

Gas Character Anomalies Found in Highly Productive Shale Gas Wells



Kevin Ferworn
John Zumberge
Jackie Reed, Reed Geochemical Consulting
Stephen Brown

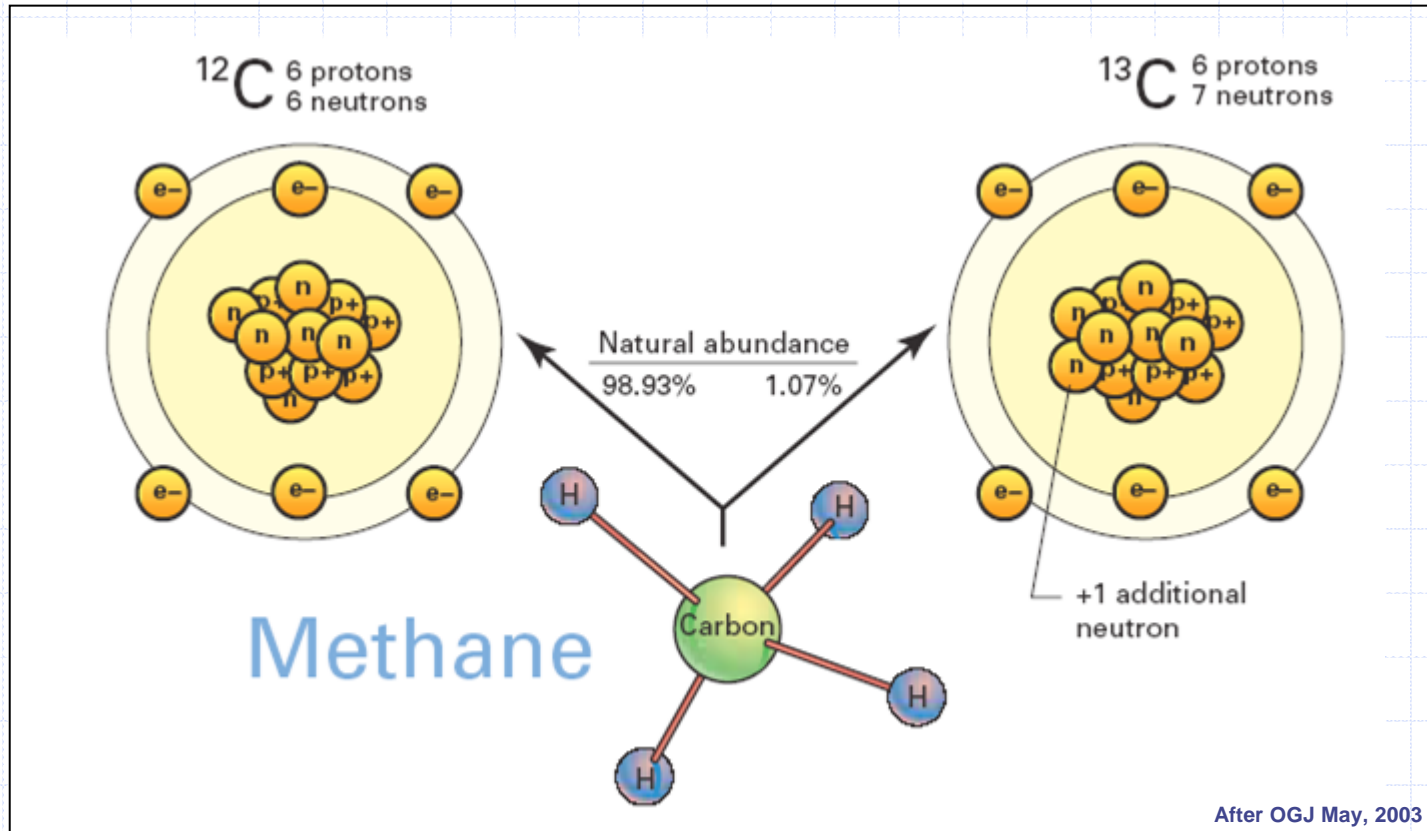
GeoMark Research
Houston, TX

Oct. 2008

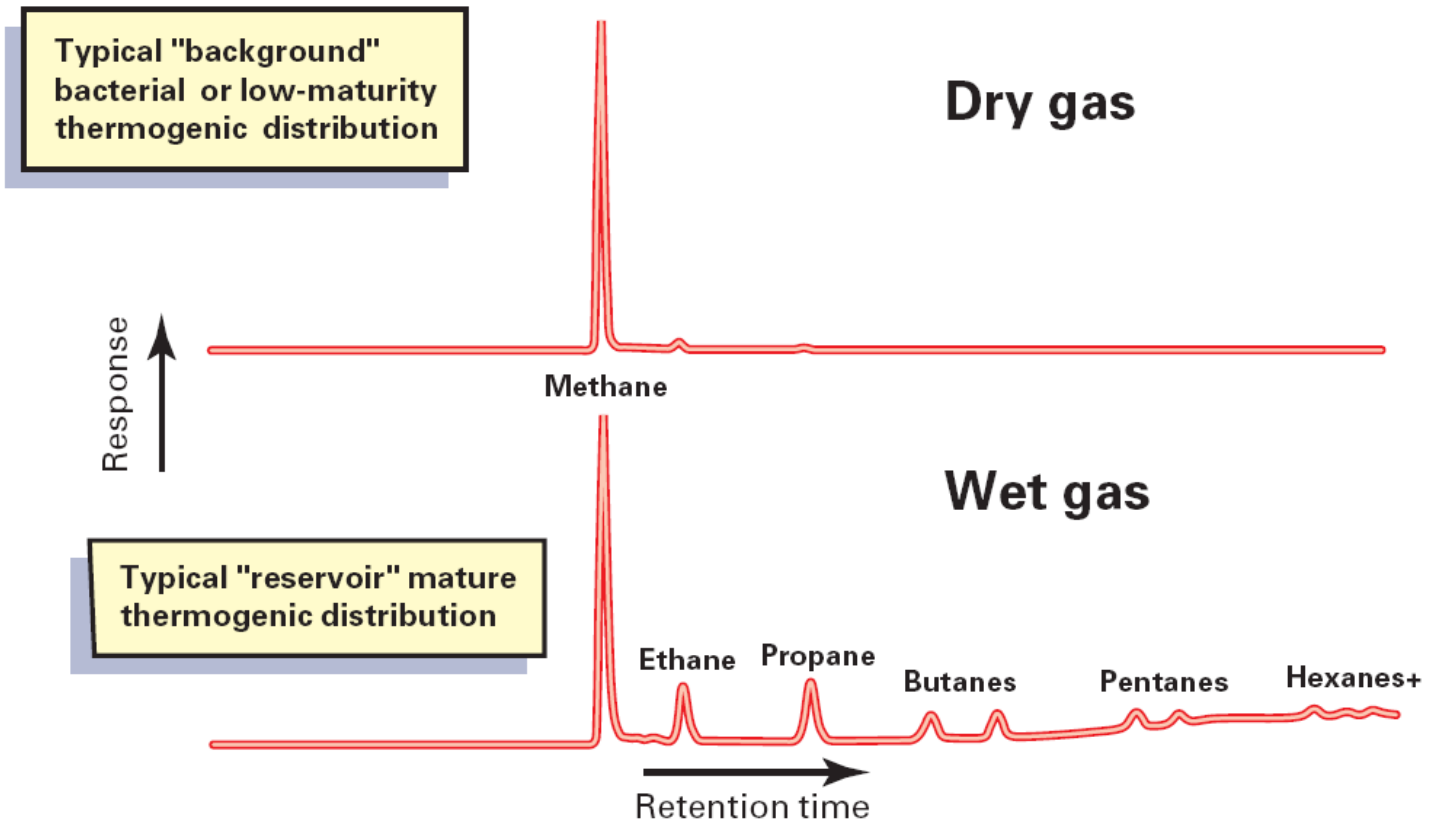
Presentation Outline

- Description of carbon isotopes and the differences between Biogenic and Thermogenic gases.
- Sample collection (from the mud stream and cuttings) during drilling.
- Ethane Isotope “rollover” suggests in-situ gas cracking and more productive wells.
- Mud Gas Isotope “reversals” indicate over-pressured shales.
- Differences between Mud (Free) and Cuttings (Adsorbed) Gases as permeability and fracturing markers.

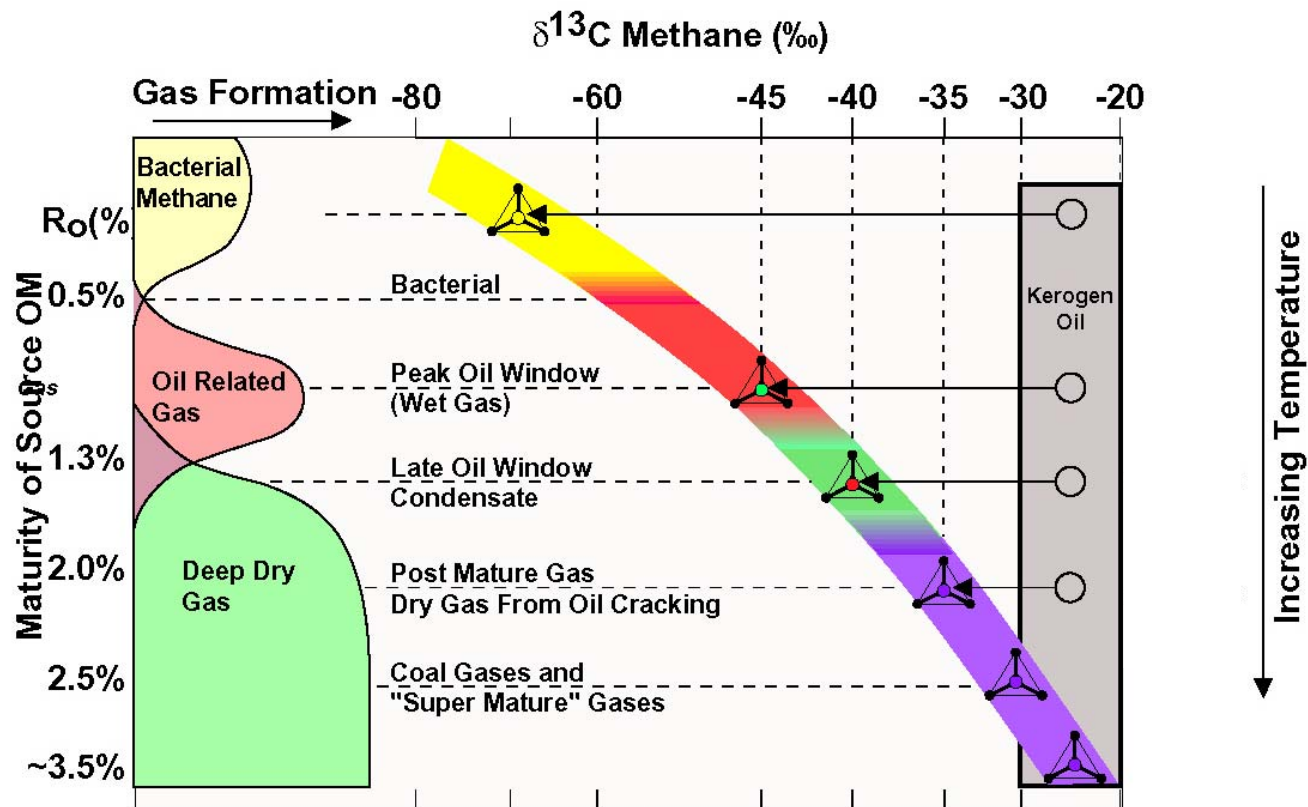
Carbon Isotopes



Dry and Wet Gas Compositions

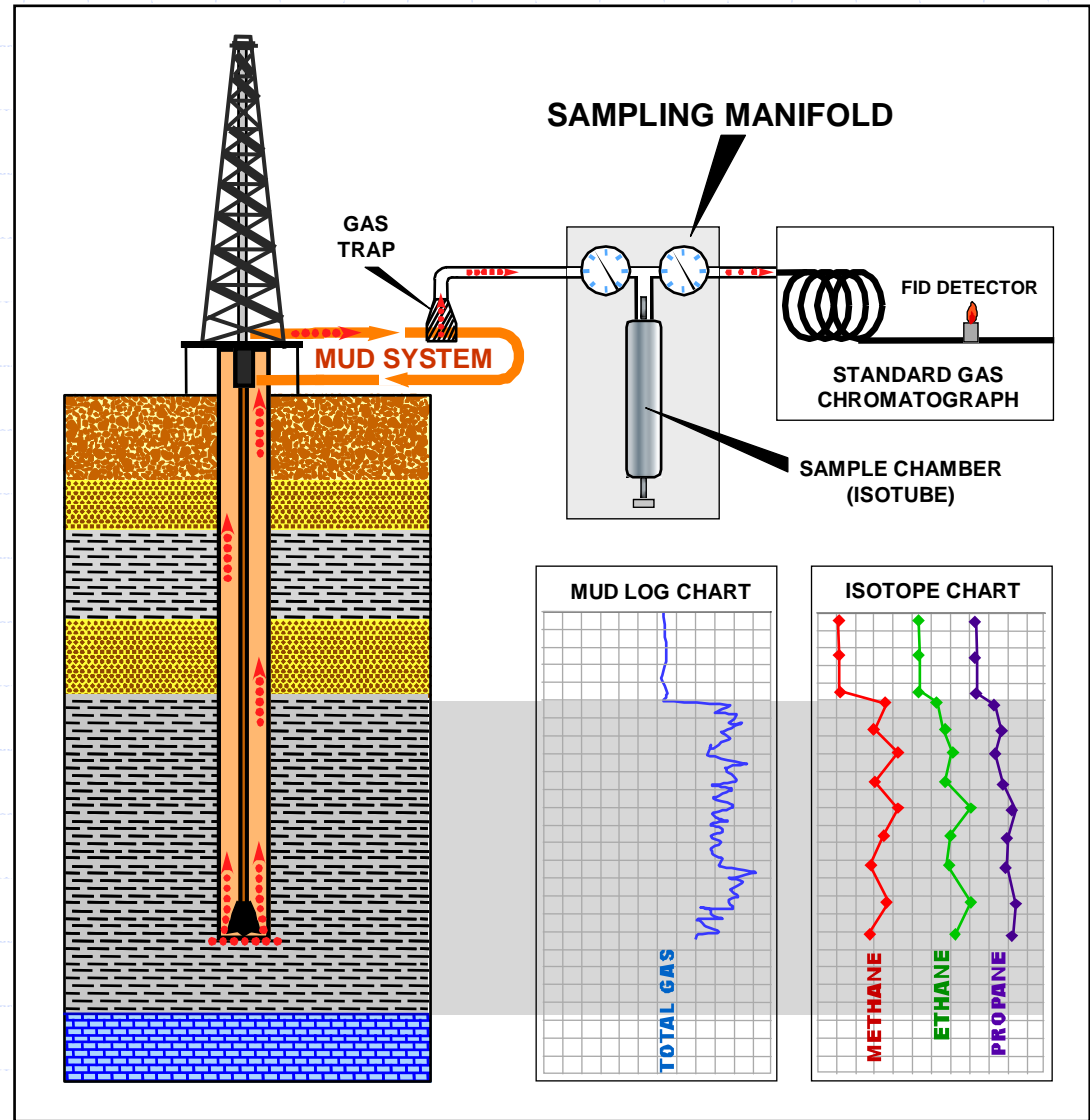


Carbon Isotope Ratios



after M. Schoell

Mud Gas Sampling



Gas Sampling for Isotopes



Mud Gas Sampling
Manifold

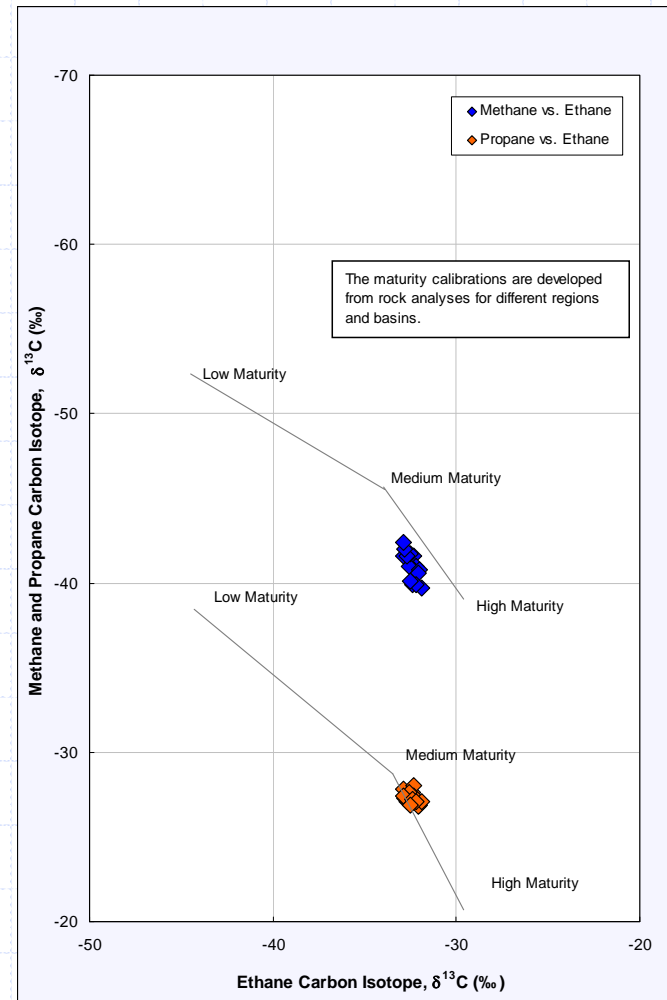
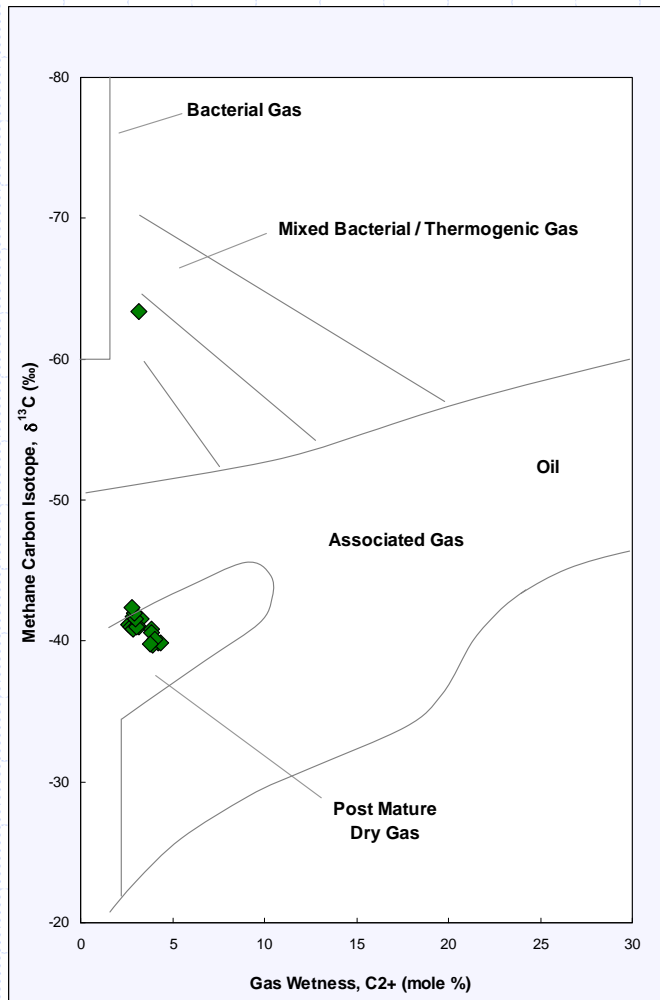


IsoLube for Mud Gases



IsoJar for
Cuttings Gases

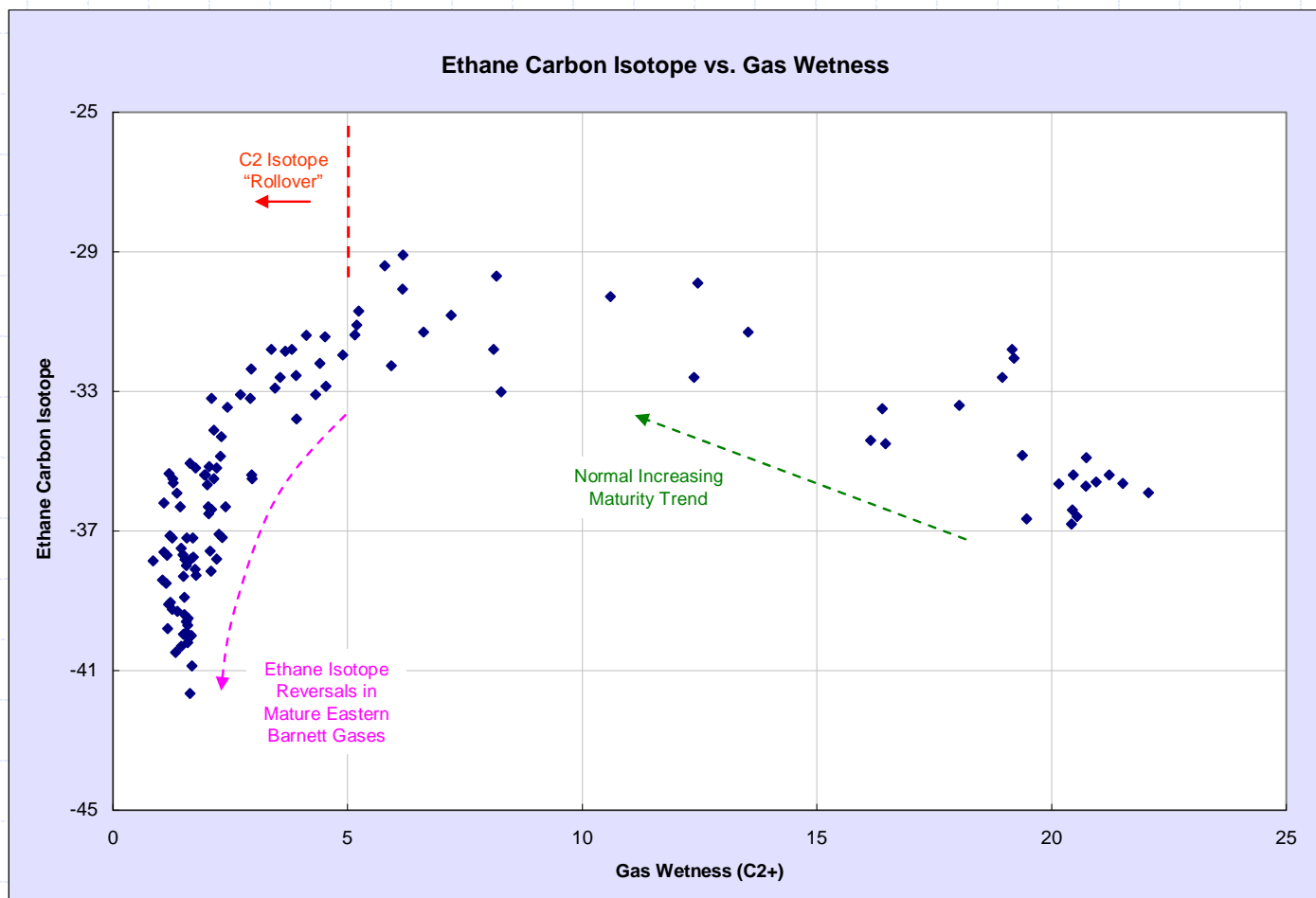
Mud Gas Interpretive Plots



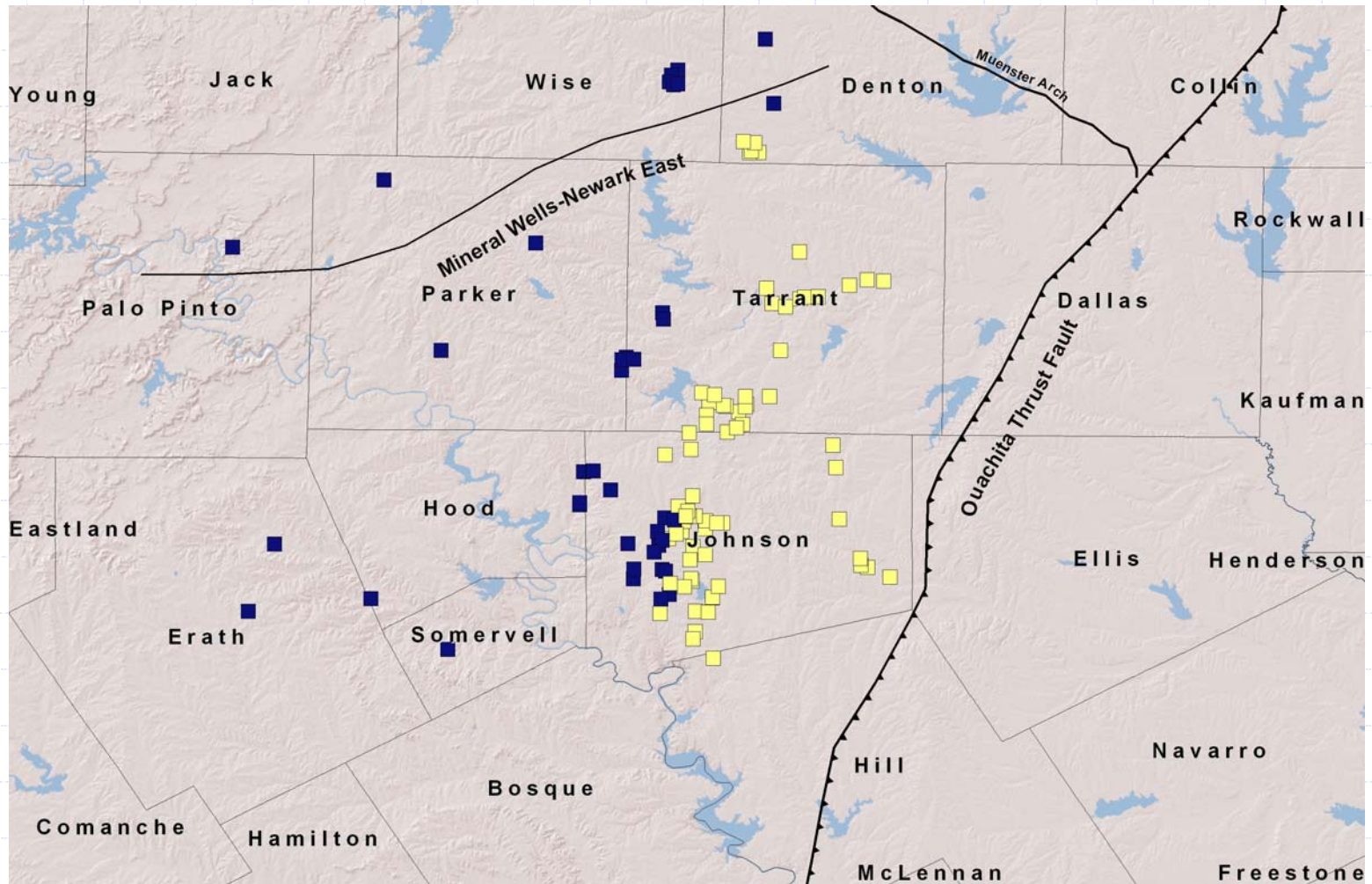
Gas Isotope / Maturity “Rollover”

- Ethane and Propane isotopes “Rollover” in increasingly high maturity Shale Gas wells
- Behavior is also observed in Fayetteville, Woodford, Haynesville, Appalachia, portions of the Rockies and Horn River Basin (Canada).
- These wells appear to be among the most productive shale wells.
 - In-situ cracking makes more smaller molecules increasing fluid pressure.
 - Organic material becomes more brittle – increased Kerogen porosity and permeability
 - Appearance of “bubble pores” increasing permeability

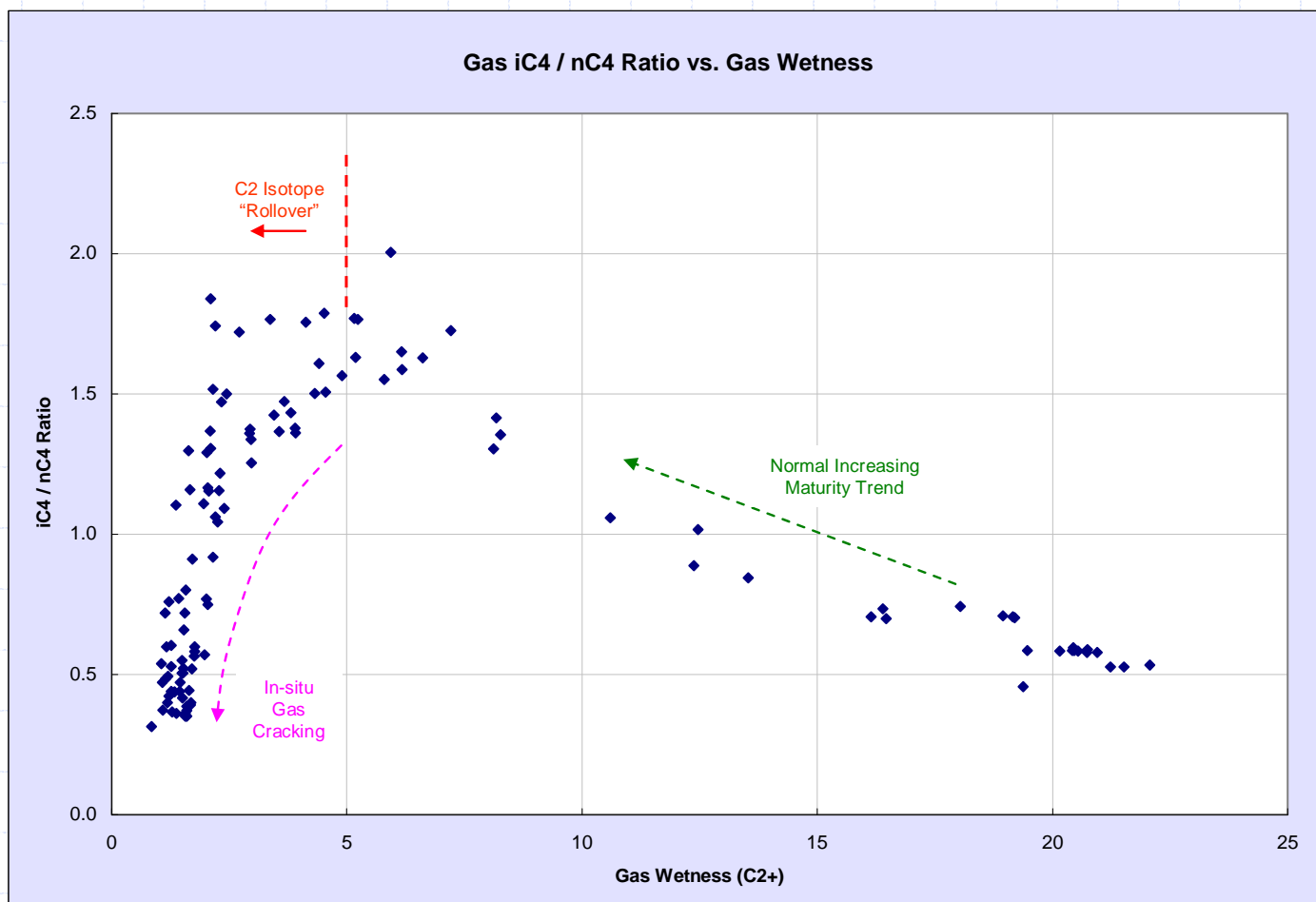
Barnett Shale Ethane Isotope "Rollover"



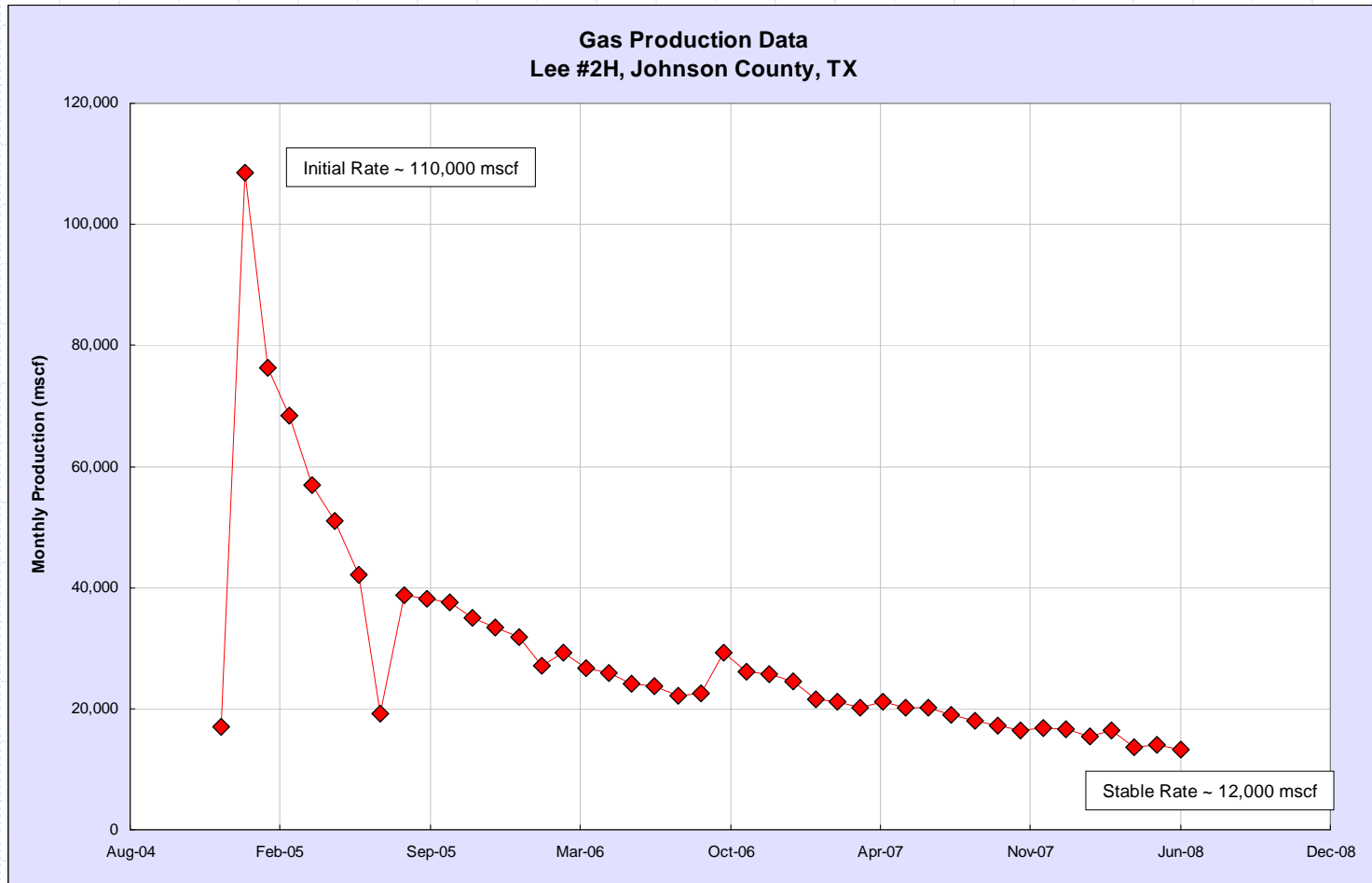
Ethane Isotope Reversals



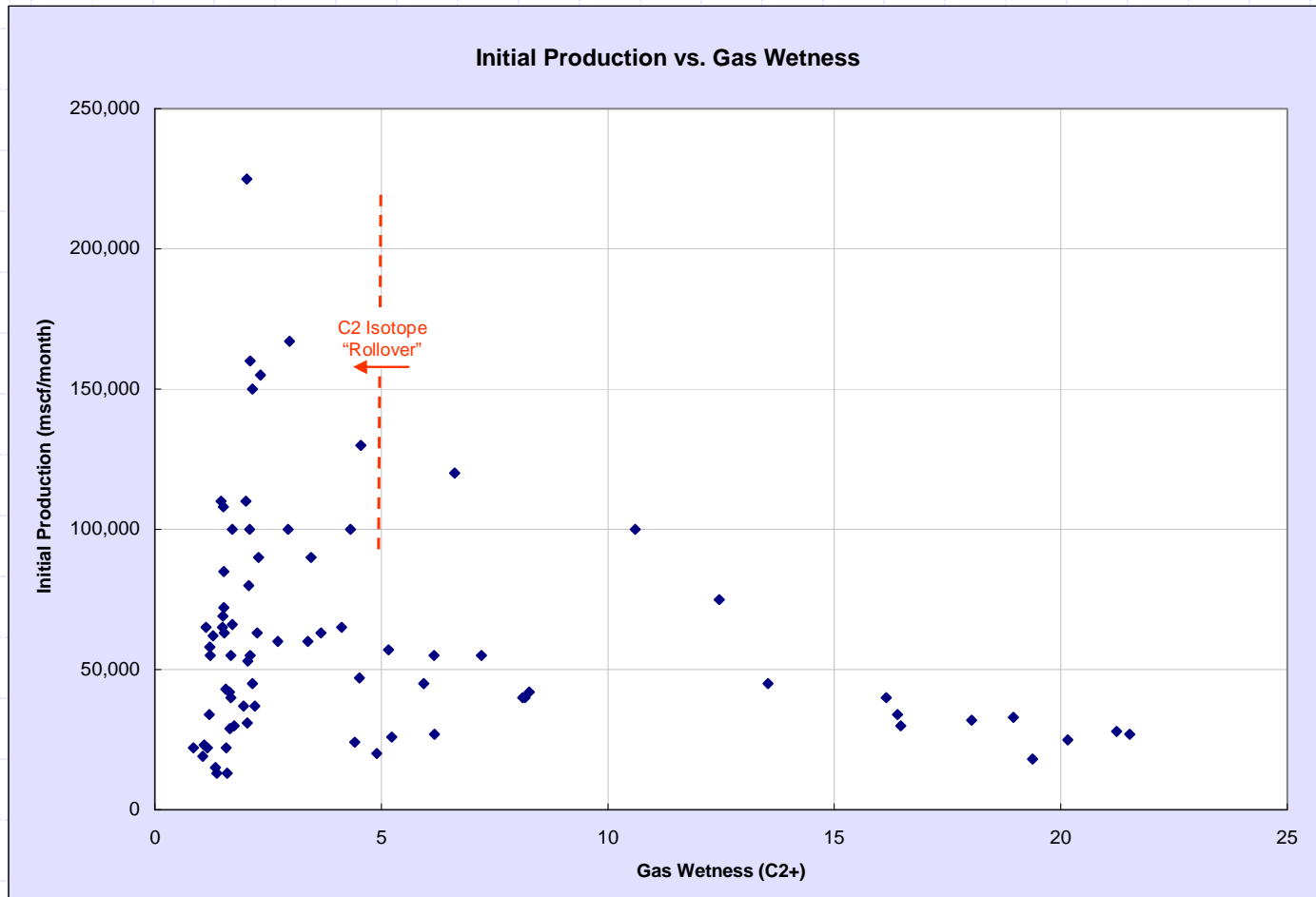
"Isotope Rollover" evidence via In-situ Gas Cracking



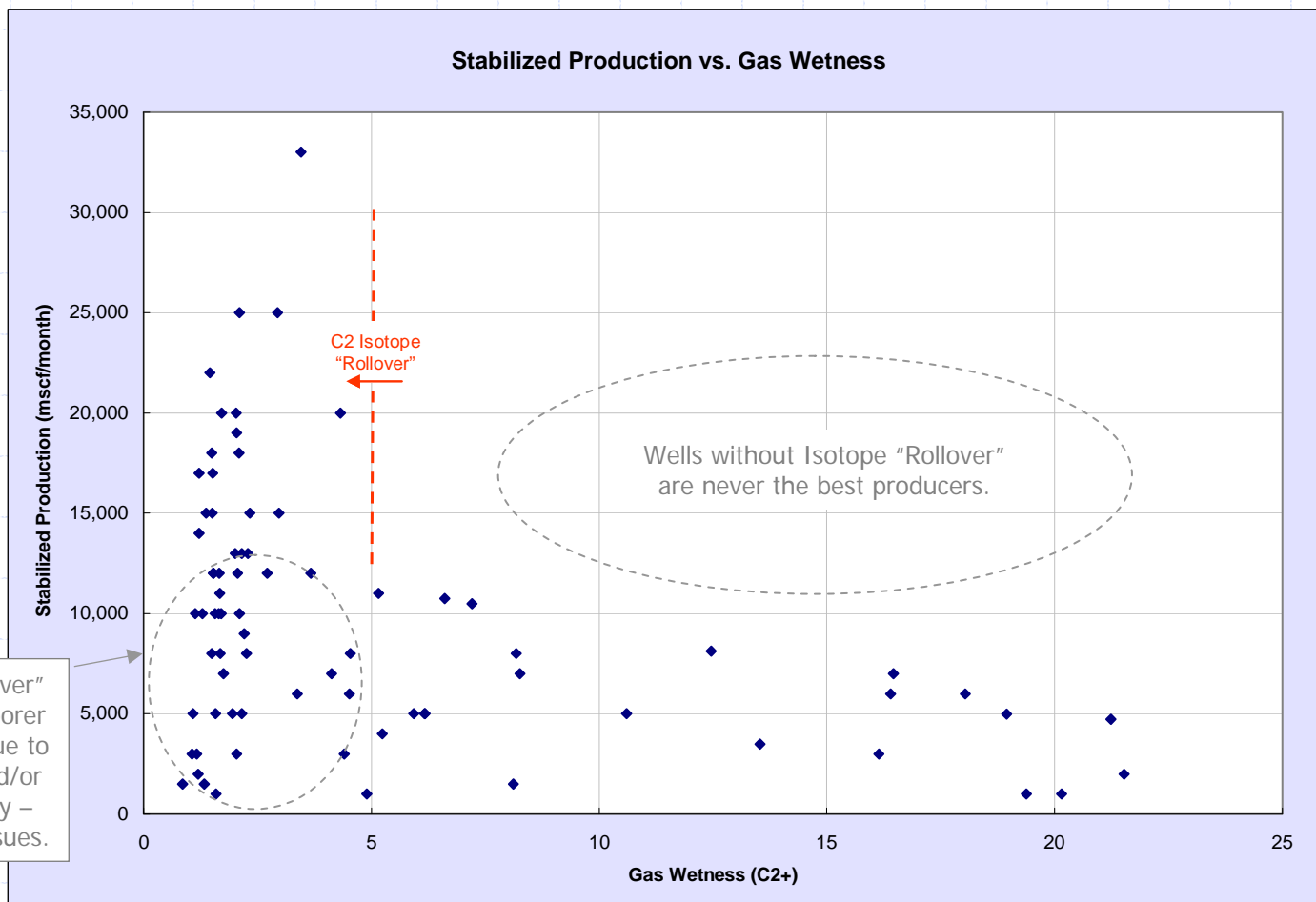
Initial Monthly Gas Production vs. Gas Wetness



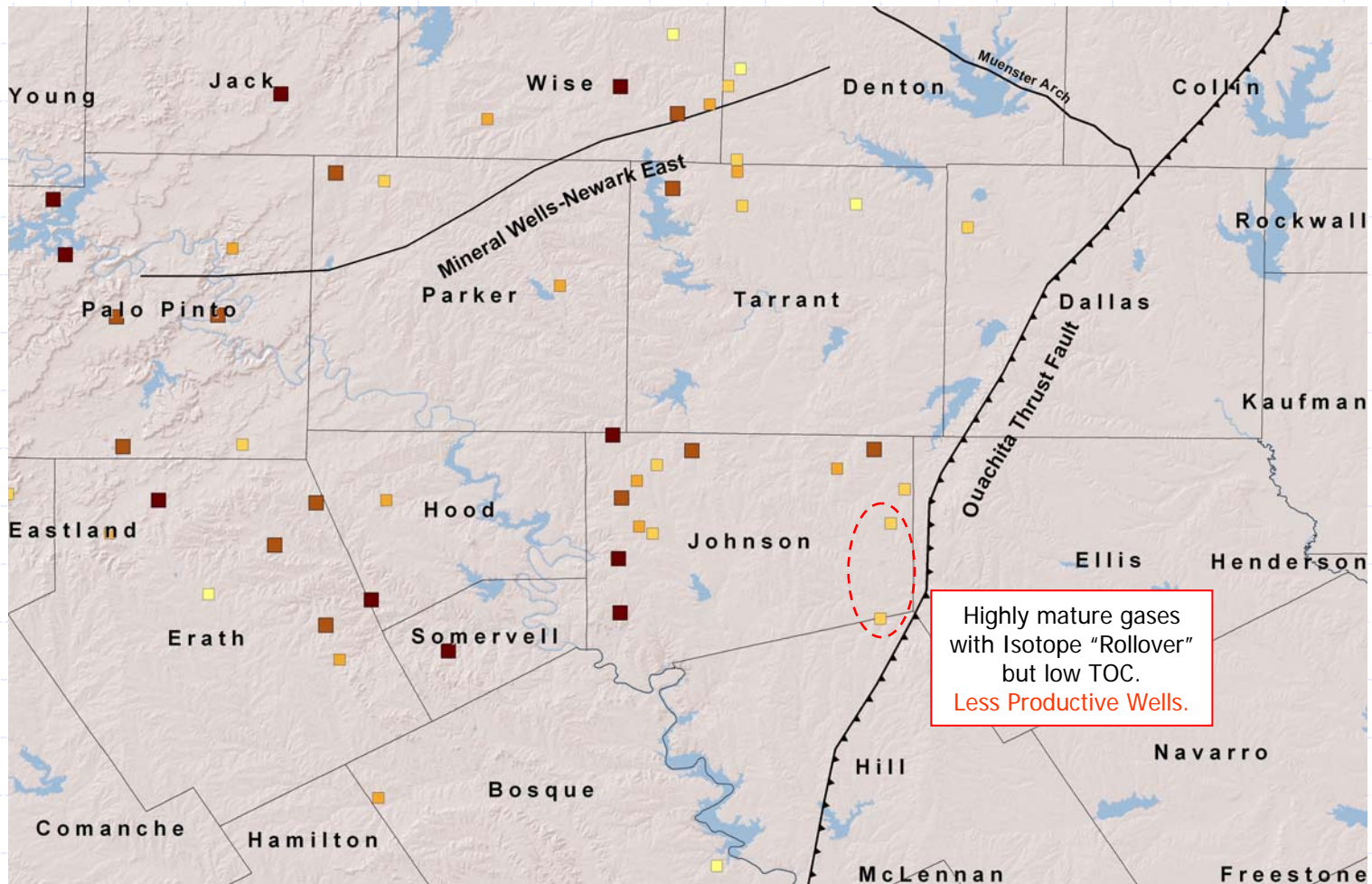
Initial Monthly Gas Production vs. Wetness



Stabilized Monthly Gas Production vs. Wetness

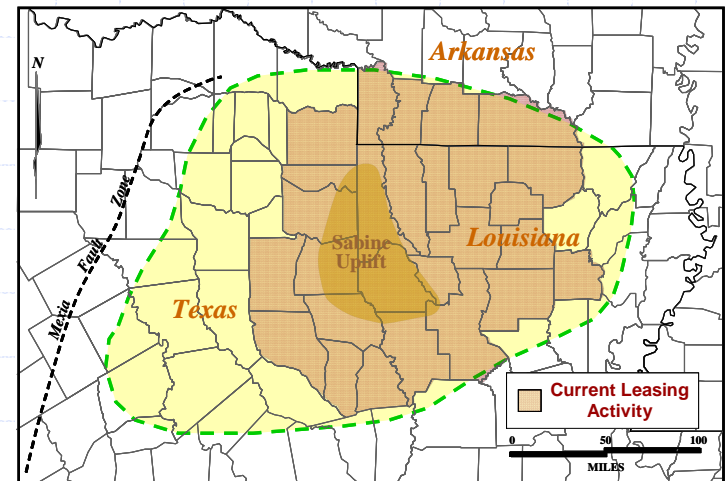


Total Organic Carbon Map

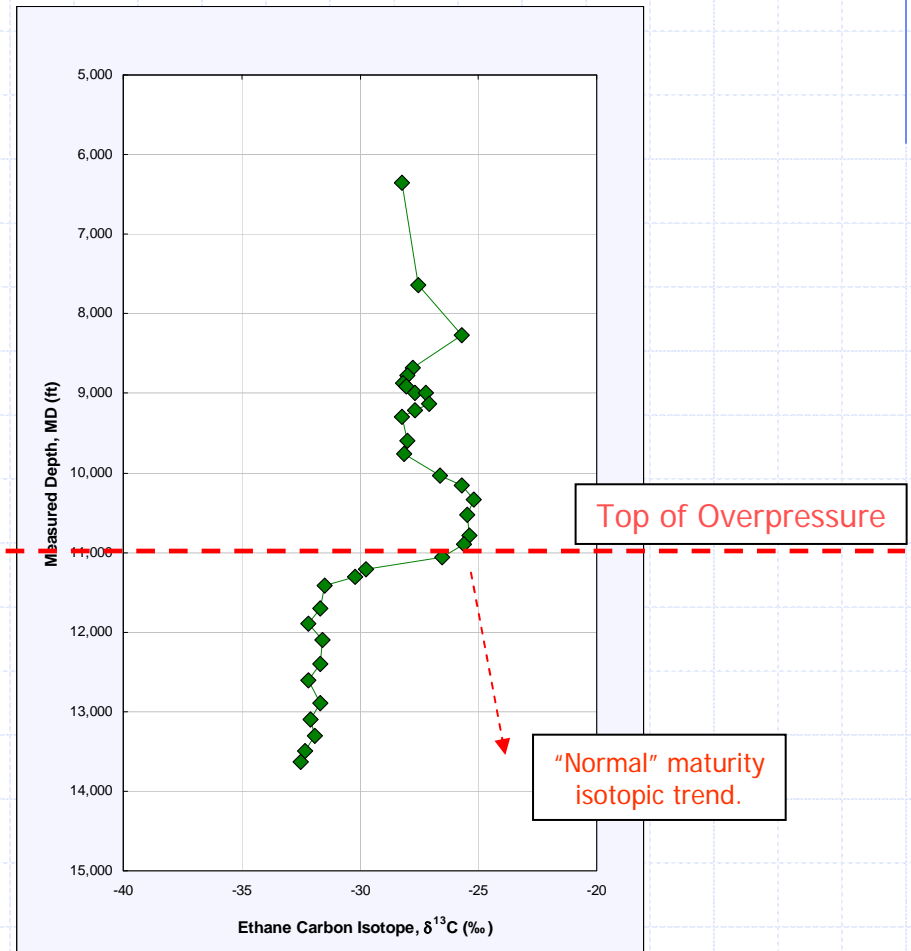
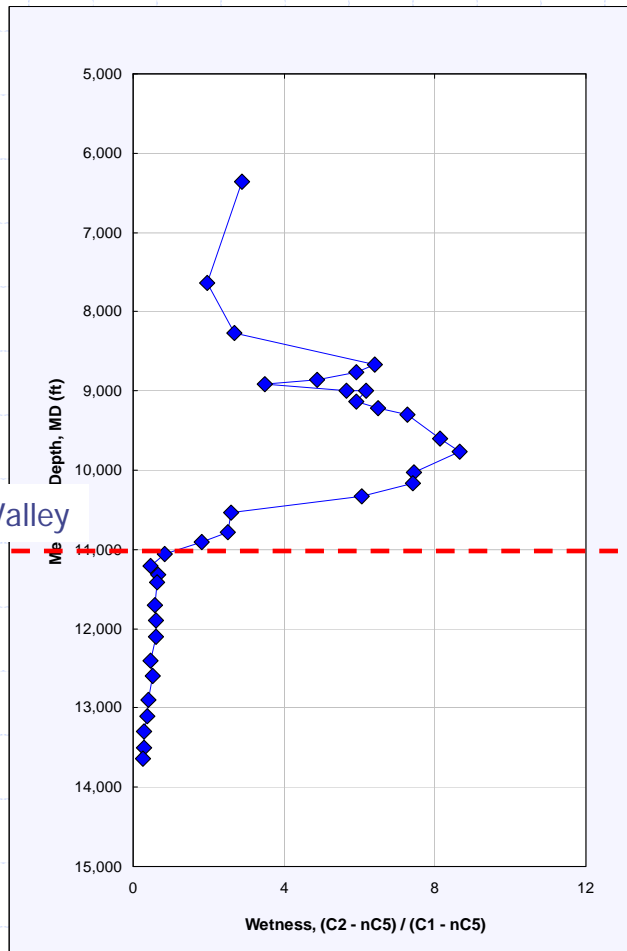


Haynesville vs. Barnett Production

- Early reports of Haynesville production rates are 2 to 3 times better than comparable Barnett wells.
- Similarities include...
 - Total Organic Carbon (TOC)
 - Source Maturity
 - “Rollover” Ethane and Propane Gas Isotopes
- A possible difference for Haynesville wells is the presence of significant over-pressure
- An Isotope “Reversal” in a Mud Gas Isotope log suggests little leakage from the Haynesville to shallower formations.
- Isotopic Reversal trend less pronounced in Barnett wells.



Mud Gas Ethane Isotope "Reversals" (Haynesville Example)



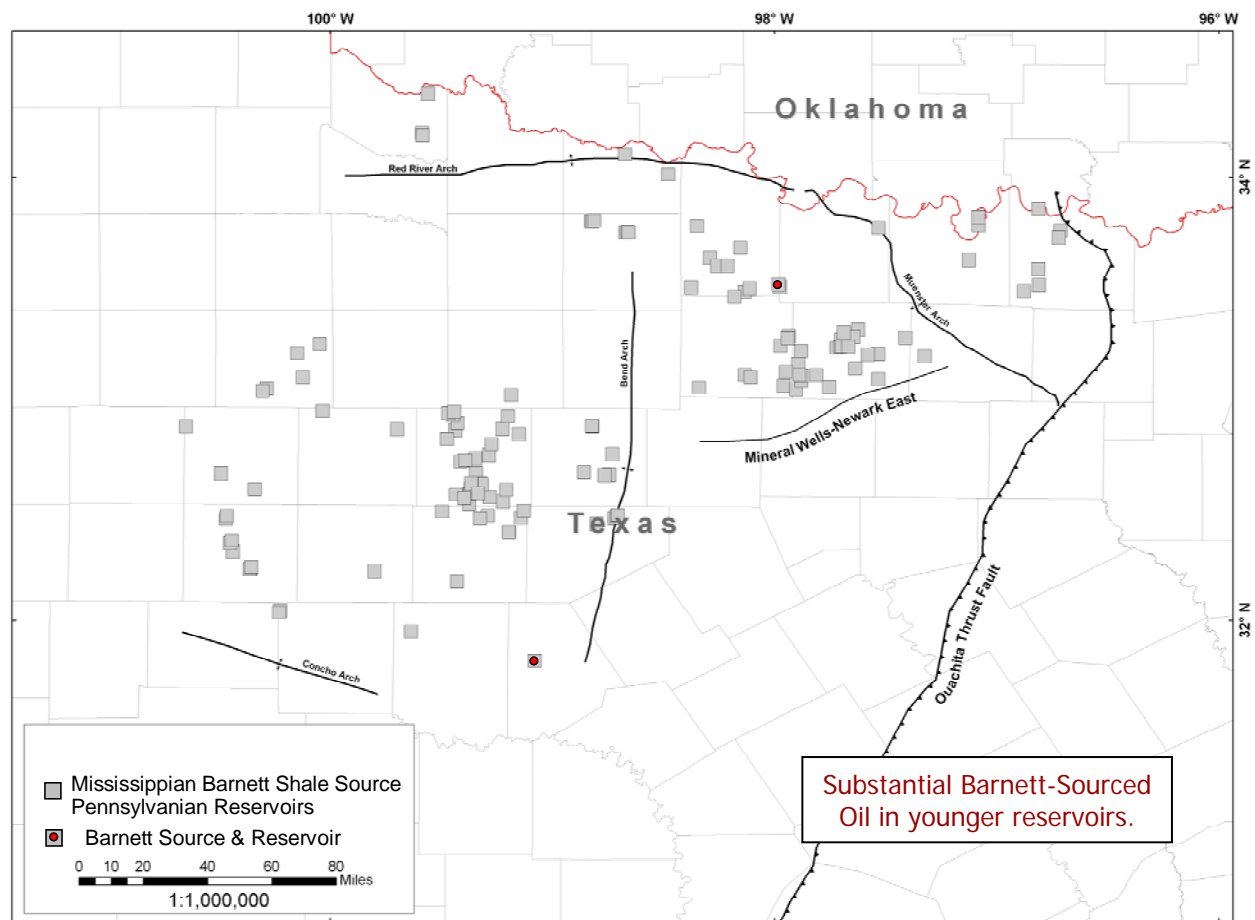
Bossier / Cotton Valley

Haynesville

Top of Overpressure

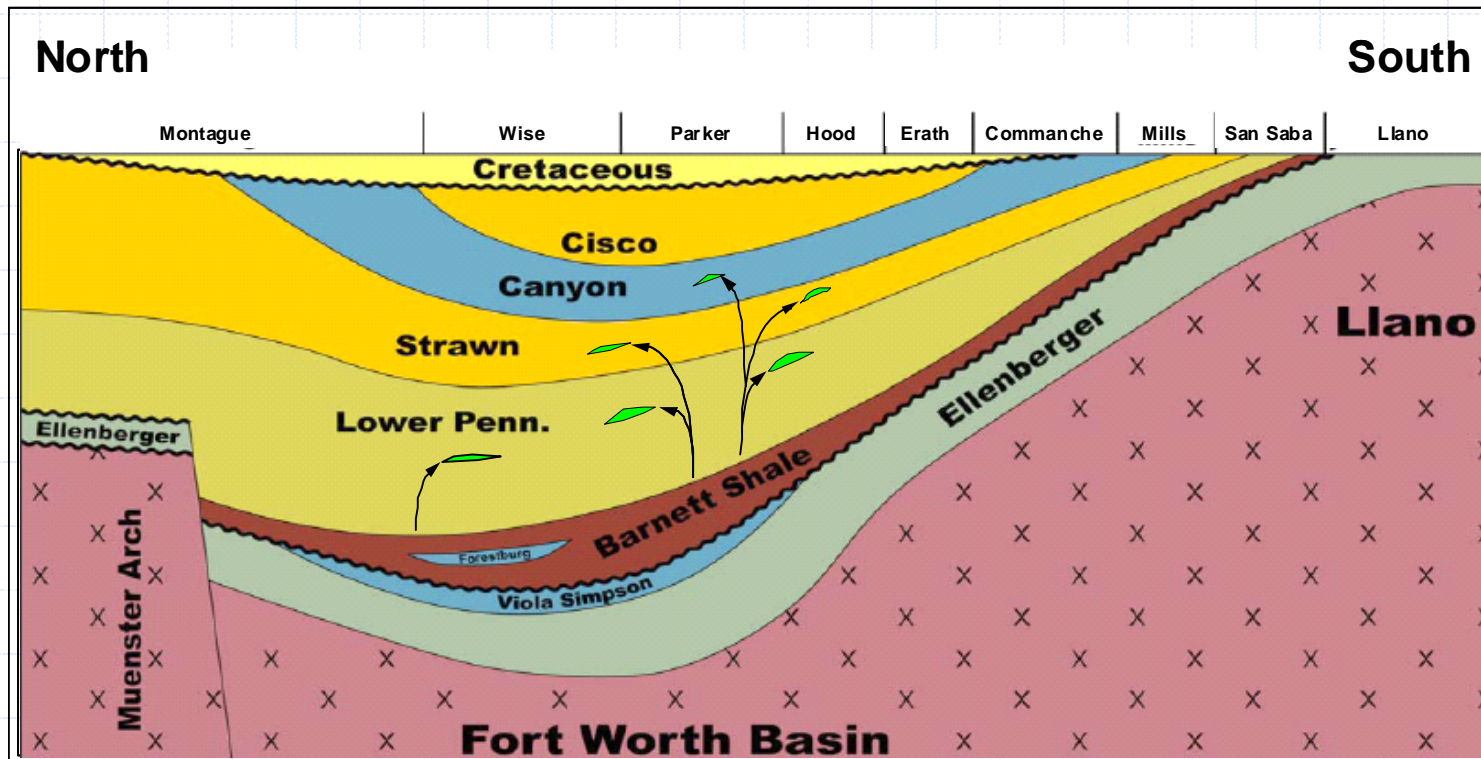
"Normal" maturity isotopic trend.

Barnett Shale Sourced Oils in Younger Reservoirs

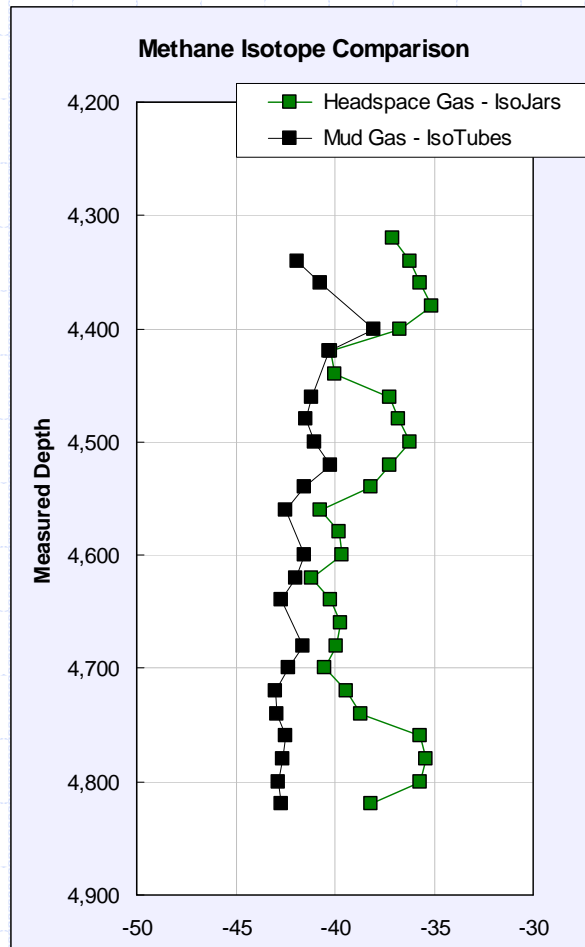


Barnett Shale Stratigraphy

Fort Worth Basin North South Cross Section



Shale Gas Analyses as Permeability Markers

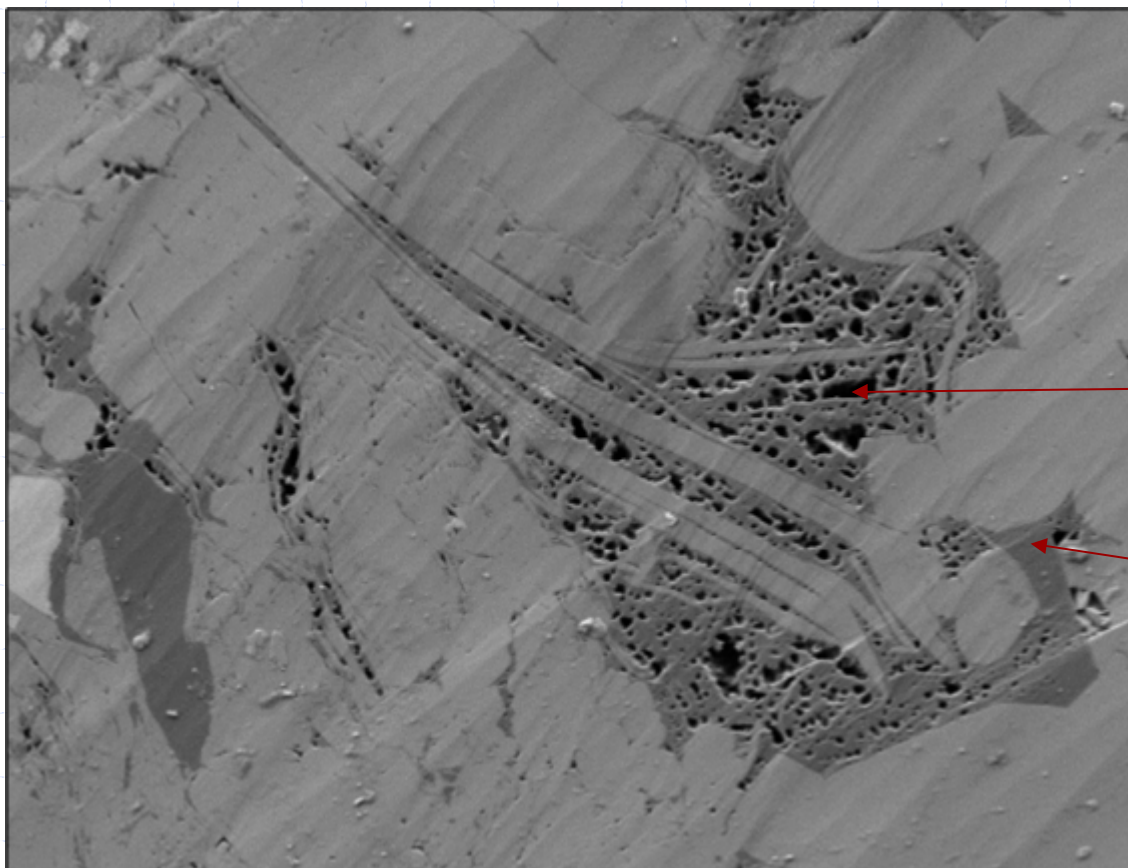


There is a clear isotopic difference between Methane from Mud Gases (black squares) and Headspace Gases (green squares).

- Mud Gas ~ Free / Solution / Lost Gas
- Headspace Gas ~ Adsorbed Gas

Larger differences between Isotube and Isojar isotopes correlate with increased Permeability.

Nanopores in Maturing Kerogen



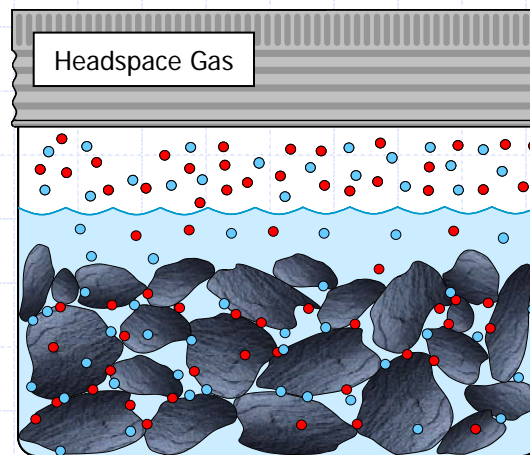
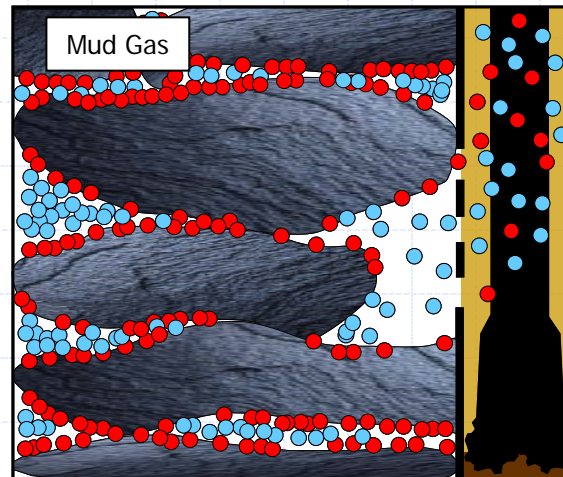
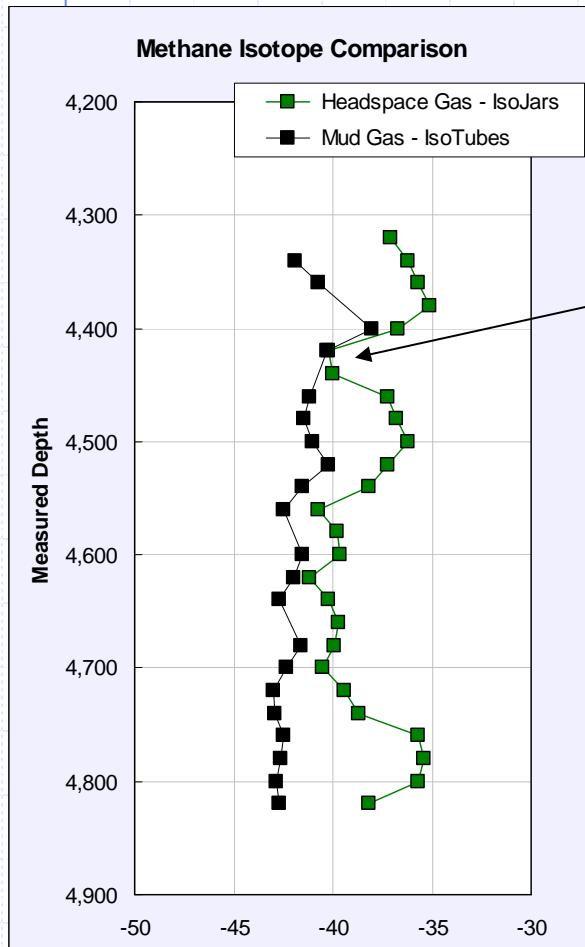
Nanopores

Darker Areas –
Higher TOC

- Reed et al. Texas BEG
- Presented by Bob Loucks, AAPG San Antonio 2008
- Submitted for publication 2008

~ 10 μm

Shale Gas Analyses as Permeability Markers

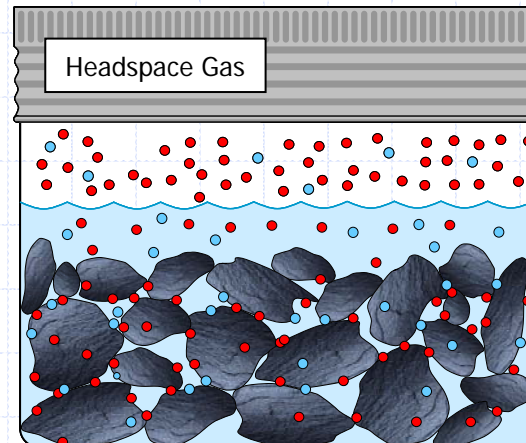
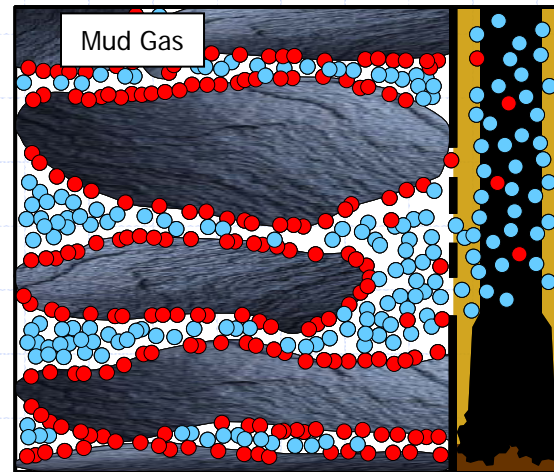
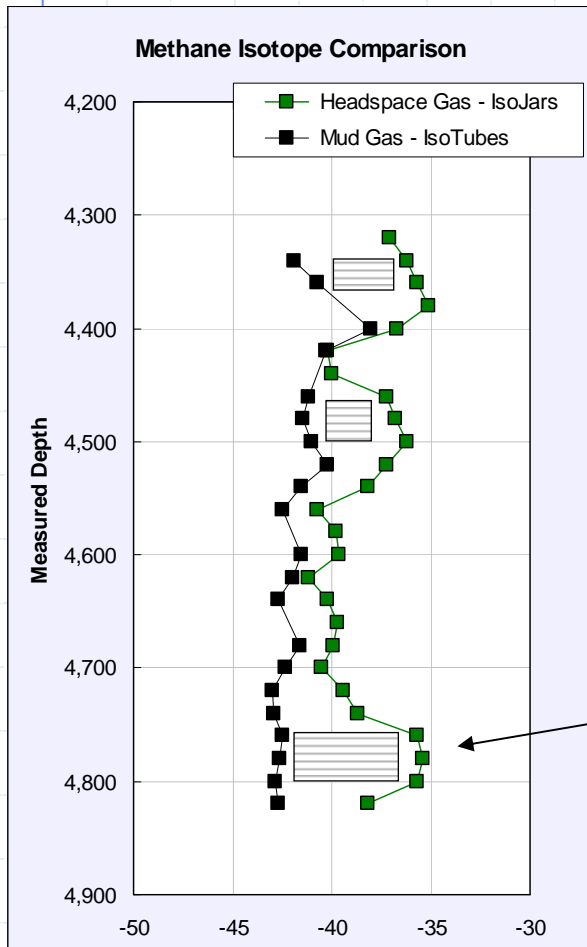


Poorer Permeability

Gas eventually evolving off cuttings has more free gas making Methane Isotopes more negative

- Free Gas – more negative isotopes
- Adsorbed Gas – more positive isotopes

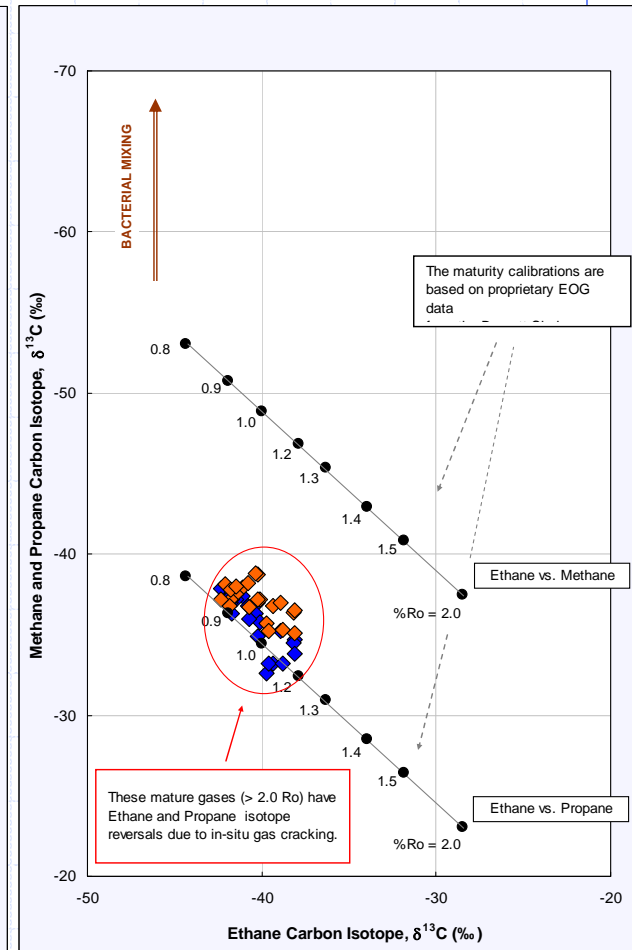
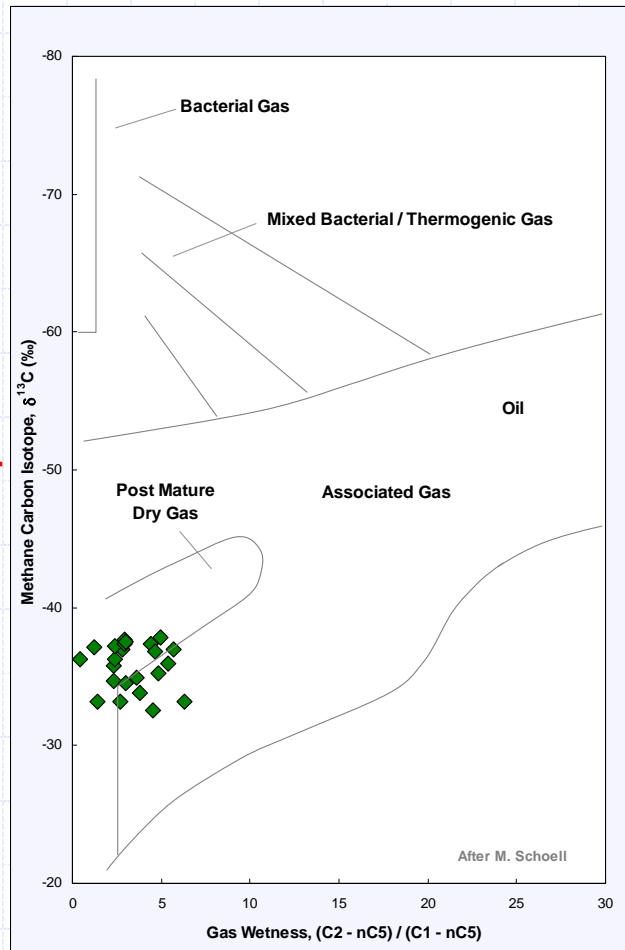
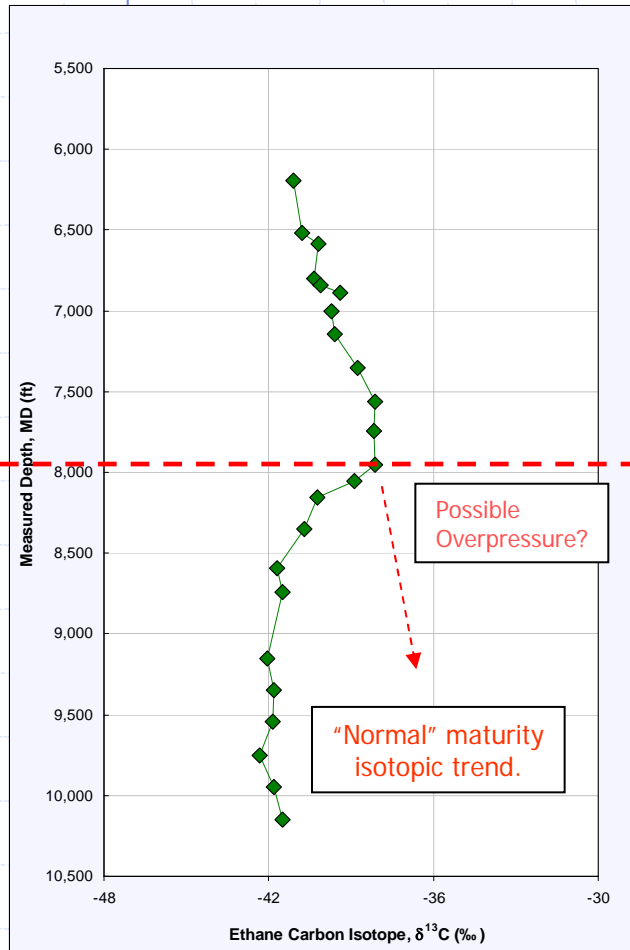
Shale Gas Analyses as Permeability Markers



Better Permeability
Gas eventually evolving off cuttings is mostly adsorbed gas

● Free Gas - more negative isotopes
● Adsorbed Gas - more positive isotopes

Marcellus Example (with Isotopic Reversal)



Conclusions

- Shale Gas well performance can be diagnosed with Mud and Headspace isotopic analyses
- Gas and Cuttings samples collected while drilling and quickly analyzed
 1. Ethane and Propane Isotope Rollover indicates in-situ gas cracking at high maturities. Increasing maturity and gas cracking creates additional nanopores within the kerogen.
 2. Ethane Isotope “Reversals” within a single well demonstrates overpressure / effective seals.
 3. Mud (Free) and Headspace (Adsorbed) gas signatures are used as Permeability / Fracturing Markers.
- Early Marcellus Shale examples look promising.