Using Cutting-Edge Surface Geochemical Techniques to Indicate Porosity, Pressure, and Hydrocarbon Phase in Shale Plays*

Rick Schrynemeeckers[1]

Search and Discovery Article #70115 (2012)
Posted February 13, 2012

*Adapted from presentation at AAPG Geoscience Technology Workshop, "International Shale Plays," Houston, Texas, October 11-12, 2011. Please refer to companion article, "Minimizing Offshore Exploration Risks by Evaluating the Charge of Subsea Structures," Search and Discovery Article #70114 (2012).

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General Comments

Shale plays:

- have large areal extent.
- are not homogeneous.
- are typically under-pressured to normal pressure.
- may not be continuous and are not uniform thickness.
- significant variation in lithology and organic content occurs both laterally and vertically.
- may or may not contain liquids.

Amplified geochemical imaging:

- can Identify Sweet spots.
- can focus exploration program and drilling early in shale plays.
- is an environmentally friendly tool.

Selected Reference

Haselton, T., and P. Willumsen, 2001, Reservoir sweet spots identified with surface geochemistry – an example from the Cambrian Pietu Siupariai oil field, Lithuania: 63rd EAGE Conference & Exhibition Case Study 5, E&P Case Studies. Web accessed 6 February 2012, http://www.earthdoc.org/detail.php?pubid=4525

North America GTW

International Shale Plays
11-12 October 2011
Houston, Texas | Norris Conference Center CITYCENTRE

Using Cutting-Edge Surface Geochemical Techniques to Indicate Porosity, Pressure, and Hydrocarbon Phase in Shale Plays

by Rick Schrynemeeckers

W.L. Gore & Associates

A Resource Triangle for Oil and Gas Reservoirs

Conventional Reservoirs
Small volumes that are easy to develop

Unconventional
Large volumes difficult to develop

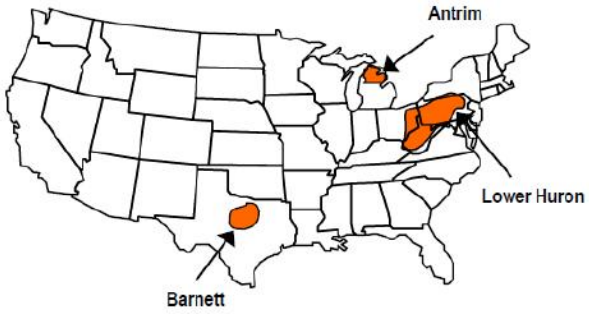
Increased pricing

Improved technology

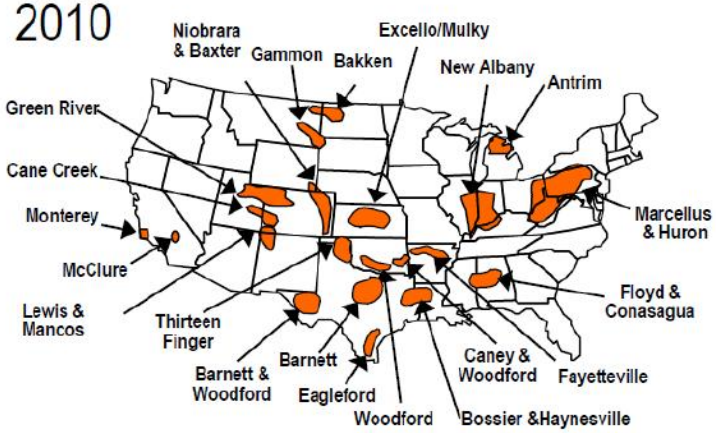
Working Document of the National Petroleum Council Global Oil & Gas Study Made Available July 18, 2007

Shale Has Transformed the US Gas Market

2000

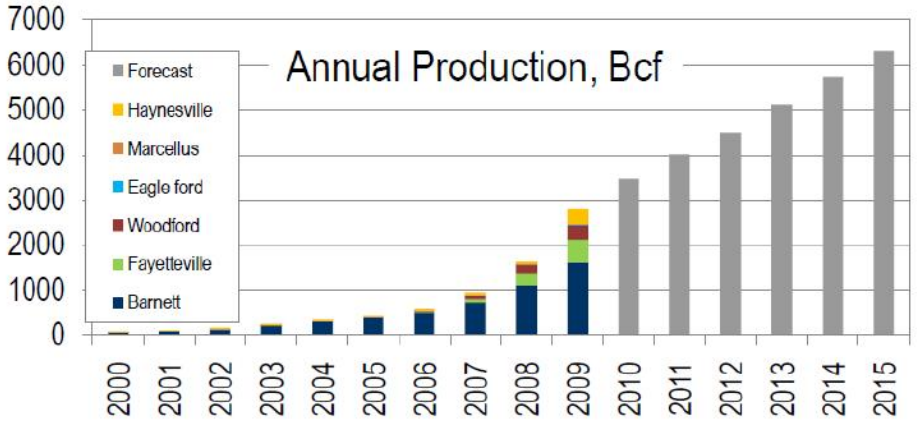


2010



2011 Developments

- Permian Shales
- Utica Shale
- New Brunswick Shale



From: Hopkins, C. SPE ATW Shale Gas, Beijing May 2011

Focused Drilling in Shale Frontiers

- Porosity
- Permeability
- Thickness or Net Pay
- Pressure
- Production Rates

} Reservoir characteristics

Focused Drilling in Shale Frontiers

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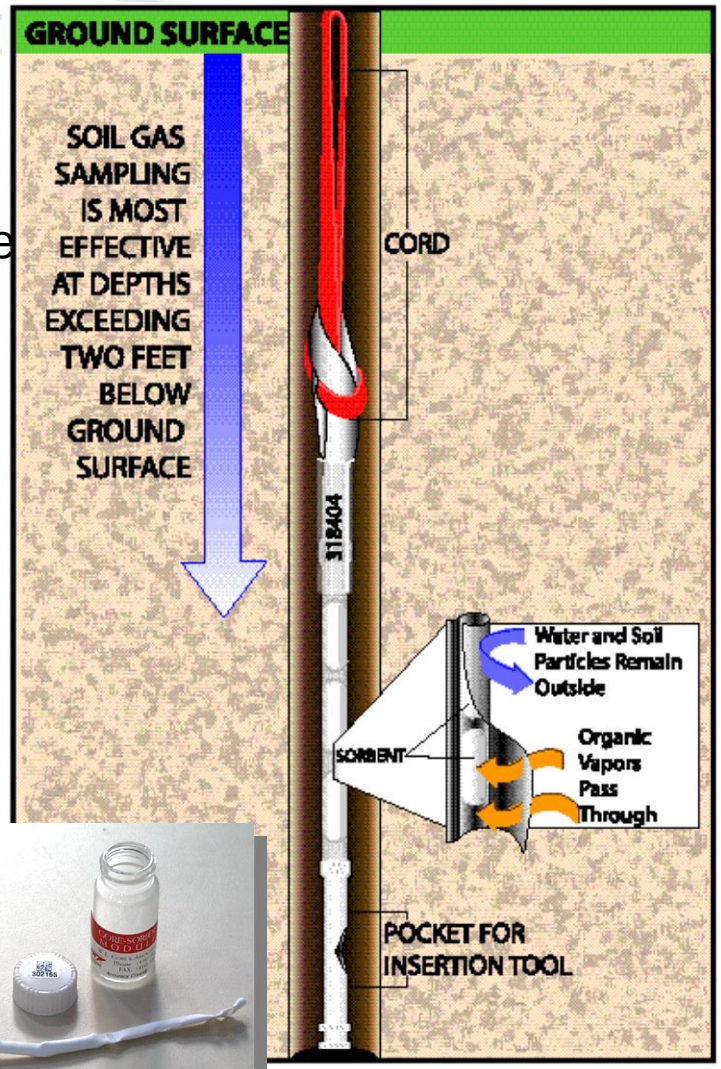
} Reservoir characteristics

Amplified Geochemical Imaging^{SM} can help define those reservoir characteristics.

GORE™ Module

- Patented, passive, sorbent-based
  - Chemically-inert, waterproof, vapor permeable
  - Direct detection of organic compounds
  - Sample integrity protected
- Engineered sorbents
  - Consistent sampling medium
  - Minimal water vapor uptake
- Time-integrated sampling
  - Minimize near-surface variability
  - Maximize sensitivity (up to C20)
  - Avoid variables inherent in instantaneous sampling
- Duplicate samples



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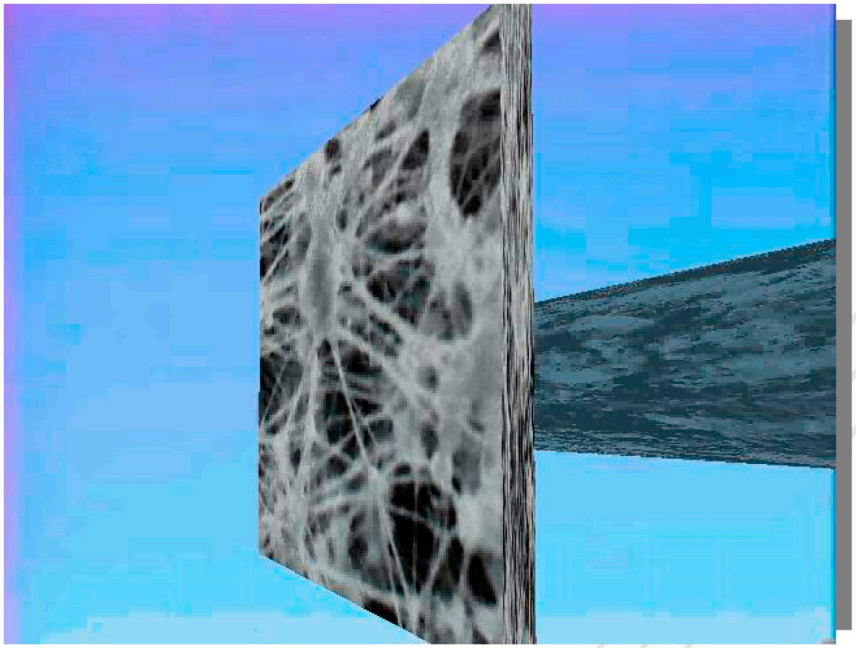
GORE™ Surveys - Collection

Based on Patented ePTFE Technology

C_2-C_{20} molecules are ~5-10A
Membrane pores are ~1000A
Water drops are >5000A

- **Passive, sorbent-based**
- **Chemically-inert, waterproof, vapor permeable, durable**
  - Sample integrity protected
- **Gore Engineered sorbents**
  - Consistent sampling medium
  - Minimal water vapor uptake
- **Time-integrated sampling**
  - ~17 day exposure
  - Minimize near-surface variability
  - Maximize sensitivity (up to C20)
  - Avoid variables inherent in instantaneous sampling
- **Duplicate samples**



ePTFE - 50,000 x magnification

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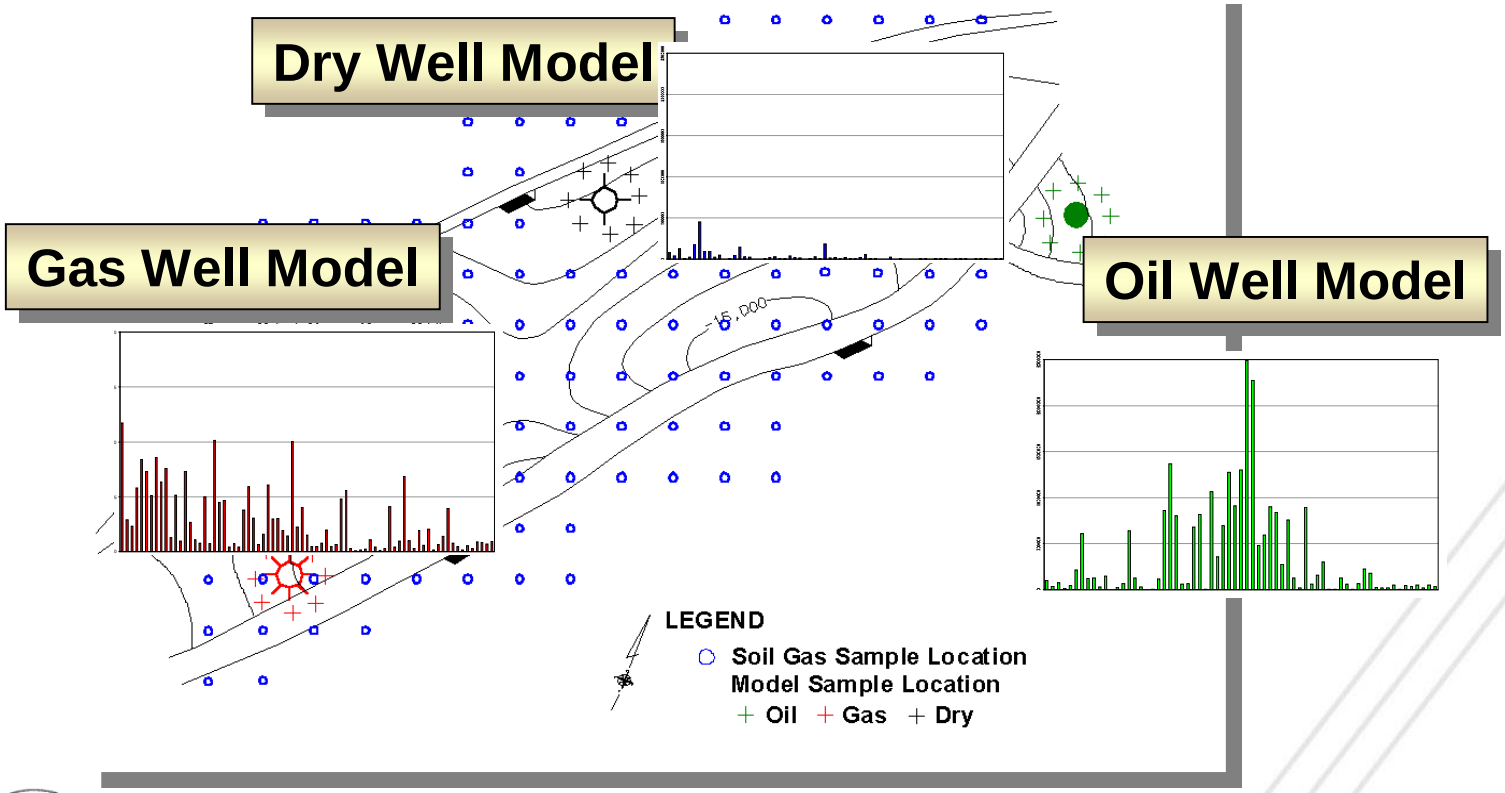
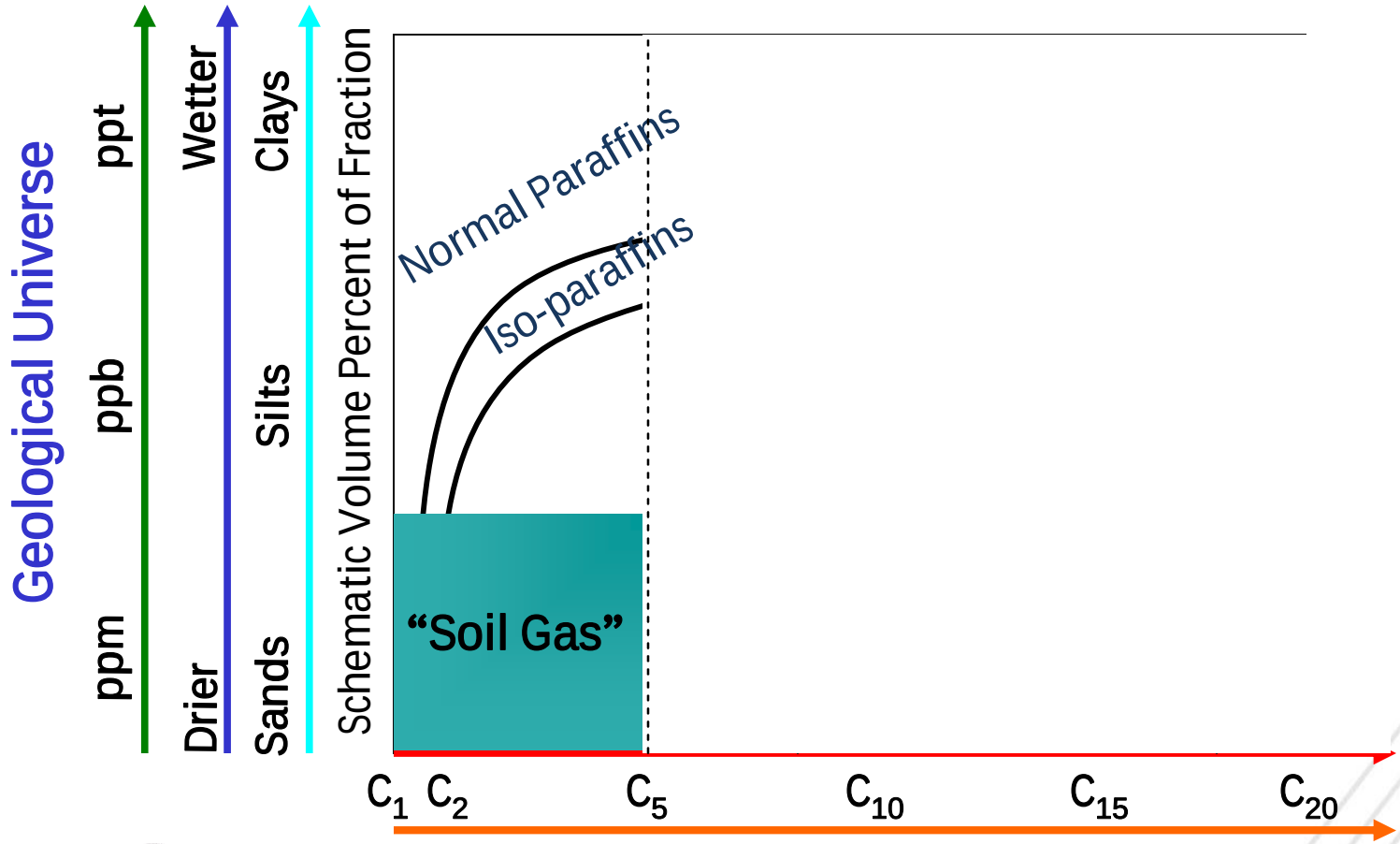
GORE™ Surveys for Offshore Exploration

Model development..



Superior to conventional surface geochemical techniques



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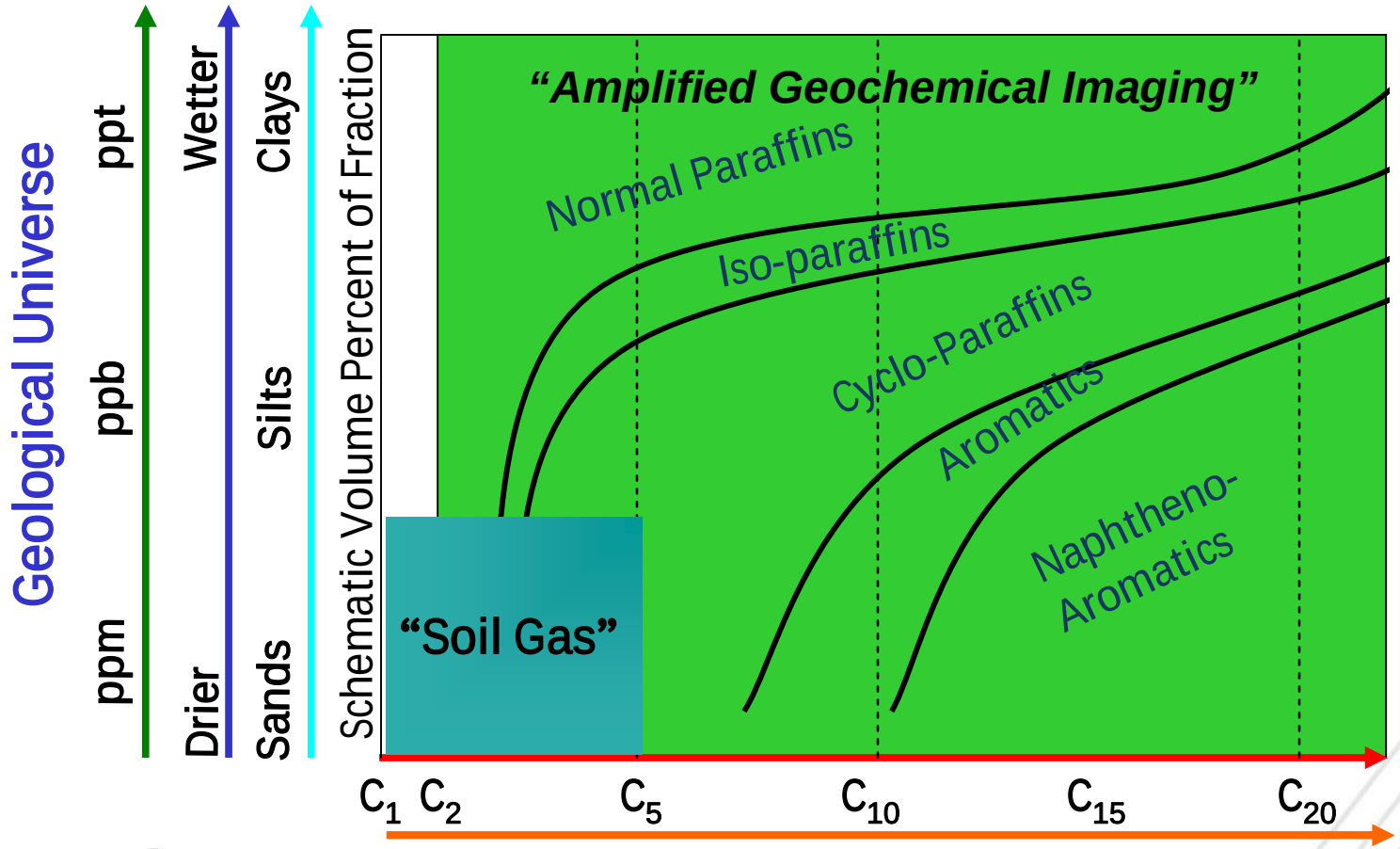


GORE™ Surveys - Analysis

Analytical Compound List by Compound Class: C2 – C20

Typical Petroleum Constituents Hydrocarbon number in ( )			
Normal Alkanes	**Iso-alkanes**	**Cyclic Alkanes**	**Aromatics and PAH***
Ethane (2) Propane (3) Butane (4) Pentane (5) Hexane (6) Heptane (7) Octane (8) Nonane (9) Decane (10) Undecane (11) Dodecane (12) Tridecane (13) Tetradecane (14) Pentadecane (15) Hexadecane (16) Heptadecane (17) Octadecane (18)	2-Methylbutane (5) 2-Methylpentane (6) 3-Methylpentane (6) 2,4-Dimethylpentane (7) 2-Methylhexane (7) 3-Methylhexane (7) 2,5-Dimethylhexane (8) 3-Methylheptane (8) 2,6-Dimethylheptane (9) Pristane (19) Phytane (20)	Cyclopentane (5) Methylcyclopentane (6) Cyclohexane (6) cis-1,3-Dimethylcyclopentane (7) trans-1,3-Dimethylcyclopentane (7) trans-1,2-Dimethylcyclopentane (7) Methylcyclohexane (7) Cycloheptane (7) cis-1,3/1,4-Dimethylcyclohexane (8) cis-1,2-Dimethylcyclohexane (8) trans-1,3/1,4-Dimethylcyclohexane (8) trans-1,2-Dimethylcyclohexane (8) Ethylcyclohexane (8) Cyclooctane (8) Propylcyclohexane (9)	Benzene (6) Toluene (7) Ethylbenzene (8) m,p-Xylenes (8) o-Xylene (8) Propylbenzene (9) 1-Ethyl-2/3-methylbenzene (9) 1,3,5-Trimethylbenzene (9) 1-Ethyl-4-methylbenzene (9) 1,2,4-Trimethylbenzene (9) Indane (9) Indene (9) Butylbenzene (10) 1,2,4,5-Tetramethylbenzene (10) Naphthalene (10) 2-Methylnaphthalene (11) Acenaphthylene (12)
Byproduct / Alteration and Other Compounds			
Alkenes	**Aldehydes**	**Biogenic**	**NSO* and Other Compounds**
Ethene (2) Propene (3) 1-Butene (4) 1-Pentene (5) 1-Hexene (6) 1-Heptene (7) 1-Octene (8) 1-Nonene (9) 1-Decene (10) 1-Undecene (11)	Octanal (8) Nonanal (9) Decanal (10)	alpha-Pinene beta-Pinene Camphor Caryophyllene	Furan 2-Methylfuran Carbon Disulfide Benzofuran Benzothiazole Carbonyl Sulfide Dimethylsulfide Dimethyldisulfide

Geochemical Model Development – using chemical clusters

Cluster Analysis

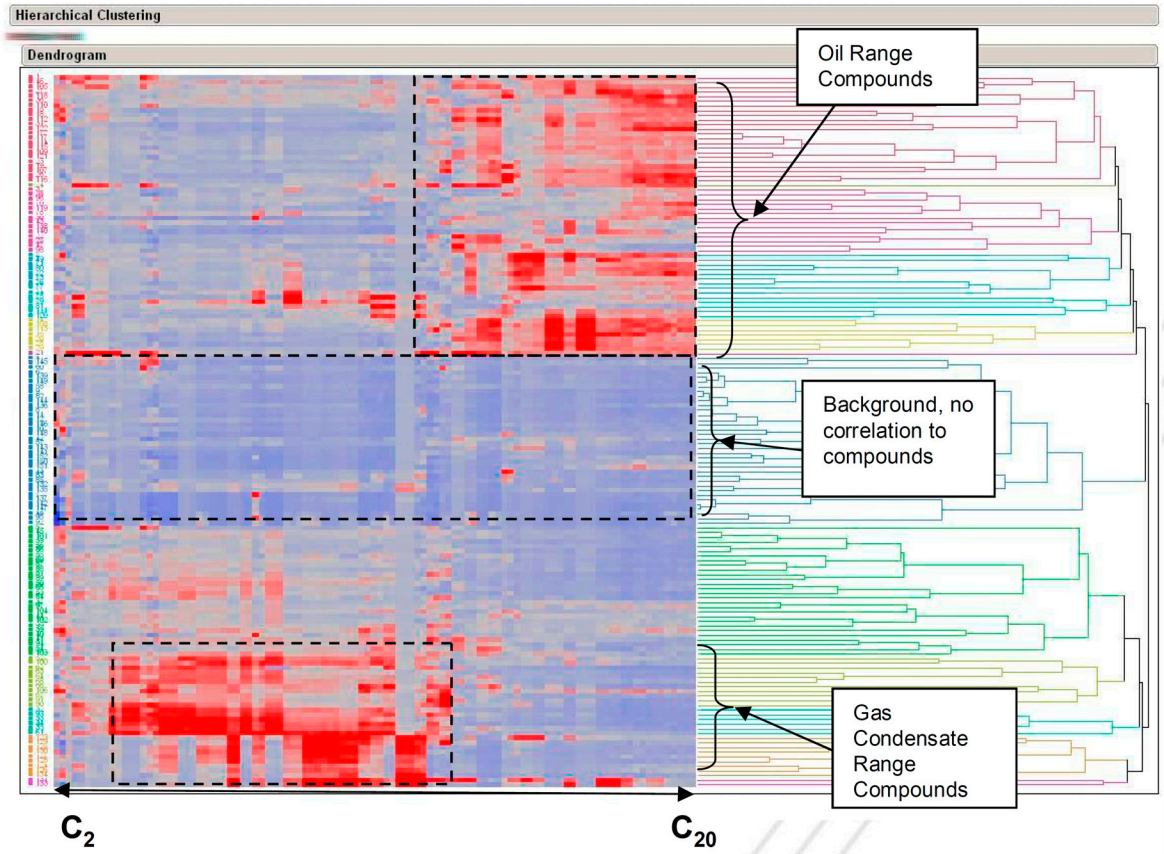
Identify geochemical similarities in data patterns

– Soil gas data grouped by clusters

- Cluster structure isolates "petroliferous" vs "background" character

- Sufficient cluster membership to sample signal variance

- Clusters have subsurface geochemical meaning



Example shown: Gas/Condensate Well and Dry well models; No oil discoveries in this area, HCA performed on Compounds post S/N, HCA clearly detects an oil signature in the data

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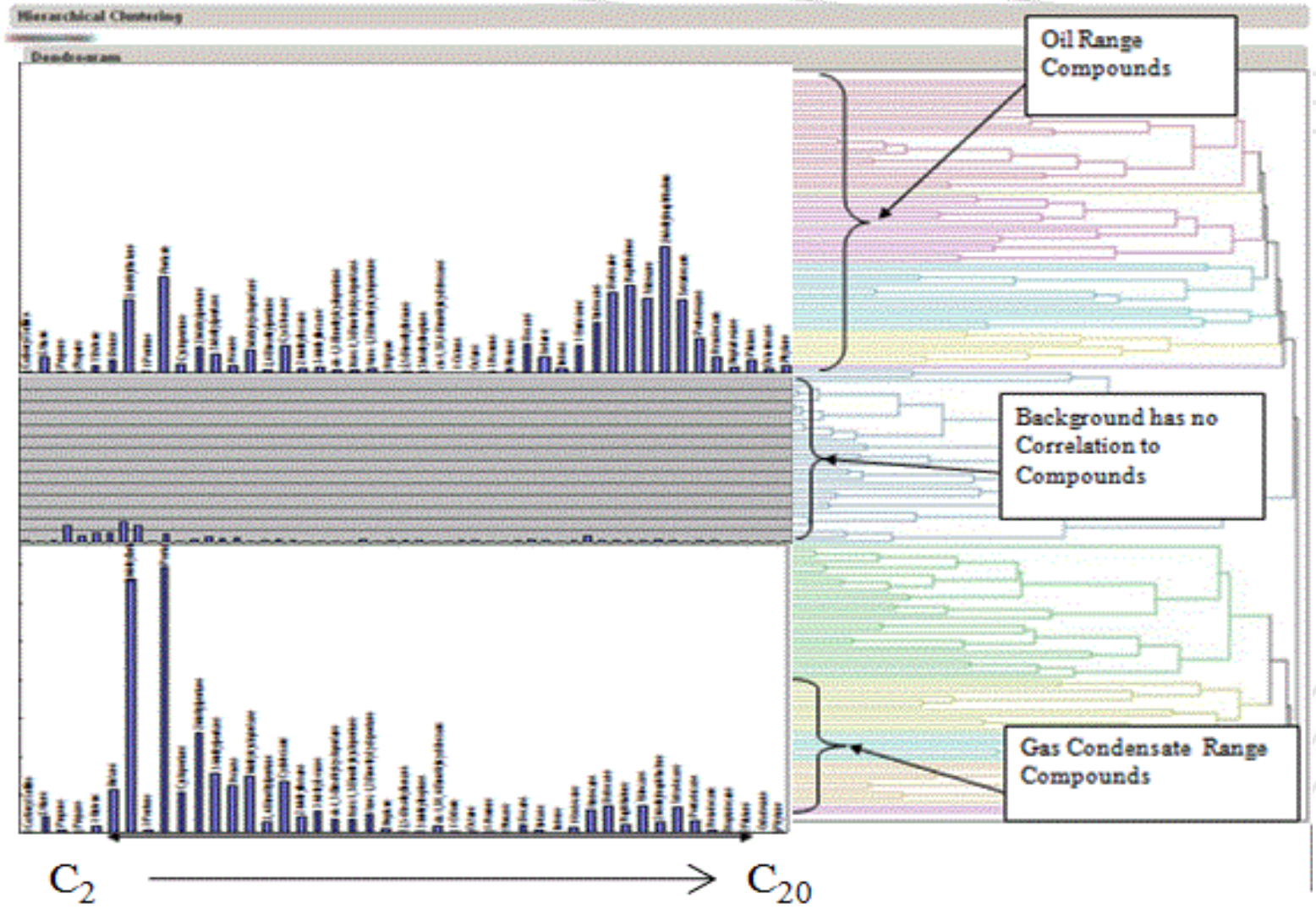
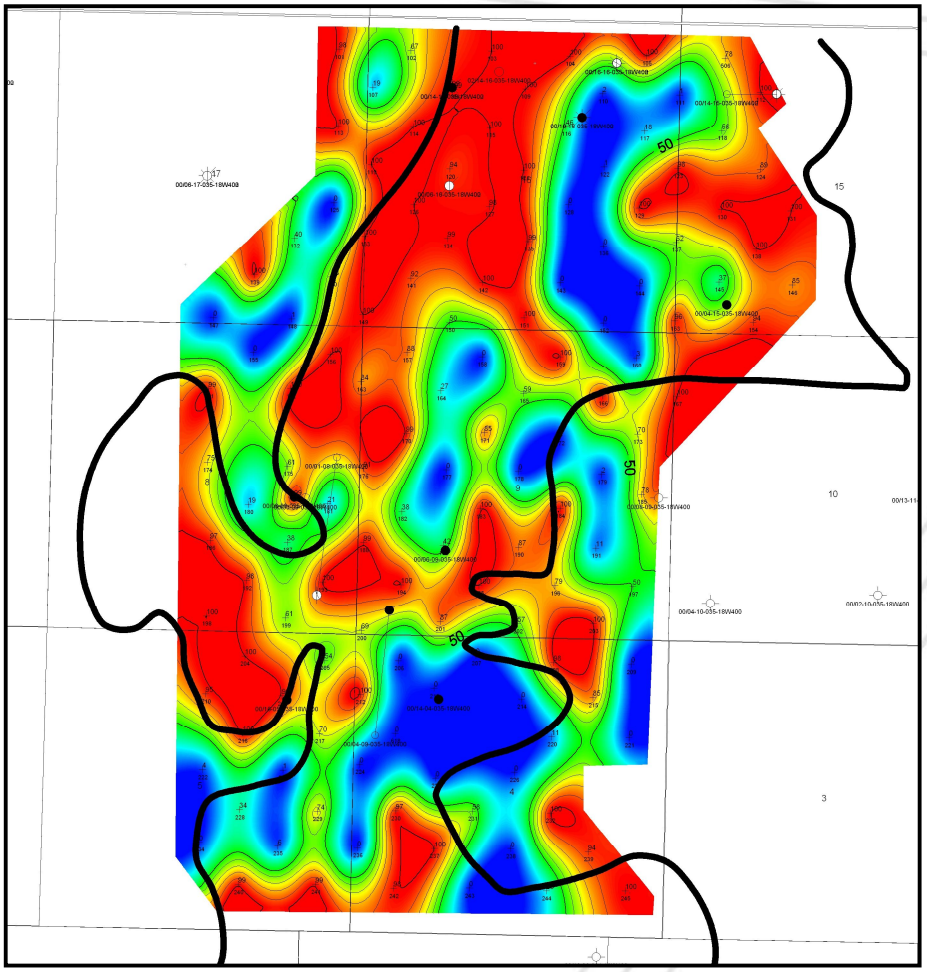
Hierarchical Cluster Analysis



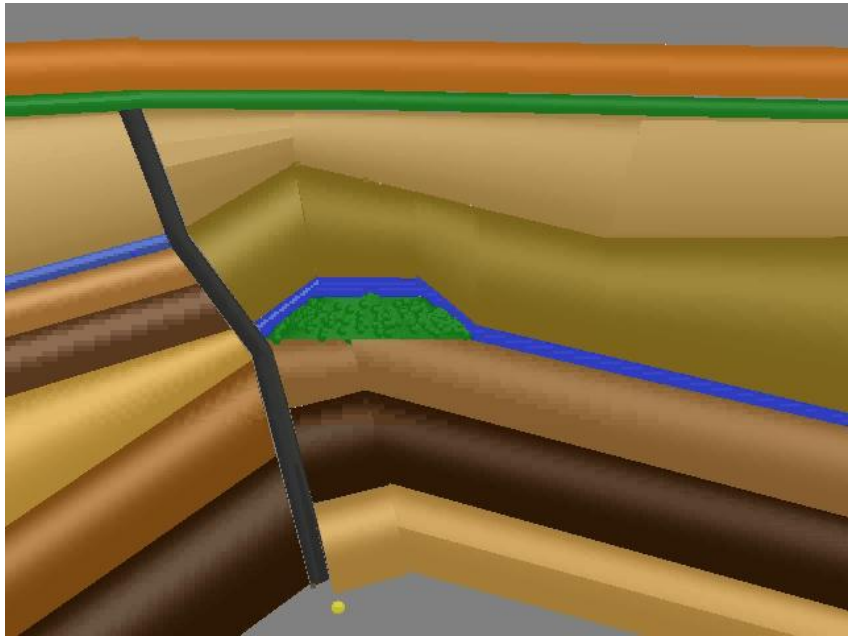
Final Report:

- Objectives, design, & field work
- QA/QC summary
- Geochemical modeling
- Results
- Summary & conclusions
- Color contour probability maps
- Supporting appendices
- Electronic, available in hard copy
- Personal presentations



The Earth´s Fractionation Process

Vertical Migration



Microseepage signal affected by:

- Pressure (P)
- Porosity (θ)
- Net Pay (h)

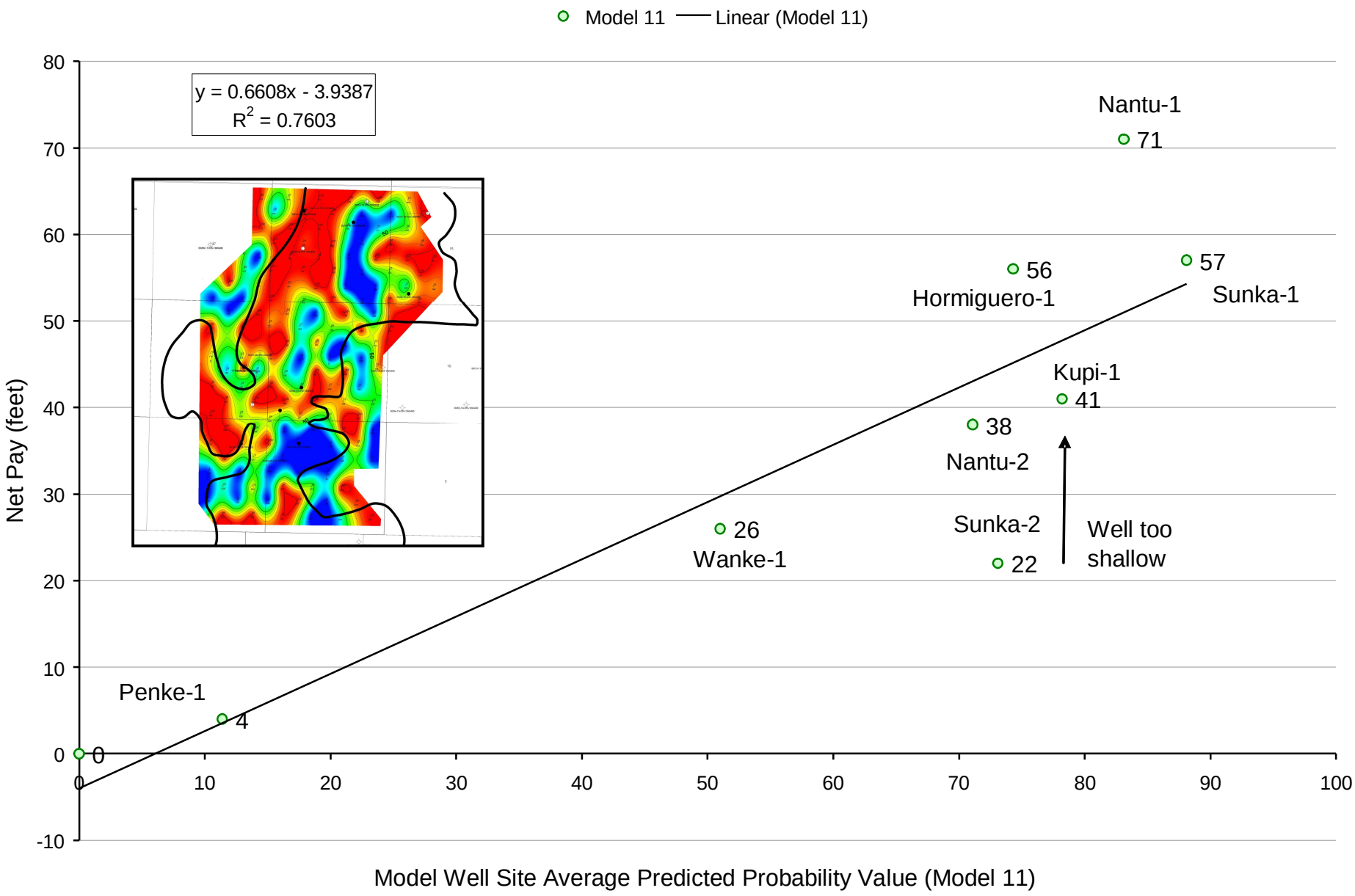
?

Macroseepage:
- Detectable in visible amounts
- Pathway follows discontinuities
- Offset from source/reservoir

VS

Microseepage:
- Detectable in analytical amounts
- Pathway is nearly vertical
- Overlie source/reservoir

Net Pay - Geochemical Probability Relationship
Oriente Basin, Ecuador



Probability versus Porosity x Thickness

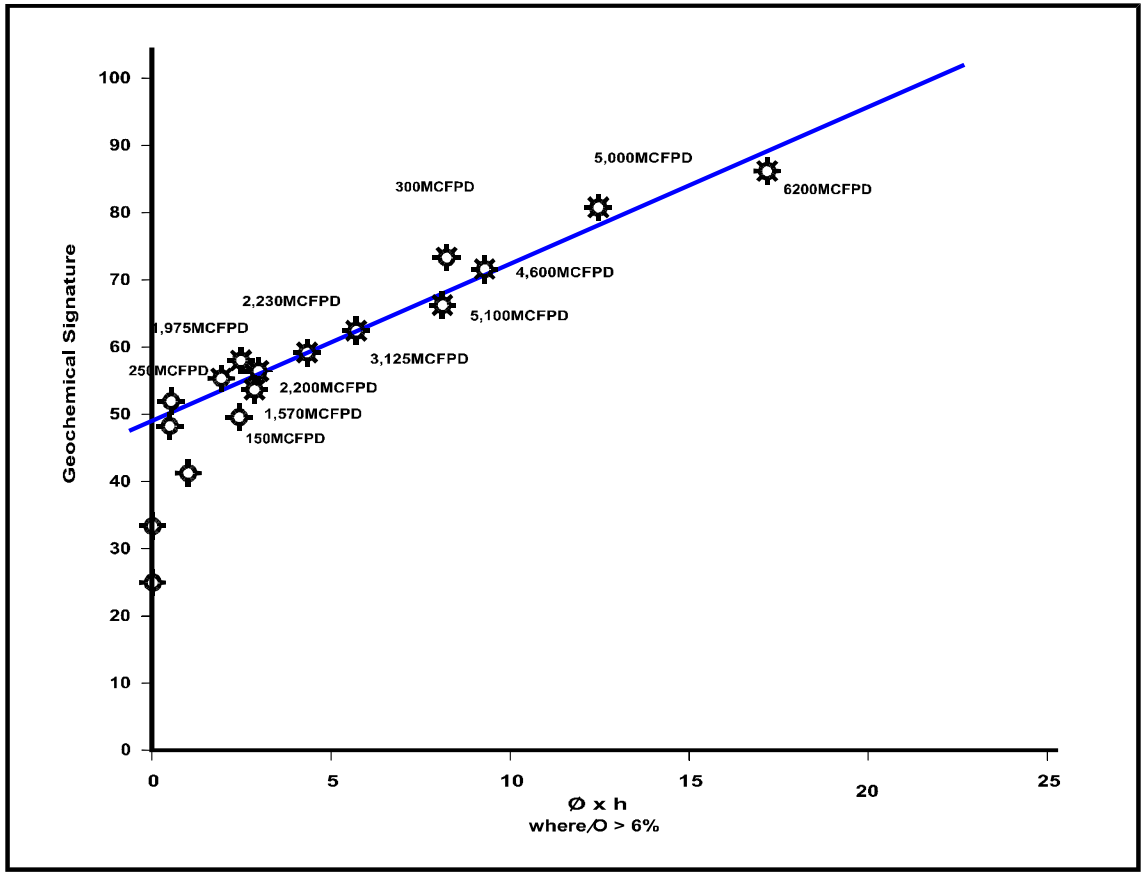
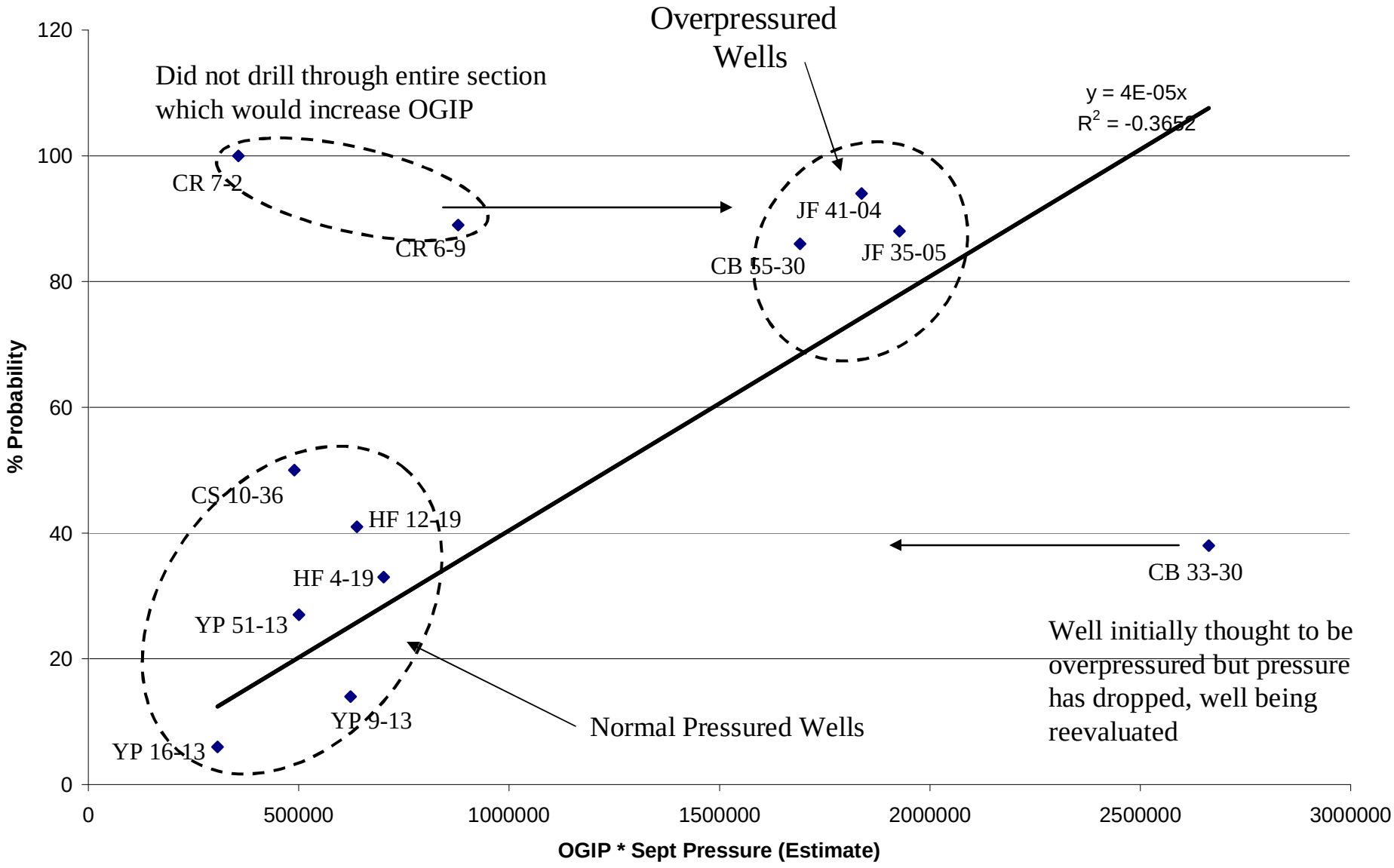
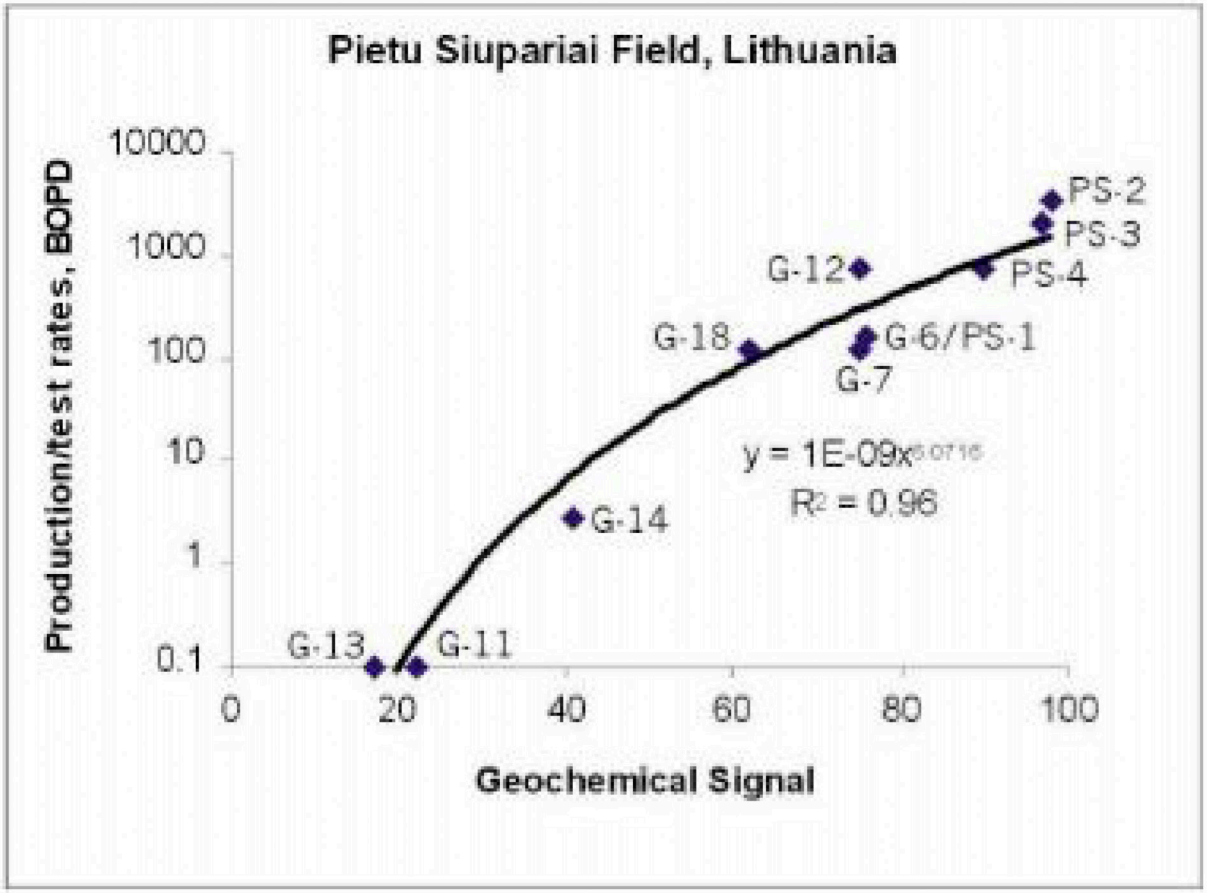


Figure 13: Porosity-thickness relationship with geochemical anomaly strength; data from the Anadarko basin.


Overpressured Wells
Did not drill through entire section which would increase OGIP
y = 4E-05x
R2 = -0.3652
CR 7-2
CR 6-9
JF 41-04
CB 55-30
JF 35-05
CS 10-36
HF 12-19
HF 4-19
YP 51-13
YP 9-13
YP 16-13
CB 33-30
Normal Pressured Wells
Well initially thought to be overpressured but pressure has dropped, well being reevaluated
% Probability
OGIP * Sept Pressure (Estimate)
0
20
40
60
80
100
120
0
500000
1000000
1500000
2000000
2500000
3000000

Probability versus Production Rate



"Reservoir sweet spots identified with surface geochemistry – an example from the Cambrian Pietu Siupariai oil field, Lithuania."

Authors: T. Haselton and P. Willumsen

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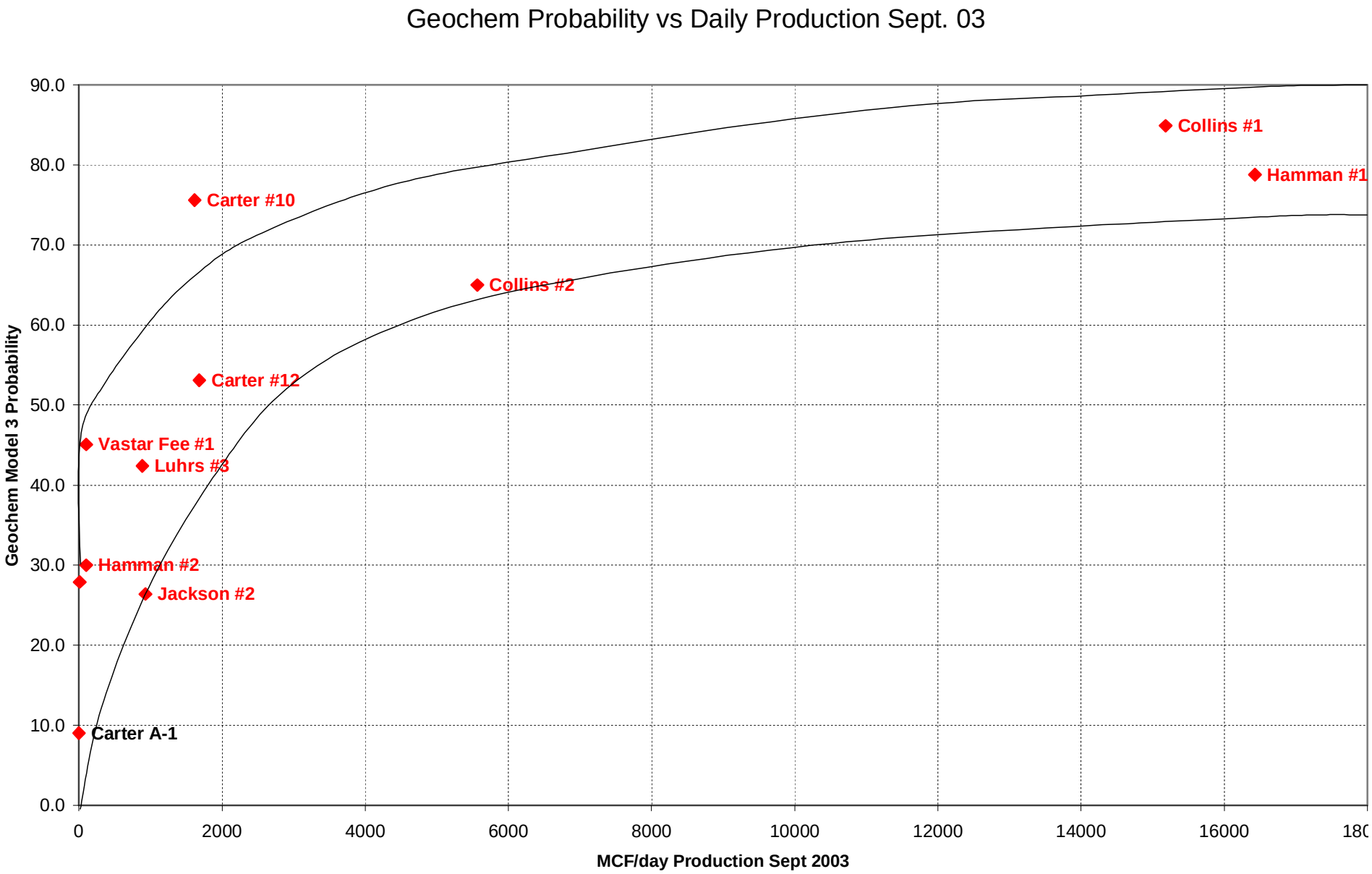
Woodbine, Texas



Conclusions: Shale Plays and Unconventional Plays

Key Factors - Shale Plays

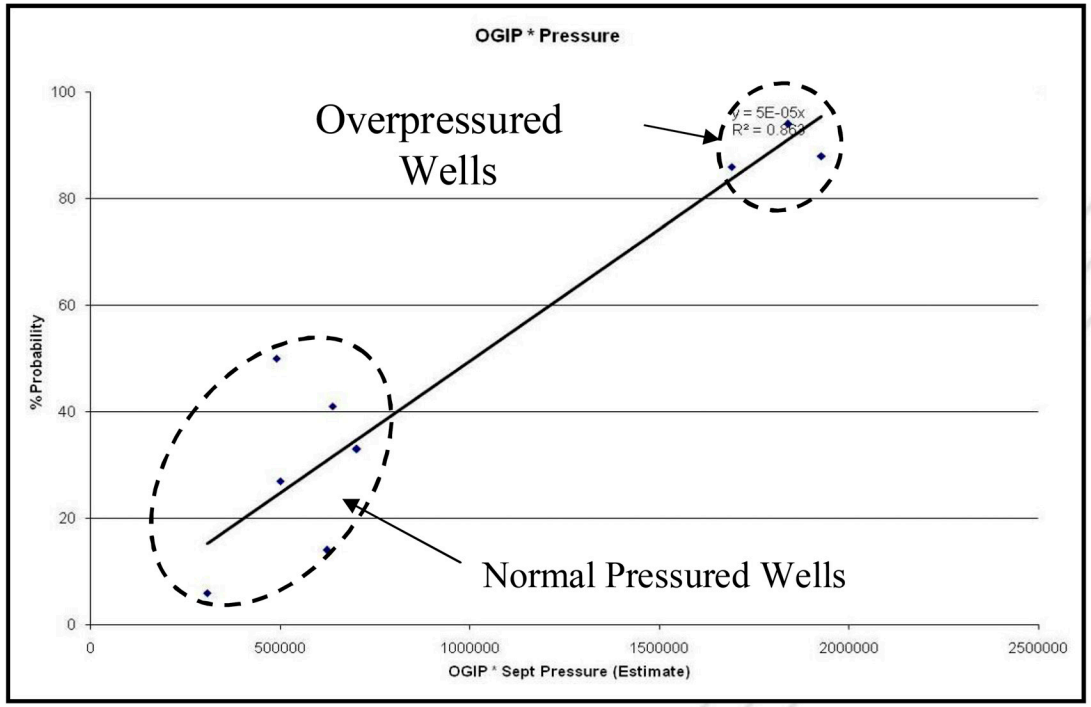
- have large areal extent
- are not homogeneous
- are typically under-pressured to normal pressure
- may not be continuous and are not uniform thickness
- significant variation in lithology and organic content occurs both laterally and vertically
- may or may not contain liquids

Shale Plays and Unconventional Plays

Sweet Spot Identifier

Geochemical Signal at surface is affected by:

- Pressure Changes

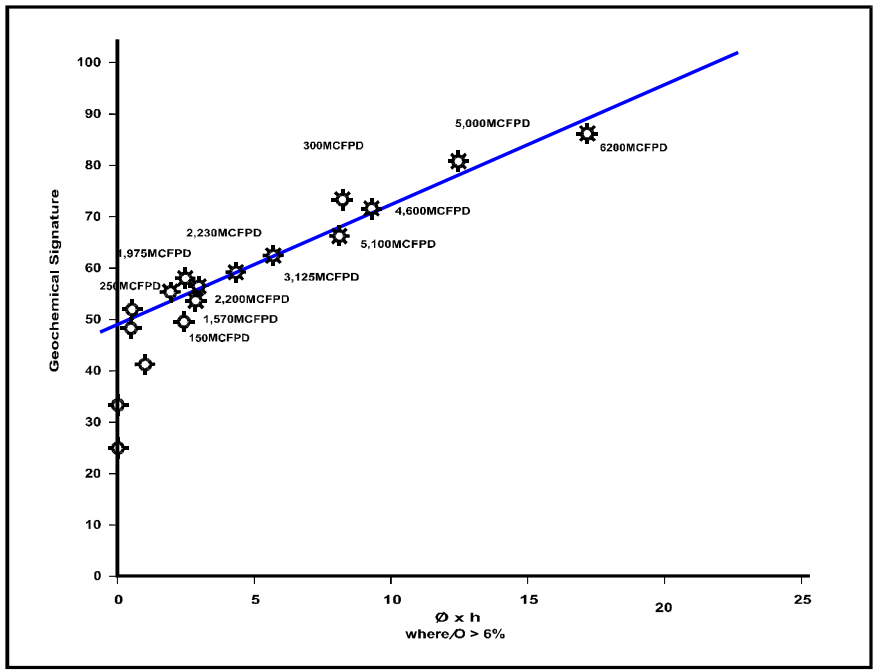


Shale Plays and Unconventional Plays

Sweet Spot Identifier

Geochemical Signal at surface is effected by:

- Pressure Changes
- Porosity Changes



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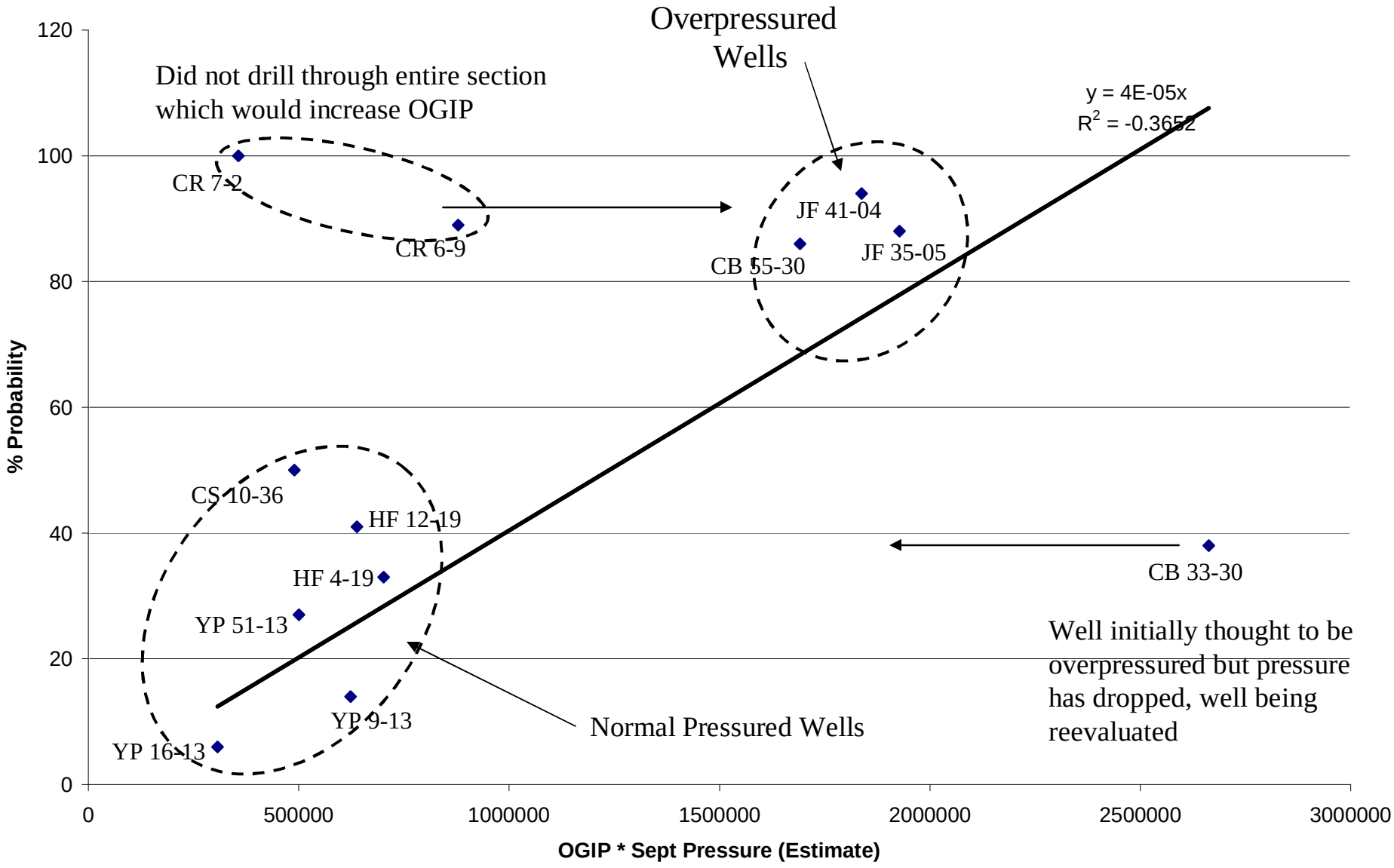
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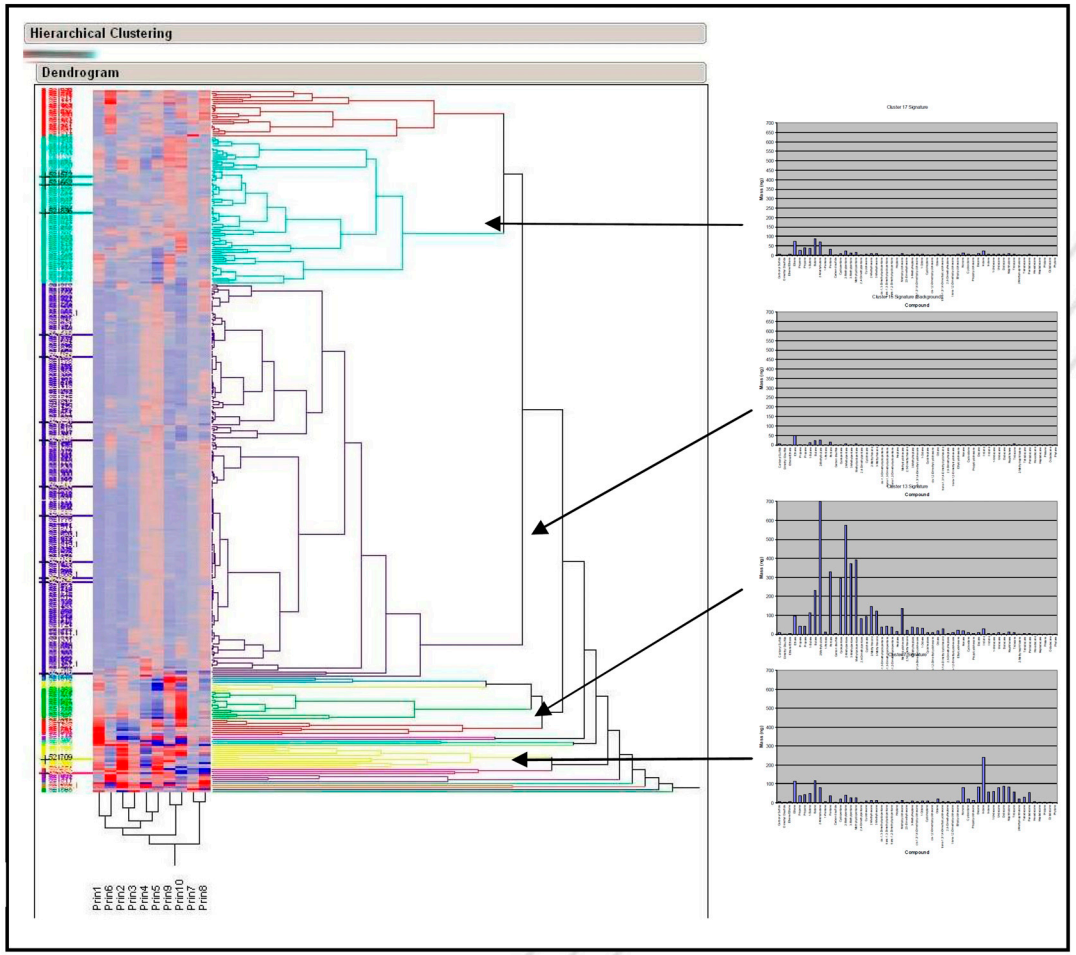
CB 33-30
Normal Pressured Wells
Well initially thought to be overpressured but pressure has dropped, well being reevaluated
% Probability
OGIP * Sept Pressure (Estimate)
0
20
40
60
80
100
120
0
500000
1000000
1500000
2000000
2500000
3000000

Shale Plays and Unconventional Plays

Sweet Spot Identifier

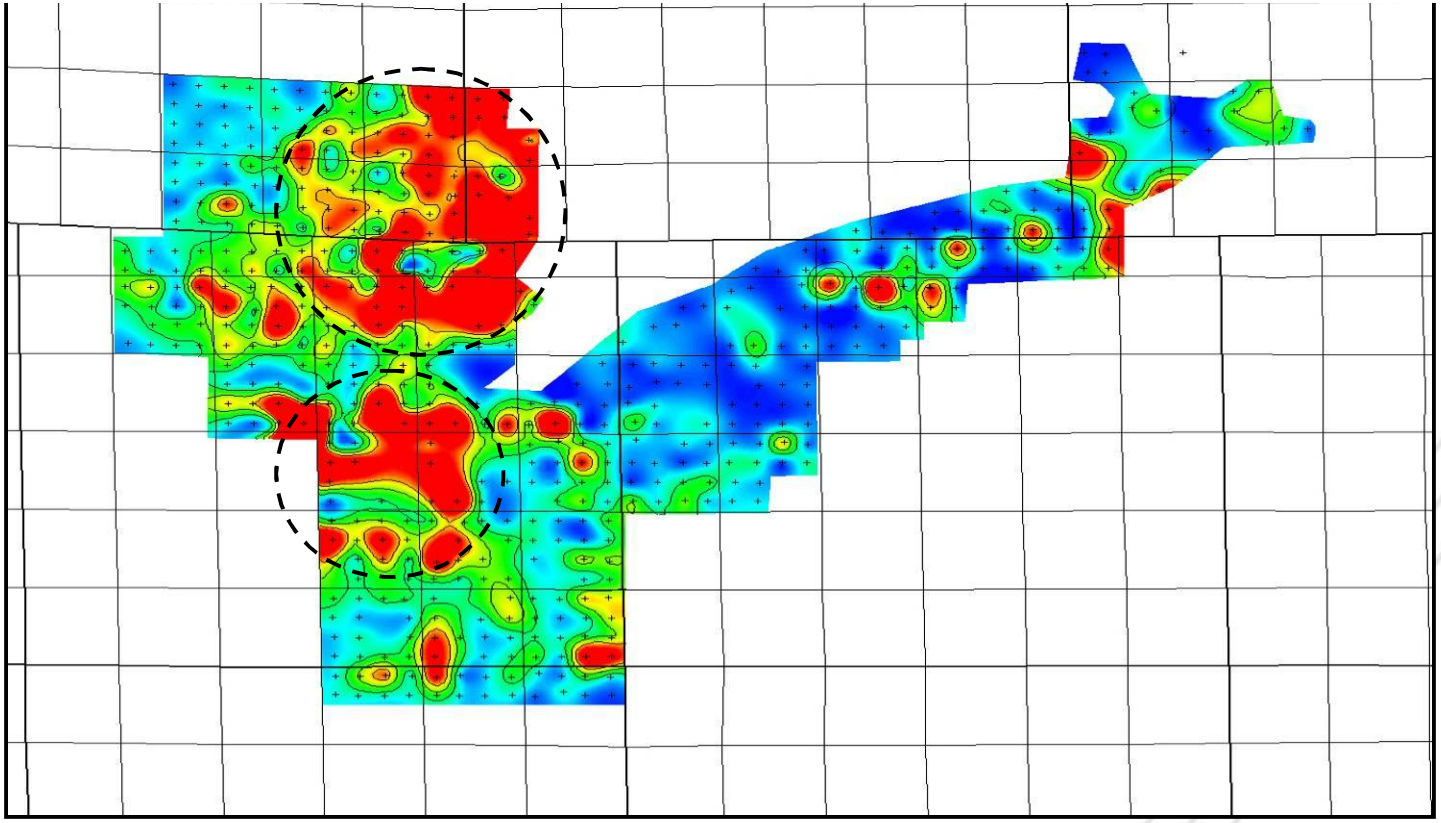
Geochemical Signal at surface is effected by:

- Pressure Changes
- Porosity Changes
- Net Pay
- Gas to Liquids



Shale Plays and Unconventional Plays

Amplified Geochemical Imaging Sweet Spot Identifier



Shale Plays and Unconventional Plays

Amplified Geochemical Imaging

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- Is an environmentally friendly tool

Thank you!