Mystery in the Mushwad: The Origin of Gas in the Big Canoe Creek Field, Saint Clair County, Alabama, USA*

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Abstract

The Big Canoe Creek Field produced gas from the Middle Cambrian Conasauga Formation. The production established in 2005 was hailed as an exciting new play in the oldest and most structurally complex formation in North America. By 2010 the field was abandoned having produced only 187 MMcf of dry gas from 13 wells out of a predicted recovery of 1 bcf. What happened to the other 800 MMcf? Is the issue with the rocks, the size of the resource, or the thermal maturity?

The Conasauga is a weak rock unit that contains the basal Appalachian Thrust detachment. It has been tectonically thickened as a result of this deformation into what is identified as the “Mushwad”, producing the multiple cycles of fracturing and cementation. Subsequent erosion has brought the Conasauga to the surface in the area of the field.

Conasauga cuttings are low in organic richness. However, thin zones were identified in core samples containing marginal-to-good organic richness. The Conasauga rocks and gases have equivalent thermal maturity within the dry-gas generation window, consistent with local generation of the hydrocarbons. Yield calculations suggest that thin moderately rich intervals were sufficient to charge the field. The kerogen porosity would be high; but total porosity would be minimal due to the low organic richness. Production from individual wells had relatively high initial rates, followed by an exponential decline to low values. The low predicted porosity is consistent with the low residual production after the fracture gas is recovered.

References Cited

Landis, C.R., and J.R. Castaño, 1995, Maturation and Bulk chemical Properties of a Suite of Solid Hydrocarbons: Organic Chemistry, v. 22/1, p. 137-149.

Schoell, M., 1983, Genetic Characterization of Natural Gas: AAPG Bulletin, v. 67/12, p. 2225-2238.

Thomas, W.A., 2001, Mushwad: Ductile Duplex in the Appalachian Thrust Belt in Alabama: AAPG Bulletin, v. 85/10, p. 1847-1869.

Thomas, W.A., and G. Bayona, 2005, The Appalachian Thrust Belt in Alabama and Georgia: Thrust-Belt Structure, Basement Structure, and Palinspastic Reconstruction: Alabama Geological Survey Monograph 16, 48 p.

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History [Recall gas boom]

- First well Amoco-Arco Young 34-2#1 1984 flow ~1 MMcf/d
- Discovery Dominion BWB Inc. Dawson 34-03-01 March 2005 [$6.50/MMBtu]
- Highmount (Lowes) acquired Dominion holdings 2007 [$7.60/MMBtu]
- Energen operator of Big Canoe Creek Field, Wrote off acreage 2010 [June, 2010; $4.60 MMBtu]

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MUSHWADD

Malleable

Unctuous

SHale

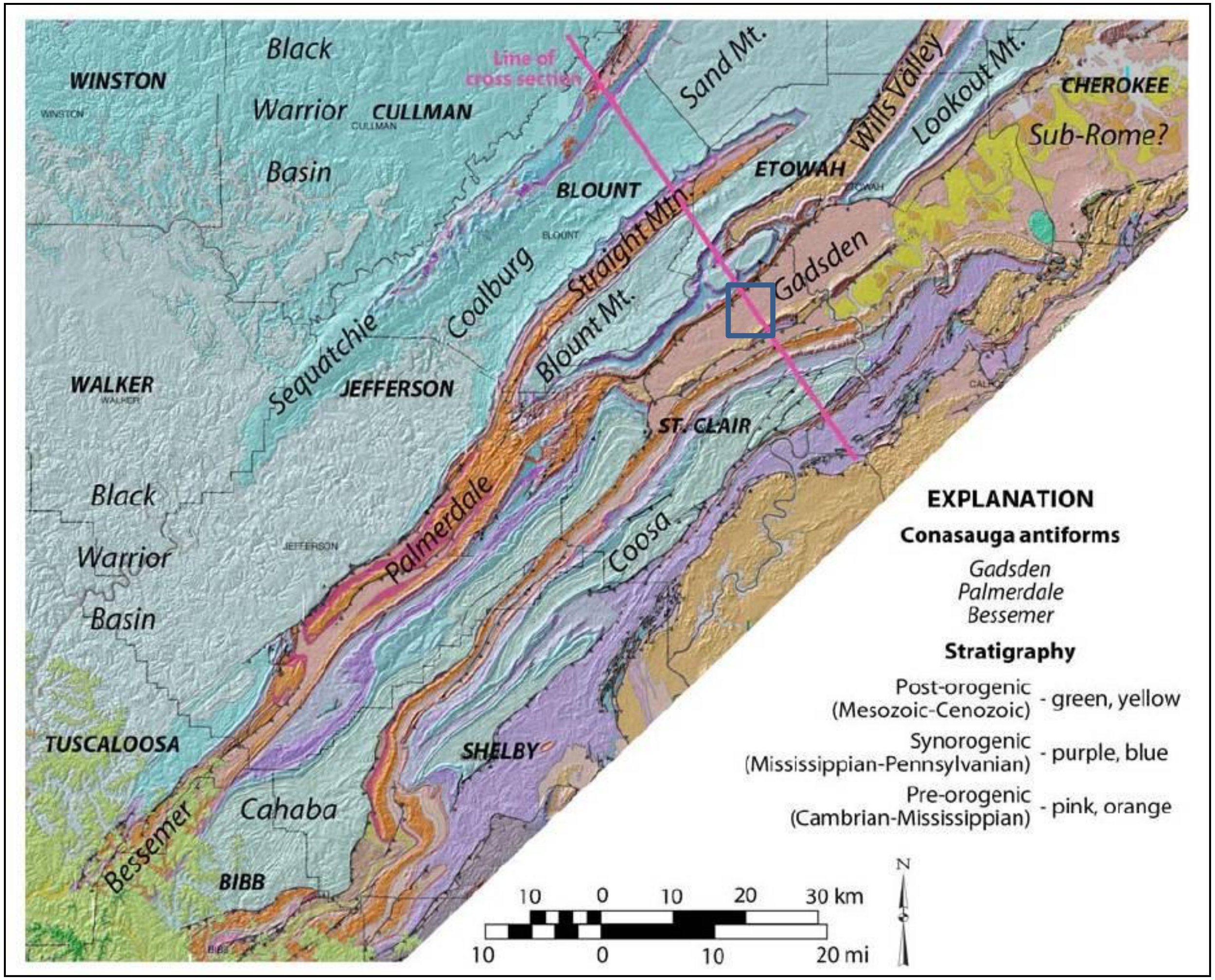
Weak-layer

Accretion in a

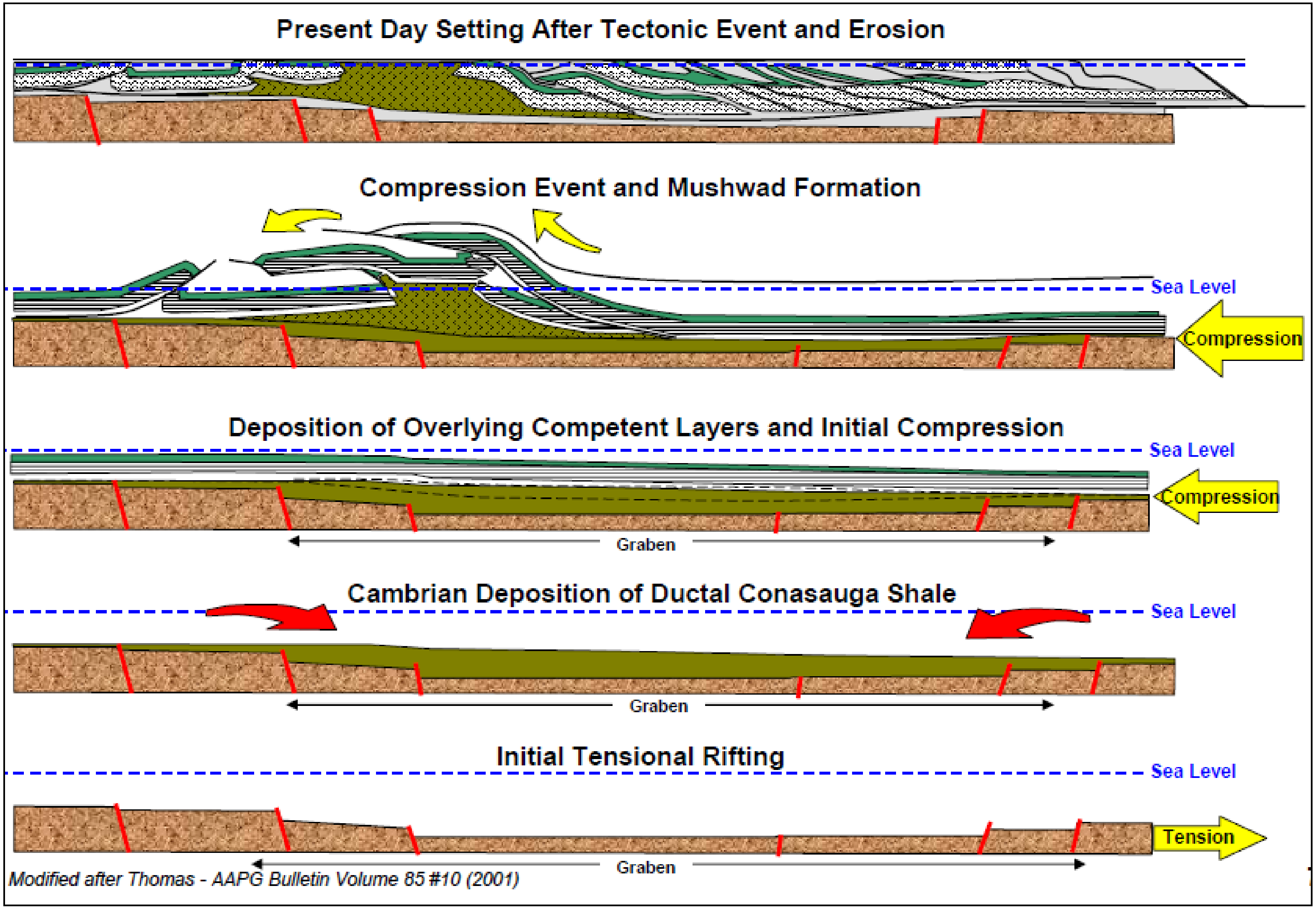
Ductile

Duplex

(Thomas, AAPG 2001)



Mushwad



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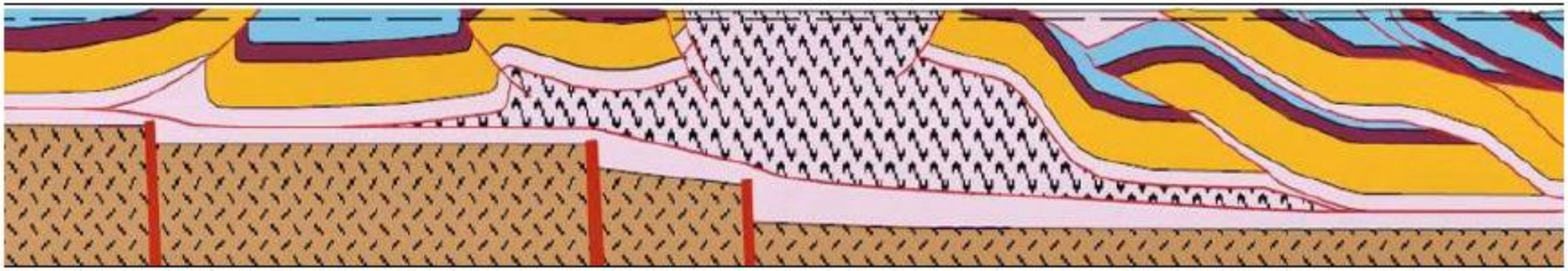
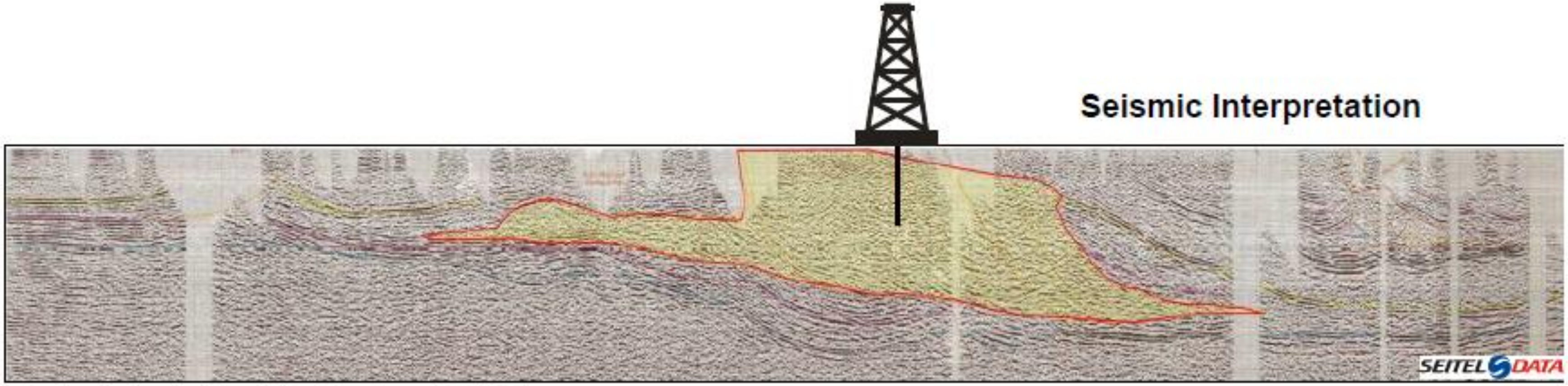
Geological Model



Geological Survey of Alabama, Monograph 16 (2005)

Seismic Interpretation



Regional seismic data published courtesy of Seitel, Inc.

Energen, Alabama Shales, 2008

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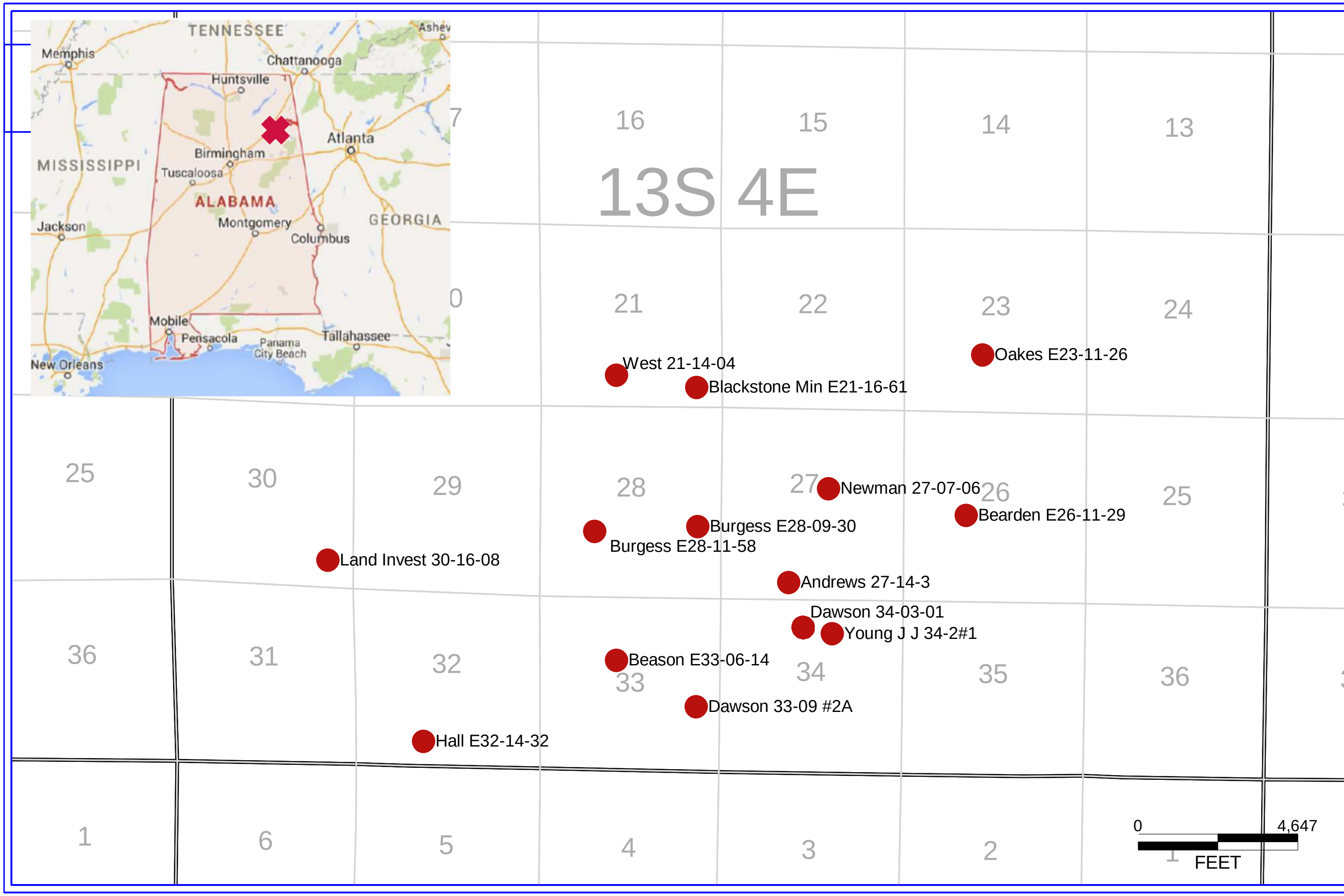
Big Canoe Creek Field



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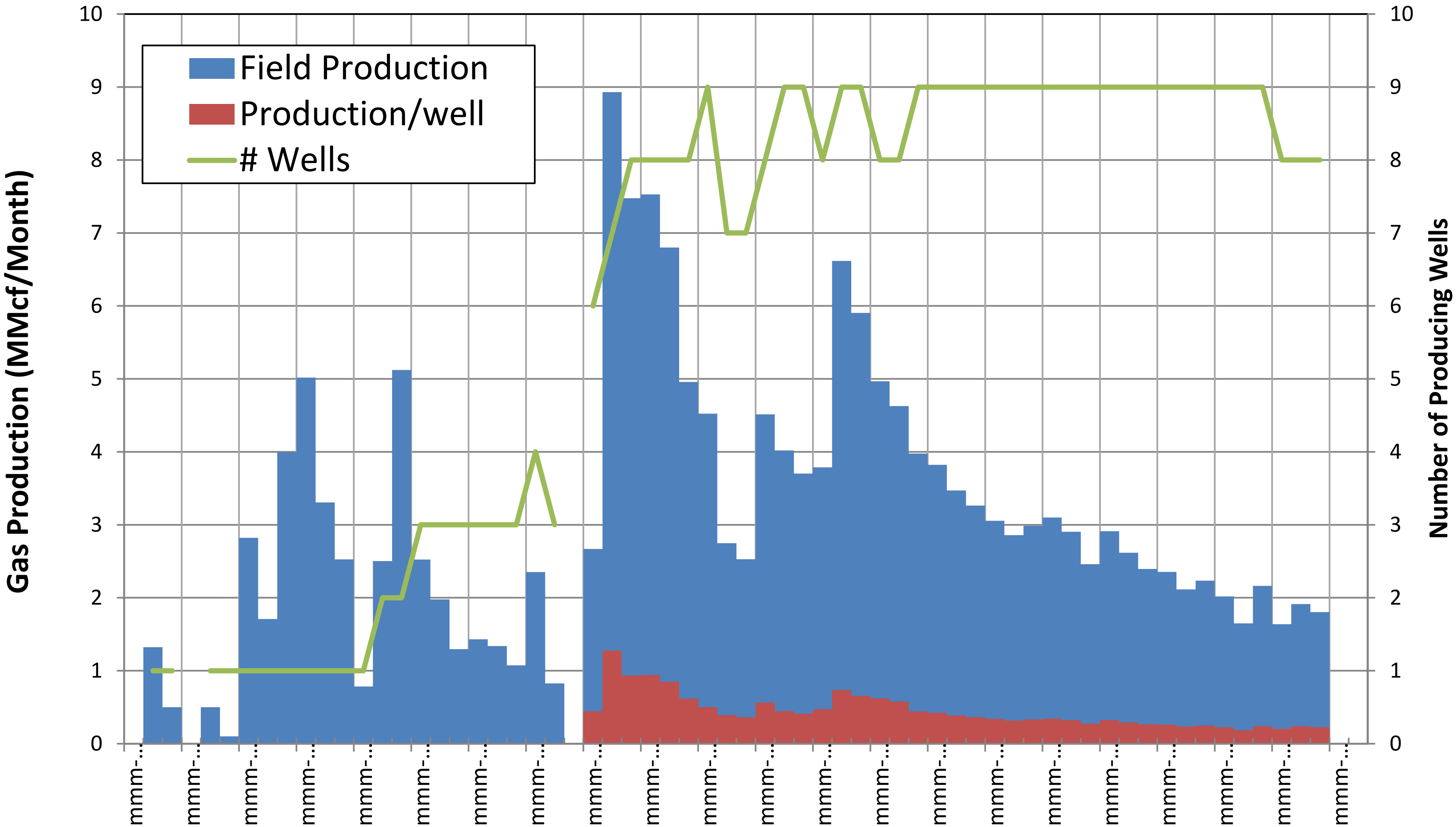
Field Production History



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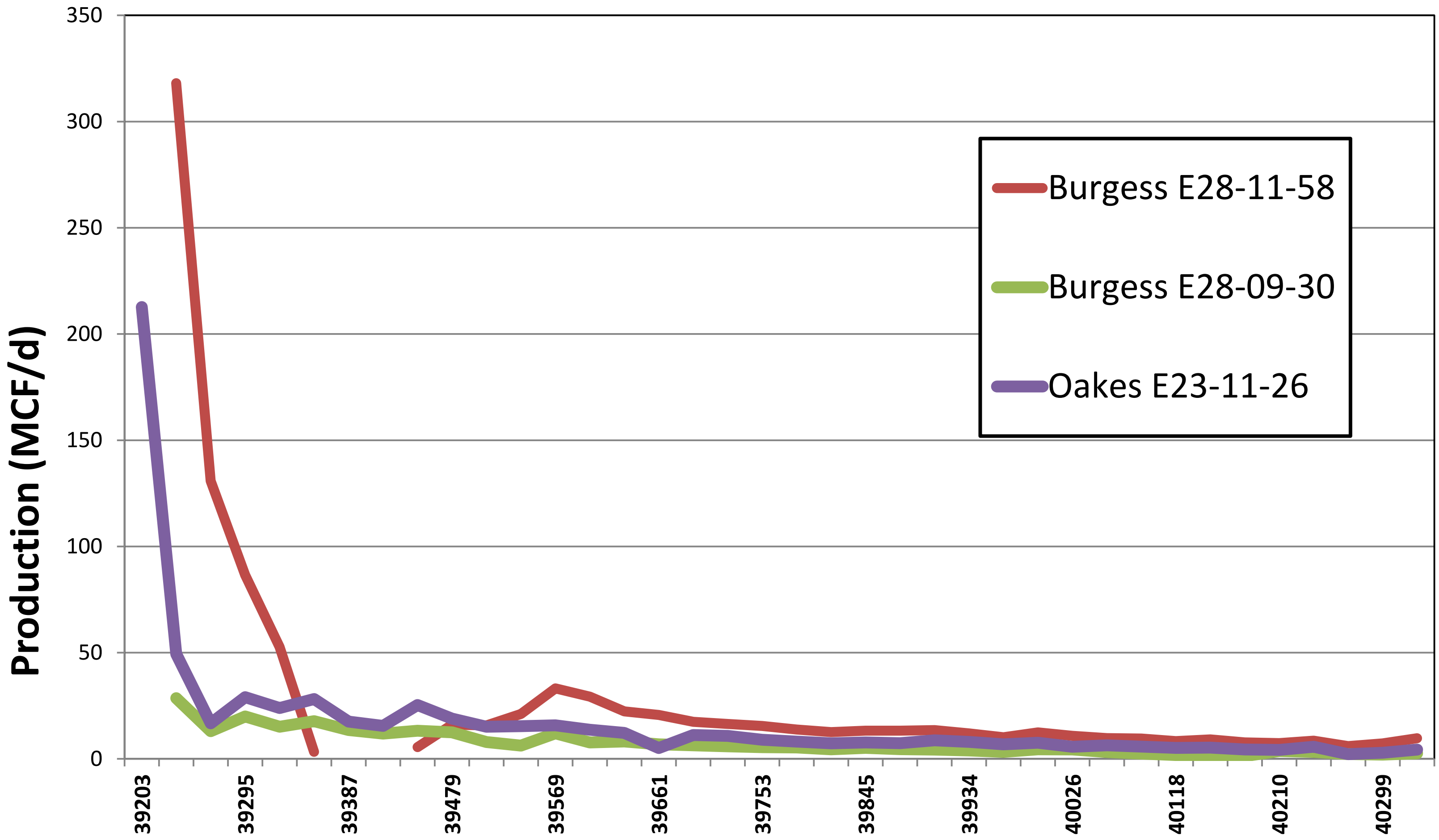
Average Daily Production by Well



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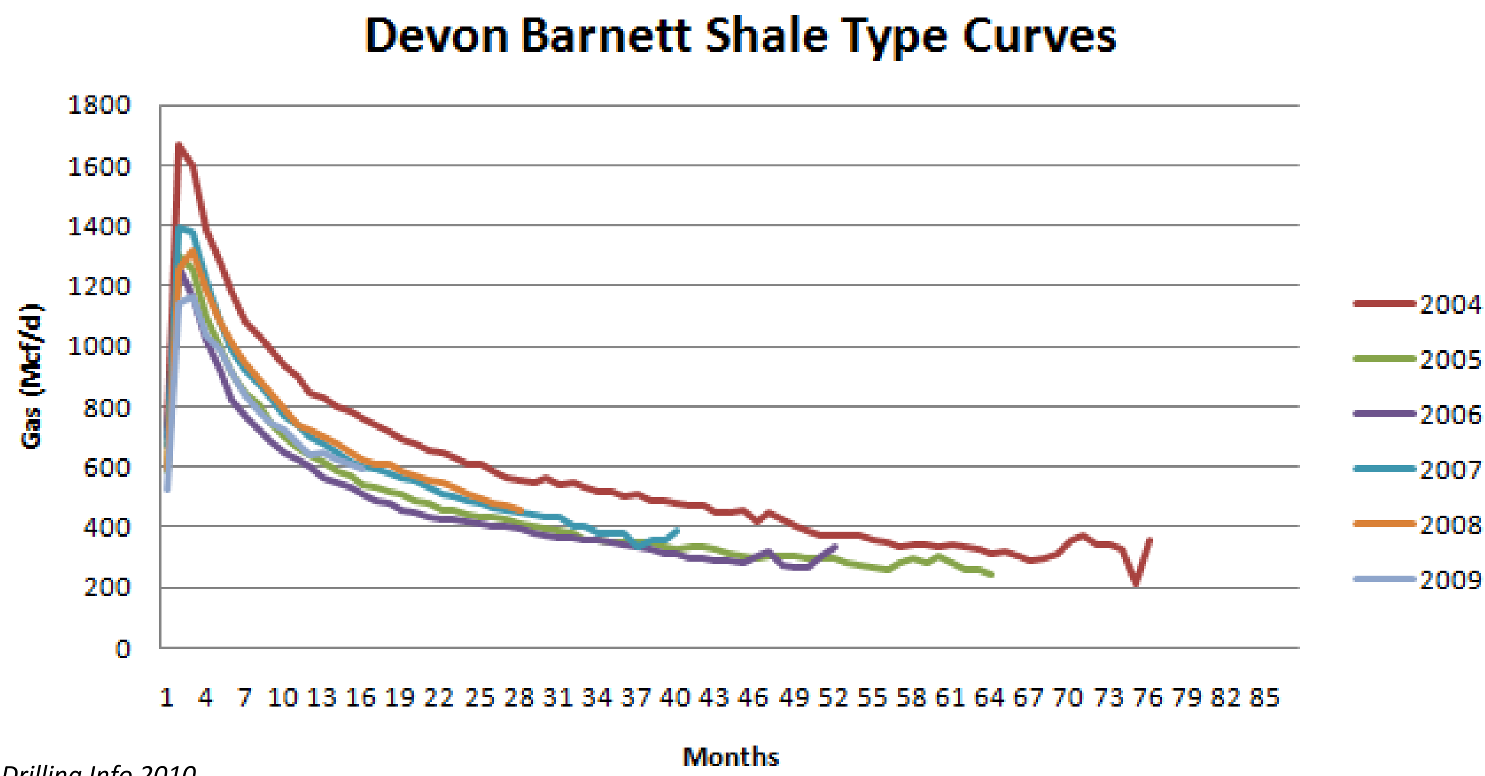
Other Decline Curves



Drilling Info 2010

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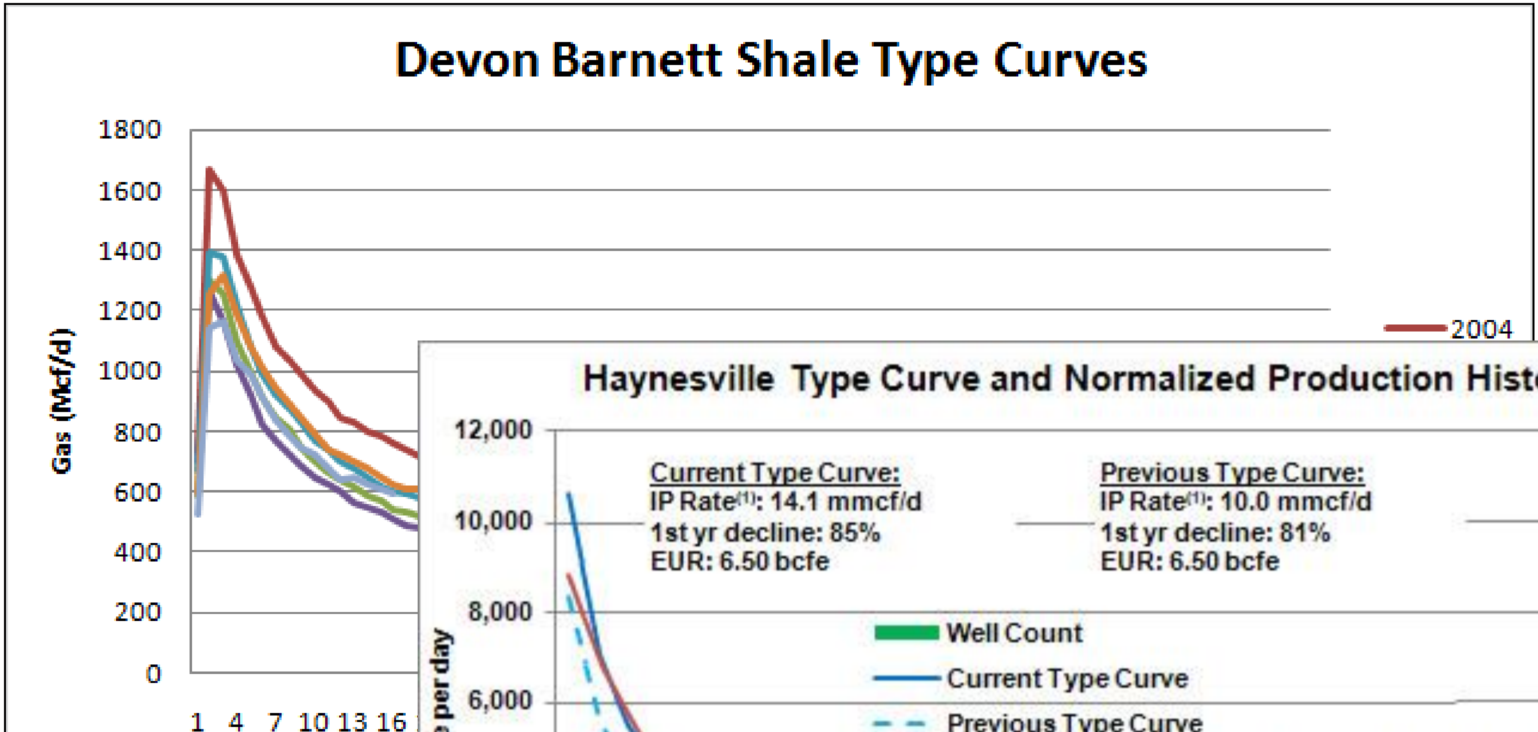
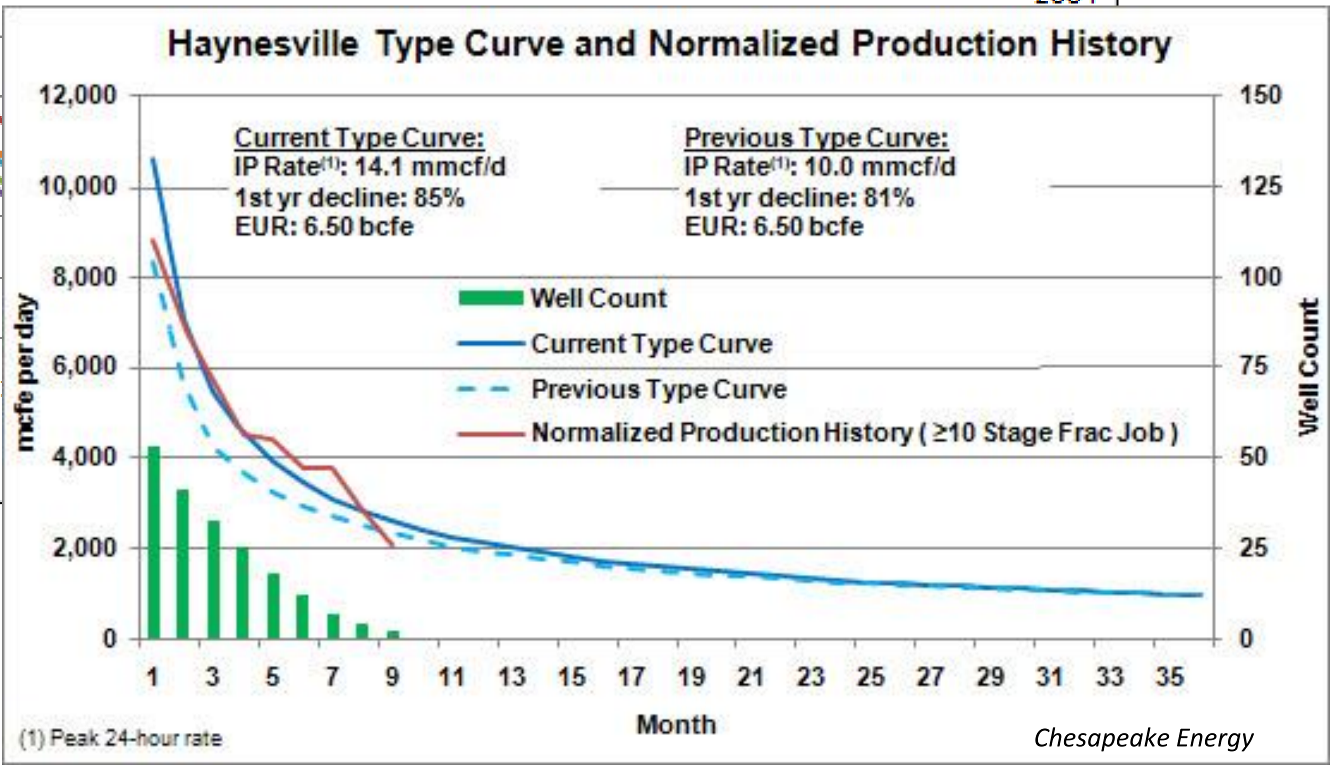
Chesapeake Energy

Other Decline Curves



Drilling Info 2010



Chesapeake Energy

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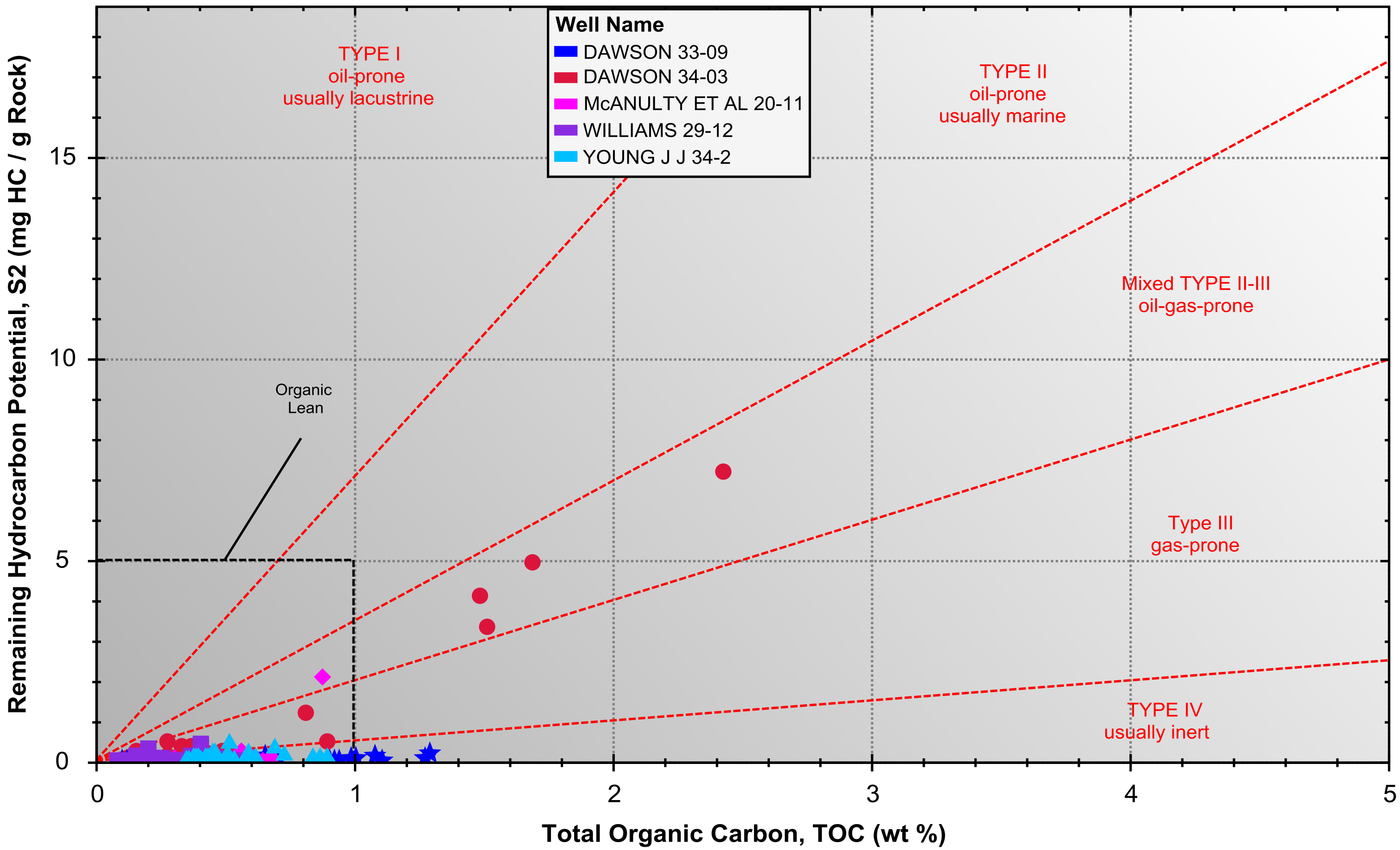
Unconventional Requirements

- Adequate organic richness (volume)
- Appropriate organic matter type (type)
- Sufficient thermal maturity, but not too extreme
- Producible hydrocarbons
- Retention of hydrocarbons (limited migration)

Kerogen Quality Plot



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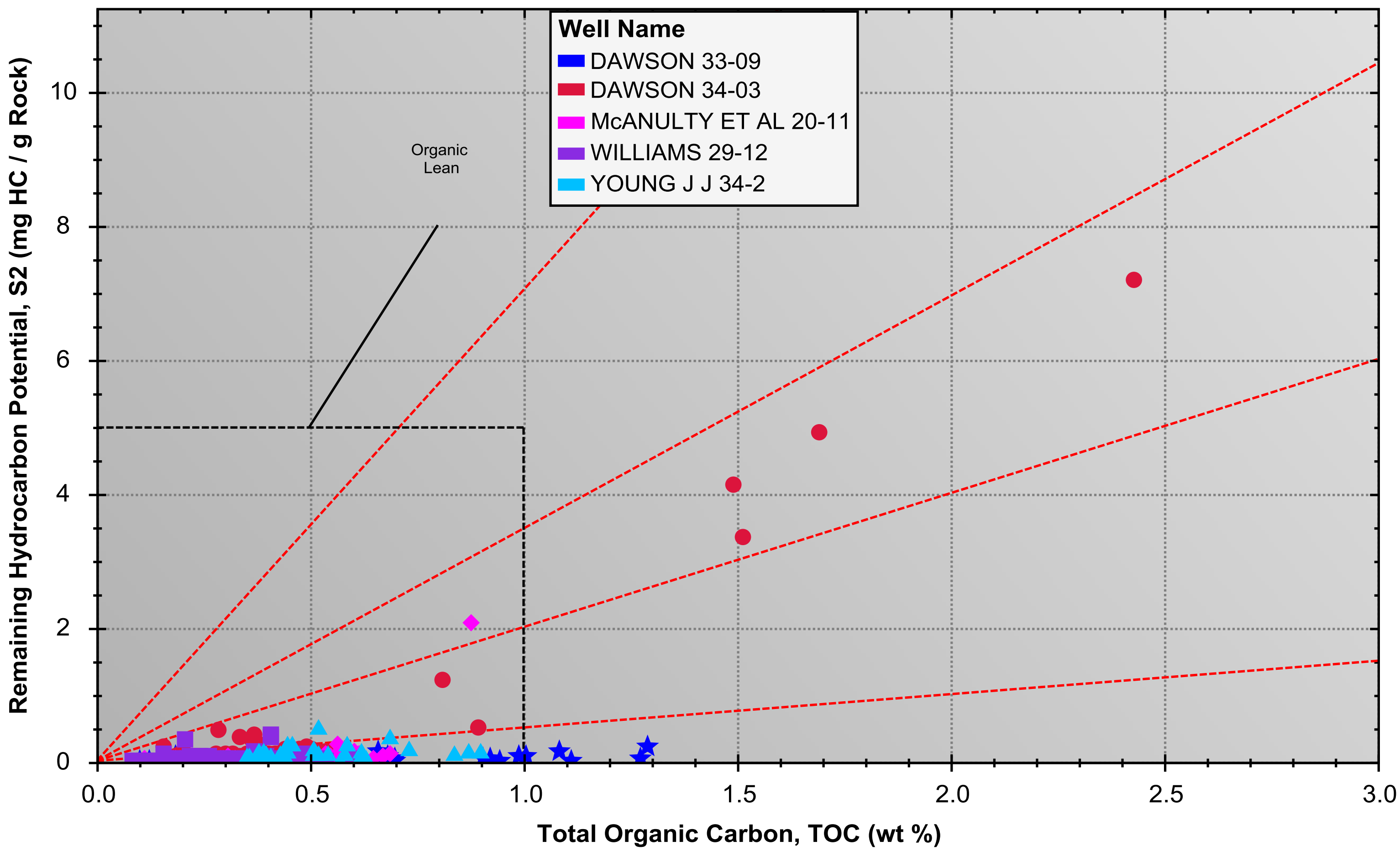
Kerogen Quality Plot



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Thermal Maturity

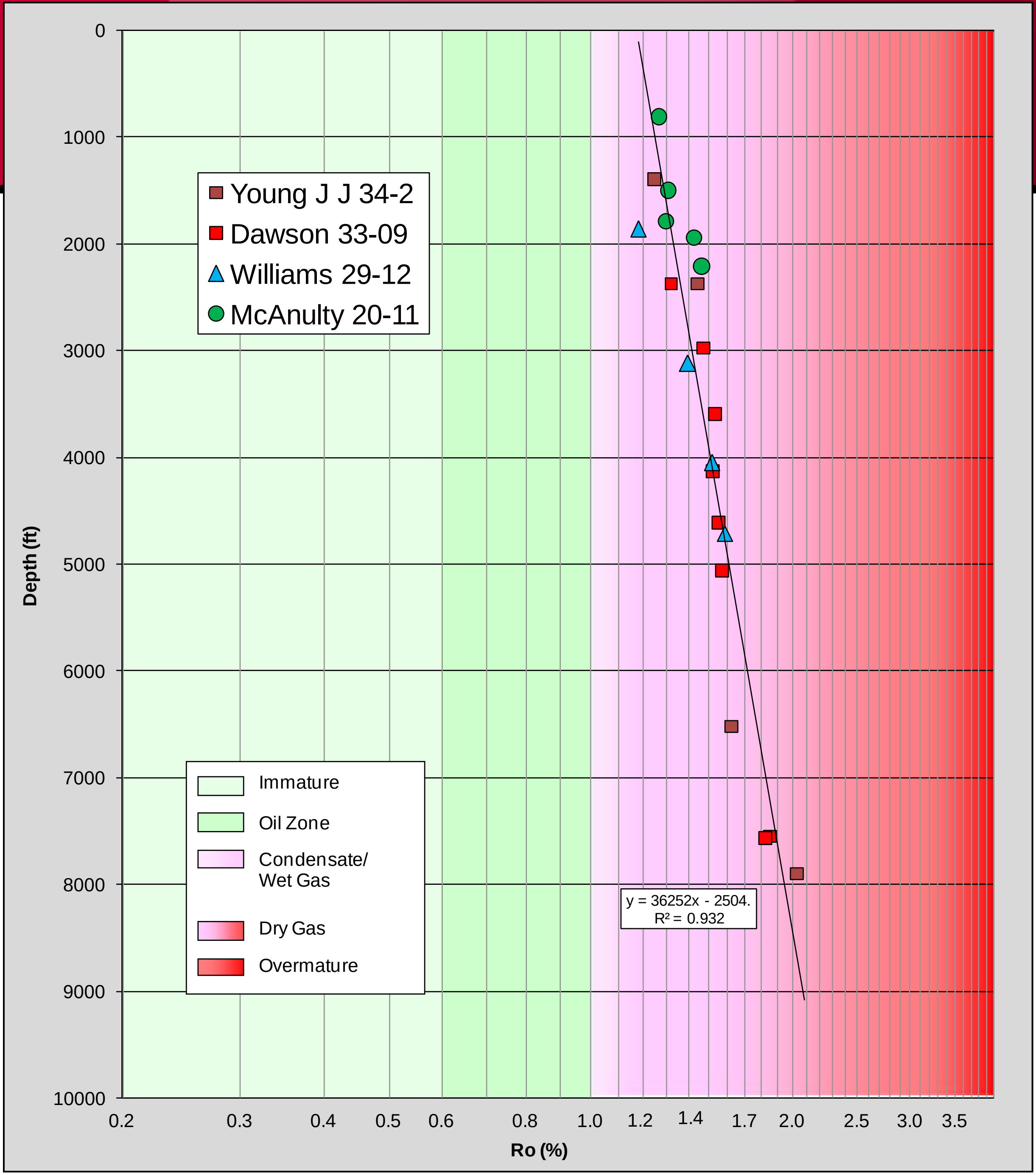
Measurements made on solid organic matter and converted to vitrinite reflectance using Landis & Castaño, 1994.

Several wells plot along the same depth trend → similar thermal history

All in gas window from 2000 ft and deeper; reaching 2% at 8000 ft

Local area has sufficient thermal maturity to have generated fairly dry gas.

Suggests ~28,000 ft of erosion since maximum thermal stress



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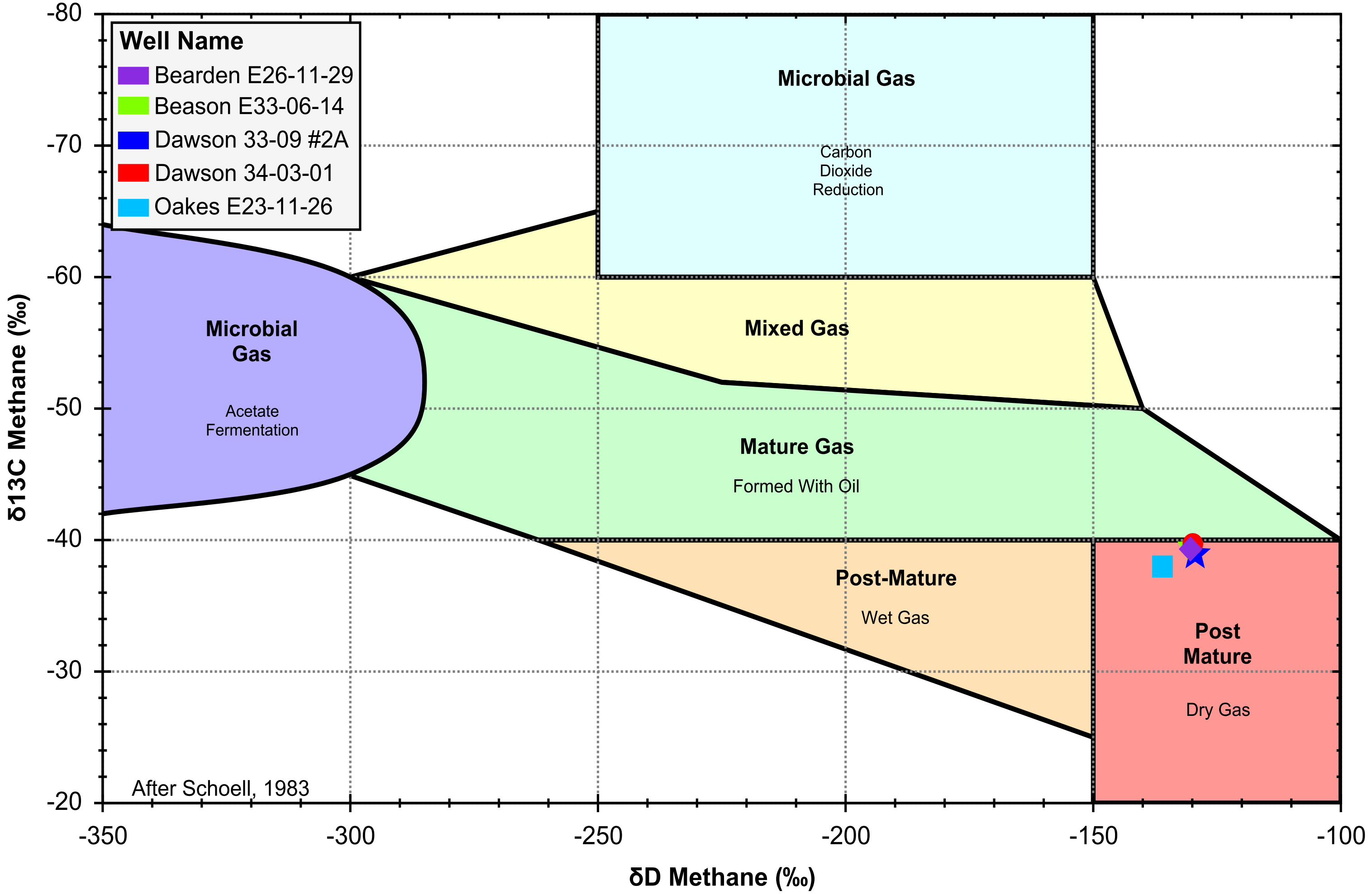
Natural Gas Geochemistry



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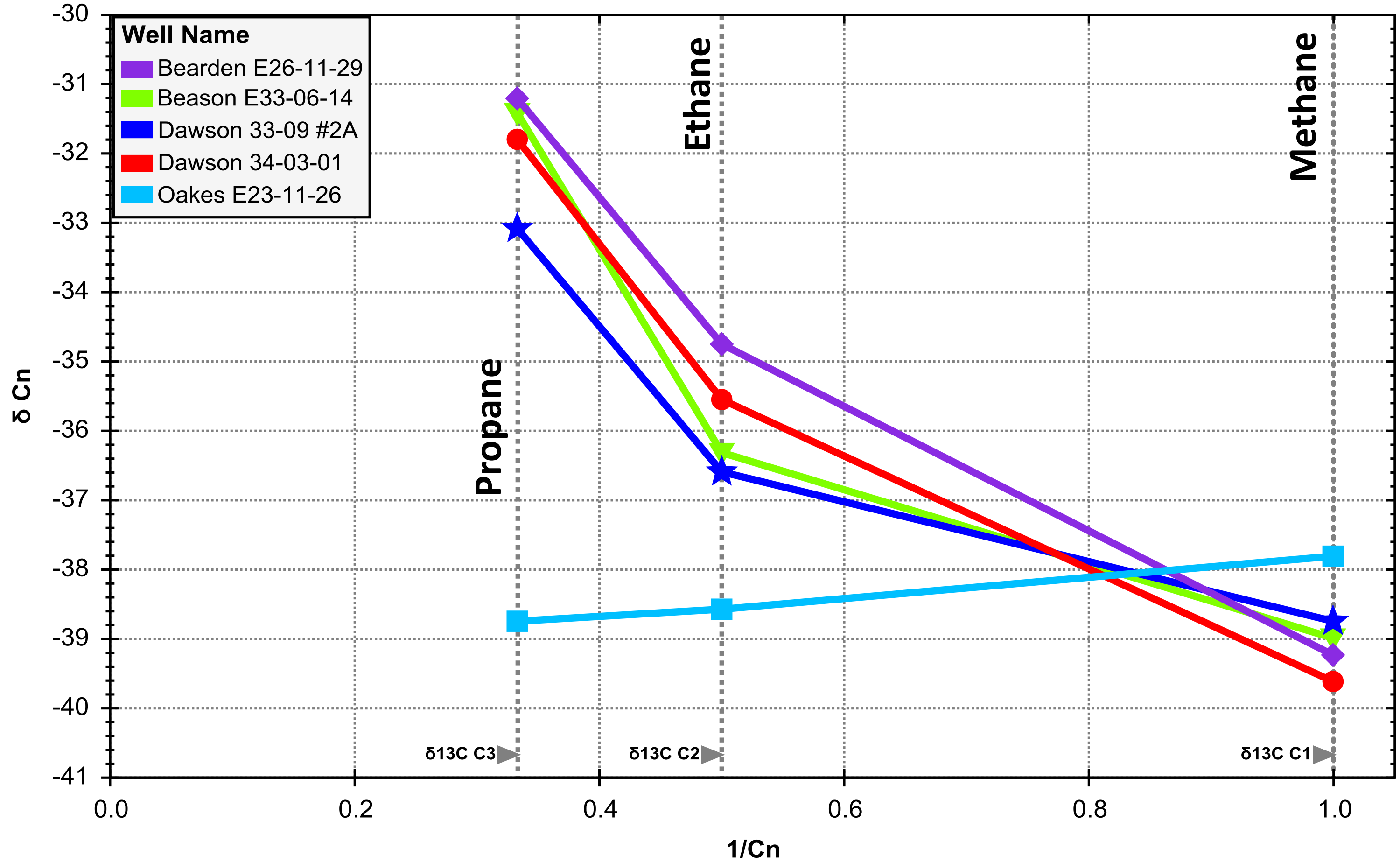
Natural Gas Geochemistry



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Geochemistry Implications

1. Source rock richness for most samples is < 1% TOC
   Does not meet threshold for commercial play
1. Limited intervals of adequate richness in core samples
2. Thermal maturity is within ideal range for natural gas generation and preservation
3. Natural gas maturity and composition is consistent with the local rocks

Geochemistry Implications

1. Source rock richness for most samples is < 1% TOC
   Does not meet threshold for commercial play
2. Limited intervals of adequate richness in core samples
3. Thermal maturity is within ideal range for natural gas generation and preservation
4. Natural gas maturity and composition is consistent with the local rocks
5. Why is there a field??? "Mystery"

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Why should anyone care?

Because

- Exploration target in the Rogersville Shale (Conasauga Group) in Rome Trough Kentucky, West Virginia, Pennsylvania
- Mixed reports on few test wells

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Examine Data Again-Yield Calculations

- Best core samples from Dawson 30-09#2A at 1.9% Ro equivalent
- Gas generated (theory) → **552 Mcf/a-ft**
- Aggregate core ~ 1 ft → **0.35 bcf/mi^2** Only ⅓ previous estimates
- Retention of gas 15% to 25% other plays
- Retention factor of 5% → 80 MMcf gas available per well in the Big Canoe Creek Field.
- At 1% retention factor → only 16 MMcf gas/well
- Dawson 34-03-01 well had the largest cumulative production at 50 MMcf of gas, closer to the 5% retention factor.
- Only seven of the thirteen field wells produced over 10 MMcf

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Model for Mystery 1

- The maximum thermal stress occurred during stacking of the "mushwad"
- Subsequent erosion has brought the Conasauga to the near surface
- The Big Canoe Creek Field gases and Conasauga sediments have equivalent thermal maturity, consistent with local generation
- Although organic richness in the Conasauga cuttings is low, the core from the Dawson 33-09#2A well has thin intervals of modest (~1% TOC) richness.

Model for Mystery 2

- Yield calculations suggest that the thin intervals are sufficient to charge Big Canoe Creek wells using a retention factor of 1%
- The kerogen porosity of the Conasauga is probably high but limited organic matter
- Production from factures → high initial flow rates followed by very low flow from micro-porosity.
- As a consequence of the complex history:
  - A source for gas outside the Conasauga is unlikely,
  - the low retention factors assigned are reasonable.

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Implications for other Conasauga Plays Contrast to Big Canoe Creek

- Need high, sustained organic richness
- Production in Marcellus up to 3.5% + Ro (CAI up to 5)
- Reversals in carbon isotope do not limit commercial production
- Gas retention factor –
  - preservation of organic and/or natural porosity a concern at high thermal maturity
  - **Areas of high tectonic disturbance may have enhanced migration pathways and low retention**

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Acknowledgements

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- Contact: Dick.drozd@weatherfordlabs.com