Regional Trends in Coalbed Gas Composition and Thermal Maturation in Eastern Kansas: Implications for Predicting Quality and Location of Coalbed Gas

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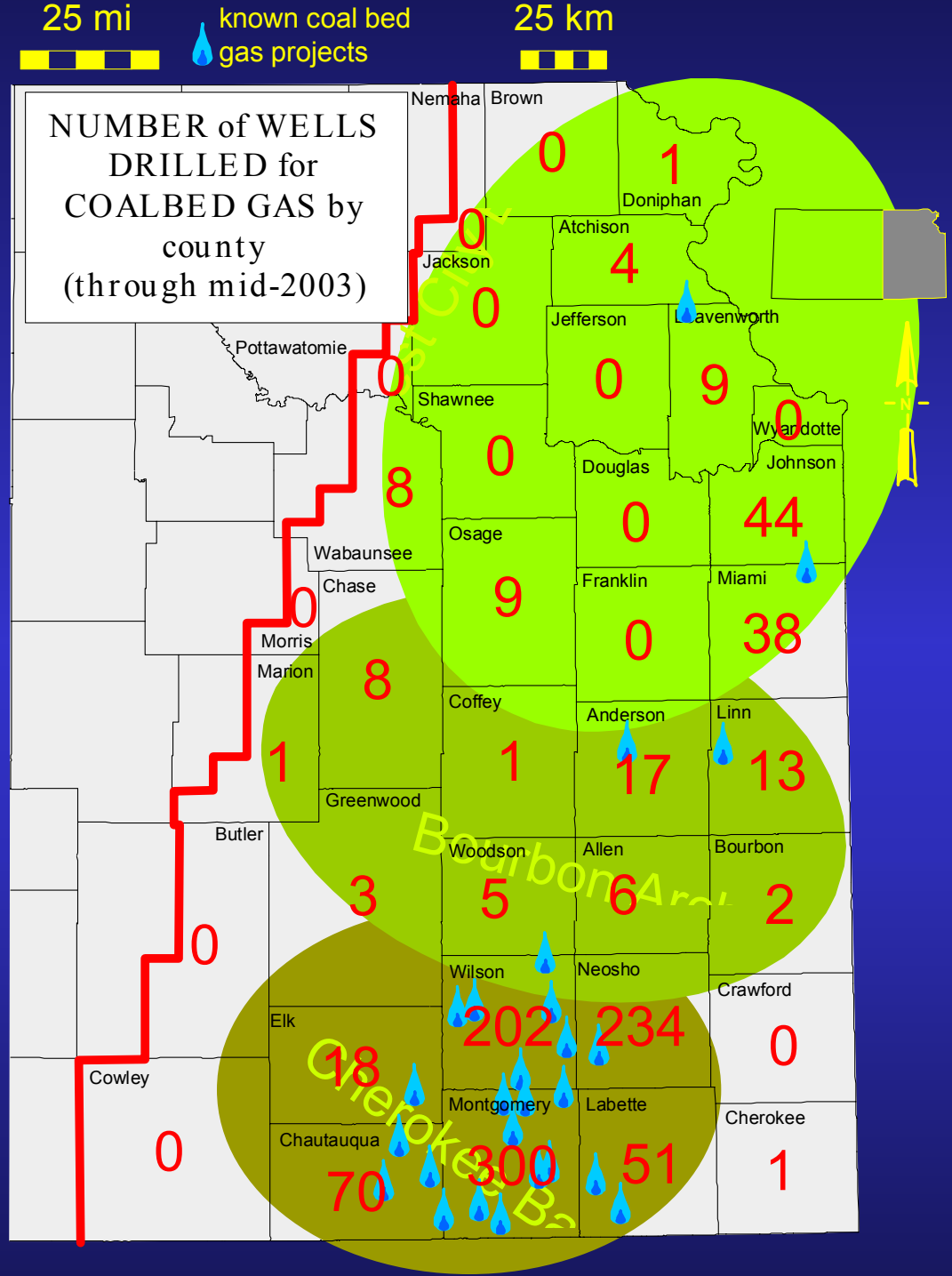
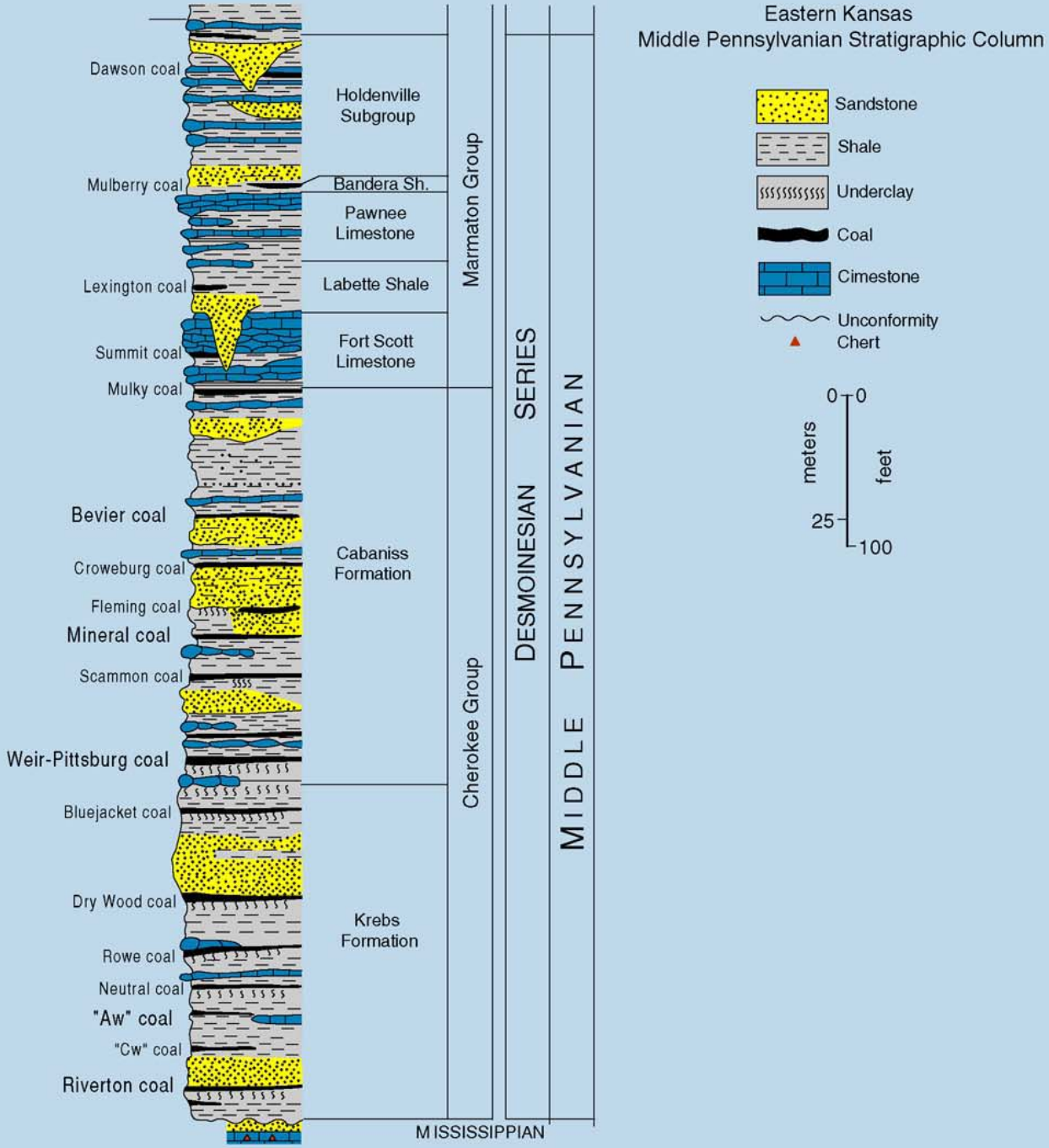
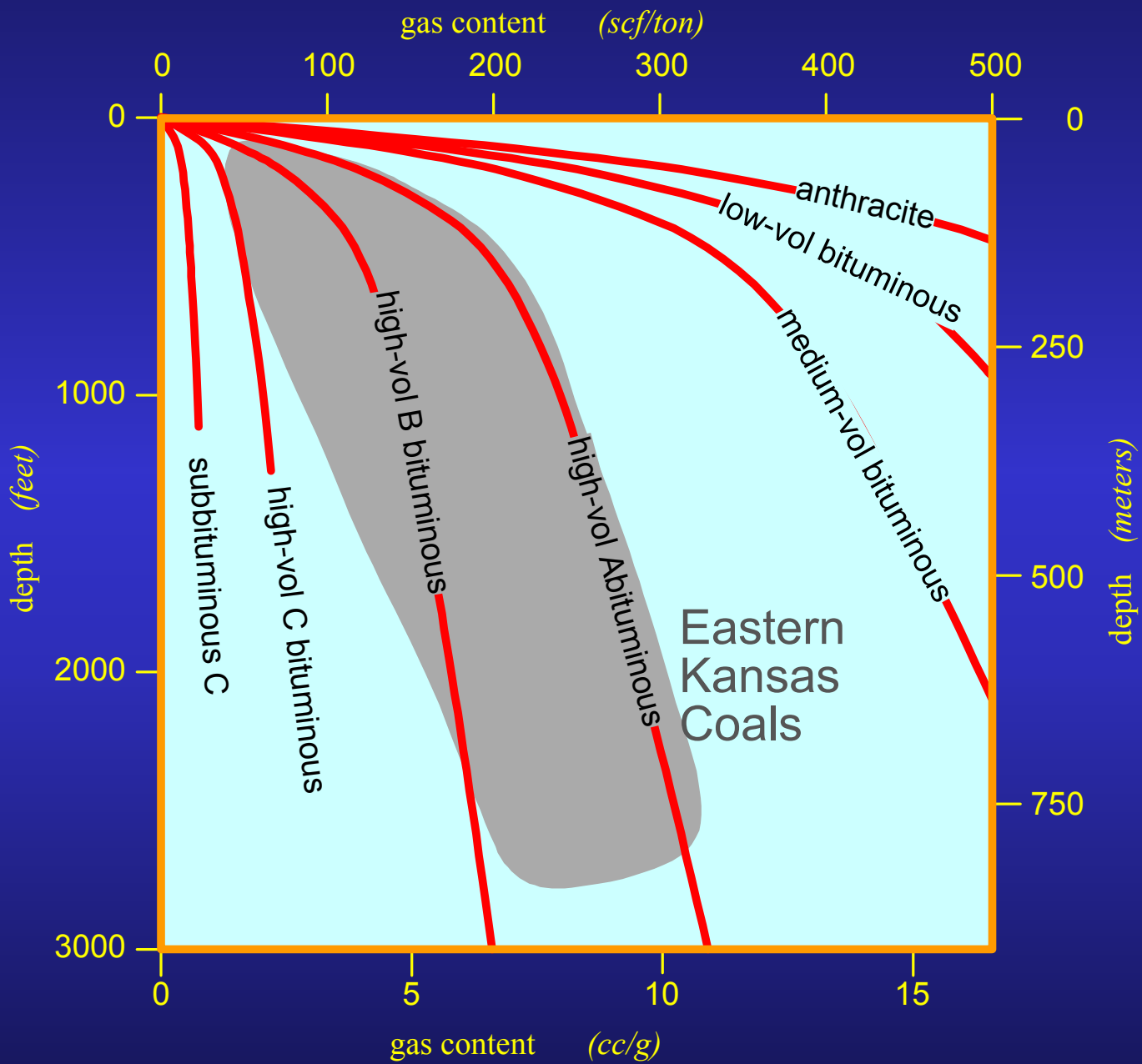

25 mi
known coal bed gas projects
25 km
NUMBER of WELLS DRILLED for COALBED GAS by county (through mid-2003)
Nemaha
Brown
Doniphan
Atchison
Jackson
Jefferson
Leavenworth
Pottawatomie
Shawnee
Wyandotte
Douglas
Johnson
Osage
Wabaunsee
Chase
Franklin
Miami
Morris
Marion
Coffey
Anderson
Linn
Greenwood
Butler
Woodson
Allen
Bourbon
Wilson
Neosho
Crawford
Elk
Cowley
Montgomery
Labette
Cherokee
Chautauqua
0
1
0
4
0
0
9
0
0
8
0
44
9
0
38
8
1
1
17
13
3
5
6
2
0
202
234
0
18
0
70
300
51
1


Eastern Kansas
Middle Pennsylvanian Stratigraphic Column
Sandstone
Shale
Underclay
Coal
Cimestone
Unconformity
Chert
0
0
meters
feet
25
100
Dawson coal
Mulberry coal
Lexington coal
Summit coal
Mulky coal
Bevier coal
Croweburg coal
Fleming coal
Mineral coal
Scammon coal
Weir-Pittsburg coal
Bluejacket coal
Dry Wood coal
Rowe coal
Neutral coal
"Aw" coal
"Cw" coal
Riverton coal
Holdenville Subgroup
Bandera Sh.
Pawnee Limestone
Labette Shale
Fort Scott Limestone
Cabaniss Formation
Krebs Formation
Marmaton Group
Cherokee Group
DESMOINESIAN SERIES
MIDDLE PENNSYLVANIAN
MISSISSIPPIAN

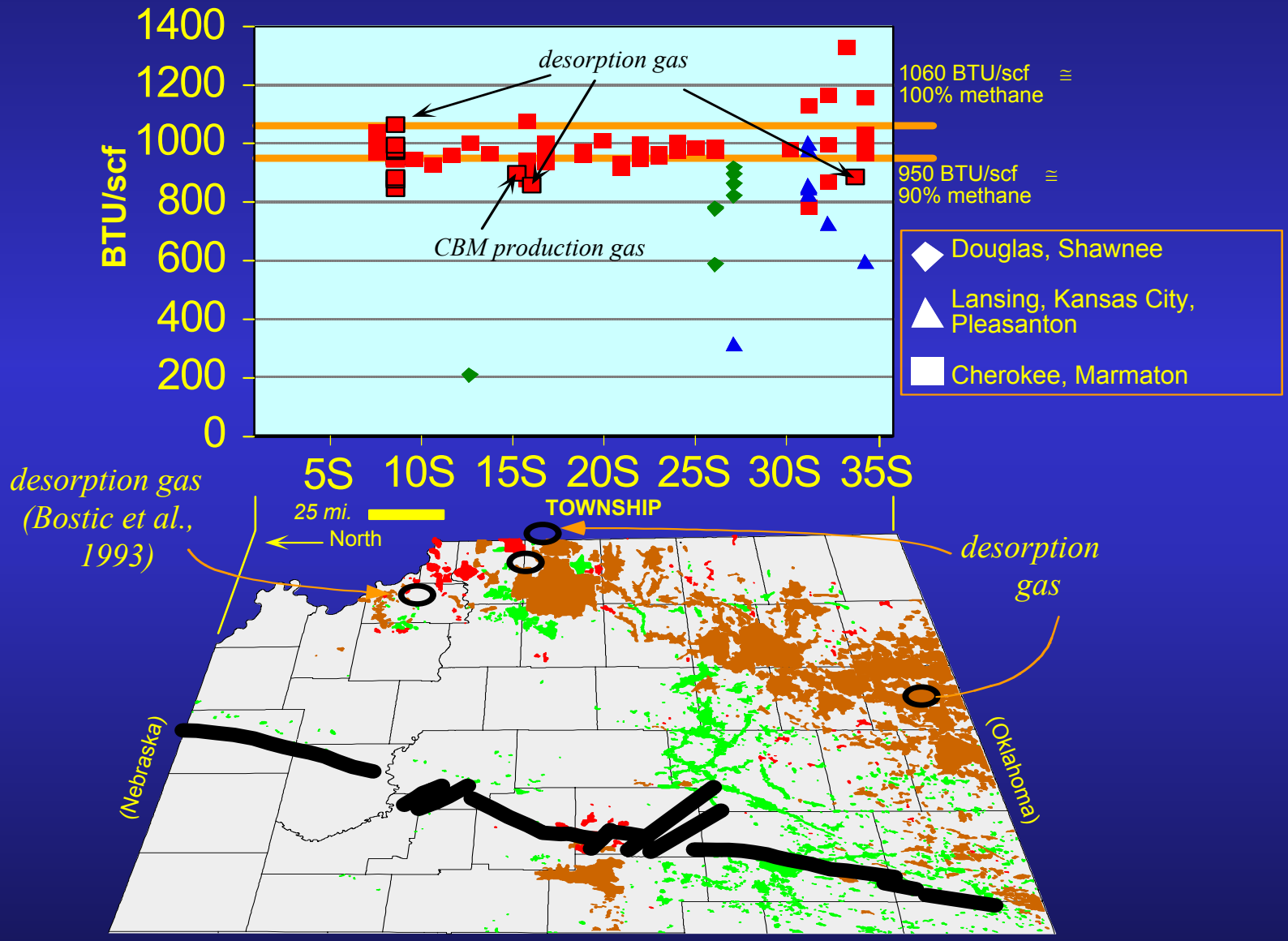
ESTIMATED MAXIMUM PRODUCIBLE METHANE CONTENT BY DEPTH AND RANK

(after Eddy, 1982; Saulsberry and others (1996))



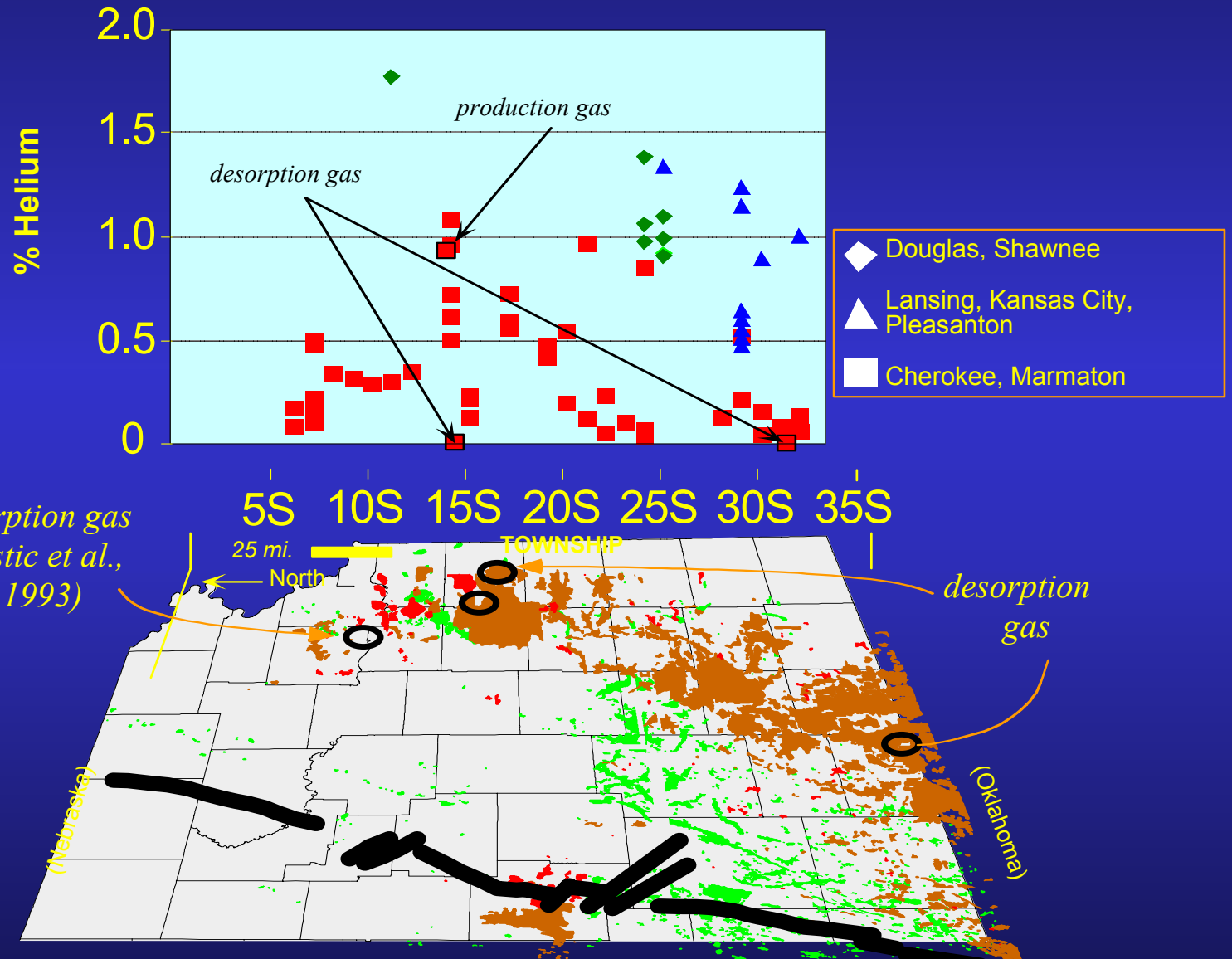
BTU content for eastern KS Pennsylvanian gases

(projected onto a north-south crossplot)

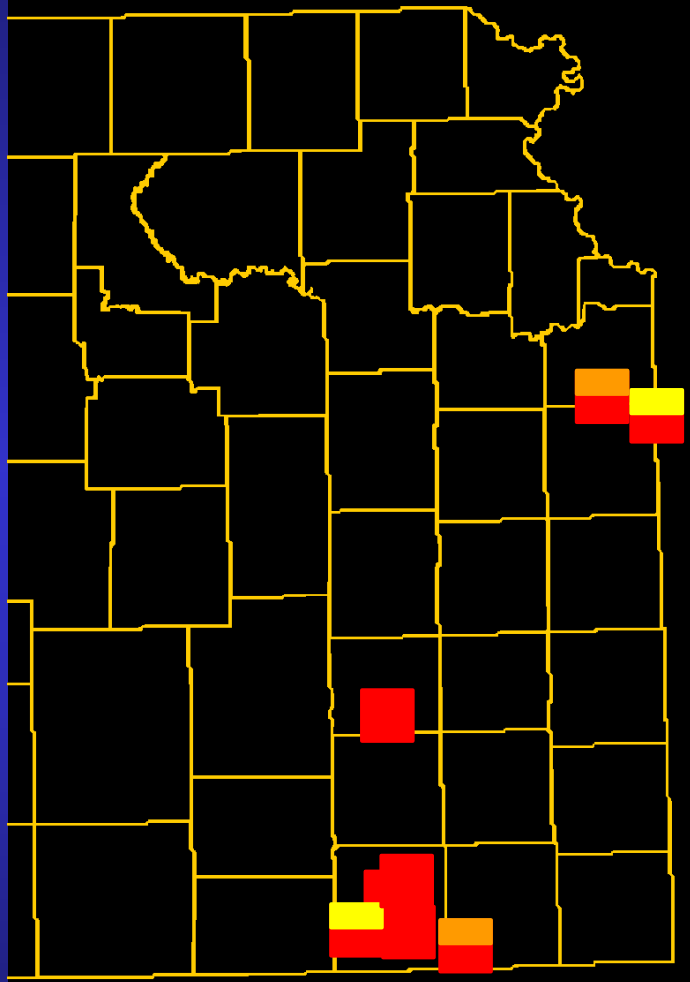


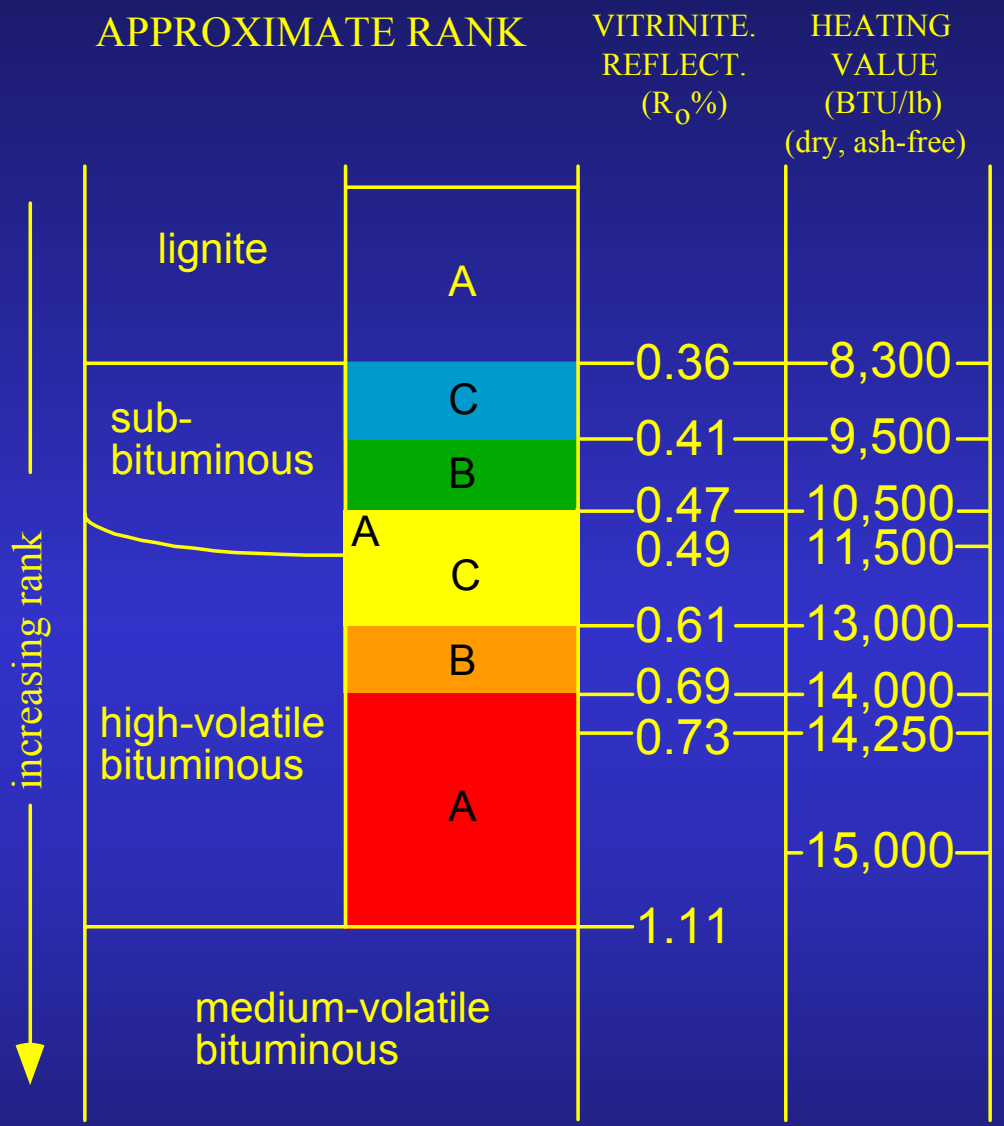
Helium content for eastern KS Pennsylvanian gases

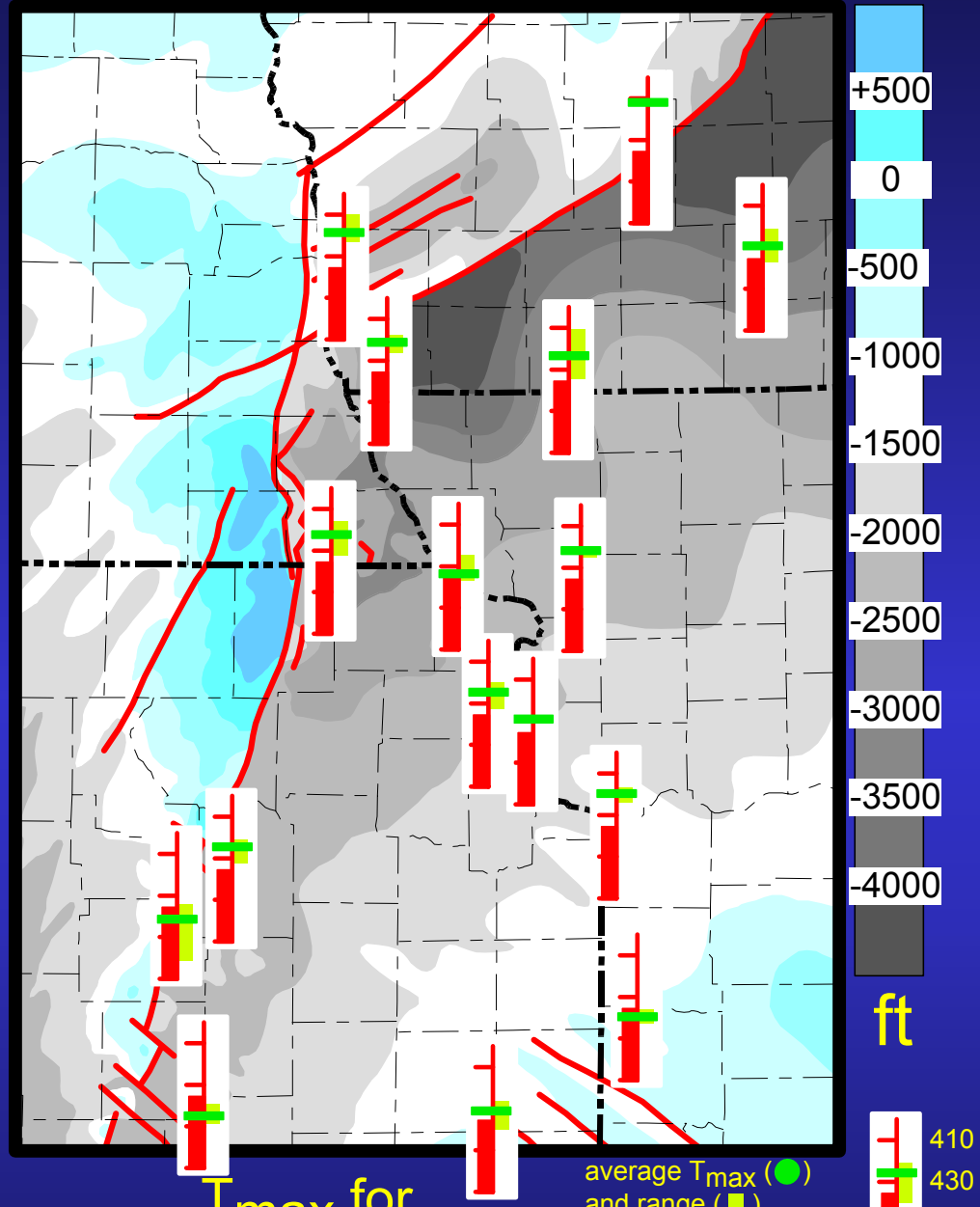
(projected onto a north-south crossplot)



COAL RANK
(color-coded to coal rank)
Cherokee & Marmaton Gps.



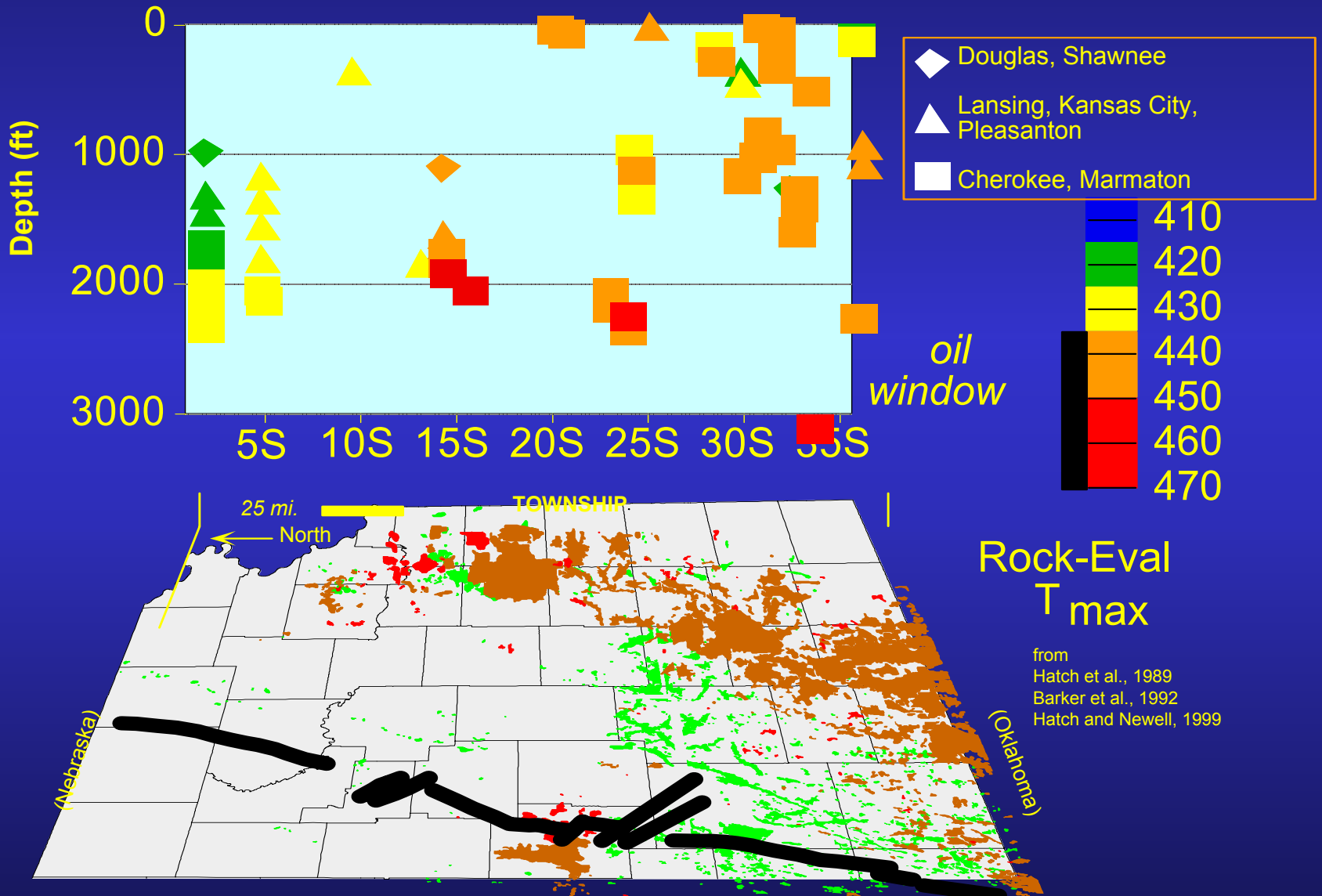




T_{max} for Pennsylvanian strata (Forest City basin)

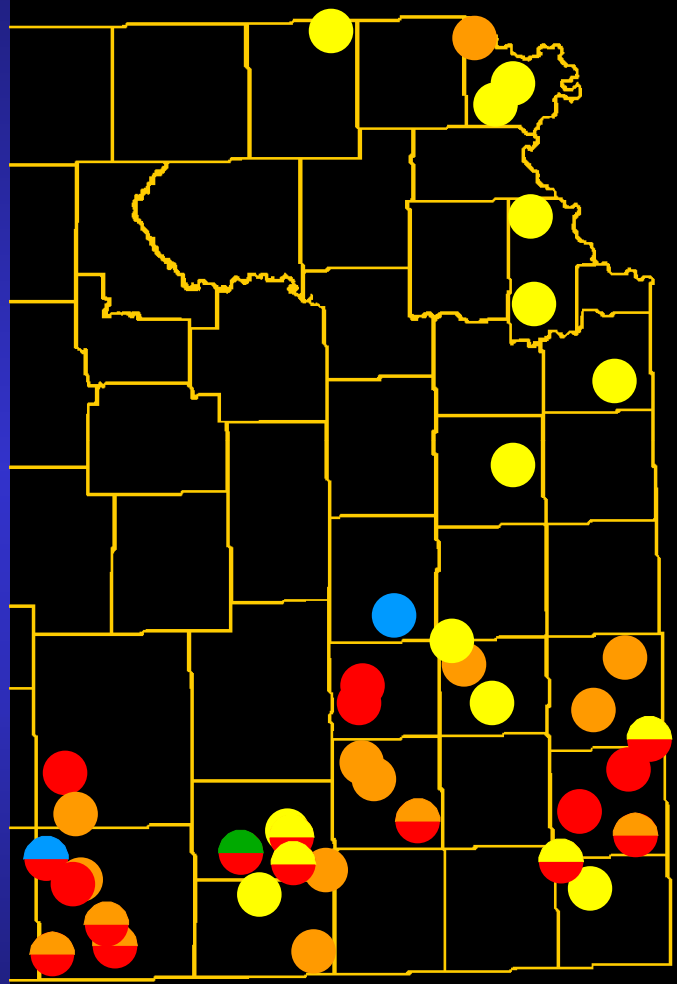
T max maturity for eastern KS strata

(projected onto a north-south crossplot)

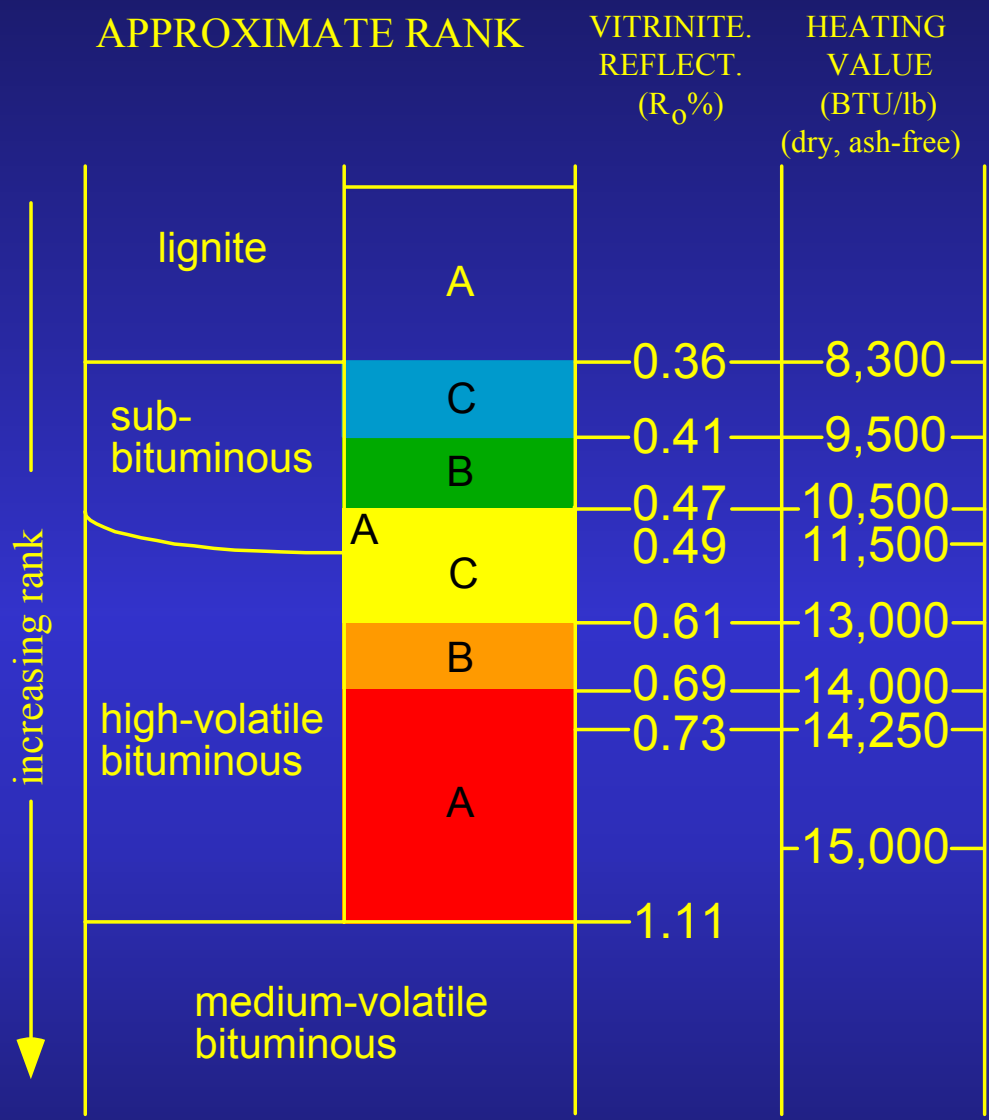


VITRINITE REFLECTANCE

(color-coded to coal rank)
Cherokee & Marmaton Gps.



after Newell (1997)



STABLE ISOTOPES

$$\delta(x) = \frac{(R_x - R_{std})}{(R_{std})} * 1000$$

where R_x is the isotopic ratio of the heavy, rare isotope versus the light, abundant isotope of the sample (i.e., $^{13}C/^{12}C$, or deuterium / hydrogen) vs. that of the standard (R_{std})

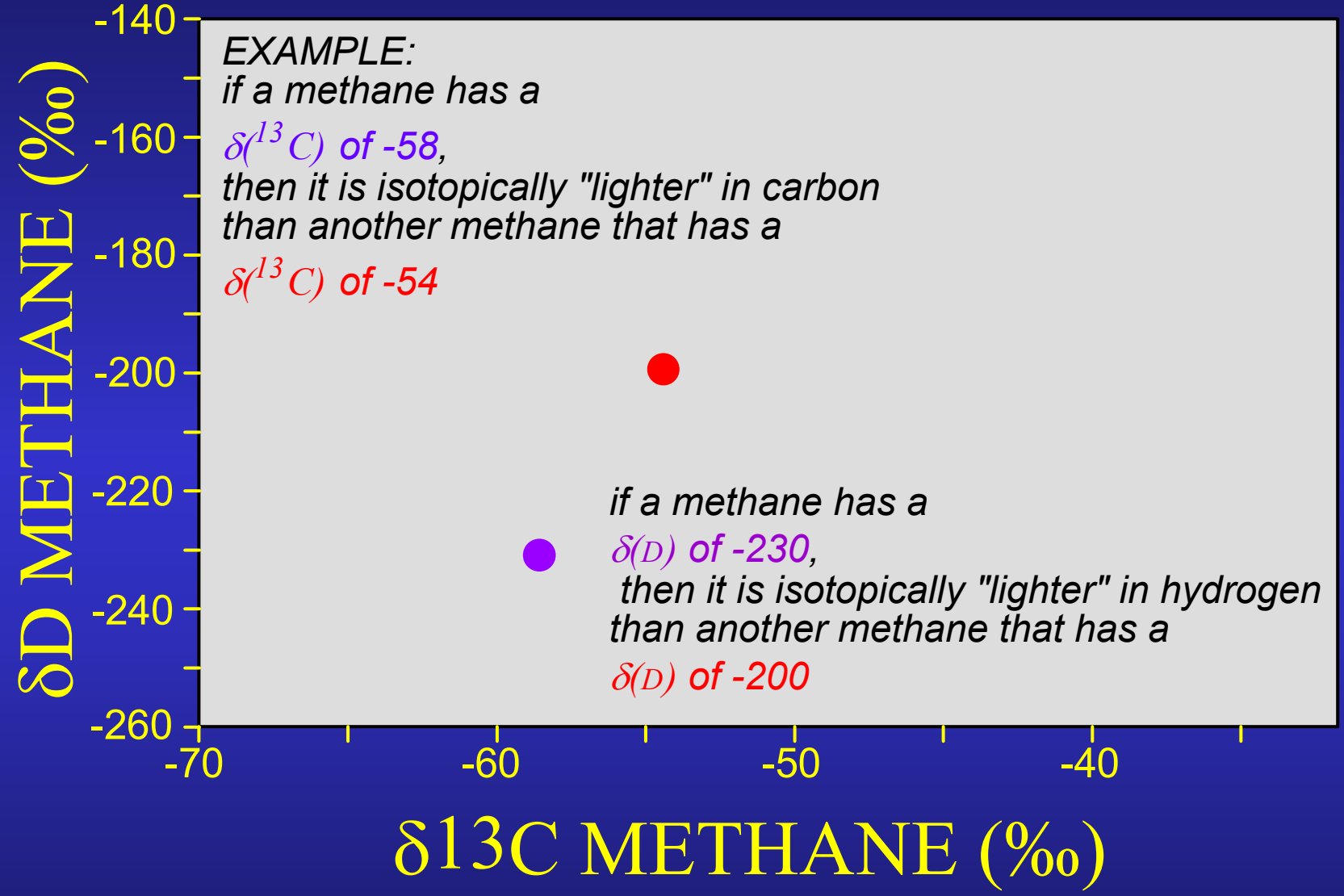
usually reported in parts per mil (‰)

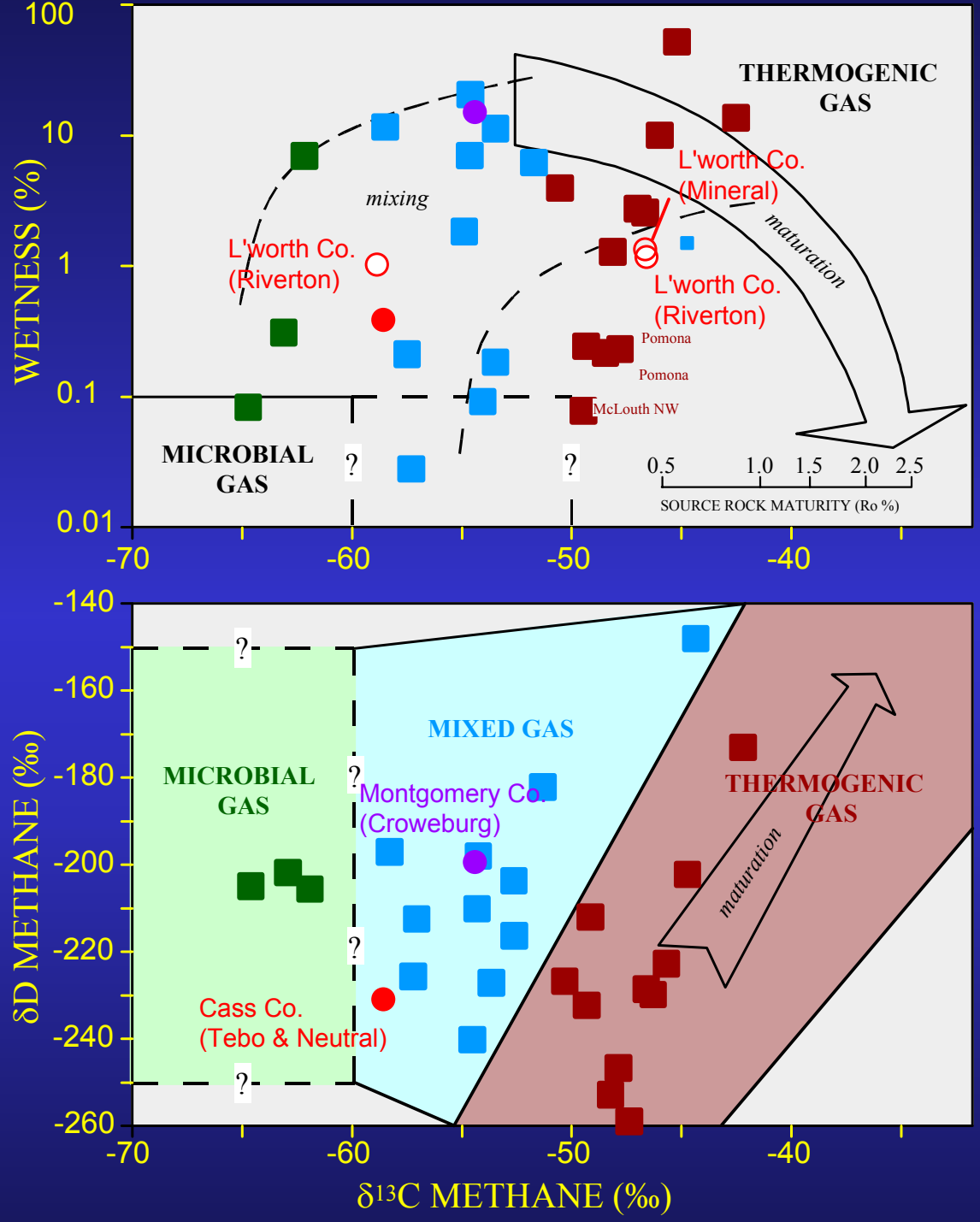
if $R_x < R_{std}$, then $\delta(x)$ is negative

if $R_x > R_{std}$, then $\delta(x)$ is positive

EXAMPLE:

if a methane has a $\delta(^{13}C)$ of -65, then it is isotopically lighter than another methane that has a $\delta(^{13}C)$ of -40


EXAMPLE:
if a methane has a
δ(13C) of -58,
then it is isotopically "lighter" in carbon
than another methane that has a
δ(13C) of -54
if a methane has a
δ(D) of -230,
then it is isotopically "lighter" in hydrogen
than another methane that has a
δ(D) of -200
δD METHANE (‰)
-140
-160
-180
-200
-220
-240
-260
-70
-60
-50
-40
δ13C METHANE (‰)



- eastern KS conventional gas (from Jenden et al., 1988)
- coalbed desorption gas (Leavenworth Co. data from Bostic et al., 1993)

MICROBIAL GAS BY:

CO_2 reduction

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$

* *CO_2 present is dominantly as HCO_3^- dissolved in formation waters*
* *methanogenic bacteria preferentially reduce $^{12}CO_2$, so ^{13}C-enriched CO_2 and ^{12}C-enriched CH_4 results*
* *microbes do not produce higher-molecular-weight hydrocarbons other than methane*

acetate fermentation

$$CH_3COOH \rightarrow CH_4 + CO_2$$

methyl group reduction by dissimilation of acetate

$$CH_3COO^- + H^+ \rightarrow CH_4 + CO_2$$

* *δD more negative than -300‰*
* *surrounding water provides only 1 of the 4 hydrogen atoms incorporated in methane*

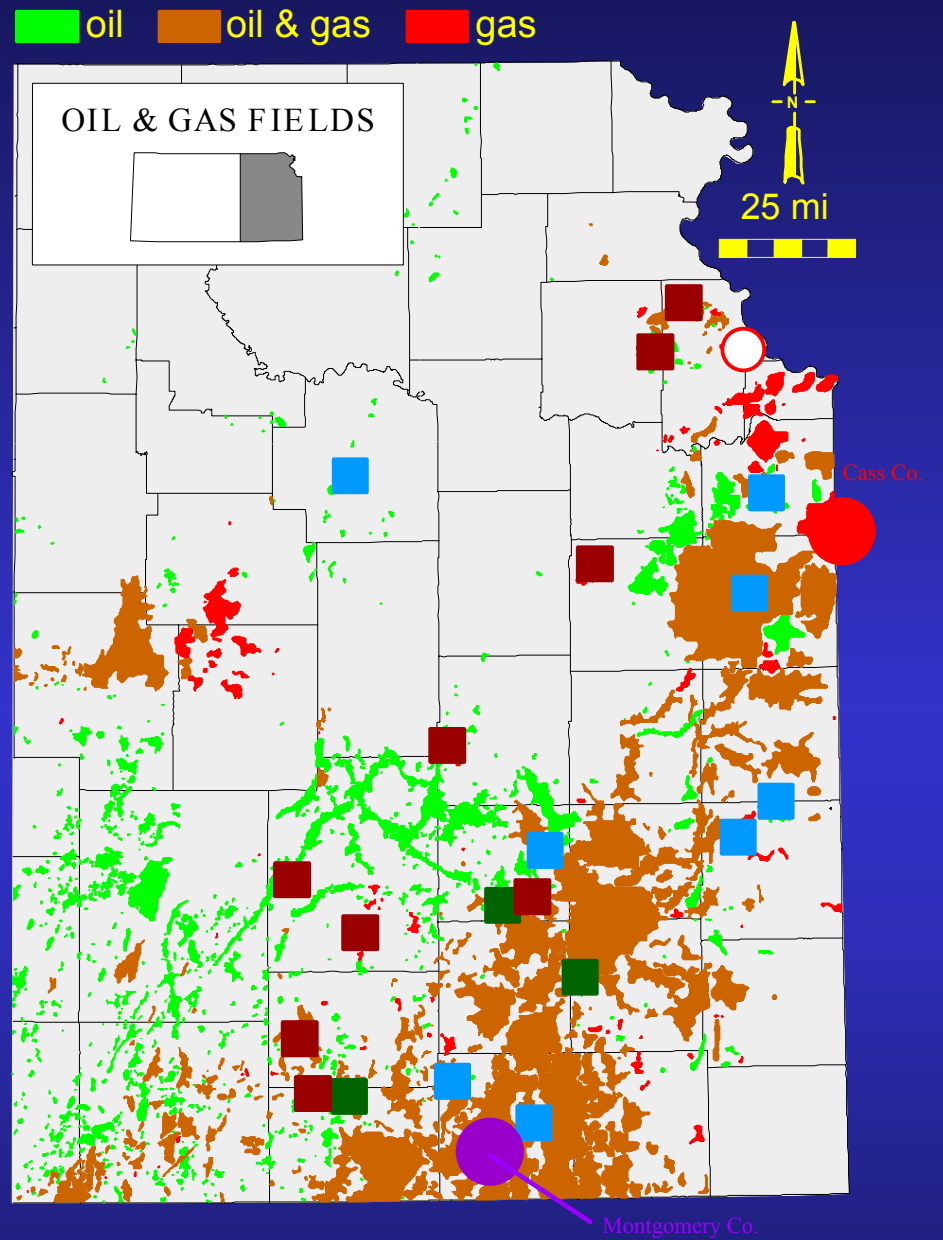
GEOGRAPHIC DISTRIBUTION of ISOTOPIC ANALYSES of GASES

AGE	NAME OF FIELD
U. PENN	Mill Creek, Schrader
M. PENN	Silver City, Thayer, Brewster, Elk City, Mapleton NE, Neosho Falls, Olathe , Clinesmith, Easton, McLouth NW, Pomona, Sallyards, Welch-Mohr
MSSP	Kingston , Brewster, Irish Valley, Neosho Falls, Paola-Rantoul, Tucker.
L. ORD	Logsden

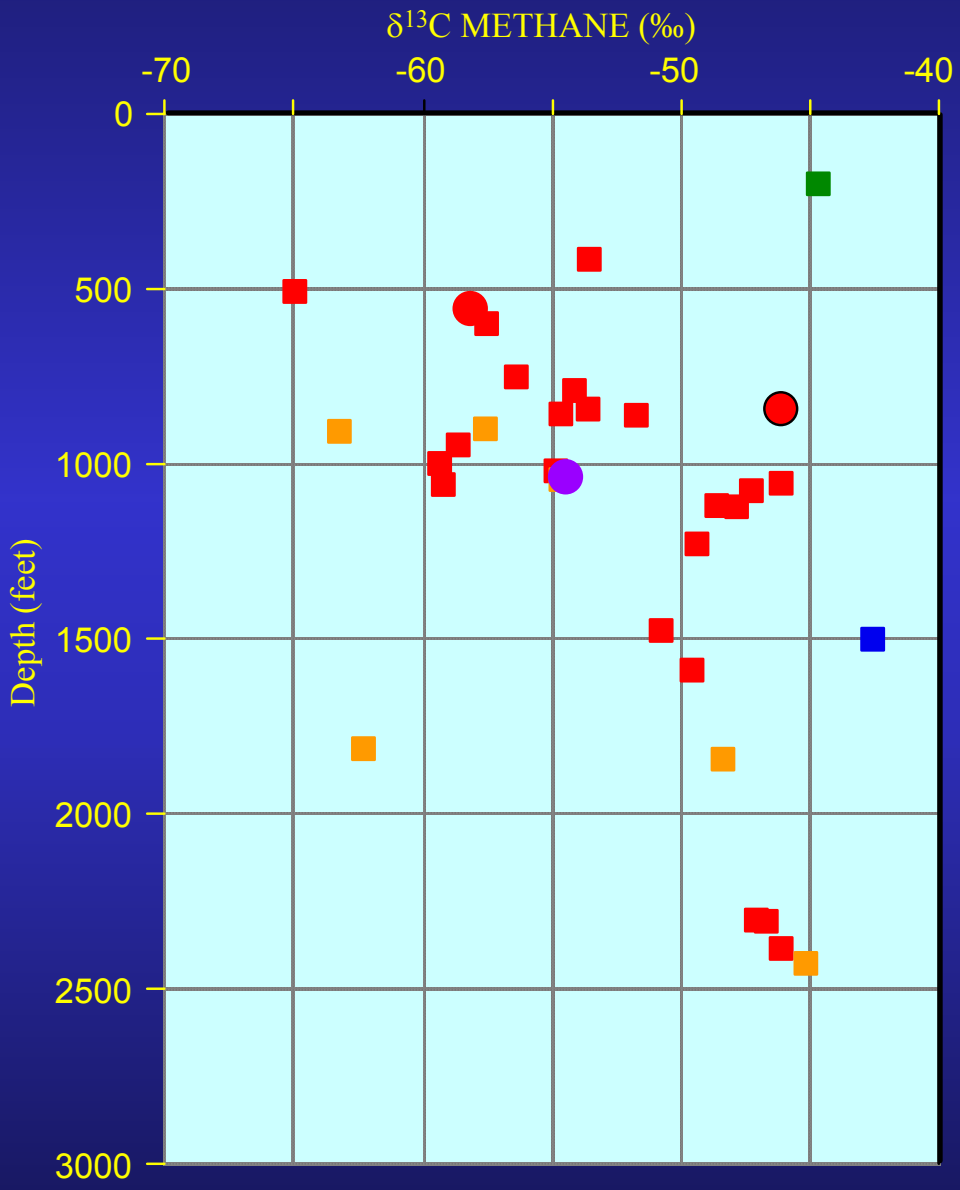
eastern KS conventional gas (from Jenden et al., 1988)

coalbed desorption gas

GREEN = BIOGENIC
BLUE = MIXED
MAROON = THERMOGENIC



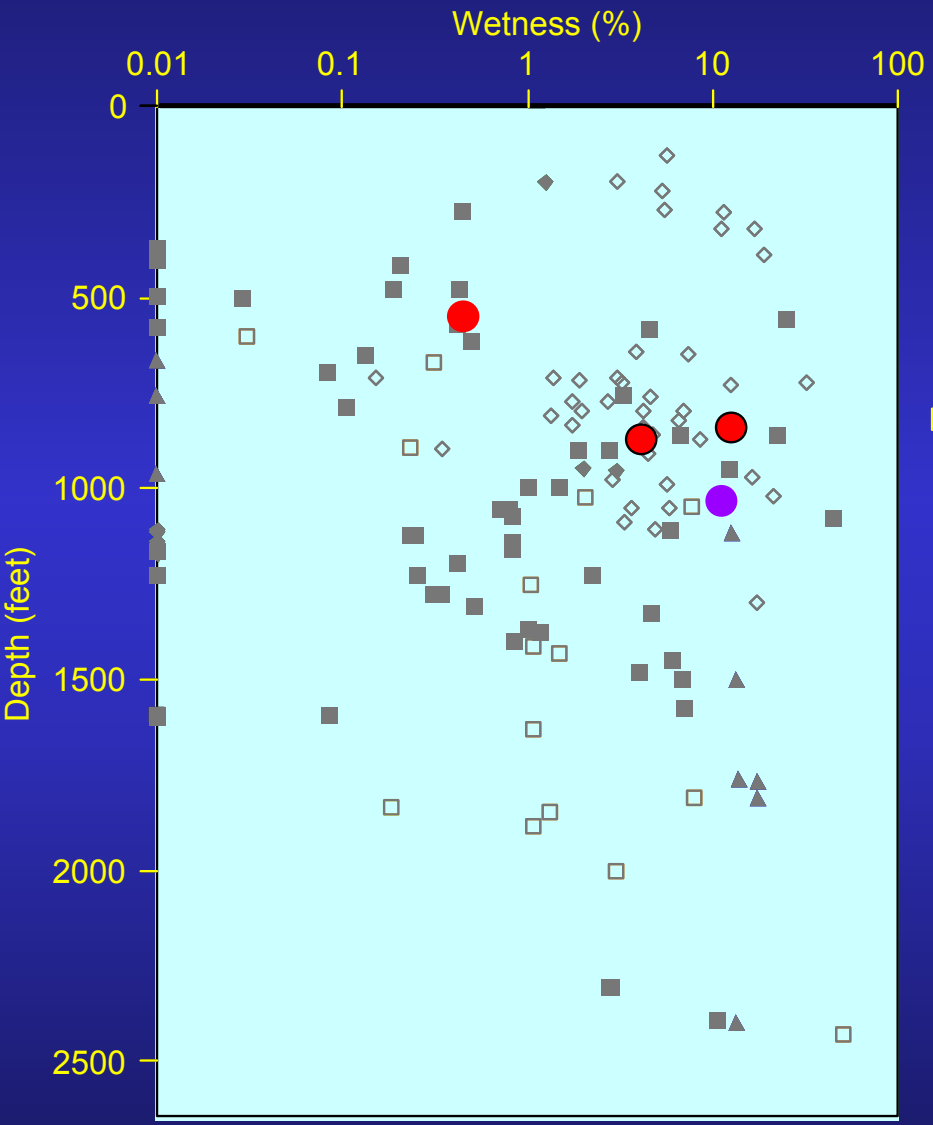
Methane Carbon Isotope vs. Depth (subsurface) Cherokee Basin and Forest City Basin



CONVENTIONAL GAS
- Douglas, Shawnee Gps.
- Lansing, Kansas City, Pleasanton Gps.
- Cherokee, Marmaton Gps.
- Mississippian, sub-Mississippian

CBM GAS
- Leavenworth Co.
- Cass Co.
- Montgomery Co.

Wetness of Gas vs. Depth (subsurface)
Cherokee Basin and Forest City Basin



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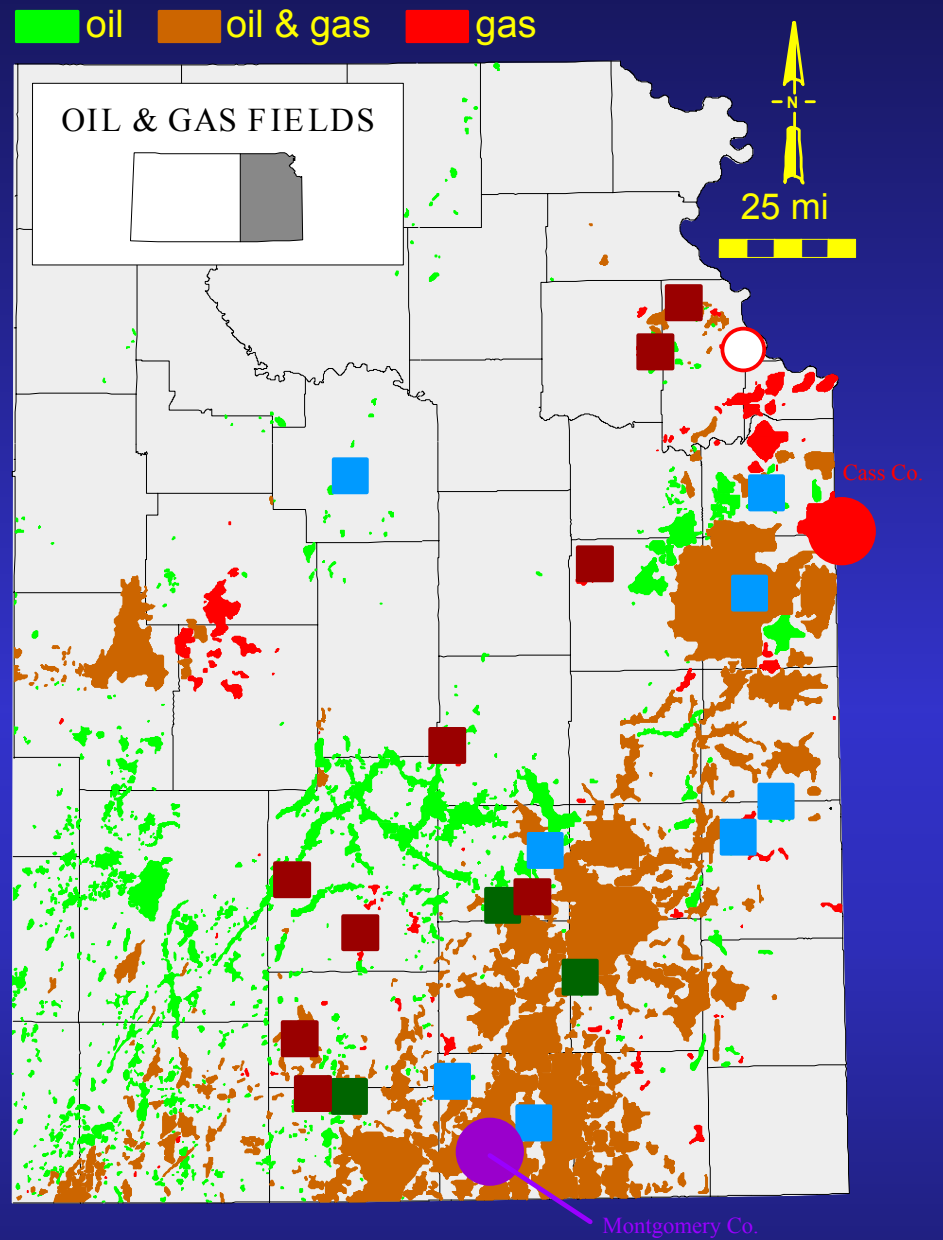
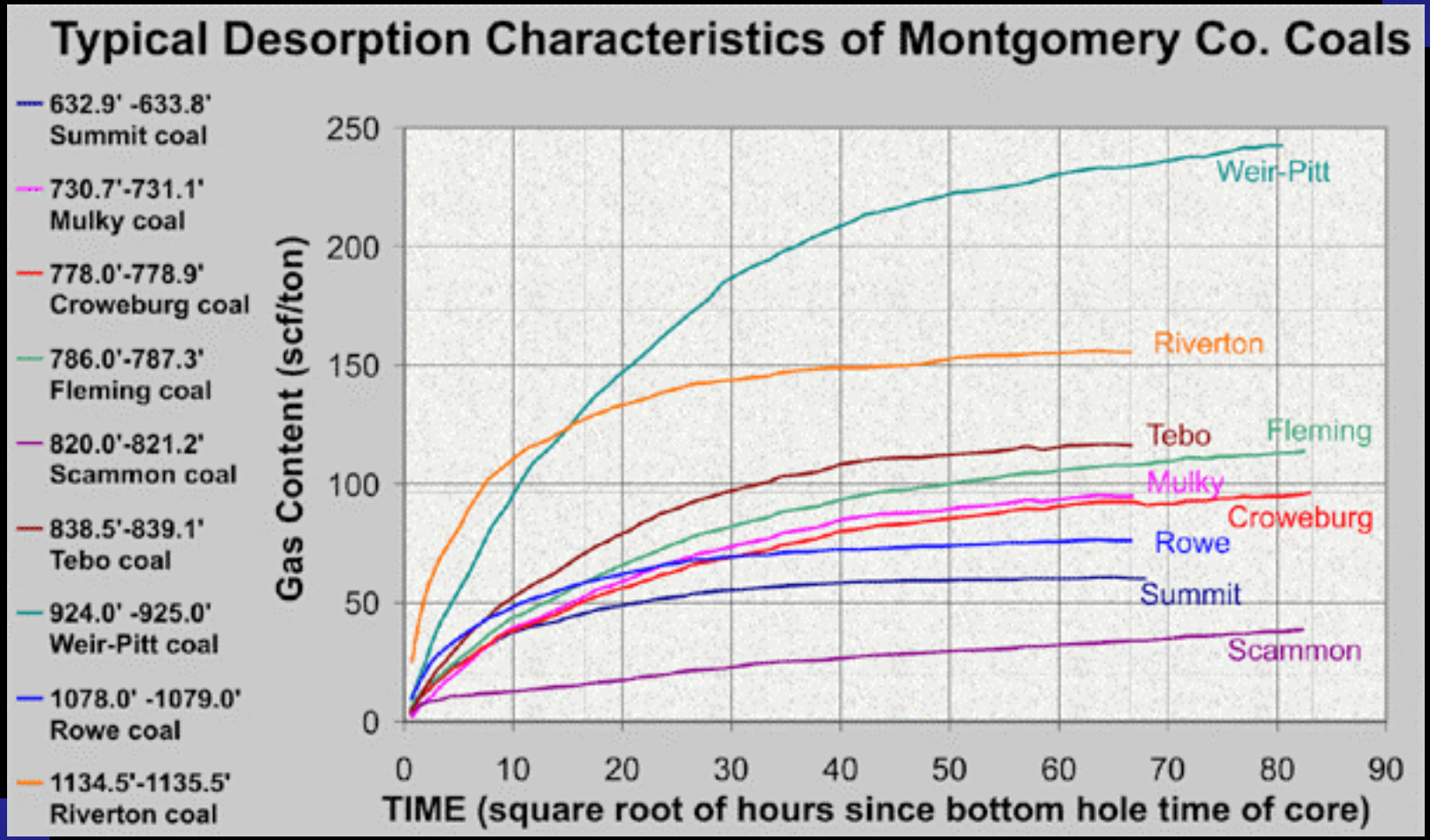
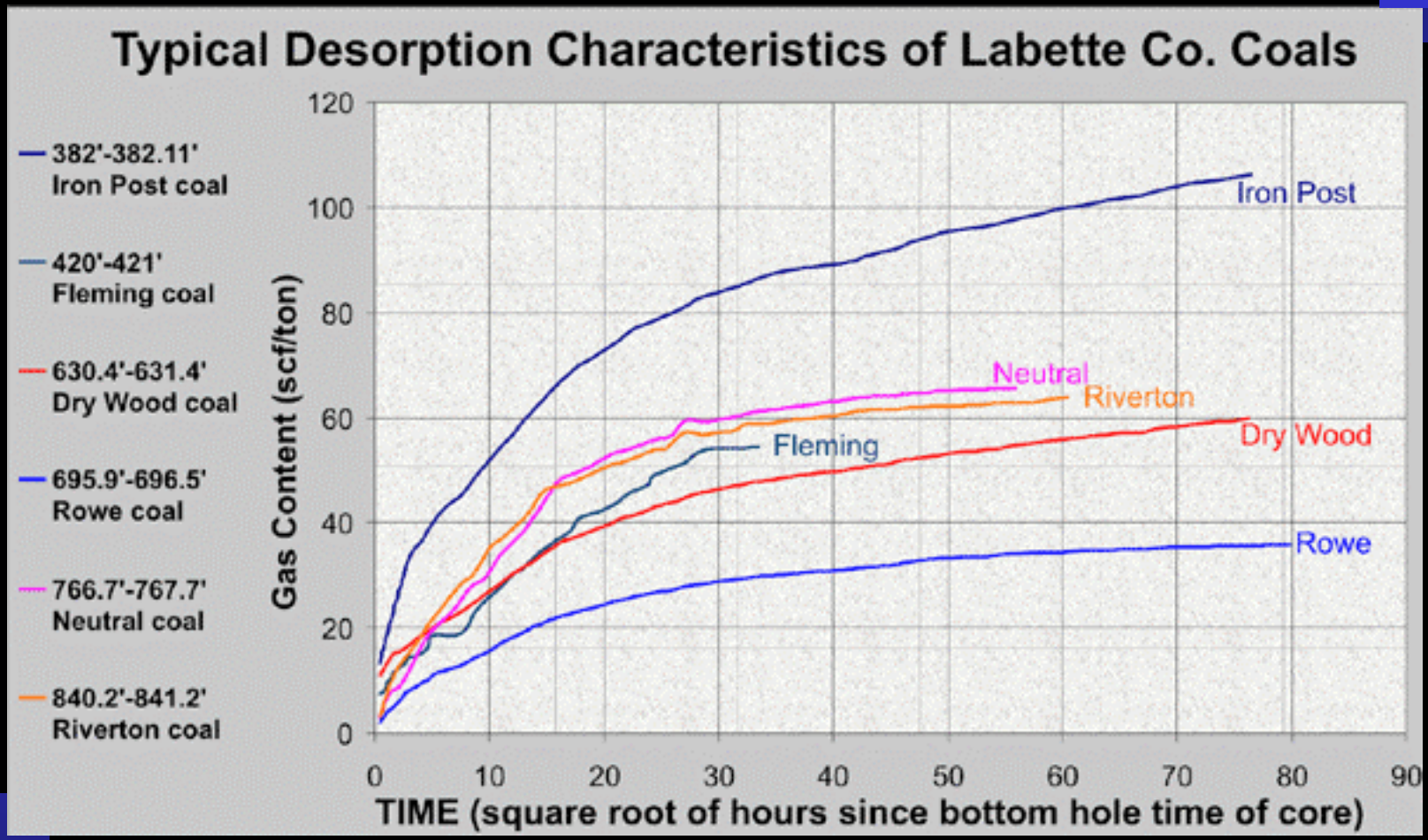


Typical Desorption Characteristics of Montgomery Co. Coals




Typical Desorption Characteristics of Labette Co. Coals
382'-382.11'
Iron Post coal
420'-421'
Fleming coal
630.4'-631.4'
Dry Wood coal
695.9'-696.5'
Rowe coal
766.7'-767.7'
Neutral coal
840.2'-841.2'
Riverton coal
Gas Content (scf/ton)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
TIME (square root of hours since bottom hole time of core)
Iron Post
Neutral
Riverton
Dry Wood
Fleming
Rowe

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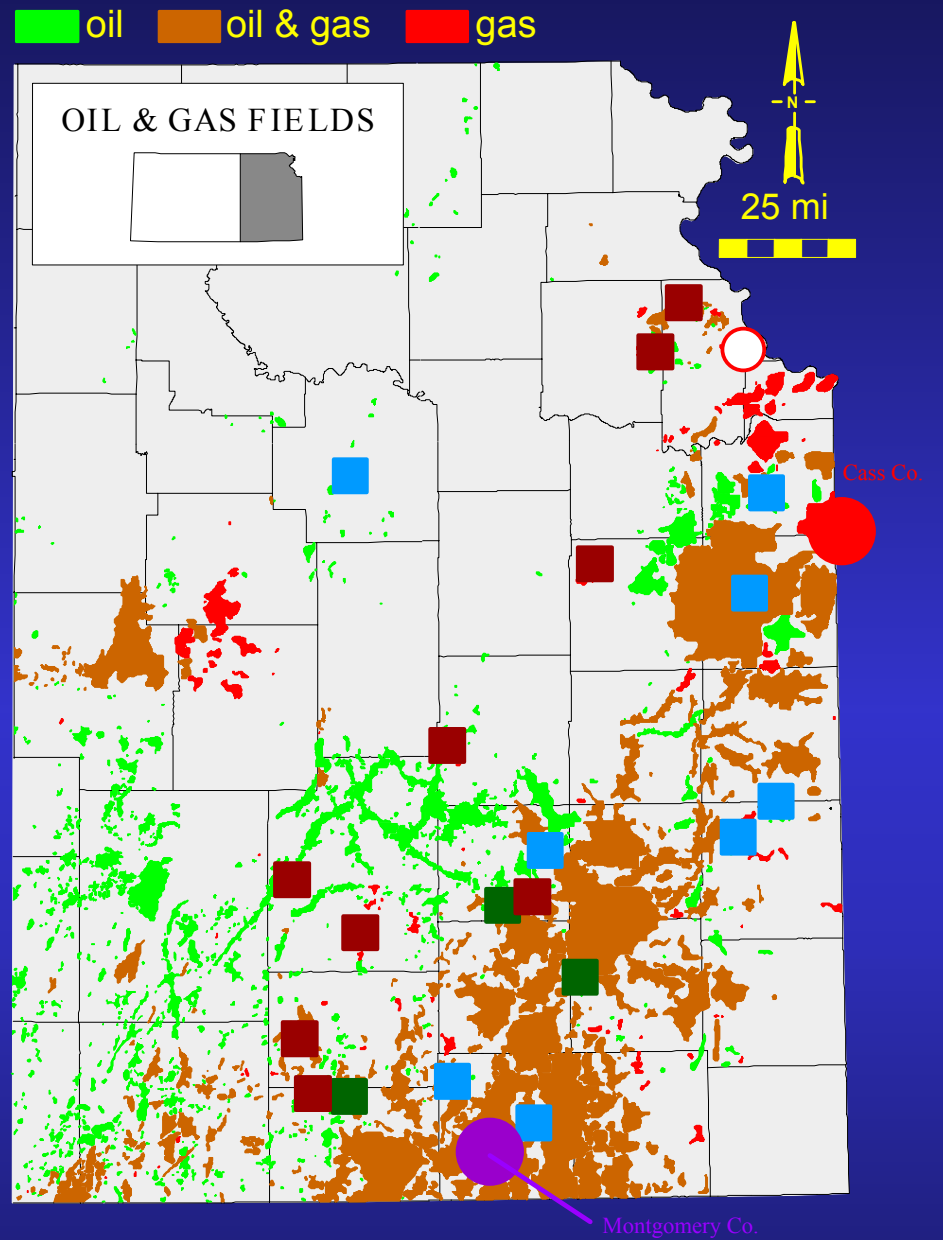

GENERALIZED REPRESENTATION of a TRANSITION ZONE in CAMBRIAN-ORDOVICIAN ARBUCKLE GP. WATERS

(from Macfarlane and Hathaway, 1987)

transition

brine

2,500 mg/L isochore

eastern KS conventional gas
(from Jenden et al., 1988)

coalbed desorption gas

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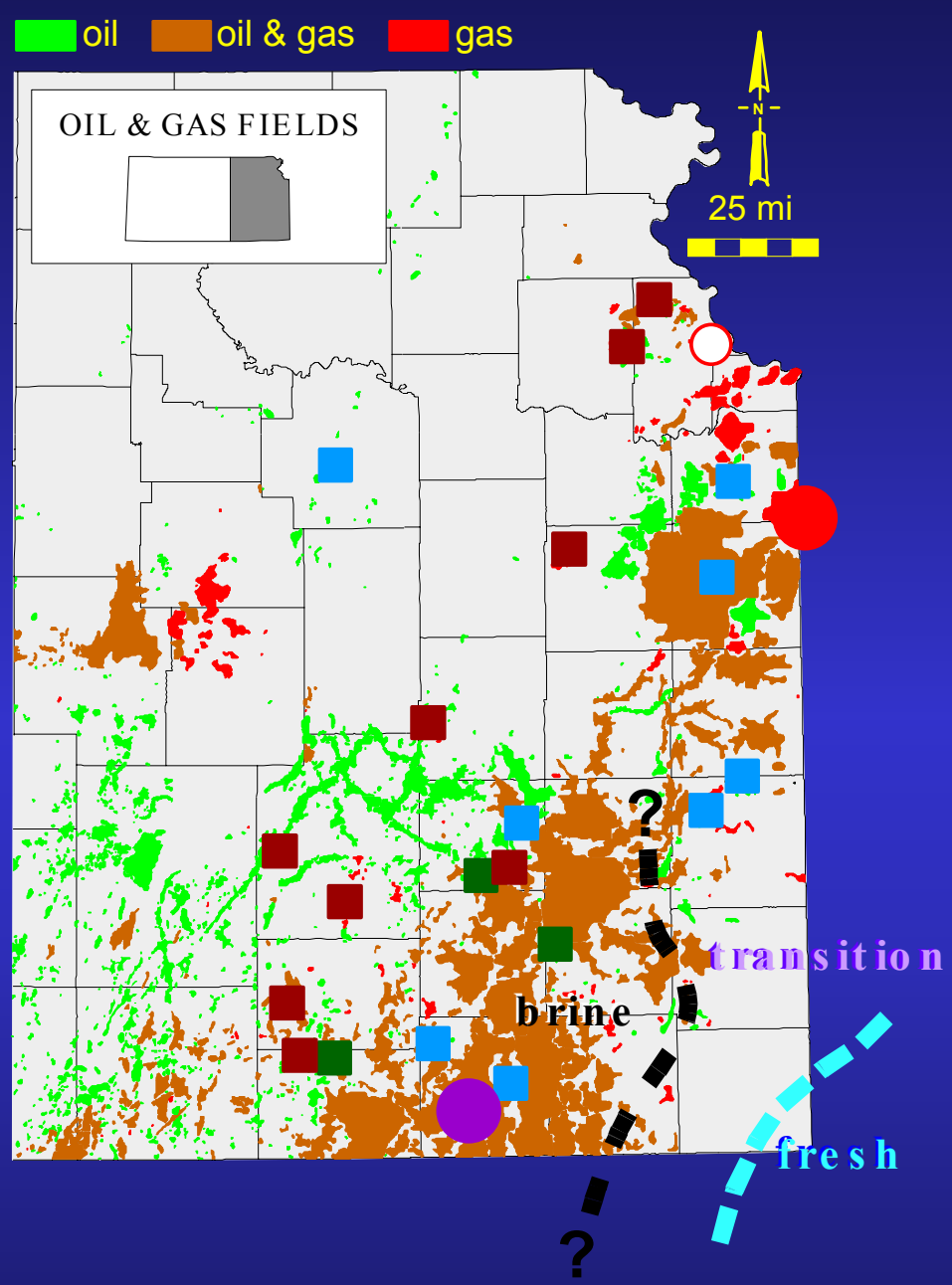

CONCLUSIONS

* maturation increases southward in Forest City and Cherokee basins
* gas content likely increases southward also, perhaps westward into th
* some coalbed gases have biogenic component
* biogenesis more important in updip areas
* separate thermogenic and biogenic production fairways are possible

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