

Cambrian Rogersville Shale: A Potential New Unconventional Reservoir in the Southern Appalachian Basin*

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Editor's note: See similar articles [Search and Discovery Article #10764 \(2015\)](#) and [Search and Discovery Article #10787 \(2016\)](#).

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Abstract

Research by the Kentucky, Ohio, and West Virginia Geological Surveys has refined the stratigraphic framework of a Cambrian extensional basin underlying the Appalachian Basin. This graben, called the Rome Trough, is filled with up to 9,000 ft of pre- Knox Group sedimentary rocks. Well log analysis and sample descriptions allowed correlation of the Cambrian Conasauga Group north from outcrops along the Eastern Tennessee Overthrust, across parts of eastern Kentucky, and into the Rome Trough. Regional distribution of these formations and the underlying Rome Formation is controlled by extensional faults that were active during and after Conasauga deposition.

To identify the source of hydrocarbons produced from various Cambrian completions in eastern Kentucky and southern West Virginia, numerous Cambrian shale samples were analyzed from across the Rome Trough. Total organic carbon content of these shales was less than 1 percent for all samples, exception for a core of Rogersville Shale from the Exxon No. 1 Smith well in Wayne County, W.Va. TOC for the Rogersville Shale in this core ranges from 1.2 to 4.4 percent, with Tmax values of 460 to 469°C. Six additional Rock-Eval analyses from the Smith core confirmed the original data, with TOC of 1.2 to 4.75 percent, and Tmax of 446 to 460°C. Low hydrogen indices and Tmax data indicate a thermal maturity in the wet gas-condensate window.

The Rogersville Shale is a dark gray fissile shale, interbedded with thin laminated and bioturbated siltstone. Hydrocarbon extracts from the No. 1 Smith core are geochemically very similar to produced condensate from Elliott and Boyd County, KY., and suggest the Rogersville was the source of gas and condensate in the Homer Field.

Challenges in developing a Rogersville Shale play include interpreting structure and stratigraphy in the deeper fault-segmented parts of the Rome Trough and predicting the distribution of organic-rich intervals. The Rogersville Shale ranges in thickness from under 200 to around 1,200 ft, and in depth from approximately 5,500 to 18,000 ft below surface. Interest in the unconventional resource potential of the Rogersville is increasing; eight deep tests have been permitted in the last 18 months.

Selected References

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Thomas, W.A., 2006, Tectonic Inheritance of a Continental Margin: *GSA Today*, v. 16/2, p. 4-11.

Thomas, W.A., 1991, The Appalachian-Ouachita Rifted Margin of Southeastern North America: *Geological Society of America Bulletin*, v. 103, p. 415–431.

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Kentucky Geological Survey - University of Kentucky



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September 21, 2015

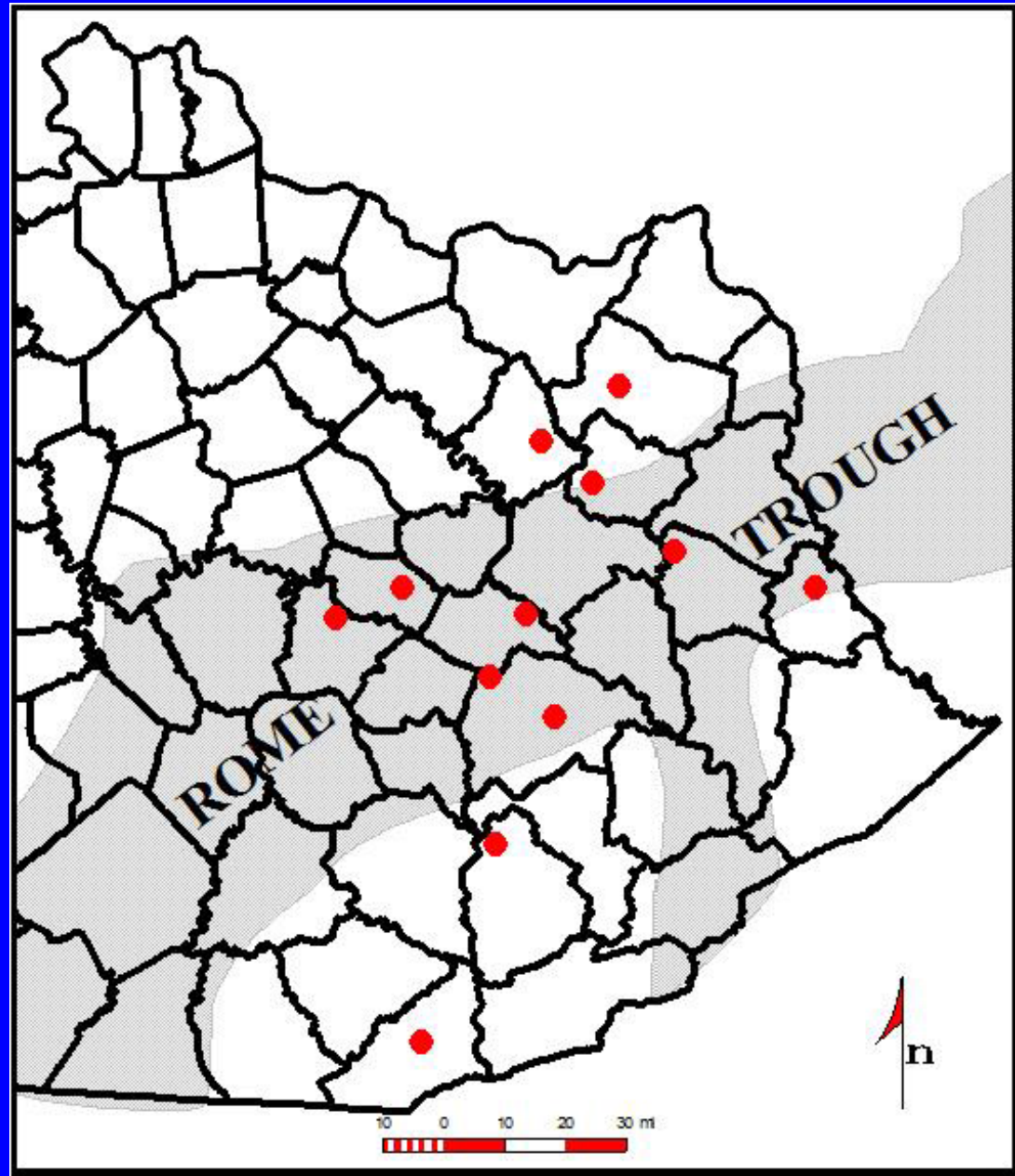


The elusive nature of Cambrian oil and gas exploration in Appalachia

Past Cambrian exploration in Kentucky

Pre-1960

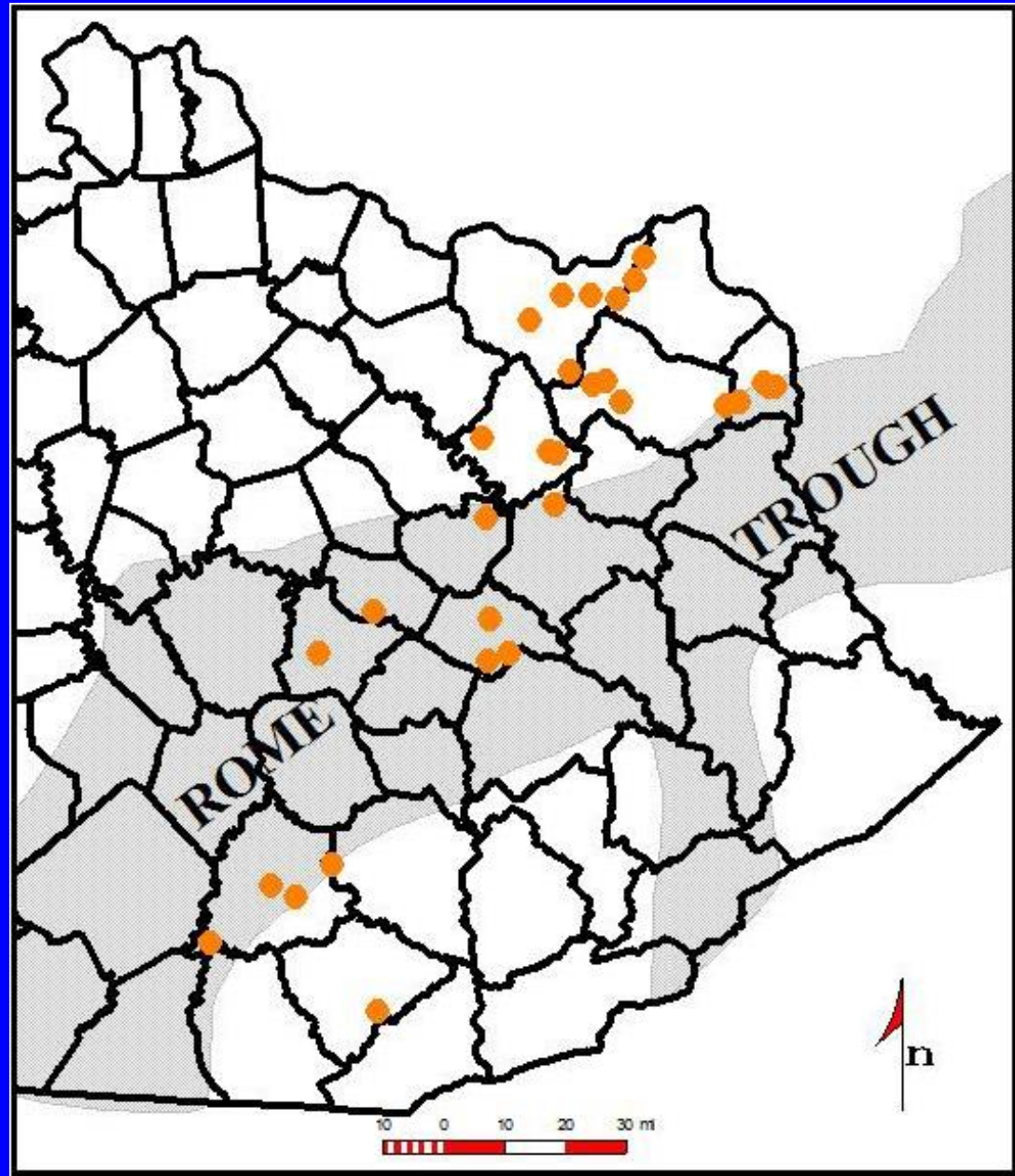
Image courtesy of J. Jenkins, Abarta Energy



Past Cambrian exploration in Kentucky

1960's wells

Image courtesy of J.
Jenkins, Abarta Energy



Past Cambrian exploration in Kentucky

1970's wells

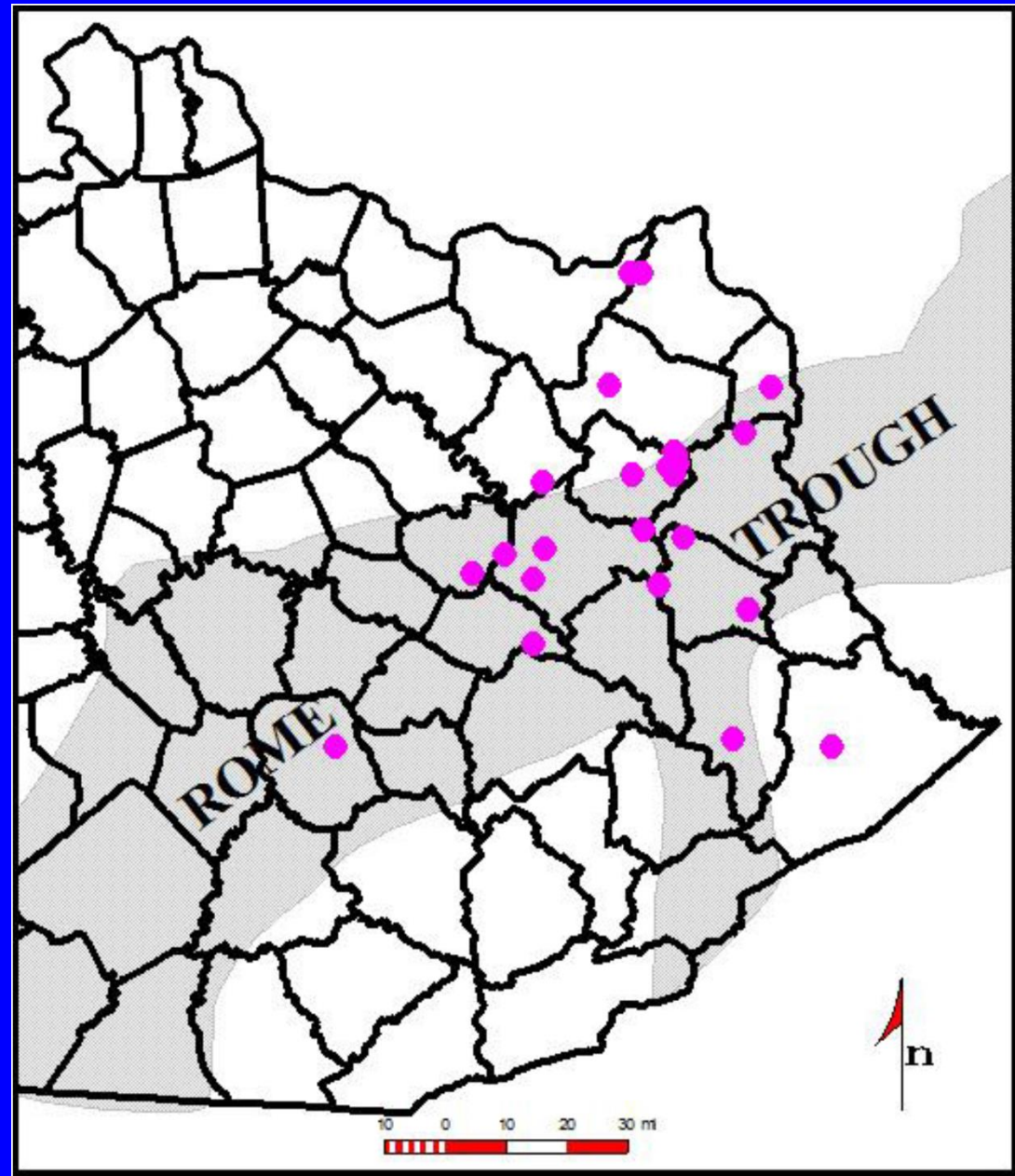
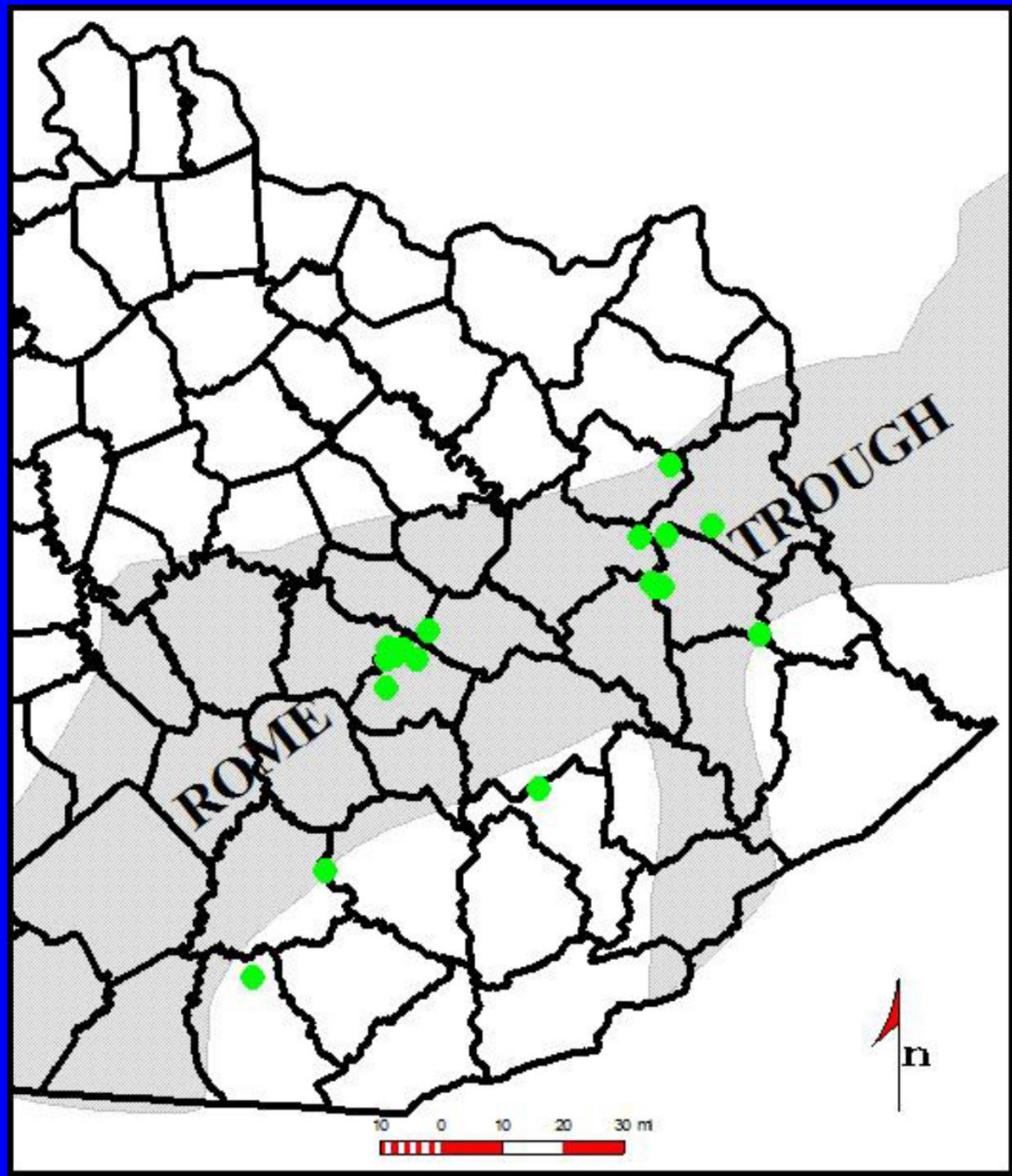


Image courtesy of J.
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Past Cambrian exploration in Kentucky

1980's wells

Image courtesy of J.
Jenkins, Abarta Energy



Past Cambrian exploration in Kentucky

1990's wells

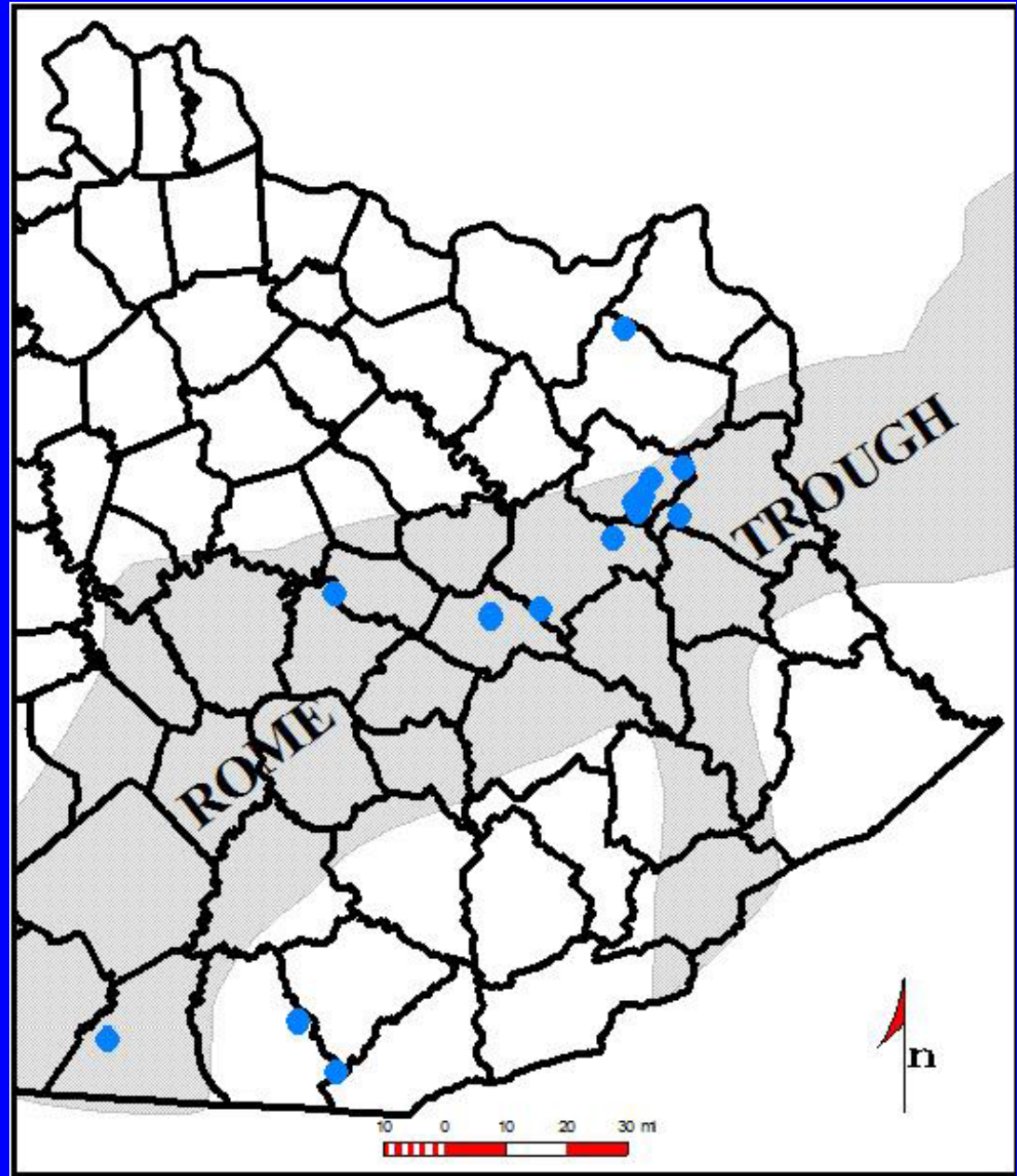


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Past Cambrian exploration in Kentucky

Early 2000's wells

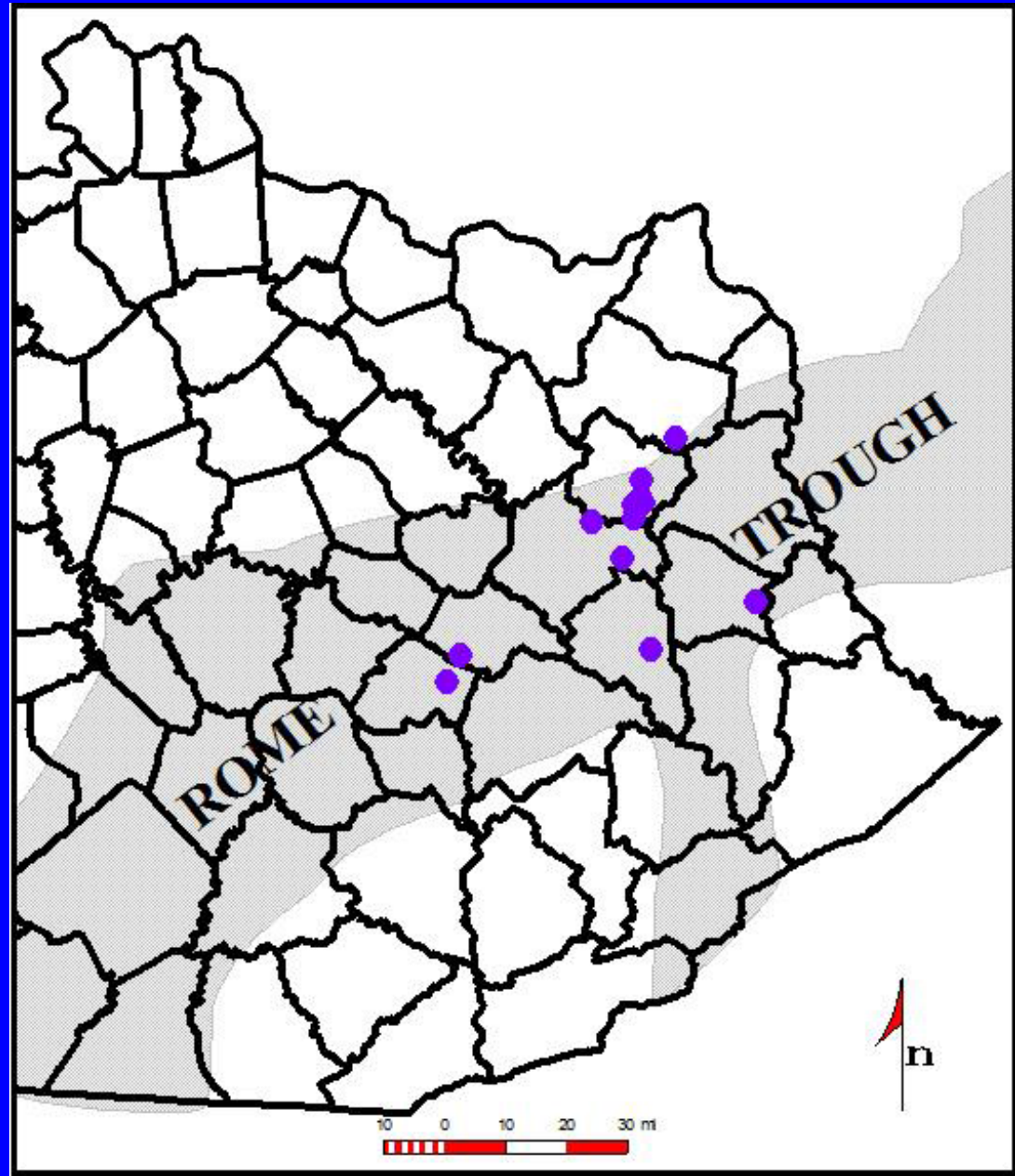


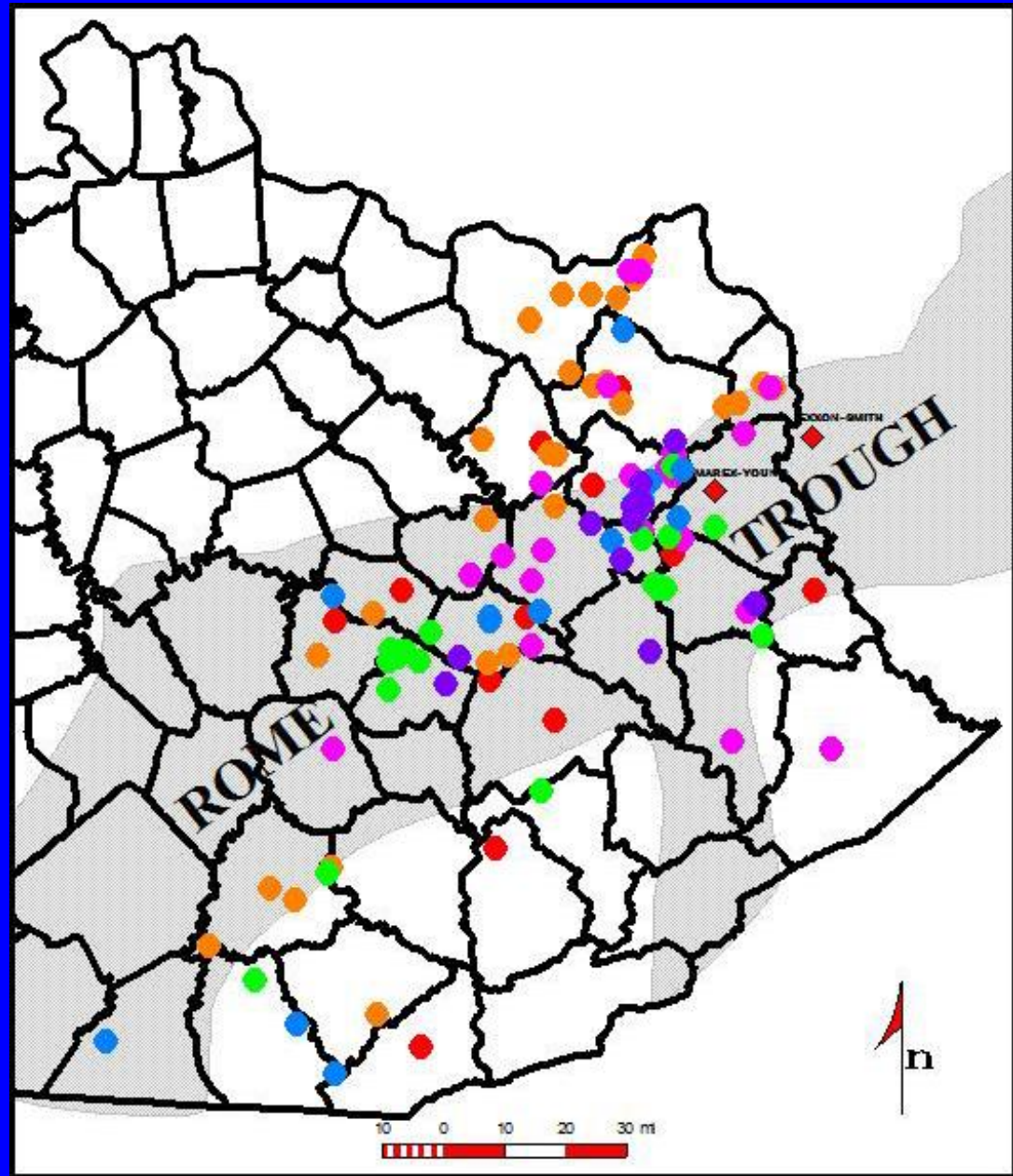
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Past Cambrian exploration in Kentucky

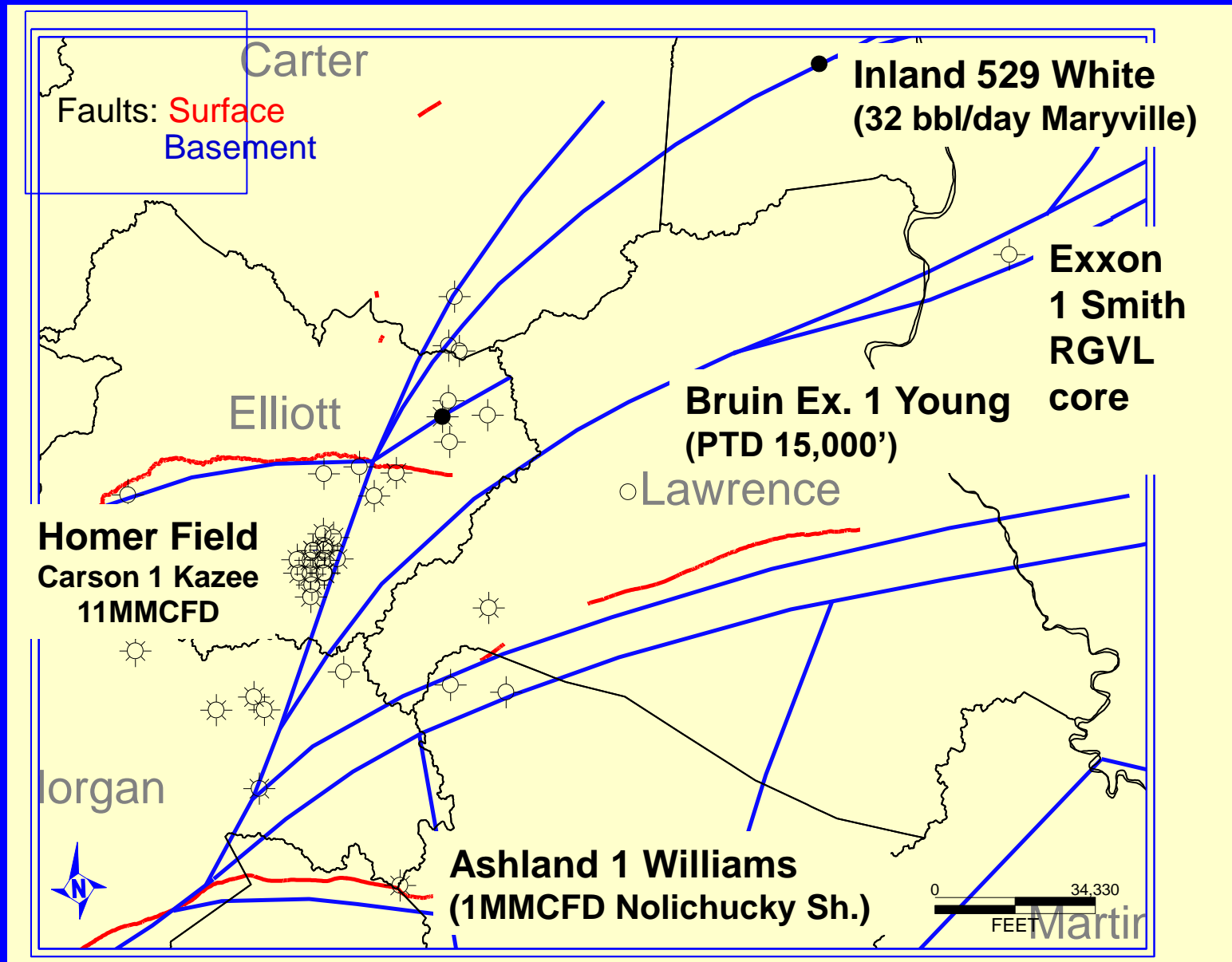
Most deep wells have
hydrocarbon shows,
however, almost all are
not sustainable or
repeatable.

Image courtesy of J.
Jenkins, Abarta Energy

All Cambrian wells, to date



Rome Trough Production



Bruin Exploration #1 Young Lawrence County, Kentucky

- Vertical stratigraphic test permitted to 15,000 ft in the Rome Fm. Drilled late 2013, to a total depth of 12,169.
- Logs, samples from strat test held confidential for 5 years.
- Re-permitted as oil and gas well in 2014 to complete and test well.
- New horizontal leg permitted 9/04/15.

New Leasing Activity

- After rumored success of the Bruin #1 Silvia Young well, leasing boom for deep rights in Johnson, Magoffin, and Lawrence Cos., Ky
- More than 4,275 deep leases were sold in 18 months ending 6/15 (Cate, 2015)
- Prices per acre are now \$250-300 where \$25-50 was common 5 years ago

Laurentian Rift History and Structure of the Rome Trough

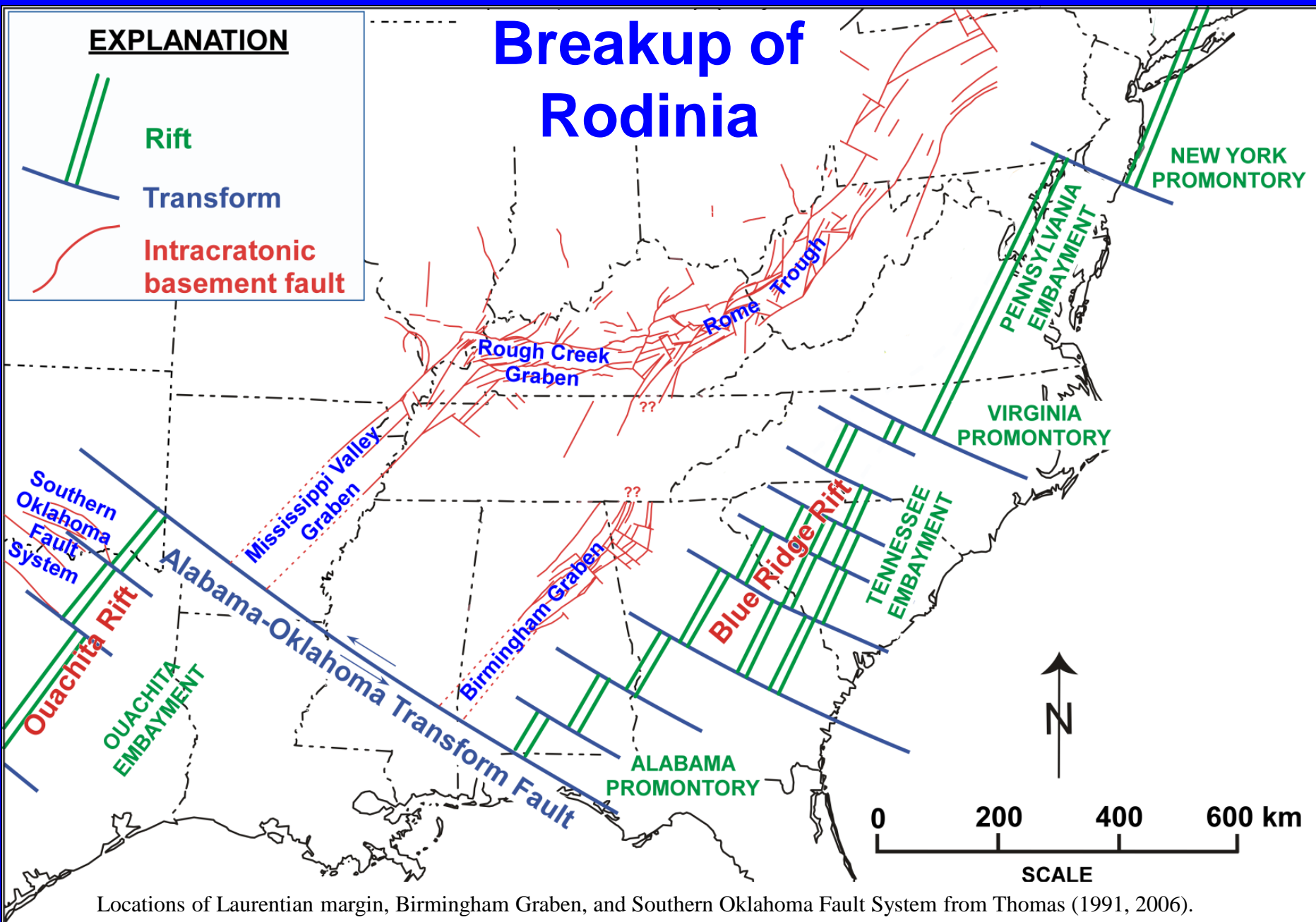
Breakup of Rodinia

EXPLANATION

Rift

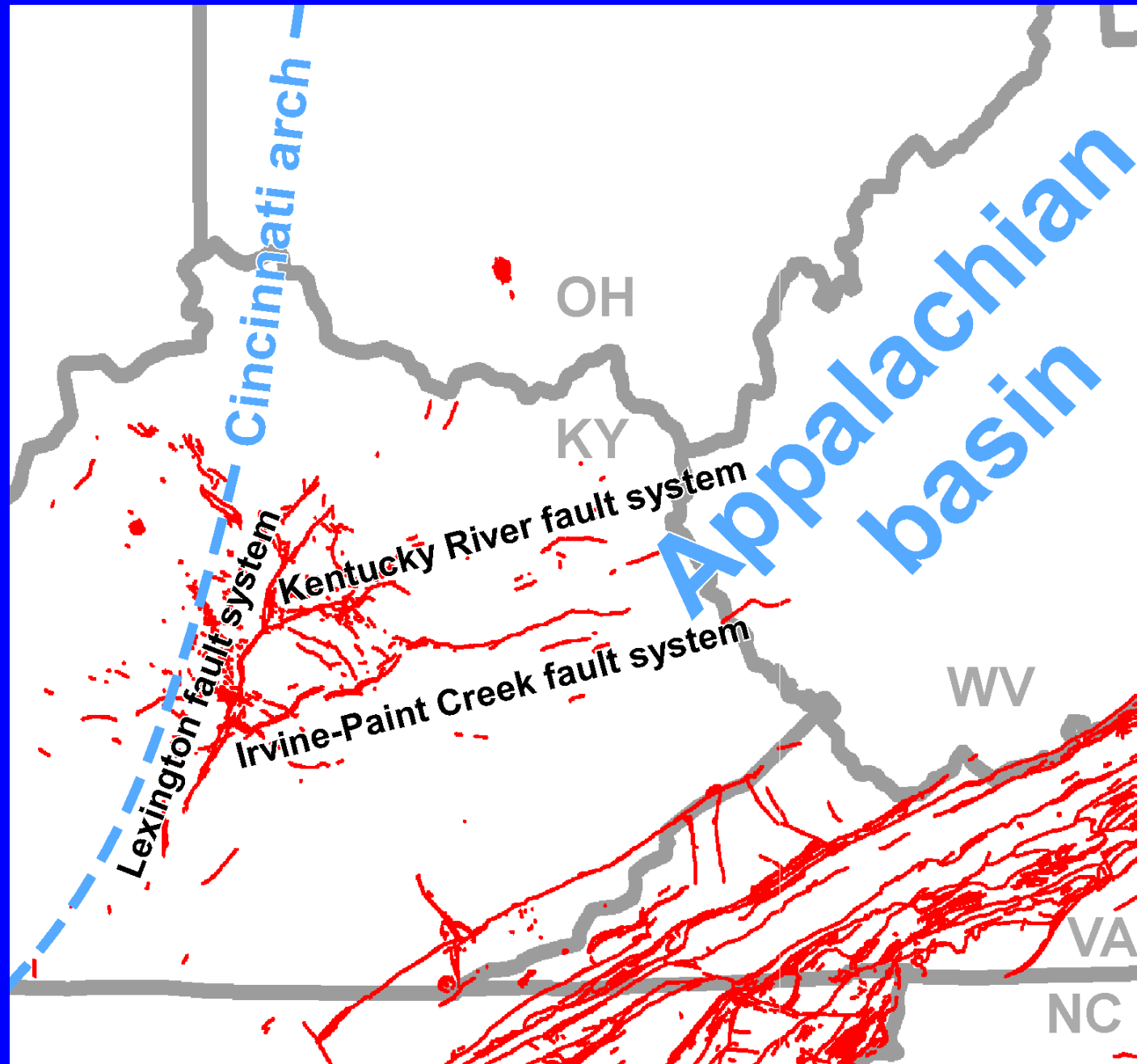
Transform

Intracratonic
basement fault

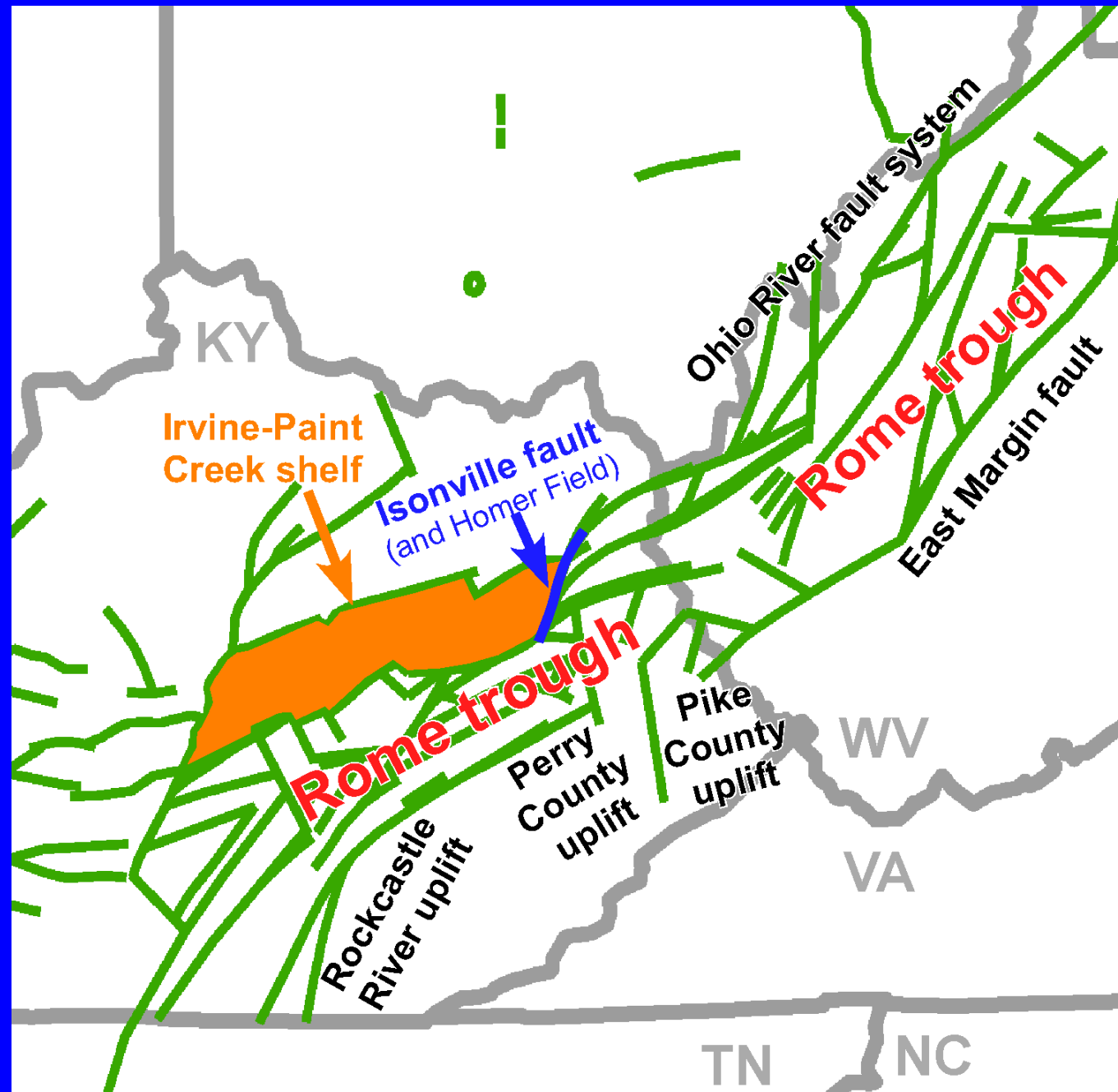


Locations of Laurentian margin, Birmingham Graben, and Southern Oklahoma Fault System from Thomas (1991, 2006).

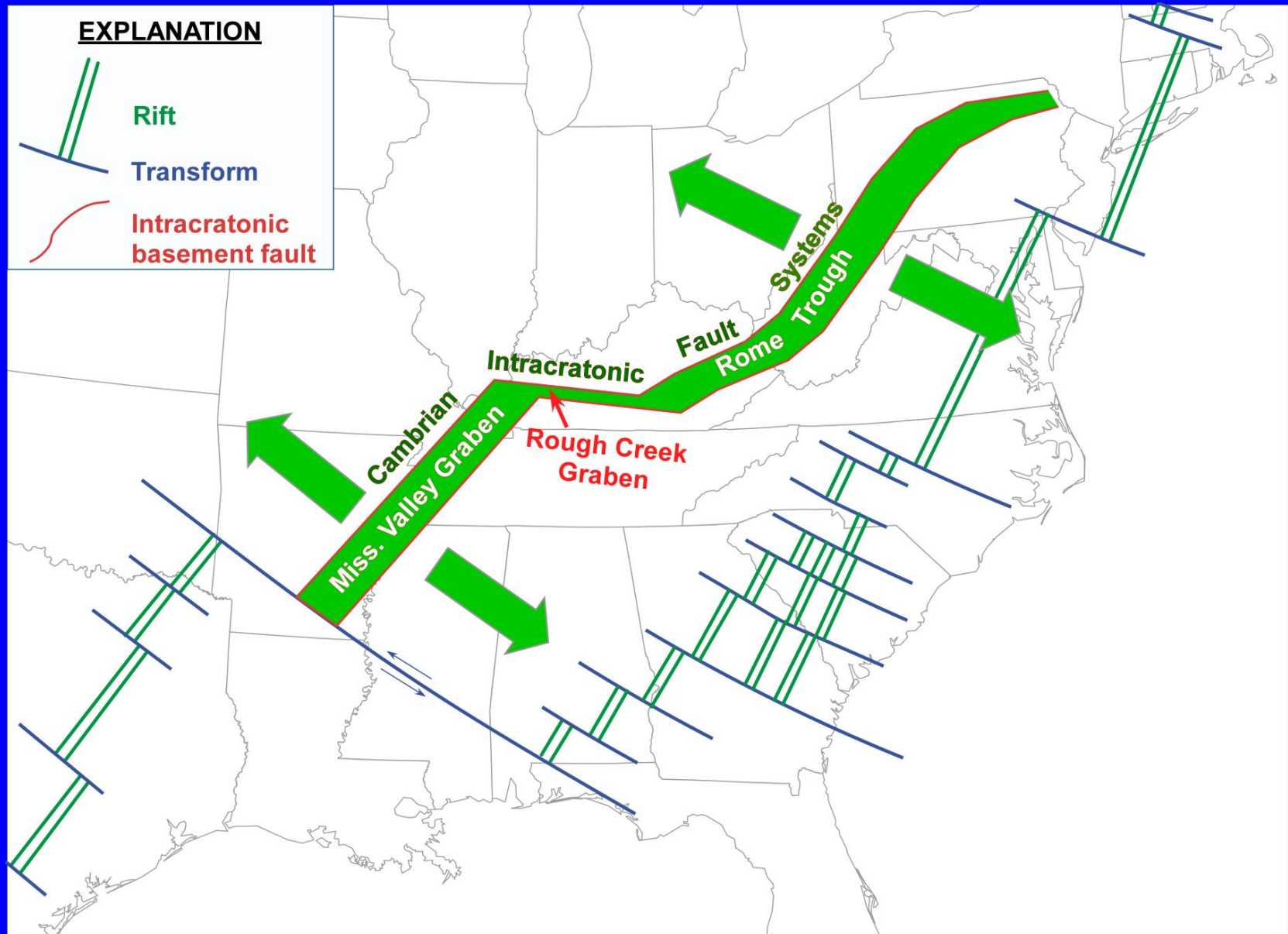
Surface Features in Rome Trough Region



Basement Features in Rome Trough Region

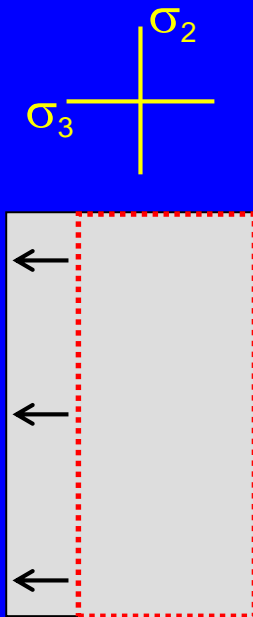


pC-C Intracratonic Rift System



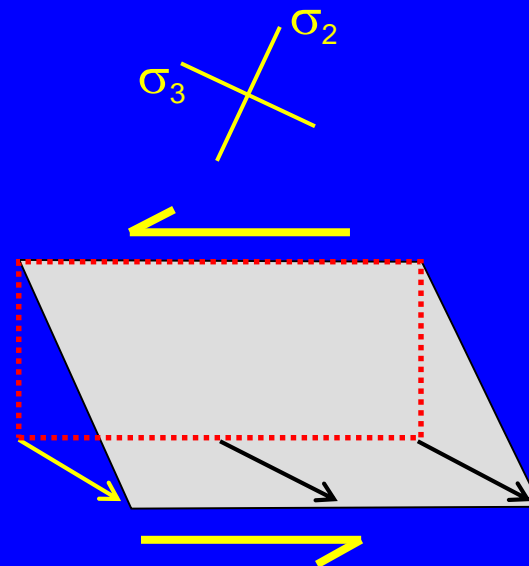
Rifting Strain Regimes

Pure extension
(plane strain)



Northern Rome Trough
(WV) & Mississippi
Valley Graben ??

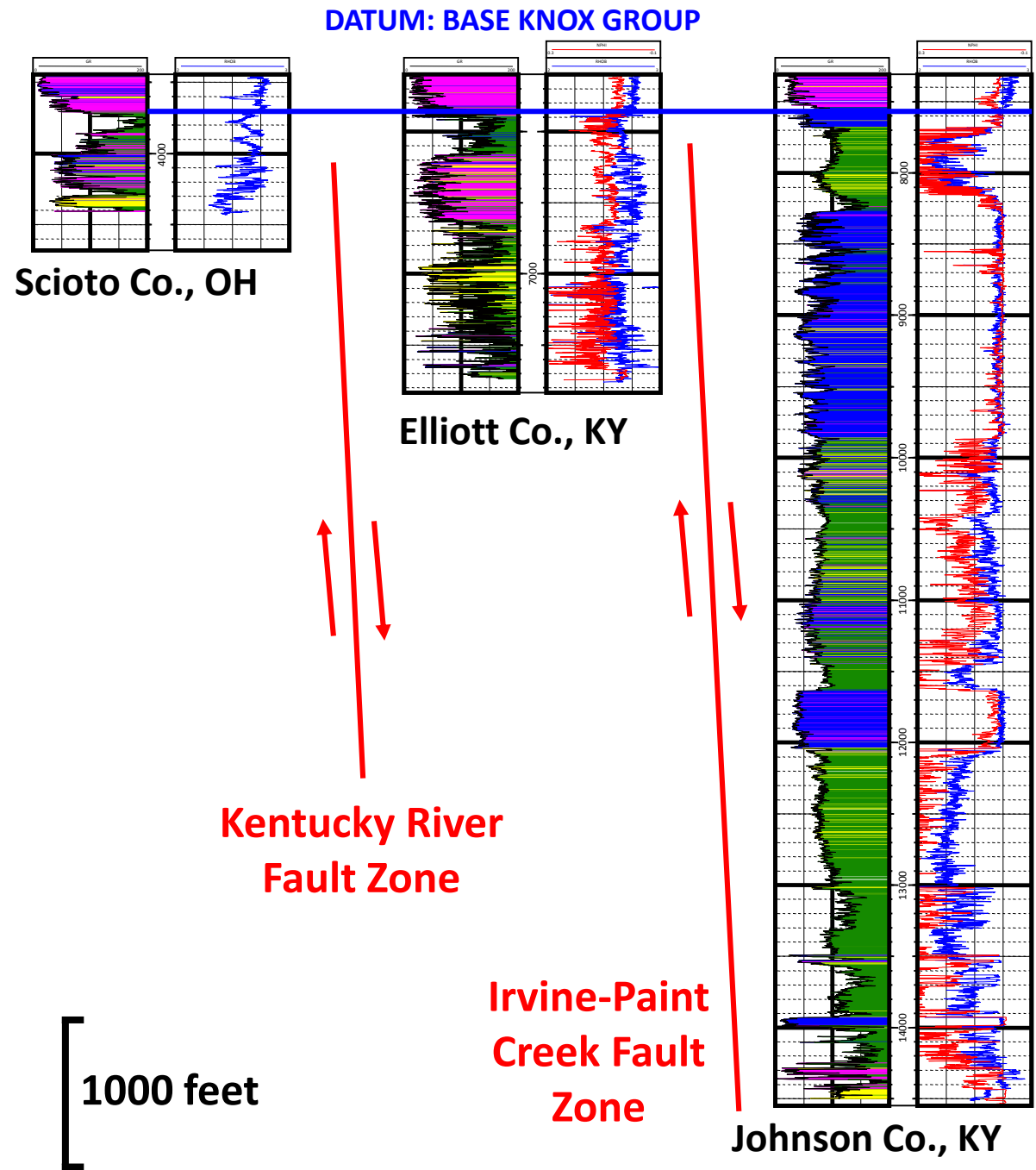
Oblique Transtension
(mixed simple and
pure shear)



Rome Trough,
Eastern KY
??

Stratigraphic Problem

- Correlations across growth faults
- Prediction of sandstone and shale distribution

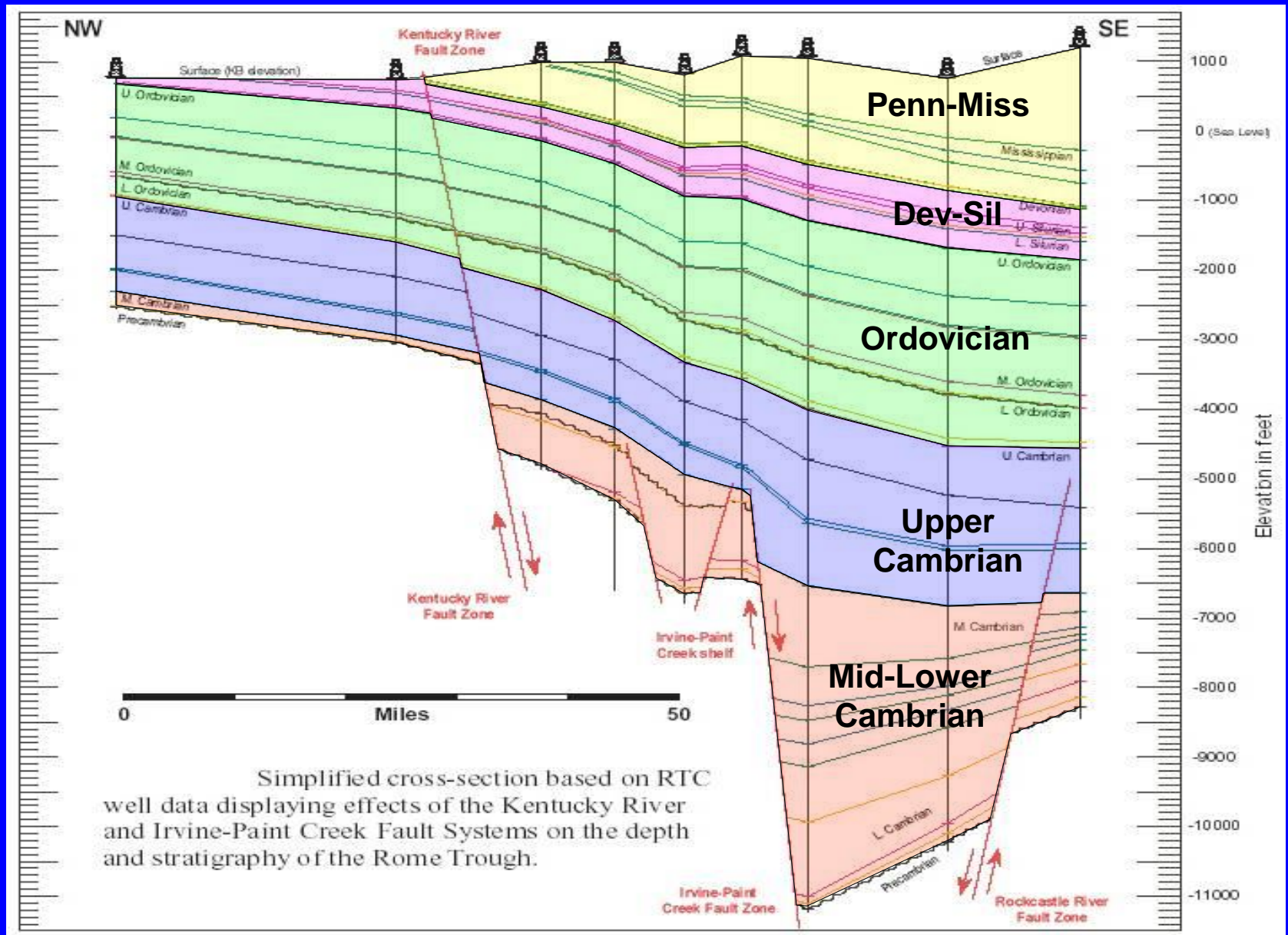


Rome Trough Consortium

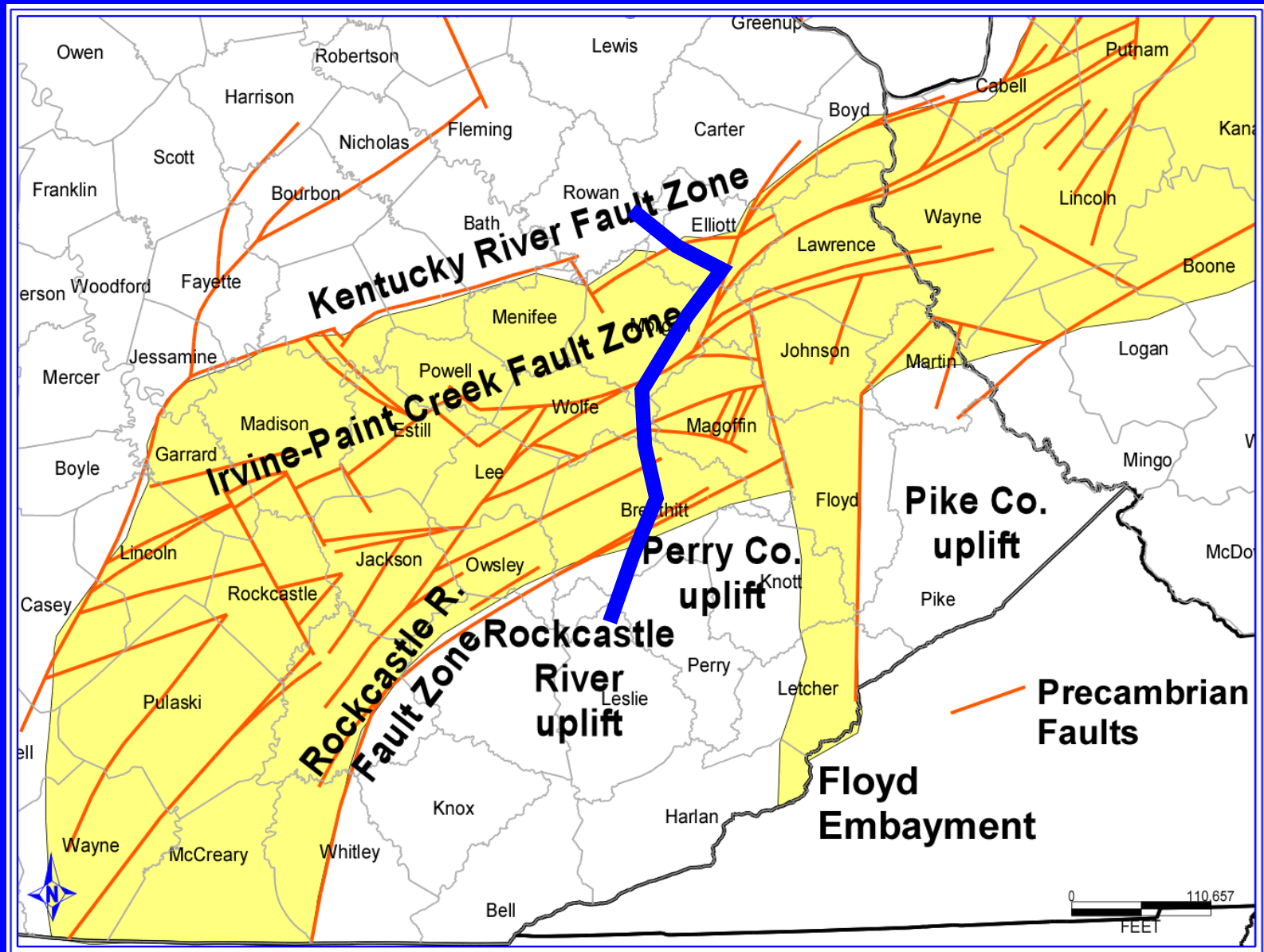
1999-2002

- Regional stratigraphic and structural interpretation
- Homer field study, Elliott County, Kentucky
- Cross sections, core descriptions, paleogeographic maps, gross/net sandstone maps
- Hydrocarbon and source rock geochemistry
- 2004 Open-file report available at KGS
- Study did not consider the unconventional resource potential

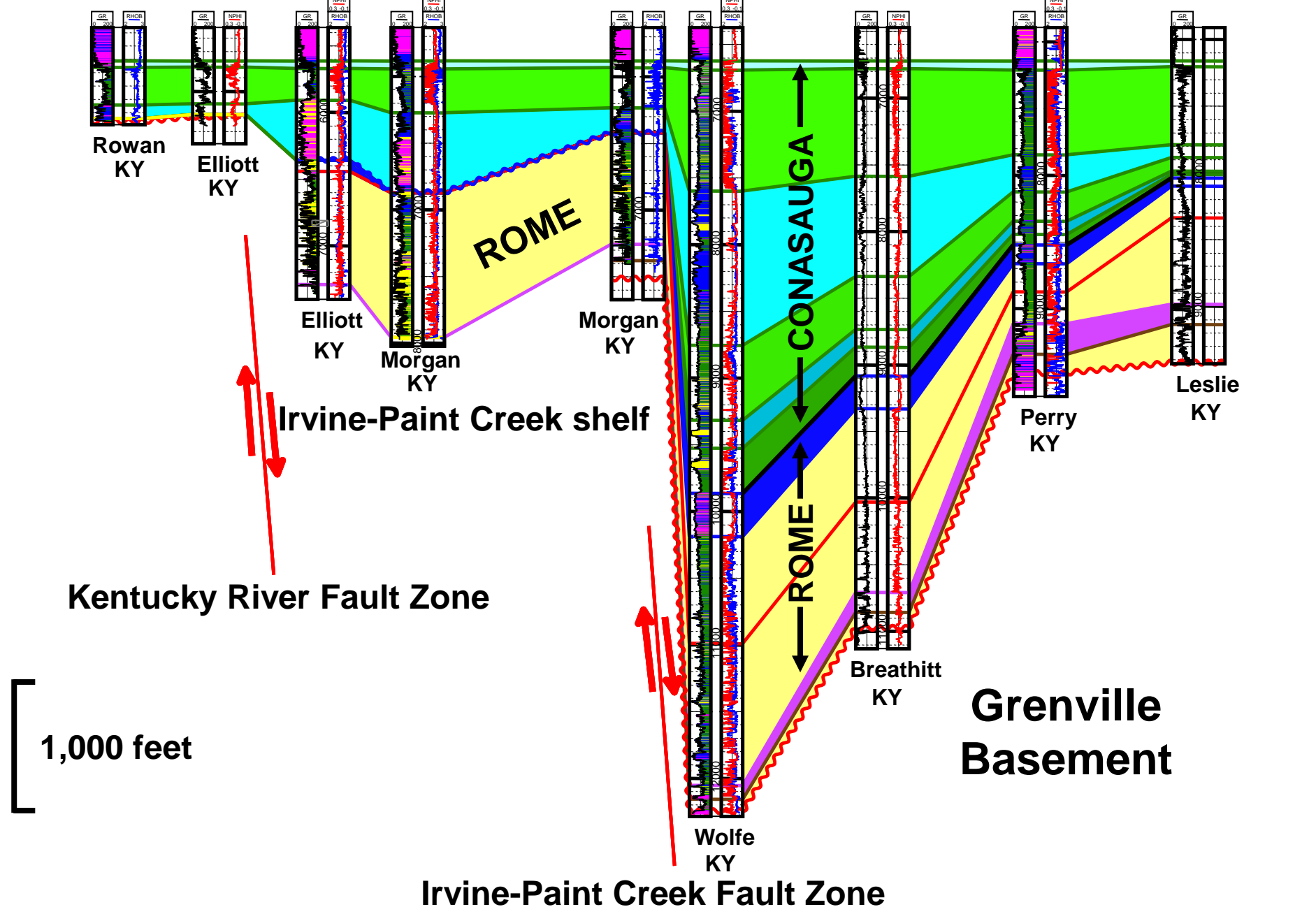
Simplified E. KY Cross Section



Rome Trough Structure

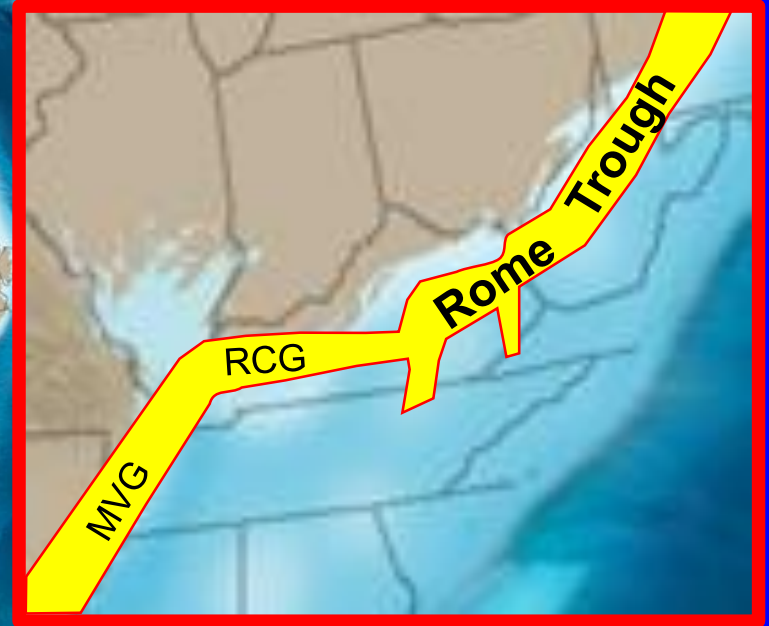
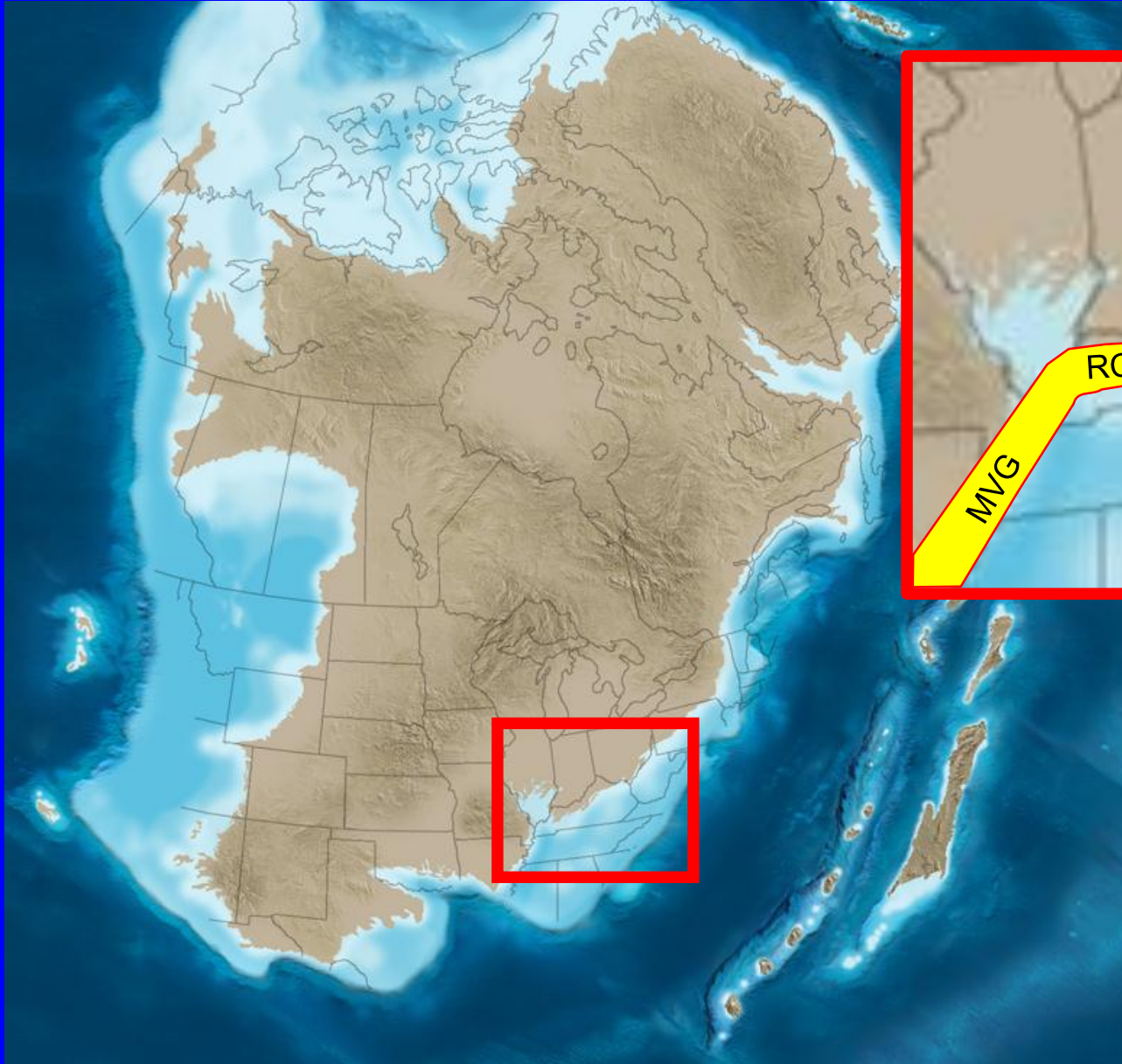


North South



Cambrian Stratigraphy and Deposition

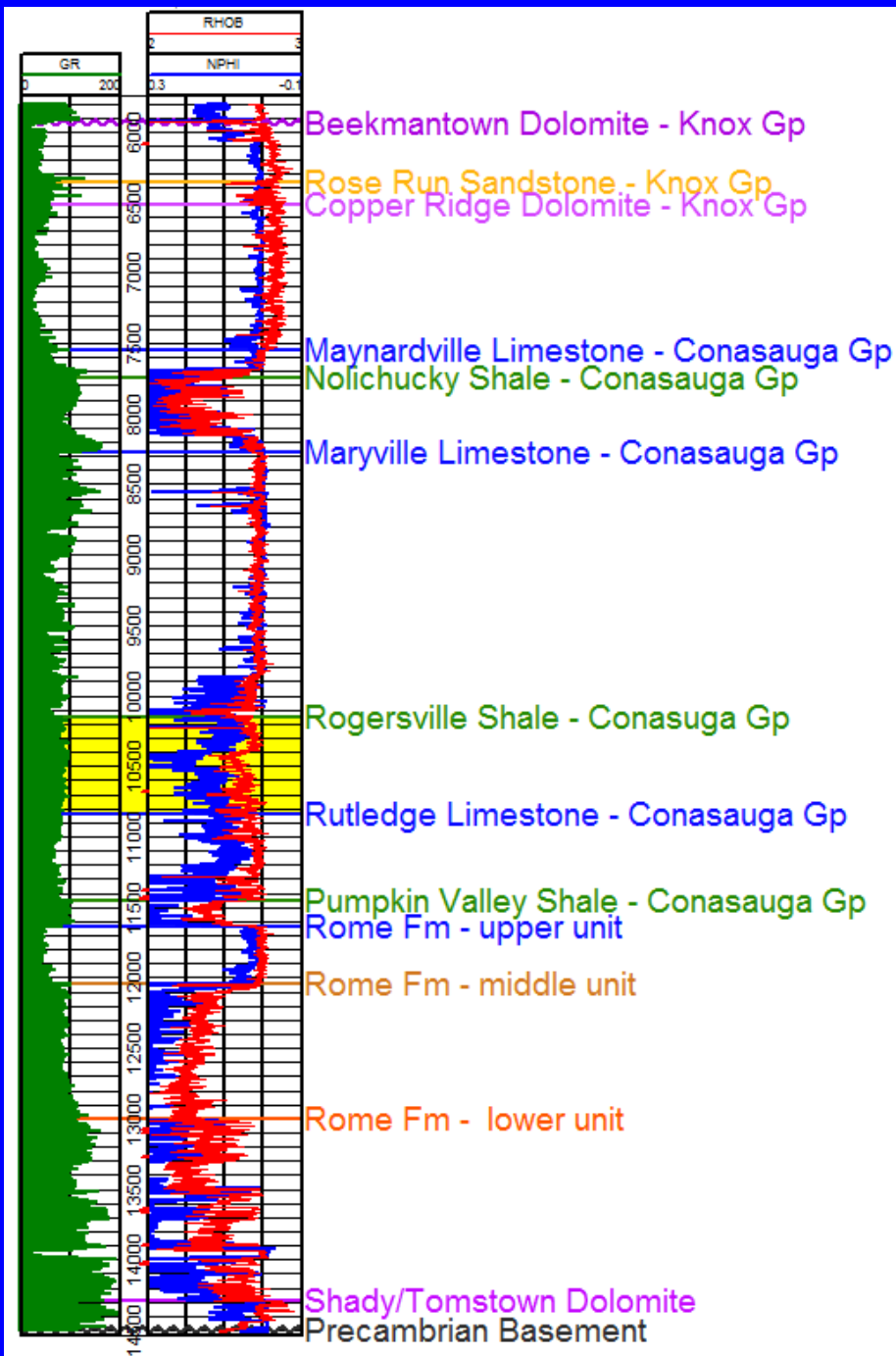
Middle Cambrian Paleogeography



Ron Blakey, Colorado
Plateau Geosystems,
Arizona USA

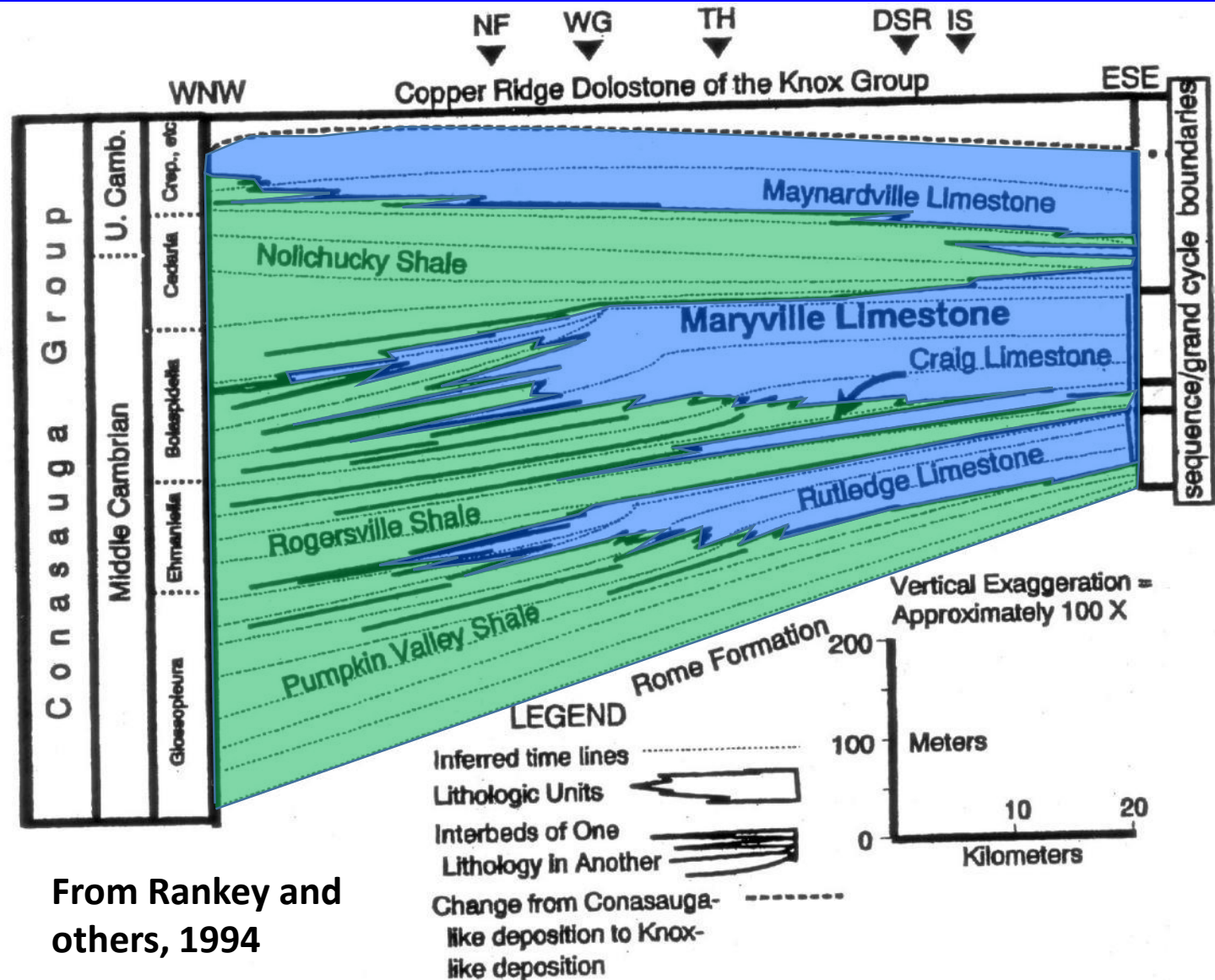
Precambrian - Early Ordovician Stratigraphy within Rome Trough

U.S. Signal #1
Elkhorn Coal
Johnson Co.
Kentucky

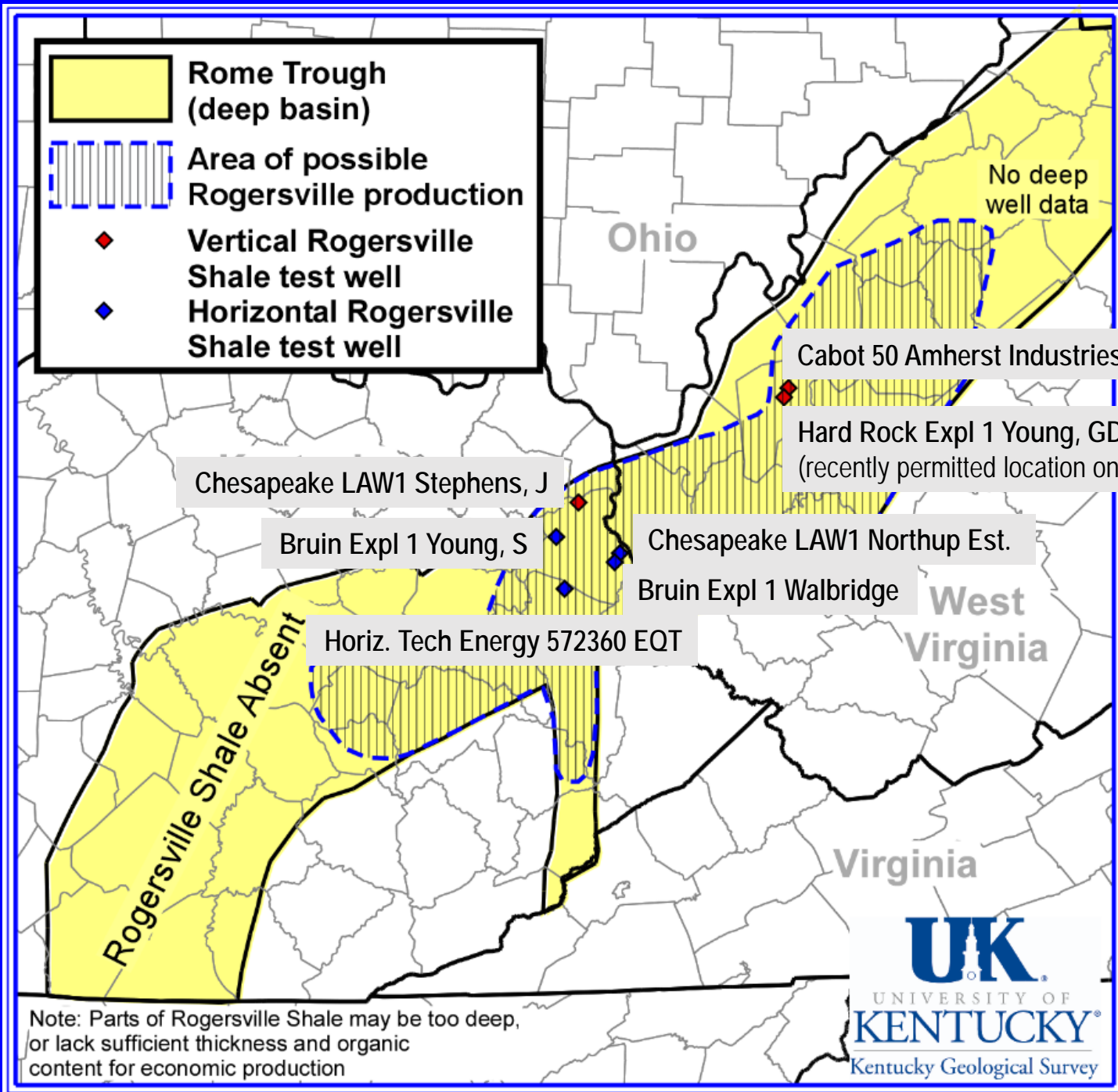


Conasauga Transgressive- Regressive Cycles

Eastern Tennessee Outcrops

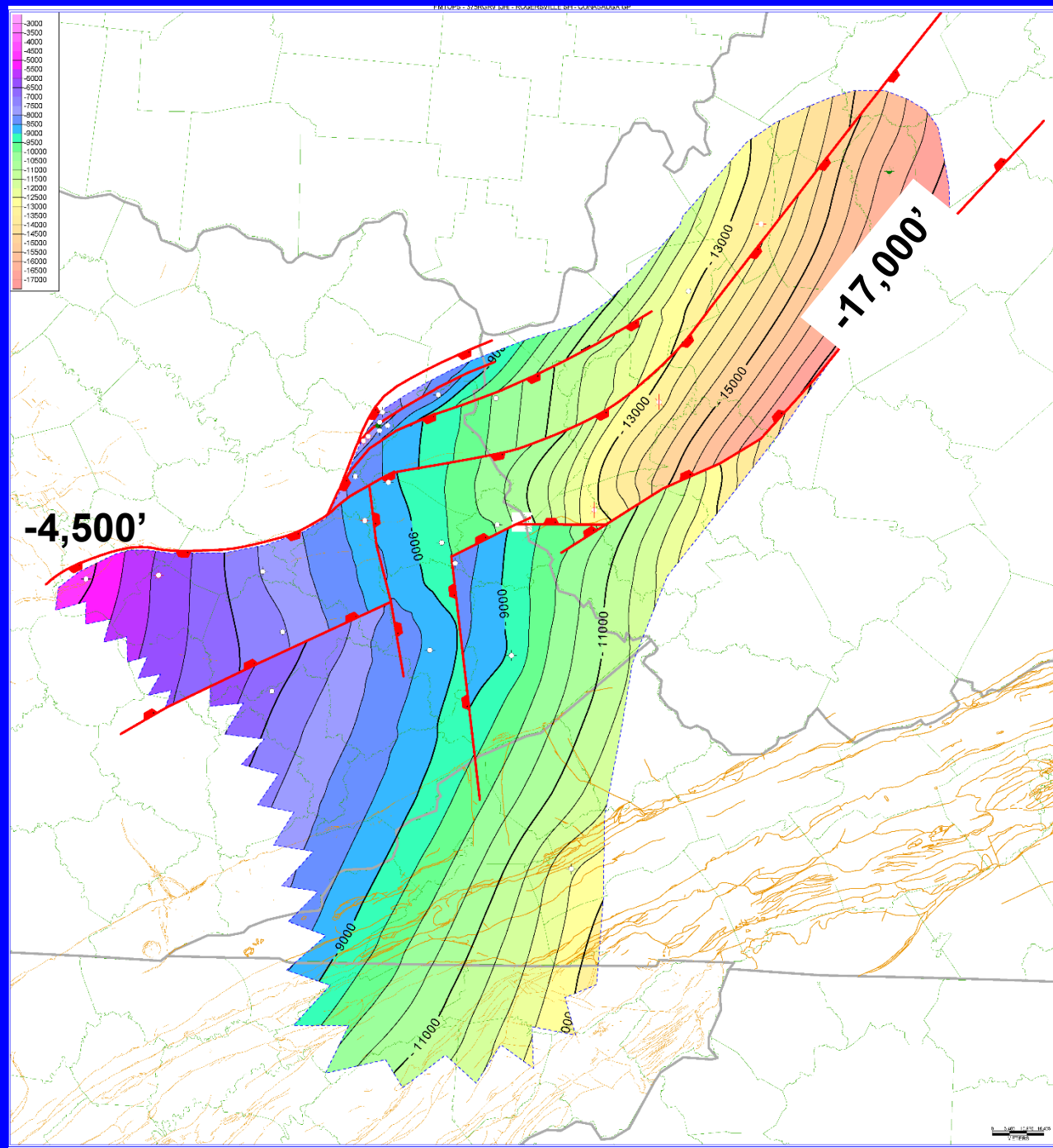


From Rankey and
others, 1994



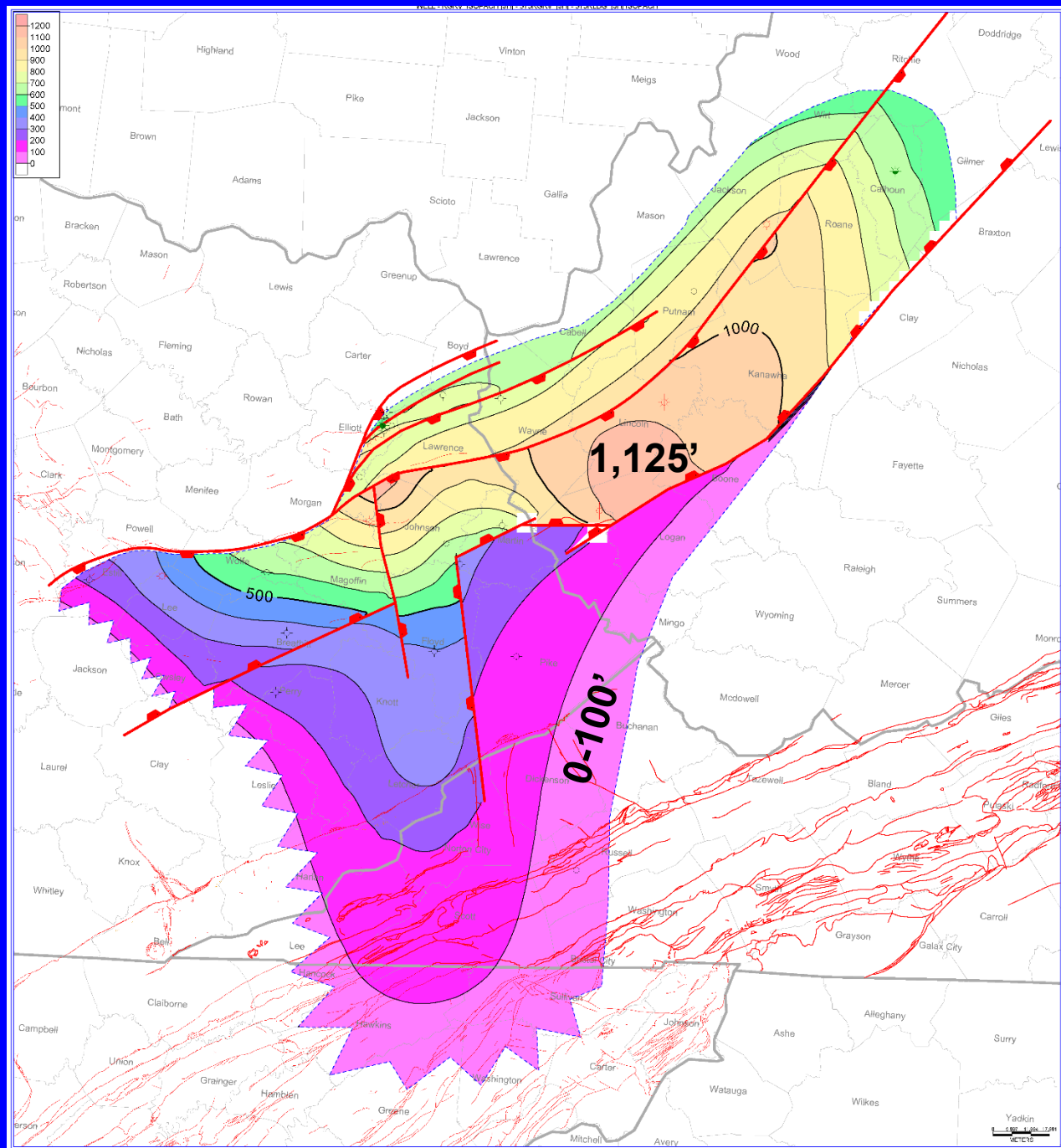
Rogersville Shale Structure Map

4,500 – 17,000
feet below sea
level



Rogersville Shale Isopach Map

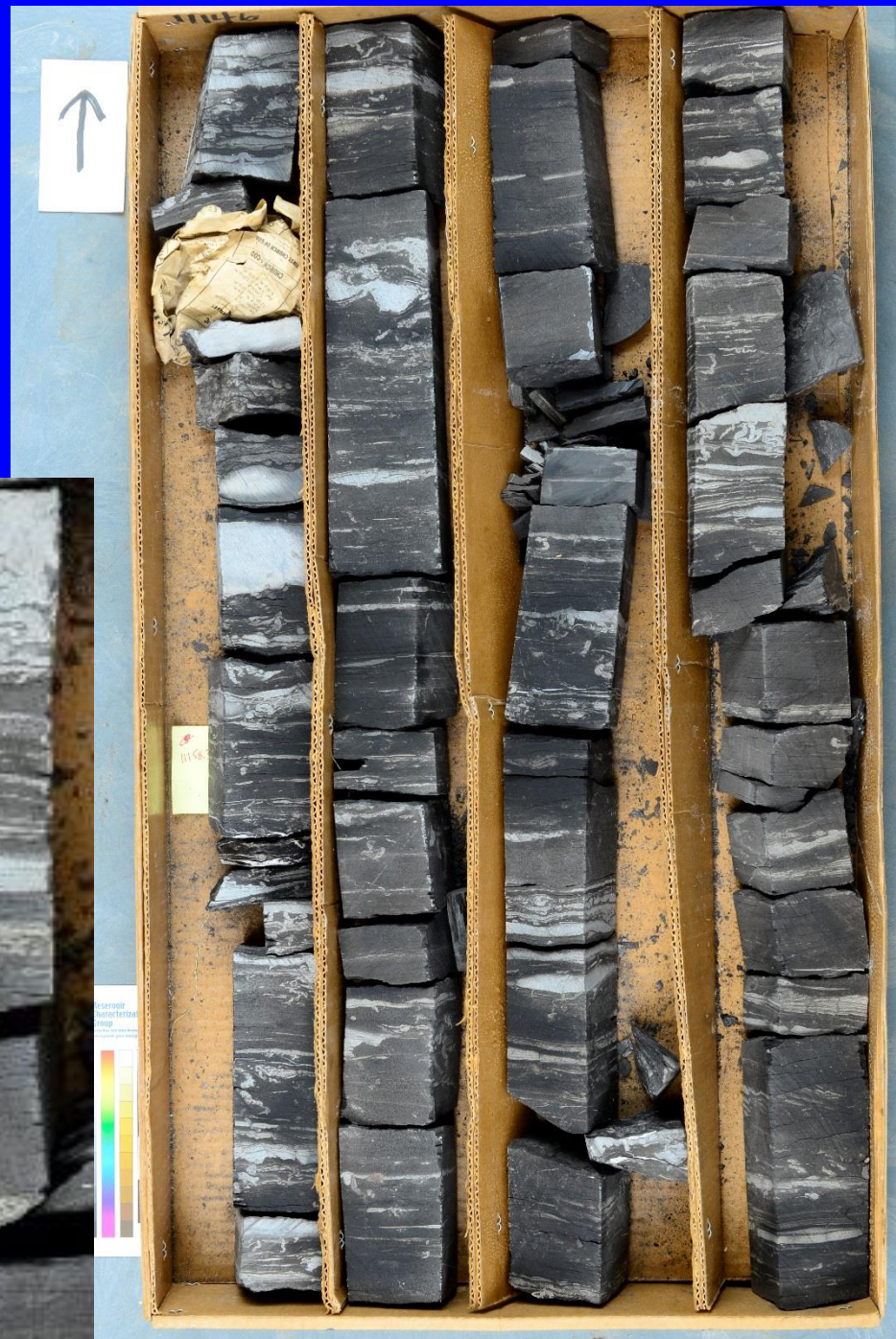
0 to ~1,125
feet thick



Rogersville Shale

Lithology and Mineralogy

Exxon #1 Smith core: 11,146-11,157'



Exxon #1 Smith
core:
11,168-11,179.5'

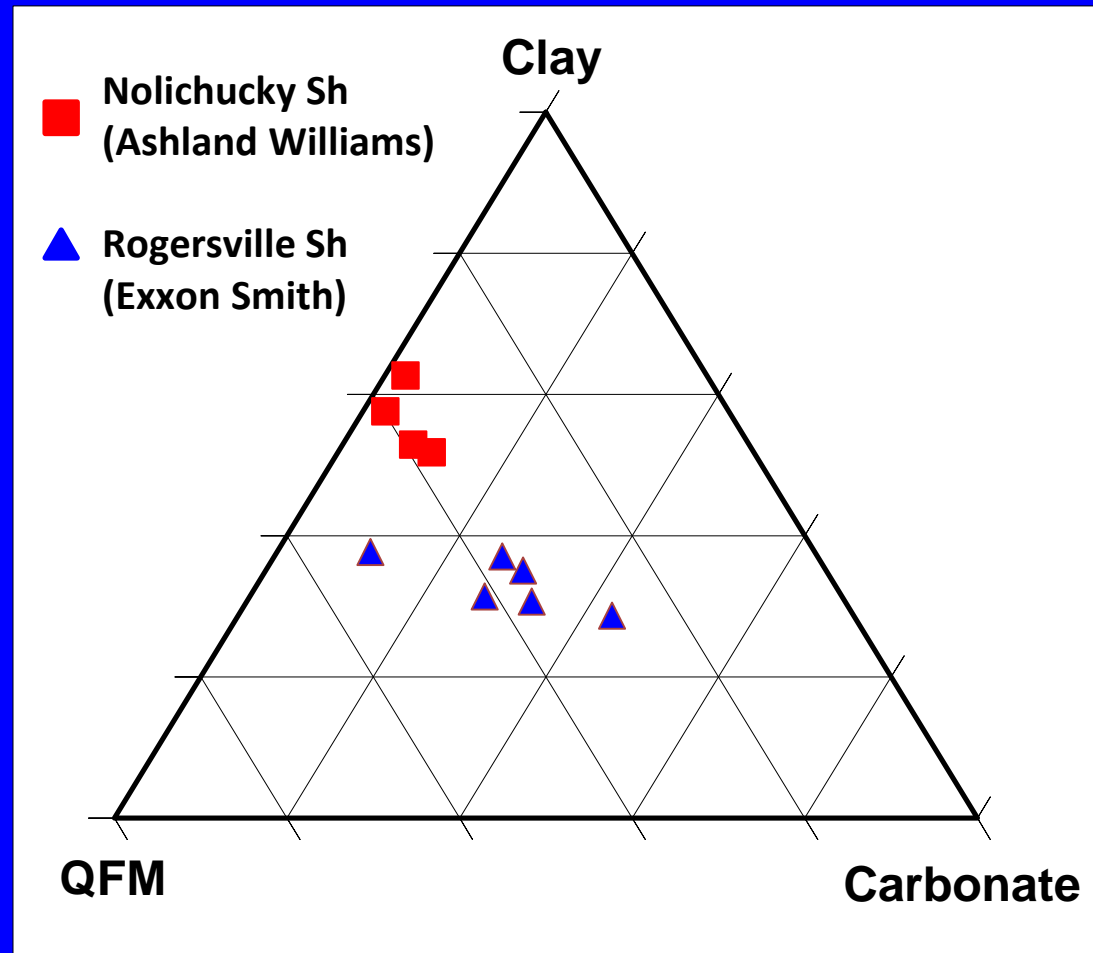


Exxon #1 Smith core: 11,191-11,200'



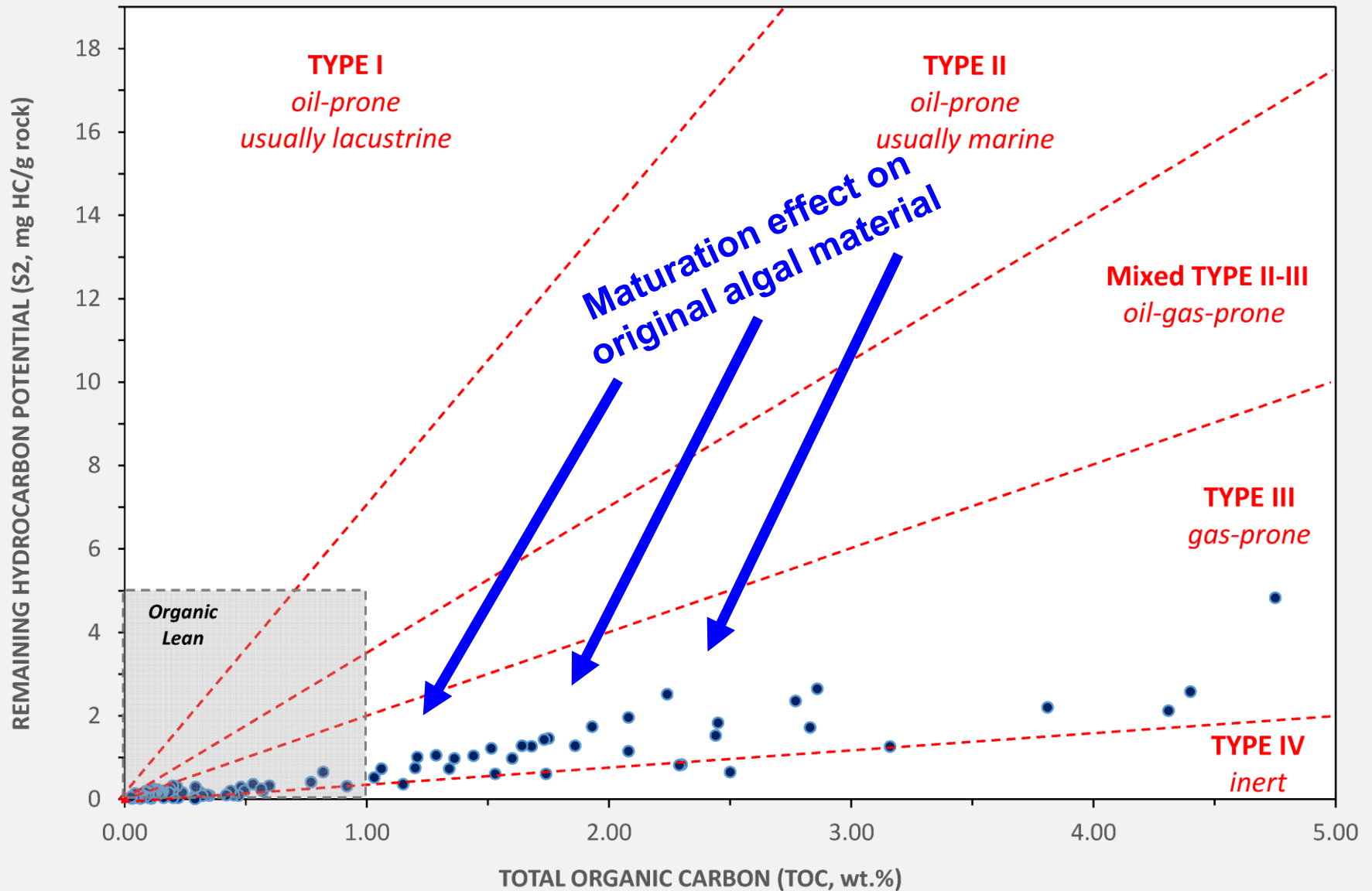
Shale Mineralogy

- XRD data from the Rogersville and Nolichucky shales
- Rogersville has:
 - Less clay
 - More quartz & carbonate
- Increased brittleness

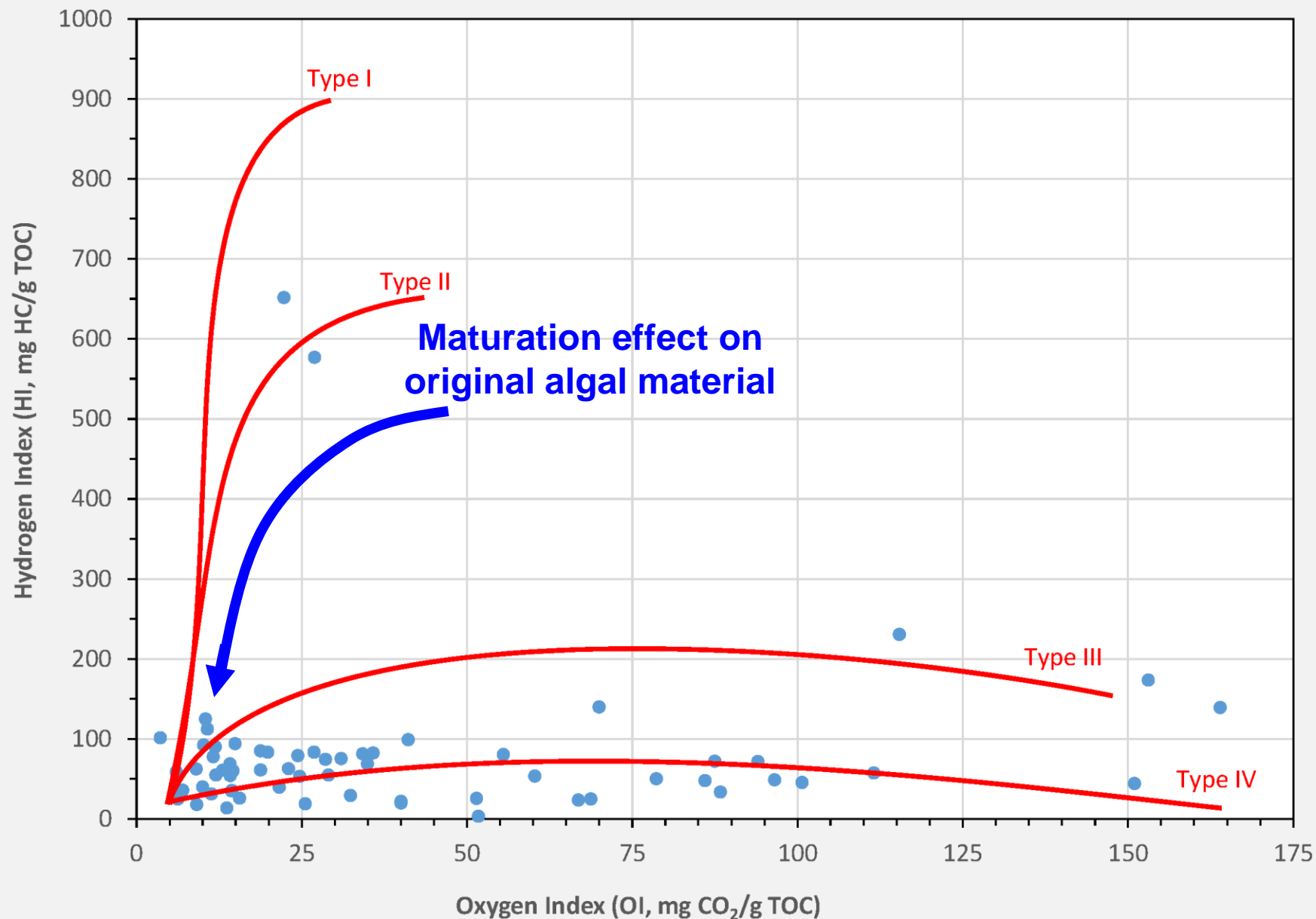


Rogersville Shale Source Rock Quality and Thermal Maturity

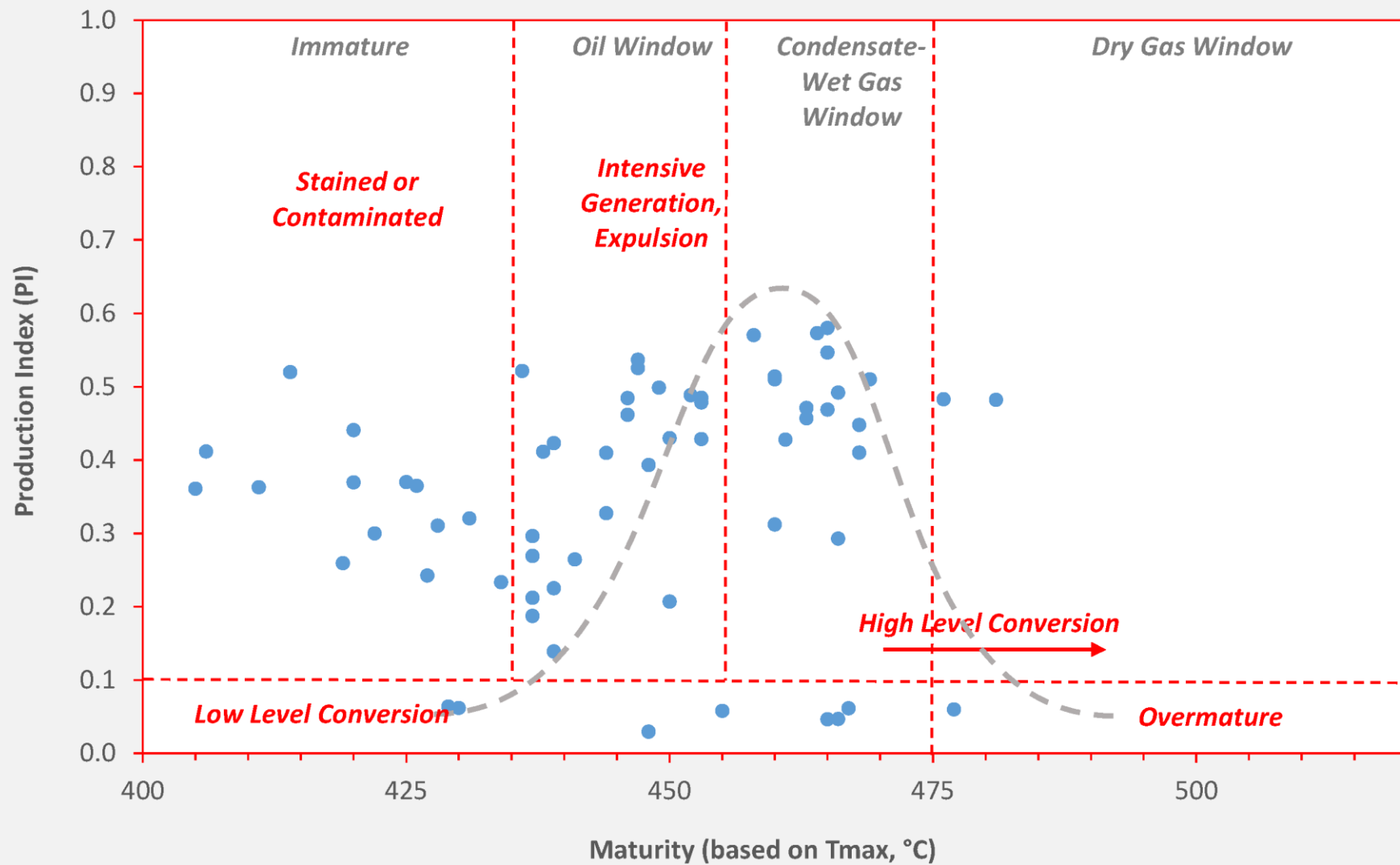
Rogersville Shale Kerogen Quality



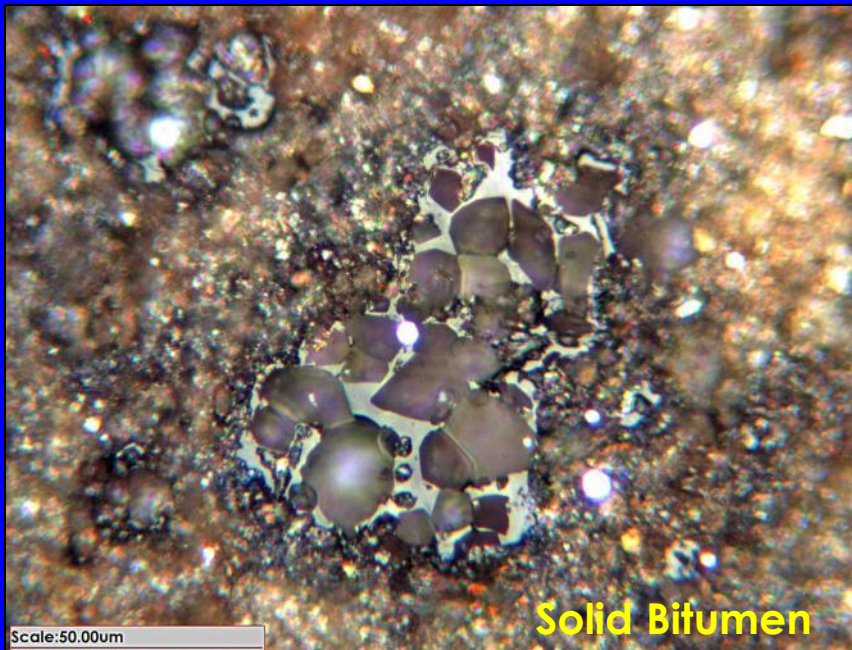
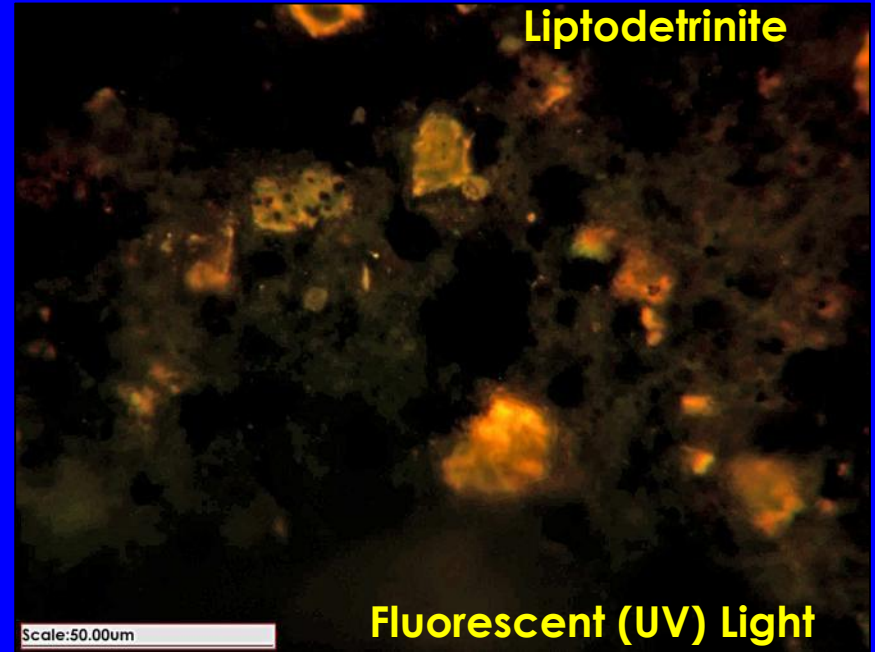
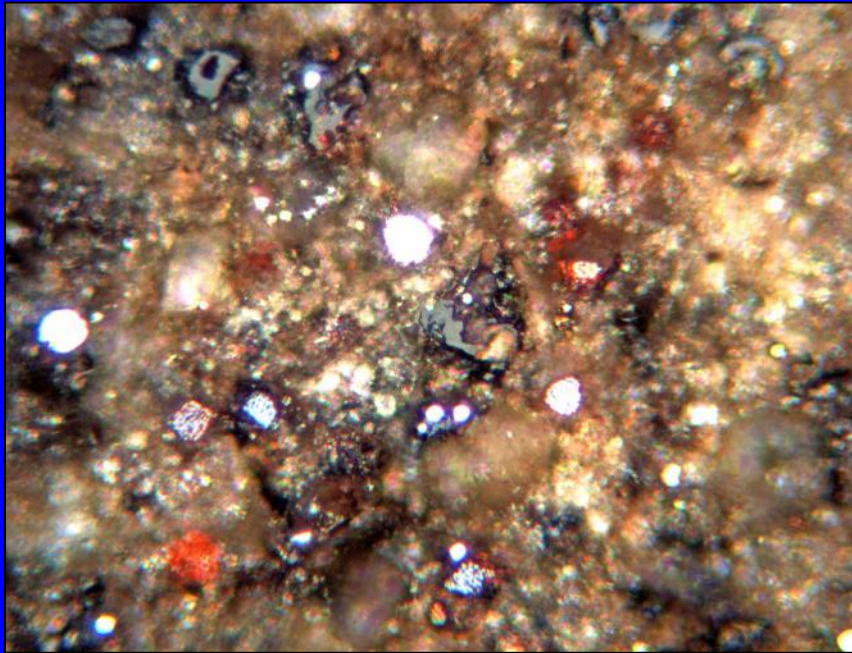
Rogersville Calculated Kerogen Type



Rogersville Kerogen Conversion



Rogersville Organic Petrography



Source Rock Maturity

4709901572 - Exxon #1 Smith, Wayne Co., WV

Bitumen Reflectance				
Core Depth (ft, md)	11167	11178	11191	11197
Average R_o random	1.76	1.80	1.80	1.84
Maximum R_o random	2.11	2.11	2.04	2.10
Minimum R_o random	1.50	1.47	1.53	1.59
Standard deviation	0.14	0.16	0.13	0.13
Observations/sample	50	50	50	50
Calculated R_o equivalent	1.49	1.51	1.51	1.54
$(R_o \text{ random} * 0.618) + 0.4$				
(Jacob, 1989)				
Indicated T_{\max} from				
calculated R_o equiv.	480	482	482	484

Source Rock Maturity

4709901572 - Exxon #1 Smith, Wayne Co., WV

<u>Spectral Fluorescence</u>				
Core Depth (ft, md)	11167	11178	11191	11197
Lambda maximum	638	648	648	645
Indicated R_o	1.35	1.45	1.45	1.45
Indicated T_{max} from				
Lambda max.	473	479	479	479

% R_o Level of Petroleum Generation

<0.6 Thermally immature

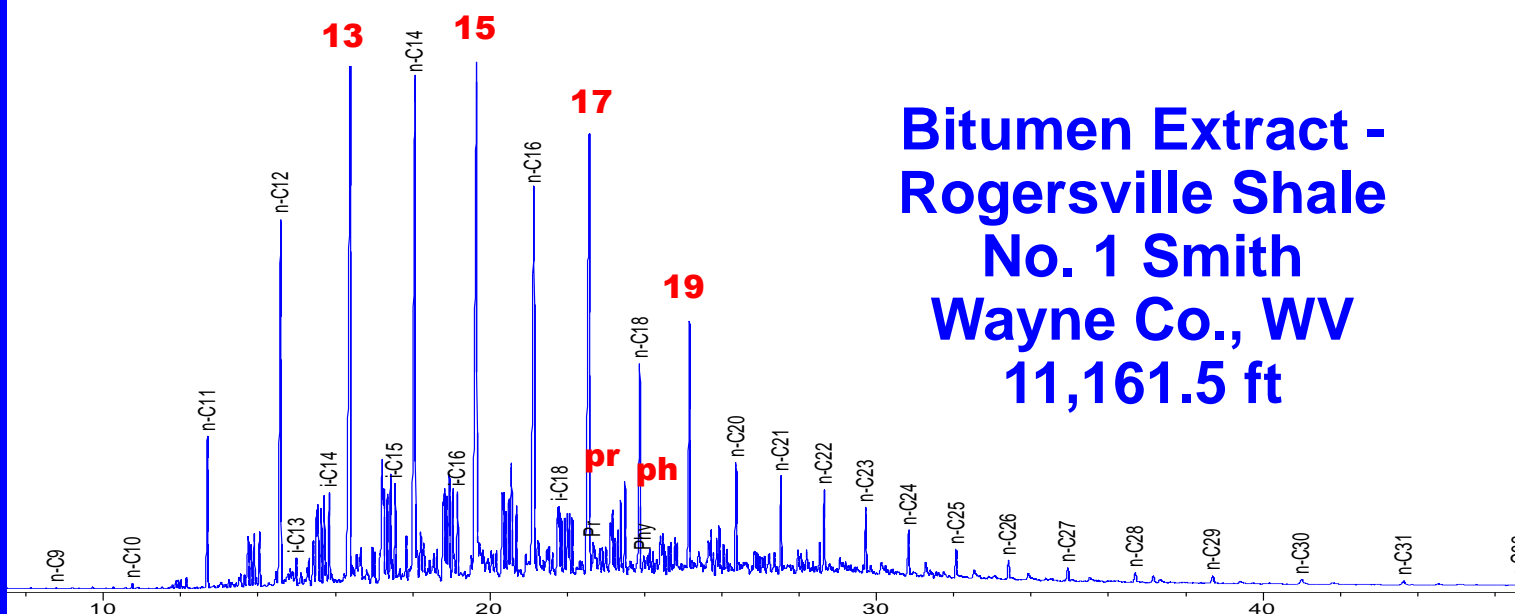
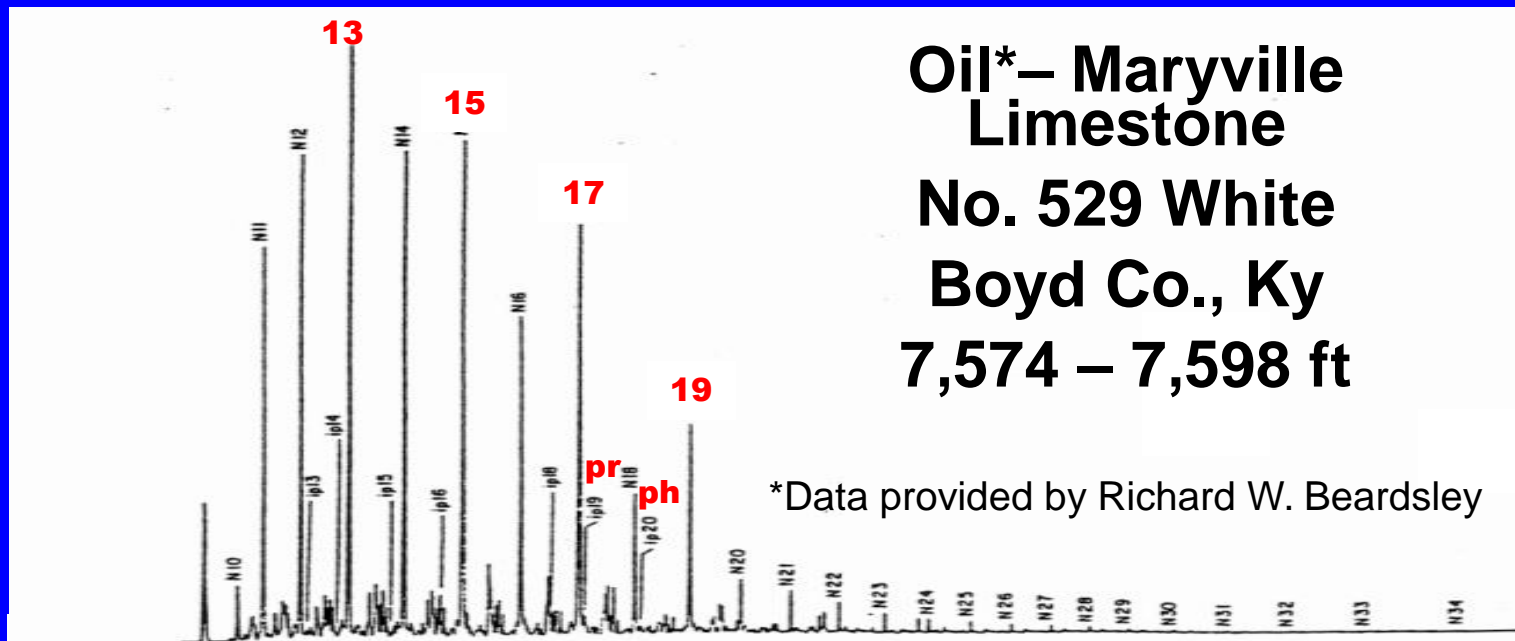
0.6 – 1.1 Oil window

1.1 – 1.4 Wet gas window

1.4 – 2.0 Dry gas window

>2.0 Catagenic gas generation

Oil to Source Rock Correlation



Rogersville Shale Summary

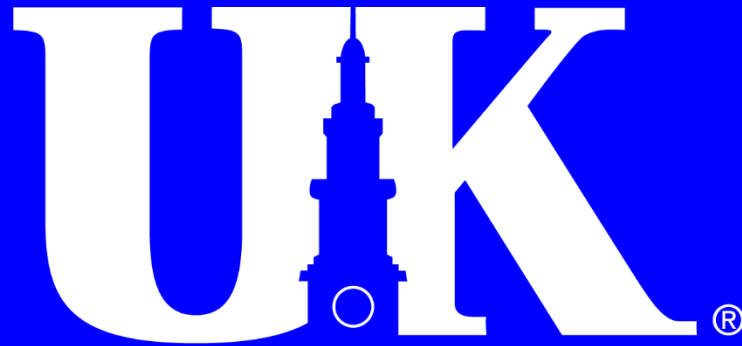
- 5,000 to 18,000 ft deep within Rome Trough
- 2–4.8% TOC in parts, and has generated gas & condensate
- Up to 1,100 ft thick, but limited to deeper parts of Rome Trough- and not all is organic rich

Conclusions

- Viable petroleum system exists in Rome Trough. Rogersville Shale (Conasauga Group) is primary source interval.
- Conasauga stratigraphic framework for three state area is key to predicting source rock distribution
- Rogersville unconventional play should be possible in higher TOC areas, but need to consider depth and economics.

Conclusions (cont.)

- Source rock quality in Rogersville is variable— not a uniformly rich source. Controls on TOC distribution not well understood.
- Shallower, less mature areas of RT likely more liquids-prone than deeper areas in W. Va.
- Structure data (seismic, gravity, magnetics) will be a key tool in developing the Rogersville



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