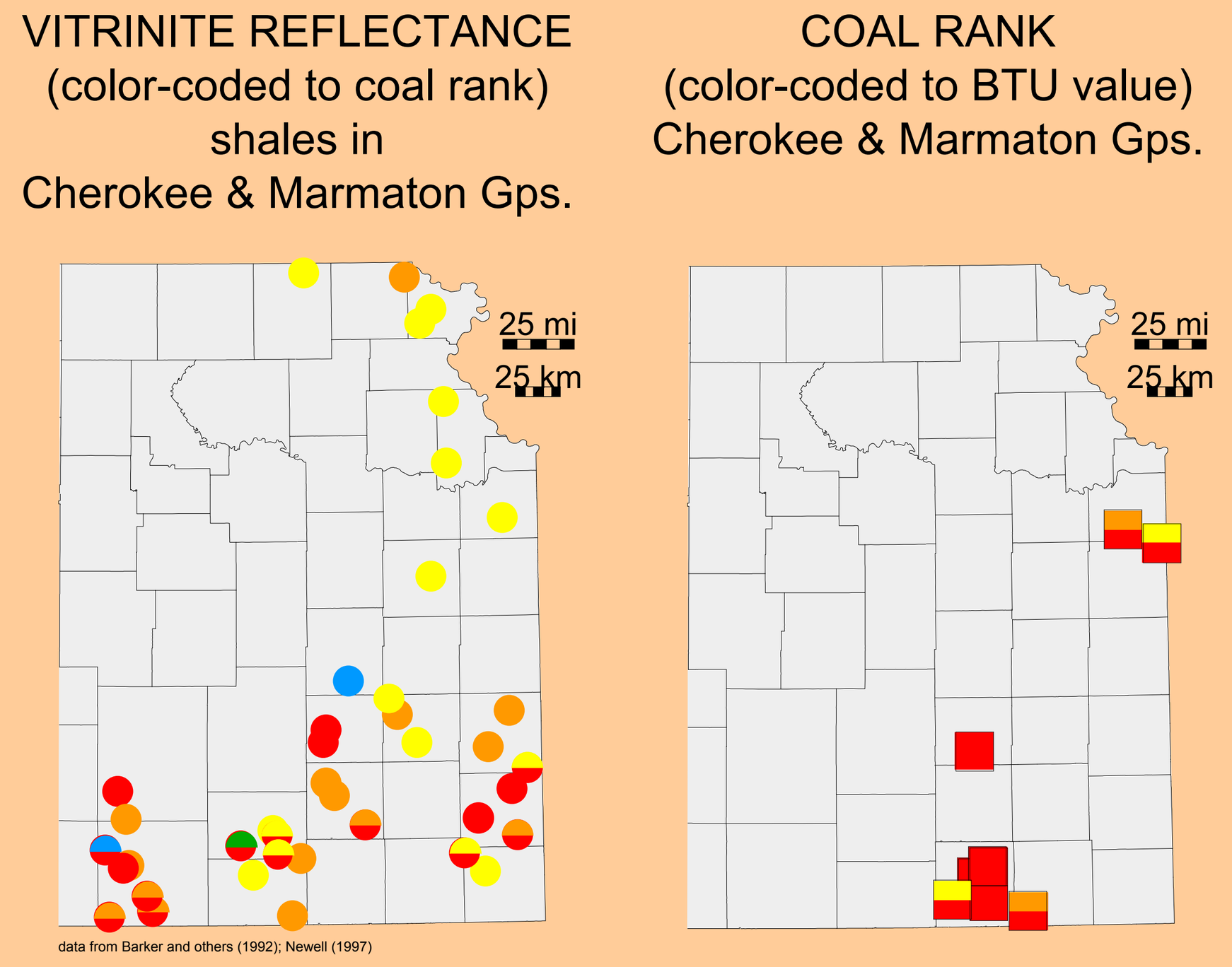
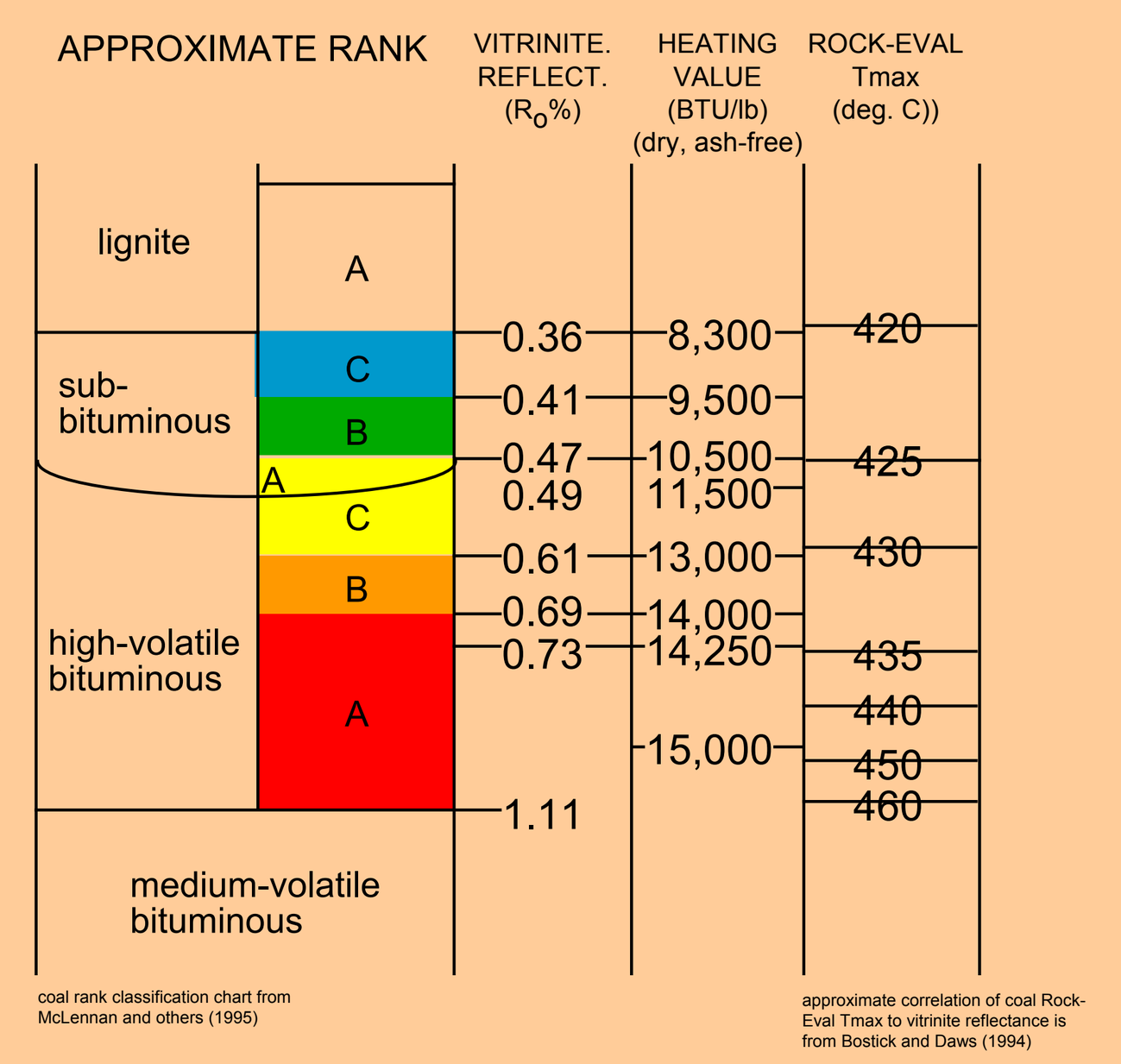
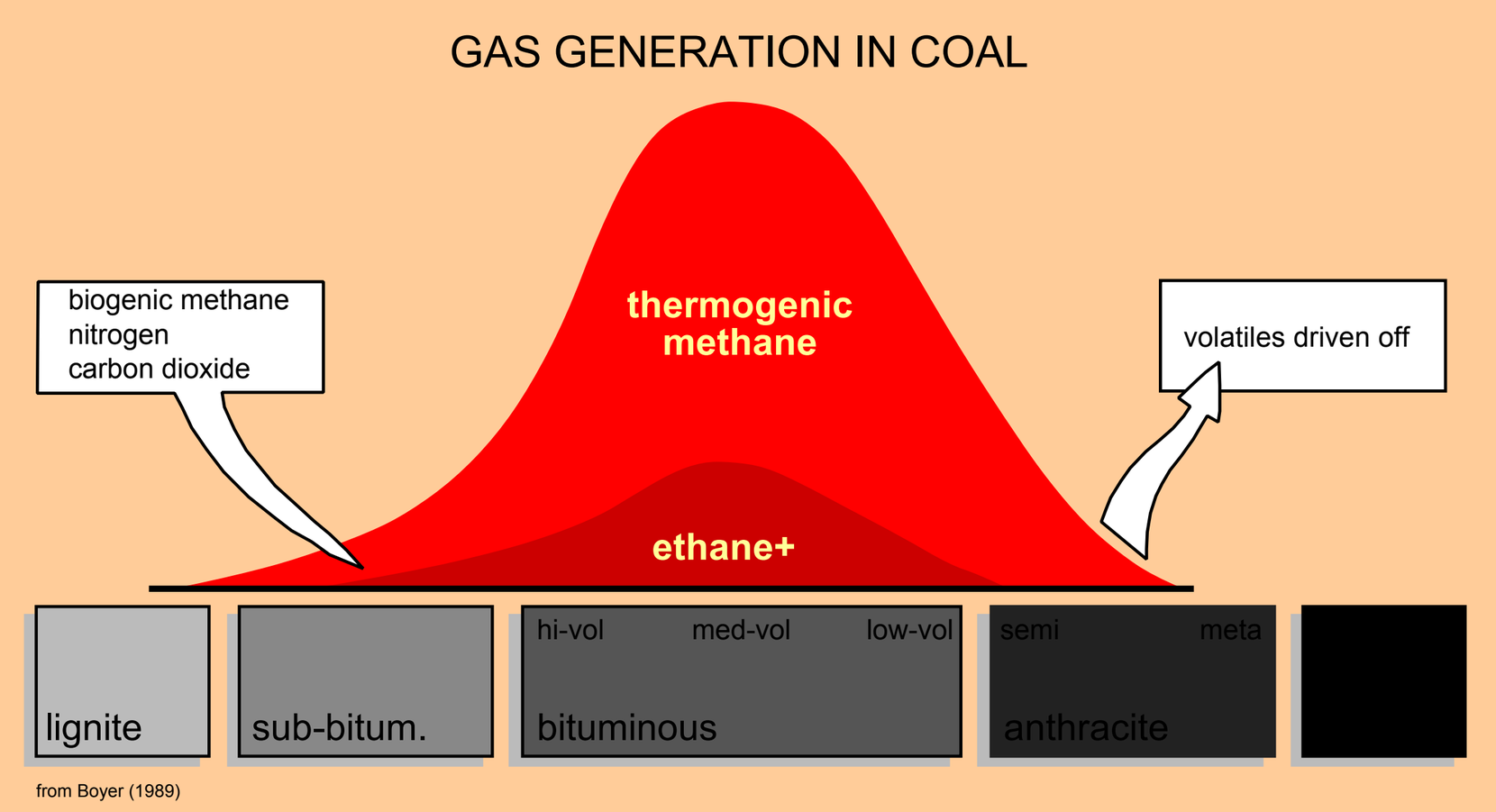




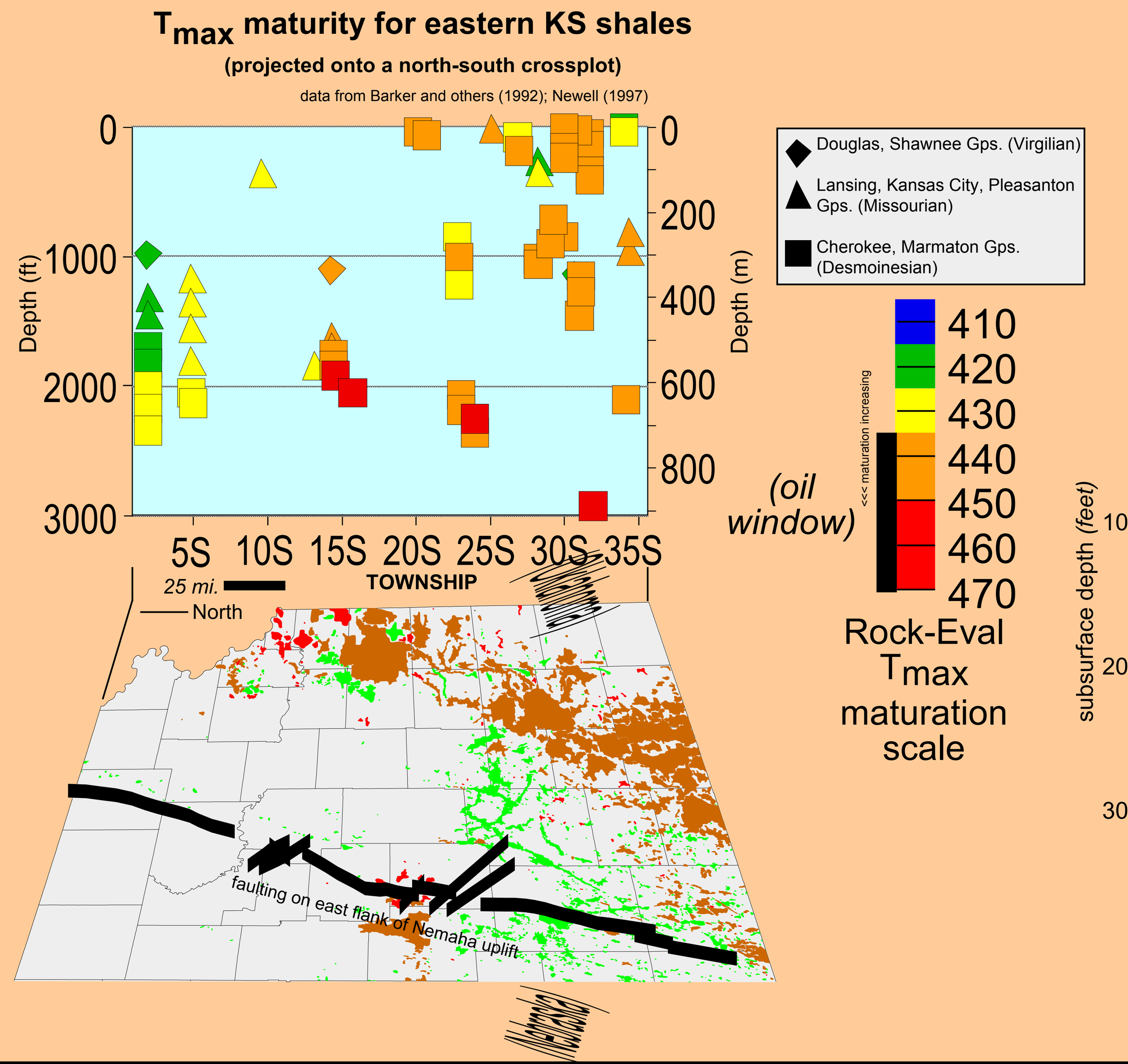


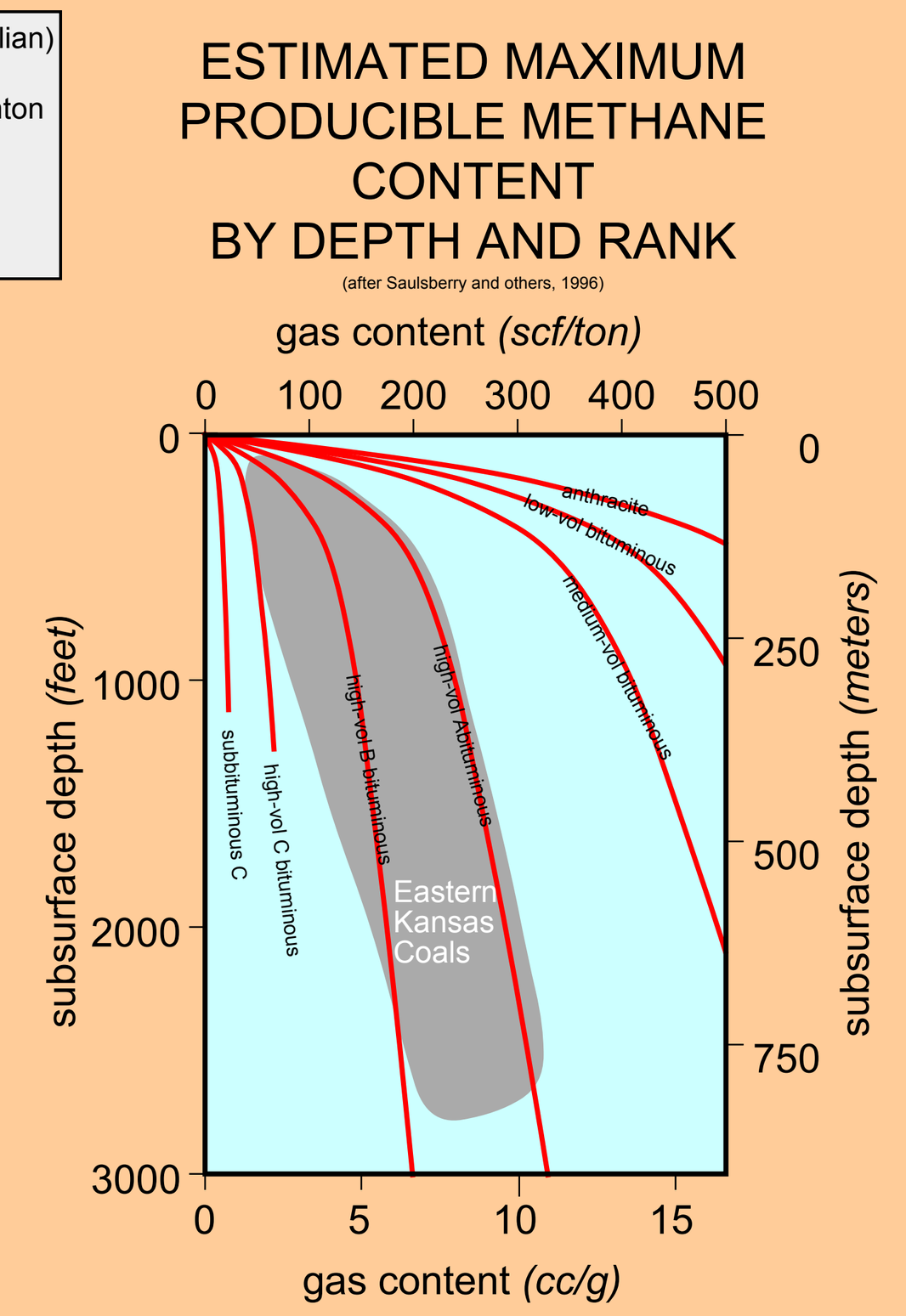
REGIONAL TRENDS IN THERMAL MATURATION

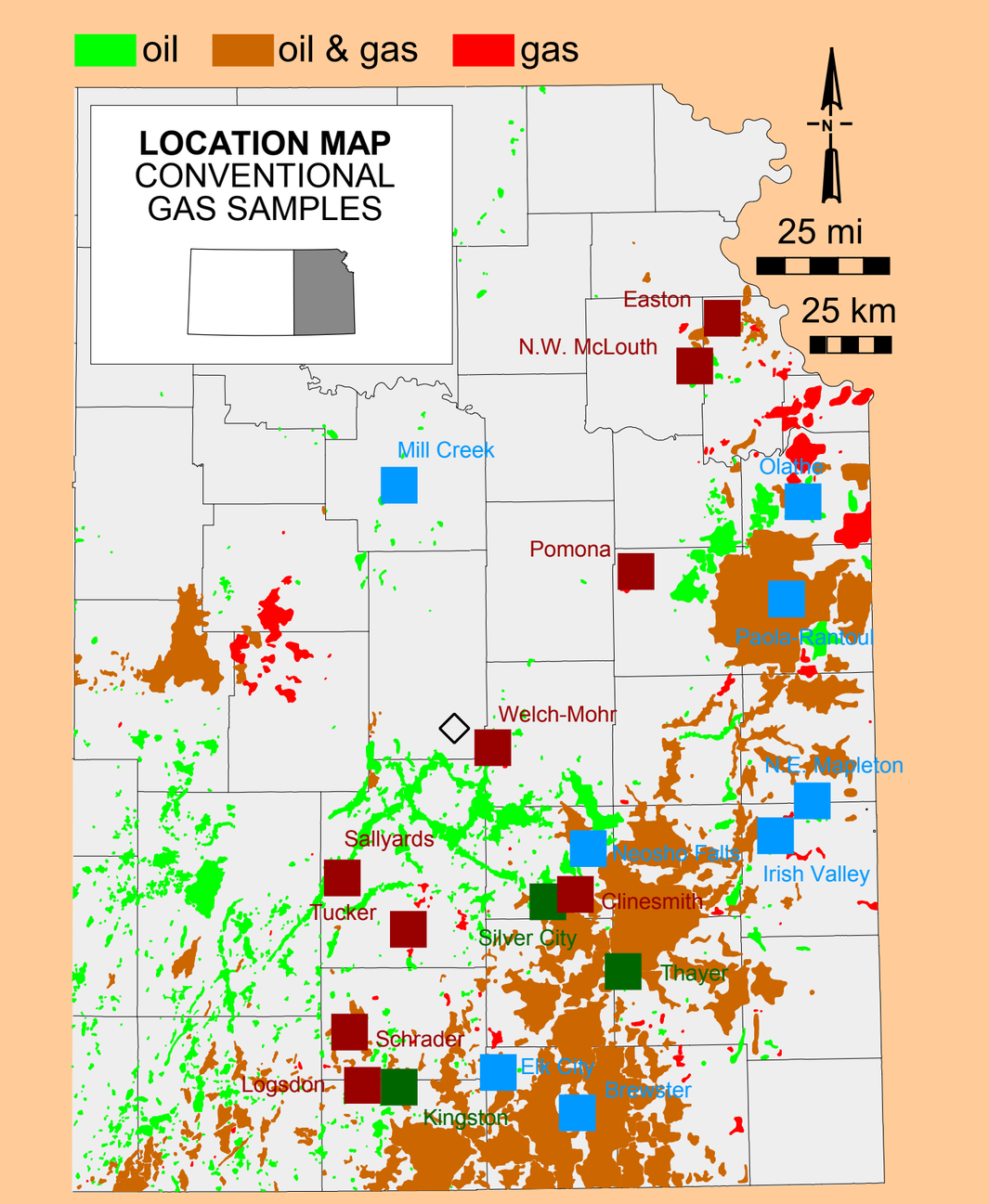
Thermal maturation, as displayed by the vitrinite reflectance and coal rank maps above, increases southward in the Kansas part of the Western Interior Coal Basin. The most prolific gas generation in coals occurs at medium-volatile bituminous rank. Kansas coals are less thermally mature (generally high-volatile bituminous ranks) and hence contain less gas.

A north-south projection of the Rock-Eval Tmax maturation parameter for shales from well cuttings and cores in the Forest City basin, Bourbon arch, and Cherokee basin (see diagram at right) also indicates a southward increase in thermal maturation. At a given depth, there is less maturation in the Forest City basin than further south in the Cherokee basin. This may be caused by higher heat flow in southeastern Kansas, or northward movement of higher-temperature waters out of the Arkoma basin onto the cratonic platform during the late Paleozoic Ouachita orogeny.

These trends in maturation indicate that operators attempting to produce coalbed gas in the marginally mature strata in the Bourbon arch and Forest City basin should concentrate on the deepest coals, which should have better gas content.



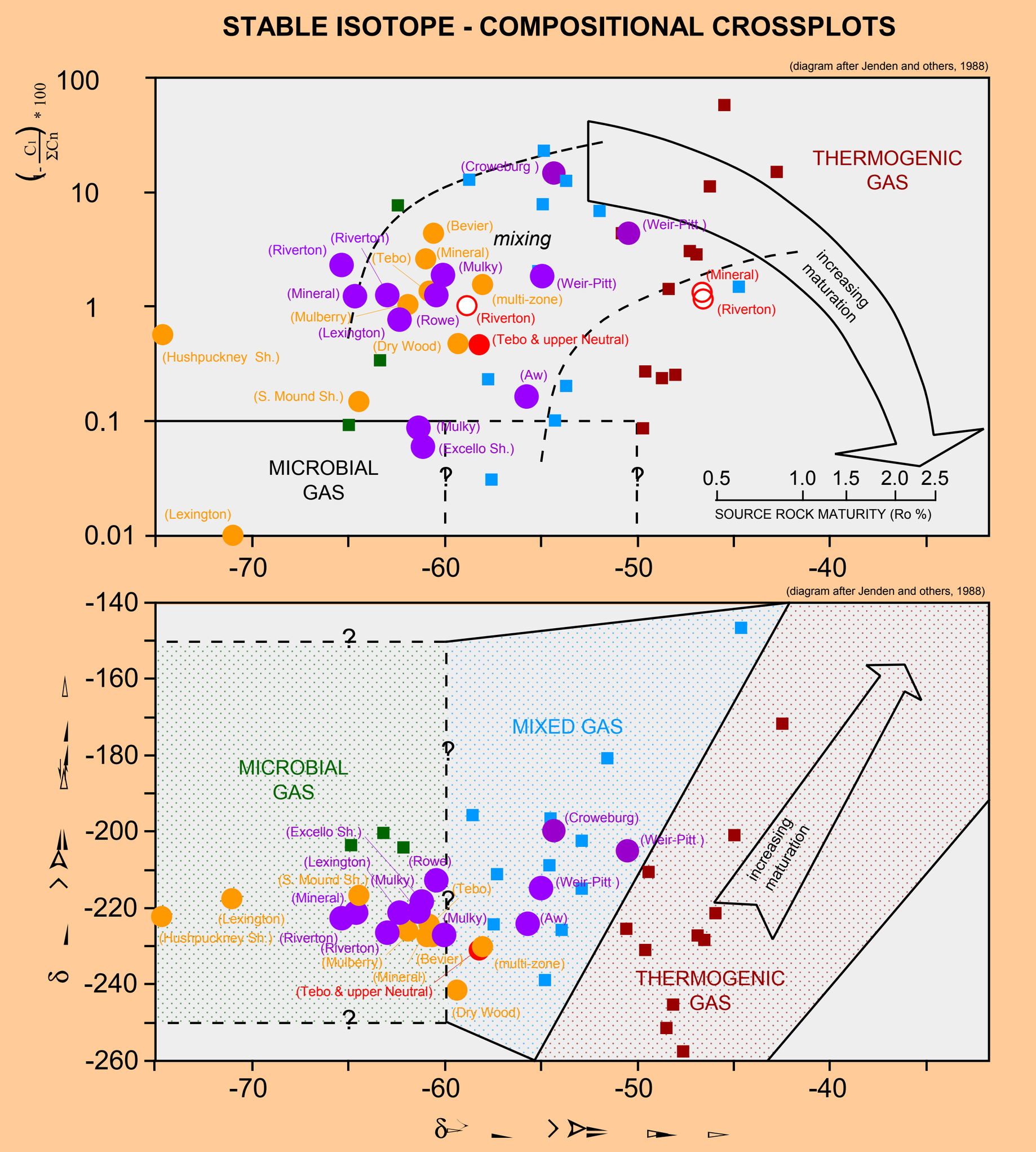


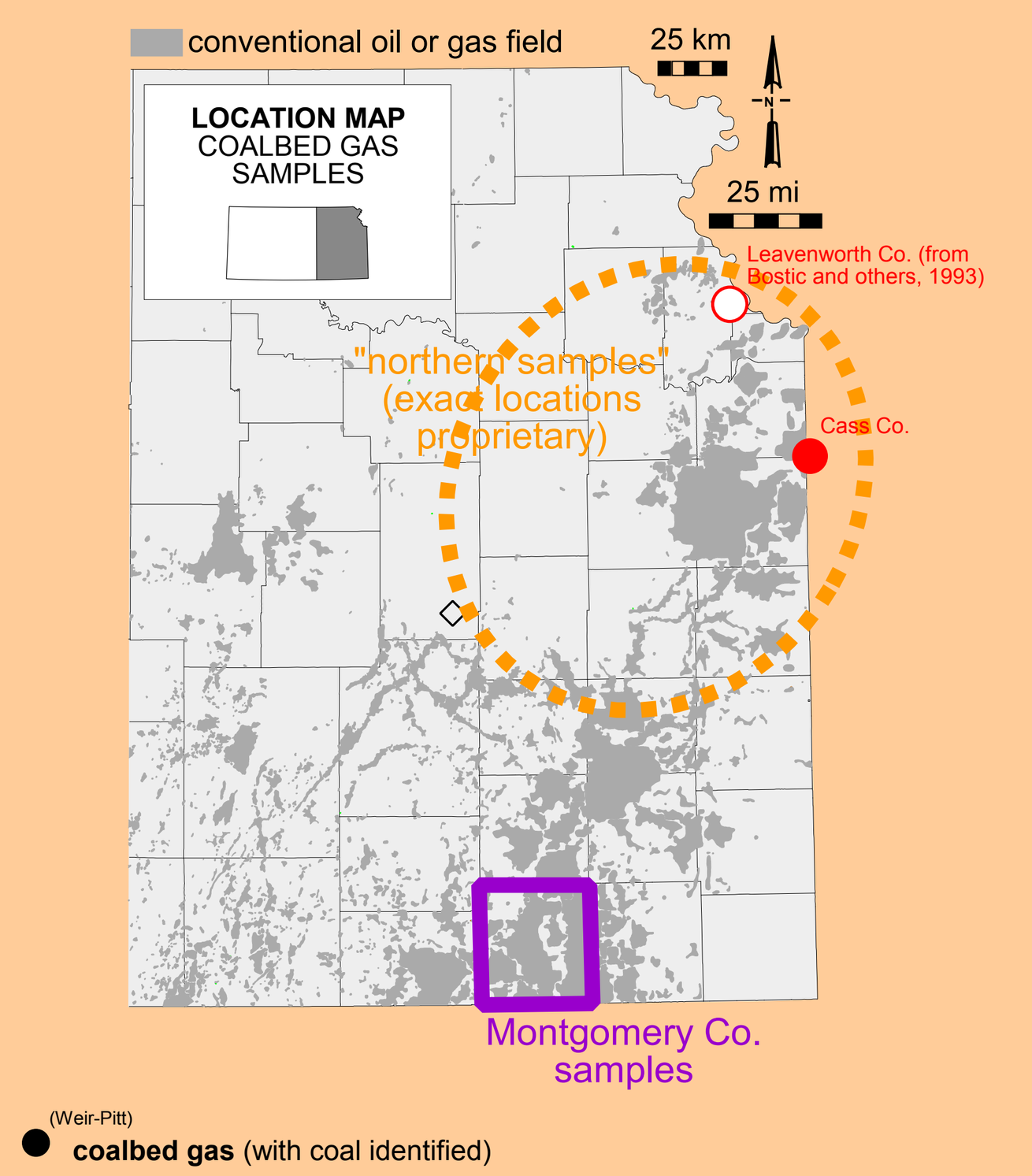


conventional gas (from Jenden and others, 1988)

field name and symbol (see map) colored coded according to origin of gas, as indicated by δ13C and δD isotope crossplot (see right) (green = microbial gas; blue = mixed gas; brown = thermogenic gas)

AGE of PAY	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





coalbed gas (with coal identified)

symbol colored-coded according to location (see map)

- Montgomery County, KS
- Cass County, MO
- Leavenworth County, KS (from Bostic and others, 1993)
- "northern samples" -- Bourbon arch and eastern flank of Forest City basin (exact locations still proprietary)

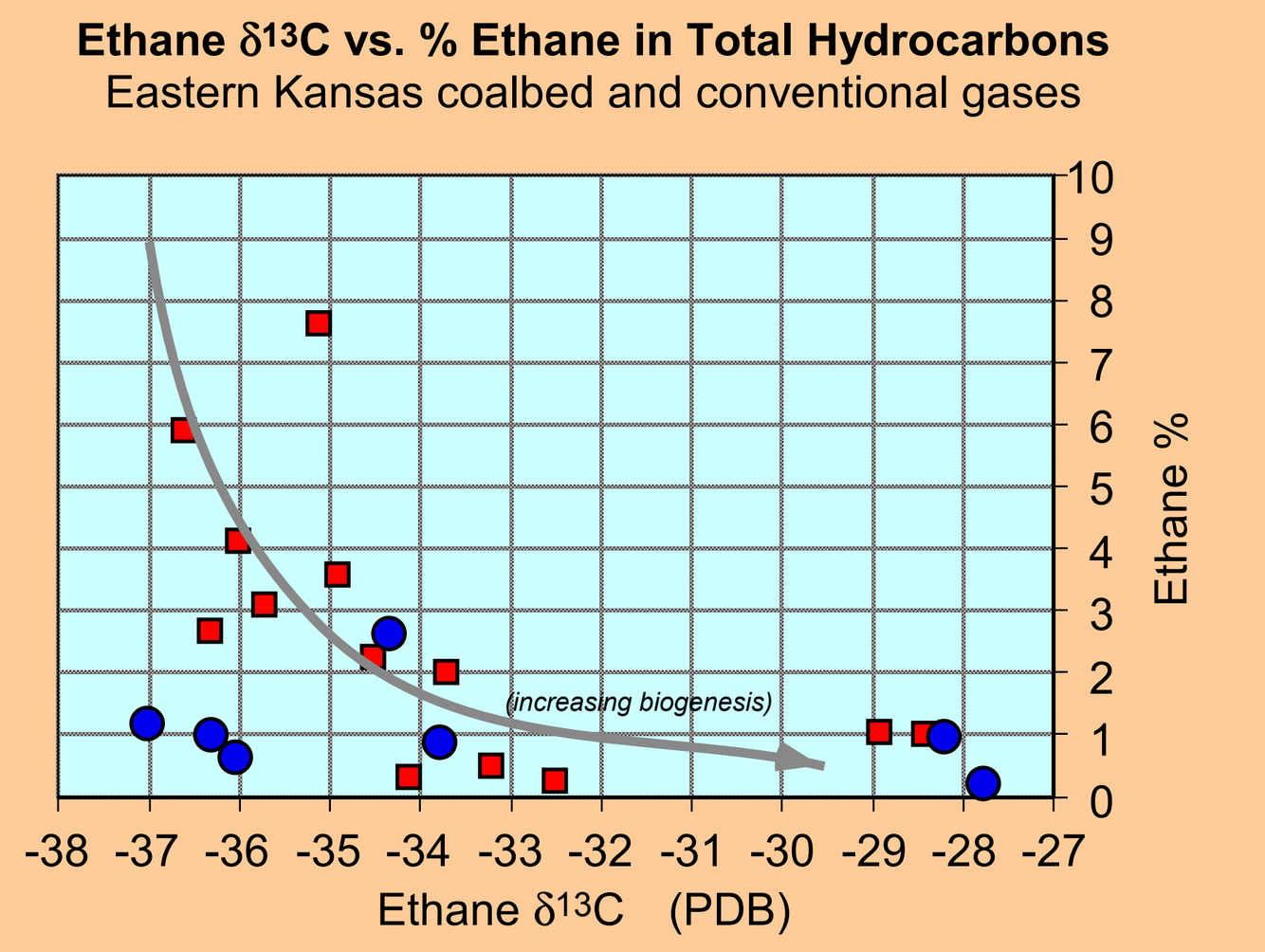
GAS ISOTOPIC DATA

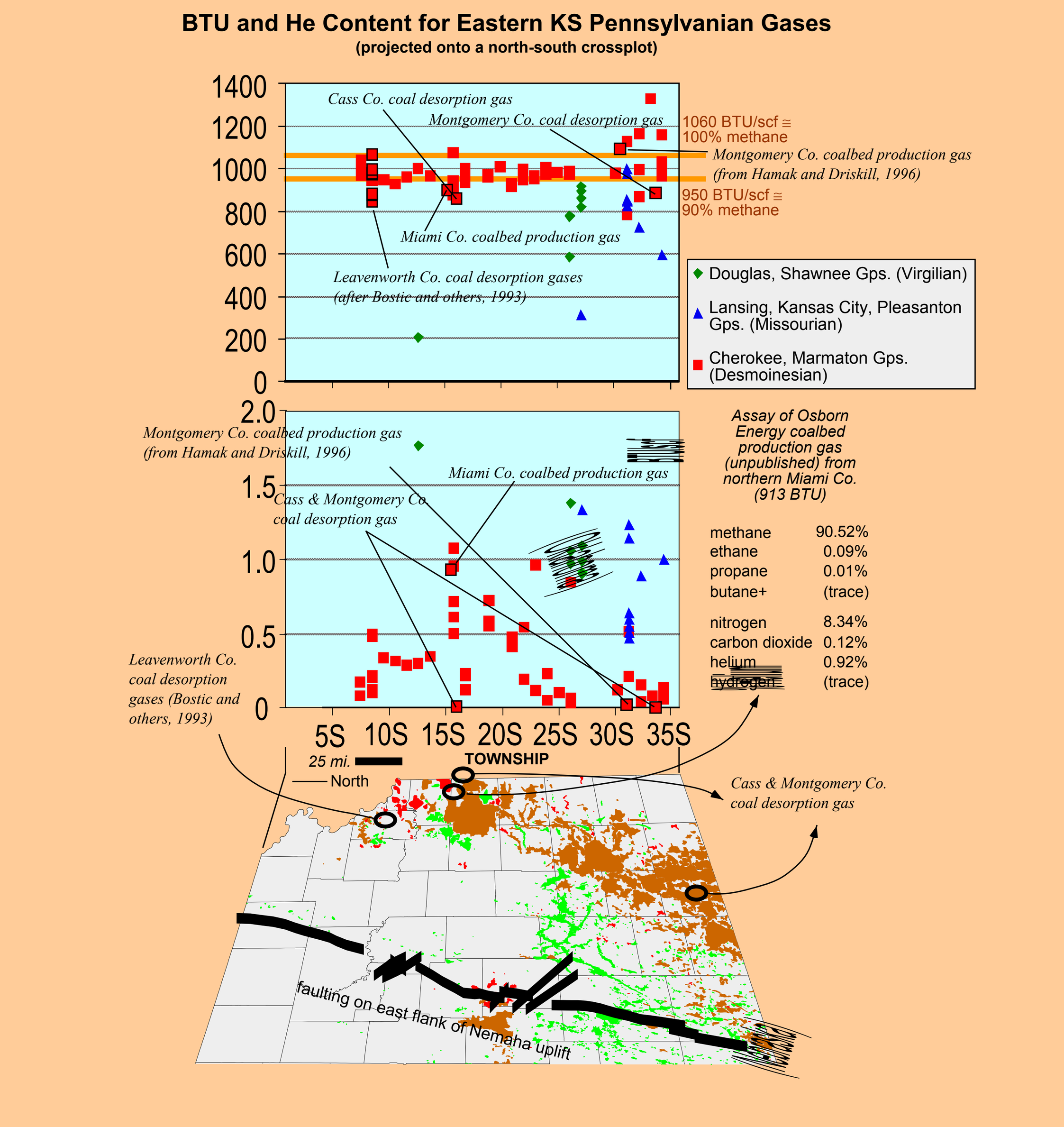
A crossplot of methane δ13C and the δD can be used to infer gas origin. Thermogenic methane carbon is typically isotopically heavy (i.e., less negative) whereas microbial methane carbon typically is isotopically light (i.e., more negative). Microbially-derived gas is also dry and largely void of heavier hydrocarbons (i.e., ethane, propane, etc.).

A data set on isotopes of conventional gases from eastern Kansas (from Jenden and others (1988) can be compared to coalbed gas samples. The conventional gases (squares in the above diagram) range from biogenic to thermogenic in origin. A map of the data (see above, left) shows most biogenic and mixed biogenic-thermogenic gases are on the shallow eastern flank of the Forest City and Cherokee basins, whereas thermogenic gases are farther west in the deeper portions of the basins. There is no strong stratigraphic differentiation of these gases in which younger, less thermally mature formations display a stronger biogenic signature (see key for location map for conventional samples). This suggests that some conventional and coalbed gases in eastern Kansas could be what Scott (1999) termed "secondary biogenic gases" in which methanogenic bacteria modify existing hydrocarbons.

Coalbed-gas methanes (circles in the above diagram) show no strong thermogenic signature. Gases from the Bourbon arch and eastern flank of the Forest City basin tend to be isotopically lighter than Cherokee basin gases, which is consistent with lesser thermal maturation northward.

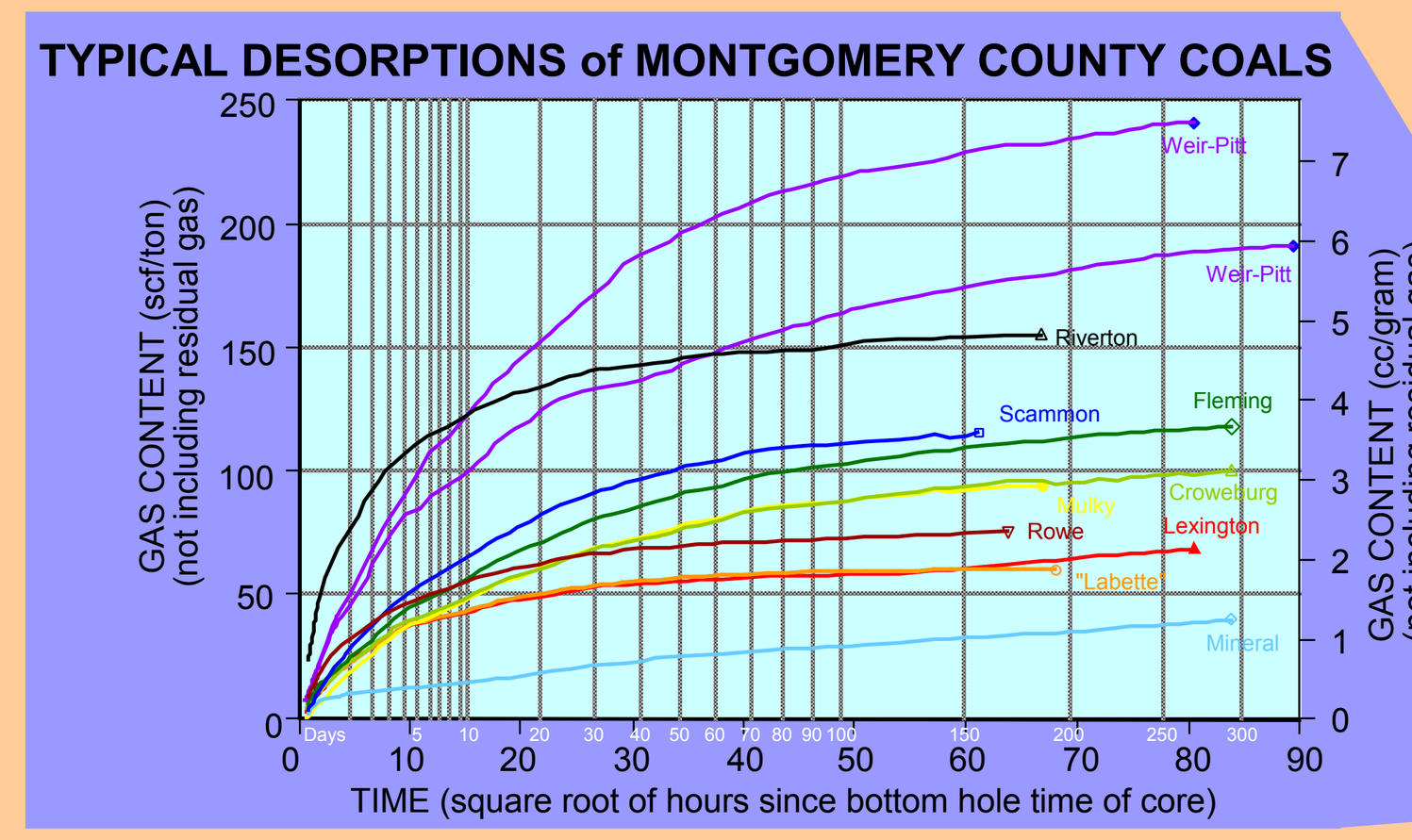
Bacterial modification of eastern Kansas coalbed and conventional gases is also suggested by the crossplotting of ethane δ13C with % ethane. Methanogenic bacteria more easily consume isotopically lighter carbon. In such circumstances, the residual ethane will become isotopically heavier (i.e., less negative) as it is consumed. Similar effects of microbial oxidation of heavier hydrocarbons in gas have been observed with Devonian shales in the Michigan basin (Schoell and others, 2001; Walter and others, 2001; Martini and others, 2003) and with Fruitland coal in the San Juan basin (Schoell and others, 2001).

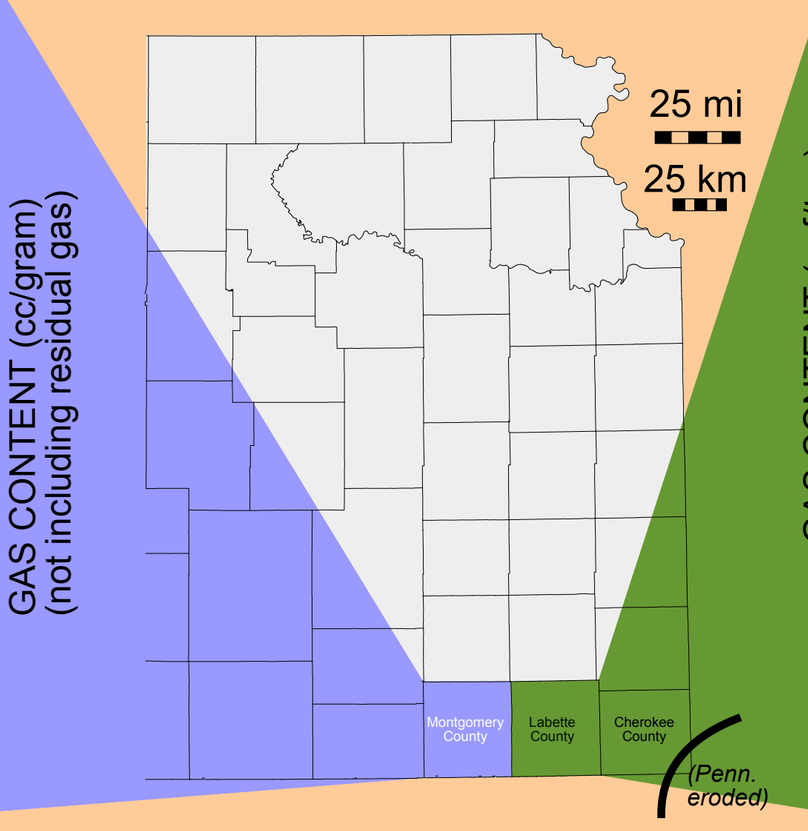


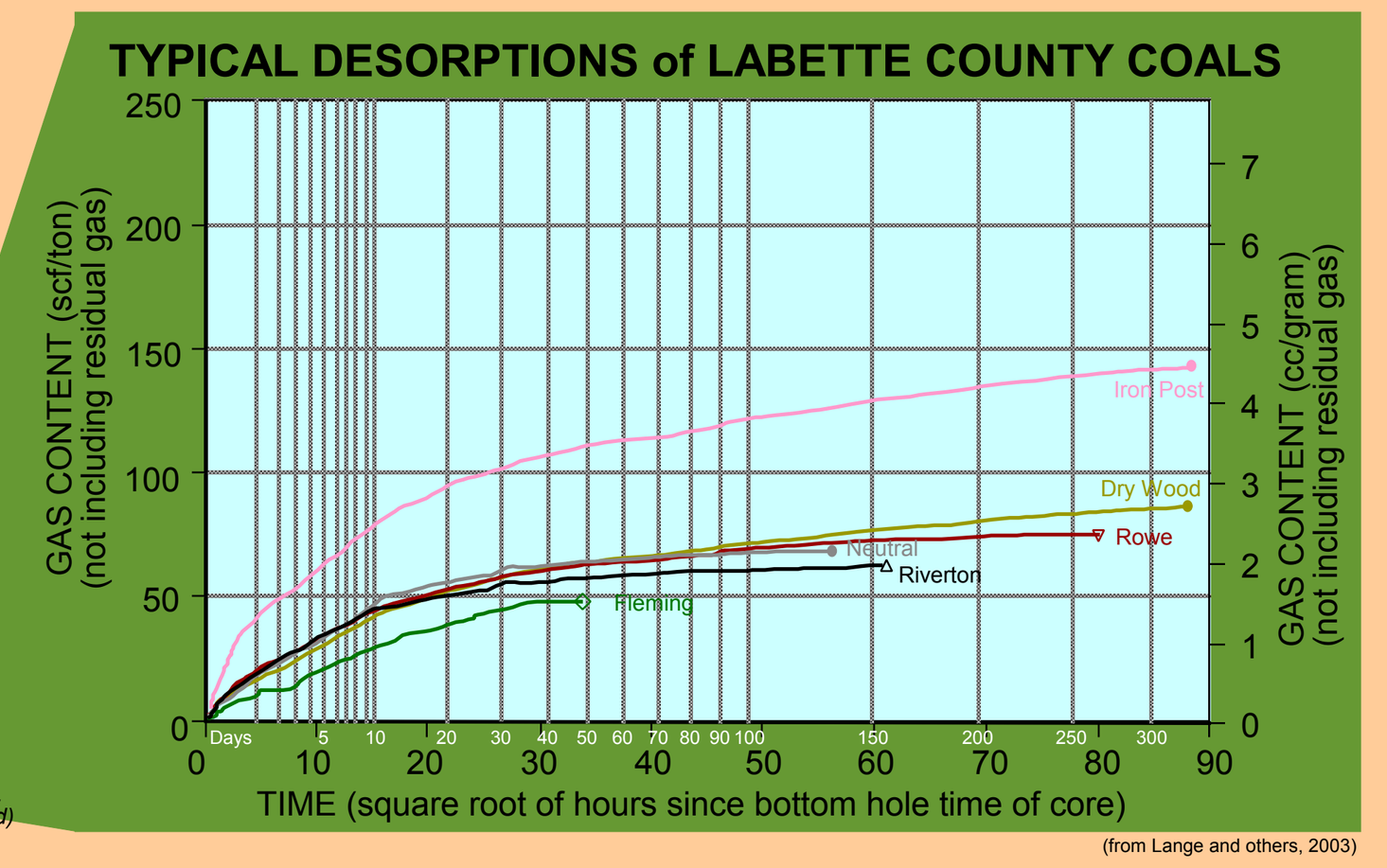


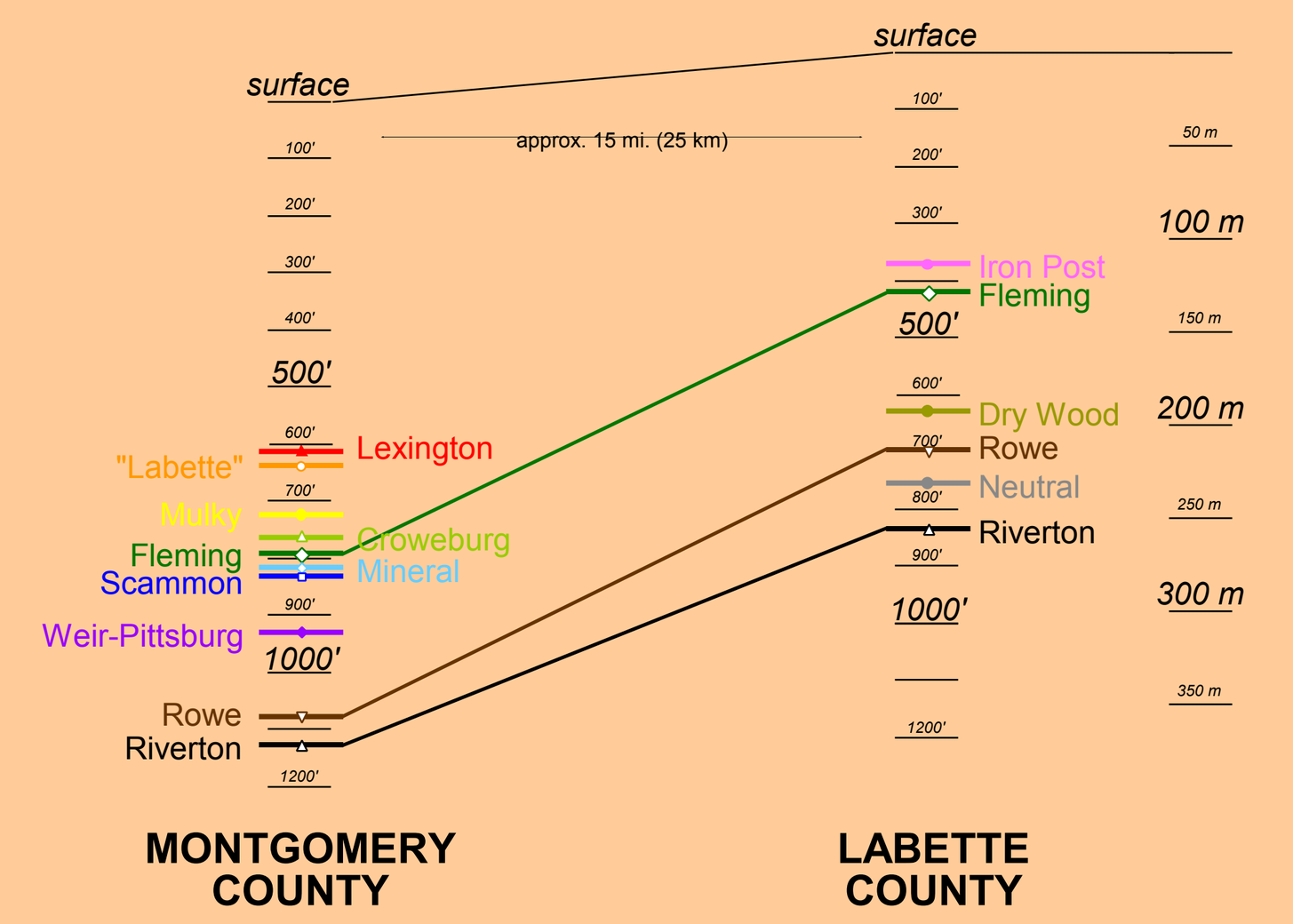
REGIONAL TRENDS IN GAS QUALITY

Conventional gases have higher BTUs in southeastern Kansas, indicating a greater proportion of heavier hydrocarbons -- a trait that is consistent with the inferred greater maturation in this region. Shallower Pennsylvanian gases from the Missourian and Virgilian part of the section have greater percentages of noncombustible gases, which significantly lowers their heating value. Heating values for coalbed gases mimic the trend established by the conventional gases. Inasmuch as helium is not easily retained by adsorption, coalbed gases generally have low helium content, but the presence of helium in some coalbed gases suggests leakage from conventional reservoirs with well completion.









POSSIBLE THERMOGENIC AND BIOGENIC ORIGINS OF KANSAS COALBED GAS

The desorption diagrams above are from two wells in adjacent counties in the Cherokee basin. The deepest coals in Montgomery County (to the west) register gas contents from 250 to 300 scf/ton. The same coals in Labette County (to the east) are buried less deeply, and they have gas contents considerably less than the Montgomery County coals. However, the Iron Post coal at 382 ft (116 m) depth in the Labette County well has an unexpectedly large gas content (>100 scf/ton), exceeding that of the deeper coals. A microbial or mixed thermogenic-microbial origin for this gas is suggested. Pennsylvanian coal-bearing units crop out at the surface in Cherokee County (the county immediately east of Labette County). Downdip movement of fresh water from the outcrop may augment biogenic production of coalbed gas in shallow coals along the eastern flank of the Cherokee and Forest City basins. A possible consequence to this model is that separate thermogenic and biogenic production fairways in the same coal may be present. The thermogenic fairway would be deeper in the basin where there is sufficient burial and confining pressure. The biogenic fairway would be updip and closer (and likely parallel) to the outcrop where basinal brines would be diluted by meteoric waters carried downdip from the outcrop.

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CONCLUSIONS

1. A marked increase in drilling for coalbed gas has occurred in southeastern Kansas in the last three years, with a commensurate increase in coalbed gas production.
2. Most of the activity for coalbed gas has been in southeastern Kansas in the Cherokee basin, but isolated projects farther north in the Bourbon arch and Forest City basin are in progress.
3. Most Kansas coals are thin (<2 ft [0.6 m] thick), but several can be encountered in a given well. Water pumped from the coals is easily disposed, usually into the Arbuckle Dolomite, which lies a few hundred feet below the deepest coals.
4. The Forest City basin has several coal seams that are likely older than the Riverton coal, which is generally the oldest coal in the Cherokee basin and Bourbon arch.
5. Thickness trends in many coals follow a NNE-SSW depositional strike.
6. Thermal maturation increases southward into the Cherokee basin. This increase in maturation is manifest in the greater heating values of conventional gas and coalbed gas in this region.
7. A mixed biogenic and thermogenic origin of the coalbed gas in eastern Kansas is indicated by gas chemistry and stable isotopes. Some of the biogenic gas may be due to biogenic oxidation of existing hydrocarbons.
8. Possible biogenic and thermogenic production fairways may be present in eastern Kansas.