An Unconventional Look at the Rome Trough, Eastern Kentucky

Or

What is Bruin Exploration Up To in Lawrence County?

Dave Harris and John Hickman

Kentucky Geological Survey

University of Kentucky

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Acknowledgements

- Rome Trough Consortium partners
  - Ohio, W. Va. and Kentucky Surveys; Industry and US DOE funding
- Bob Ryder, USGS: cross-sections and geochemical data
- Monte Hay, Hay Exploration: oil and gas samples from Homer field

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Outline of Presentation

- Rome Trough regional geology and stratigraphy
- Production history
- Cambrian petroleum system
- Review new geochemical data
- Bruin Exploration deep test, Lawrence County
- Potential for a deep unconventional play

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Rome Trough Consortium 1999-2002

- Regional stratigraphic and structural interpretation
  - 760 wells, 157 digital well logs
  - Regional cross sections: poster paper
  - Lithology modeling from digital logs
- Homer field study, Elliott County
- Core descriptions
- Regional paleogeographic and sandstone distribution maps
- Hydrocarbon and source rock geochemistry
- Exploration recommendations
- 2004 Open-file report available at KGS

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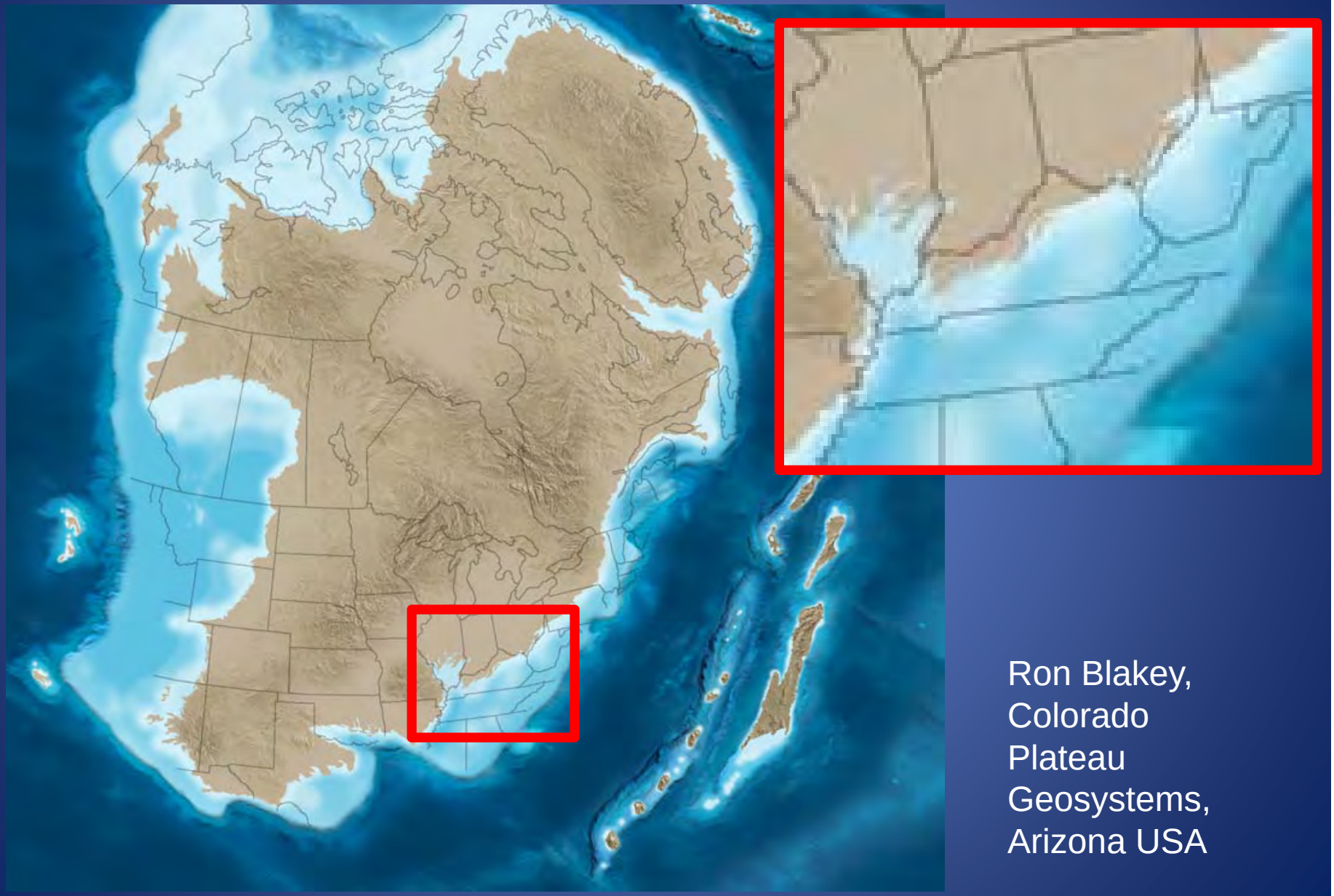
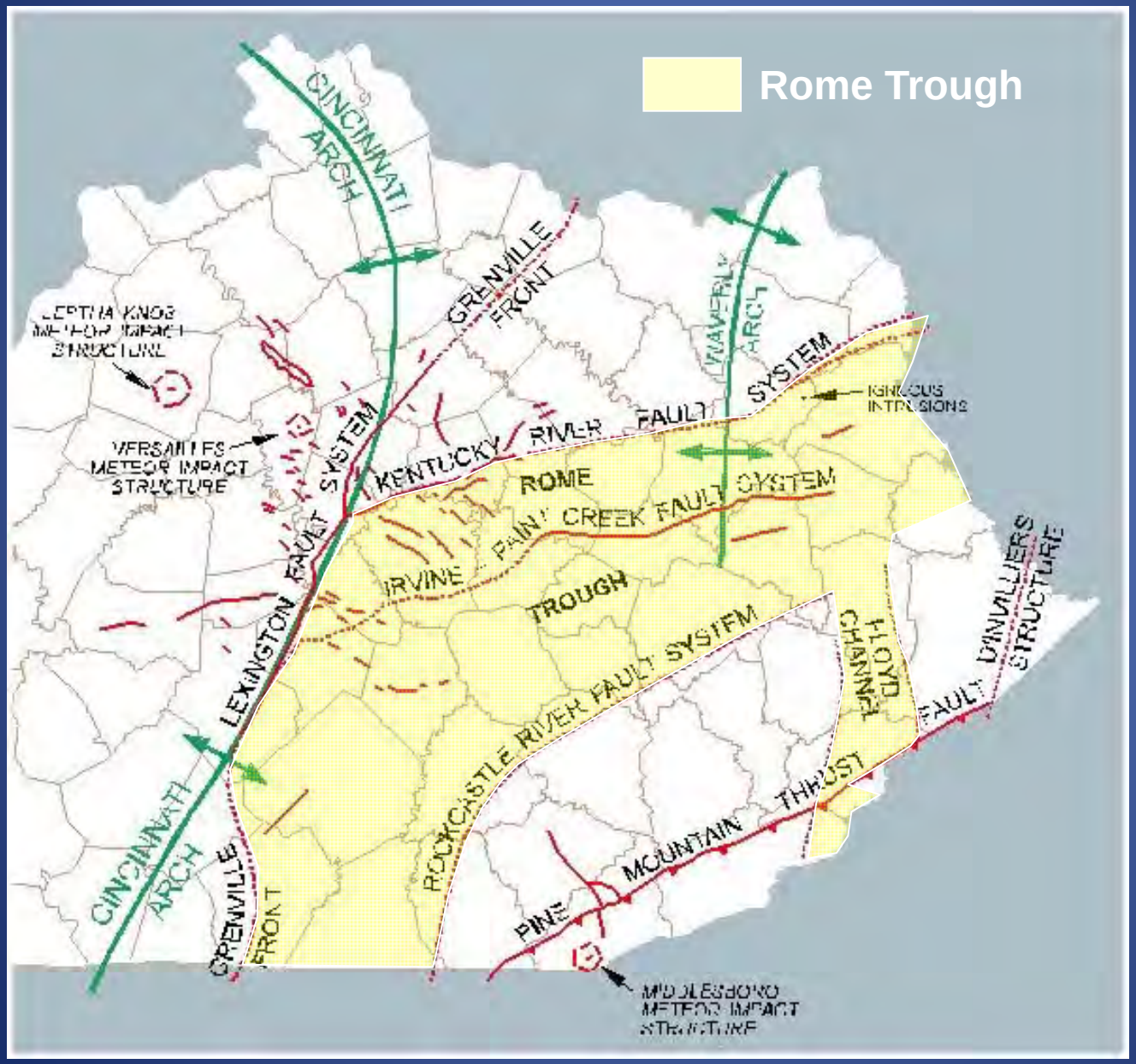
Middle Cambrian Paleogeography



Ron Blakey,
Colorado
Plateau
Geosystems,
Arizona USA

Structural Features, Eastern Kentucky



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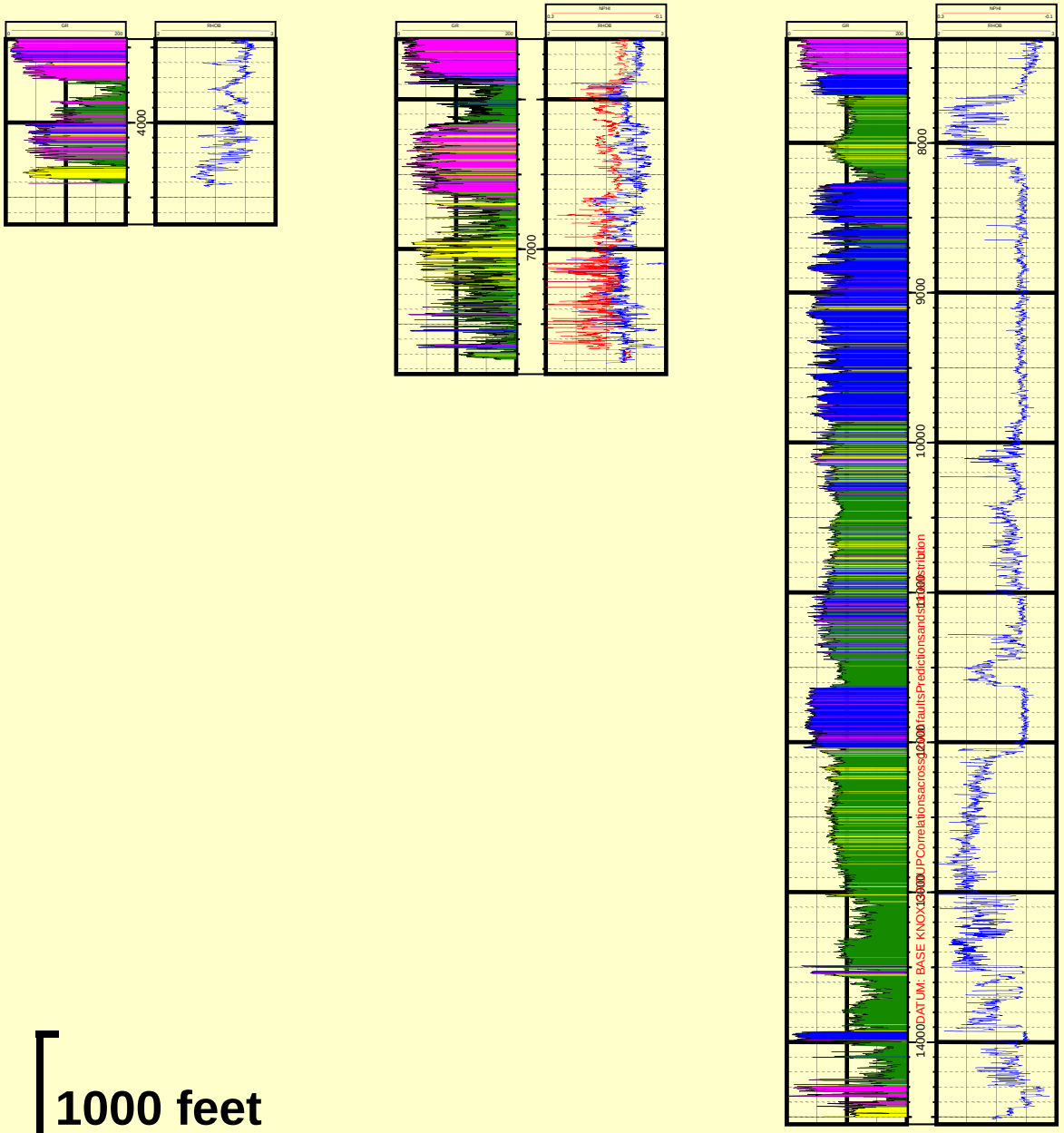
Pre-Knox Stratigraphy

- Inconsistent names across 3-state area
- Problems in defining Rome and Conasauga, Mt. Simon, basal sandstone
- Use of Rome in Ohio (Janssens, 1973)

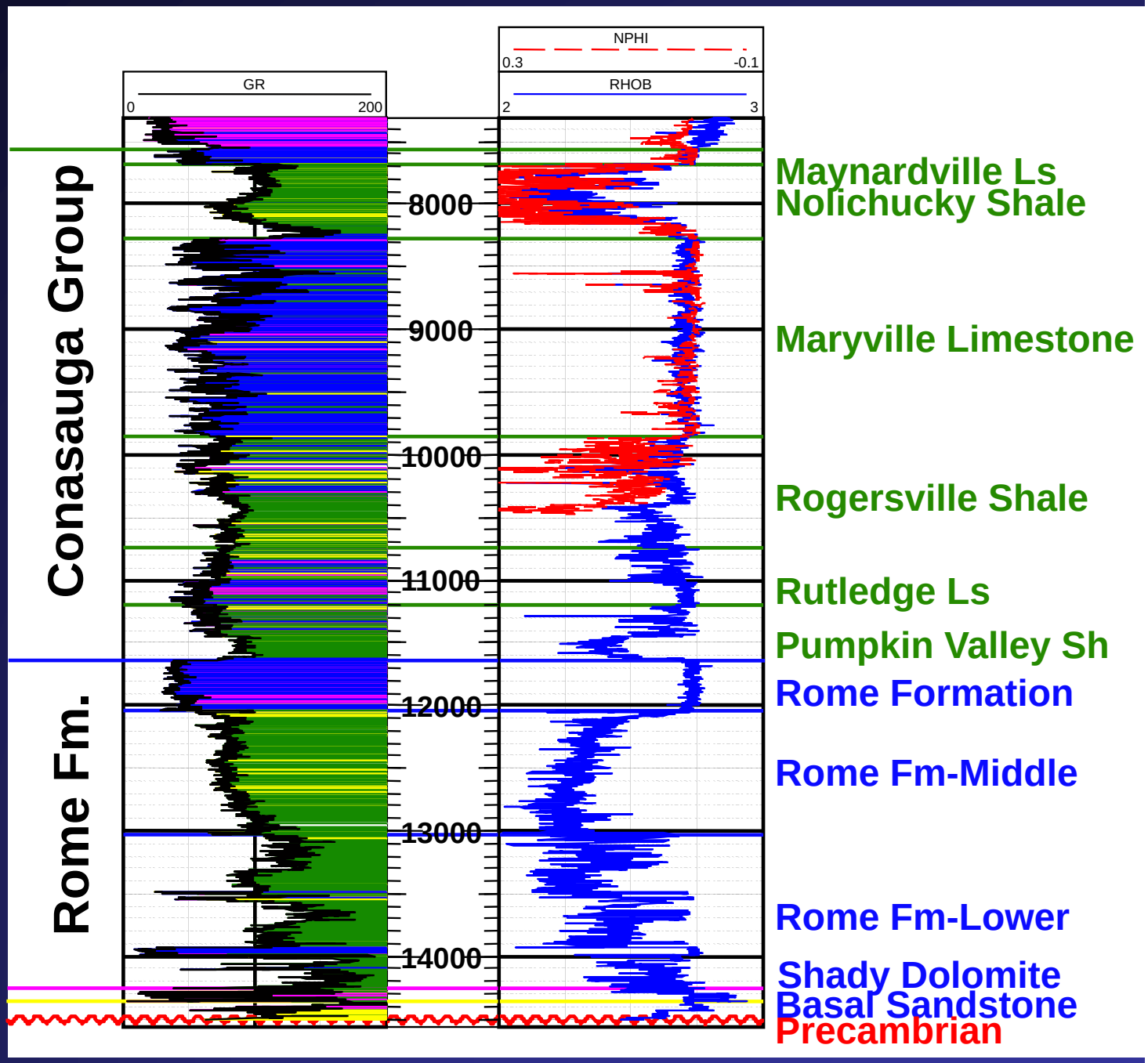
Stratigraphic Problem

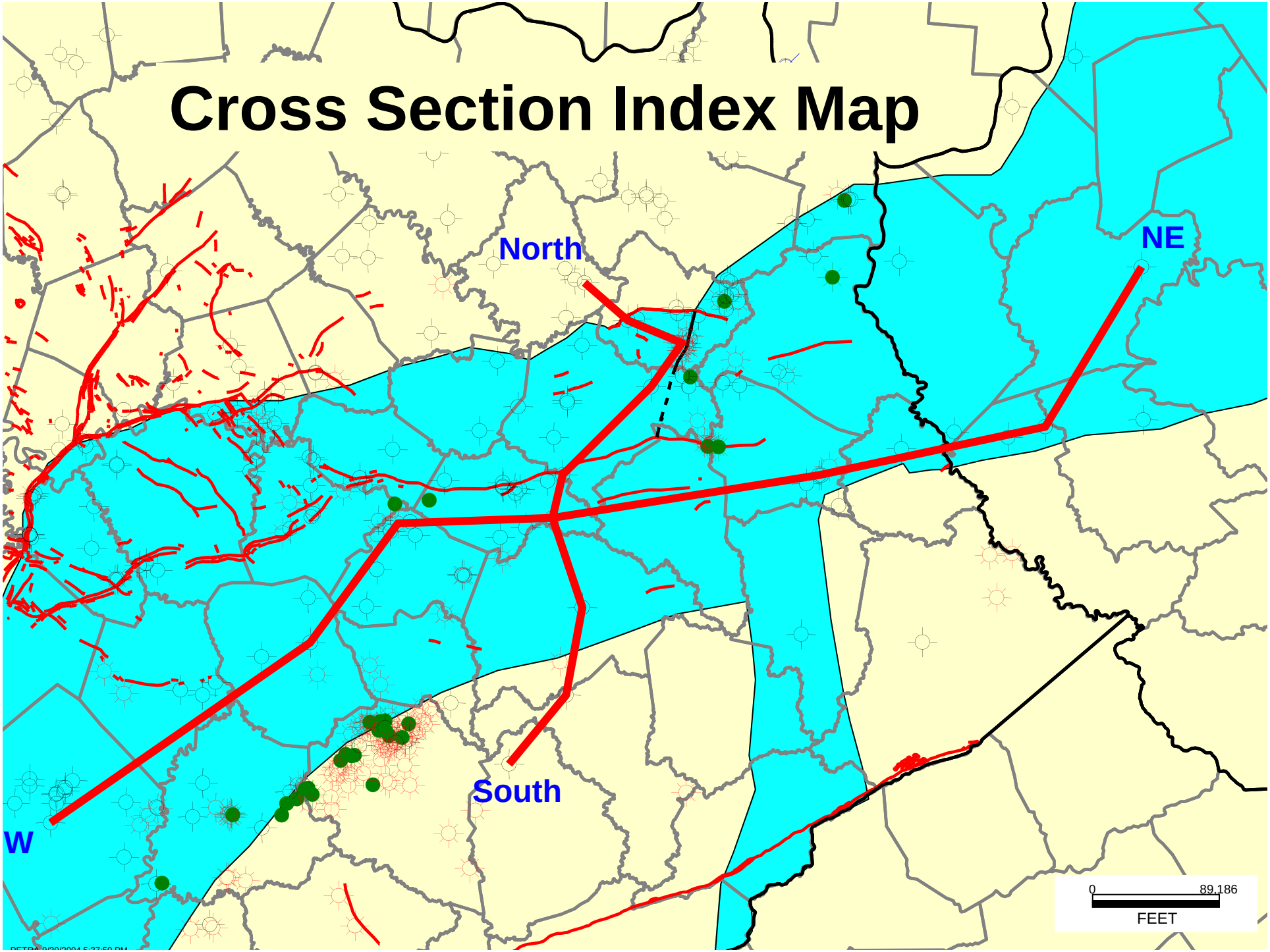


Pre-Knox Type Log

U.S. Signal
Elkhorn Coal
Johnson Co.
Kentucky

Gamma ray shaded
By log-calculated
lithologies

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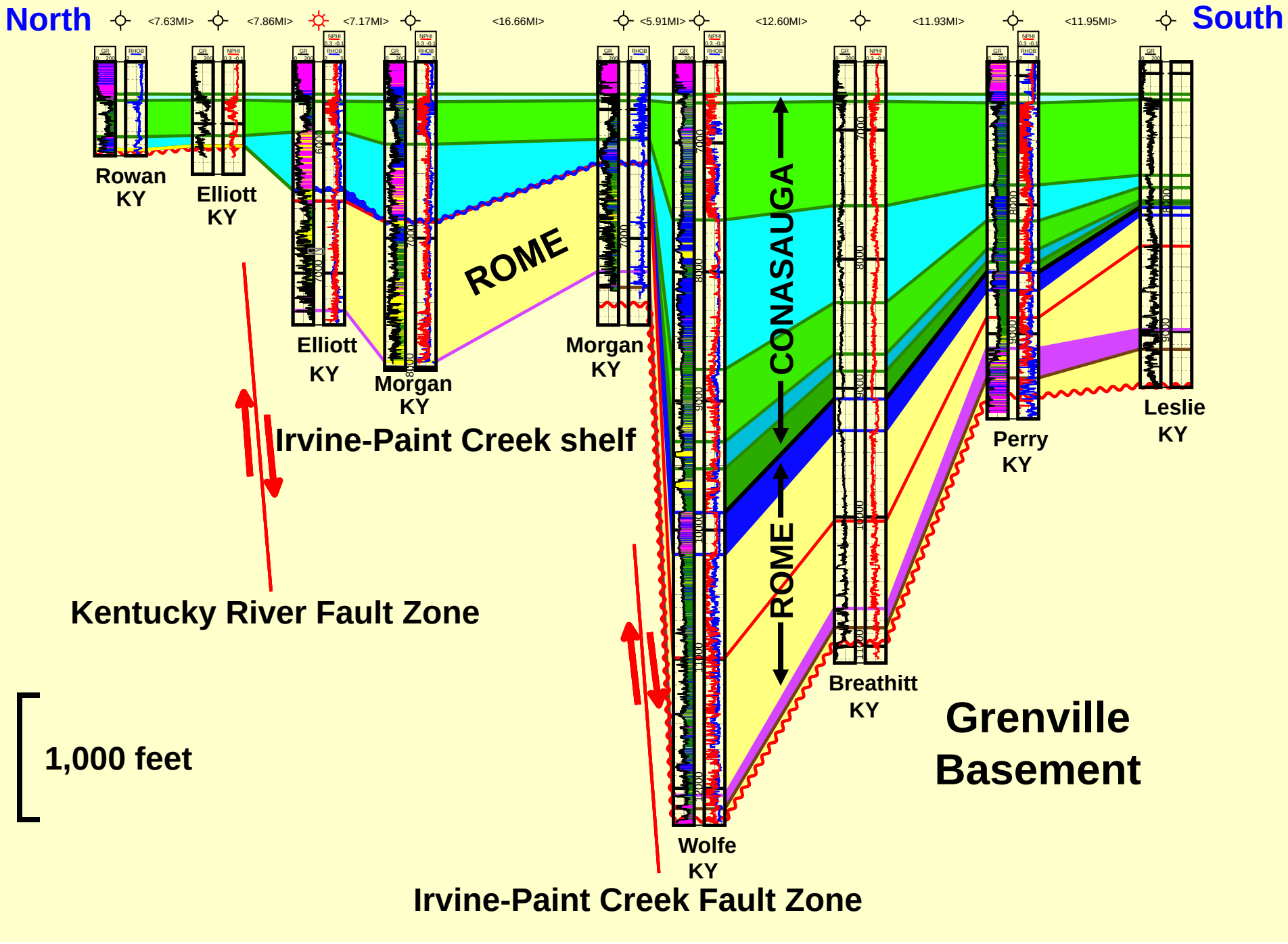
NE
South
W
0
89,186
FEET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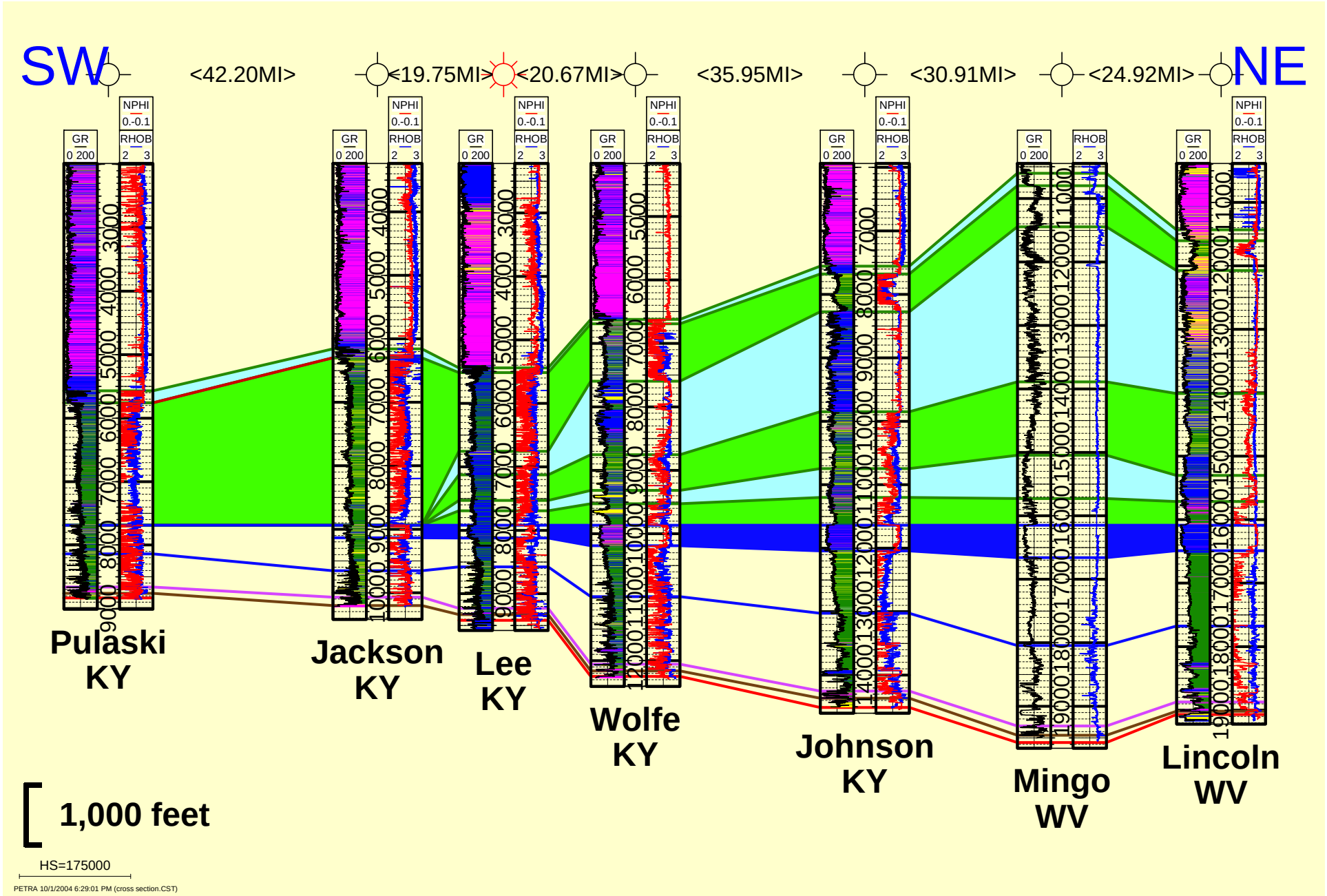
Rowan KY
Elliott KY
Elliott KY
Morgan KY
Morgan KY
ROME
CONASAUGA
ROME
Irvine-Paint Creek shelf
Kentucky River Fault Zone
Perry KY
Leslie KY
Breathitt KY
Wolfe KY
Irvine-Paint Creek Fault Zone
1,000 feet
Grenville Basement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<20.67MI>
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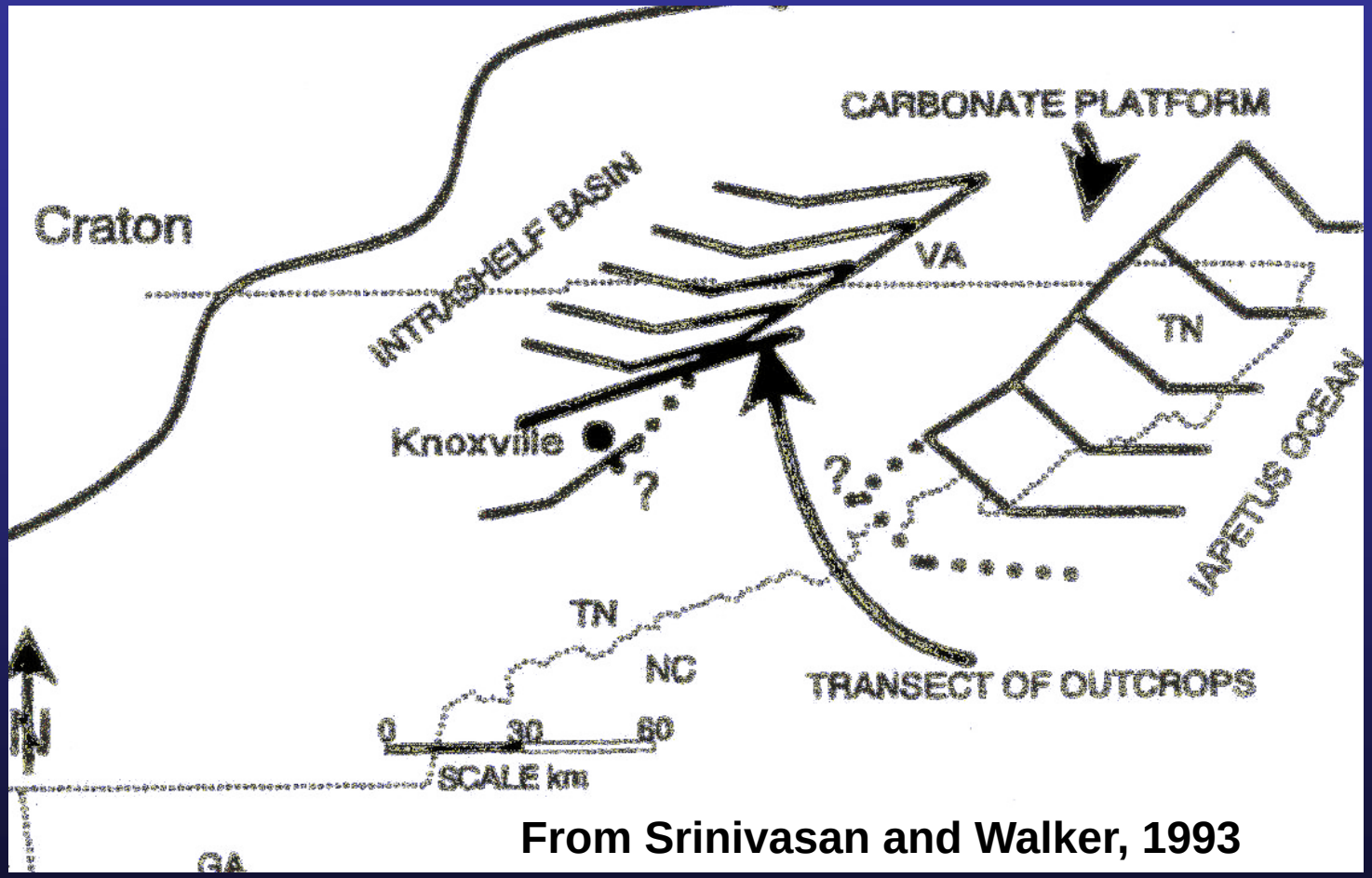
NE
GR
0 200
NPHI
0.-0.1
RHOB
2 3
Pulaski
KY
Jackson
KY
Lee
KY
Wolfe
KY
Johnson
KY
Mingo
WV
Lincoln
WV
1,000 feet
HS=175000
PETRA 10/1/2004 6:29:01 PM (cross section.CST)

Conasauga Paleogeography



From Srinivasan and Walker, 1993

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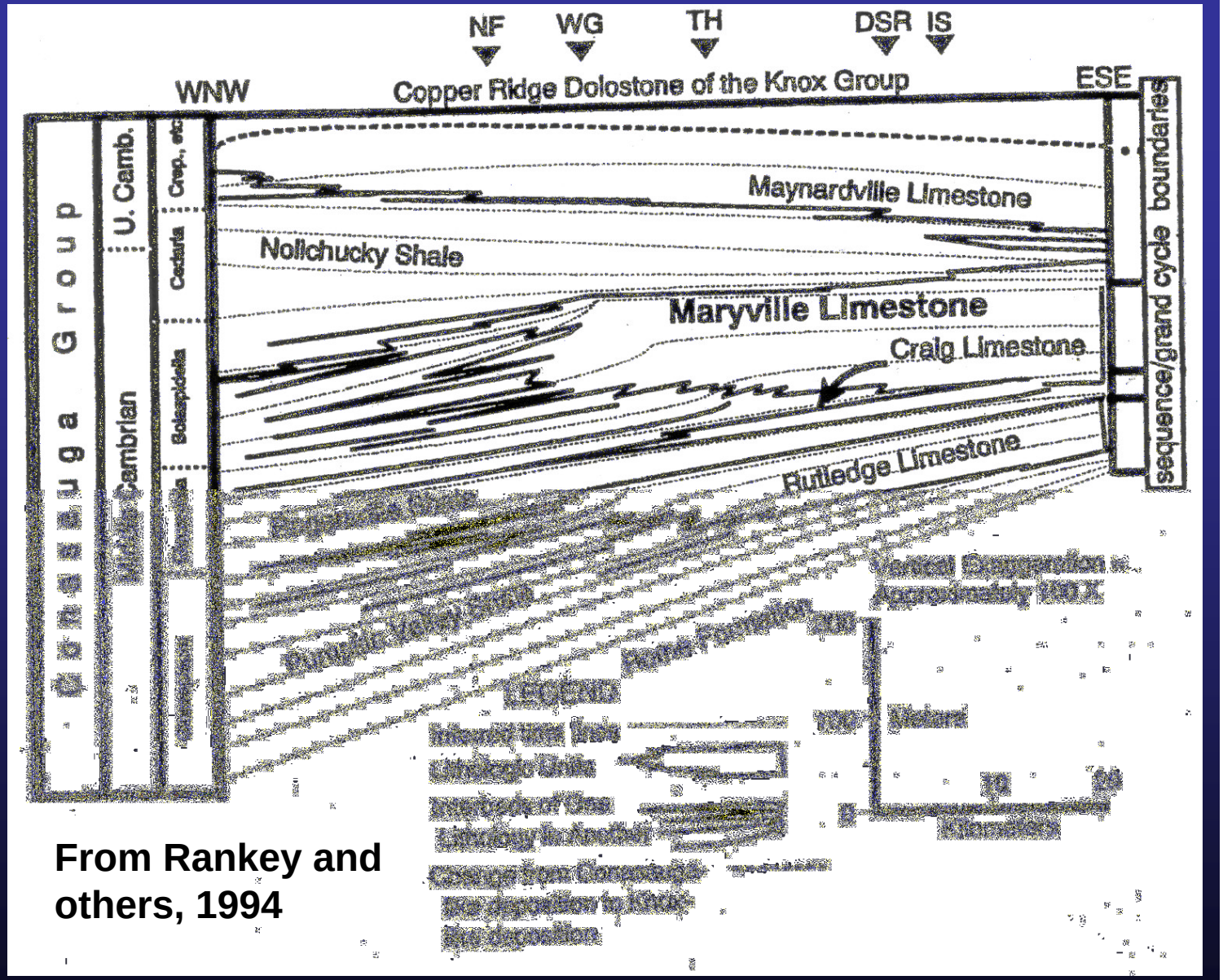
Conasauga Trangressive-Regressive Cycles

Eastern Tennessee Outcrops



From Rankey and others, 1994

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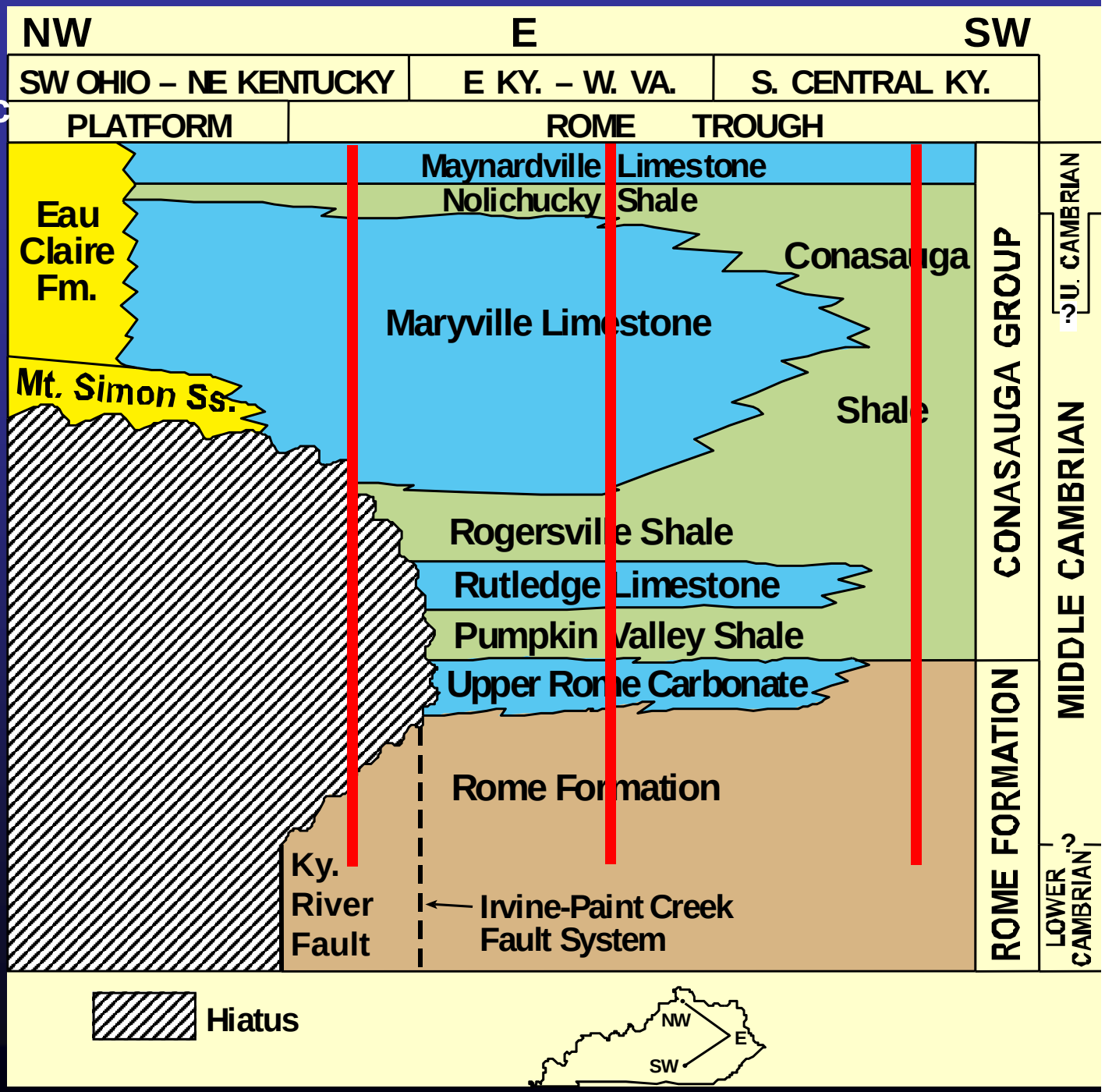
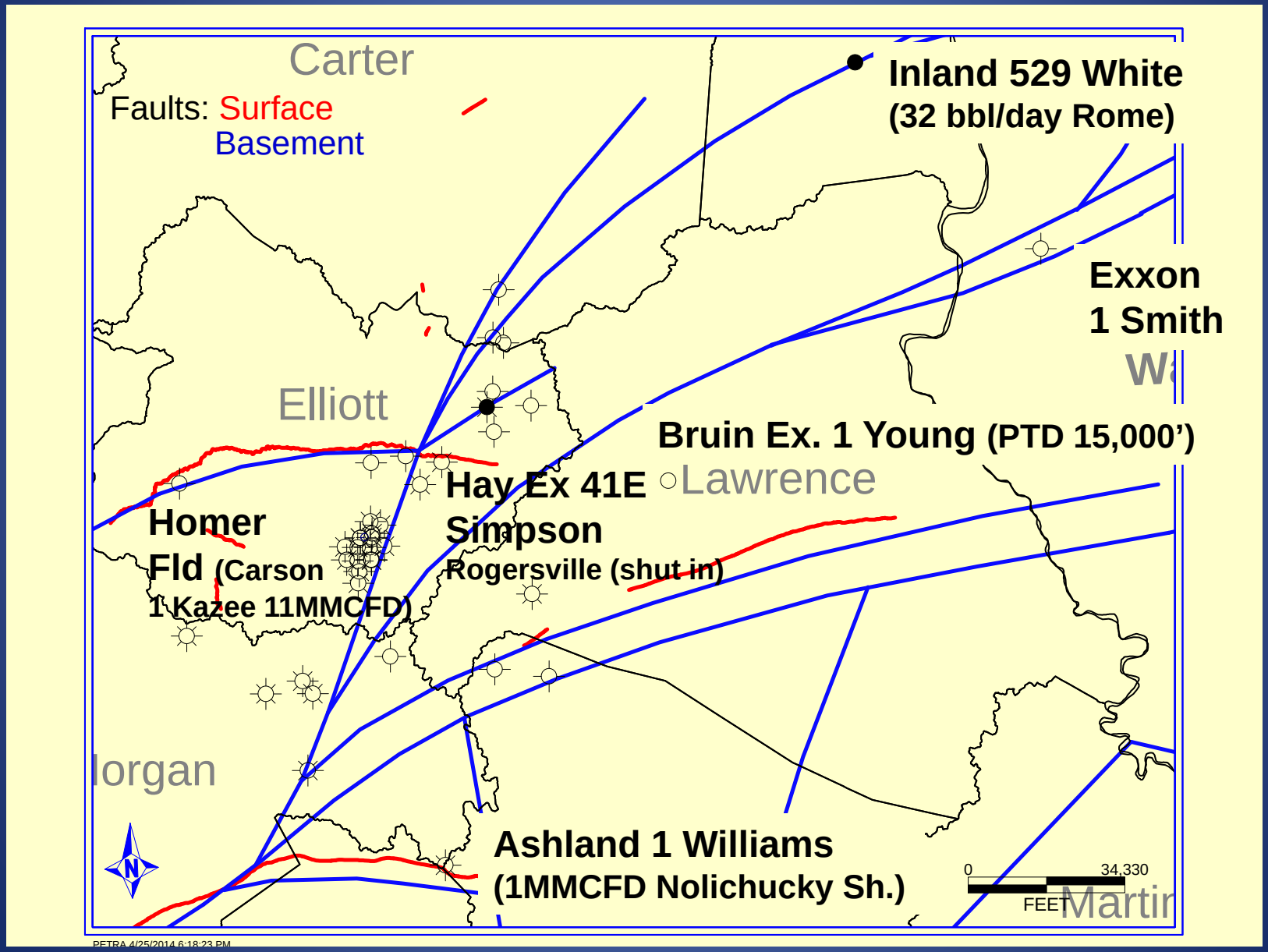
Chronostratigraphic Diagram

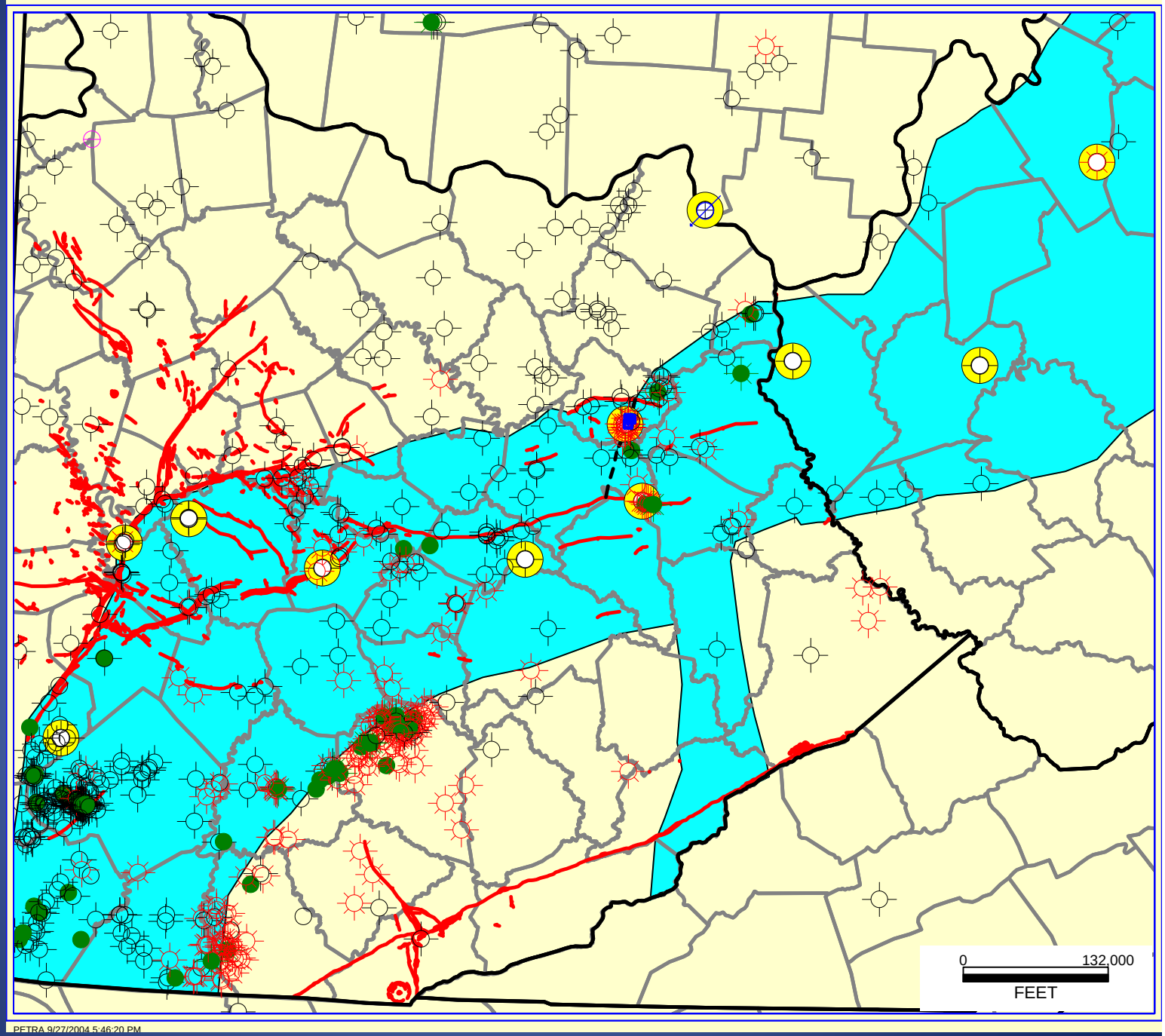
Middle Cambrian, Rome Trough, Eastern Kentucky



Locations of Selected Pre-Knox Wells



Distribution of TOC/ Rock-Eval Analyses



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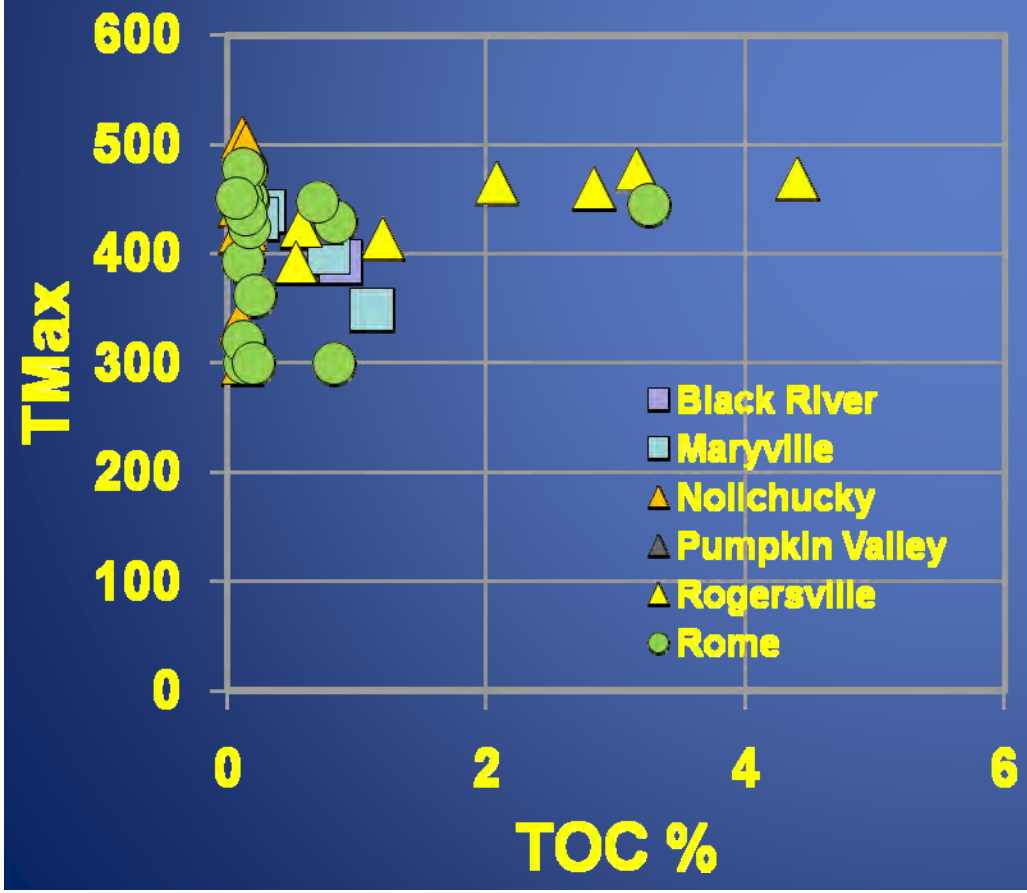
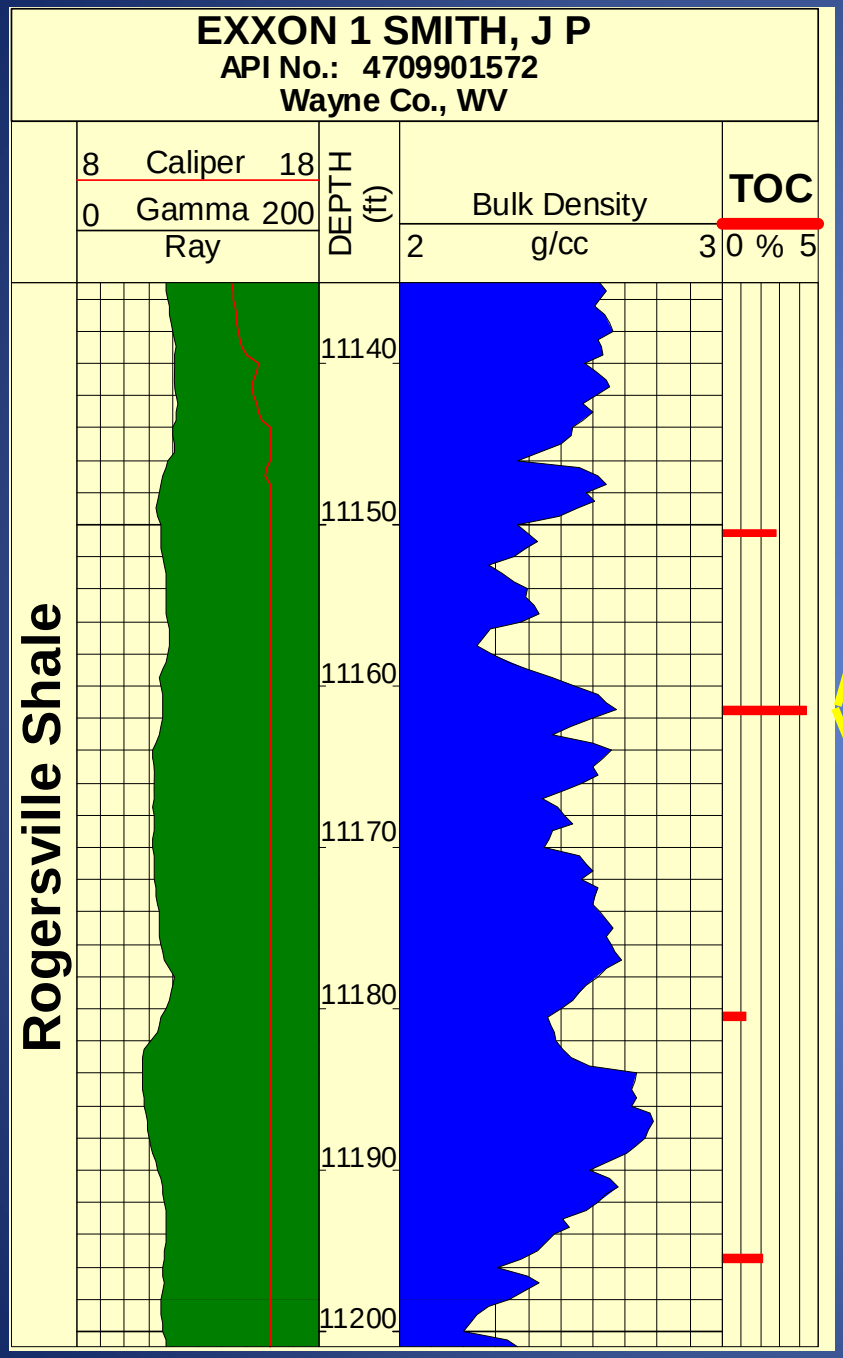
Cambrian Source Rocks in Rome Trough

- USGS Open-File 05-1443
  - http://pubs.usgs.gov/of/2005/1443/



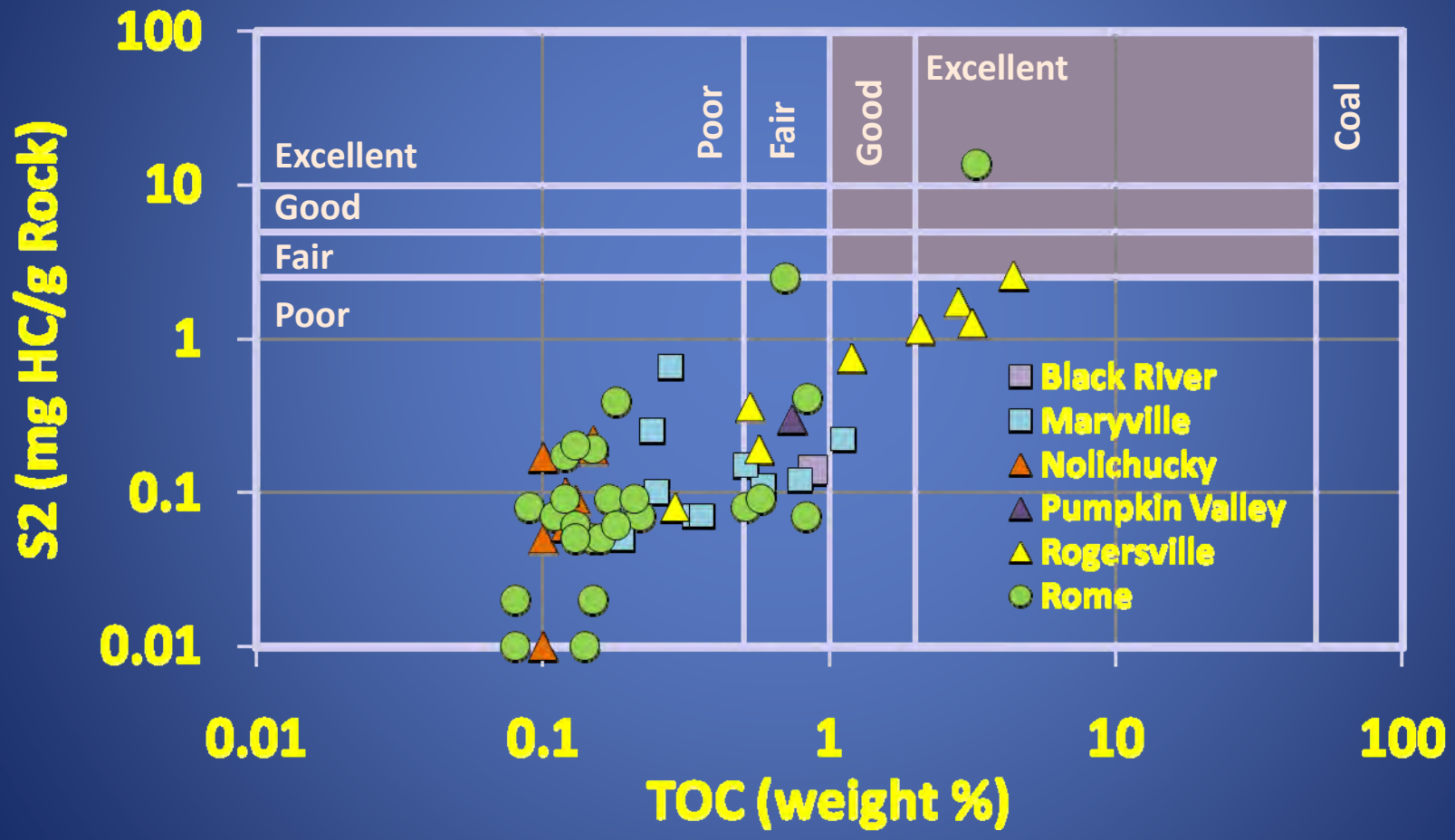
Exxon 1 Smith, WV
Rogersville Shale, 11,175.5 ft.



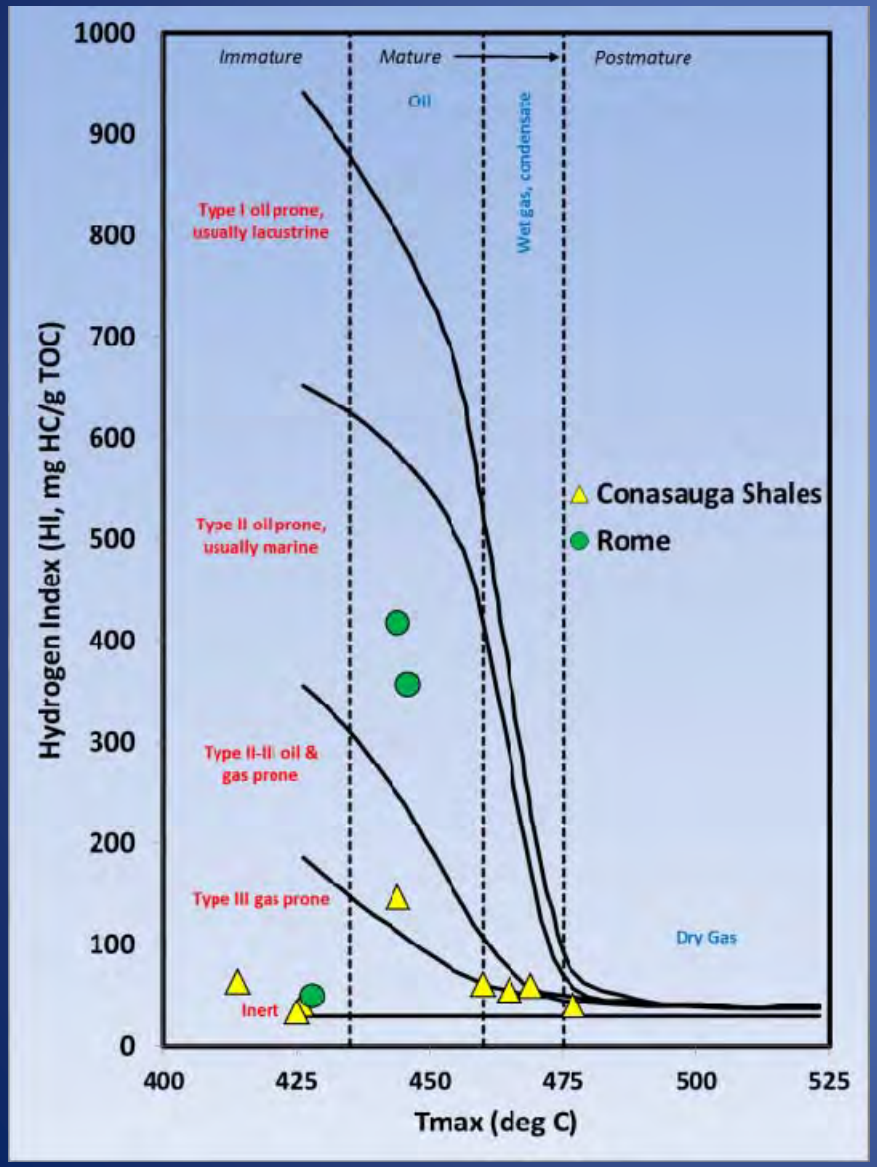
TOC range 1.2–4.4%, n=4

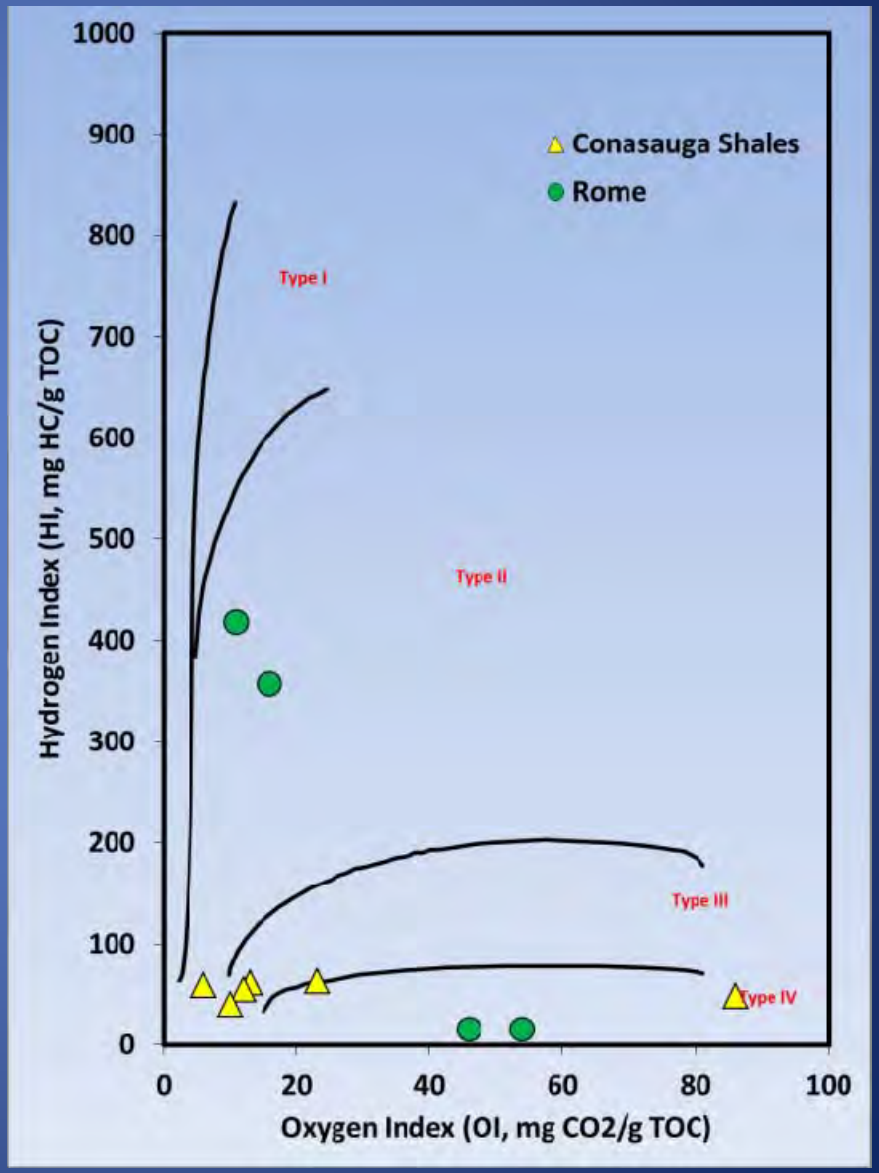
Rogersville Core, Exxon Smith

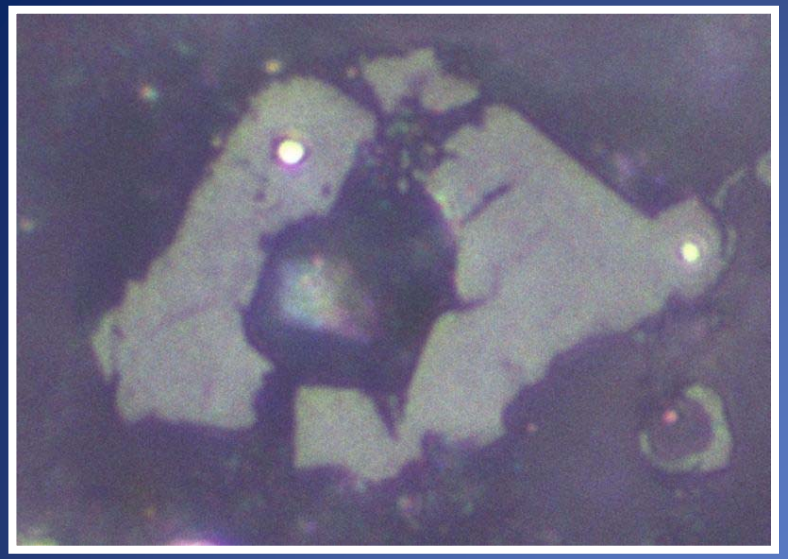
Maturity

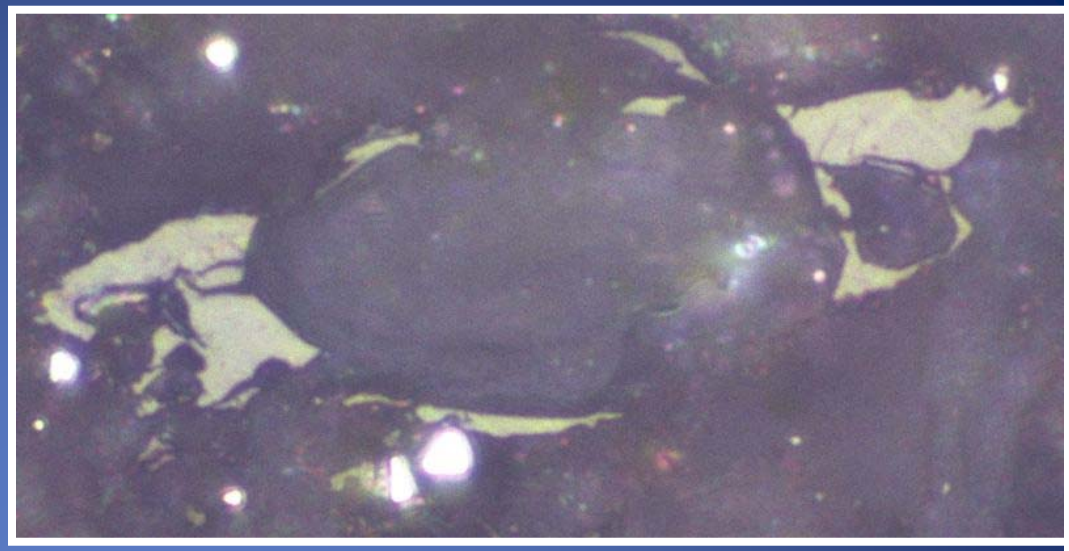

100
10
1
0.1
0.01
S2 (mg HC/g Rock)
Excellent
Good
Fair
Poor
Poor
Fair
Good
Excellent
Coal
Black River
Maryville
Nolichucky
Pumpkin Valley
Rogersville
Rome
0.01
0.1
1
10
100
TOC (weight %)

RTC Maturity and Kerogen Data

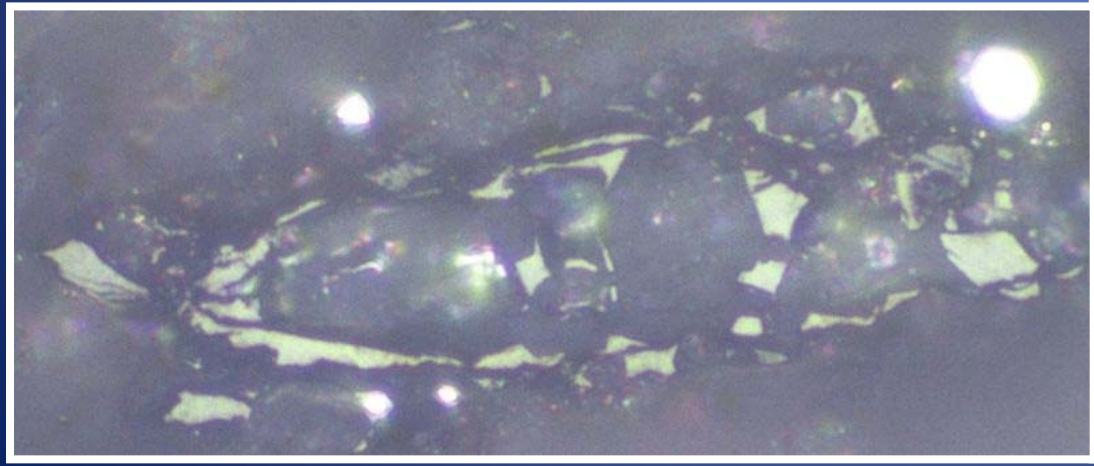


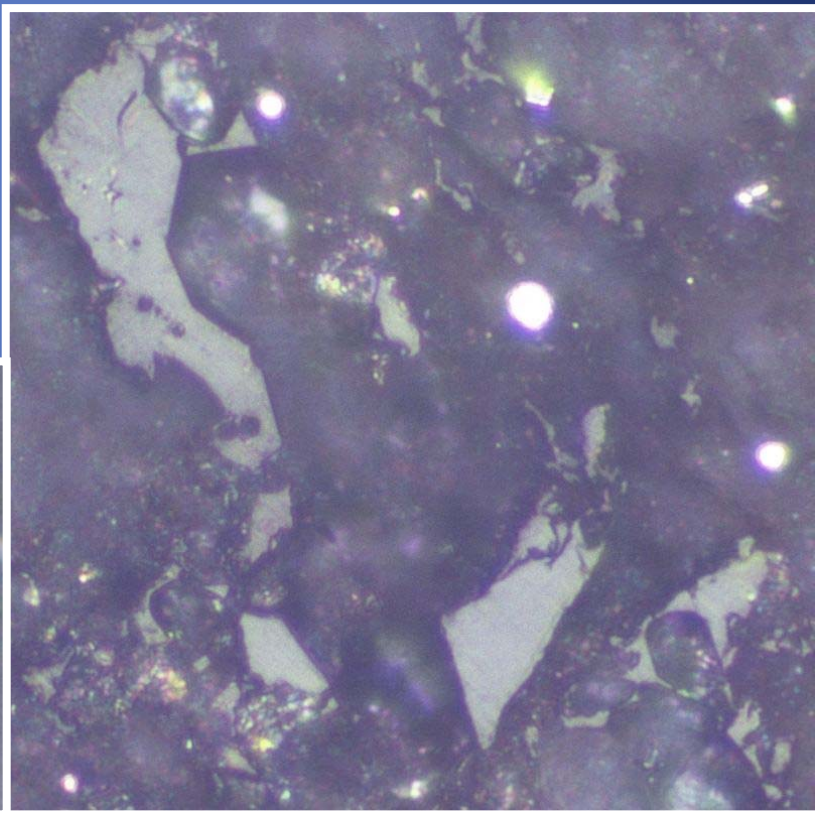




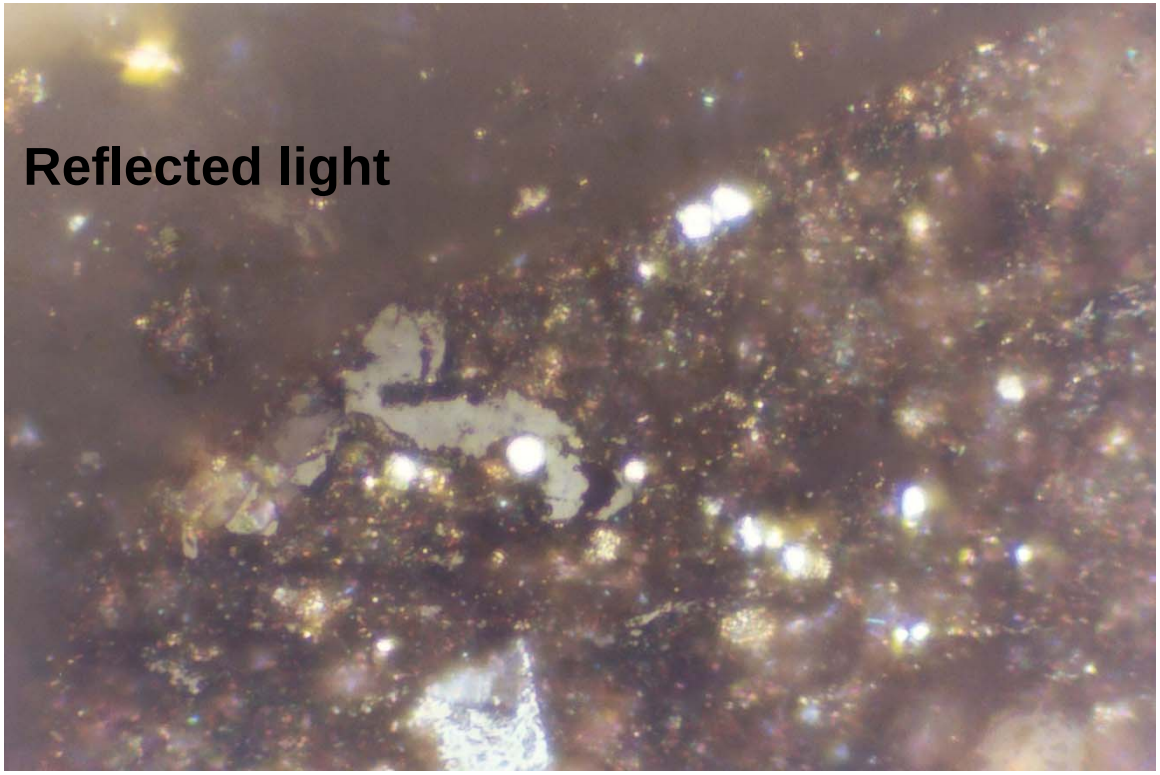


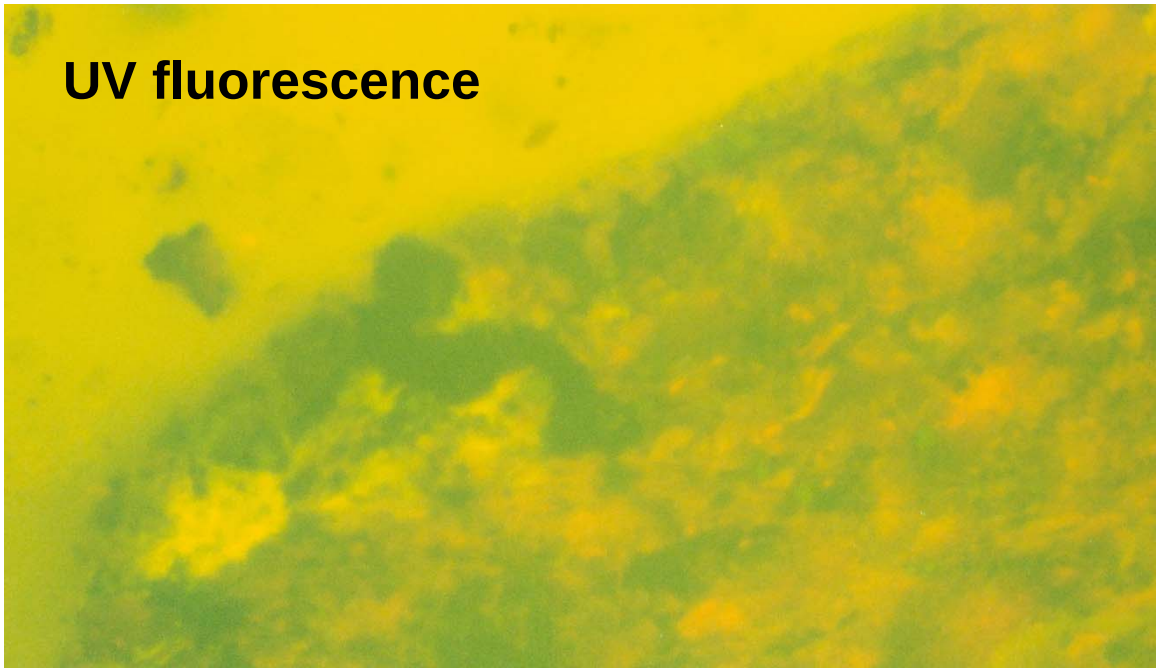
“Vitrinite-like” macerals

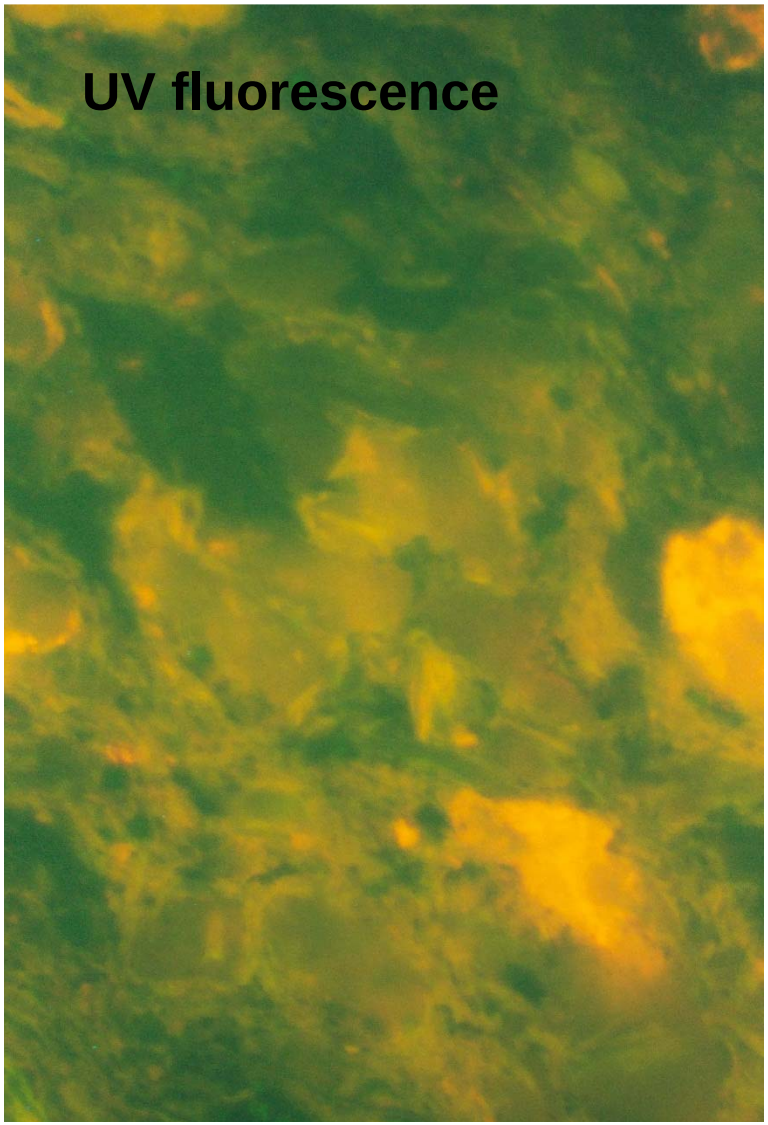




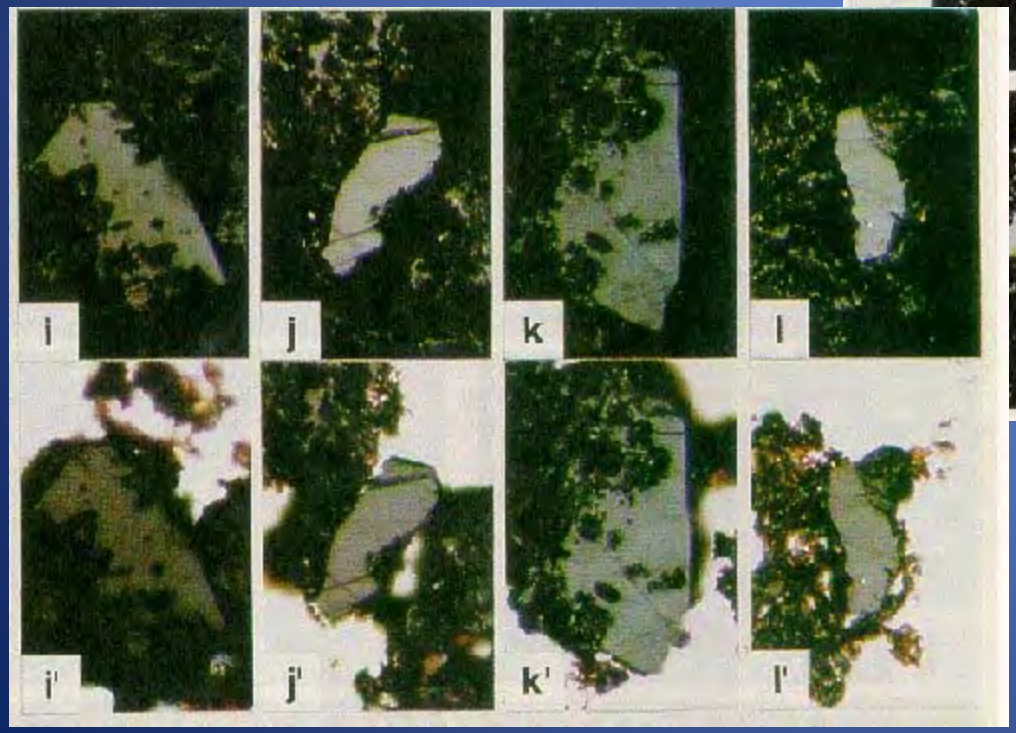
Exxon Smith Rogersvile Shale Organic petrology

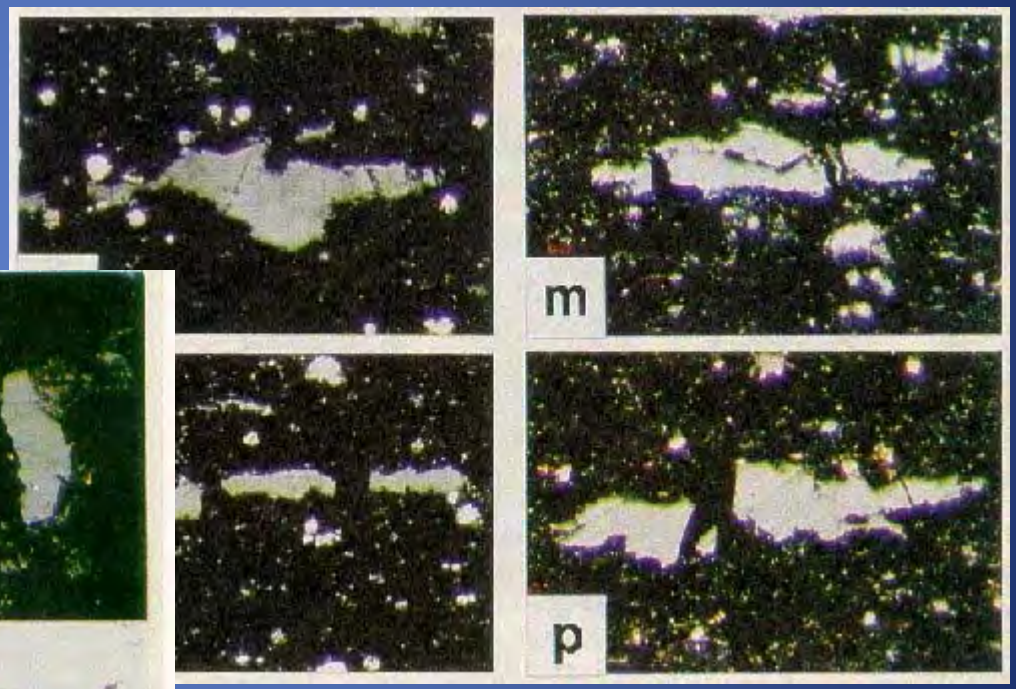






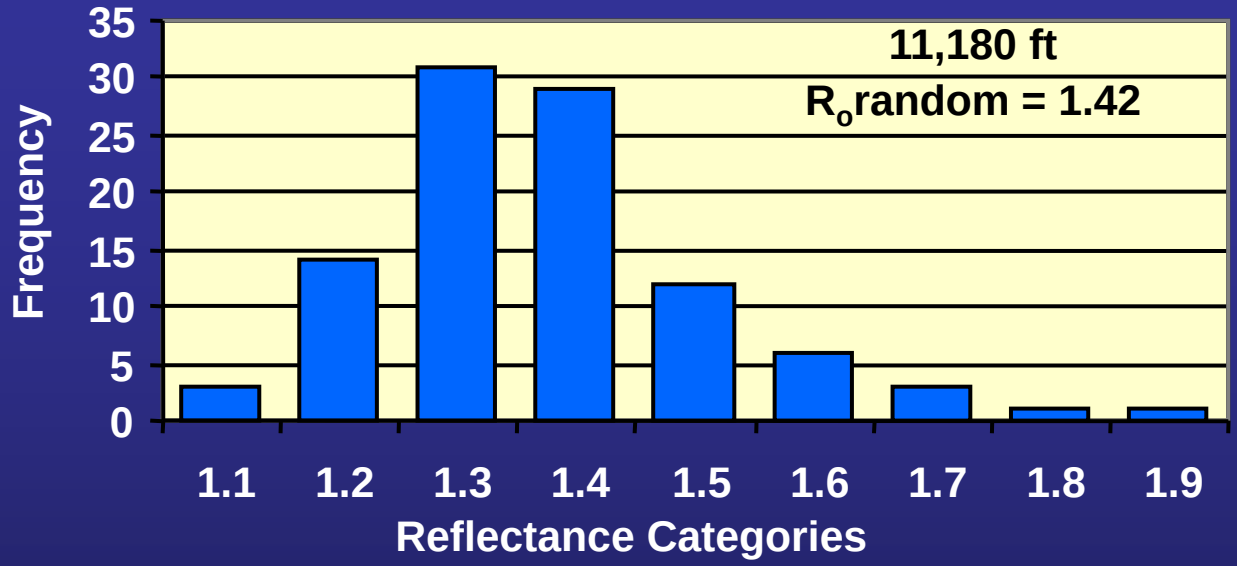
Vitrinite-like macerals from the Cambrian Alum Shale, Scandinavia

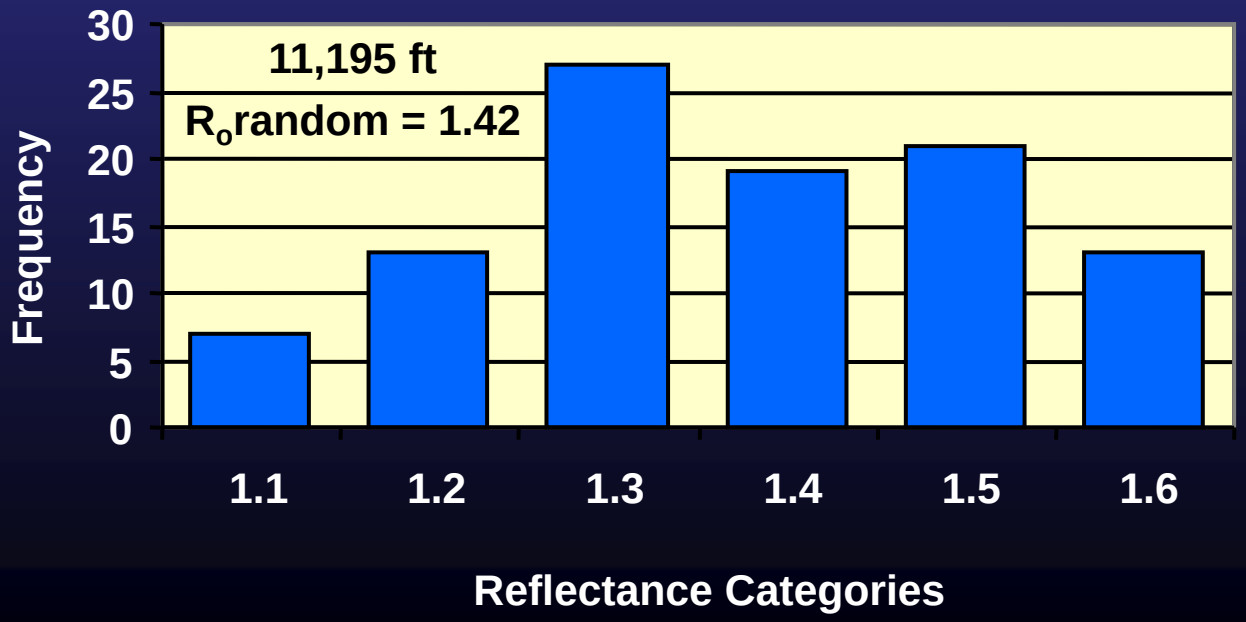




From Buchardt and Lewan, 1990

Exxon Smith vitrinite-like reflectance measurements indicate wet gas window





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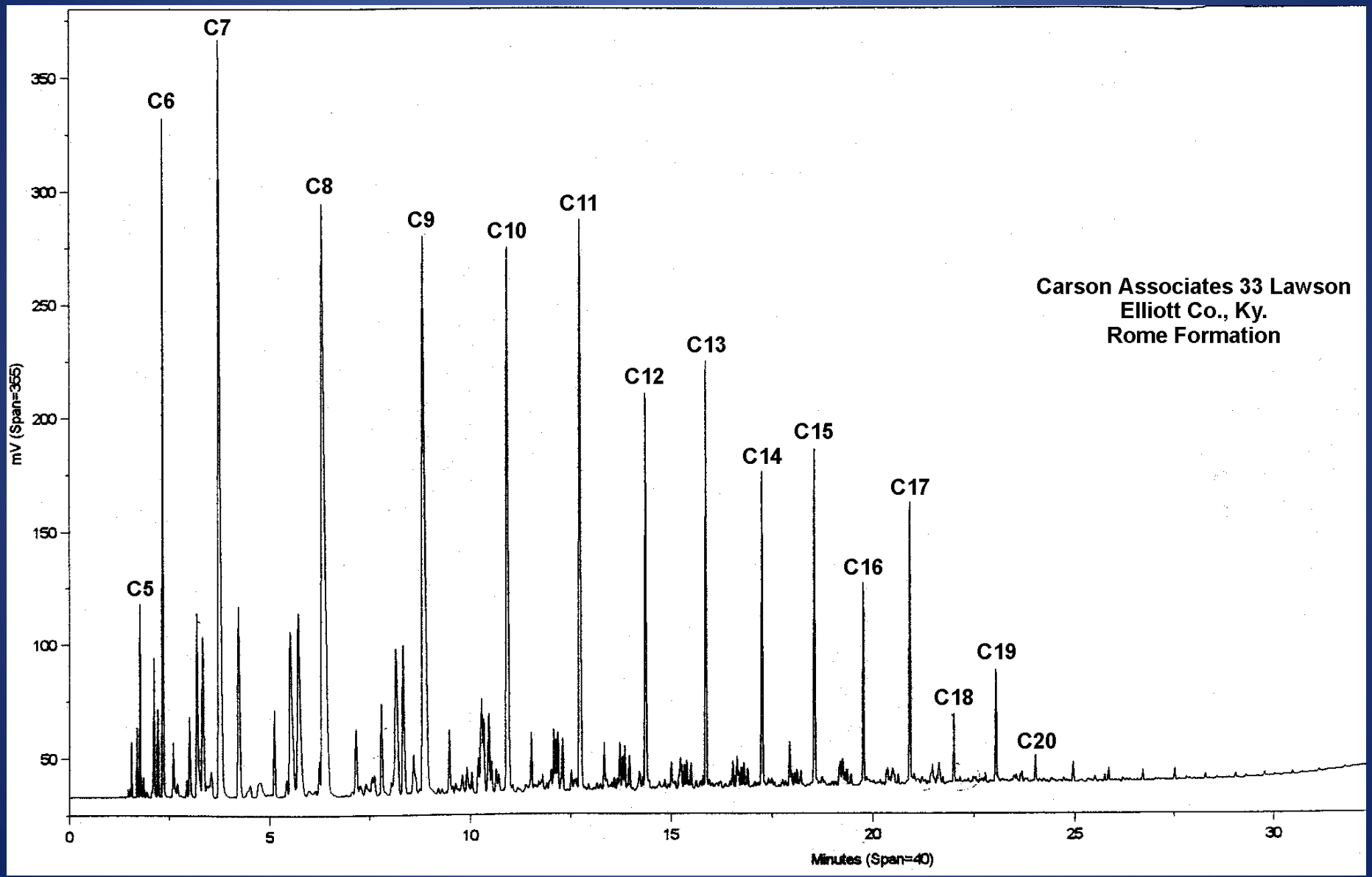
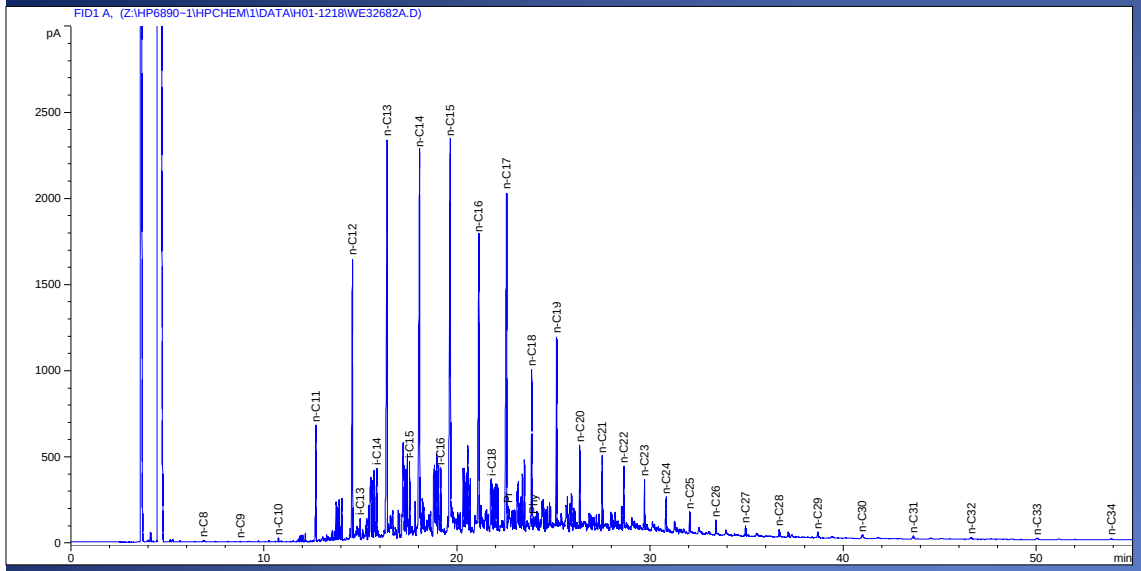
Characteristics of Ordovician (and Cambrian?) Oils

- Odd carbon normal paraffins predominate
- Low abundance of normal paraffin's > C_{20}
- Very low concentrations of pristane and phytane
- Organic source attributed to *G. prisca*
  - well-documented in Ordovician; not so in Cambrian

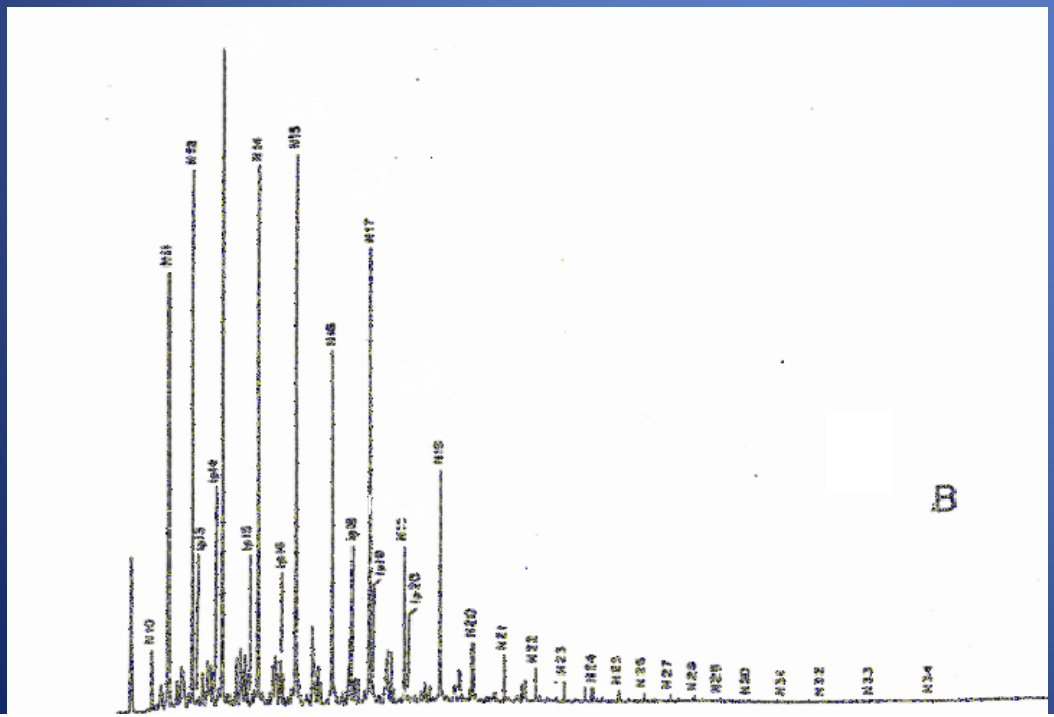
Rome oil composition



Oil – Source Rock Correlation

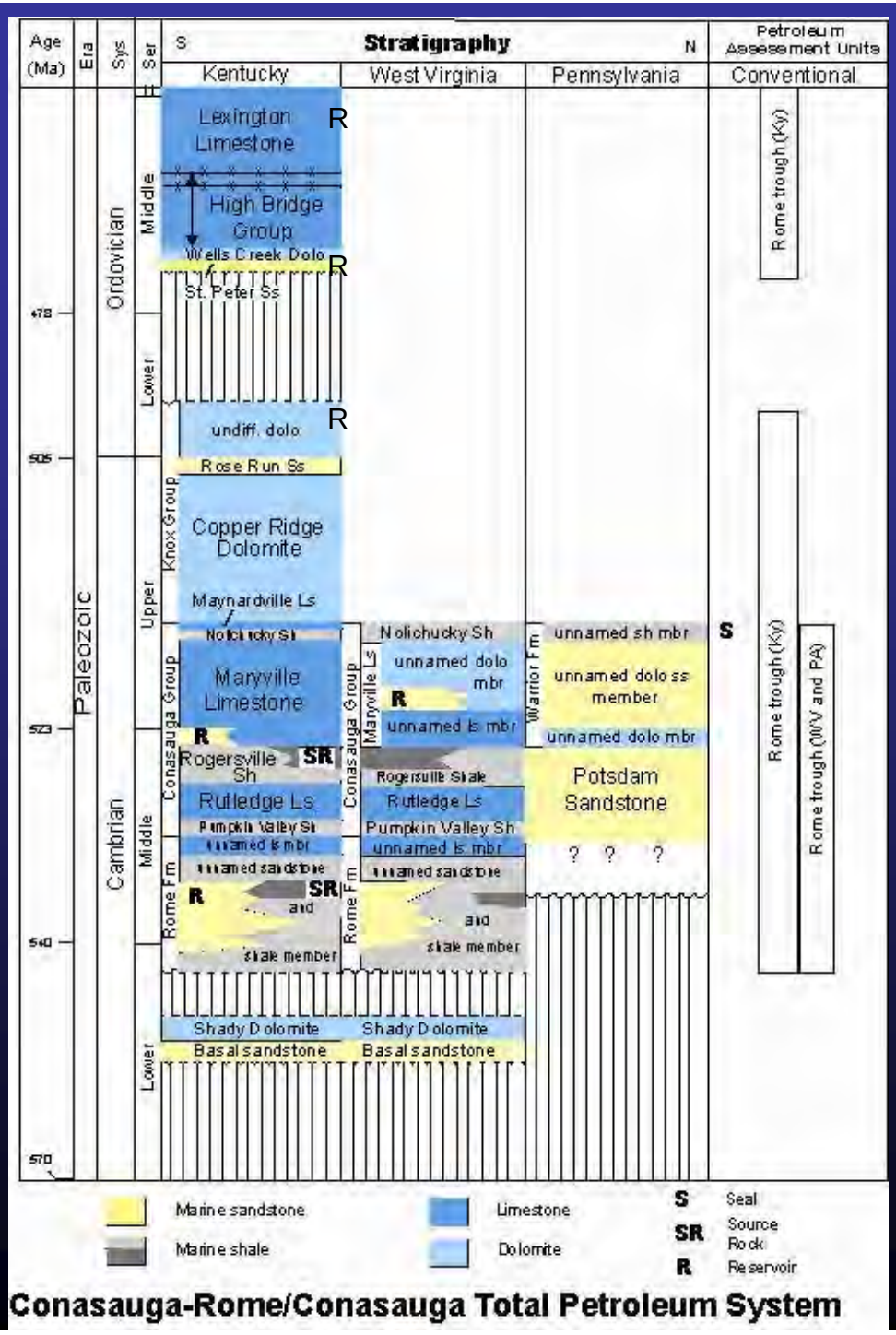


Bitumen Extract - Rogersville Shale
No. 1 Smith
Wayne Co., WV
11,161.5 ft



Oil*– Maryville Limestone
No. 529 White
Boyd Co., Ky
7,574 – 7,598 ft

***Data provided by Richard W. Beardsley**



Conasauga-Rome/Conasauga Total Petroleum System

Conasauga – Rome/ Conasauga Petroleum System

From Ryder and others, 2005
USGS open file report

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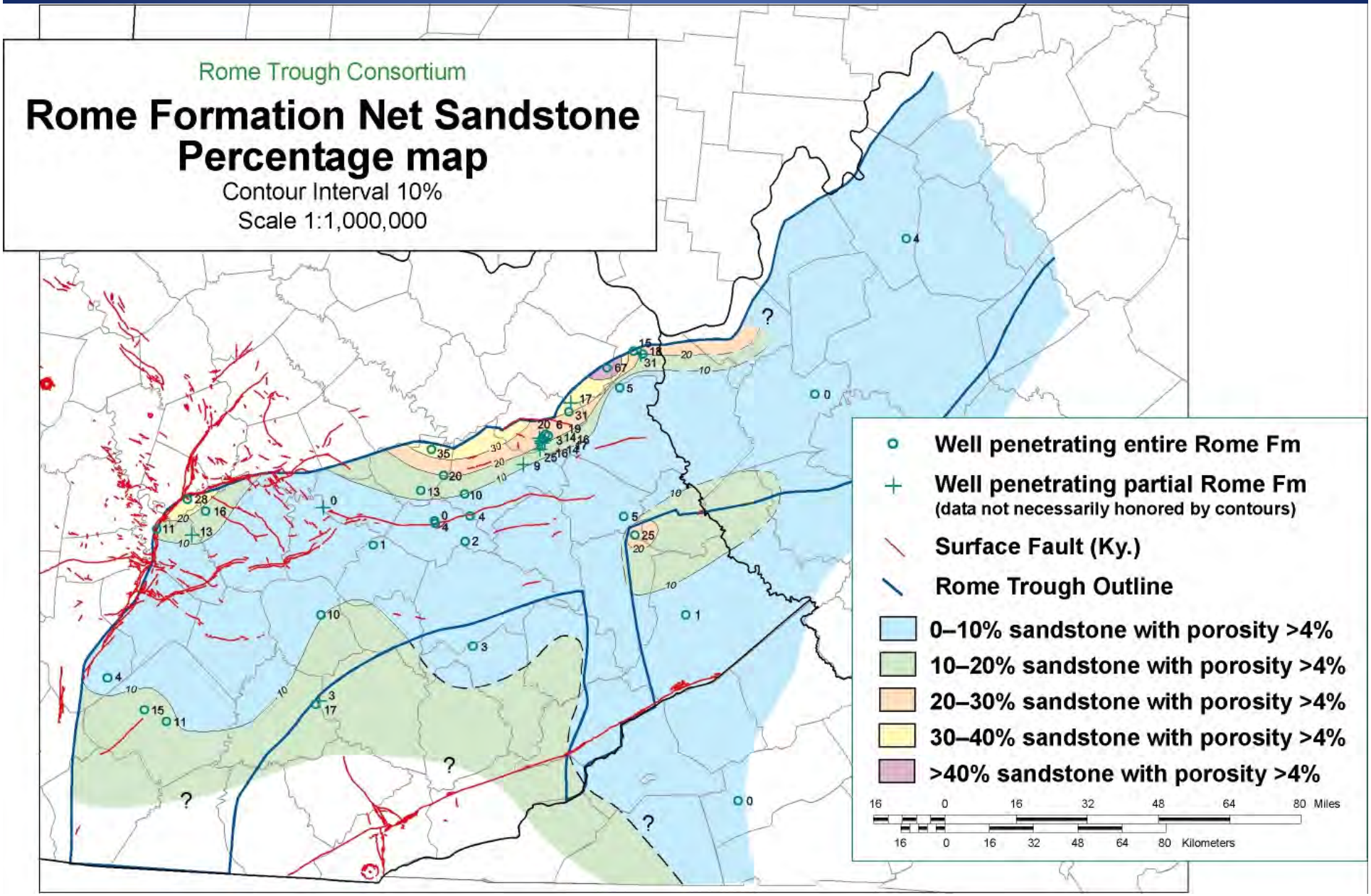
Rome Trough Conventional Play



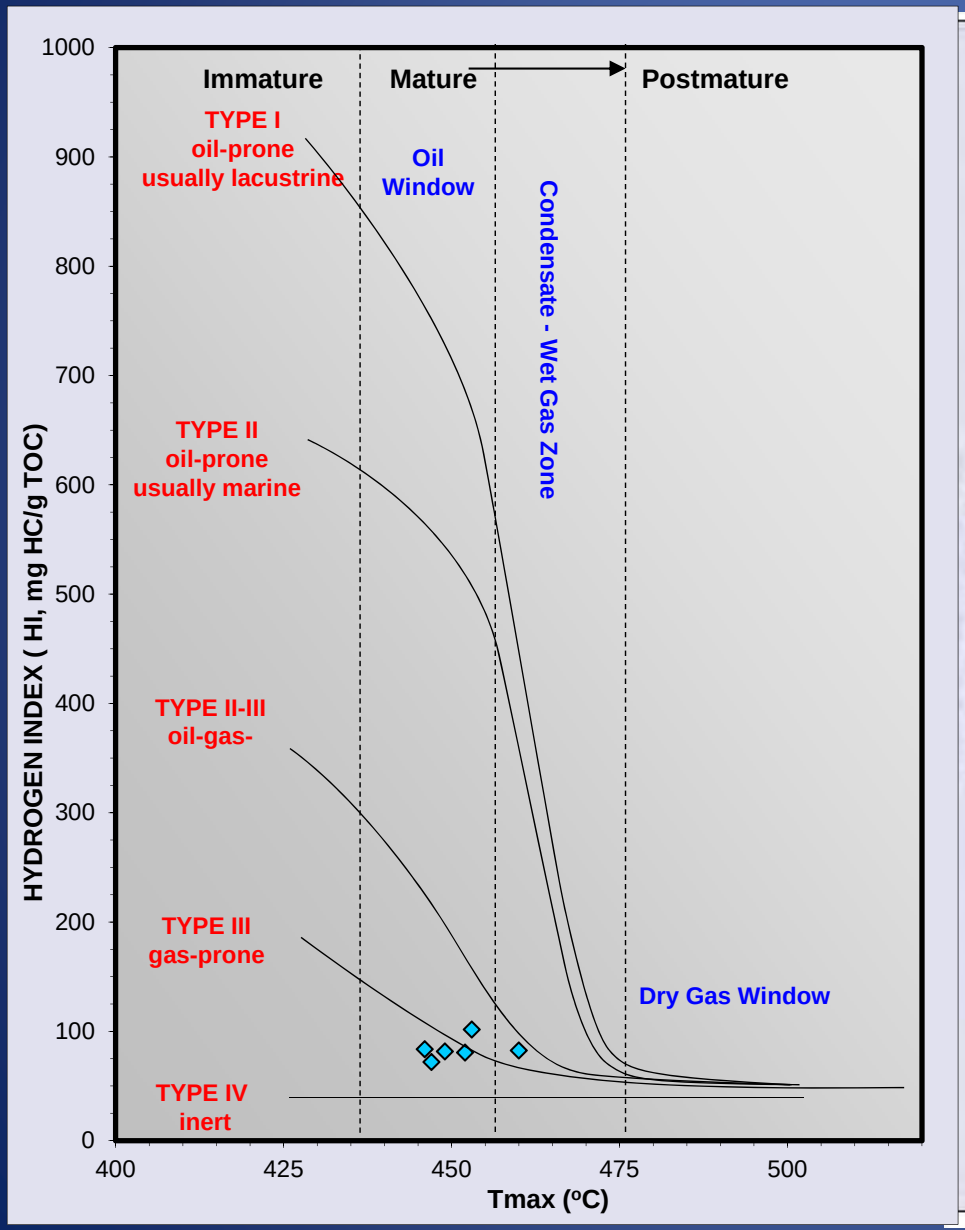
New TOC/Rock-Eval Data

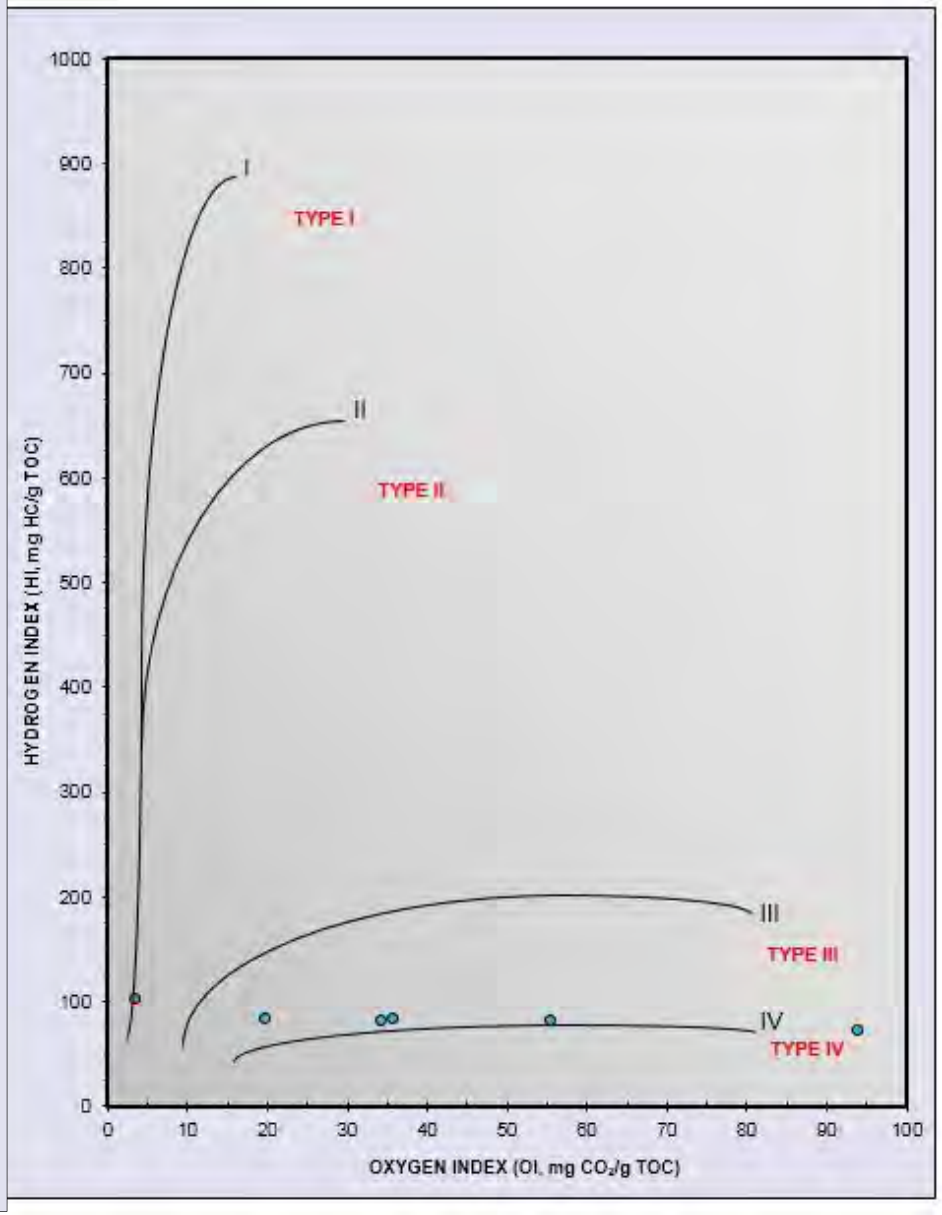
- GeoMark data set, 2007
  - 2 wells sampled, Exxon Smith core and Monitor C. Ison in Elliott Co.
    - Confirmed TOC in Exxon Smith core (1.3 and 2.4%)
    - 4 Rogersville Shale samples in the Monitor C. Ison well
      - 3 were lean (0.3-0.4%)
      - 1 was very rich (5.9%, confirmed in duplicate analysis 5.7%)
- Talisman data set, 2009
  - Rock-Eval/TOC for 96 cuttings samples, 8 Ky. wells
  - 10 samples with TOC > 1%, max= 7.2 in Nolichucky

New TOC/RE Data (cont.)

- KGS-industry RE/XRD study, 2010
  - Ten additional Rock-Eval/TOC and XRD for Smith and Williams cores
  - 6 Rogersville samples (Smith) ranged from 1.3 to 4.8% TOC
  - 4 Nolichucky samples (Williams) were all lean (0.12-0.16% TOC)
- Petro-Hunt data set, 2011
  - Rock-Eval/TOC data for 137 samples, 12 Ky. wells
  - Disappointing results: highest TOC was 0.24%

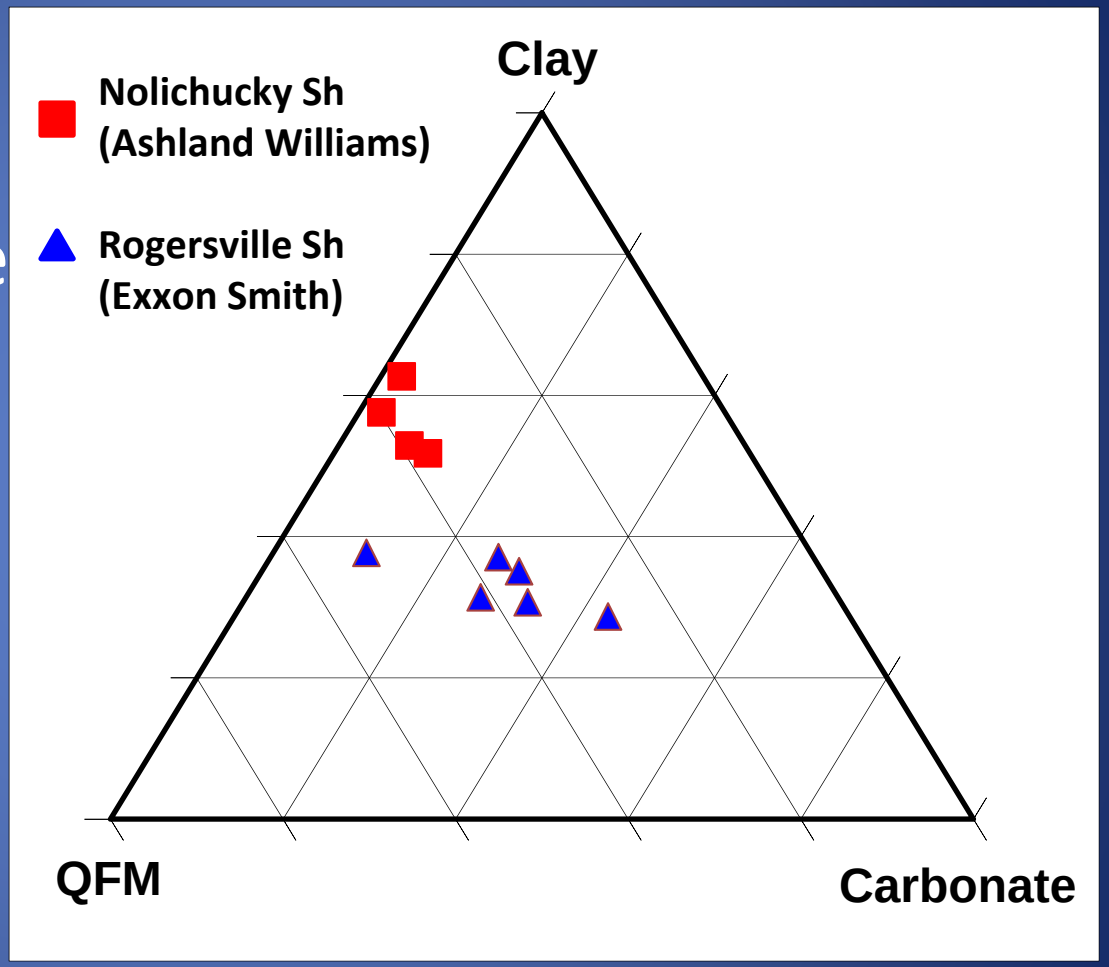
2010 KGS Data, Exxon Smith





Shale Mineralogy

- X-ray diffraction data for 10 samples from the Rogersville and Nolichucky shales
- Rogersville has less clay and more quartz & carbonate than Nolichucky, increasing brittleness



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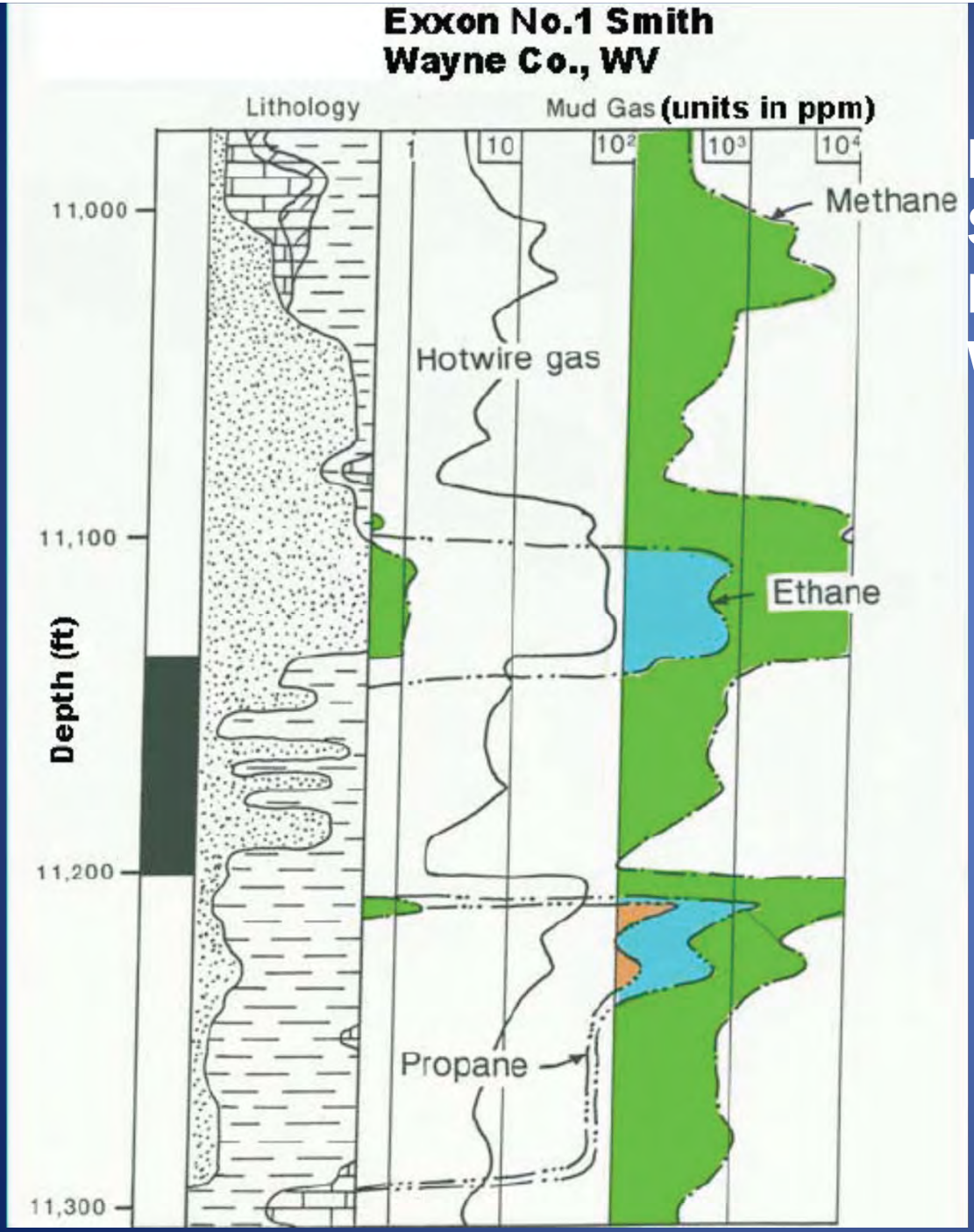

Mud log over Rogersville Shale Interval, Exxon #1 Smith Wayne County, WV

From Ryder and others, 2005
USGS open file report

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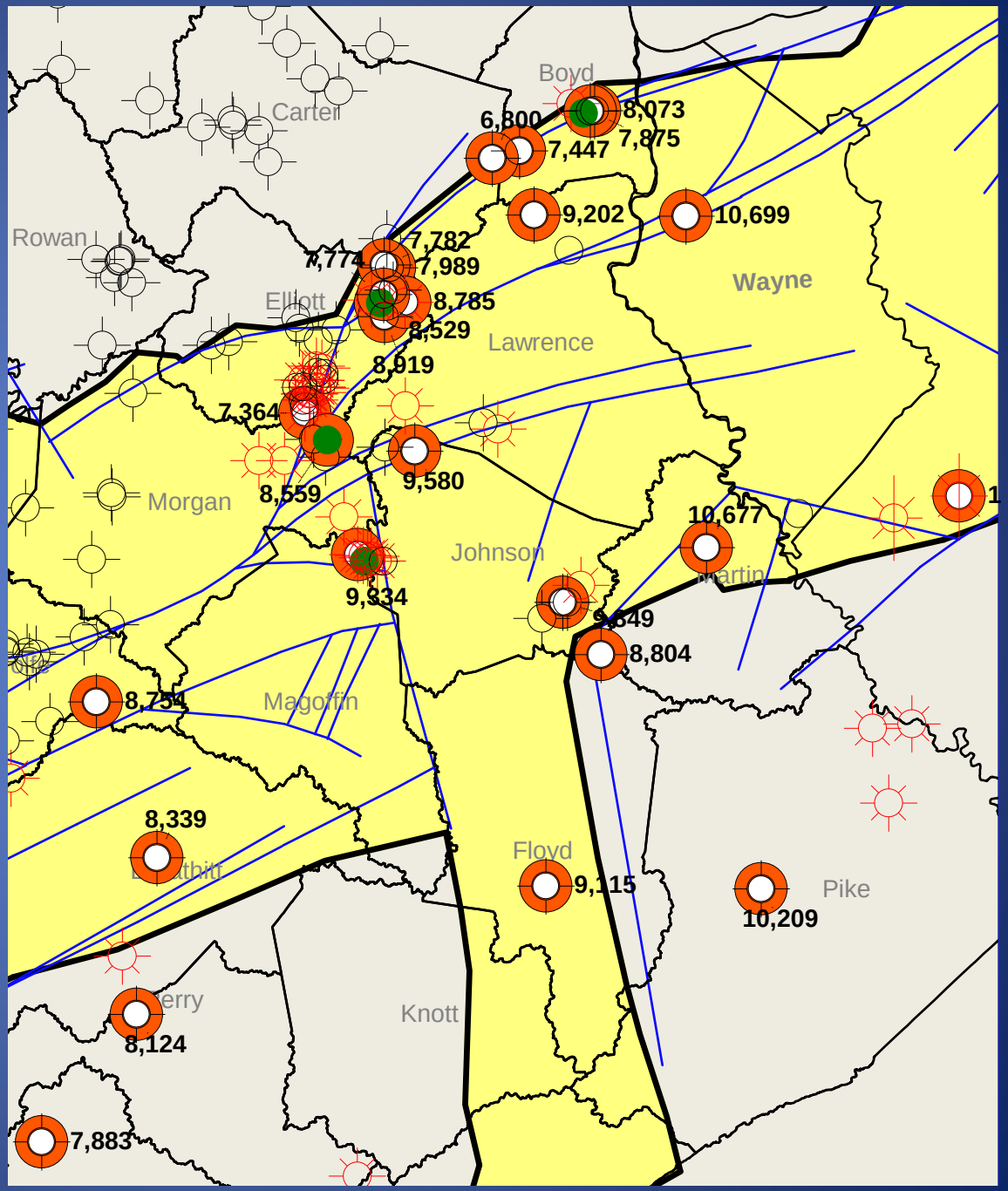
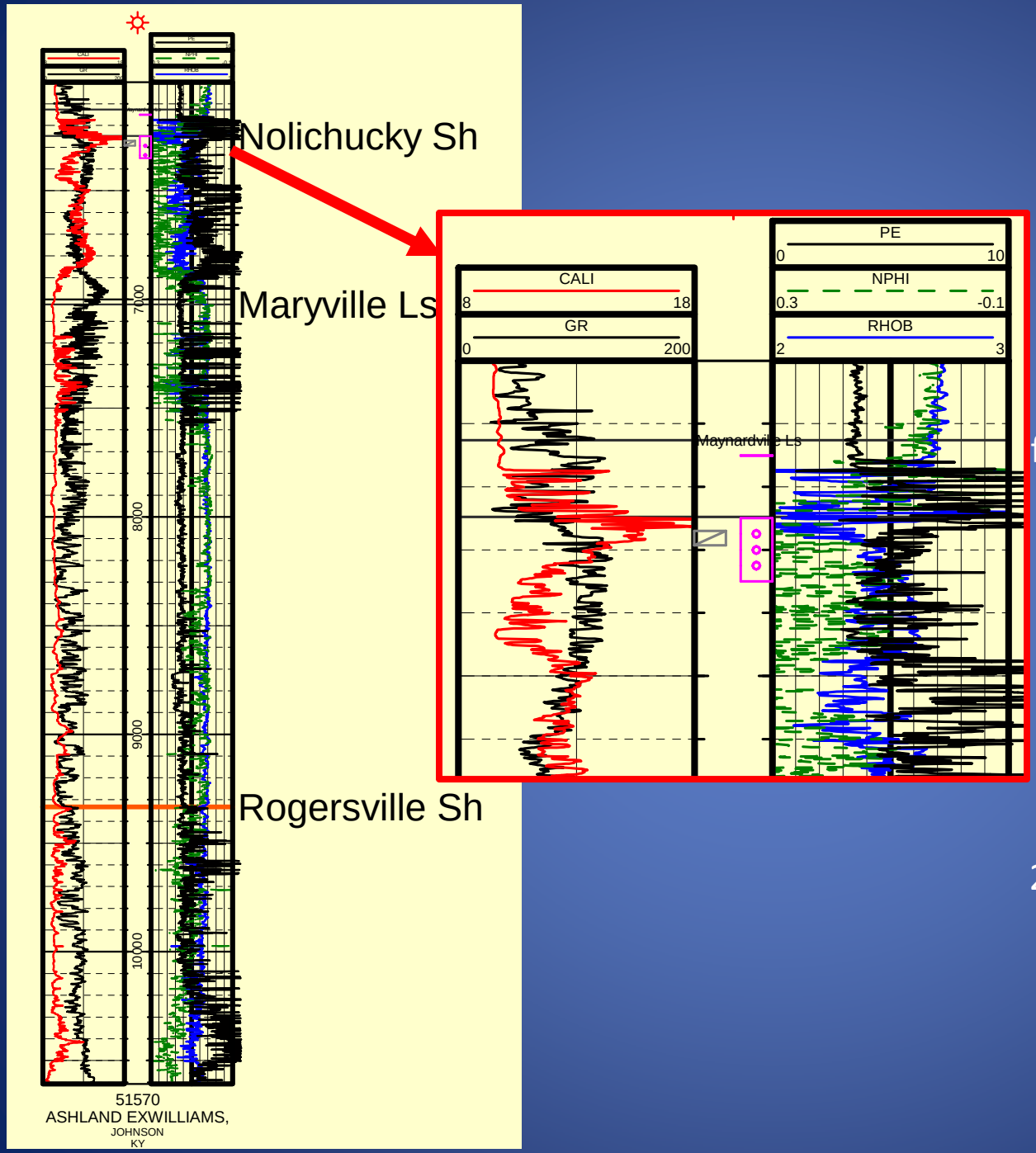
Distribution and drilling depth of Rogersville Shale



Ashland #1 Williams, Johnson Co.



IP 1.05 MMCFD from fractured Nolichucky Shale @ 6,200 ft

1.2BCF with 42,000 bbl condensate since 1985

Core in Nolichucky, but low TOC - not the source

2011 Production: 7.7 MMCFG with 171 bbl condensate

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Rogersville Shale Test:
Hay Exploration 41E Simpson
Permit 105679, 16-T-79, Elliott County

- 3 miles south of Monitor Freddie Ison well
- Drilled 2009 to 8,842 ft in Rogersville Shale
- Ran 4 1/2 in. casing to TD
- Completion 8,535–8,690 ft in Rogersville, no treatment reported
- No IP reported, well listed as shut-in on 2011 production report

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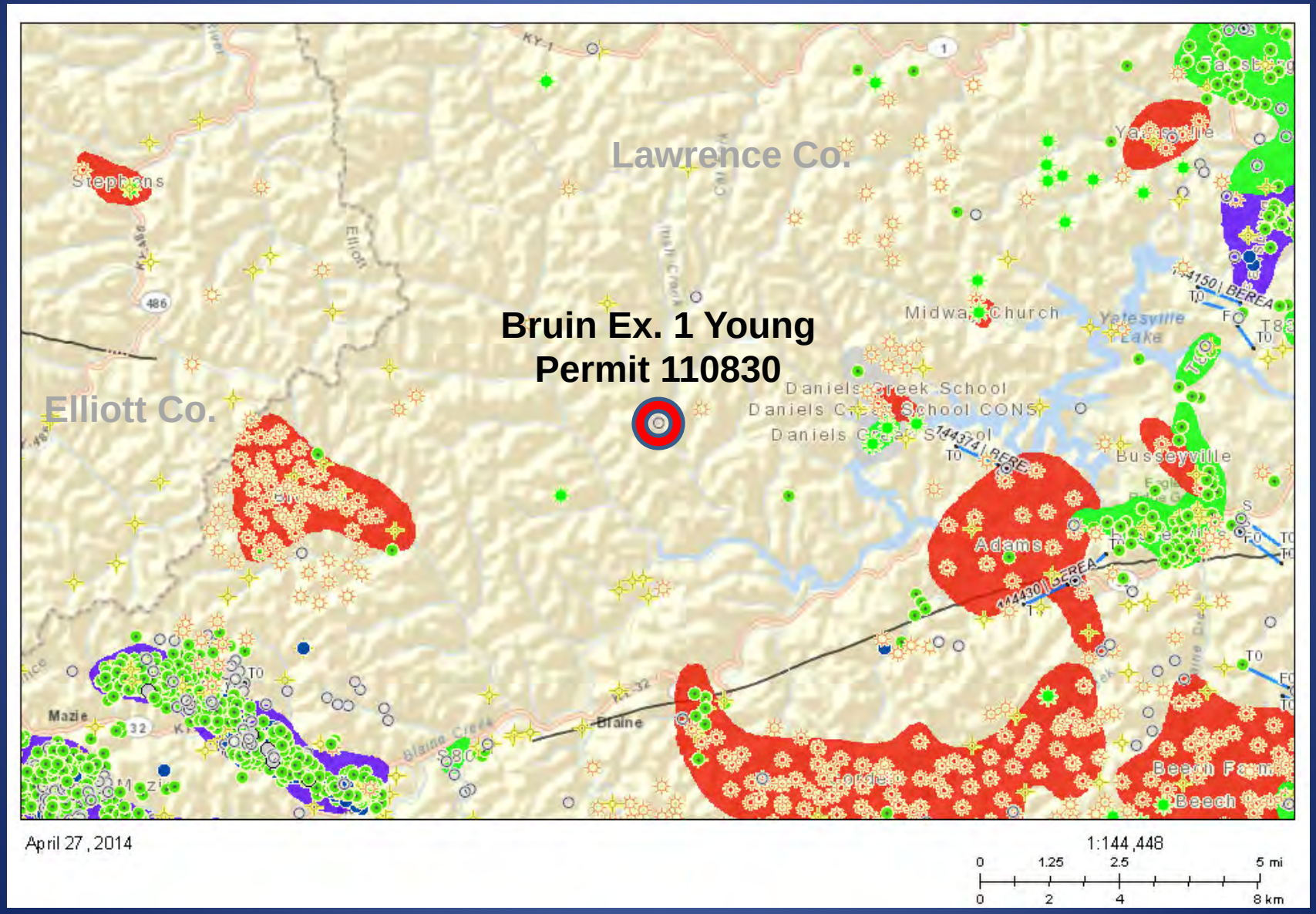
Bruin Exploration #1 Young Lawrence County, Kentucky

- On Irish Creek, W of Yatesville Lake (25-T-81)
- Well permitted as stratigraphic test to 15,000 ft in the Rome Fm. Drilled late 2013, total depth not known.
- Oil and gas permit issued to reopen/test well February 28, 2014 (Permit 110830)
- Testing in progress
- Logs, samples from strat test held confidential for 5 years; data from oil & gas permit up to 1 year if requested

Bruin Ex. #1 Young Location



Rogersville Shale Summary

- 5,000 to 10,000 ft deep in E. Ky.
- 2-4.8% TOC, and has generated gas & condensate
- 868 ft thick in Exxon Smith well, Wayne Co., W. Va.
- Up to 1,100 ft thick in E. Ky., but limited to deeper parts of Rome Trough

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Conclusions

- Consistent stratigraphic framework established for 3-state area helps to predict source rock distribution
- Viable petroleum system exists in Rome Trough. Rogersville Shale (Conasauga Gp) is primary source interval.
- Source rock quality in Rogersville is variable– *not* a uniform rich source. Controls on organic carbon distribution not well understood.

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Conclusions (cont.)

- Rogersville Shale gas or oil play should be possible in higher TOC areas, but need to consider depth and economics.
- Shallower parts of RT in Kentucky likely more liquids-prone than deeper areas in W. Va.
- High nitrogen gas is a risk in western Rome Trough (central Kentucky).

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