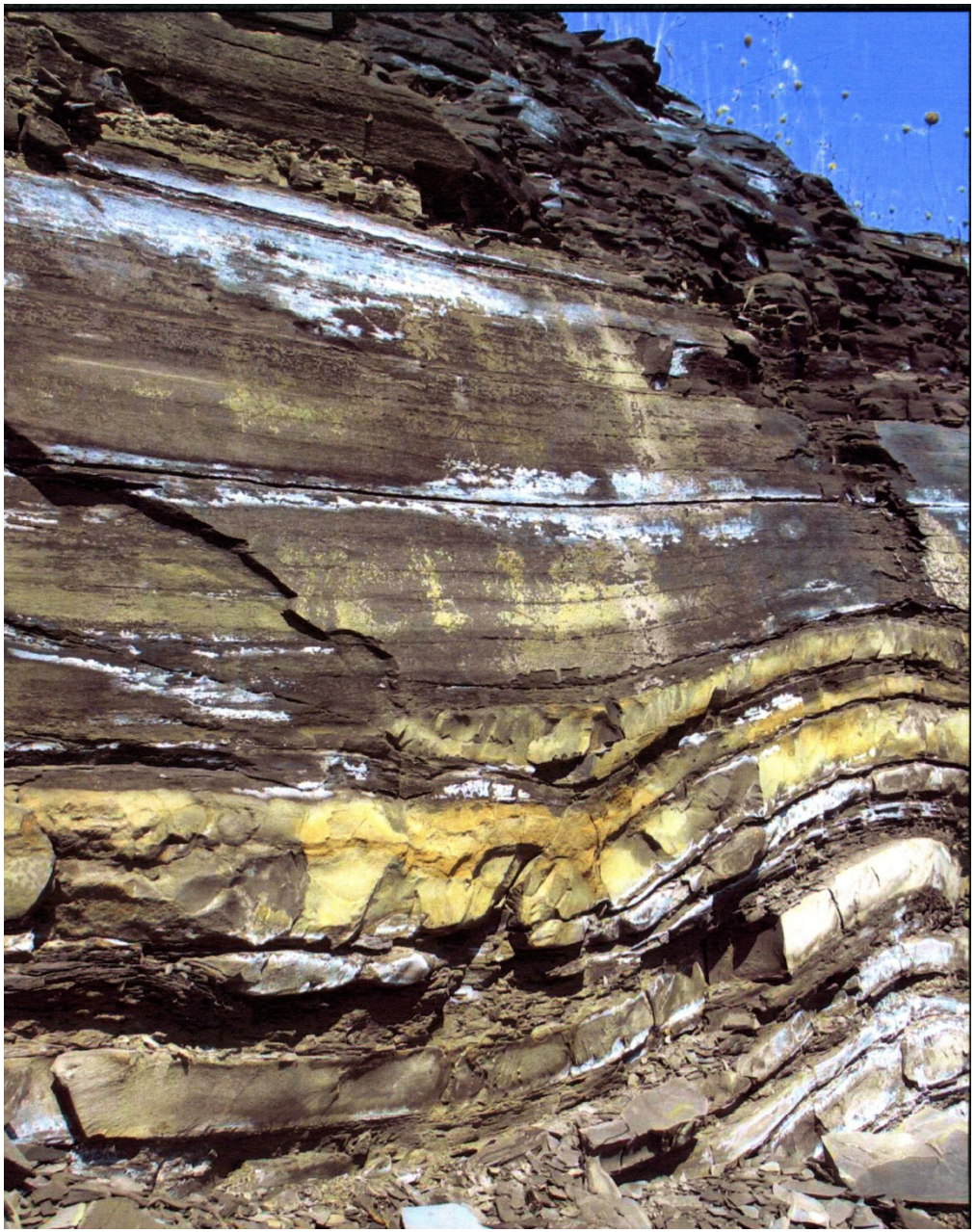
**Very little carbonate**

**TOC 1 – 3%**

**Upper Trenton Limestone**
(Dolgeville of New York)

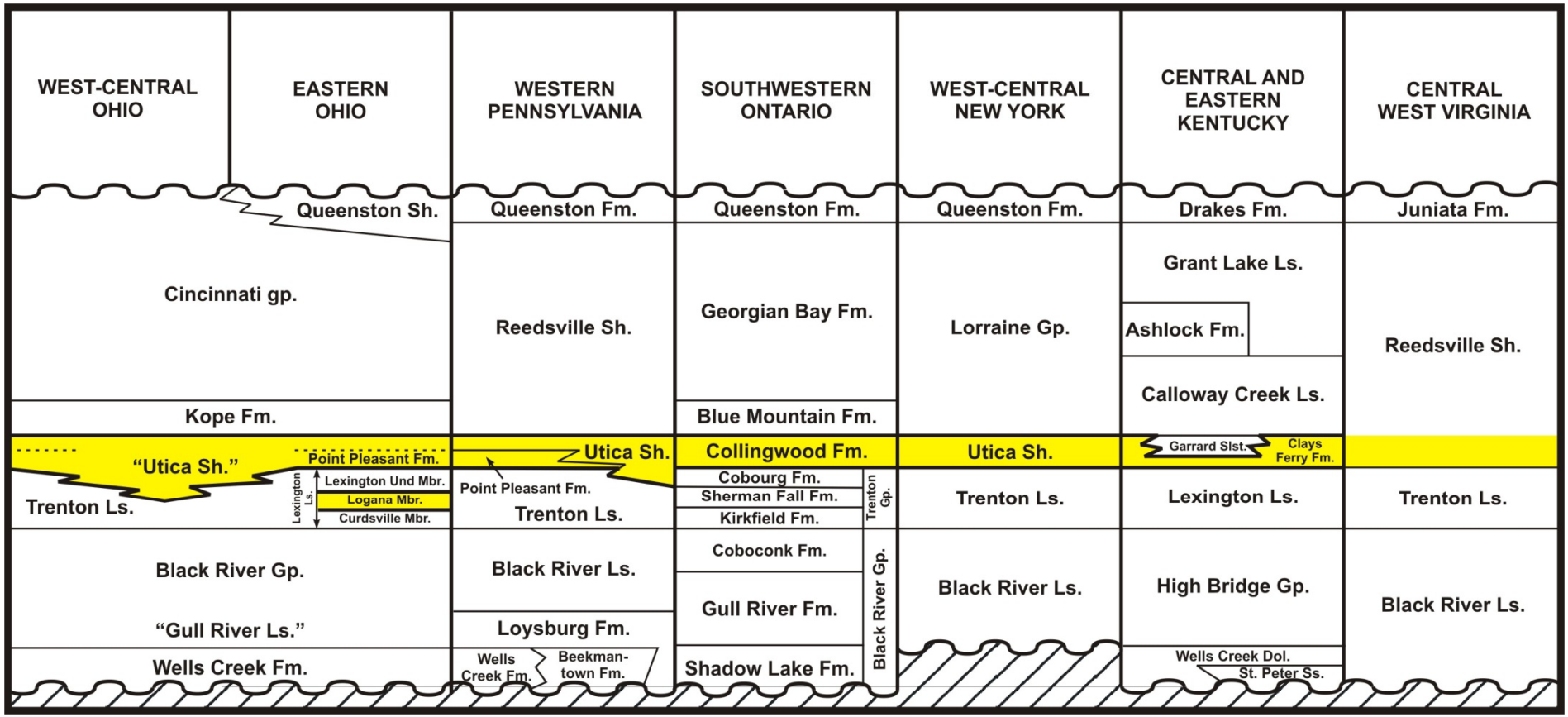
**Limestone and shale**

**Shale TOC up to 3%**



Modified from Smith, 2011

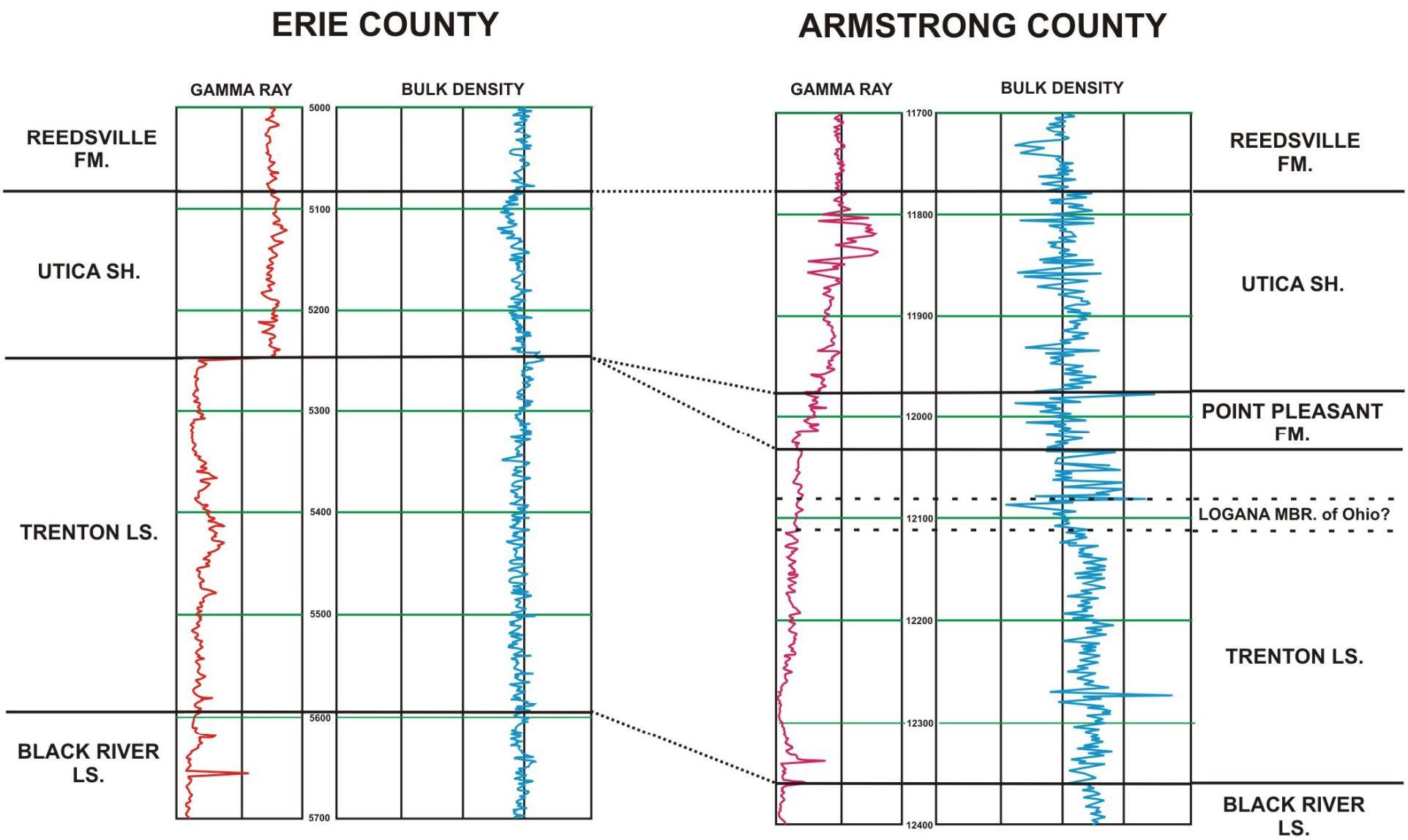
# CORRELATION OF UTICA PLAY STRATA IN THE APPALACHIAN BASIN



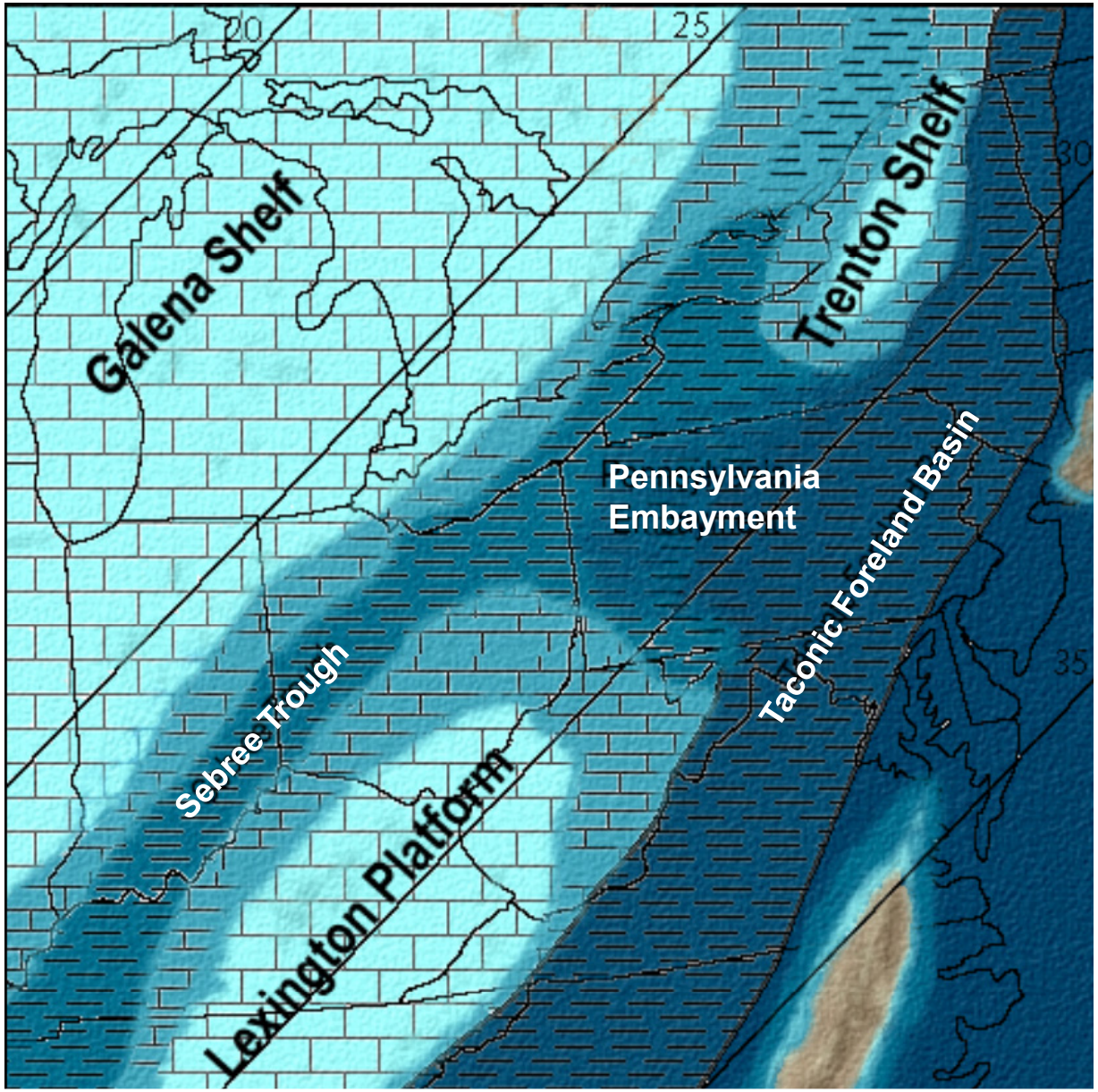

The Utica play involves more than just the Utica Shale. The Point Pleasant Formation and Logana Member of the Lexington Limestone provide additional target potential.

Modified from Patchen and others, 2008

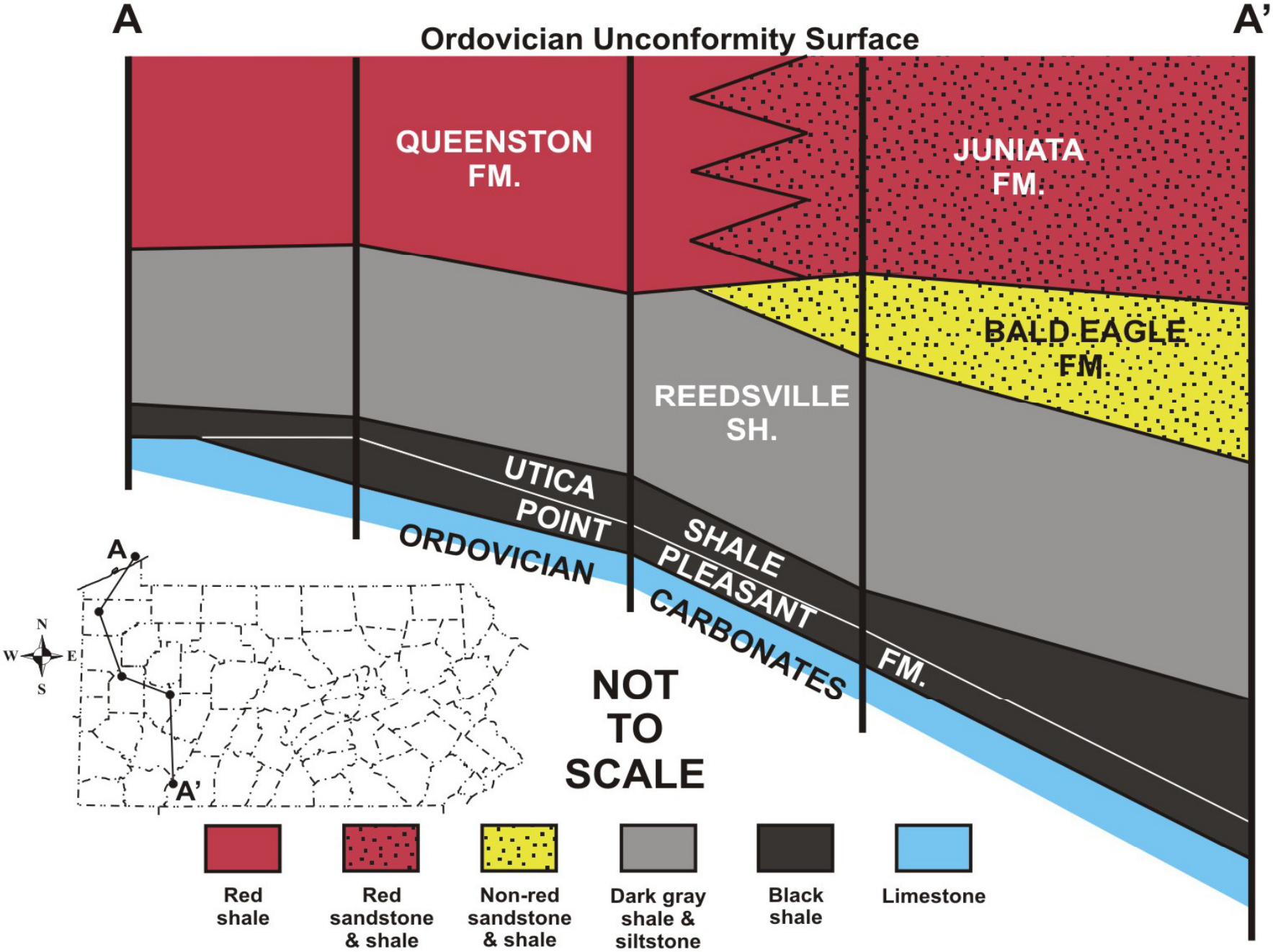
# COMPARISON OF UTICA TO UTICA/POINT PLEASANT IN PENNSYLVANIA

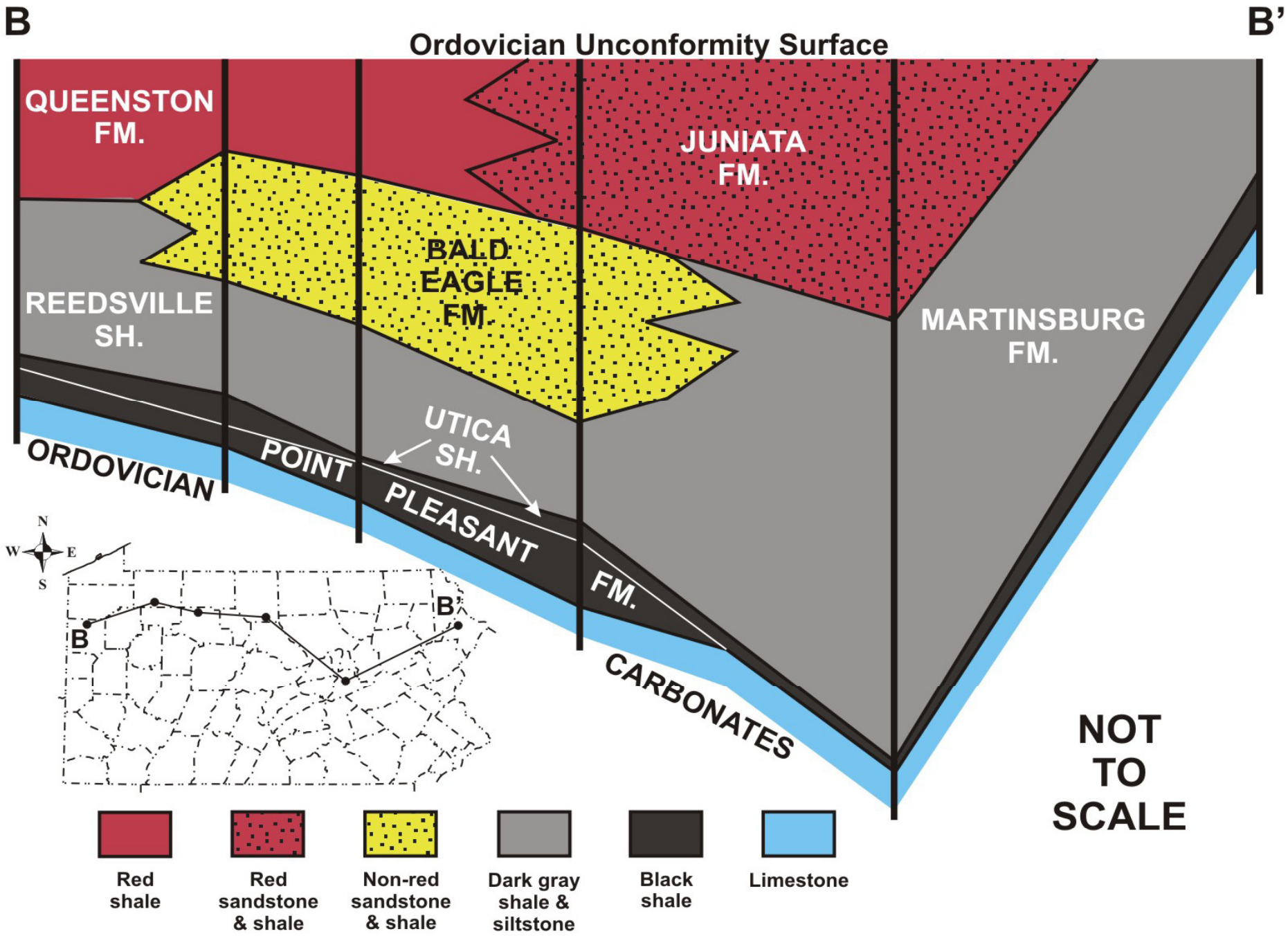


# BASIN PALEOGEOGRAPHY DURING TRENTON-UTICA DEPOSITION

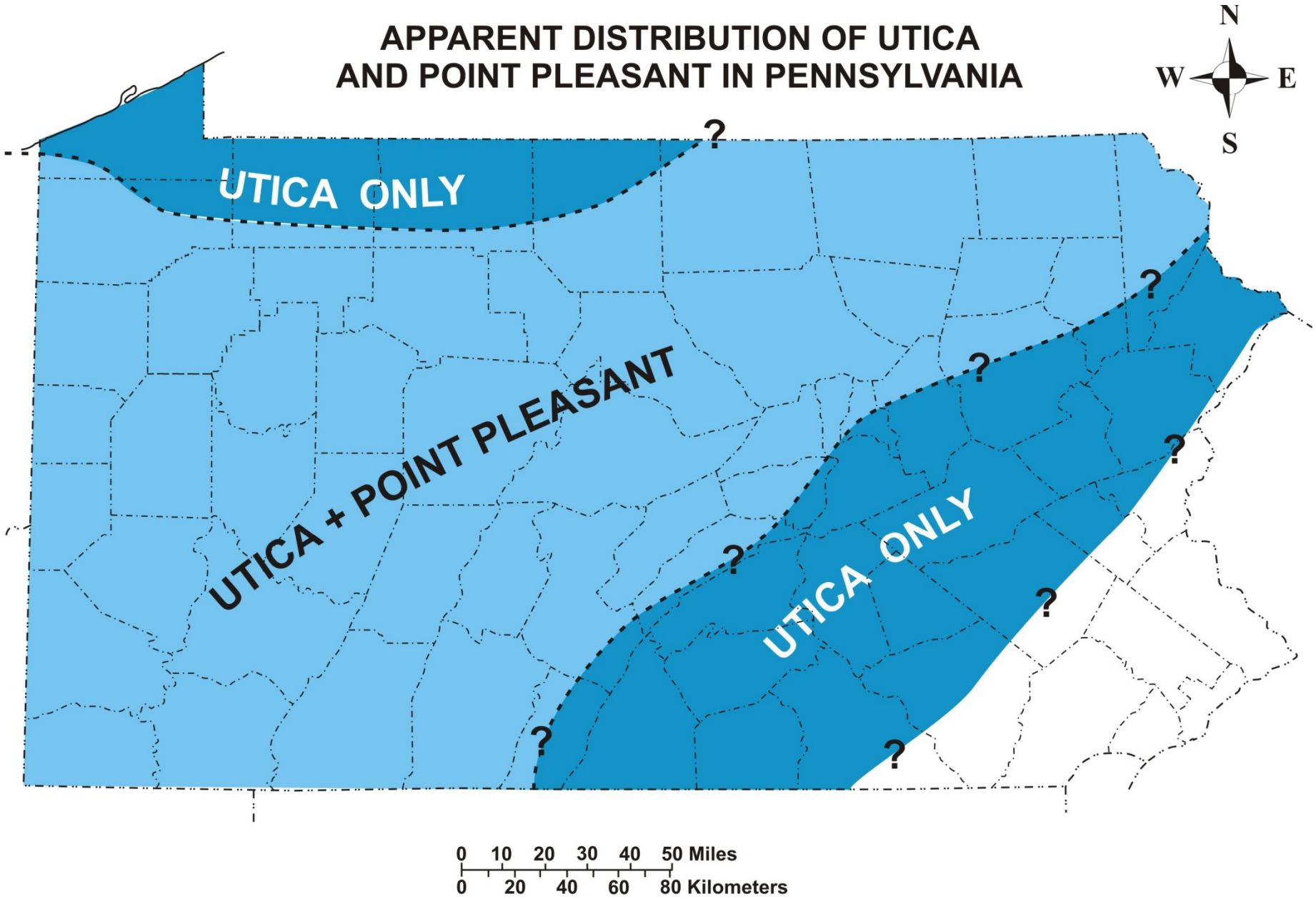



Modified from Wickstrom and others, 1992


A
A'
Ordovician Unconformity Surface
QUEENSTON FM.
JUNIATA FM.
BALD EAGLE FM.
REEDSVILLE SH.
UTICA POINT
ORDOVICIAN
SHALE
PLEASANT
CARBONATES
FM.
NOT TO SCALE
N
W
E
S
Red shale
Red sandstone & shale
Non-red sandstone & shale
Dark gray shale & siltstone
Black shale
Limestone


B
B'
Ordovician Unconformity Surface
QUEENSTON FM.
JUNIATA FM.
BALD EAGLE FM.
REEDSVILLE SH.
MARTINSBURG FM.
UTICA SH.
ORDOVICIAN
POINT
PLEASANT
FM.
CARBONATES
N
W
E
S
B
B'
NOT TO SCALE
Red shale
Red sandstone & shale
Non-red sandstone & shale
Dark gray shale & siltstone
Black shale
Limestone

# APPARENT DISTRIBUTION OF UTICA AND POINT PLEASANT IN PENNSYLVANIA

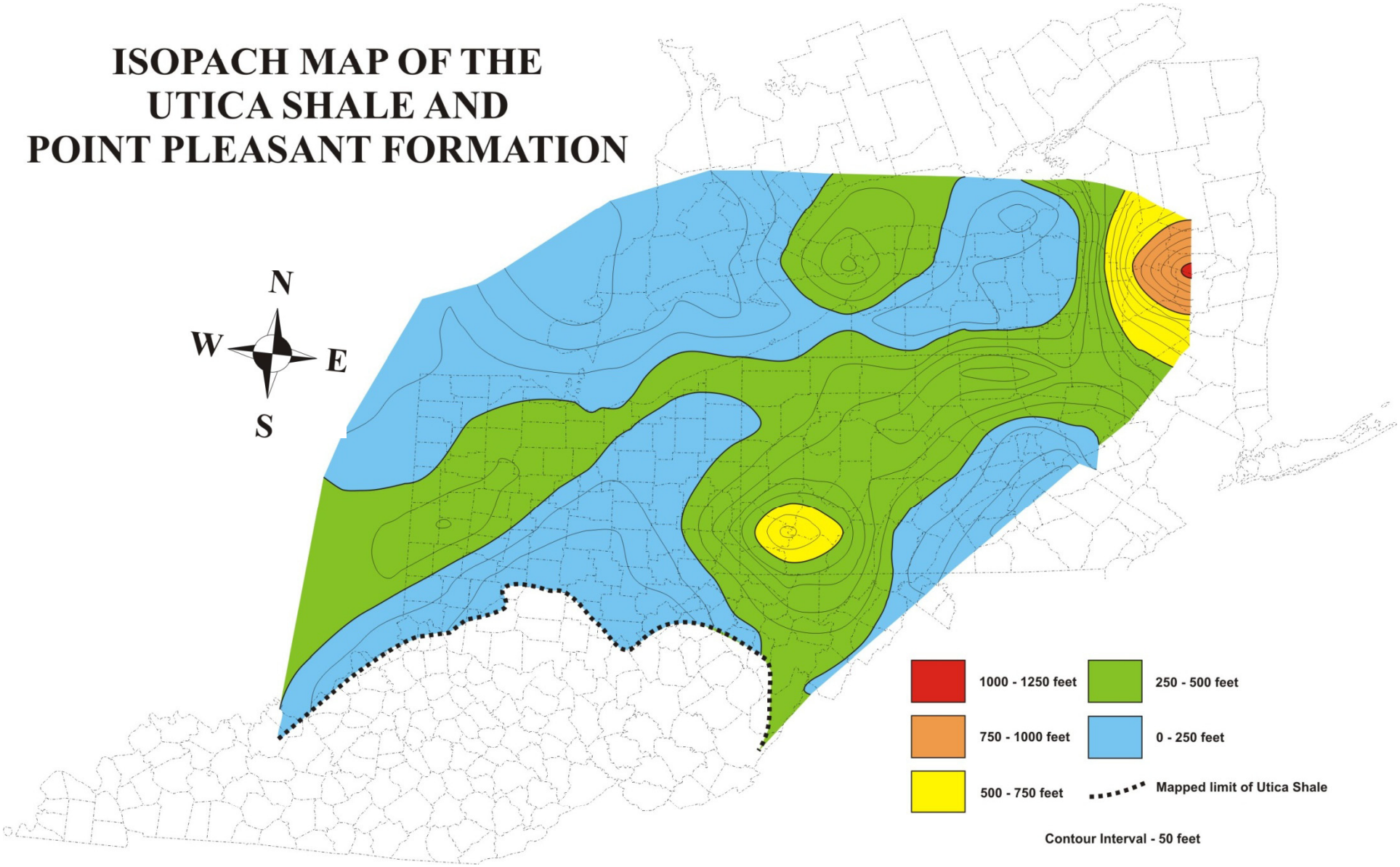


HOW THICK?

HOW DEEP?

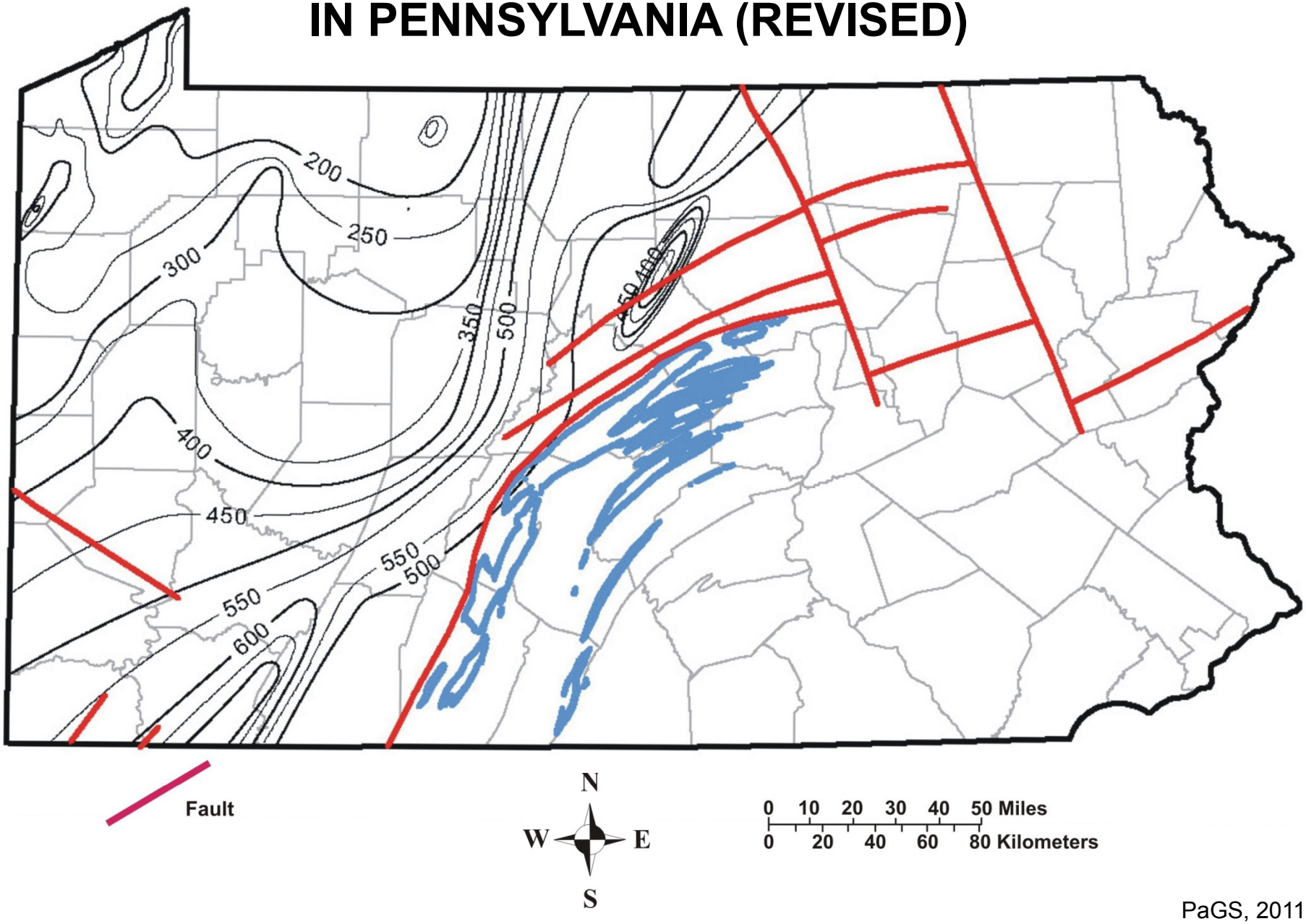
STRUCTURAL CONTROLS?

# ISOPACH MAP OF THE UTICA SHALE AND POINT PLEASANT FORMATION




Modified from Patchen and others, 2008

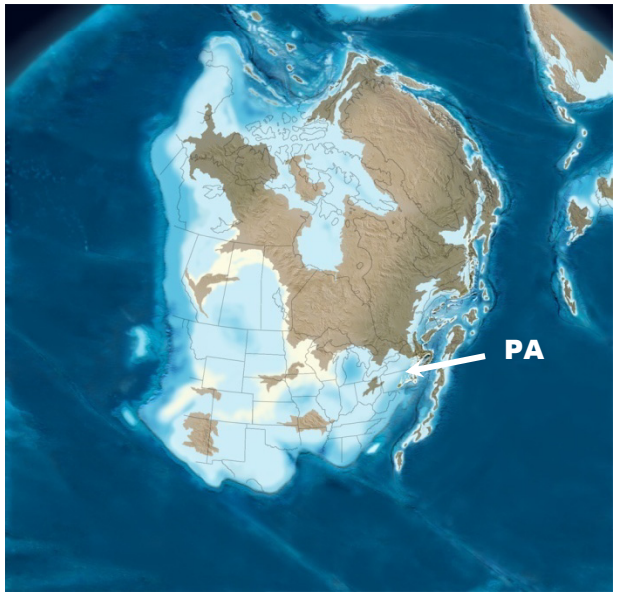
# ISOPACH MAP OF THE UTICA/POINT PLEASANT IN PENNSYLVANIA (REVISED)



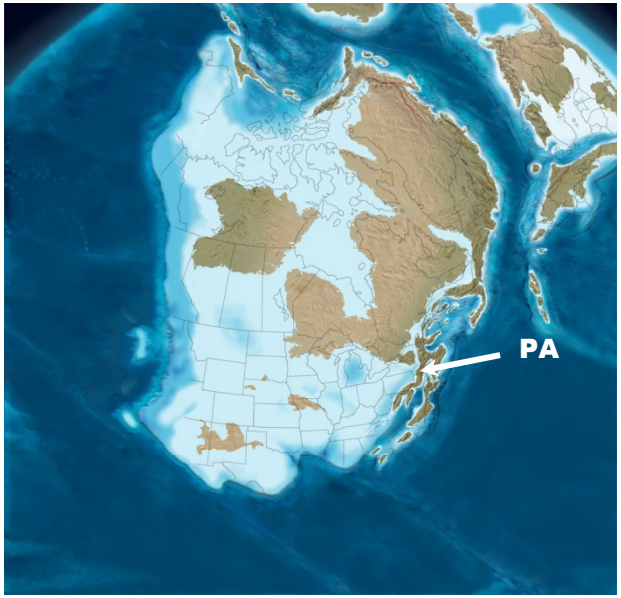

PaGS, 2011a

# THE UTICA SHALE WAS DEPOSITED DURING THE TACONIC OROGENY IN THE LATE ORDOVICIAN

Early Ordovician

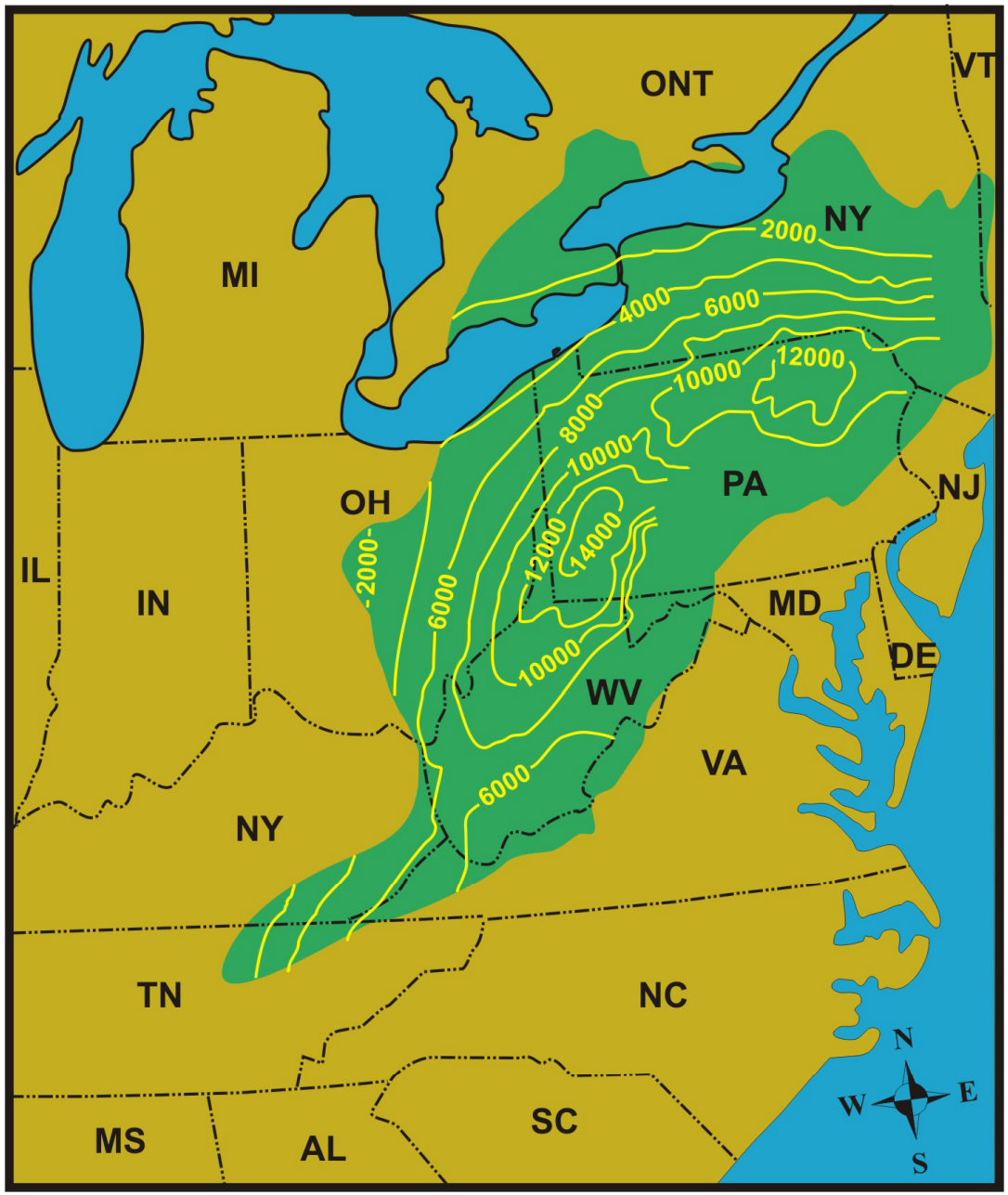



Middle Ordovician




Late Ordovician

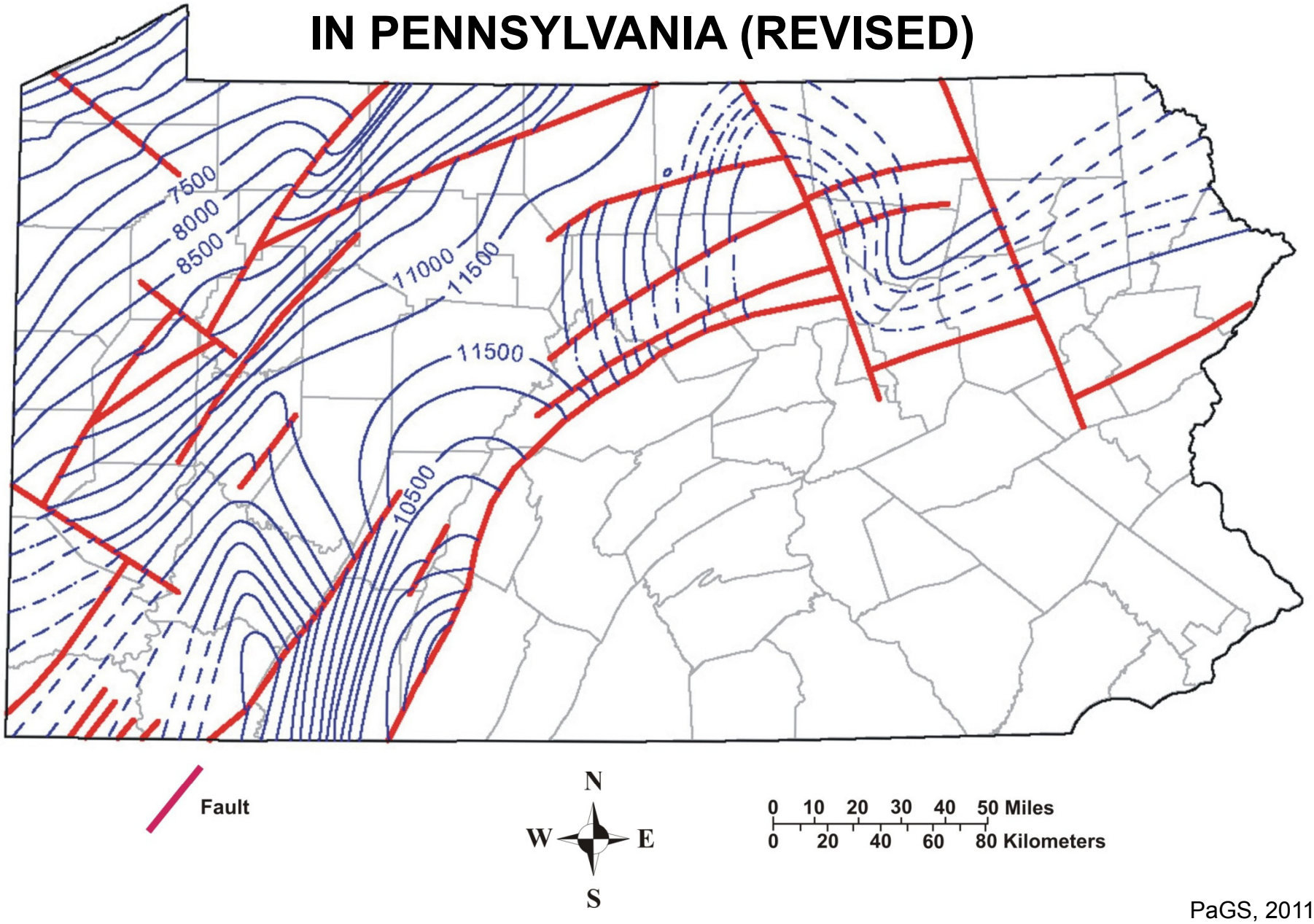
From Blakey, 2011




# SUBSEA ELEVATION OF THE BASE OF THE UTICA/POINT PLEASANT INTERVAL

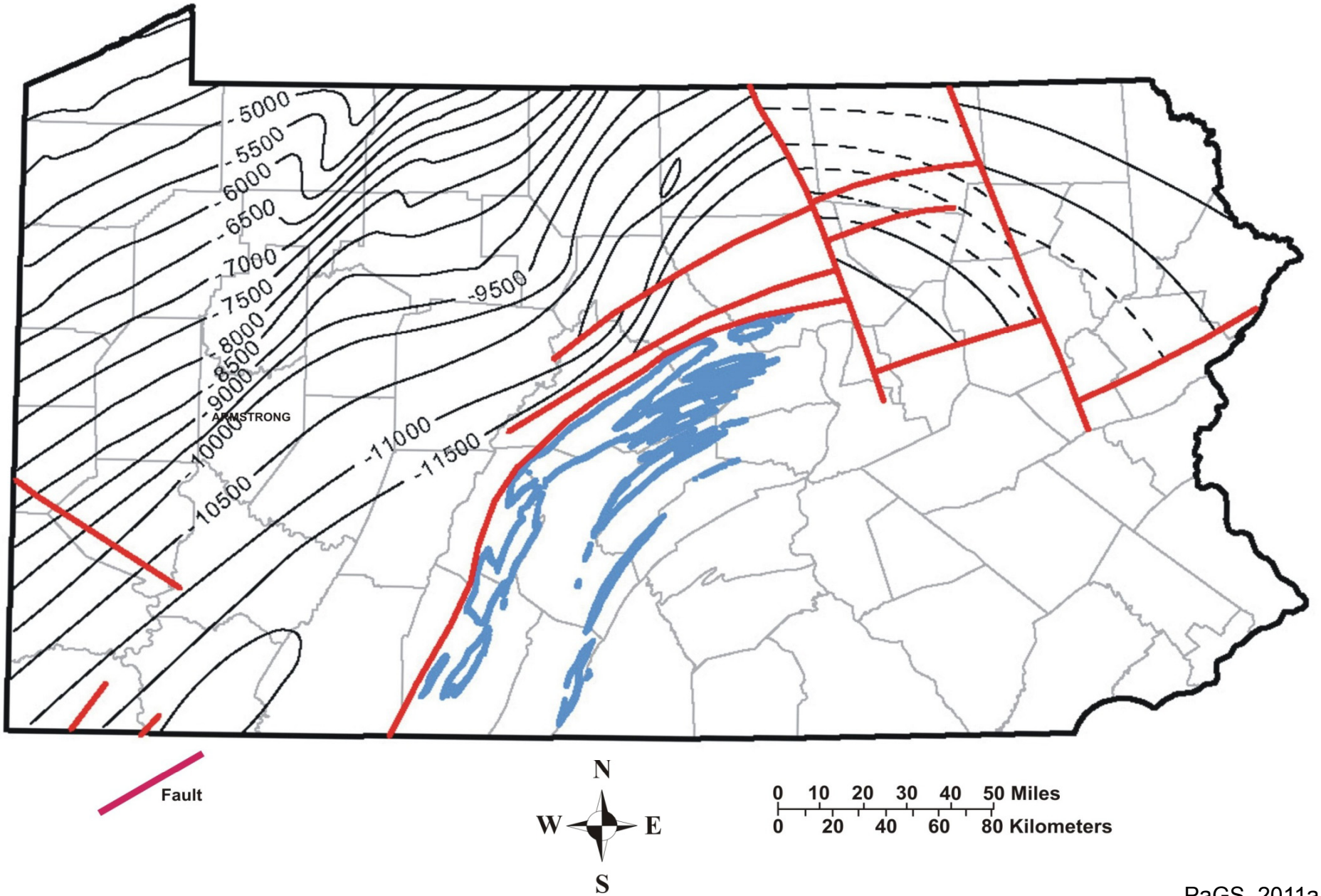
Modified from Geology.com, 2011, based on Patchen and others, 2008

# DRILLING DEPTH TO THE BASE OF THE UTICA/POINT PLEASANT IN PENNSYLVANIA (REVISED)




PaGS, 2011a

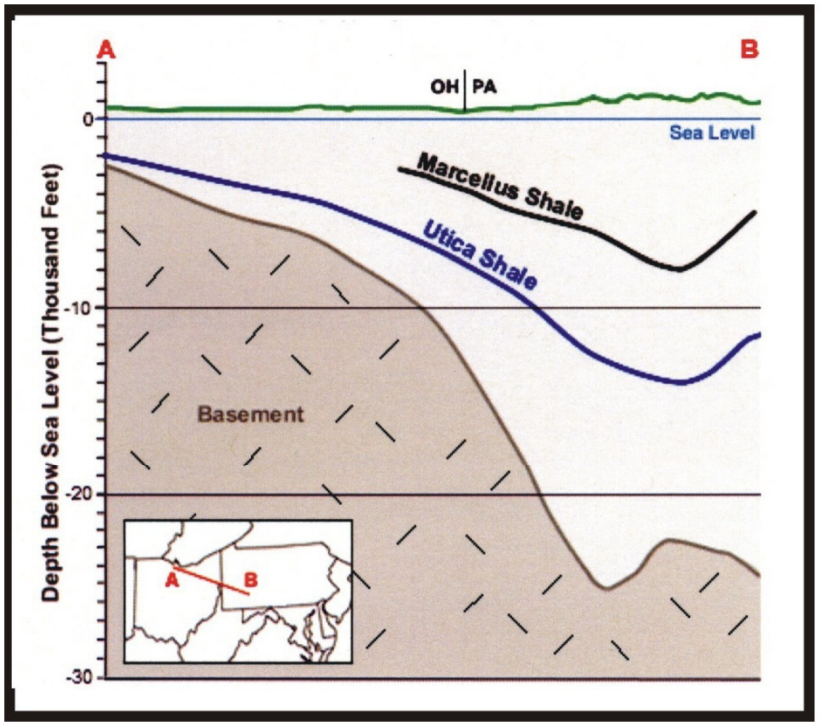
# STRUCTURE ON TOP OF THE UTICA SHALE (REVISED)

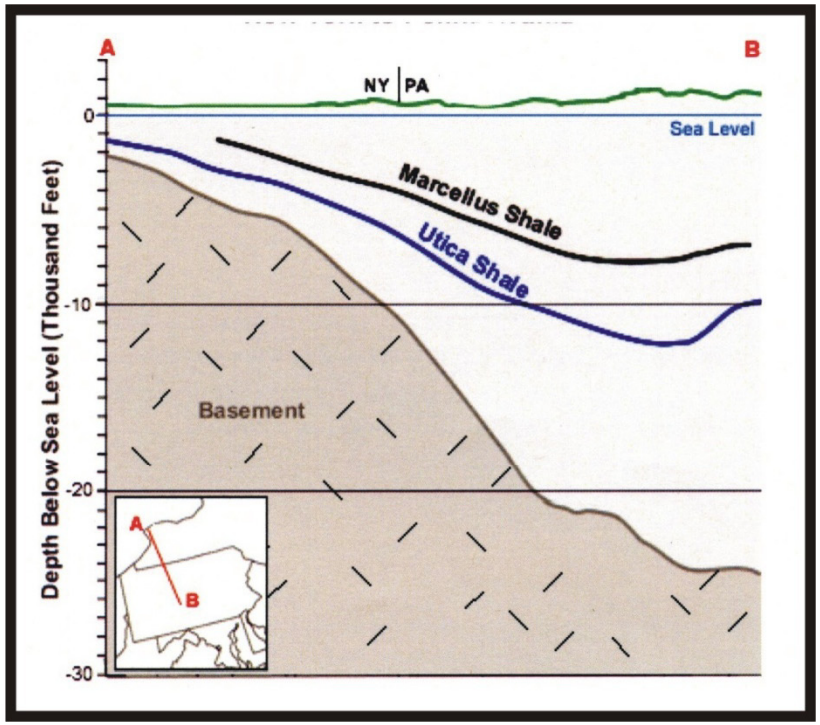



PaGS, 2011a

# SIMPLE CROSS SECTIONS, BASEMENT TO SURFACE

**Based on seismic data**

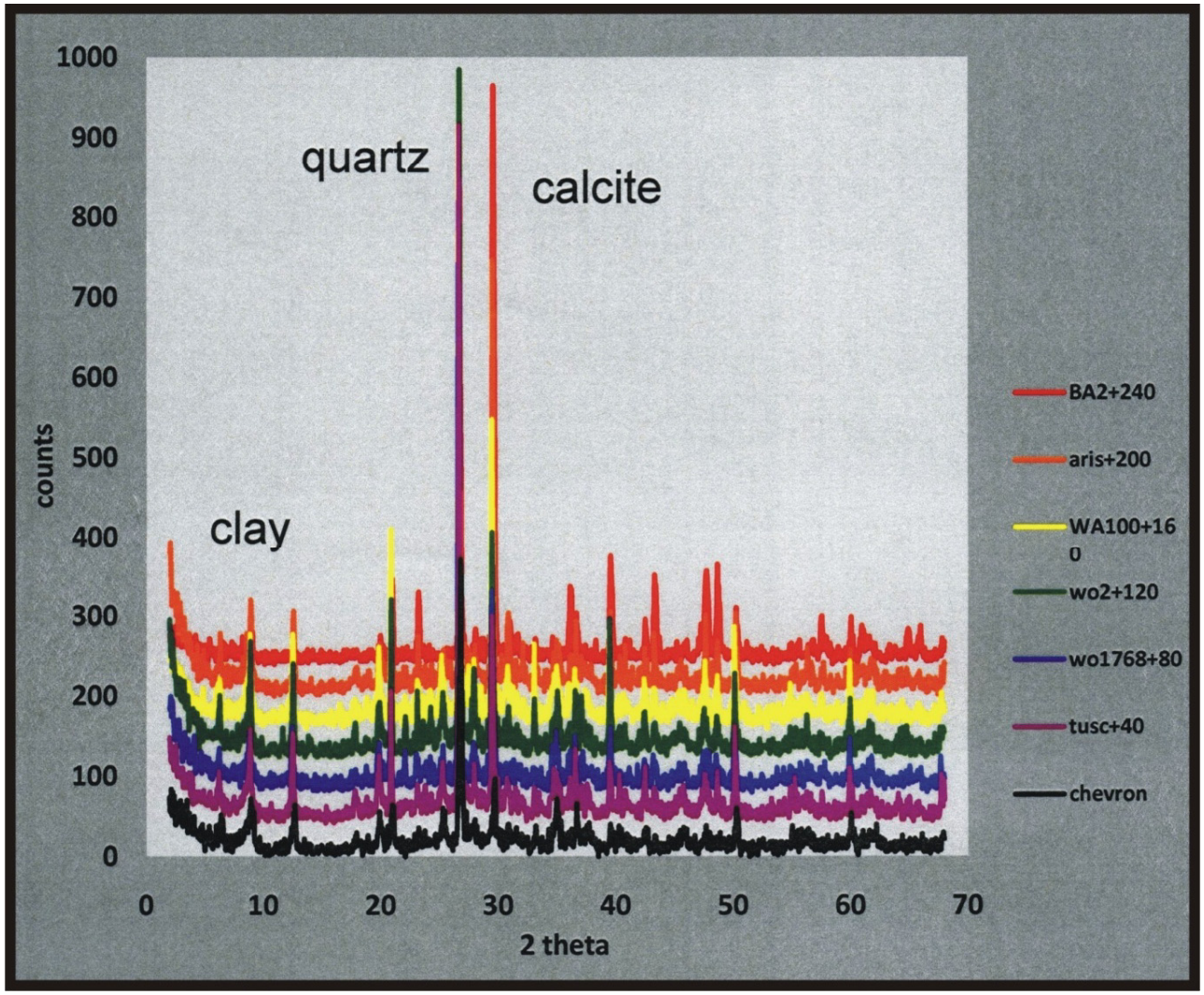



Modified from Geology.com, 2011, based on Ryder, 2008

# MINERALOGY AND PETROGRAPHY

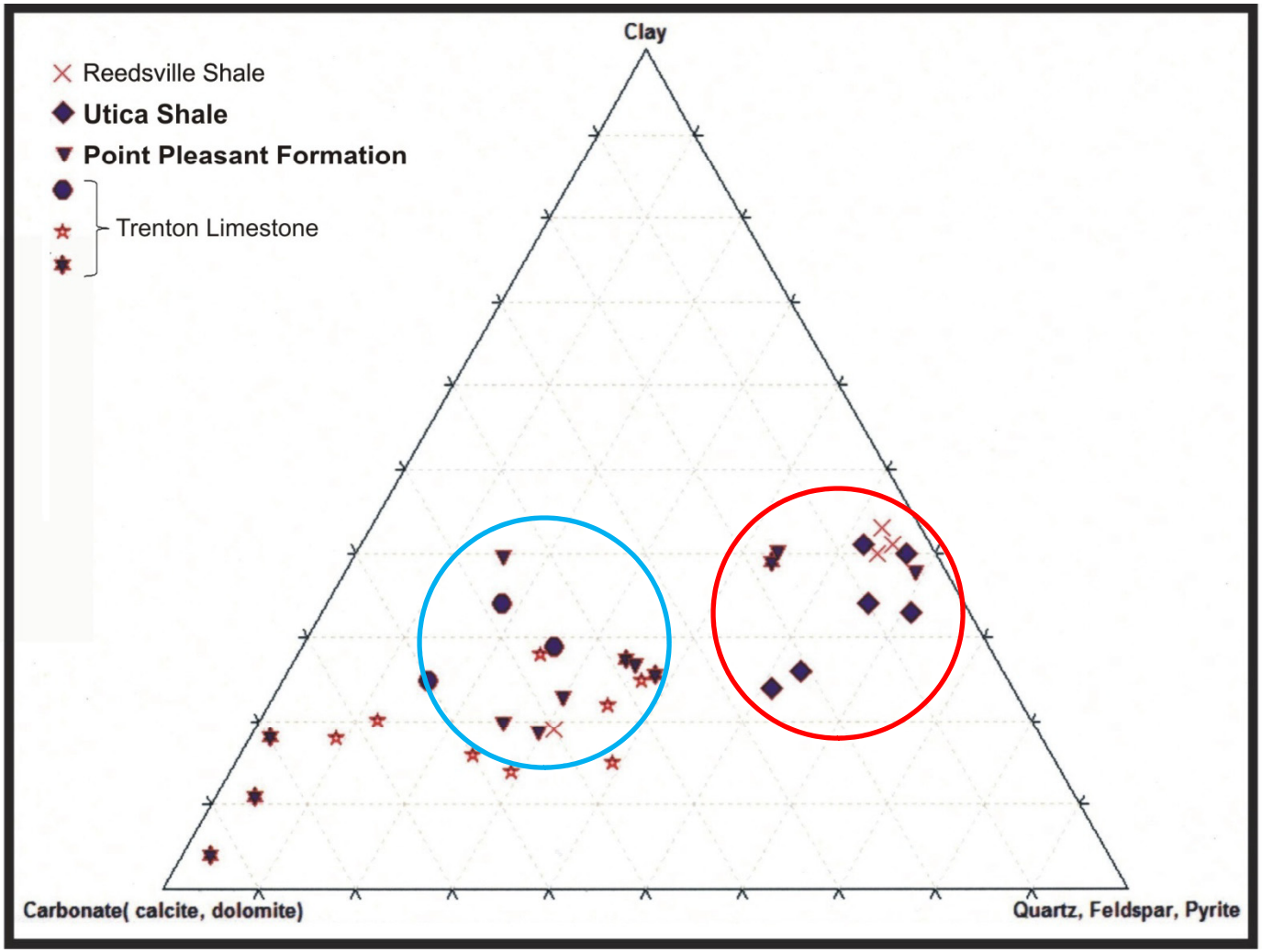
# XRD RESULTS FROM OHIO




Mineralogy for all samples dominated by clays, quartz, and calcite/dolomite

From Daniels and others, 2011

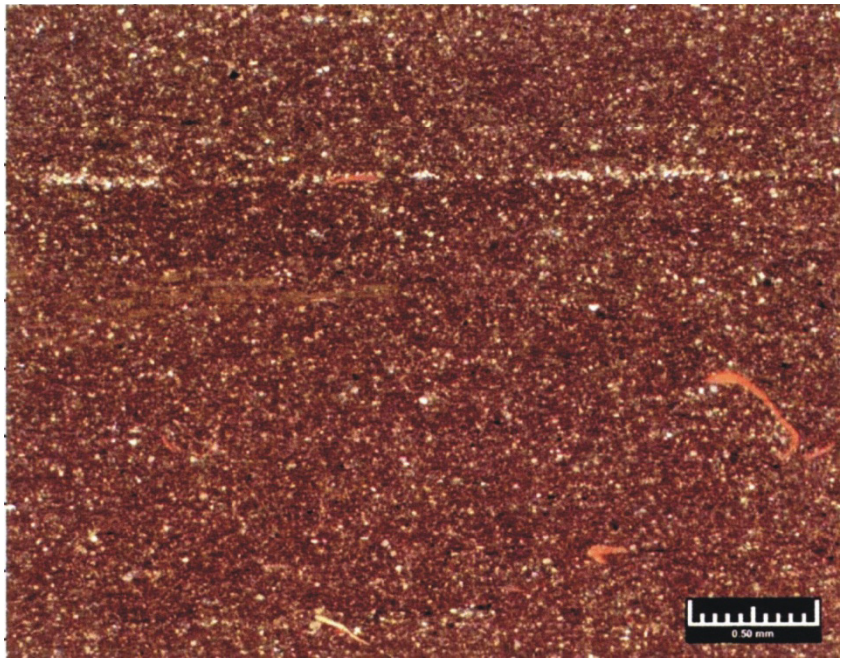
# XRD RESULTS FROM NEW YORK

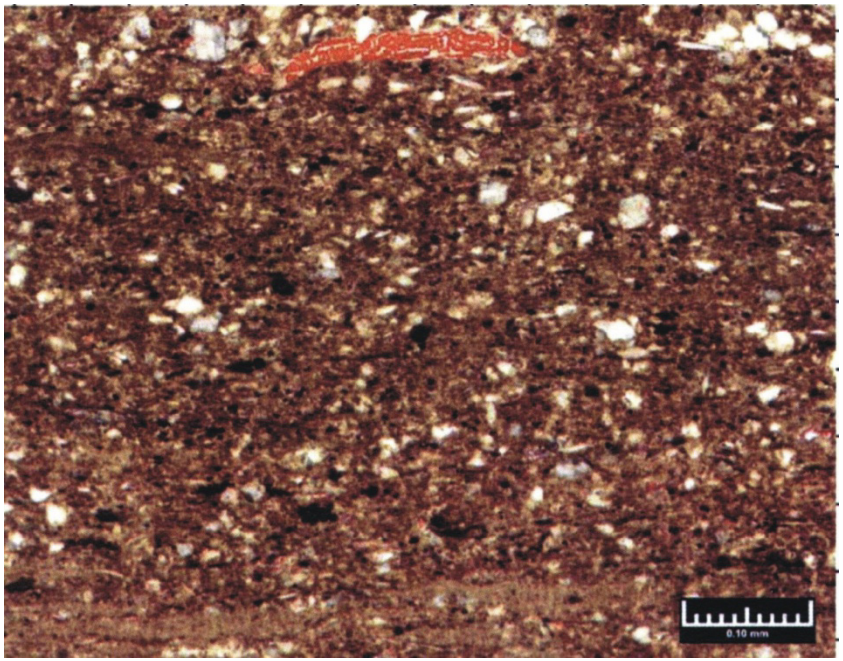



Utica – red circle
Point Pleasant – blue circle

Modified from Nyahay, 2011

# THIN SECTION PHOTOMICROGRAPHS OF THE UTICA SHALE, TUSCARAWAS COUNTY, OHIO



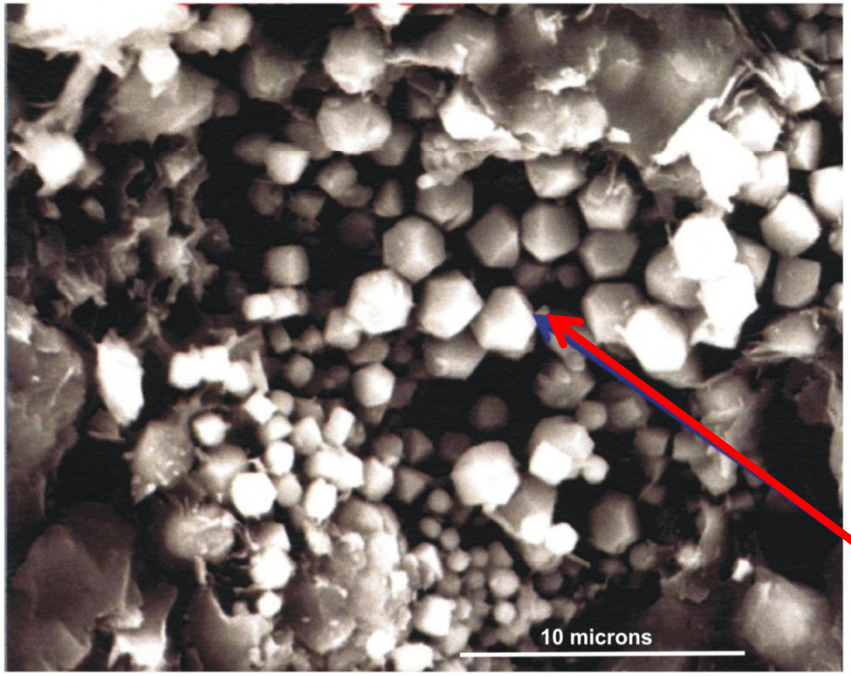




Scale bars = 0.5 mm

**Lithology** – slightly fossiliferous silty mudstone (silty shale). Common fine to medium silt-sized quartz and mica, abundant detrital clay, minor calcite cement, ferroan dolomite, and microcrystalline pyrite replacing some fossils, organic material, and matrix.

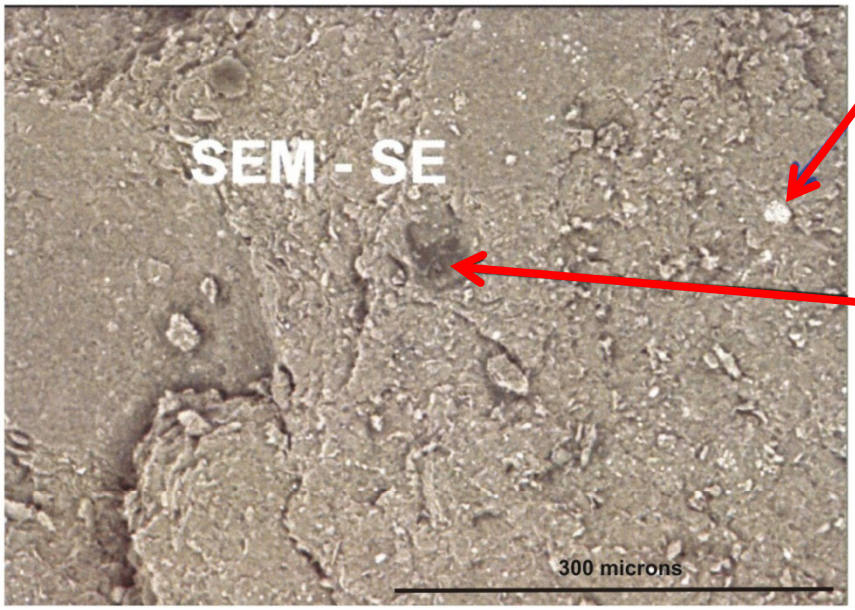
Modified from Riley and Baranoski, 2011

# SEM PHOTOMICROGRAPHS OF UTICA AND POINT PLEASANT FROM OHIO




From a well in Tuscarawas County, OH

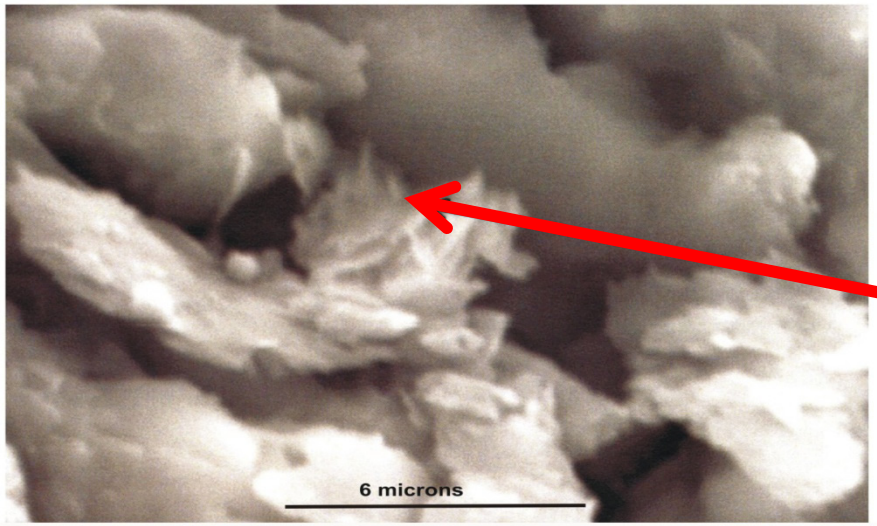
Euhedral pyrite crystals wrapped with clay



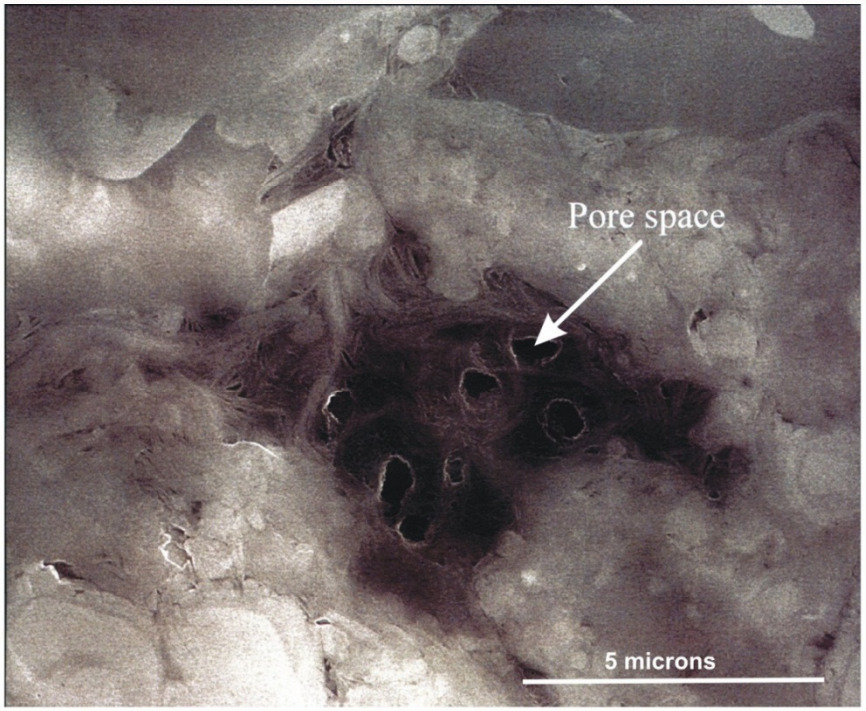

Lower magnification shows organic-rich region

From Daniels and others, 2011

# SEM PHOTOMICROGRAPHS OF UTICA AND POINT PLEASANT FROM OHIO AND NEW YORK



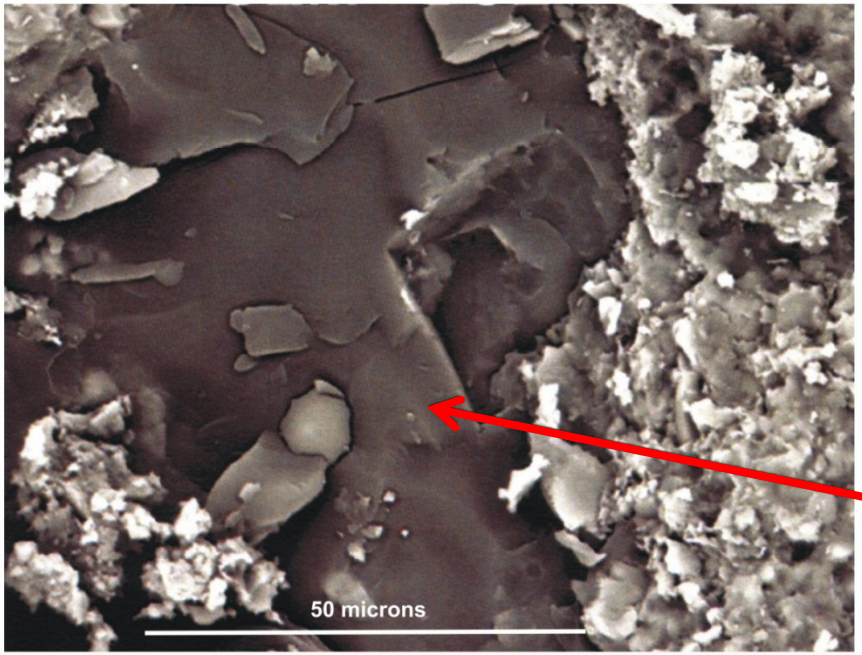

Layered clays – chlorite and illite are dominant, from a well in Morgan County, OH



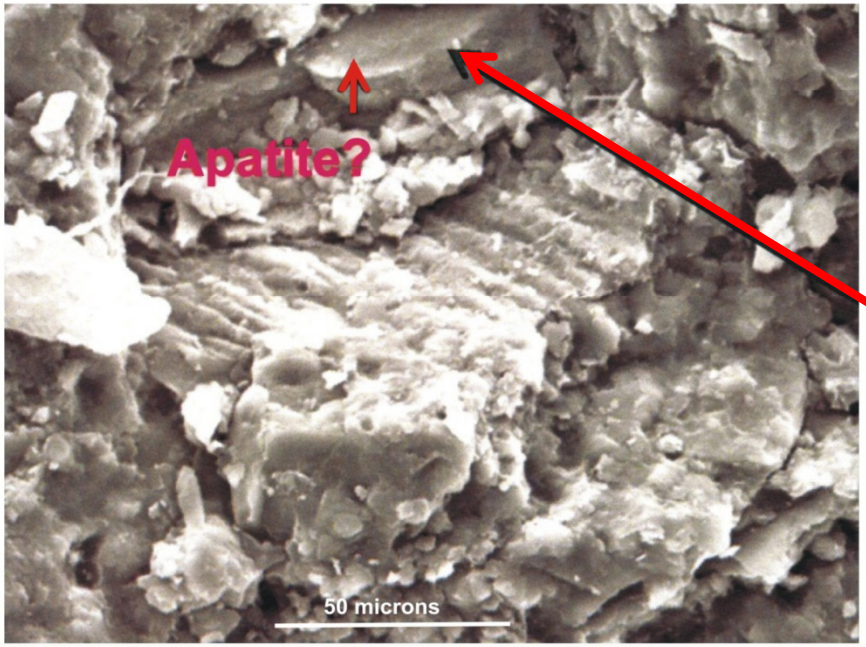

Good porosity in organic matter from a core near the outcrop belt of the Utica Shale-equivalent Indian Castle Shale of NY.

From Daniels and others, 2011

# SEM PHOTOMICROGRAPHS OF UTICA AND POINT PLEASANT FROM OHIO WELLS




Organic-rich regions

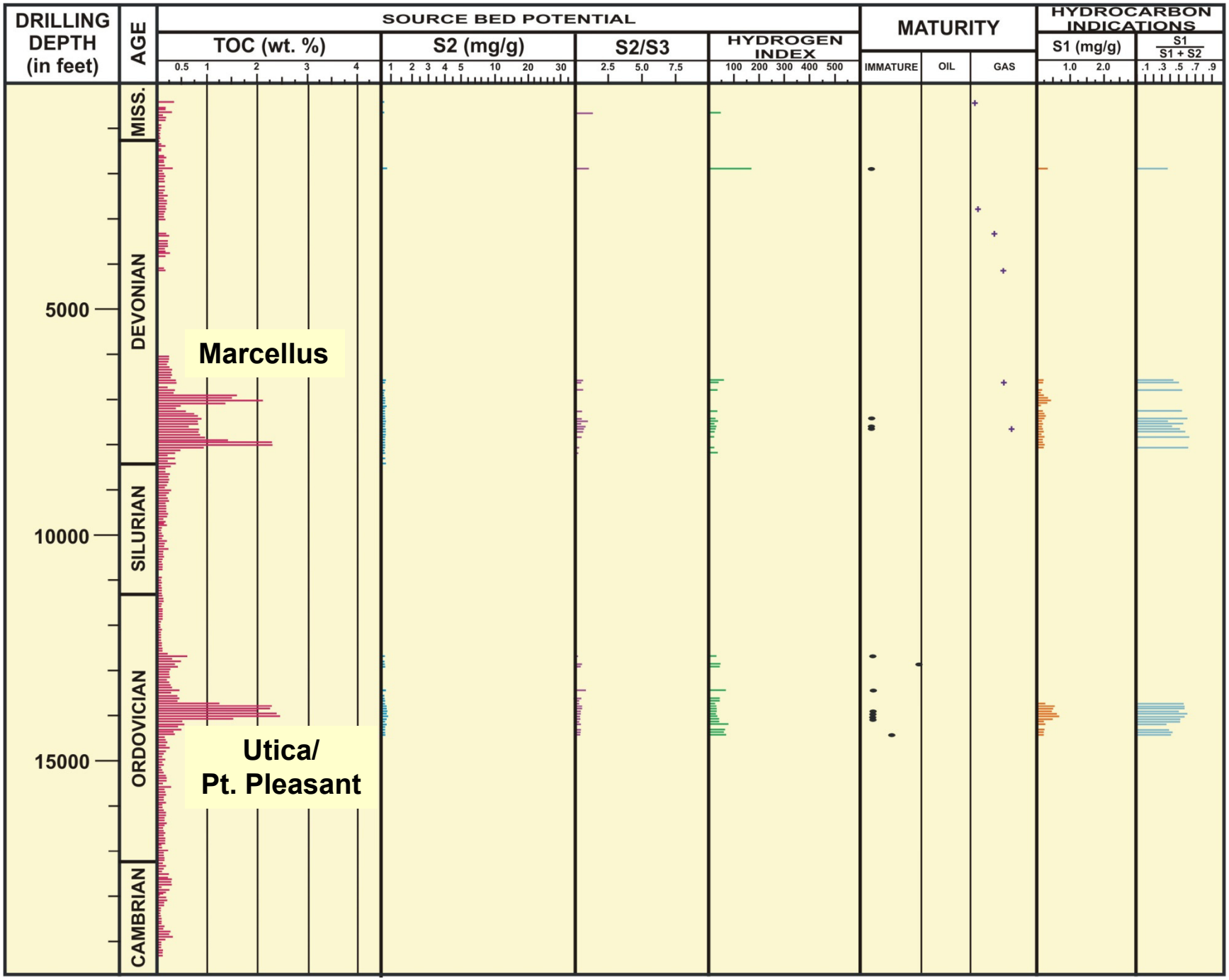



Calcium and phosphorus-rich grain, may be apatite or some other calcium phosphate phase mineral

From Daniels and others, 2011

# GEOCHEMISTRY OF THE UTICA/POINT PLEASANT

## As much as we know or suspect


DRILLING DEPTH (in feet)
AGE
SOURCE BED POTENTIAL
TOC (wt. %)
0.5 1 2 3 4
S2 (mg/g)
1 2 3 4 5 10 20 30
S2/S3
2.5 5.0 7.5
HYDROGEN INDEX
100 200 300 400 500
MATURITY
IMMATURE
OIL
GAS
HYDROCARBON INDICATIONS
S1 (mg/g)
1.0 2.0
S1 / S1 + S2
.1 .3 .5 .7 .9
MISS.
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
5000
10000
15000
Marcellus
Utica/
Pt. Pleasant

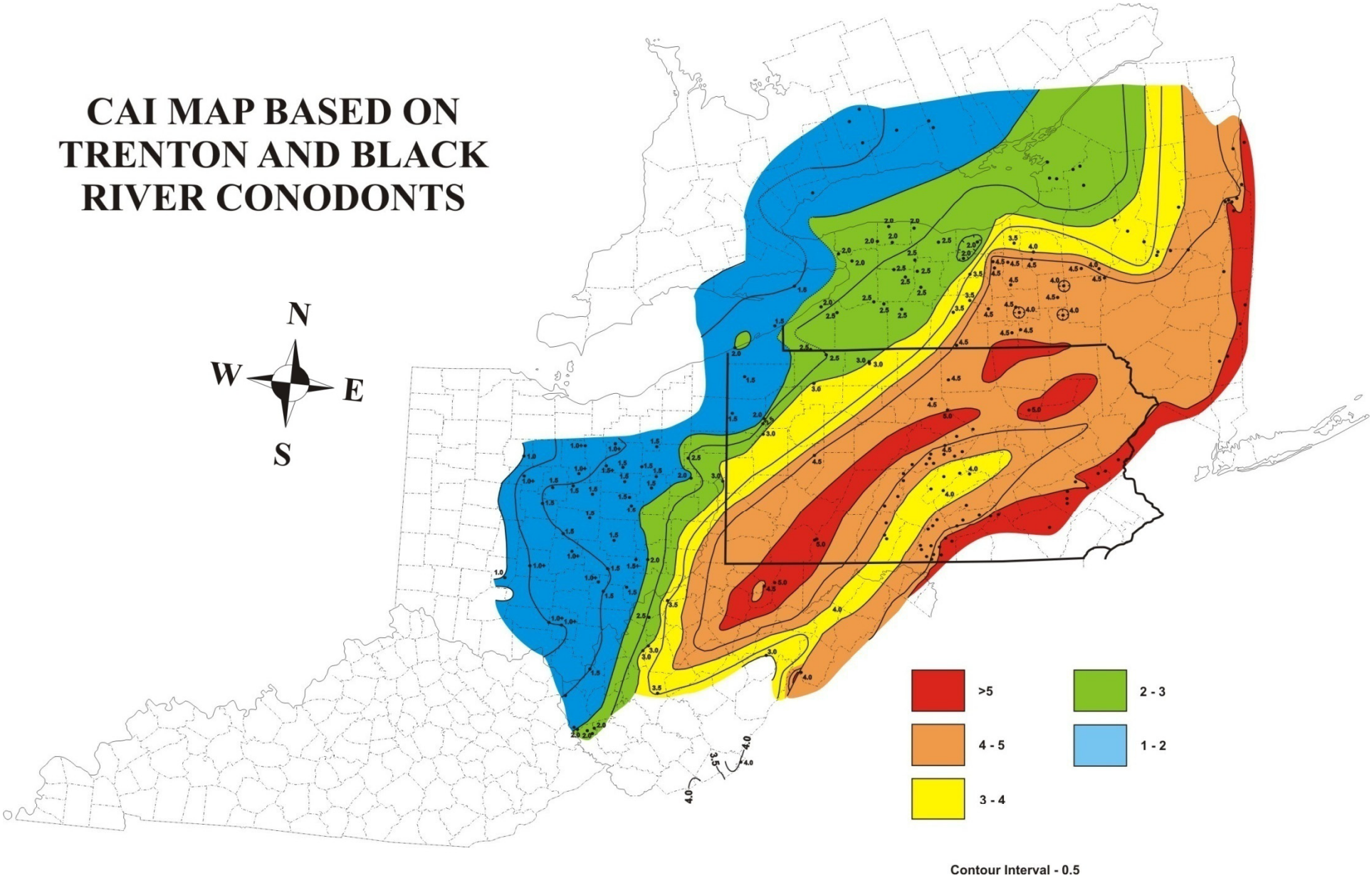
# SOURCE ROCK GEOCHEMISTRY AVAILABLE ON PENNSYLVANIA GEOLOGICAL SURVEY'S WEBSITE

Armstrong County, Pennsylvania
PNG-Martin No. 1
API Number: 3700521201

| Depth | Formation* | TOC | QT | S1 | QT | S2 | QT | S3 | $T_{max}$ | $R_o$ | HI | Type | OI | S2/S3 | Type | S1/TOC | PI | trhi | k | toco |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Total Organic Carbon* | *Petroleum Potential* | *Free Hydrocarbons* | *Petroleum Potential* | *Pyrolytic Hydrocarbons* | *Petroleum Potential* | *CO2 produced during cracking of thermal kerogen* | *Temp of max pyrolysis* | *Vitrinite Reflectance* | *Hydrogen Index* | | *Oxygen Index* | | *Hydrocarbon Type* | | *Production Index* | | | |
| 11150-11210 | Reedsville | 0.13 | p | | | | | | | | | | | | | | | | | |
| 11210-11270 | Reedsville | 0.16 | p | | | | | | | | | | | | | | | | | |
| 11270-11330 | Reedsville | 0.16 | p | | | | | | | | | | | | | | | | | |
| 11330-11390 | Reedsville | 0.19 | p | | | | | | | | | | | | | | | | | |
| 11390-11450 | Reedsville | 0.22 | p | | | | | | | | | | | | | | | | | |
| 11450-11510 | Reedsville | 0.23 | p | | | | | | | | | | | | | | | | | |
| 11510-11570 | Reedsville | 0.22 | p | | | | | | | | | | | | | | | | | |
| 11570-11630 | Reedsville | 0.26 | p | | | | | | | | | | | | | | | | | |
| 11630-11690 | Reedsville | 0.32 | p | 0.09 | p | 0.09 | p | 0.23 | | | | | 71 | | | 0.28 | | | | |
| 11690-11750 | Reedsville | 0.49 | p | 0.09 | p | 0.09 | p | 0.36 | | | | | 73 | | | 0.18 | | | | |
| 11750-11810 | Utica | 1.27 | g | 0.17 | p | 0.09 | p | 0.45 | | | | | 35 | | | 0.13 | | | | |
| 11810-11870 | Utica | 2.87 | vg | 0.37 | p | 0.5 | p | 0.5 | | | 8 | gas | 17 | 1.00 | gas | 0.13 | 0.43 | 0.99 | 0.15 | 4.27 |
| 11870-11930 | Utica | 2.33 | vg | 0.36 | p | 0.25 | p | 0.65 | | | 11 | gas | 28 | 0.38 | gas | 0.15 | 0.59 | 0.98 | 0.15 | 3.41 |
| 11930-11990 | Utica | 2.38 | vg | 0.36 | p | 0.53 | p | 0.51 | 413 | | 22 | gas | 22 | 1.04 | gas | 0.15 | 0.40 | 0.97 | 0.15 | 3.47 |
| 11990-12050 | Utica/Point Pleasant | 3.06 | vg | 0.56 | f | 0.4 | p | 0.61 | 411 | | 13 | gas | 20 | 0.66 | gas | 0.18 | 0.58 | 0.98 | 0.15 | 4.57 |
| 12050-12110 | Point | 2.8 | vg | 0.61 | f | 0.1 | p | 0.55 | 421 | | 4 | gas | 20 | 0.18 | gas | 0.22 | 0.86 | 0.99 | 0.15 | 4.16 |
| 12110-12170 | Trenton | 1.03 | g | 0.29 | p | 0.28 | p | 0.6 | 417 | | 27 | gas | 59 | 0.47 | gas | 0.28 | 0.51 | 0.96 | 0.14 | 1.45 |
| 12170-12230 | Trenton | 0.7 | f | 0.17 | p | 0.23 | p | 0.56 | 424 | | 34 | gas | 80 | 0.41 | gas | 0.24 | 0.43 | 0.95 | 0.14 | 0.97 |
| 12230-12290 | Trenton | 0.64 | f | 0.16 | p | 0.18 | p | 0.67 | 386 | | 27 | gas | 104 | 0.27 | gas | 0.25 | 0.47 | 0.96 | 0.14 | 0.89 |
| 12290-12350 | Trenton | 0.76 | f | 0.35 | p | 0.81 | p | 1.32 | 413 | | 107 | gas | 174 | 0.61 | gas | 0.46 | 0.30 | 0.84 | 0.13 | 1.02 |
| 12350-12410 | Black River | 0.42 | p | 0.13 | p | 0.17 | p | 0.54 | 424 | | 40 | gas | 130 | 0.31 | gas | 0.31 | 0.43 | 0.94 | 0.14 | 0.58 |
| 12410-12470 | Black River | 0.34 | p | 0.15 | p | 0.23 | p | 0.73 | 428 | | 66 | gas | 215 | 0.32 | gas | 0.44 | 0.39 | 0.90 | 0.14 | 0.46 |
| 12470-12530 | Black River | 0.29 | p | | | | | | | | | | | | | | | | | |

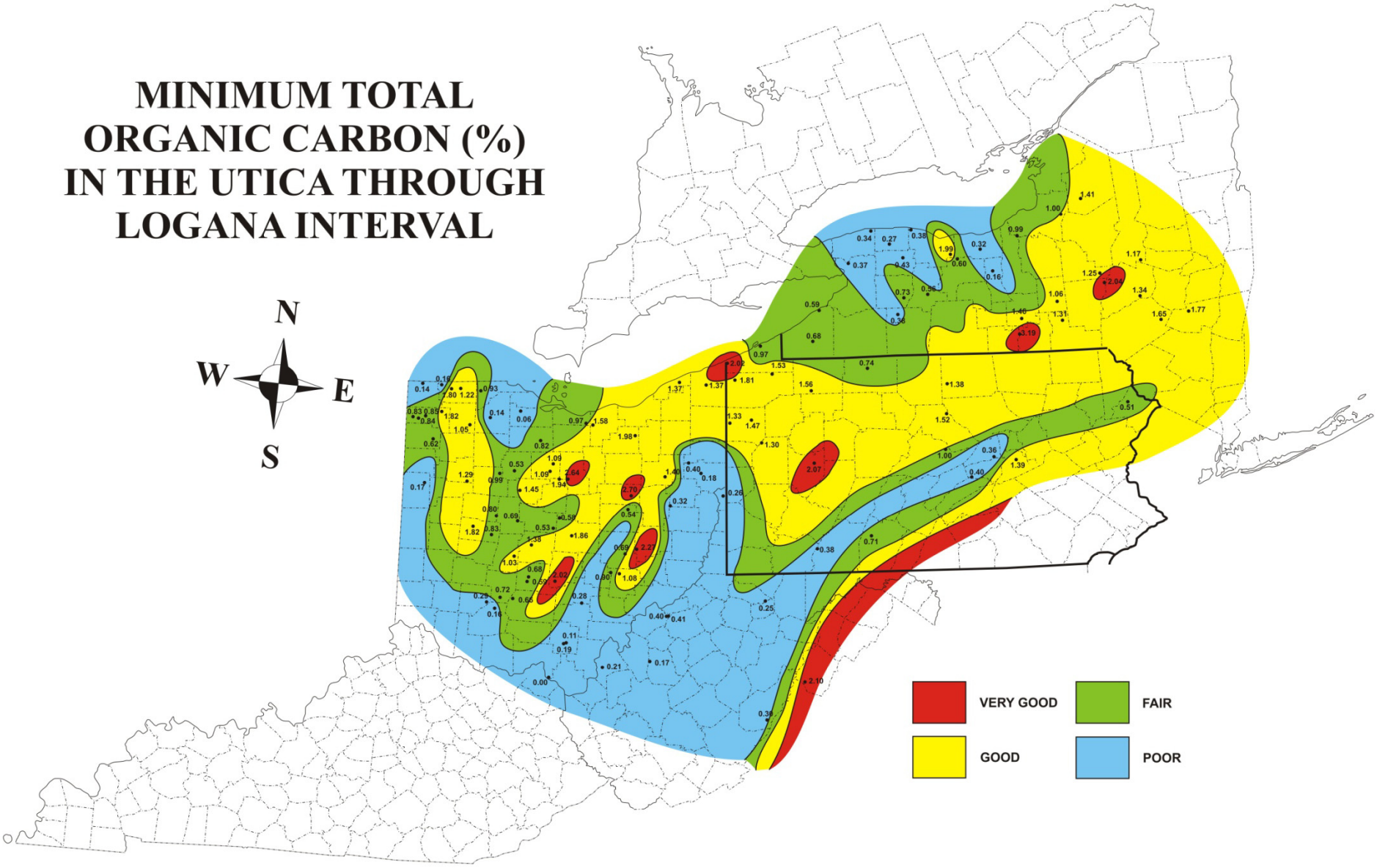
http://www.dcnr.state.pa.us/topogeo/oilandgas/sourcerock_sampledata.aspx

# CAI MAP BASED ON TRENTON AND BLACK RIVER CONODONTS



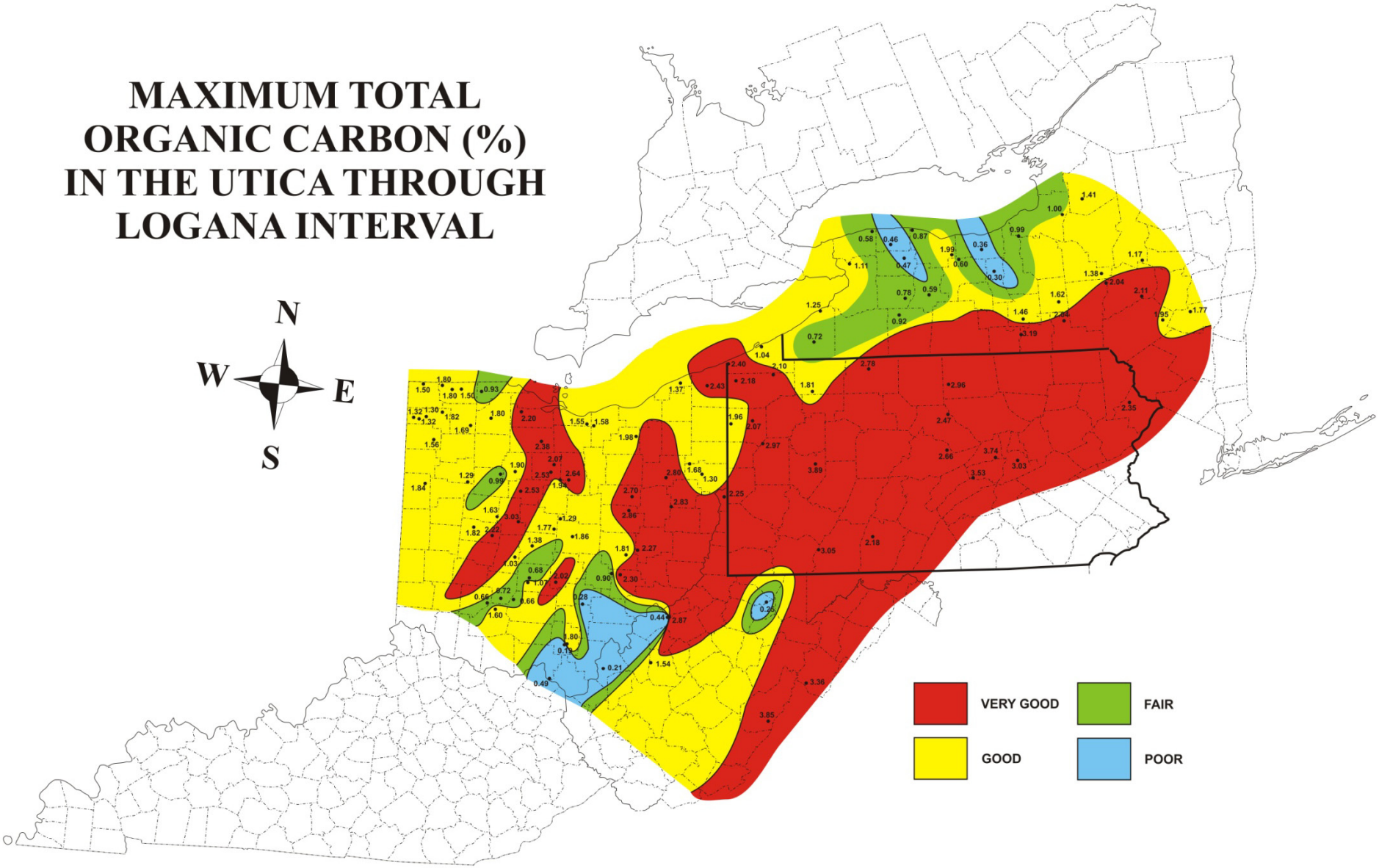

Modified from Patchen and others, 2008

# MINIMUM TOTAL ORGANIC CARBON (%) IN THE UTICA THROUGH LOGANA INTERVAL



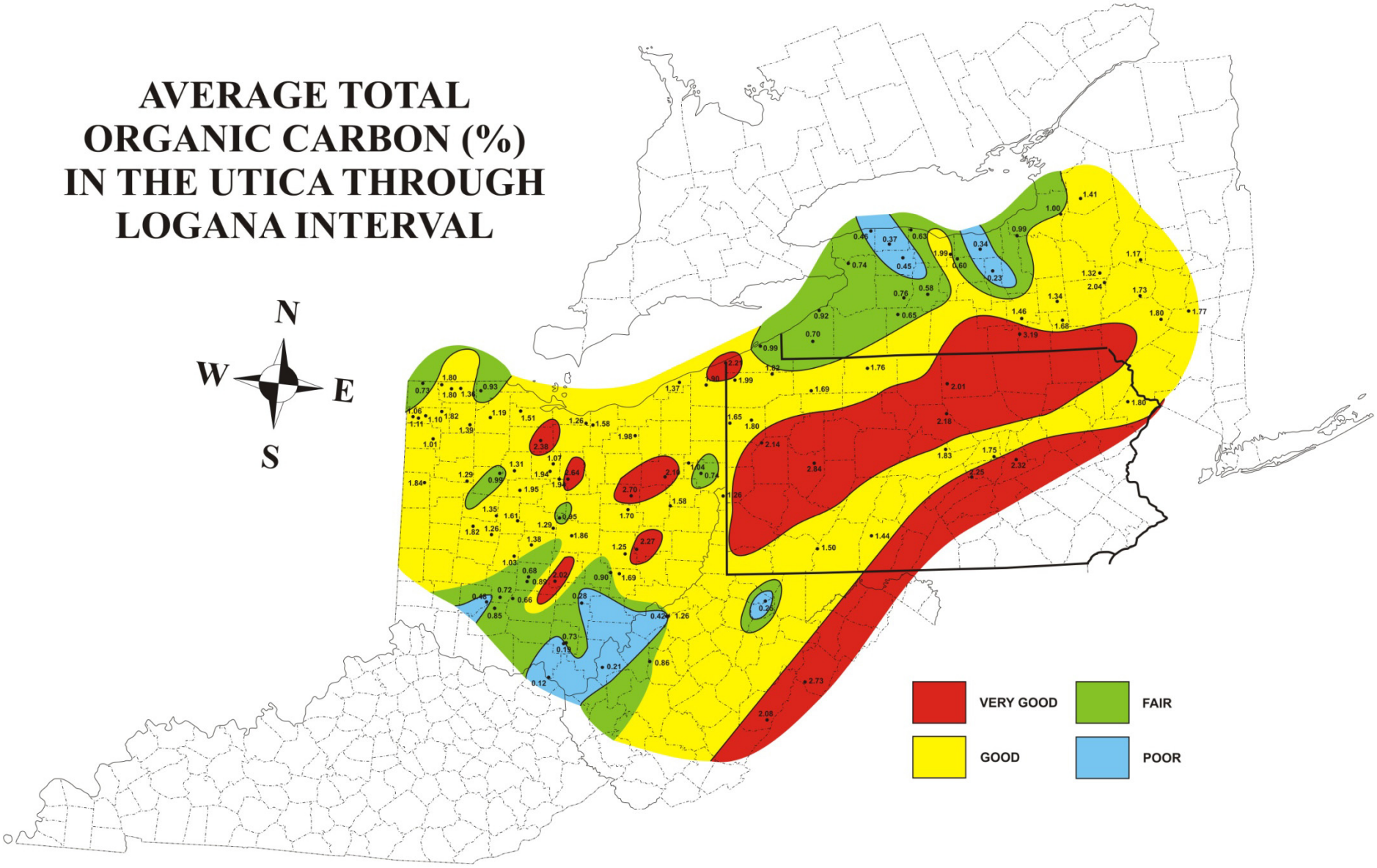

Modified from Patchen and others, 2008

# MAXIMUM TOTAL ORGANIC CARBON (%) IN THE UTICA THROUGH LOGANA INTERVAL



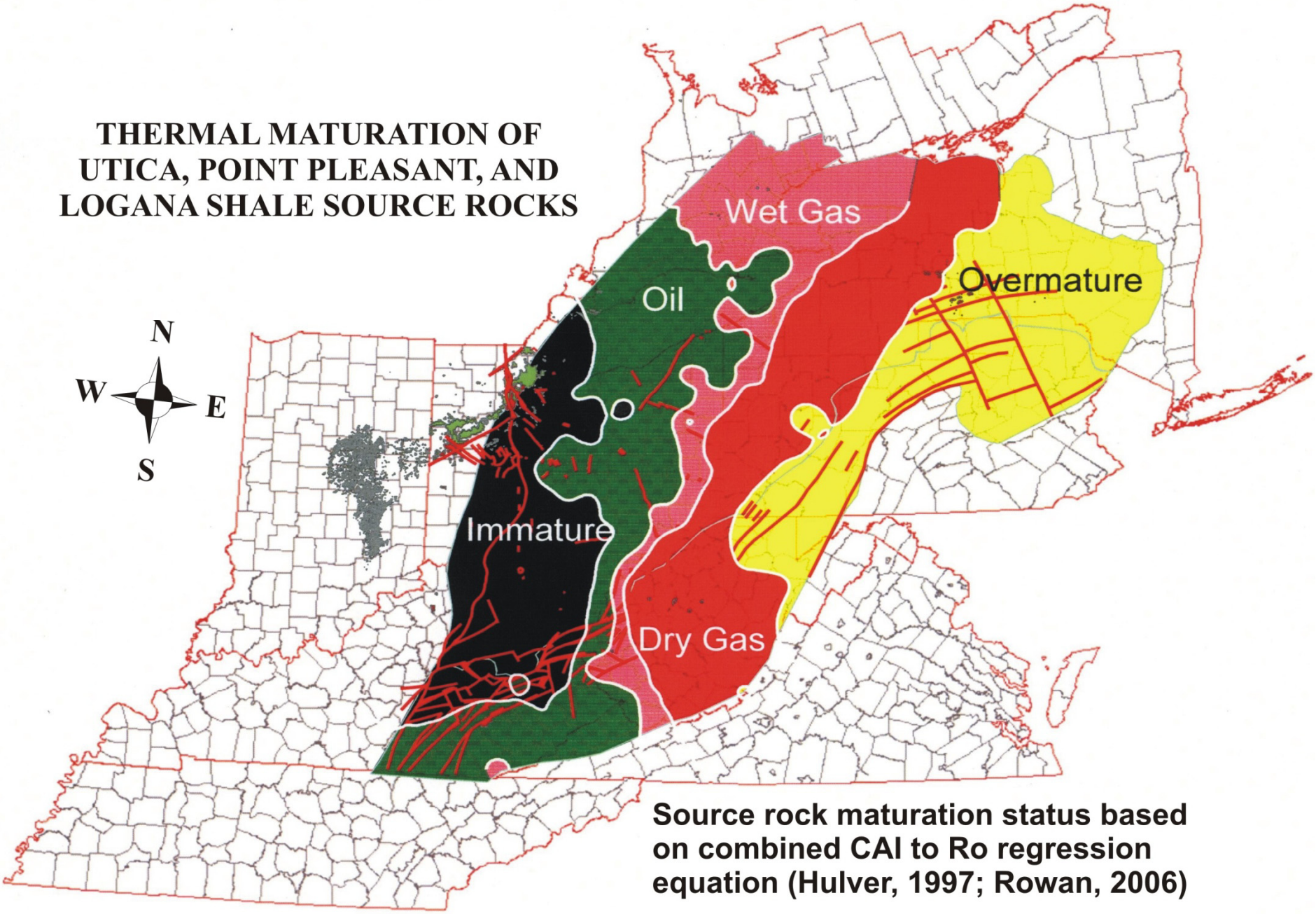

Modified from Patchen and others, 2008

# AVERAGE TOTAL ORGANIC CARBON (%) IN THE UTICA THROUGH LOGANA INTERVAL




Modified from Patchen and others, 2008

# THERMAL MATURATION OF UTICA, POINT PLEASANT, AND LOGANA SHALE SOURCE ROCKS



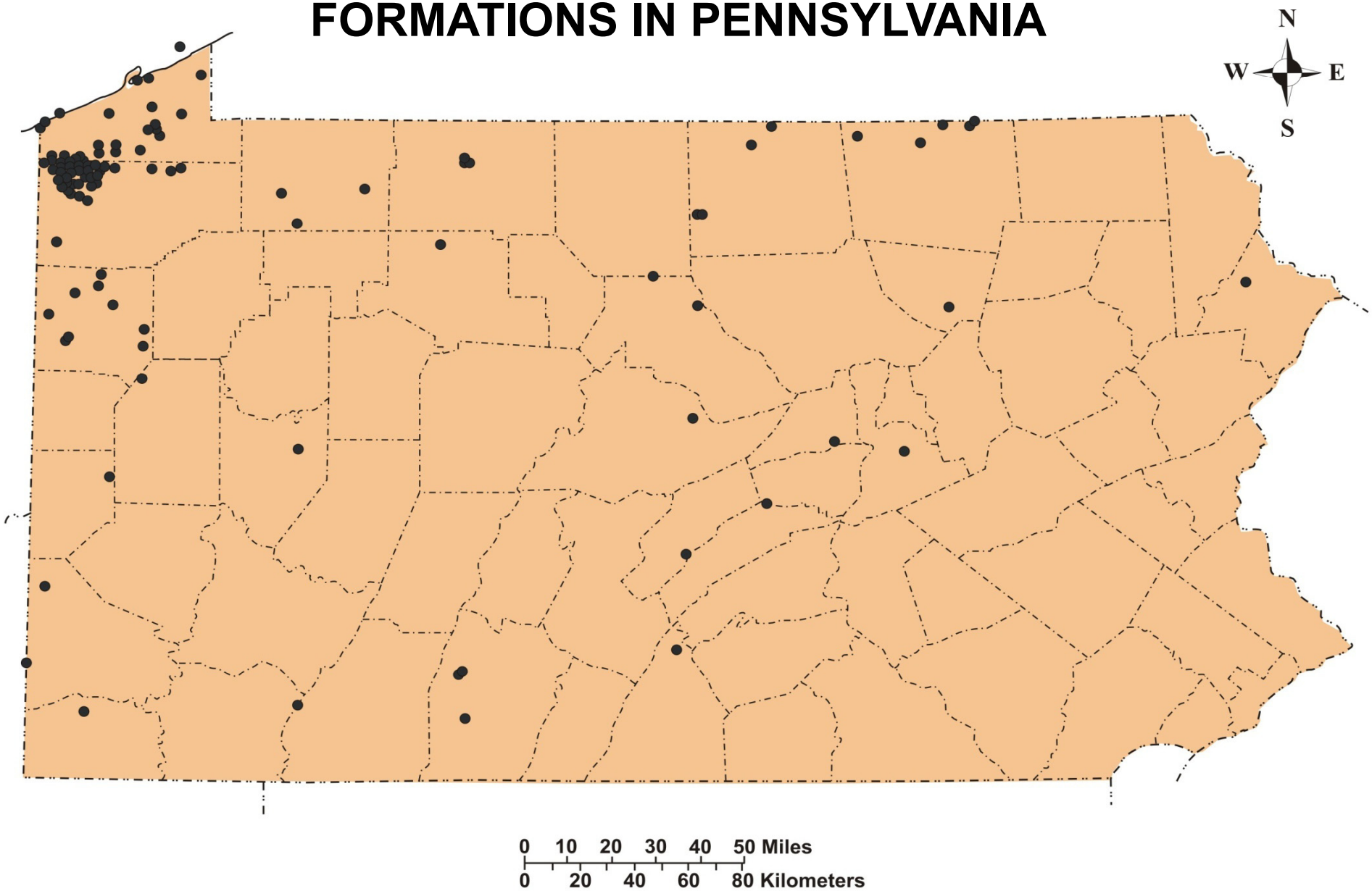

**Source rock maturation status based on combined CAI to Ro regression equation (Hulver, 1997; Rowan, 2006)**

Modified from Patchen and others, 2008

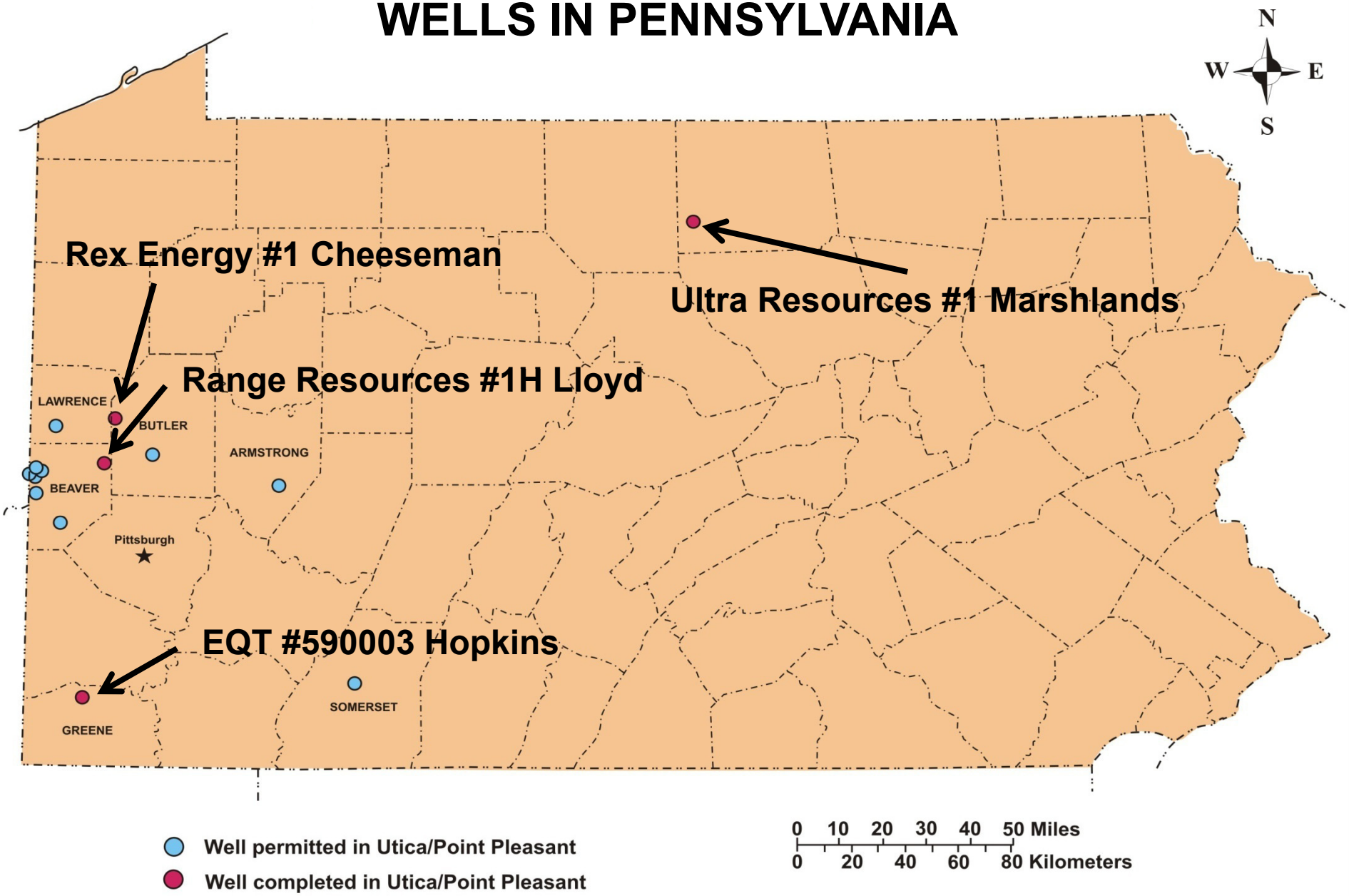
# DRILLING AND PERMITTING ACTIVITY IN PENNSYLVANIA

## What little there has been

# WELLS PENETRATING THE UTICA OR DEEPER FORMATIONS IN PENNSYLVANIA



# PERMITTED AND COMPLETED UTICA/POINT PLEASANT WELLS IN PENNSYLVANIA



**3711720131**
**Ultra Resources #2 Marshlands**
**Tioga Co., Gaines Twp.**
**Deviated Hole – 13511'**

**Reedsville at 11245'**
**Trenton at 12099'**
**Depth to Utica and Point Pleasant unknown**

**Drilling completed 2/15/2007**

**Utica and Point Pleasant perfed and fraced 6/4-7/6/2007**
**from 11712' to 12087'**
**Trenton perfed and fraced 5/16-17/2007**

**Total results: 141 Mcfgpd**

**Reported production for 2008 and 2009: 24533 Mcf**

**3705924659**
**EQT #590003 Hopkins**
**Greene Co., Morris Twp.**
**TVD – 14464' (vertical hole)**

**Utica at 13269'**
**Point Pleasant at 13423'**
**Trenton at 13548'**

**Drilling completed 6/9/2008**

**Utica and Point Pleasant perfed and fraced 7/15-31/2008 from 13345' to 13490'**

**Results: N/A**

**Reported production for 2008 and 2009: 0 Mcf, 0 Bbl**
**Considered inactive in 2009**

**3700720293**
**Range Resources #1H Lloyd**
**Beaver Co., Marion Twp.**
**TVD – ~9580', MD – 12700'**

**"Shale" at 9450'**

**Drilling completed 1/6/2010**

**Utica perfed and fraced 3/22/2010**
**from 10300' to 12600'**

**Results – 4.4 MMcfgpd**

**No production reported for 2009**

**3701921706**
**Rex Energy #1 Cheeseman**
**Butler County, Muddycreek Twp.**

**Permitted as horizontal, 12930' (TVD – 10000')**

**Drilling completed in September**

**Reported results: 9.2 MMcfgpd**

**No other information available as of 11/7/2011**

# UTICA SHALE RESOURCE POTENTIAL (QUEBEC)

## Resource Potential

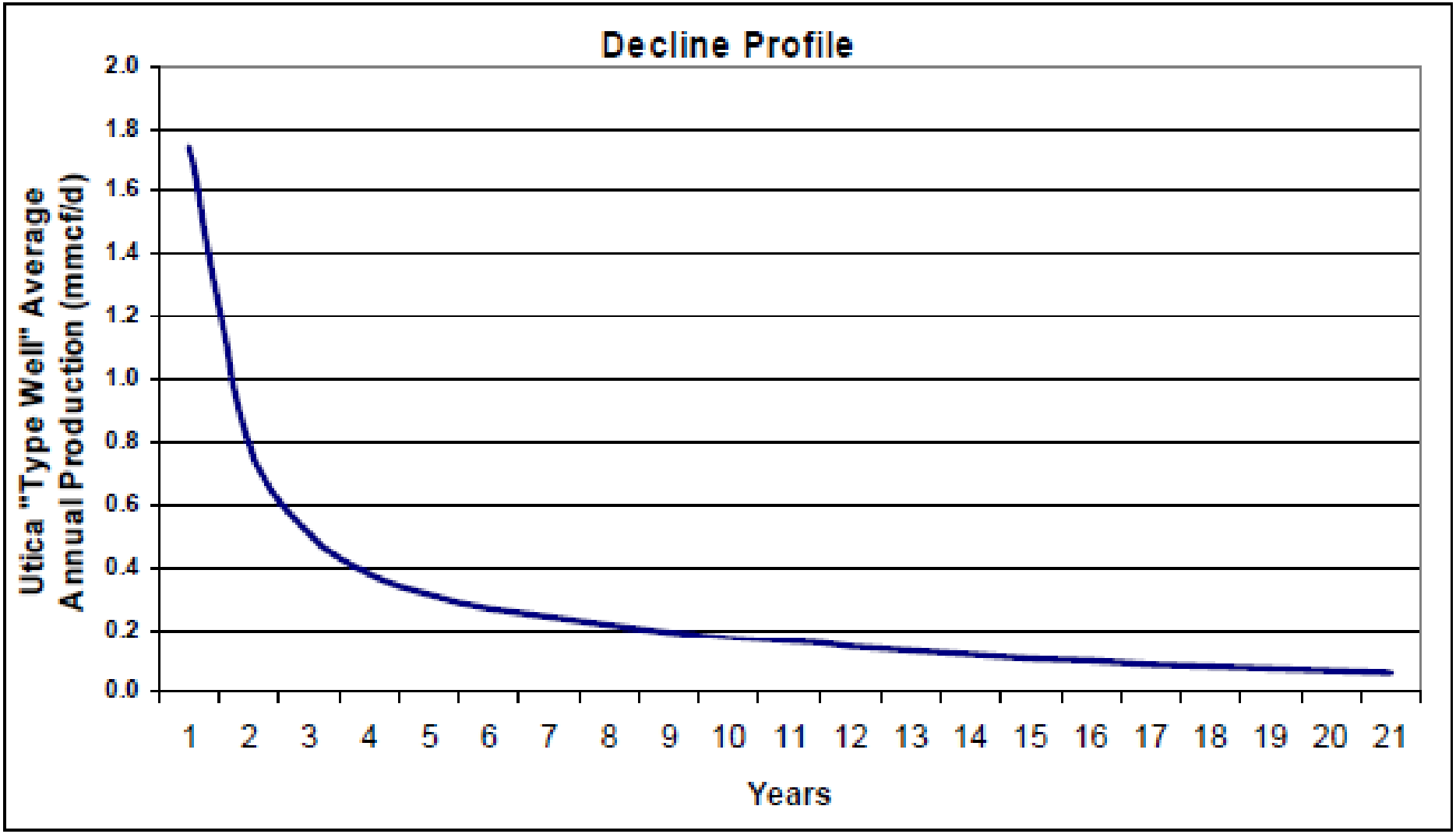
| Recovery Efficiency | Net Recoverable Tcf | Net Bcf per Well @ 100-acre spacing |
|---|---|---|
| 15% | 3.1 | 1.3 |
| 20% | 4.1 | 1.7 |
| 25% | 5.2 | 2.2 |

## Well Information

- 4,000-7,000' total measured depth
- 4-stage frac
- 2008 activity $2.5 to 4.0 MM per well
- Target $2.5 MM for ultimate program

Modified from Forest Oil Co., 2008

# PROJECTED TYPE DECLINE CURVE OF UTICA SHALE (QUEBEC)




Modified from Forest Oil Co., 2008

# SOME THINGS TO PONDER

- Significant natural gas flows have been reported from the Utica in Quebec from vertical wells with single stage completions
- Chesapeake Energy has been finding natural gas liquids in the Utica in eastern OH
- Based on data from NY, the Utica play may be more structurally complex than many other unconventional plays
- TOC values appear to be smaller than for Marcellus, although they have proven to be higher in some wells
- Utica/Point Pleasant mineralogy in wells from NY, OH, and PA is similar to that from Quebec

**The Utica/Point Pleasant is an emerging play – not much is really known in PA yet, and more work needs done across the basin**

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