Evidence of Oil Generation in Early Mature Shale, Devonian New Albany Shale, Breckinridge County, Kentucky

Brandon C. Nuttall[1], Speaker

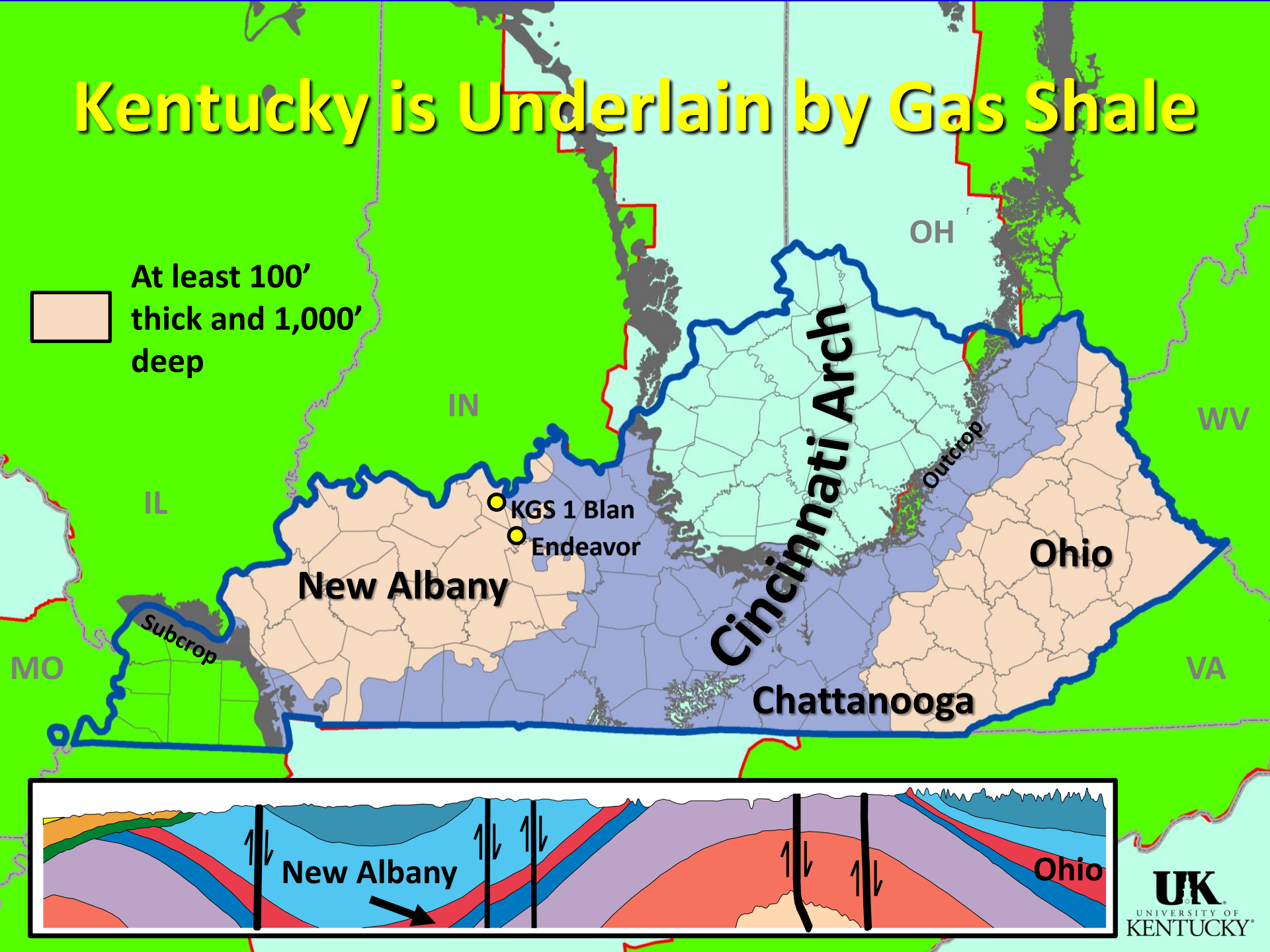
Marty Parris[1], Glynn Beck[1], Wallace Dow[2]

[1]Kentucky Geological Survey

[2]Cimarex (Retired)

Kentucky Section AIPG, Lexington, KY 17-Apr-2015

Kentucky is Underlain by Gas Shale



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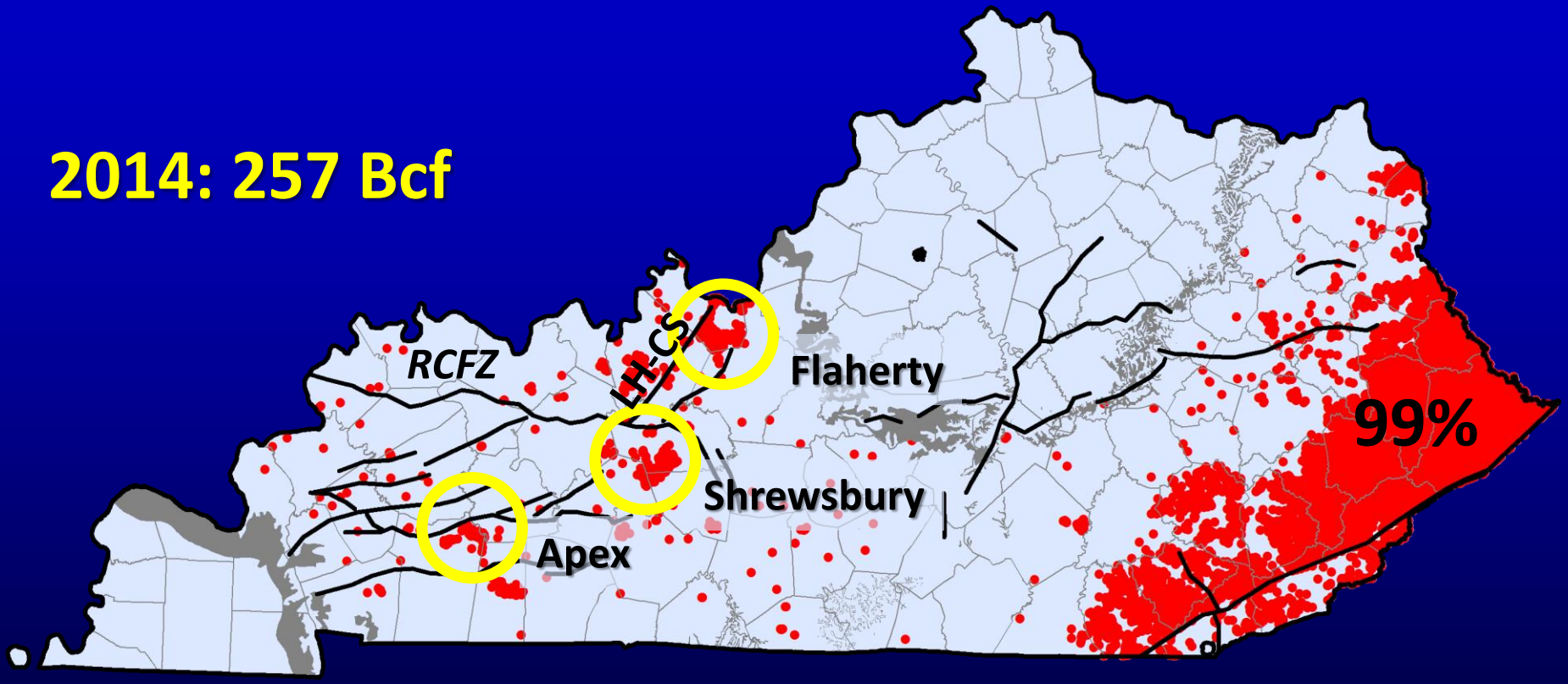
Kentucky Shale Gas Wells

2014: 257 Bcf



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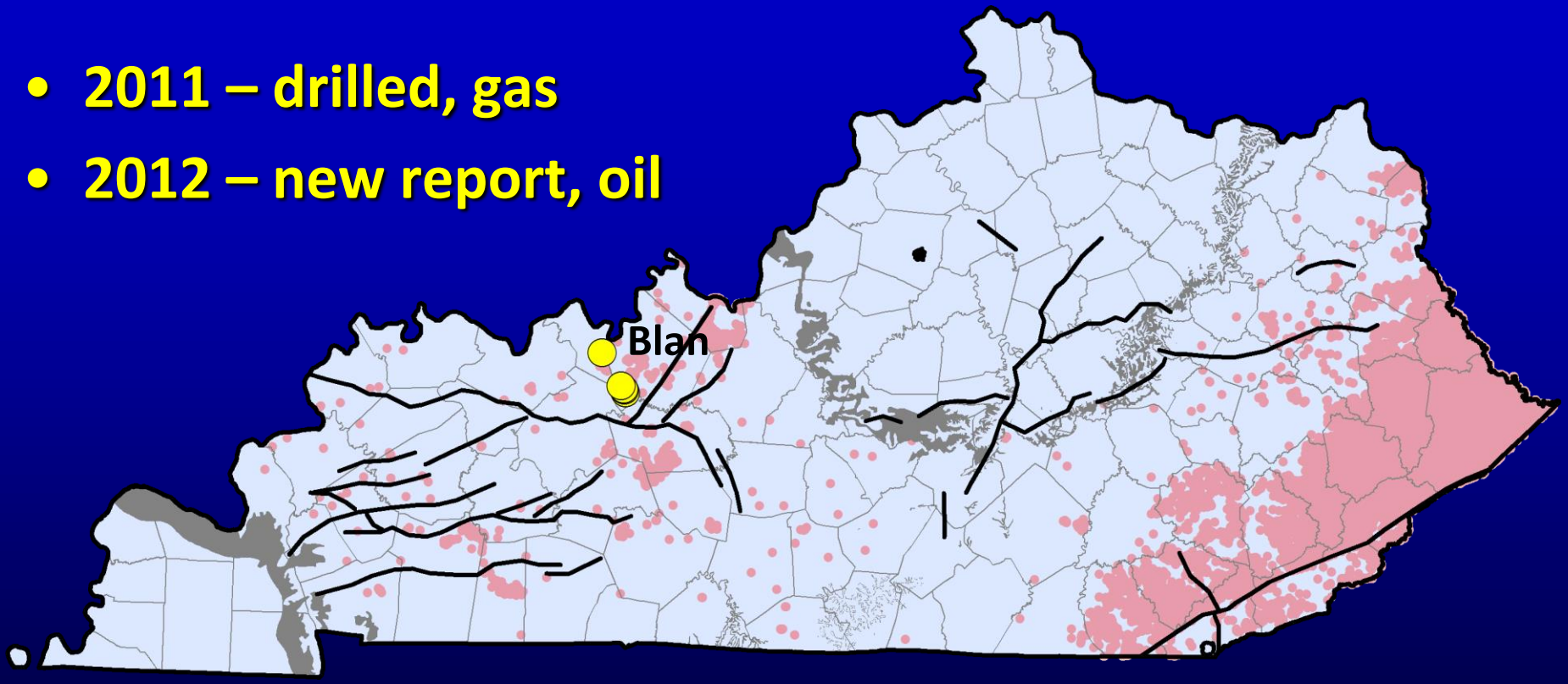
Endeavor Wells in Breckinridge Co.

- 2011 – drilled, gas
- 2012 – new report, oil



Initial GOR from 1.8 to 4

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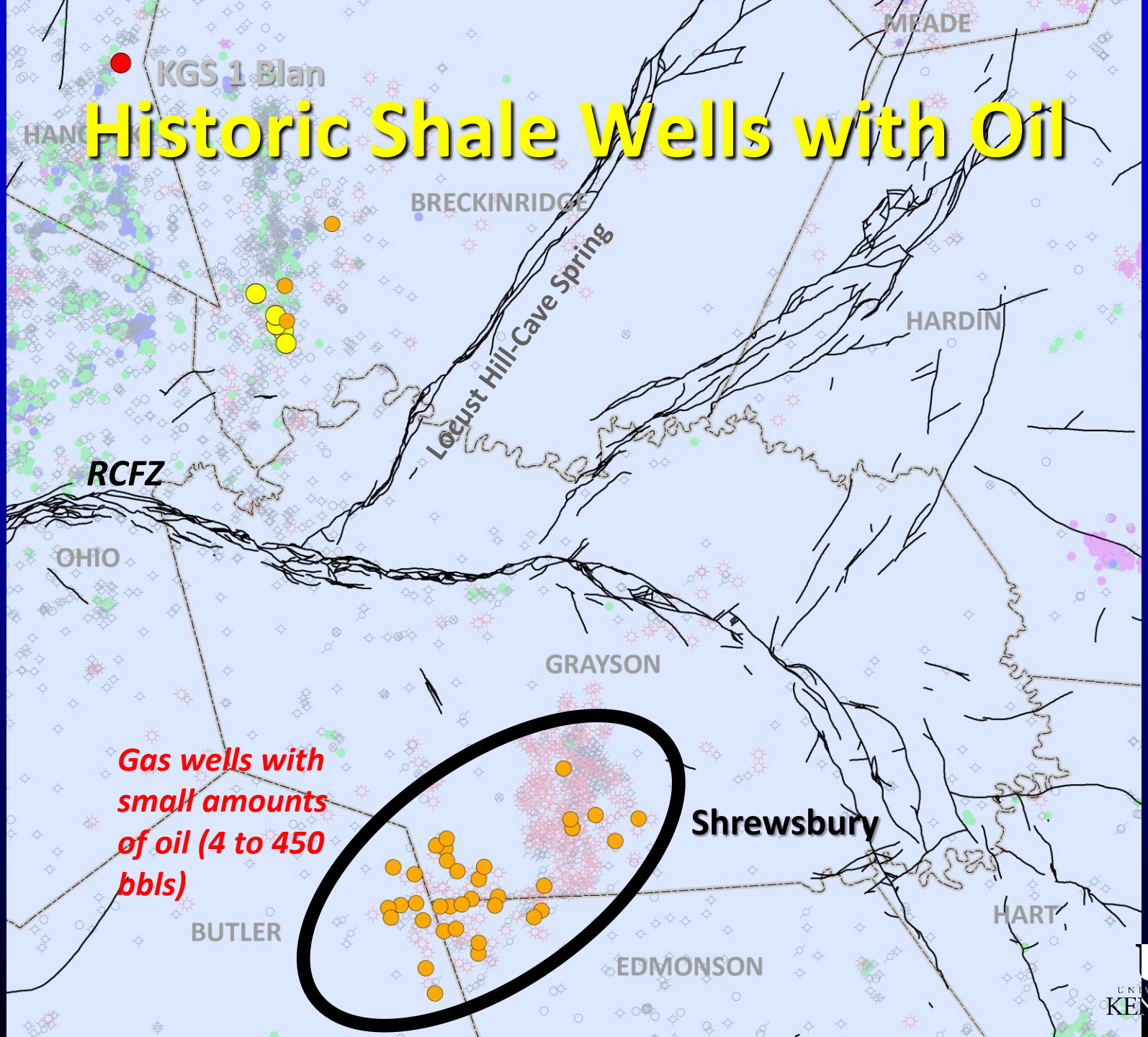
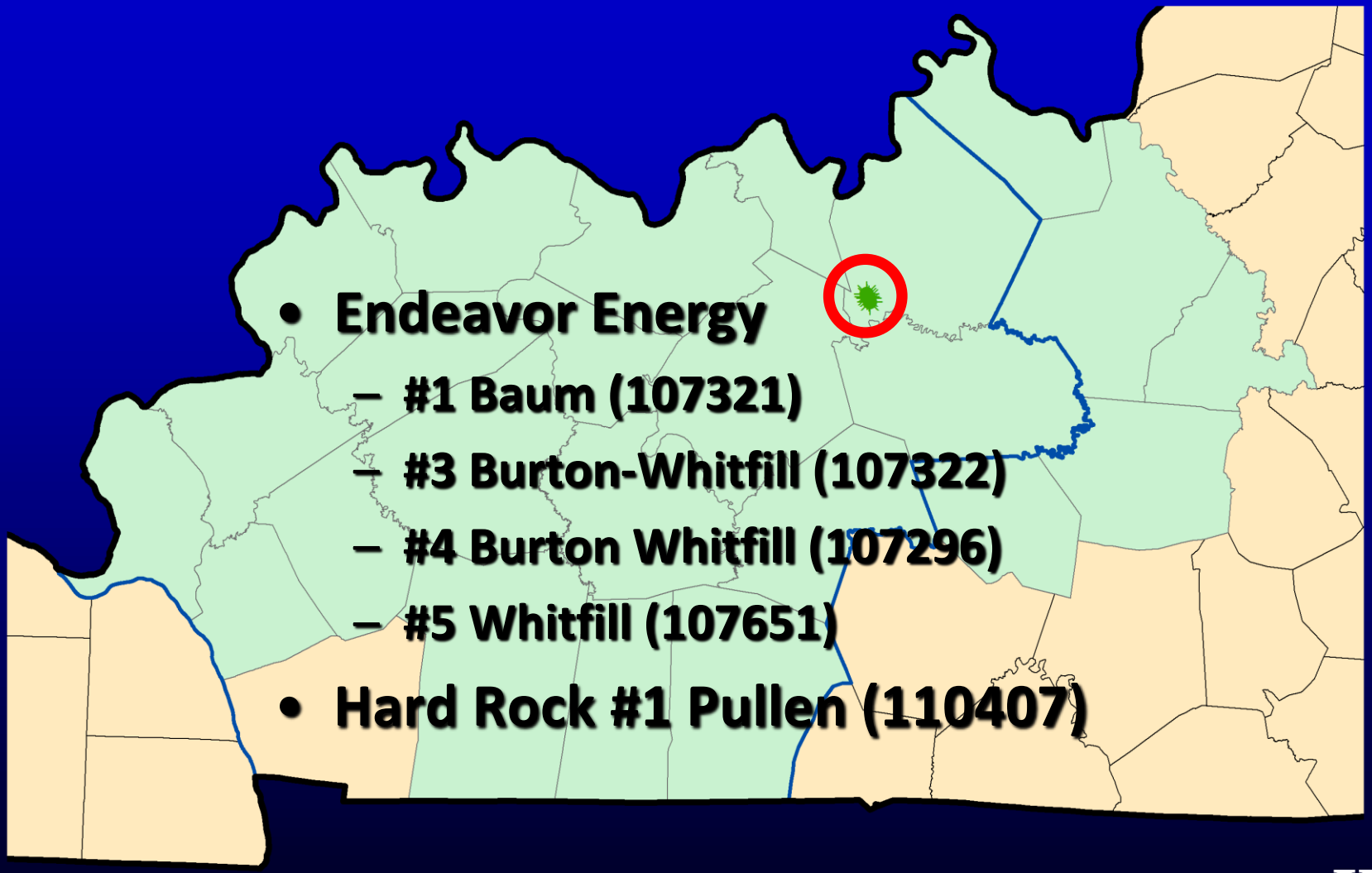

Historic Shale Wells with Oil
KGS 1 Blan
MEADE
BRECKINRIDGE
Locust Hill-Cave Spring
HARDIN
RCFZ
OHIO
GRAYSON
Gas wells with small amounts of oil (4 to 450 bbls)
Shrewsbury
BUTLER
HART
EDMONSON

Oil Production from New Albany



- **Endeavor Energy**
  - **#1 Baum (107321)**
  - **#3 Burton-Whitfill (107322)**
  - **#4 Burton Whitfill (107296)**
  - **#5 Whitfill (107651)**
- **Hard Rock #1 Pullen (110407)**

Thanks to Dave Harris for digging these out

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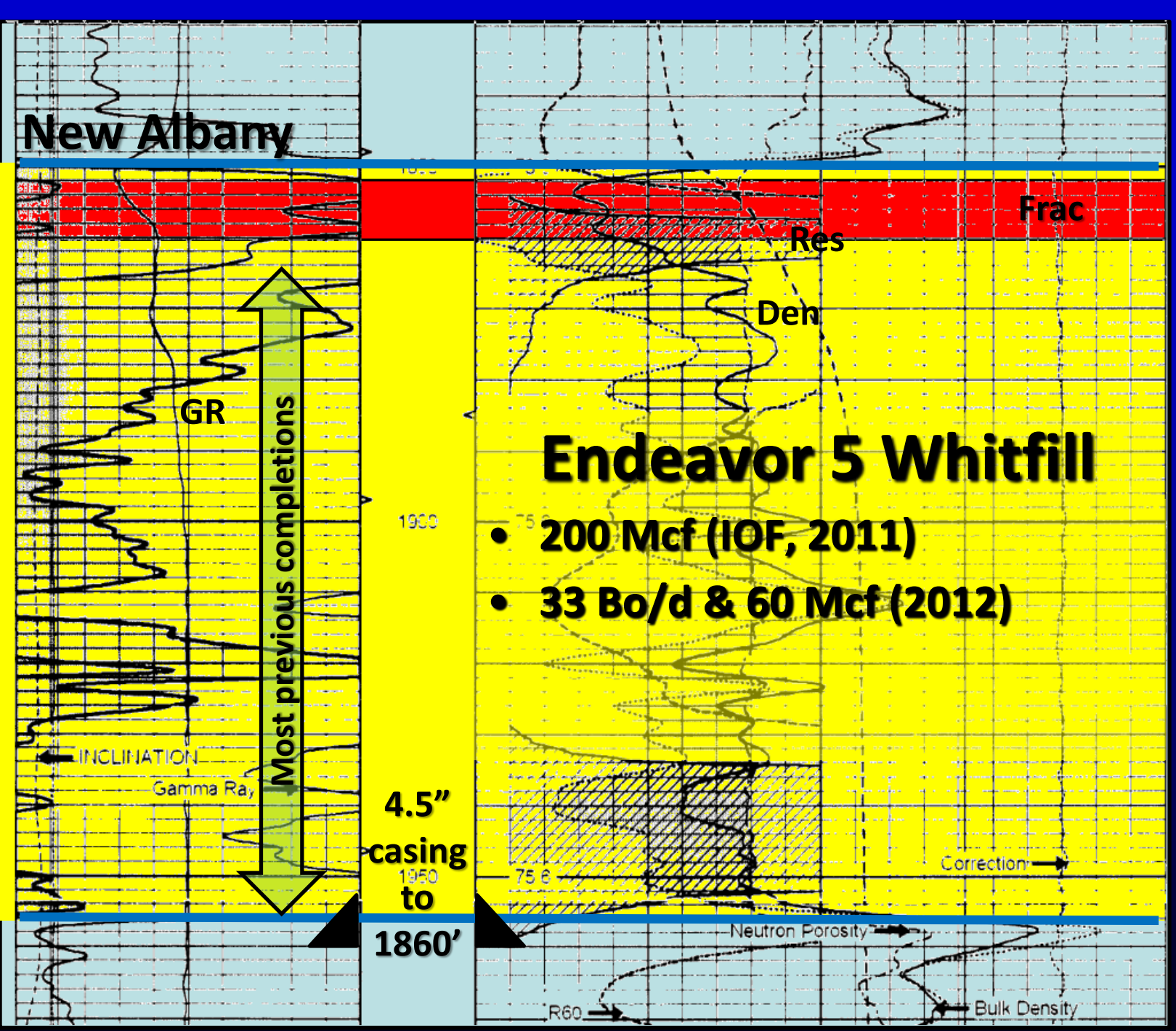

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Initial Completions

- Endeavor wells
  - Vertical wellbore
  - Cased hole
  - High GR in Grassy Creek
  - 7’ to 8’ interval
  - Water: 376 to 390 bbl
  - Sand: ≈45,000 lb
  - IOF 150 to 200 Mcf/d
    - Oil after 1 yr +/-
- Previous wells
  - Vertical wellbore
  - Cased hole
  - Entire New Albany
  - 113’ to 160’ interval
  - N_2 or N_2-foam frac
  - Sand: ≈60,000 lb
  - IOF 20 to 500 Mcf/d
    - Some production data indicate possible oil

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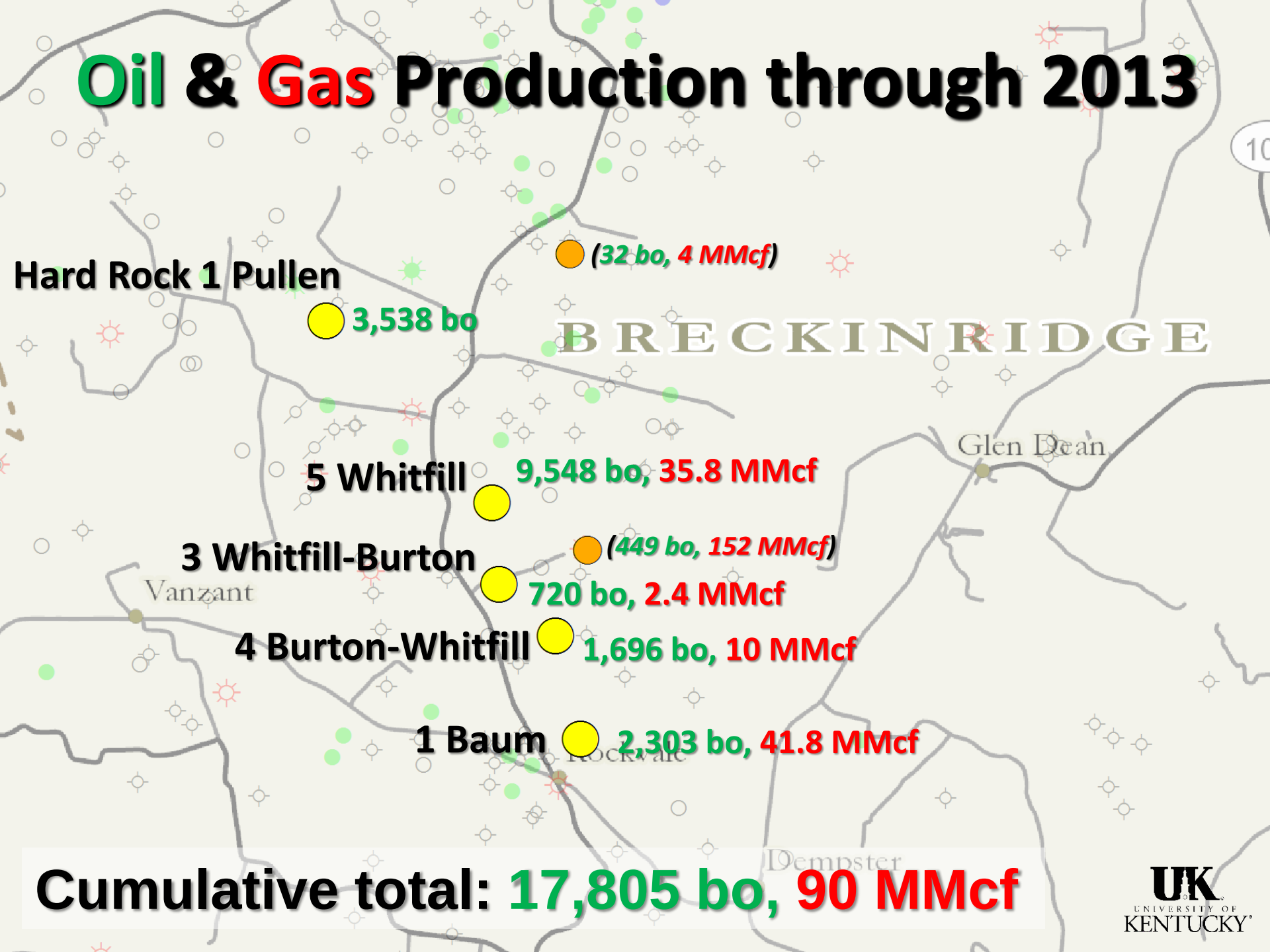
Oil & Gas Production through 2013



Cumulative total: 17,805 bo, 90 MMcf

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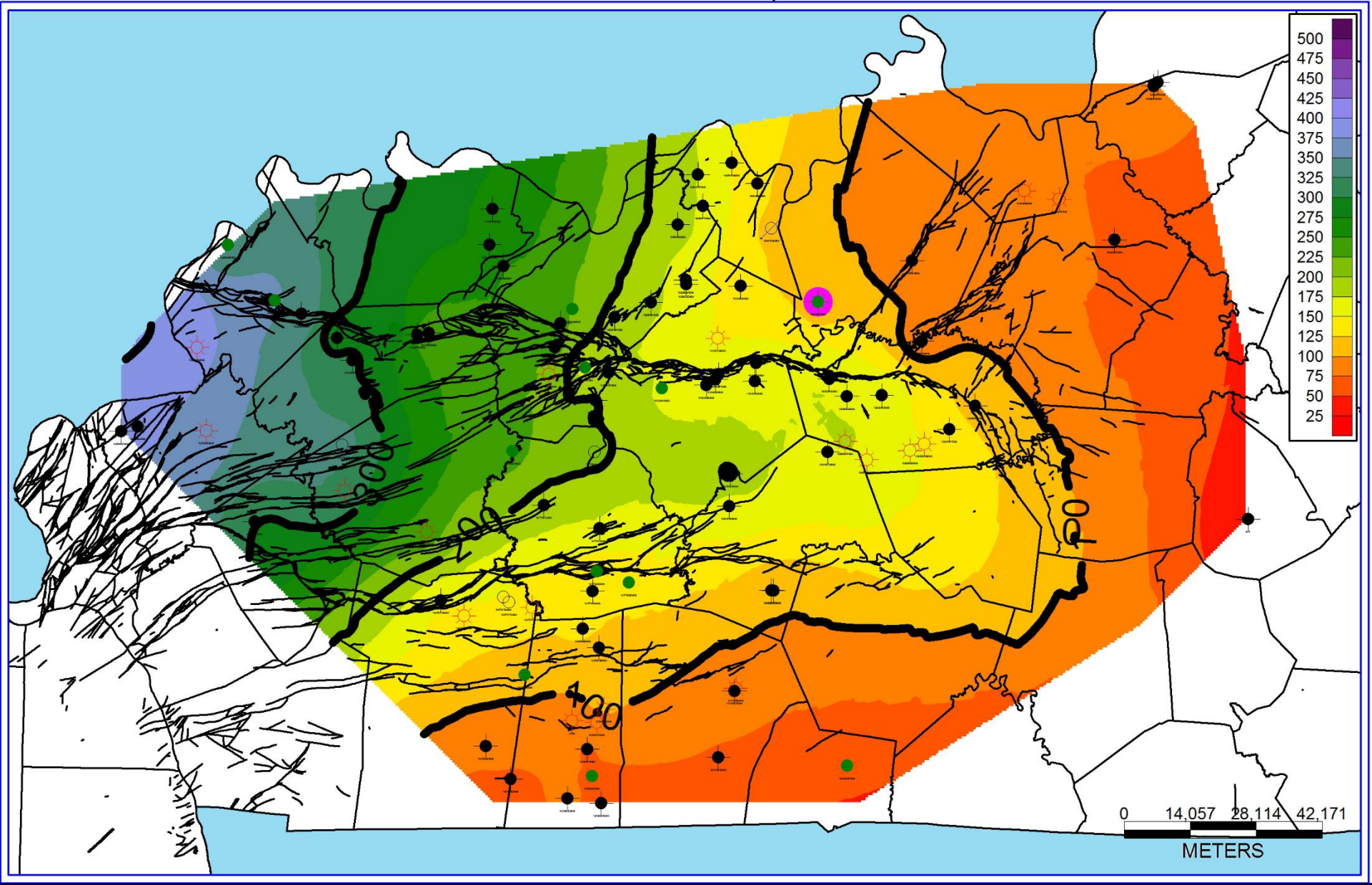

Isopach of New Albany

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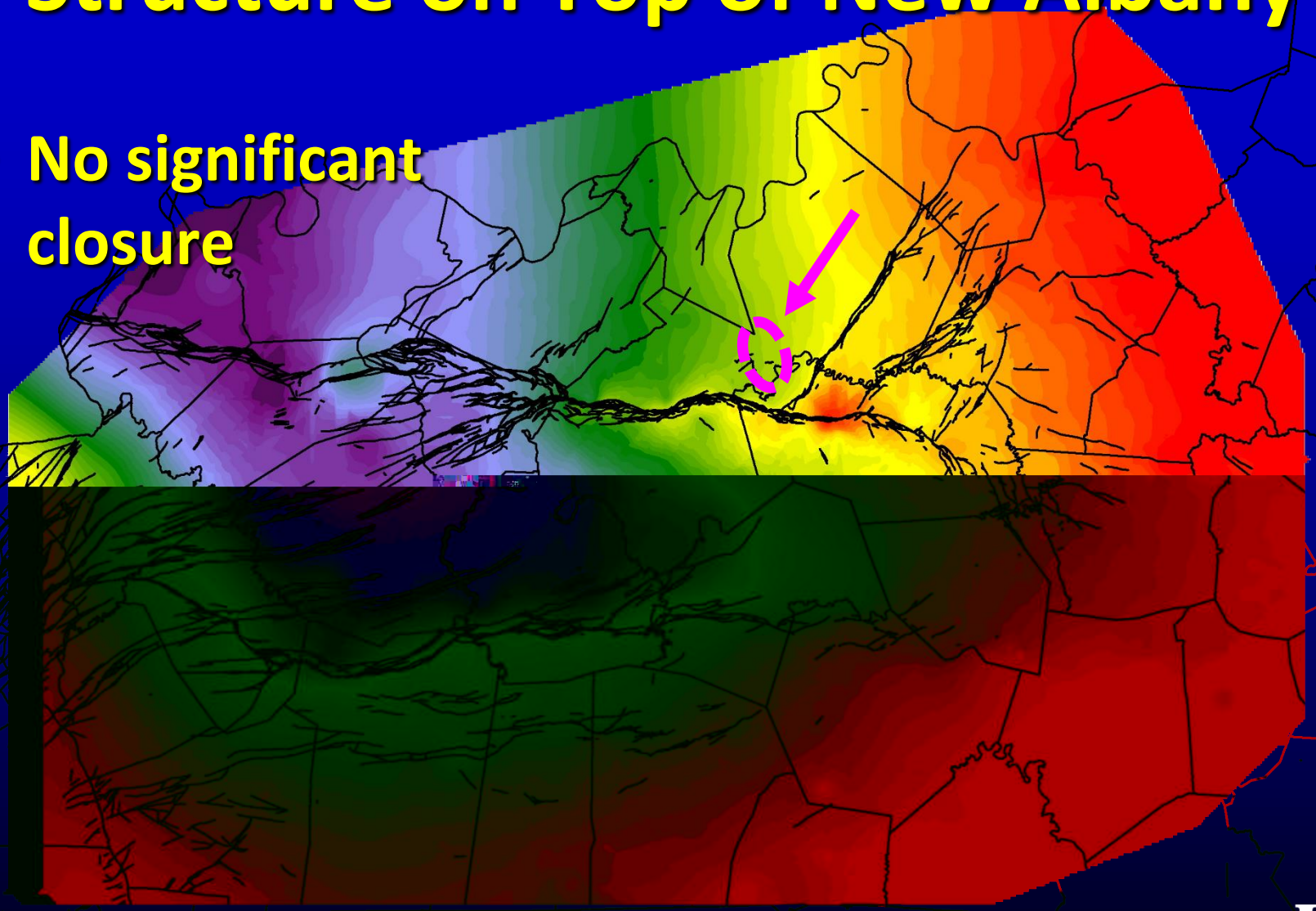
Structure on Top of New Albany

- No significant closure



Endeavor #5 Whitfill

During visit:

- Estimated
  - 10-12 bo/d
  - 20 Mcf/d
- 400 psi backpressure
- Paraffin
  - AT 60 bo/d
  - Declines to 5 bo/d

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Preparing to Sample Fluids

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Sampling

- Medium olive, 42° API oil
- All sampling done in closed systems

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Analyses & Data Sets

	Endeavor 4	Endeavor 5	KGS 1 Blan
Natural gas Composition Isotopes	✓	✓	Other data see Nuttall (2013) KGS RI 17
Oil Whole oil GC Isotopes MPLC	✓	✓	
Cuttings/Core Extract GC Aromatic GCMS Saturate GCMS MPLC	✓		✓

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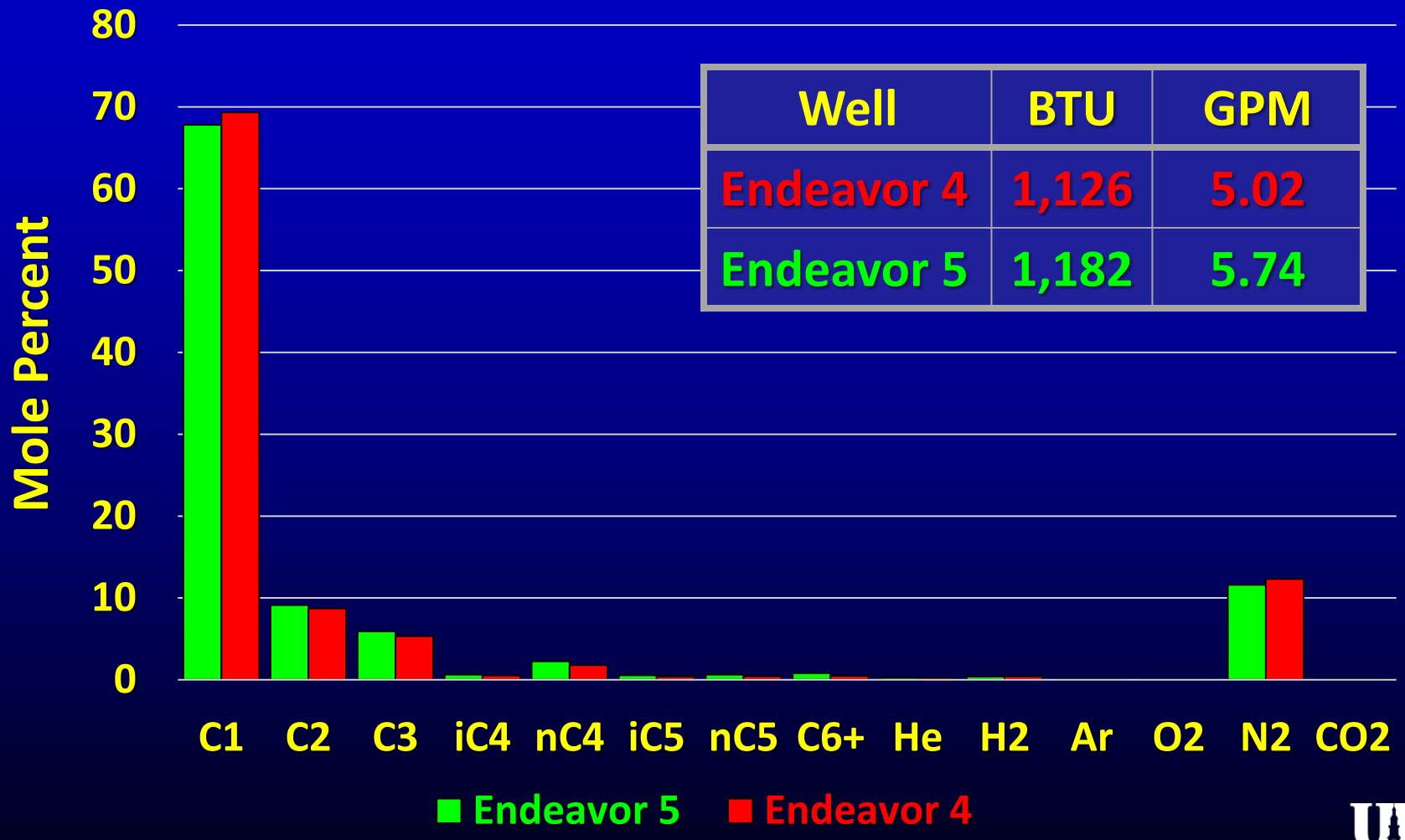
Gas Analysis



Well	BTU	GPM
Endeavor 4	1,126	5.02
Endeavor 5	1,182	5.74

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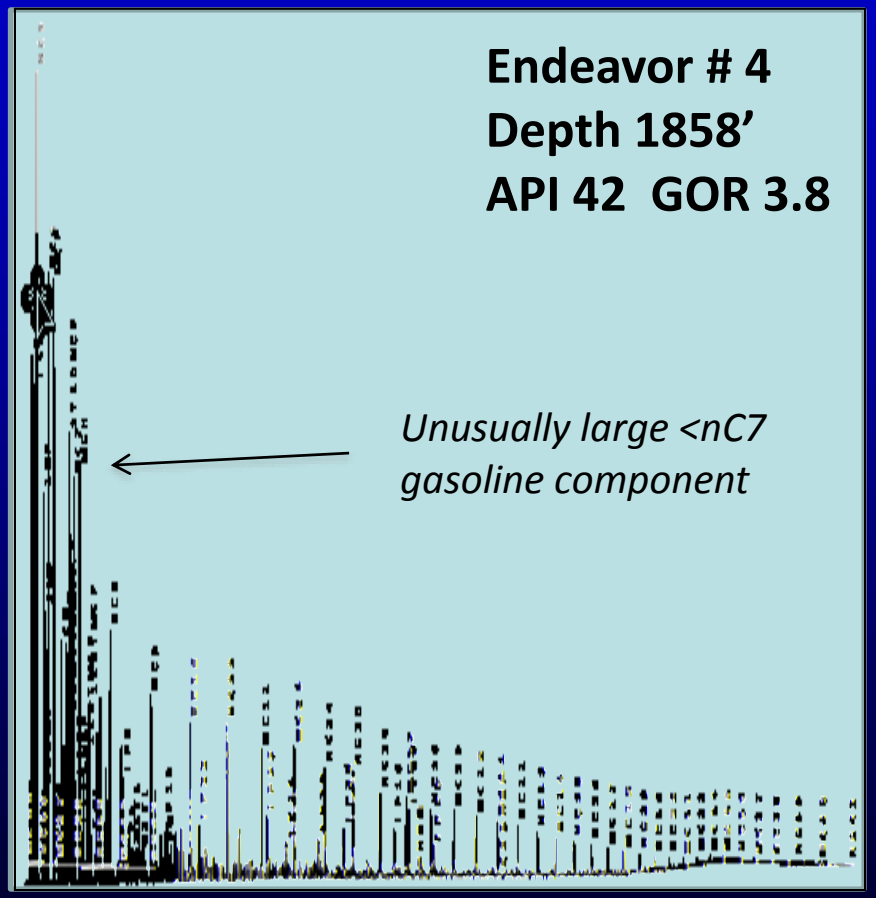
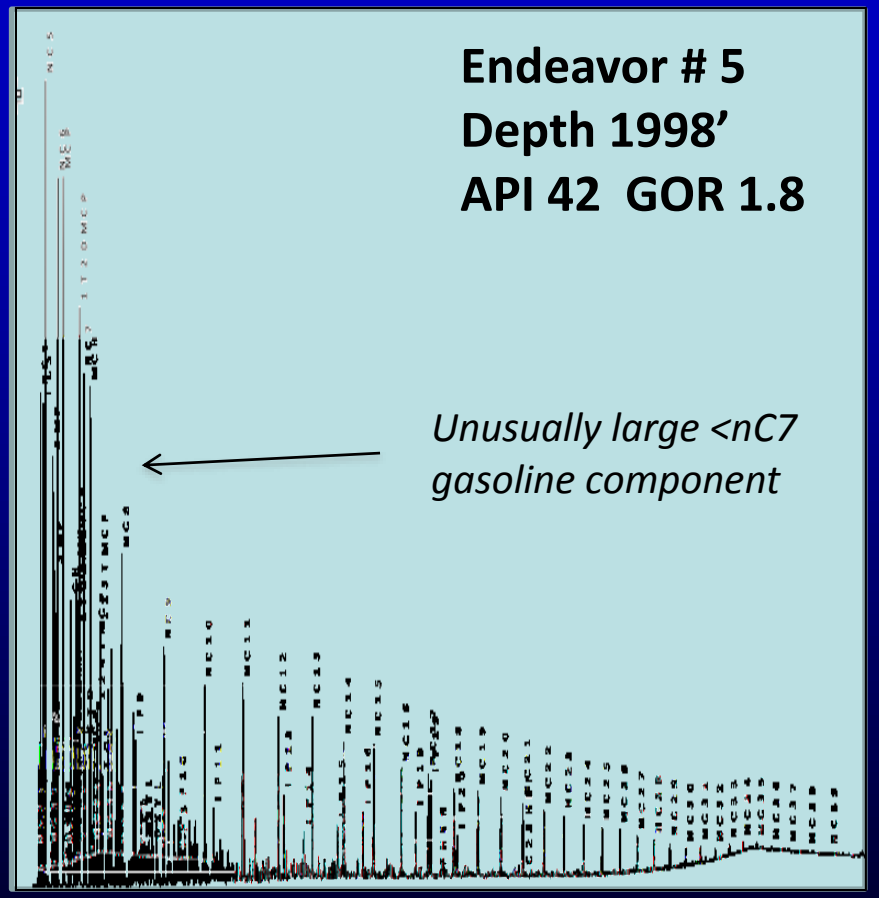
Gas Chromatograms of Whole Oil





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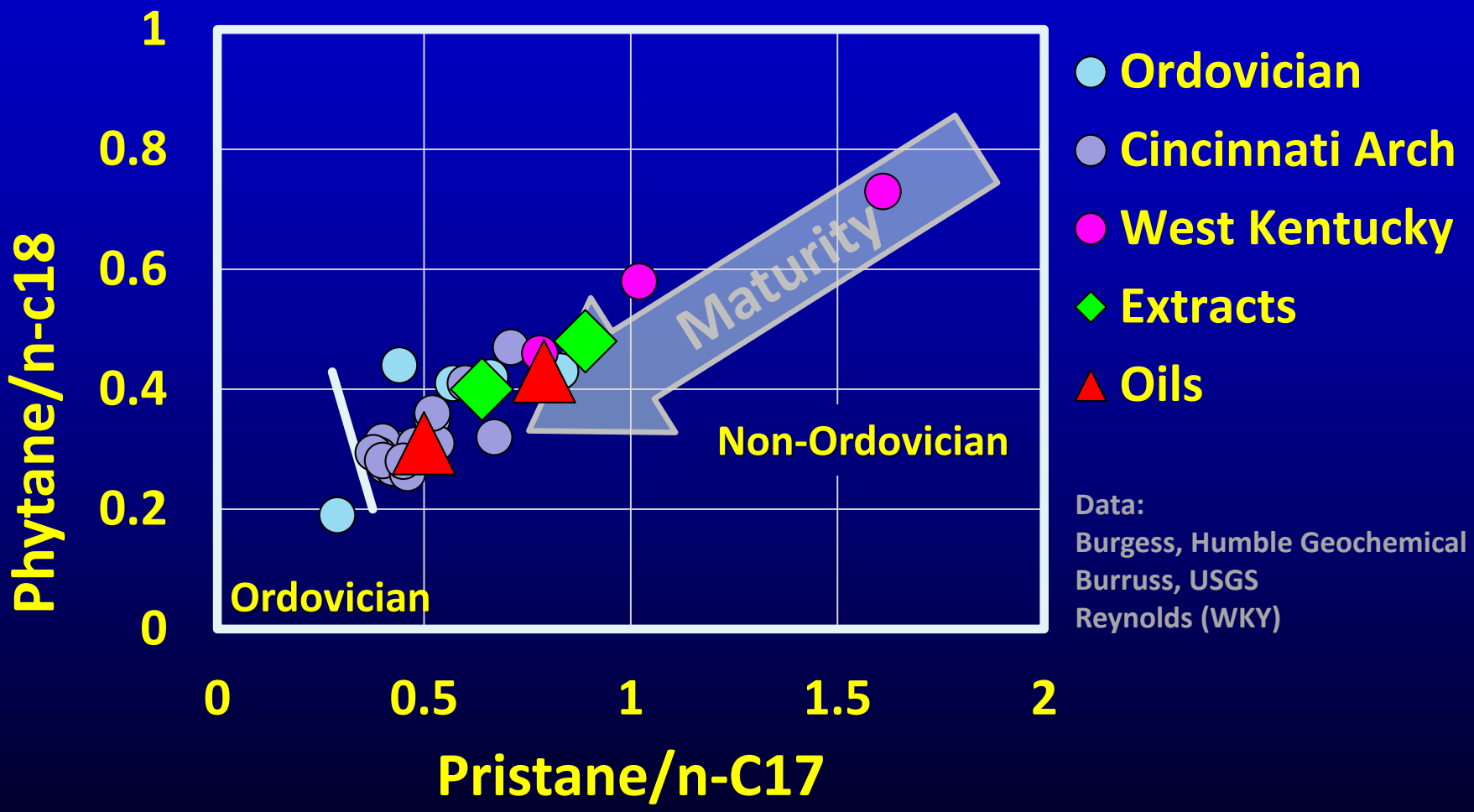
Oil & Extract Gas Chromatographs



Modified from Hamilton-Smith (KGS unpublished)
Hunt (1995)

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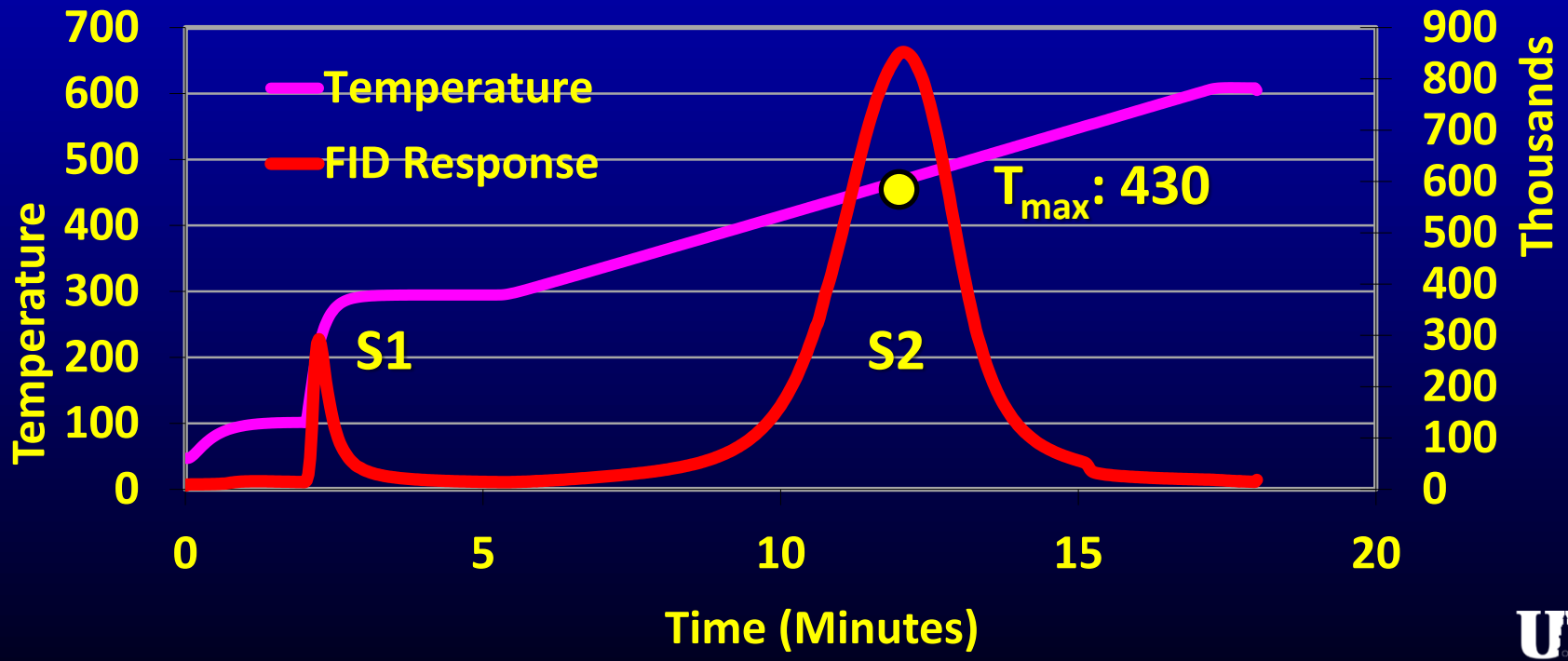
Not a Geochemist

Rock-Eval Definitions

- S1 – free oil content
- S2 – remaining hydrocarbon potential
- T_{max} – temperature of maximum rate of evolution of S2 hydrocarbons, thermal maturity
  - $\%R_o = 0.018*T_{max}-7.16$ (Jarvie, 2001)
- Kerogen types:
  - HI – normalized hydrogen content
  - OI – normalized oxygen content

Endeavor #4 Pyrogram

- Organic-rich, early mature source rock
- Broad S2 indicates large capacity to generate hydrocarbons



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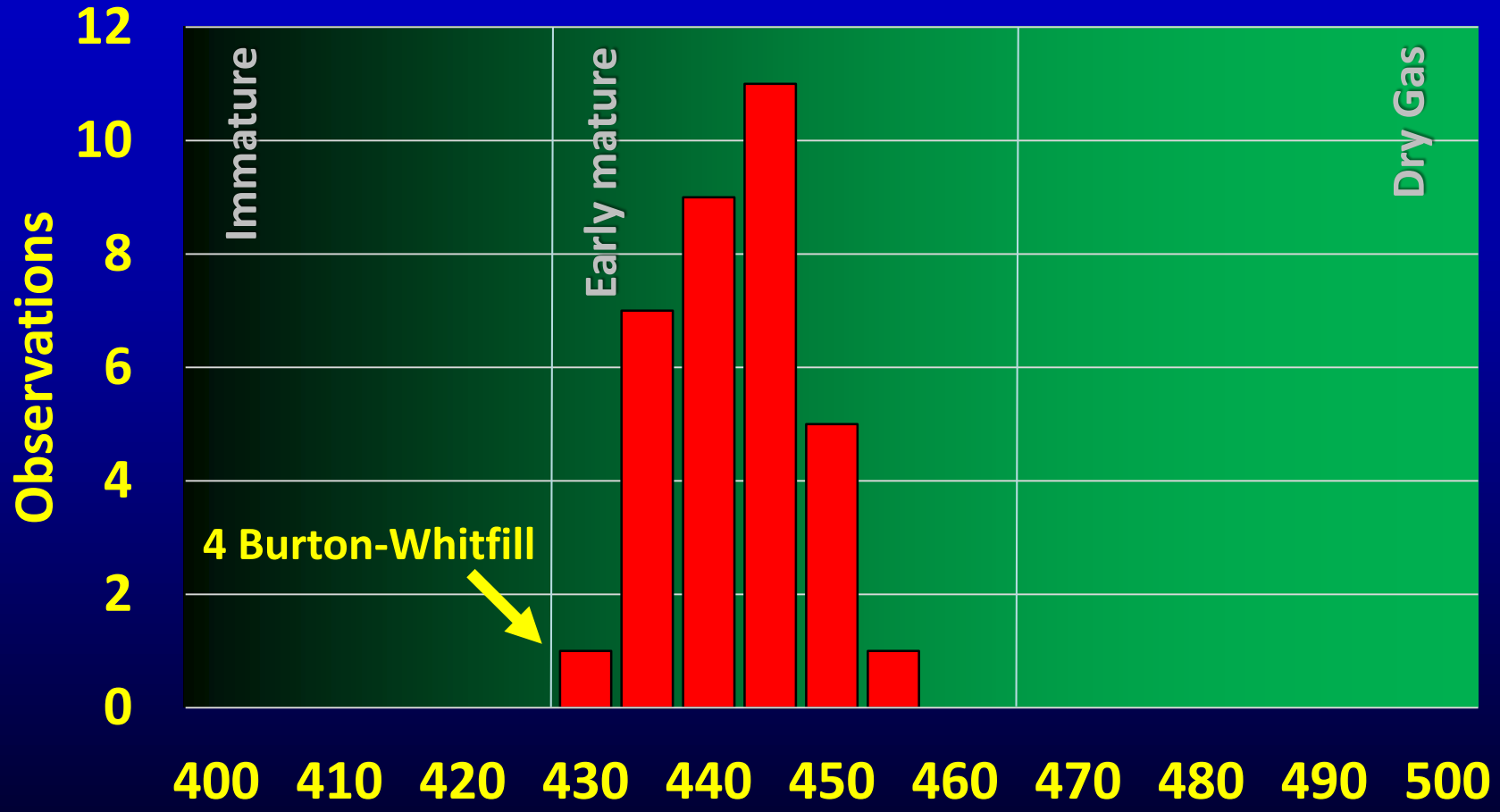
T_{max} (°C) – Max. Rate S2 Conversion



After Cole et al (1994)
Data from Endeavor 4, Blan, IP136, RPSEA

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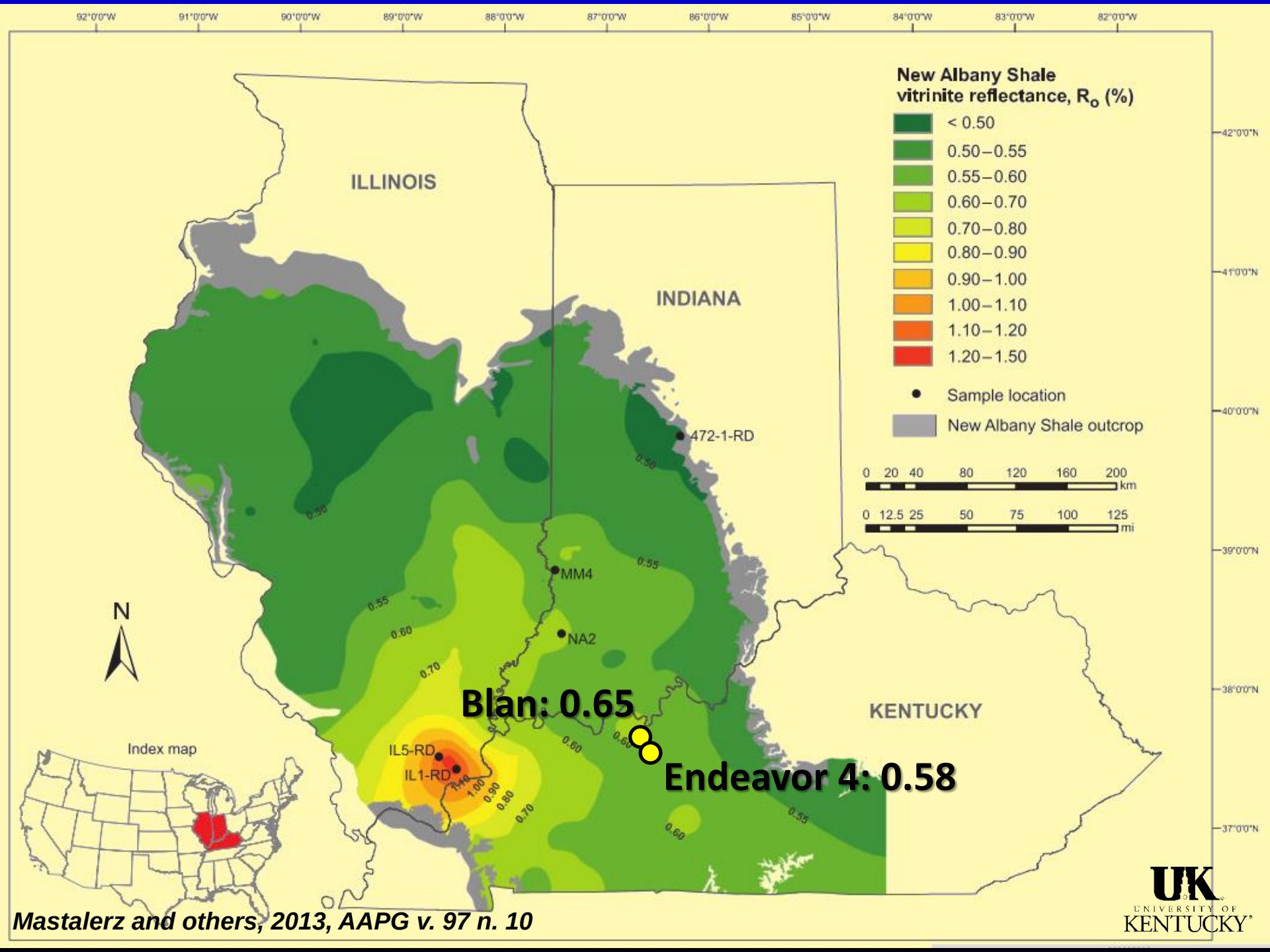

Mastalerz and others, 2013, AAPG v. 97 n. 10

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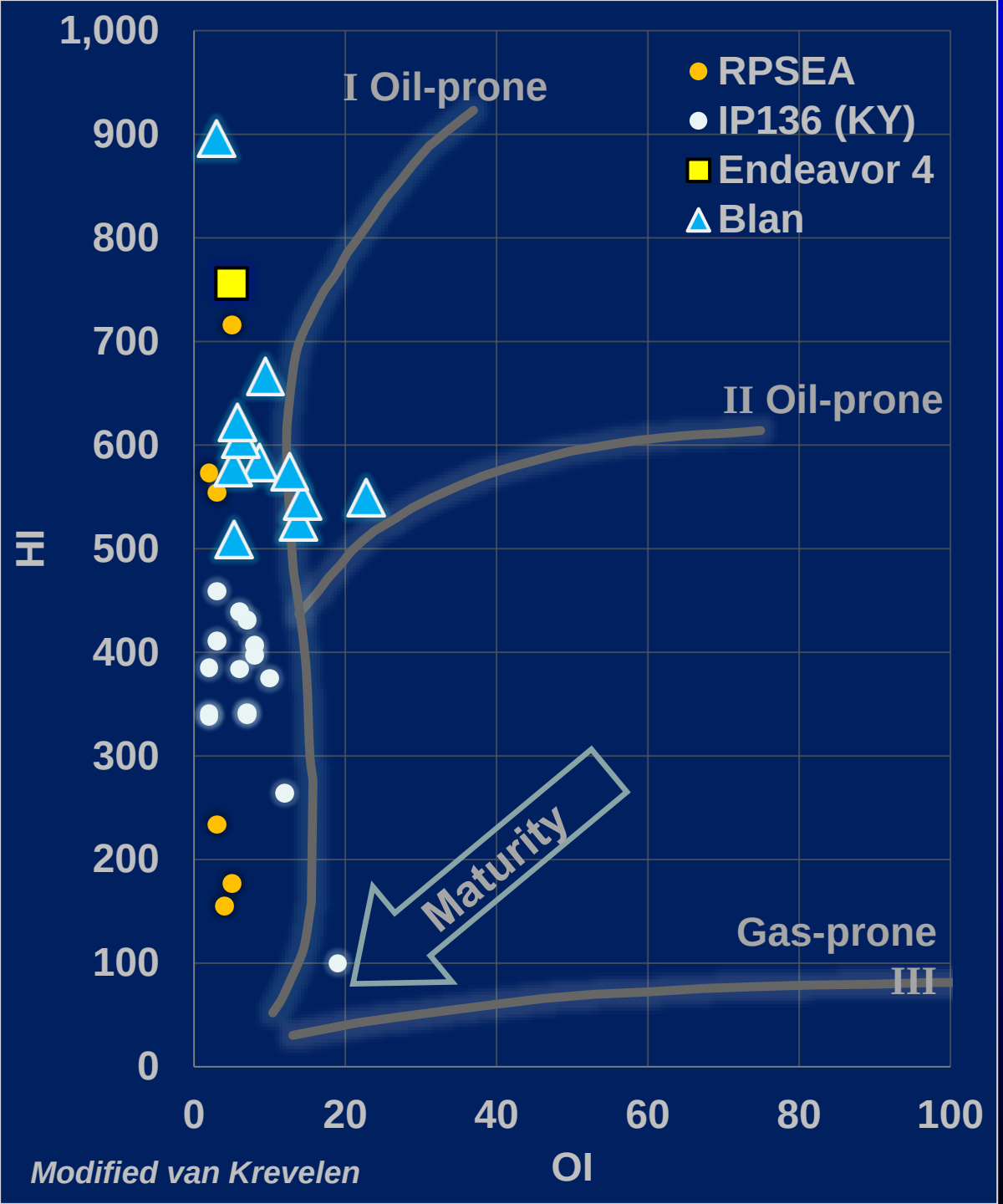

Rock-Eval

- Early mature
- Type I & II
- Oil prone
- Marine

Blan: Nuttall (2013) KGS Ser 12, RI 17

IP136: Chou and others, (1991)

RPSEA: Salehi and others, (2010) contract 07122-6

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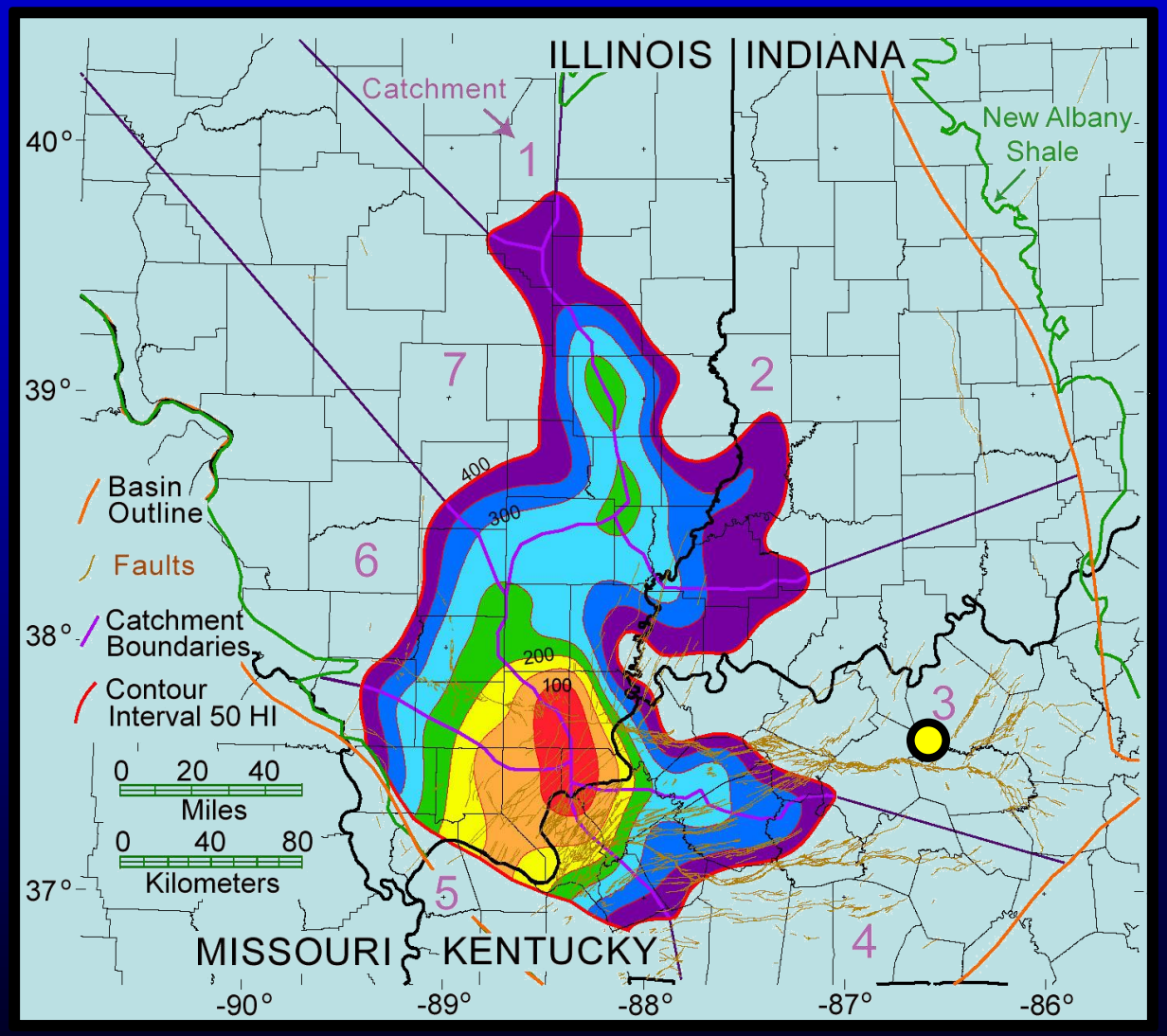
HI – Kerogen Conversion



New Albany Shale Petroleum System

Smaller HI indicates more conversion

Higley et al (2003) pubs.usgs.gov/of/2003/ofr-03-037/

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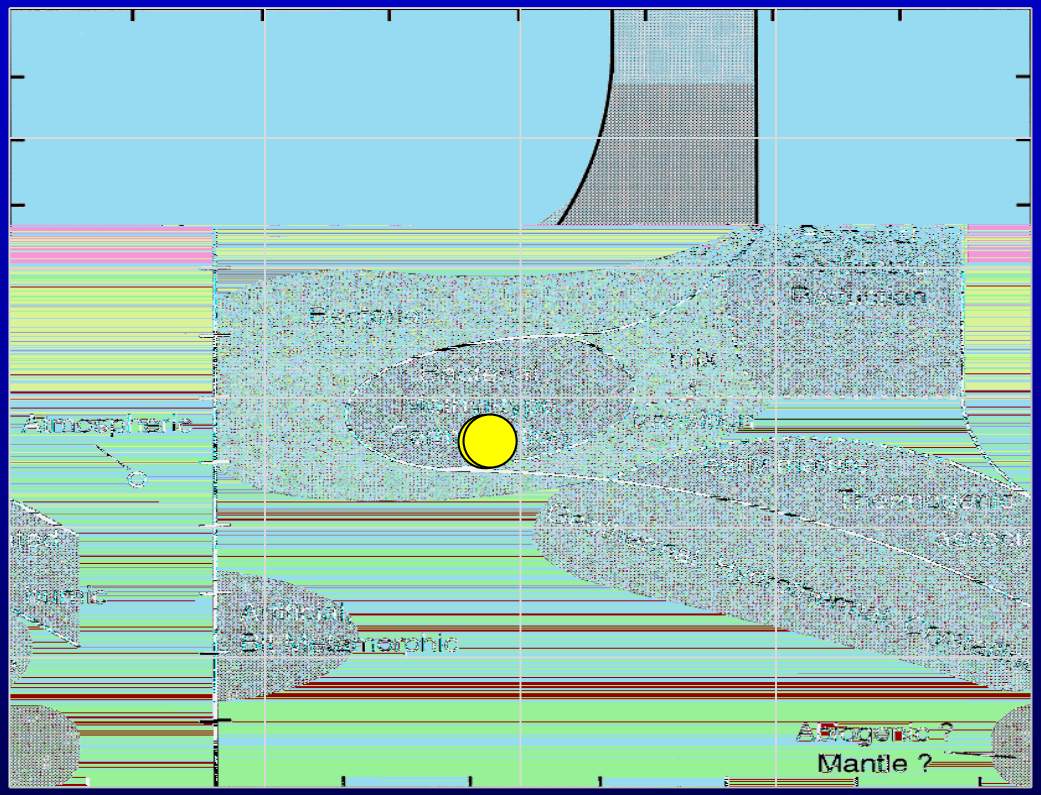
Methane Isotopes



-120
-100
-80
-60
-40
-20
0

$\delta^{13}C$

-450 -350 -250 -150 -50

δD_{C1}

Early mature thermogenic

Whiticar (1999)

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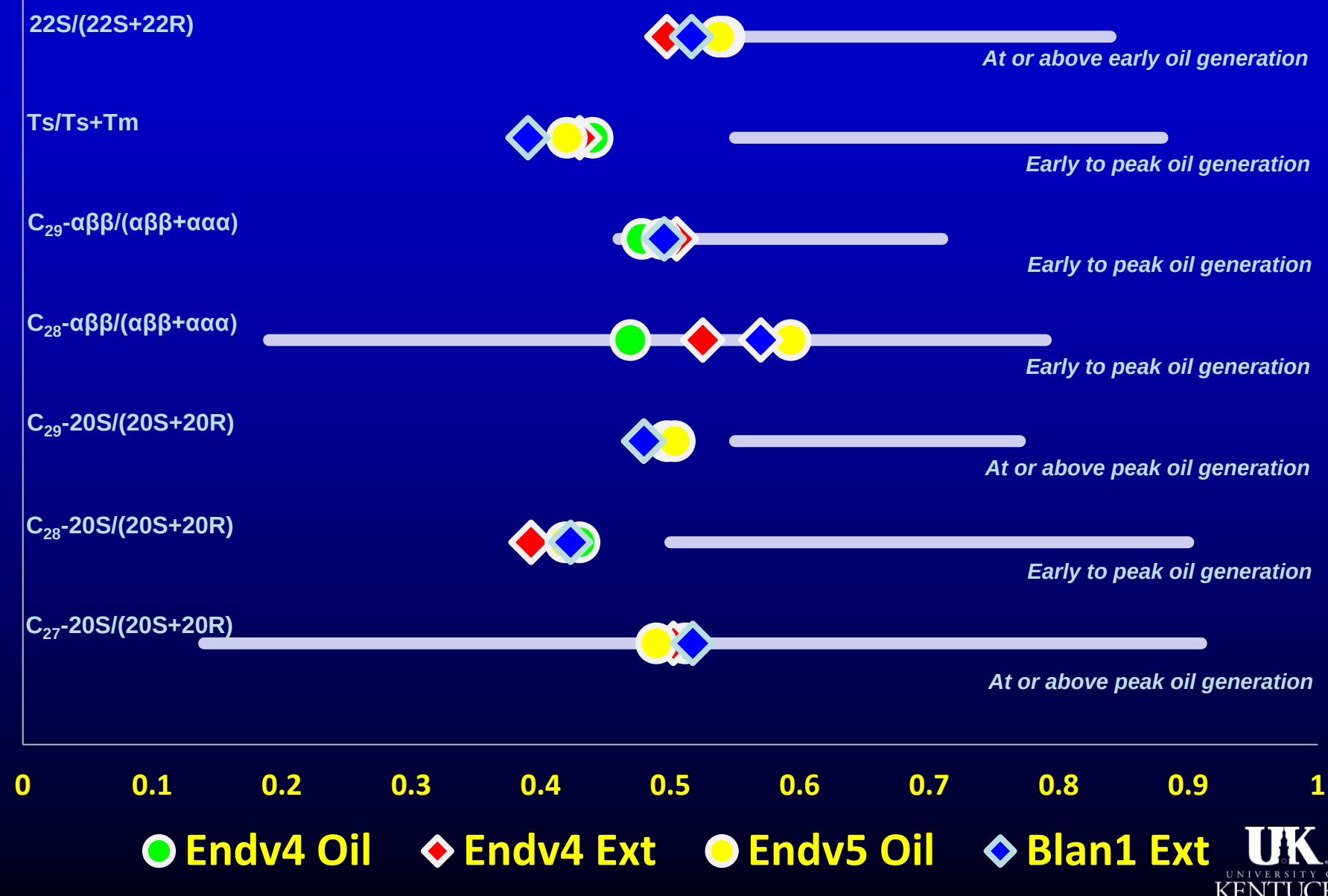
Biomarkers: Early Mature



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Key Data Summary

		Endeavor 4	Endeavor 5	Blan 1
	Depth (ft)	1,858	1,998	1,876.5
Rock-Eval	TOC (%)	9.93		7.93
	HI	756		896
	S1	4.73		6.16
Oils	%Saturates (Oils)	61.69	62.95	
	%Aromatics (Oils)	28.43	26.84	
	Sat. $\delta^{13}C$	* -30.9	* -30.8	
	Arom. $\delta^{13}C$	* -29.8	* -29.8	
Extracts	%Saturates (Ext)	21.37		31.68
	%Aromatics (Ext)	17.57		19.72
	Sat. $\delta^{13}C$	* -29.2		* -29
	Arom. $\delta^{13}C$	* -29.1		* -29.1

Consistent with having been generated in place

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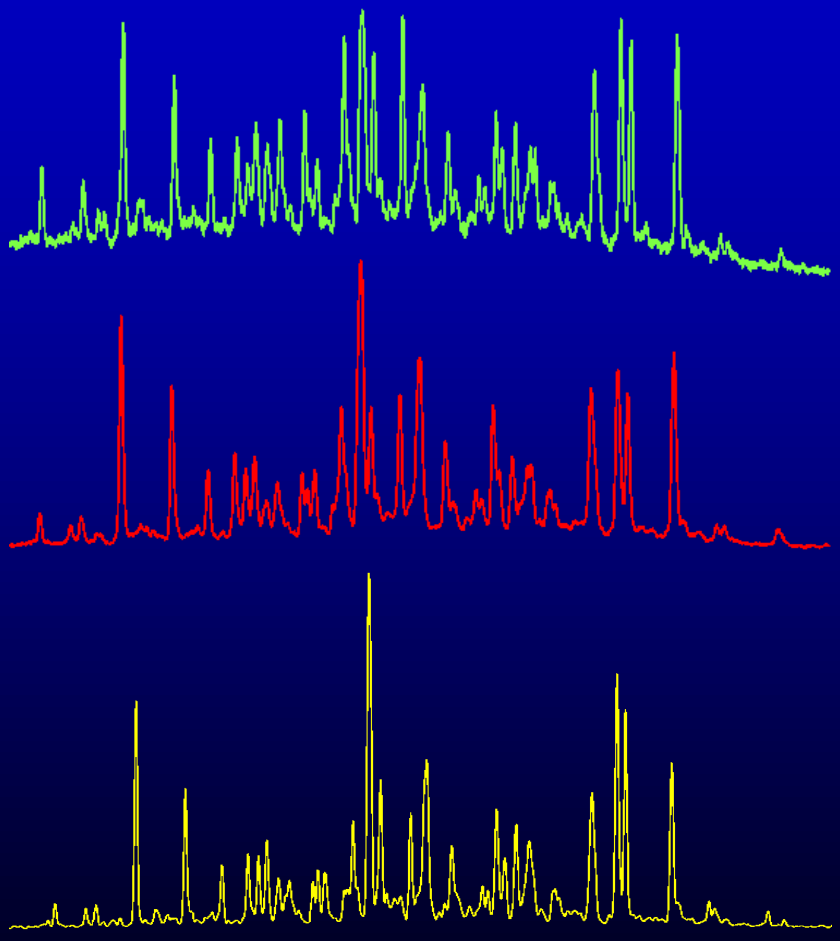
Biomarkers: Sterane Distributions (GCMS)



Cuttings Extracts

Oil

Endeavor 4

KY0014 *Geomark*

(U. Devonian, distal marine shale, moderate maturity)

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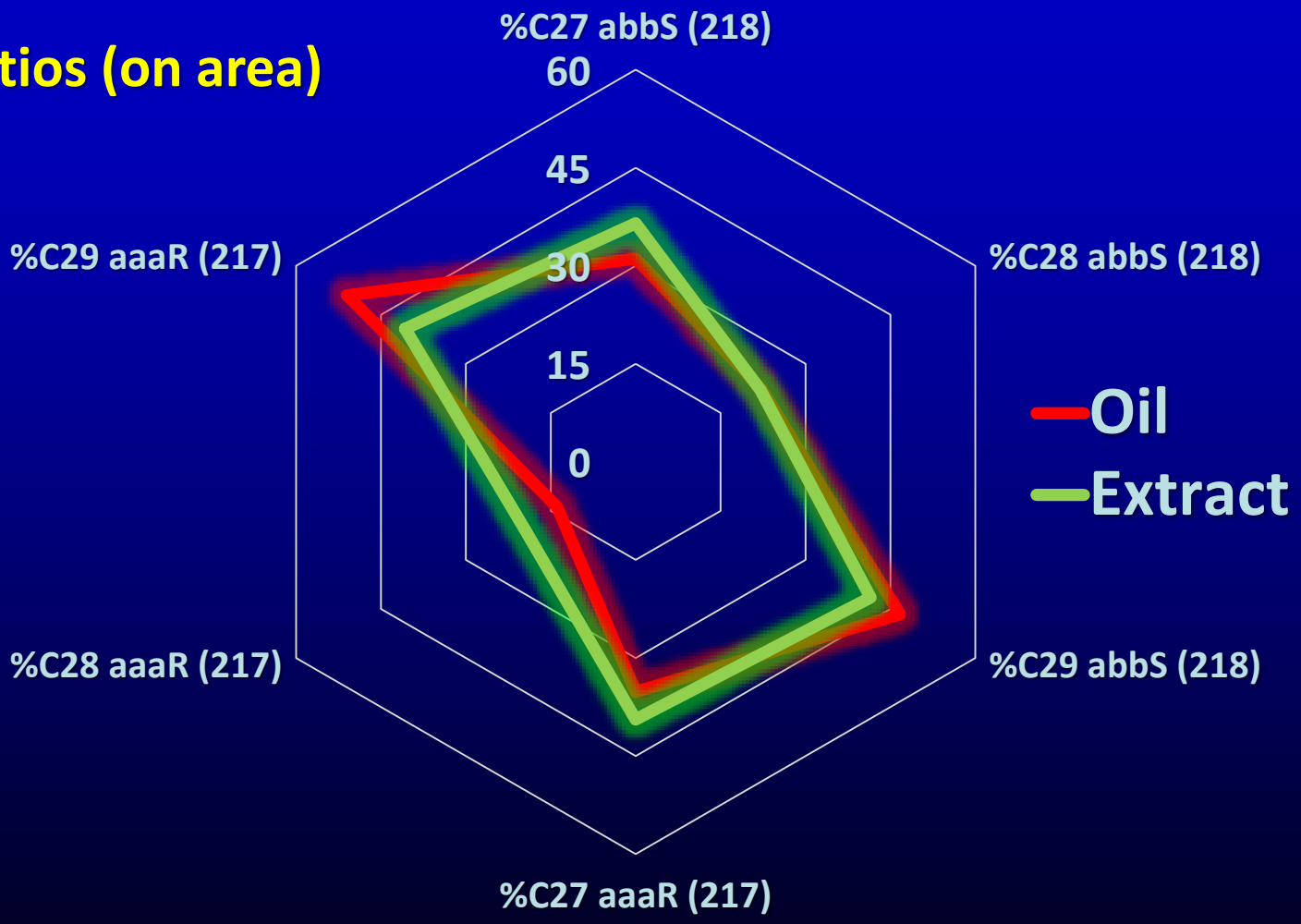
Endeavor 4 Saturates (Steranes)

GCMS ratios (on area)



Drawn from same population (X^2 @ 95% confidence)

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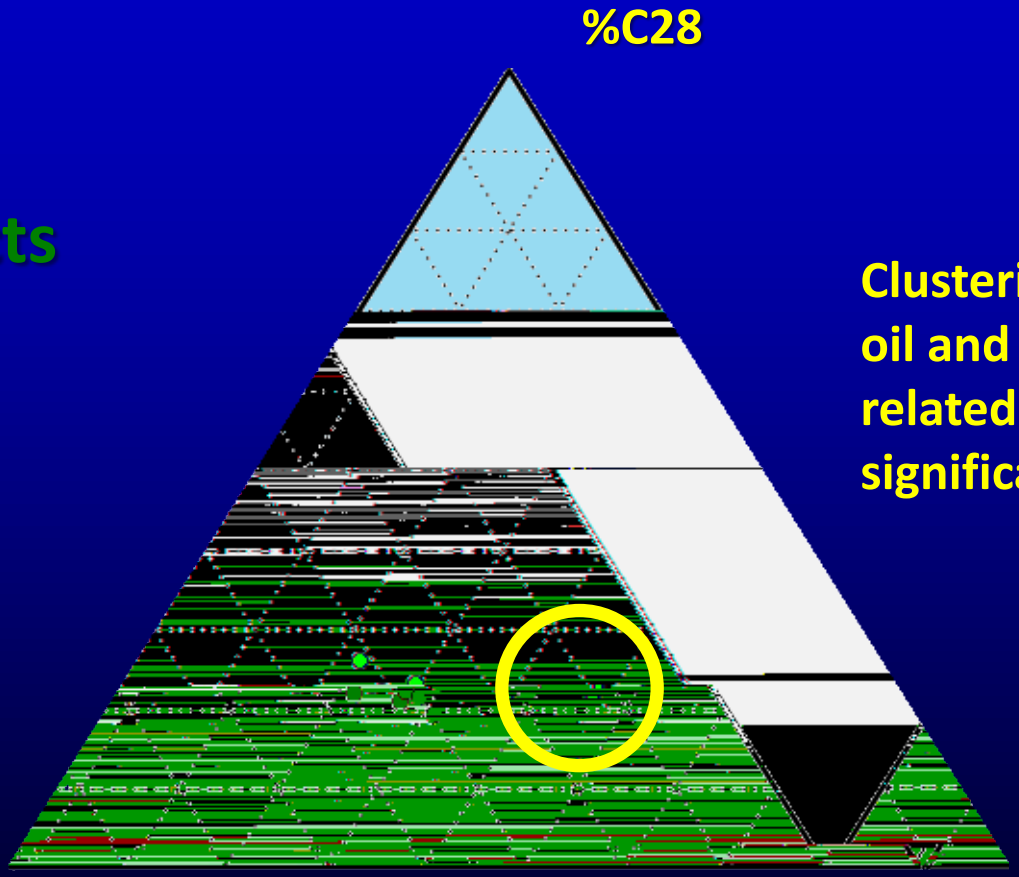
Oils and Extracts

Oils

Extracts



Clustering indicates oil and source are related (statistically significant)

Some data courtesy of Geomark

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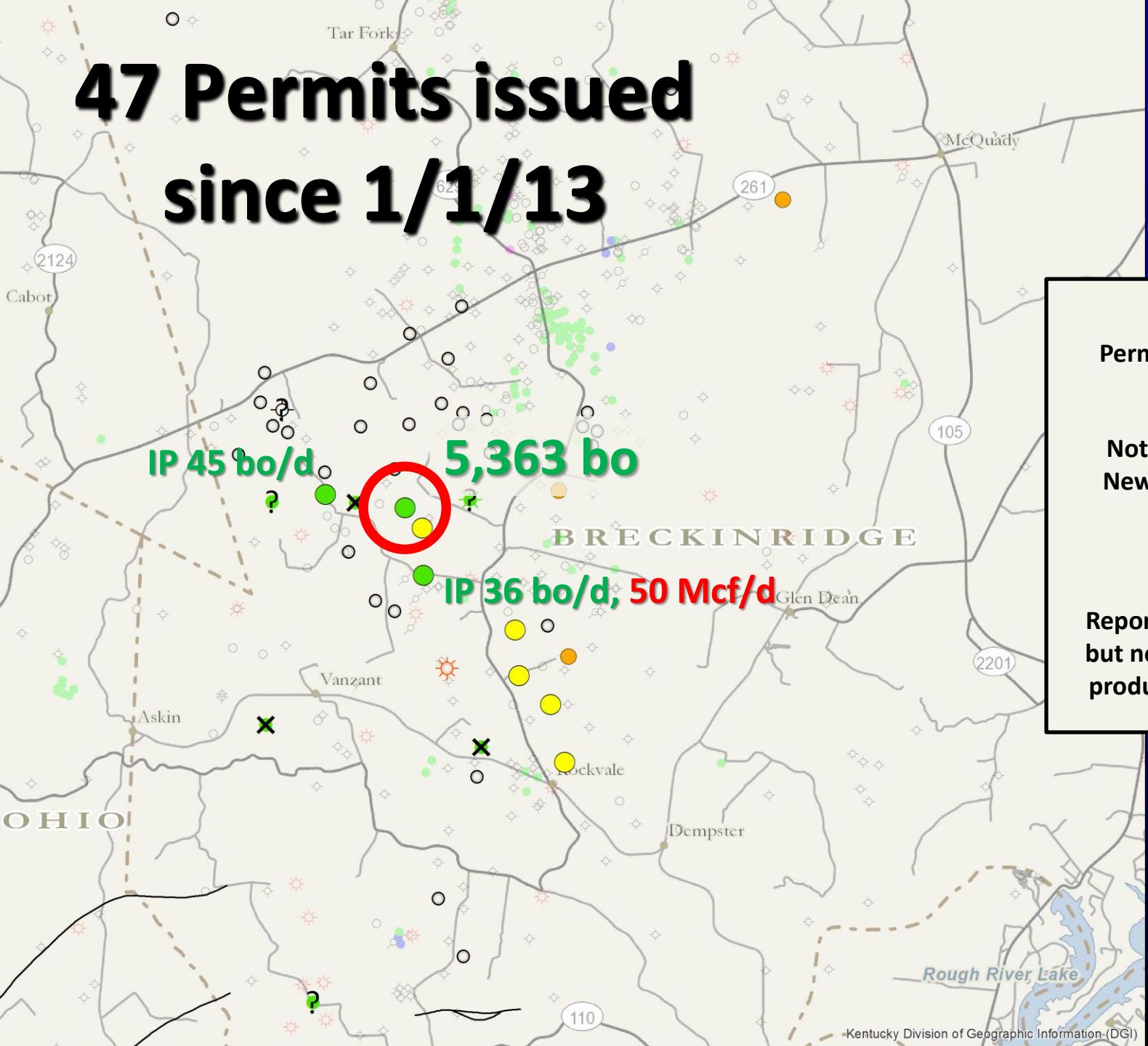
47 Permits issued since 1/1/13



○

Permitted location

×

Not completed in New Albany Shale

?

Reported completed, but no completion or production available

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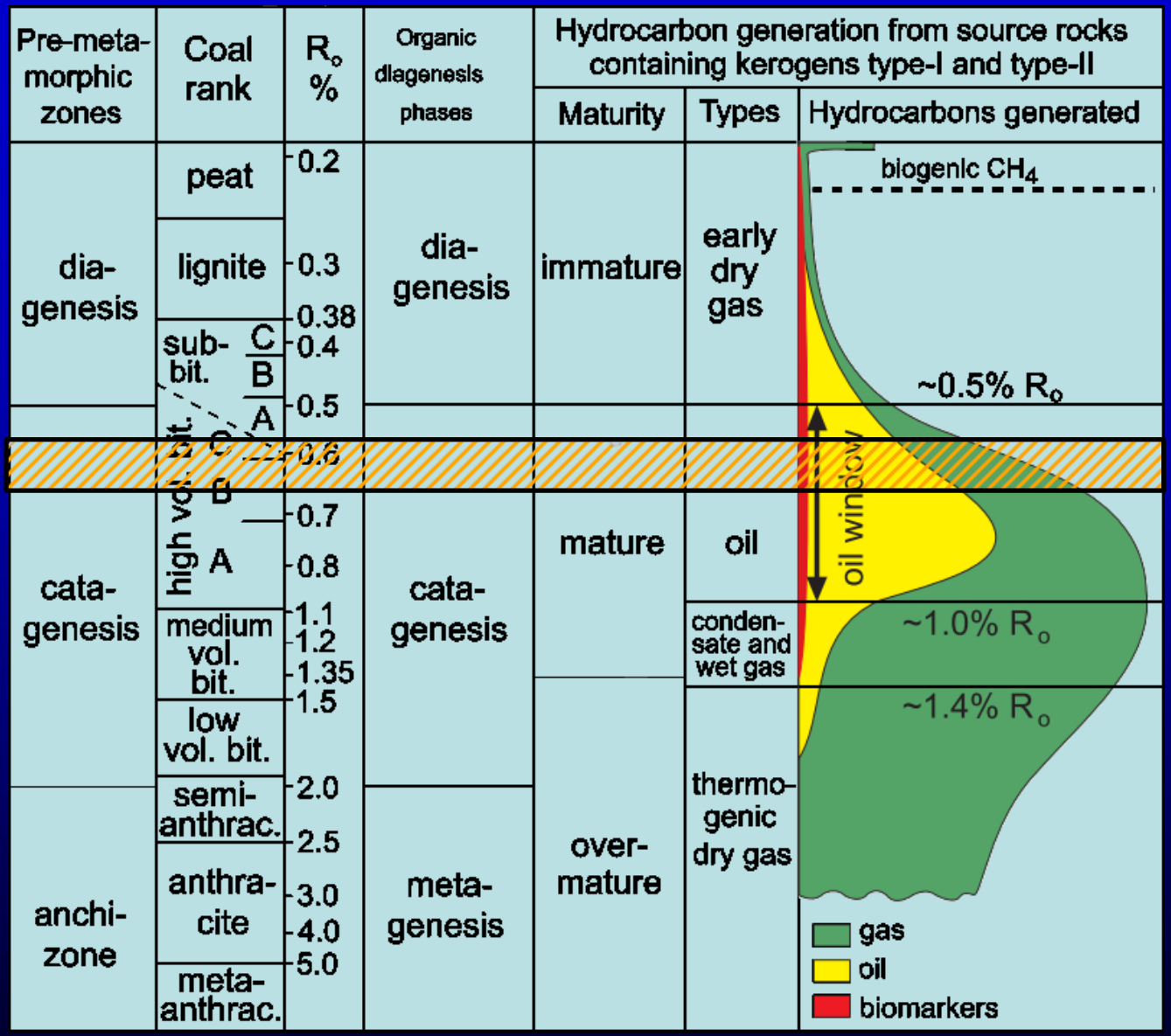
Maturity Summary



- Good source rock
- Early mature
- Type I & II
- Oil prone
- Marine
- Thermogenic

Modified from Mastalerz and others (2013) AAPG v. 97, n. 10

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Conclusions

- Early mature source rock
- Consistent with generation in New Albany
- Not consistent with classic measures of thermal maturity
  - Wet gas
  - Higher than expected light gasoline fractions

Takeaway

- Extremely limited data set
  - 2 data points do not make a play
- Potential for oil and NGLs
  - Down dip?
  - West of Locust Hill-Cave Spring Fault?
  - North of the Rough Creek Fault?
  - More mature in Rough Creek Graben?

Takeaway

- Extremely limited data set
  - 2 data points does not make a play
- Potential for oil and NGLs
  - Down dip?
  - West of Locust Hill-Cave Spring Fault?
  - South of the Rough Creek Fault?
  - More mature in Rough Creek Graben?

The current wellhead price of oil and gas!

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Acknowledgments

Glynn Beck
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Wally Dow
John Zumberge

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Thanks

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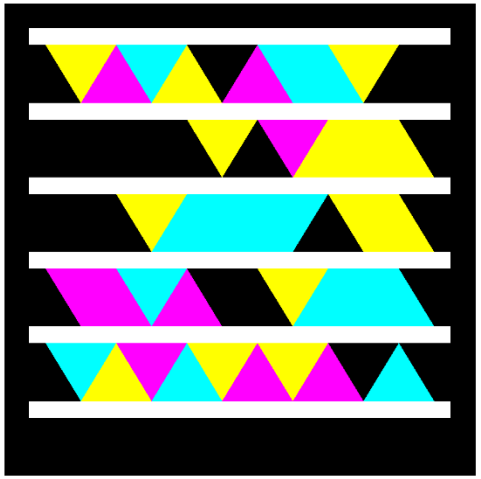

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RPSEA Contract 07122-16

RPSEA

Final Report

07122-16.FINAL

New Albany Shale Gas Project
07122-16

November 23, 2010

Iraj Salehi
Manager, Shale Gas Research

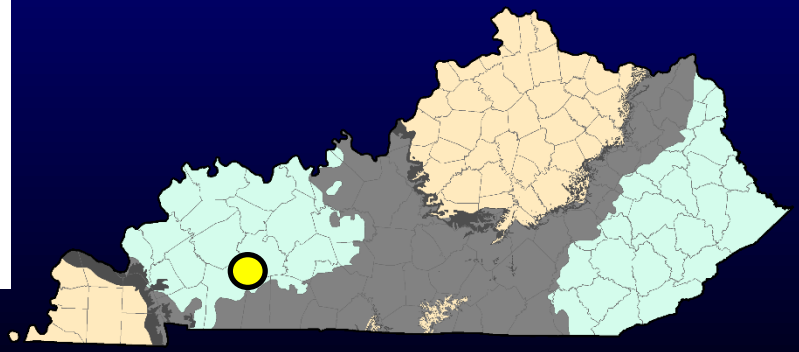
Gas Technology Institute
1700 South Mount Prospect Road
Des Plaines IL, 60018

gti

RPSEA/GTI, 2010

Detailed geochemical and geomechanical assessment of selected wells in Indiana and Kentucky

- **www.rpsea.org**
- **www.gastechnology.org**
- **www.isgs.Illinois.edu**



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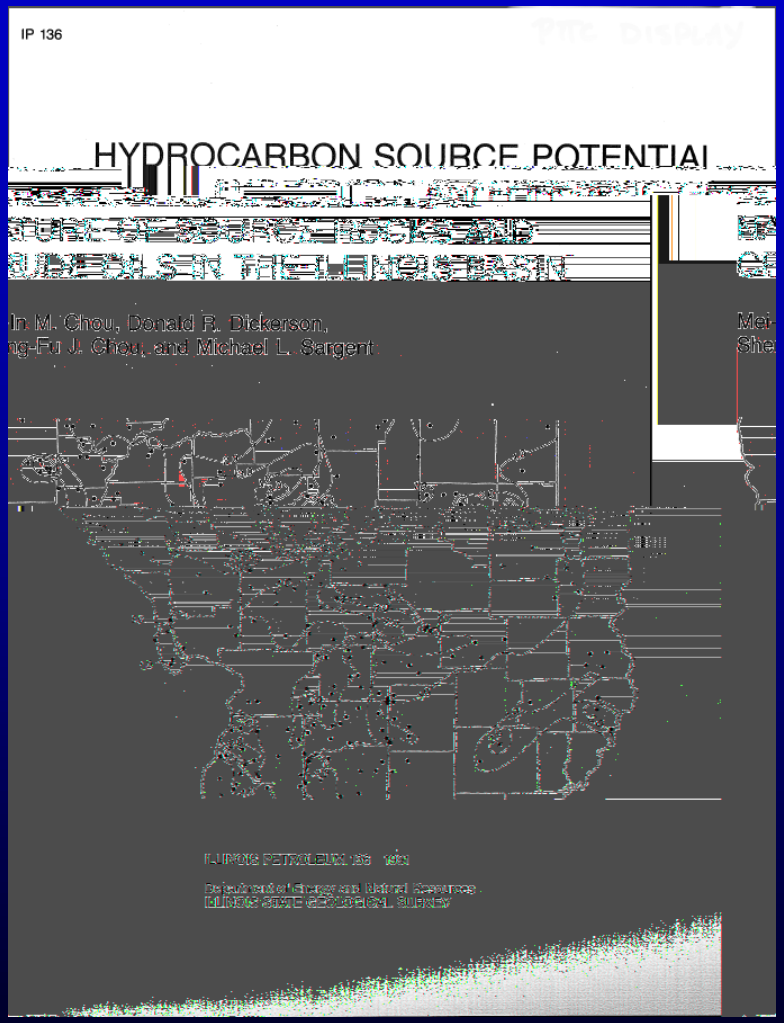
Chou and others, IP 136



Rock-Eval pyrolysis and oil fingerprinting data for wells in Illinois, Indiana, and Kentucky (includes data other than New Albany Shale)

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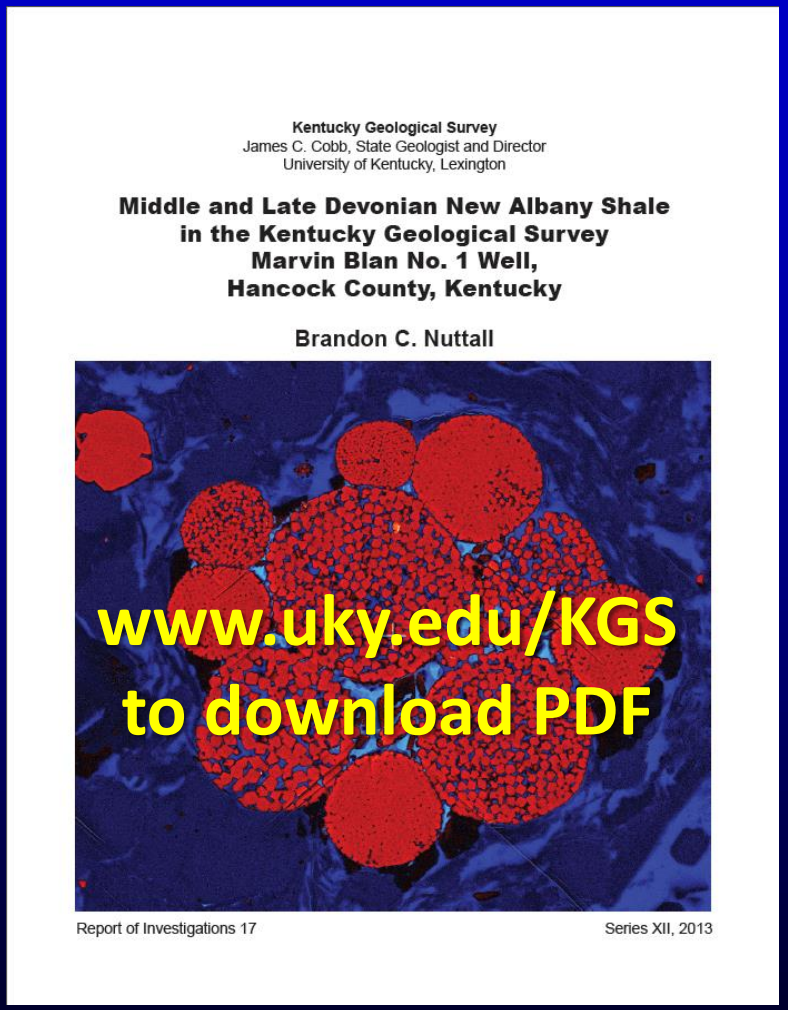
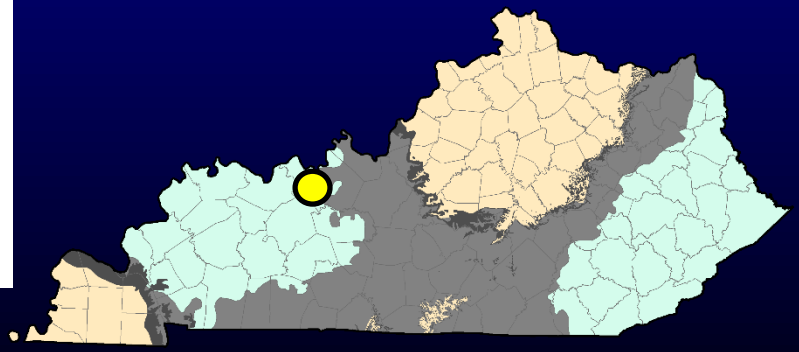
KGS #1 Blan Publication



- TOC – 4.75% to 9.74%
- Oil to wet gas
  - TAI – 2 to 2.3
  - Ro_{max} – 0.45% to 0.55%
  - T_{max} – 431°C to 440°C
- k – 9.48×10^{-5} md



RI 17, 2013

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