Maturity and Organofacies Assessment of Bakken Shale: Implications for New Areas for Exploration and Production©

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- Mike Johnson
- Julie LeFever
- USGS
  - Leigh Price
  - Rich Pollastro
  - Mike Lewan
  - Ron Hill (Marathon)
- and...

A toast to Fred Meissner:
Meissner Cider 1988

Talk Outline

- Introduction
- Geological background
- Geochemical Results
- Hypothesis on generation and alteration processes
- Conclusions

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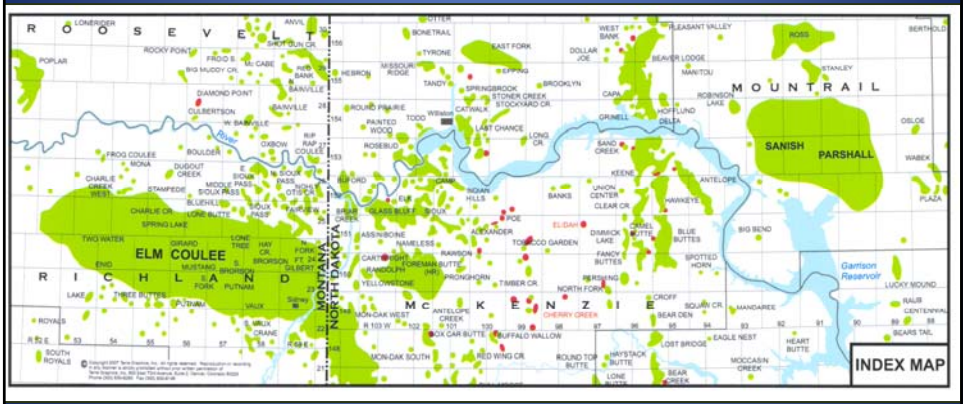
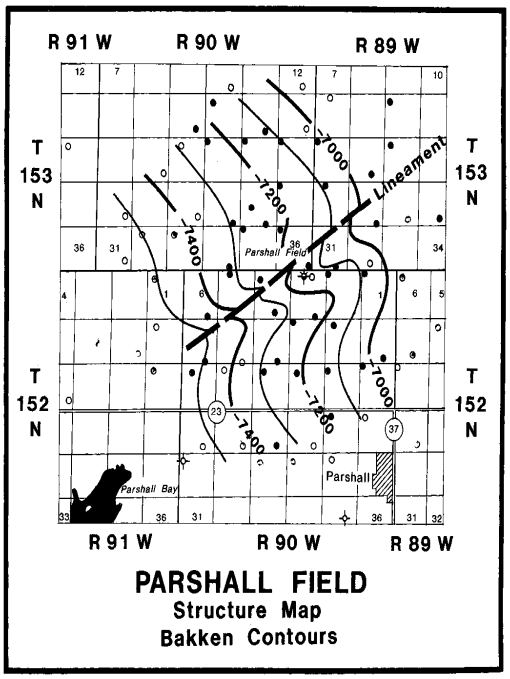
Areas of Current Activity Williston Basin





PRODUCTION DATA-NDIC

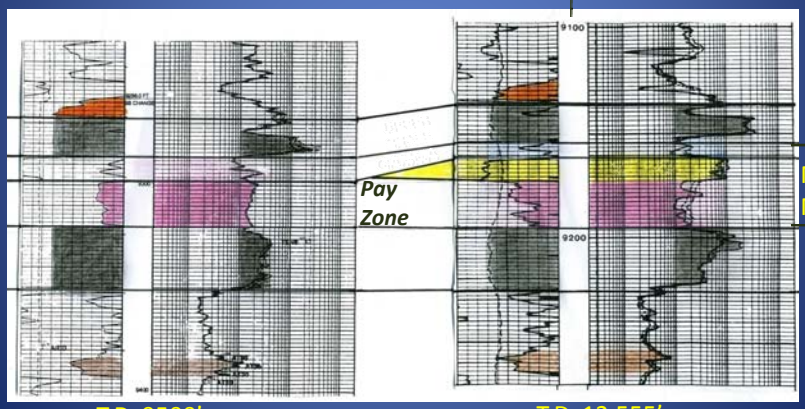
Well Name	Cum. BO	March 08'	Months
• Bartelson 1-3H	192,188	7154	17
• Warberg 1-25H	162,698	10,965	15
• Patten 1-02H	169,945	13,044	13
• Ehlert 1-35H	179,788	11,770	12
• Geving 1-09H	90,838	9,150	8
• Herbert 1-26H	93,947	16,254	4

Payout- Less than one year

CROSS SECTION: Parshall Field

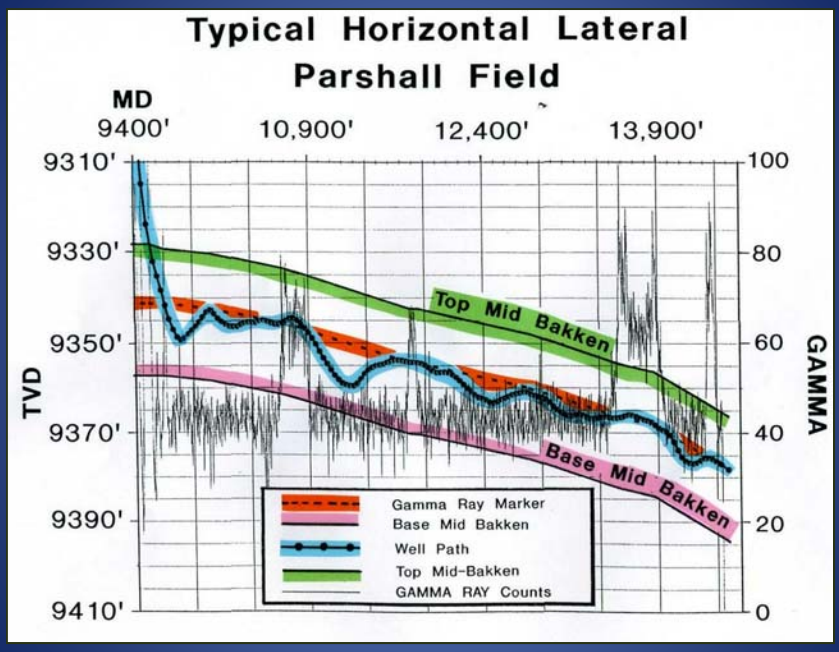
EOG #2 Parshall
36-T153N-R90W
NWNW

Lear #1 Parshall
3-T152N-R90W
NENW



T.D. 9500'

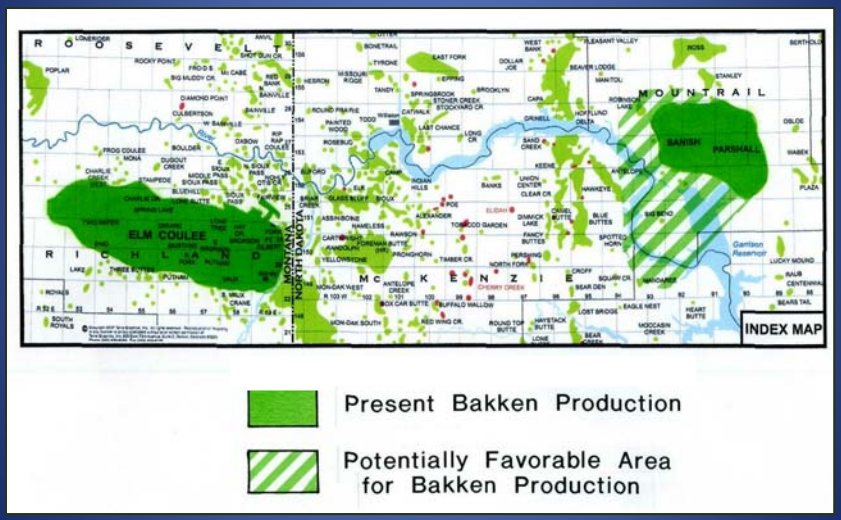
T.D. 12,555'



MAJOR TRAP COMPONENTS- PARSHALL FIELD

- Periodic wrench-type faulting, mostly right-lateral
- Fracturing caused by overpressuring of the black shales
- Dolomite is the preferred carbonate facies
- Trap lying near the edge of the mature-immature hydrocarbon generation boundary
- A new type trap for the Bakken and perhaps many other "overlooked" lower maturity areas in other basins

Next !



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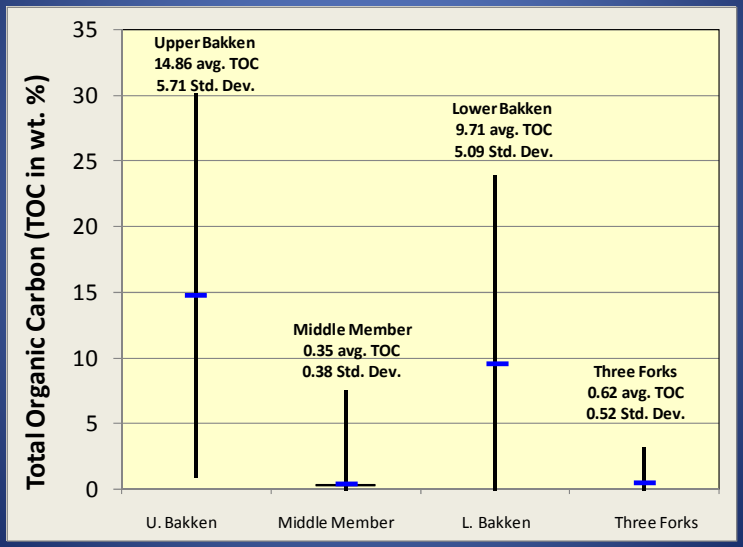
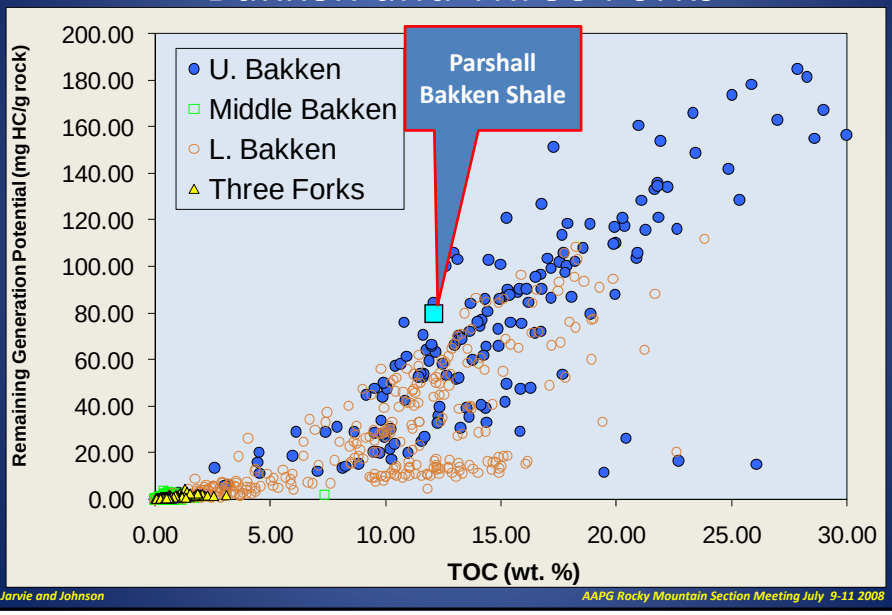
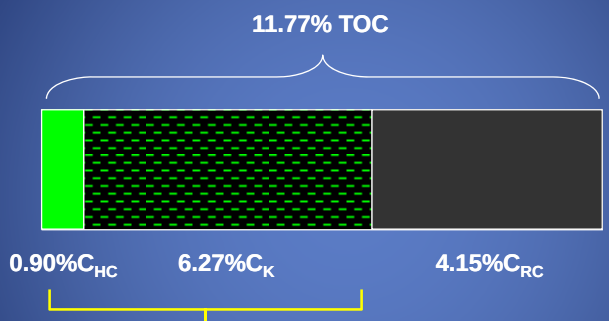
Average TOC Values with standard deviations



TOC and Generation Potentials
Bakken and Three Forks



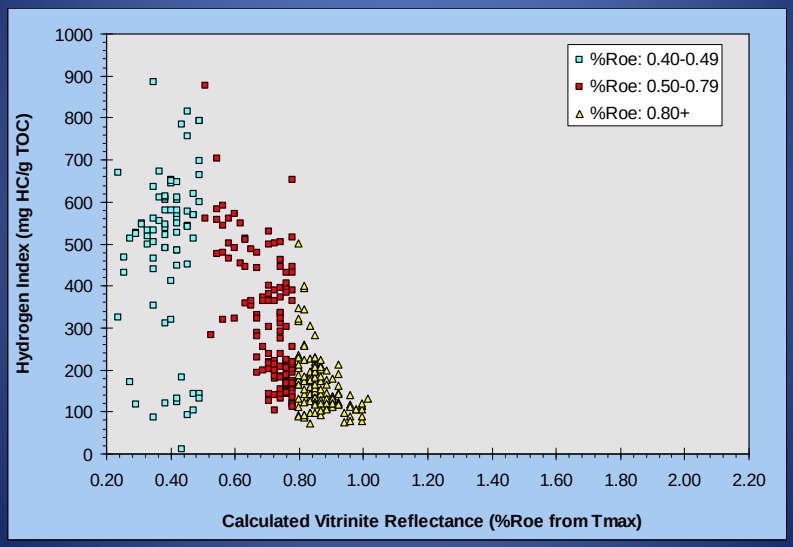
Bakken Shale, Parshall Field



61% convertible organic carbon
ca. 1900 bo/af upon complete conversion*
ca. 320 bo/af upon 20% conversion*

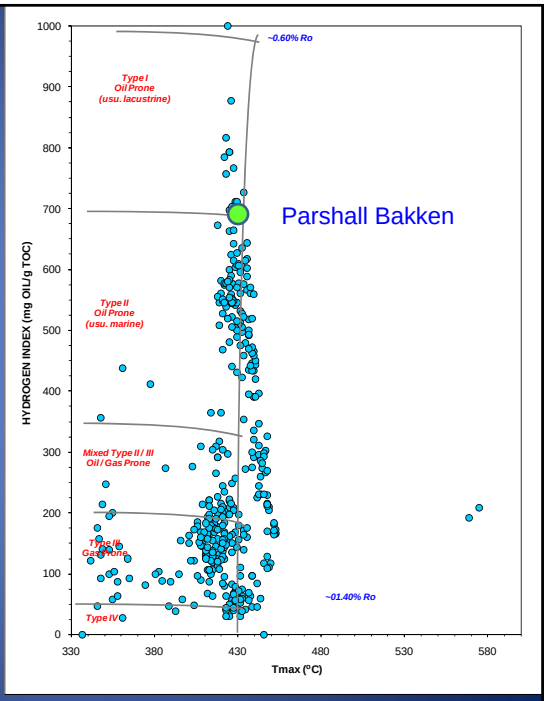
* assumes 85% oil; 15% gas from primary generation

Segregation of Bakken Shale by thermal maturity from Tmax

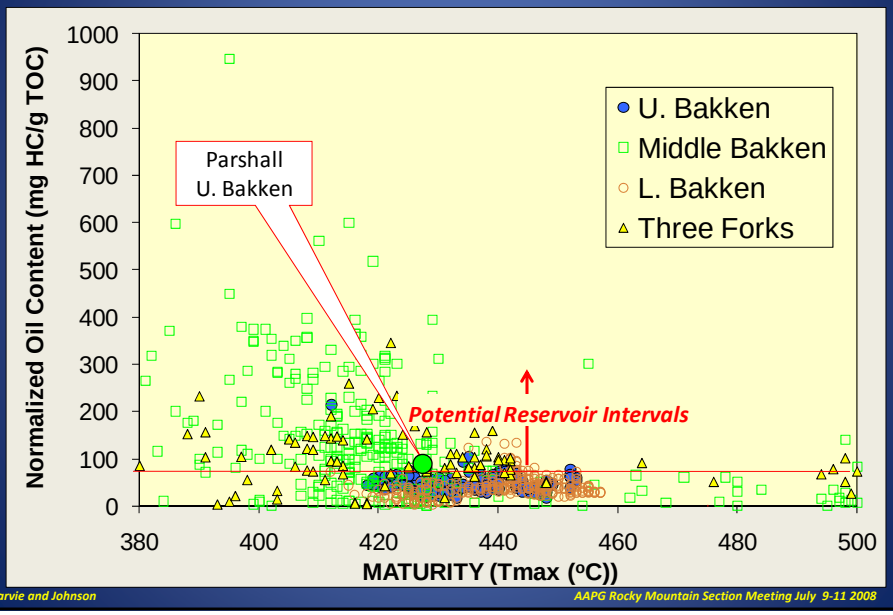


Parshall Field Bakken Shale:

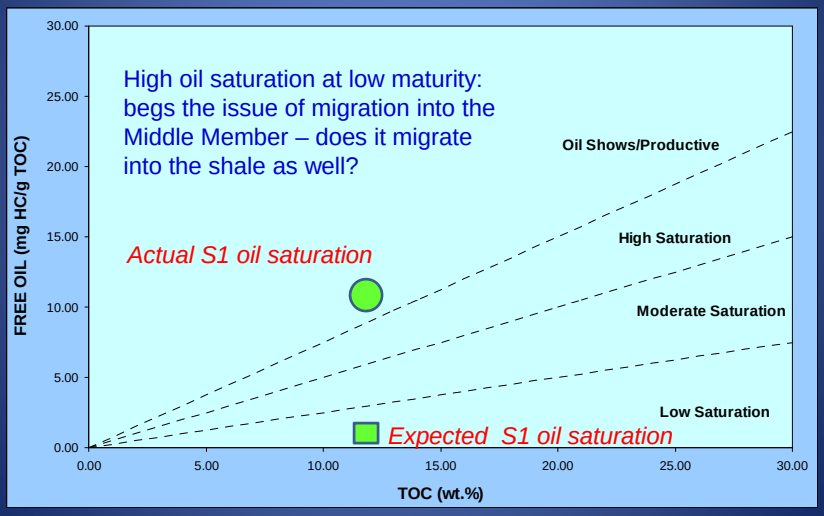
High remaining hydrocarbon generation potential and low Tmax (0.58-0.65%Roe)



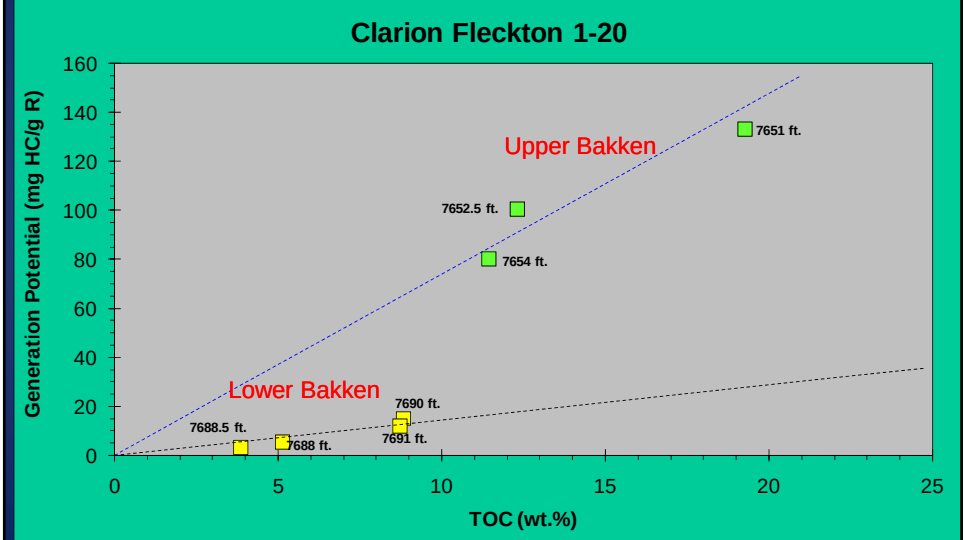
Normalized Free Oil vs. Thermal Maturity



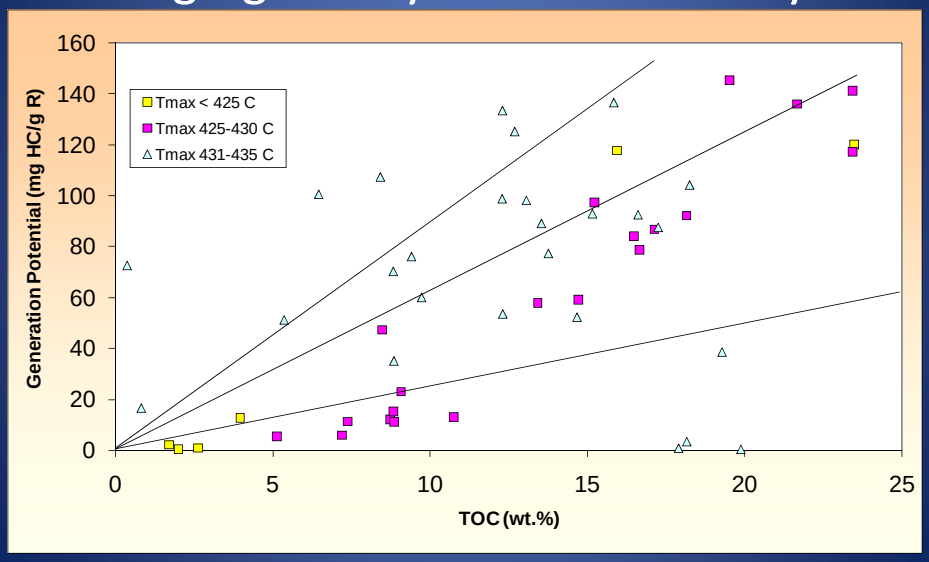
Parshall Bakken Shale:
Free Oil Content (Rock-Eval S1) vs. TOC



Organofacies Variations:
U. and L. Bakken Shale: Fleckton 1-20

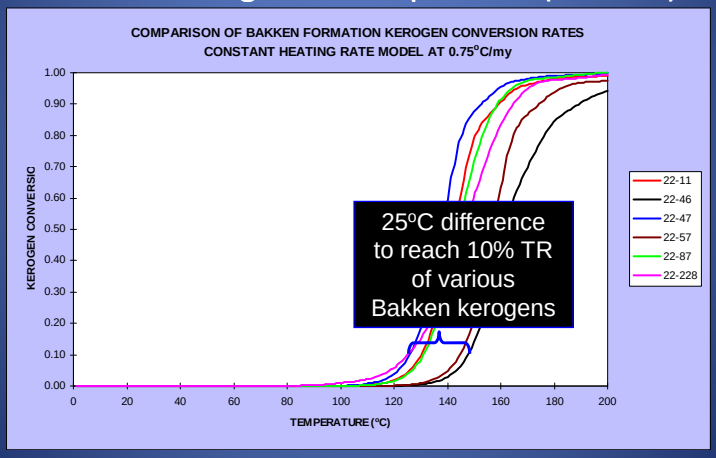


Bakken Shale: Variation in Organofacies segregated by thermal maturity



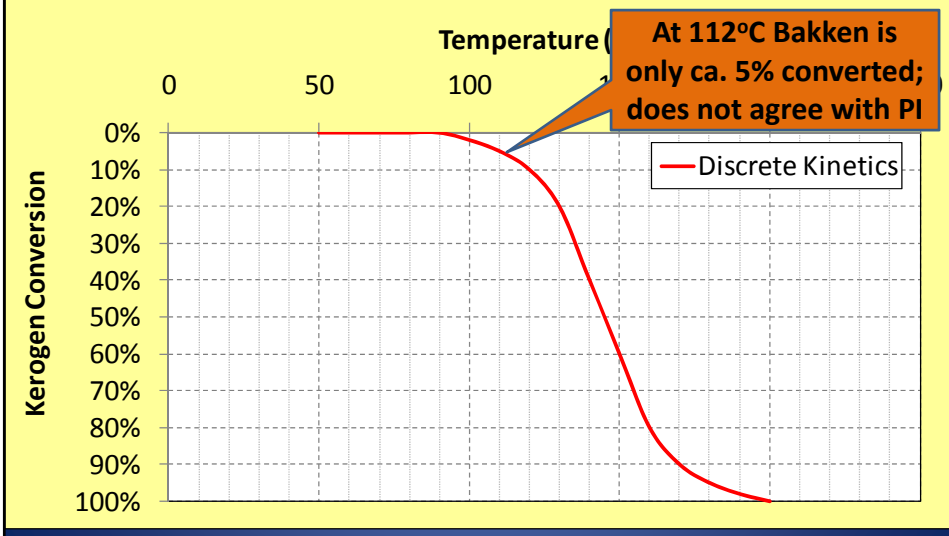
Why do we tend to mis-represent the postion of the oil and gas windows?

Rates of Kerogen Decomposition (kinetics)



Jarvie and Inden, 1996

Differences in Kinetic Computations:
Mathematical Models



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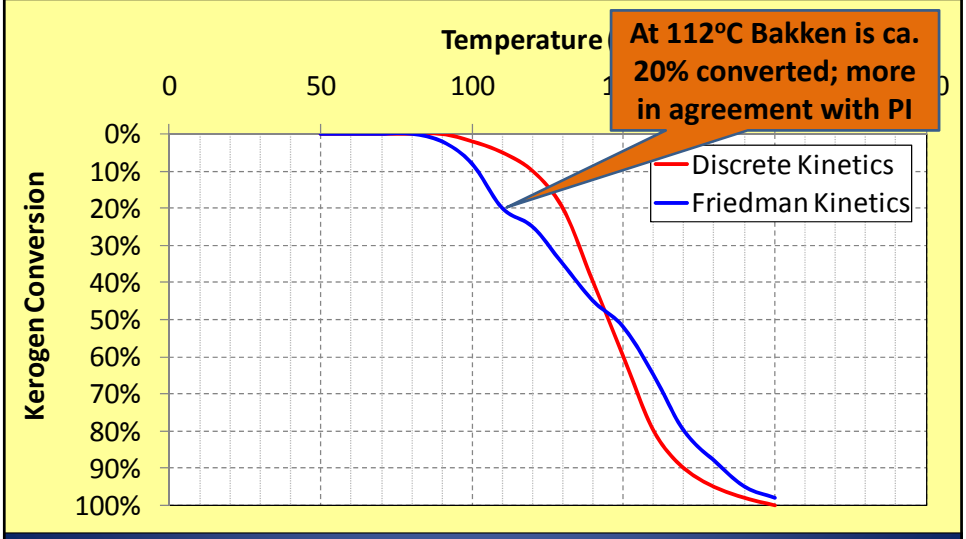
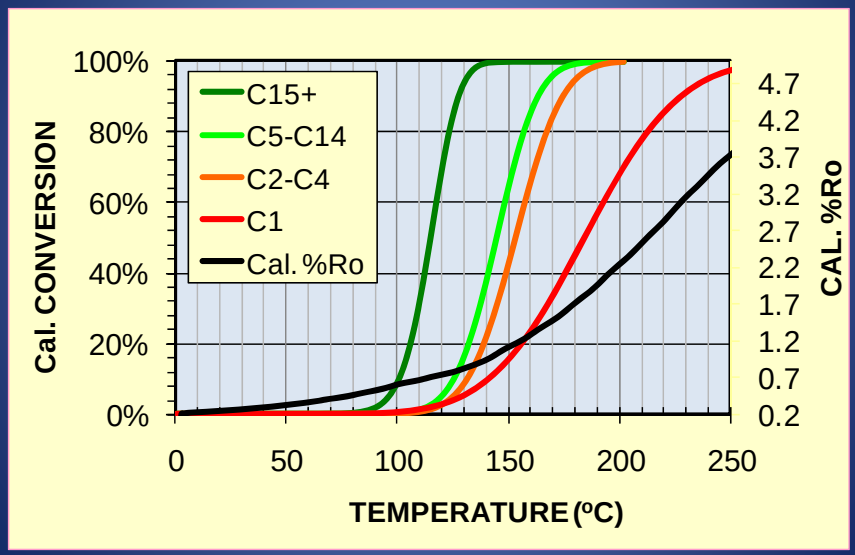
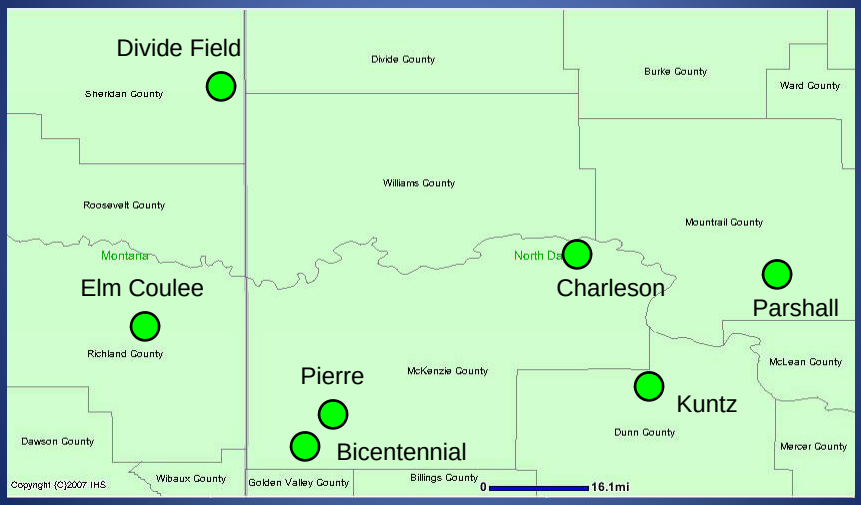


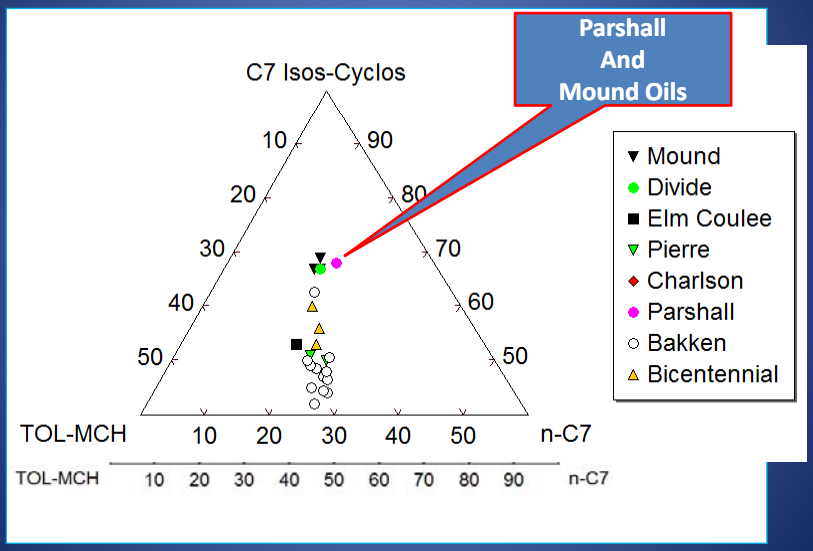
Bakken Shale:
Compositional Differences in Timing of Generation



Selected Bakken Oil Sample Locations

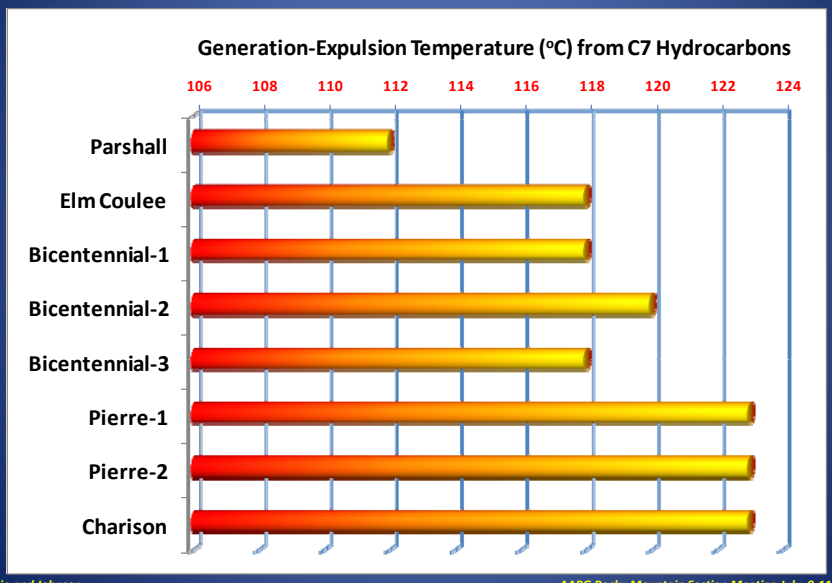


C7 Hydrocarbon Distribution

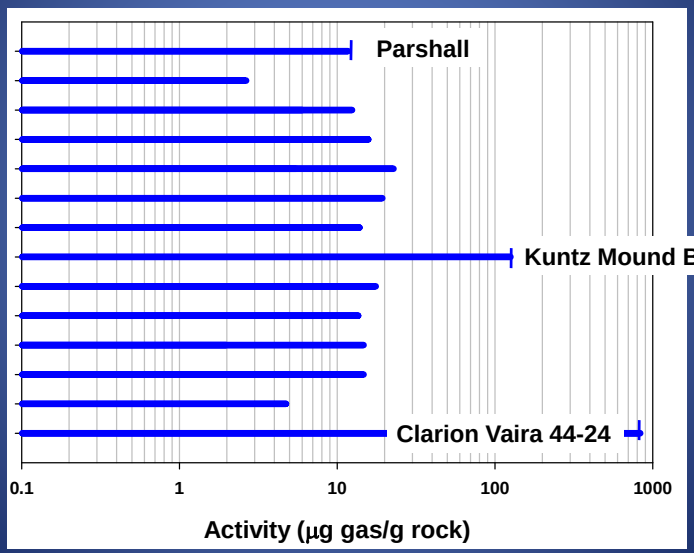


Modified from Jarvie, 2001

Comparison of Bakken Oils: Generation-Expulsion Temperatures based on C_7 Hydrocarbons



Catalytic Activity based on Mango Assay



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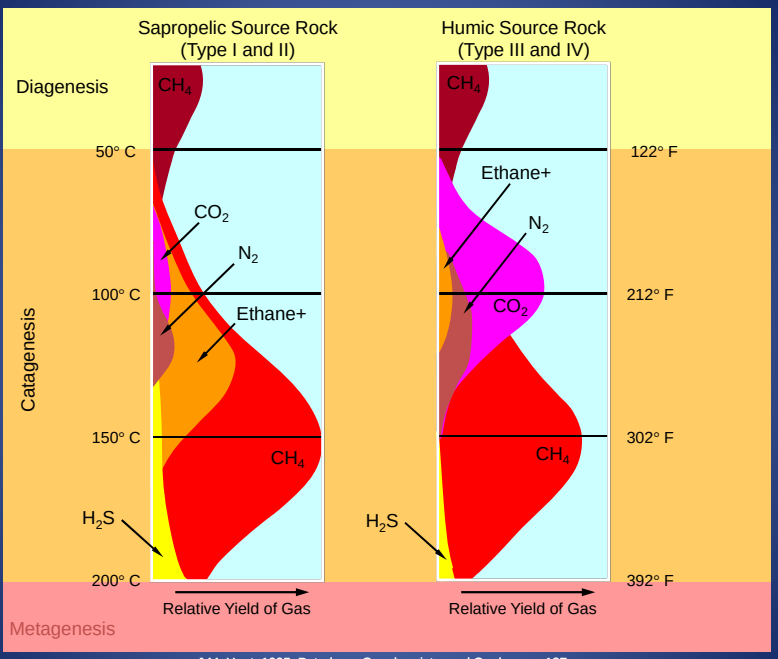
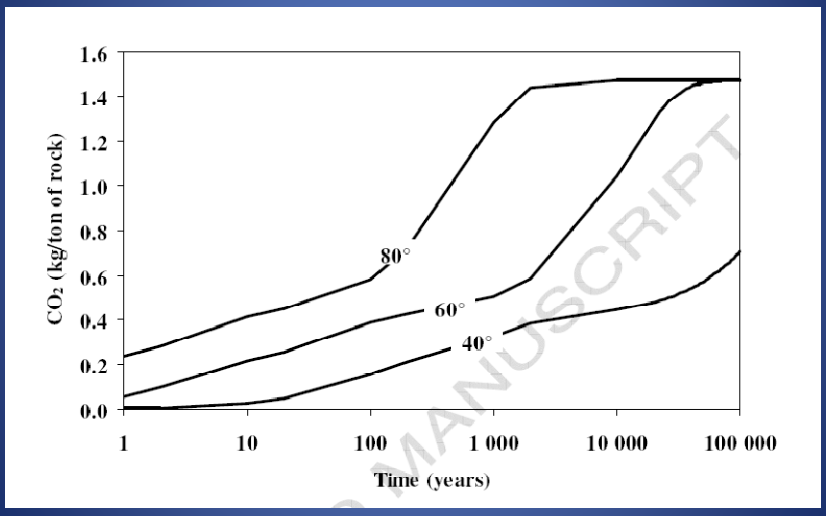
Hypothesis on Generation Processes

1. Kerogen formation processes release water, carbon dioxide and organic acids
2. Carbon dioxide and organic acids create
   a) moderate overpressuring
   b) etch or create conduits for expulsion and potentially secondary porosity in carbonates
3. Early hydrocarbon generation is underestimated due to self-imposed Arrhenius factor averaging
4. Kerogen and early oil both flow with primarily oil escaping the shale itself
5. Hydrogen index is artificially increased due to organic carbon loss as carbon dioxide during decarboxylation



J.M. Hunt, 1995, Petroleum Geochemistry and Geology, p. 187

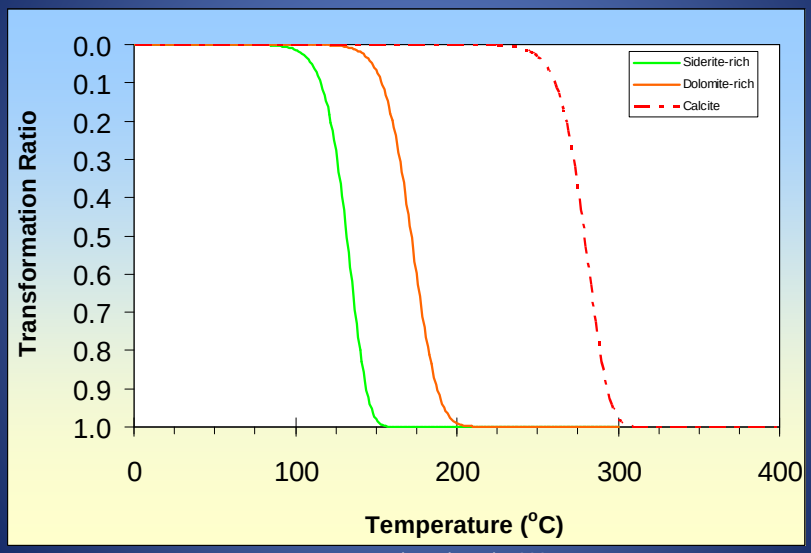
Carbon Dioxide Yield from Immature Boom Clay Decomposition under Radiogenic Heat Exposure



Lorant et al., 2008

Carbonate Decomposition

based on kinetic measurements and geological heating rates



Jarvie and Jarvie, 2007

Summary

- Parshall Field Bakken Shale has unusually high oil saturations for low thermal maturity and is postulated to be the source of the oil rather than migrated oil
- Parshall Field Middle Member oil is one of the lowest thermal maturity Bakken Shale sourced oils
- Organofacies differences exist in the Bakken Shale as shown by simple organofacies plots and kerogen kinetic parameters
- Carbon dioxide and organic acids may play a role in overpressuring and conduits/storage for early oil
- Production and these geochemical interpretations suggest the possibility of other modest maturity oil plays

Thank you

and

peace be with you !

(shalom, salam alakum)

XXXBJKOOO