Shale Gas in New Zealand

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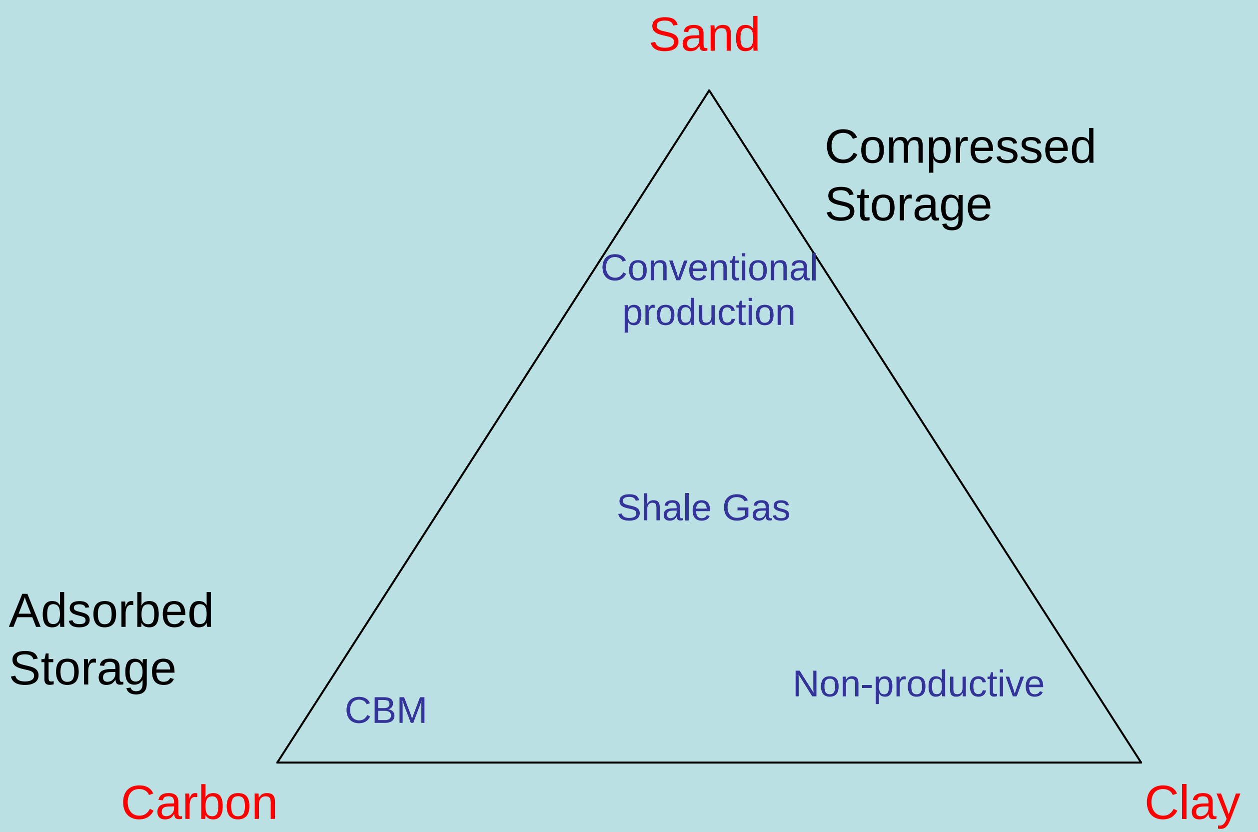
Outline

- Introduction to Shale Gas
- Technical Methods
- Development cost comparison
- Shale gas plays in New Zealand
- Conclusions

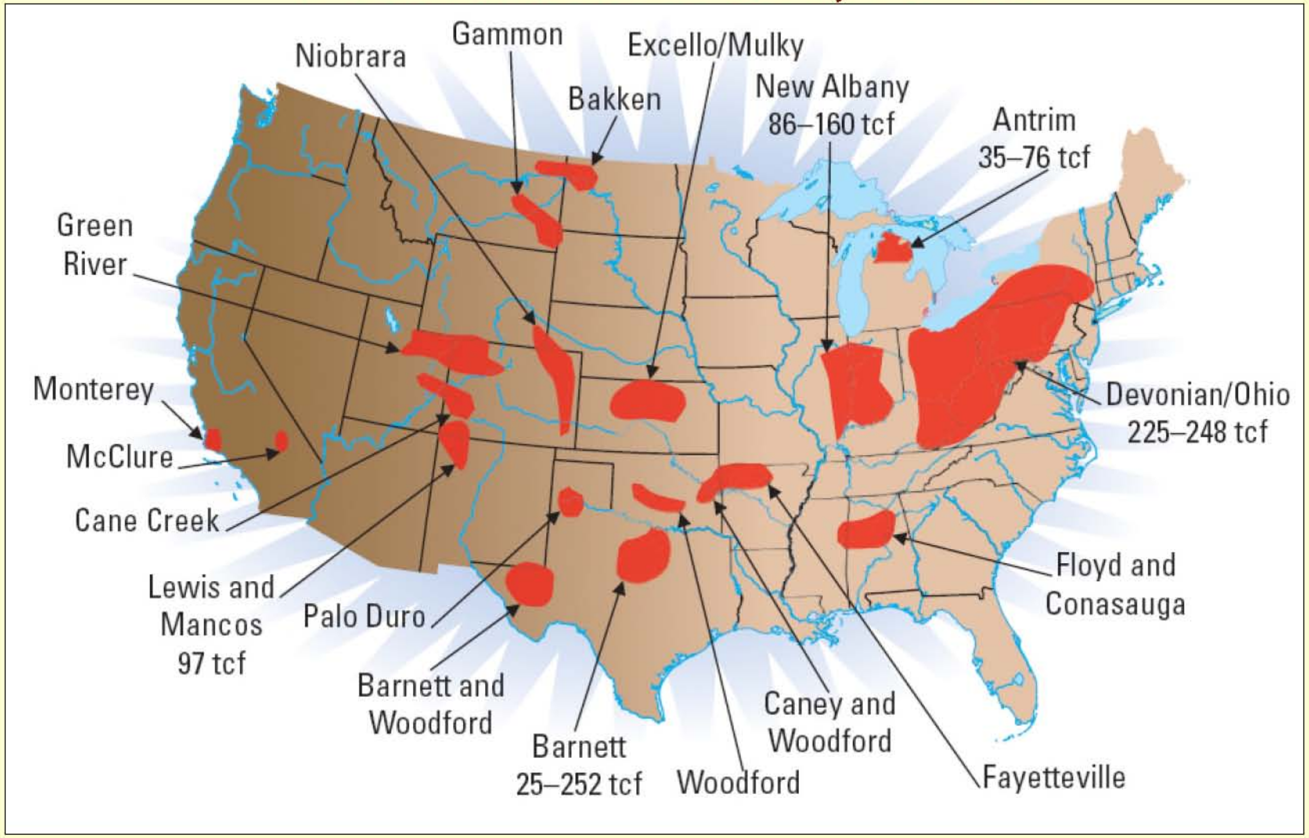
Introduction to Shale Gas

- Shale gas production started in eastern US in 1821
- Laterally extensive, “Resource” play
- Very long well and field life
- Long known, but overlooked as conventional reservoirs were pursued
- Economics depend on managing costs, optimizing completions, experimentation to find best production methods
- 16,000 TCF world wide shale gas reserves (2)
- Significant contribution to US production
  - From less than 1.6% in 1996 to 5.9% of US production in 2006 (1)
  - 2006 Production 1.1 TCF (1)
  - Reserves estimated to be at least as large as conventional gas; 1,000 TCF out of 2,000 TCF total US reserves with uncertainties about recovery (2,3,4)

Gas Storage


Sand
Compressed
Storage
Conventional
production
Shale Gas
Adsorbed
Storage
CBM
Non-productive
Carbon
Clay

U.S. Basins with Total Shale Gas Resource Potential of 500 to 1,000 Tcf



From Franz and Jochen, 2005, Shale Gas: Schlumberger, White Paper, 9 p.
www.oilfield.slb.com/whitepaper/shalegas

Geology and Reservoir

- Shales found in restricted circulation, euxinic, oxygen starved basins; reducing environment preserves organic carbon
- Shale is both the source rock and reservoir
- Hybrid reservoir-adsorbed+compressed gas storage
- Very low matrix permeability
- High TOC content

  association with radioactive shales not essential
- Gas generation thermogenic, catalyzed, or biogenic

Common Features to All Shale Plays

- Shale plus clastic, carbonate or chert
- Mud Log Shows
- Low Matrix Permeability
- Gas adsorbed to organic carbon plus free phase gas

Definable parameters for Success

- Development Cost

  well depth

  completion practice-low cost stimulation

  operating cost (water production)

  low development cost is essential

- Gas Recovery

  Gas In Place

    TOC content

    Langmiur isotherm

    maturity

  Total system permeability

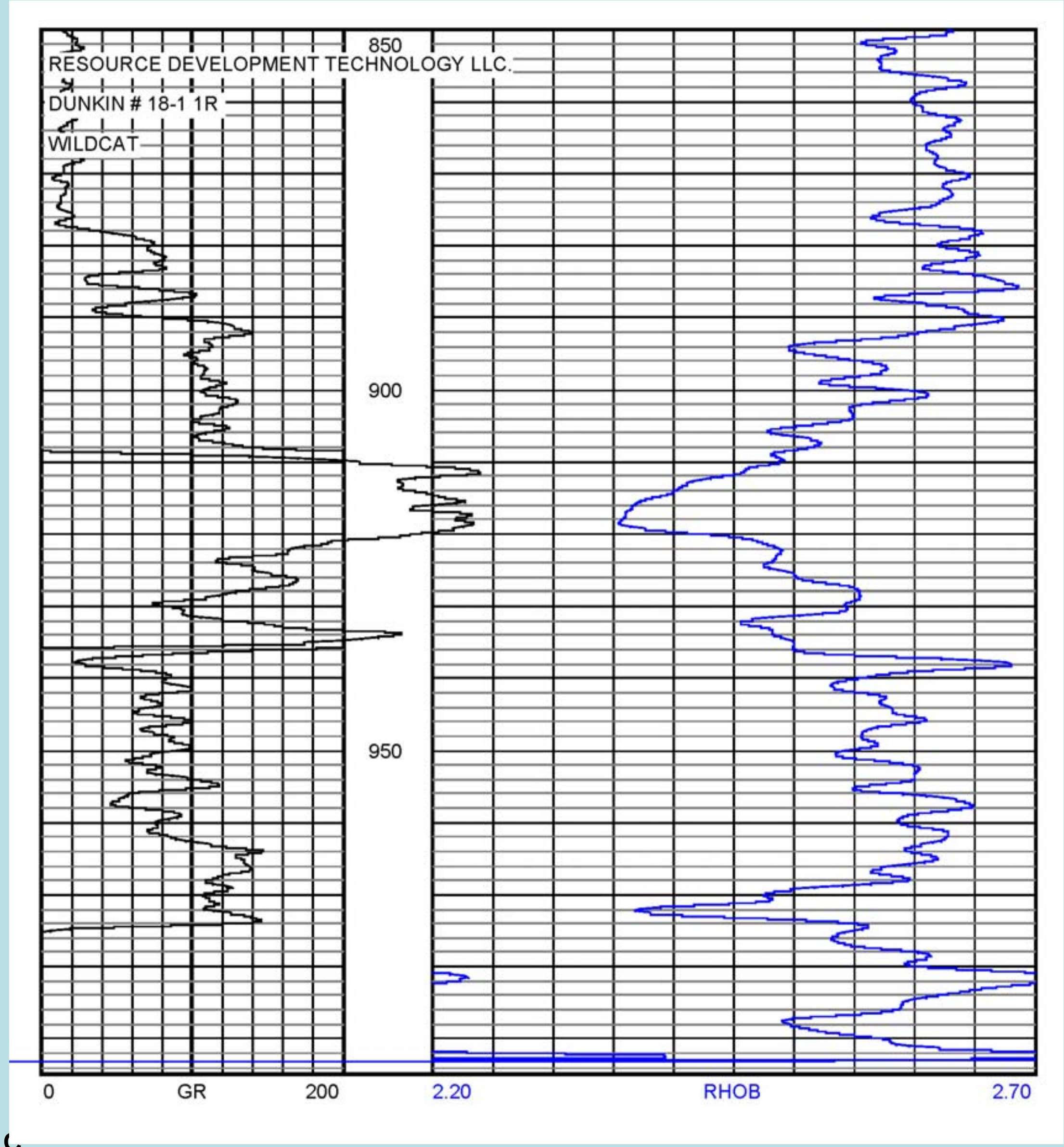
    brittle clastic or carbonate component

- Gas Price

- Woodford Shale Core

Woodford Shale, Oklahoma

- Woodford interval cored
- Core porosity 1% does not match density log porosity of 20%
- TOC 6-12% by weight



Langmiur Isotherm

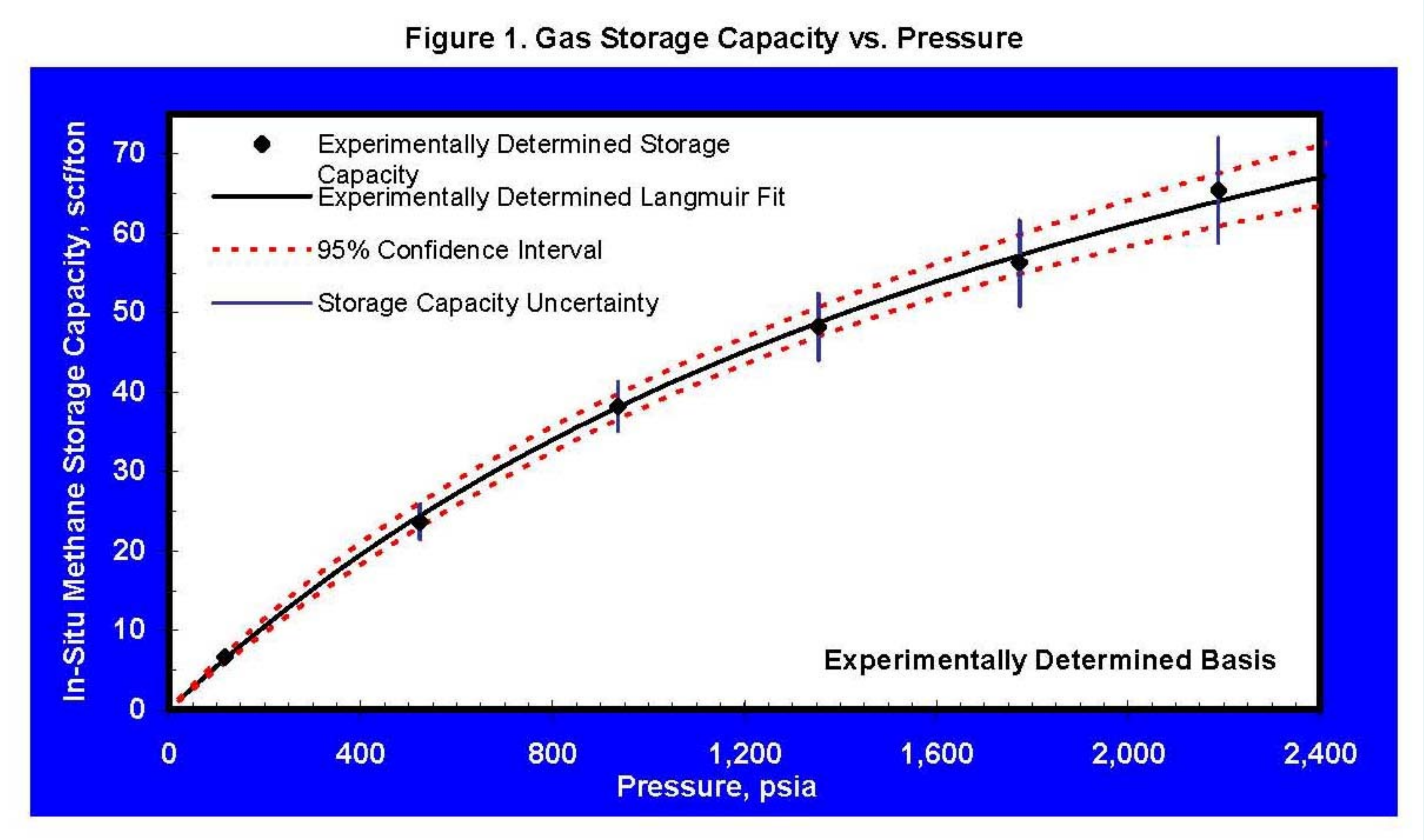


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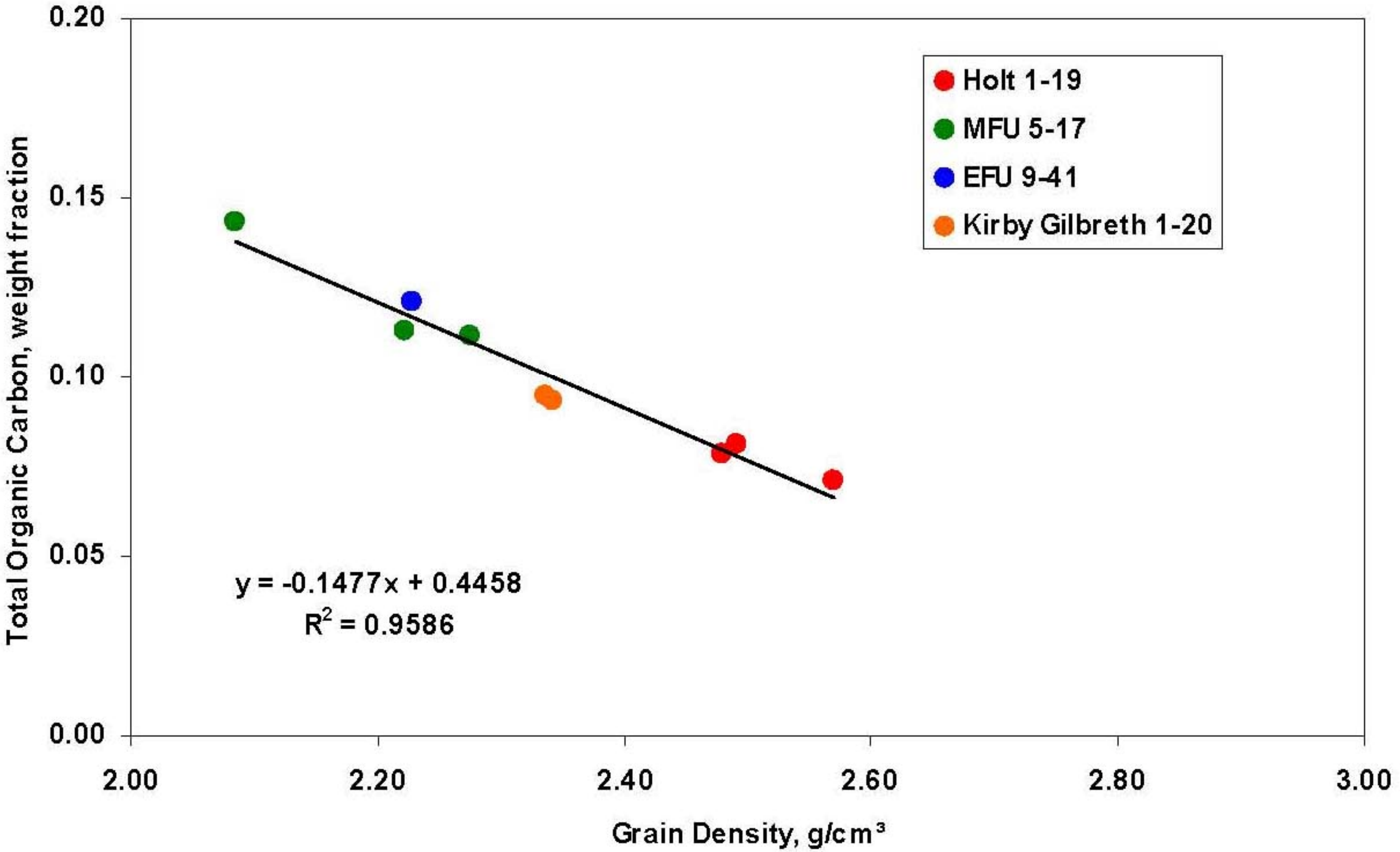
Figure 3-1 Reciprocal Helium Density versus TOC Content



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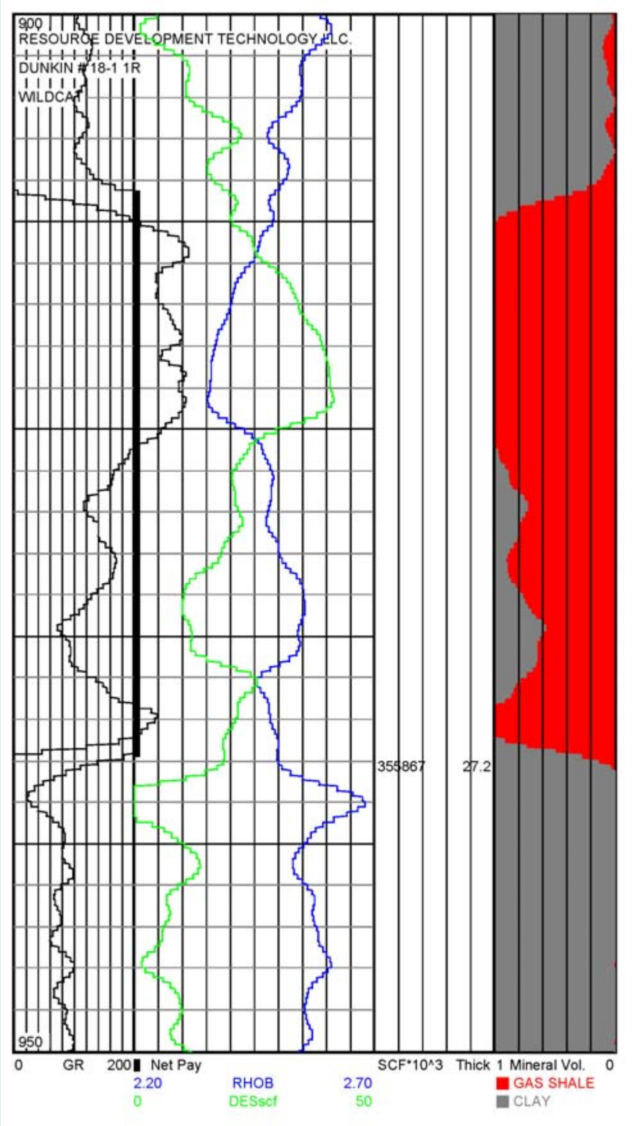
Dunkin 18-11R Woodford Evaluation

- Match core porosity to log porosity
  organic carbon invisible to density log
  organic carbon density 1.0-1.25 gm/cc
  water density 1.0-1.04 gm/cc
  shale density 2.60-2.68 gm/cc
  Adsorbed gas 222 SCF/ton DAF
- Calculate TOC from Density
  Calculate gas from TOC
- Completed without frac stimulation;
- IP 200 BWPD + increasing gas rate; gas increased to 120 MCFD as water decreased

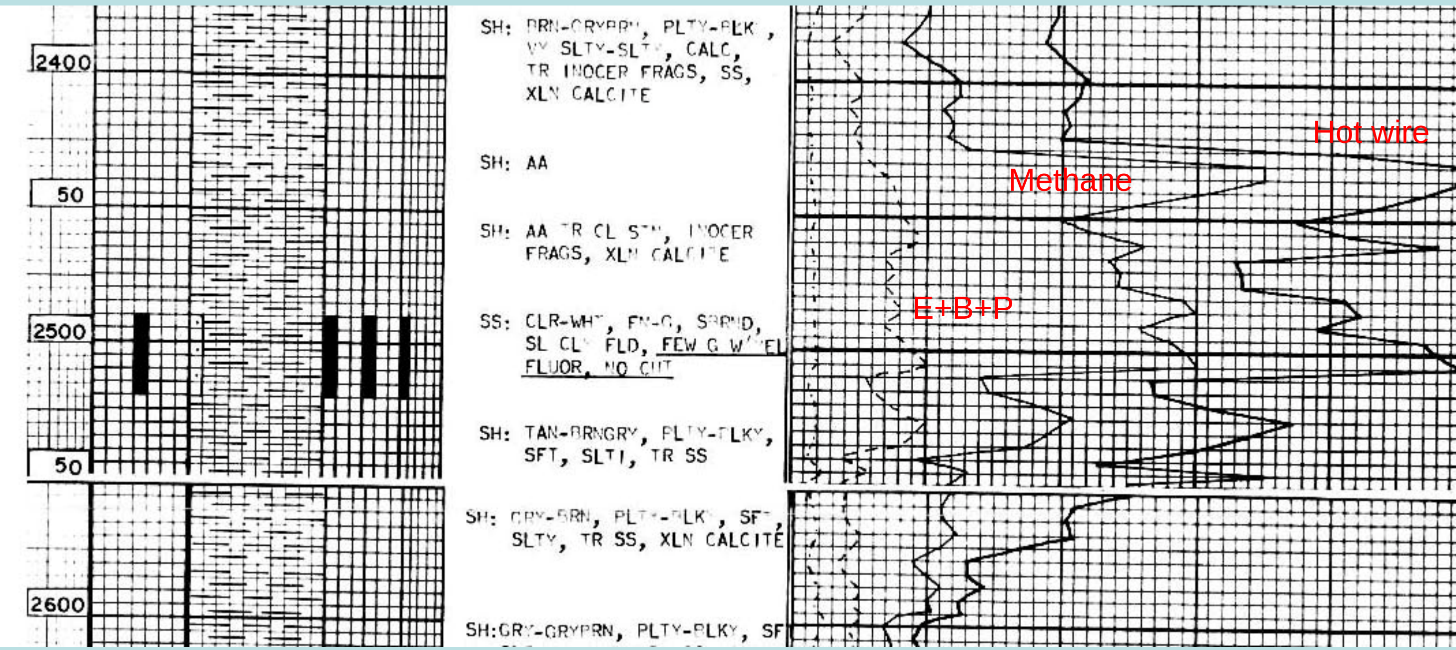


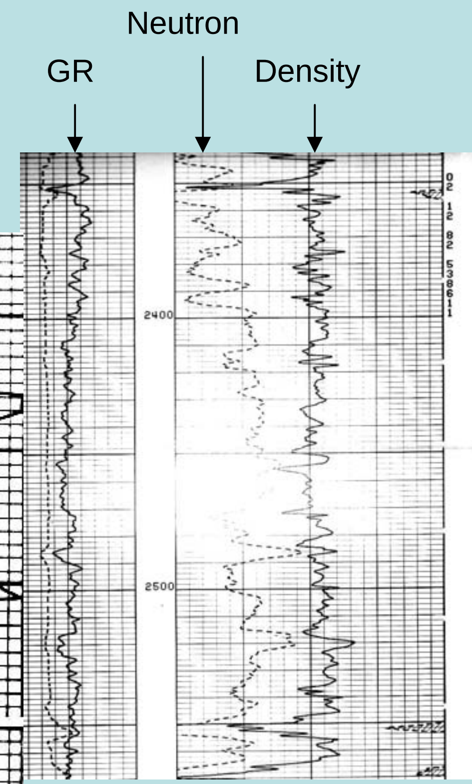
RDT Data, JLog software

Lewis Shale

1.0 to 2.2% TOC Ro=1.6

Shale with 50+% silt





Criteria for Failure

- Insufficient gas content
- High development cost compared to gas price
- Shale plasticity

  low permeability without effective stimulation
- Significant fraction of liquid hydrocarbons

  liquid hydrocarbon surface tension blocks gas flow

Comparison of Selected US Shale Plays

Table 1. Key properties of selected productive gas shales in the US-Metric data

Formation	Barnett	Lewis	Antrim	Woodford
Depth, m	1,980-2,590	914-1,830	180-670	240-300
Net Thickness, m	15-30	60-90	20-37	7.5
TOC %	4.5	.45-2.5	1-20	10
Maturity Ro	1.0-1.3	1.6-1.88	.4-.6	.8
Gas Content, SCF/ton	200-350	1-45	40-100	25
Pressure, MPa	20-28	6.9-10.4	2.7	2.7
Well Cost, NZ$	$2,500,000	$940,000	$450,000	$150,000
Water Prod, LWPD	0	0	790-63,500	15,800-31,800
Reserves, PJ per well	1	0.6	.5	.3
Cost, NZ$/GJ	$2.50	$1.56	$0.90	$0.50
Gas Price, NZ$/GJ	$9.40	$8.75	$12.50	$10.00
Gas Type	Thermogenic	Thermogenic	Biogenic	Catalyzed

From Hill and Nelson, 2000; Ayers and Tian, 2007; RDT data; Mango, 2007
Vertical wells only

Application to New Zealand

We are looking for:

- Restricted basin with organic rich shales
- Maturity=Vitrinite .4-.6 biogenic .5-1.0 catalyzed 1.0+thermogenic
- Clastic or carbonate component for brittle deformation
- Aerial extent
- Combined thickness and TOC
- Depth for economic development
- Low drilling and completion cost (onshore)
- Proximity to pipeline
- Steady market demand

Well Cost Comparison

Table 2. Drilling Cost Comparison, NZ Dollars

	320 m Oklahoma	520 m NZ Onshore	1,800 m New Mexico	2000 m NZ Onshore
Site work	$ 6,250	$ 10,000	$31,250	$125,000
Drill, case and equip	$130,000	$ 650,000	$687,500	$2,600,000
Open hole logs	$ 6,250	$ 50,000	$25,000	$100,000
Completion	$ 6,250	$ 20,000	$25,000	$50,000
Frac stimulation	$ 60,000	$ 300,000	$187,500	$750,000
TOTAL WELL	$208,750	$1,030,000	$956,250	$3,625,000
		4.9x		3.8x

Cost in New Zealand dollars NZ$

Cost based on recent RDT experience and quotes for similar work in New Zealand

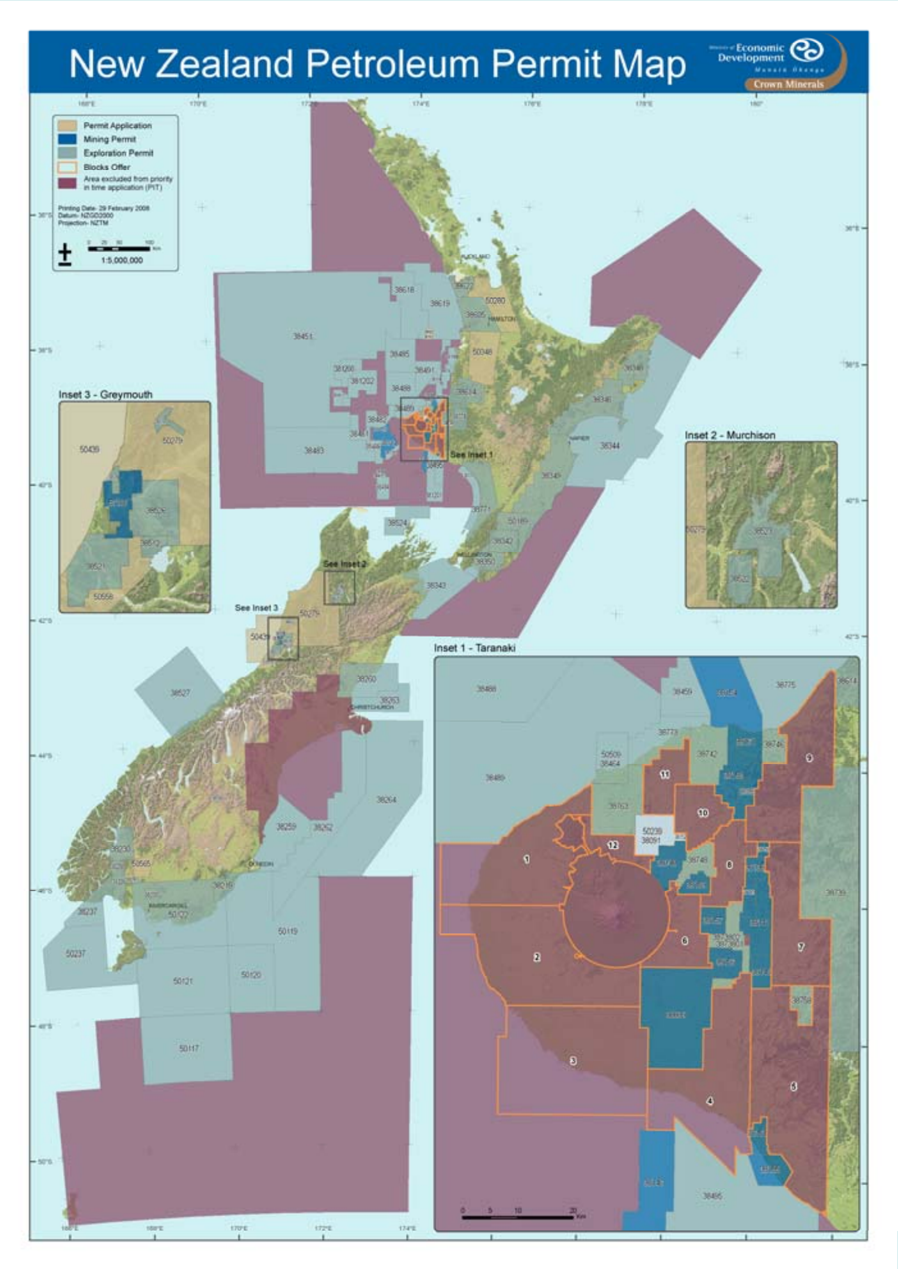
Comparison of Characteristics of New Zeland Shales

Table 3. Key Properties of Potential Shale Plays, New Zealand (with speculation about wells)

Basin	Waipawa North	Waipawa ECB	Whangai ECB	Taranaki-Turi
Depth, m	300	300-1800	400-2000	3000-4000
Net Thickness, m	15	17	400	200
TOC %	6-12%	3.6%	.56%	2%
Maturity Ro	?	.32-.37	.65	.44-.52
Gas Content, SCF/ton		25-100	10-40	25-200
Pressure, MPa	2.7	2.7-10.4	3-12	12-20
Well Cost, NZ$	$1,100,000	$1,100,000- $3,600,000	$1,500,000 $5,500,000	$6,000,000- $12,000,000
Water Prod, LWPD	1,000-30,000	1,000-30,000	0	0
Reserves, PJ per well	.3	.3-1.0	1	1
Cost, NZ$/GJ	$3.67	$3.60-$3.70	$5.00-$5.50	$6.00-$12.00
Gas Price, NZ$/GJ	$6.00	$6.00	$6.00	$6
Gas Type	Biogenic	Biogenic	Mixed	Thermogenic

Data from King and Thrasher, 1996; Lowery, 1988; Sproule/GNS 2007;
Pressure assumed to be hydrostatic
Gas content estimated from Langmiur isotherm at hydrostatic pressure; gas reserves from gas content, TOC value, depth, thickness, analogy to shale gas in the US

- Permits cover most prospective shale basins



Conclusions

- The Waipawa shales and equivalents have similar lithology and TOC to productive US shales
- Shales in onshore NZ are less mature than any producing US shale plays
- Shales gas is only economic near existing pipelines
- Shale gas does not have sufficient deliverability for offshore costs
- Shale in onshore basins is not continuous enough for development
- Occurances of Waipawa shale onshore, near pipeline are under existing concessions
- The high costs of drilling in New Zealand make shale development uneconomic at gas prices below $7.20/GJ