Pitfalls in Assessing Lacustrine Shale Versus Marine Shale Prospects*

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Abstract

Most organic shales that are evaluated for oil and gas potential were deposited in a marine environment. Explorationists commonly incorporate a number of techniques and analyses to quickly evaluate or screen the quality of these shales.

However, these techniques are not always appropriate for the evaluation of lacustrine shales. This is due to the significant differences in the water and rock chemistries, and the organic deposition, between marine and lacustrine environments.

Newly deposited organic material can extract uranium ions from seawater that results in increased radioactivity in marine shales. High gamma ray counts often signal high total organic carbon (TOC) shales. Uranium concentrations in lake waters are quite variable and generally much lower than ocean waters. Thus in some cases, the highest TOC shales are marked by lower gamma ray signatures than associated non-prospective shales.

Lakes can be internally, or poorly, drained, which can lead to the precipitation of a wide range of minerals depending upon the lake chemistry. In some cases, these minerals have a high density that can mask the TOC content and porosity of the rock.

RockEval analyses from lacustrine shales may also be misleading. Lacustrine shales are generally rich in Type I organic material, whereas marine shales are rich in Type II organic material. Type I organic carbon contains approximately one third more generative organic carbon than Type II. Thus, marine shales have more non-generative organic carbon that is of little value. In mature lacustrine shale, this results in low TOC values that may condemn the play whereas, in reality, there have been significant hydrocarbons generated and significant secondary porosity created.

Examples from the Frederick Brook shale of southern New Brunswick will be used to illustrate these points.

Reference Cited

Jarvie, D.M., 2012, Shale resource systems for oil and gas: Part 2 – Shale oil resource systems, *in* J. Breyer, (ed.), Shale reservoirs – Giant resources for the 21st century: AAPG Memoir 97, p. 1-31.

PITFALLS IN ASSESSING LACUSTRINE SHALE VERSUS MARINE SHALE PROSPECTS

Tom Martel

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Companies Searching for New Opportunities

- Exploration companies searching globe for new shale plays
- Screening criteria derived from North American shales
- However, all these were deposited in marine environments
- Frederick Brook shales of New Brunswick, Canada were deposited in lacustrine (lake) environments
- Typical shale screening methods do not apply

Initially Screen For High Organic Shales

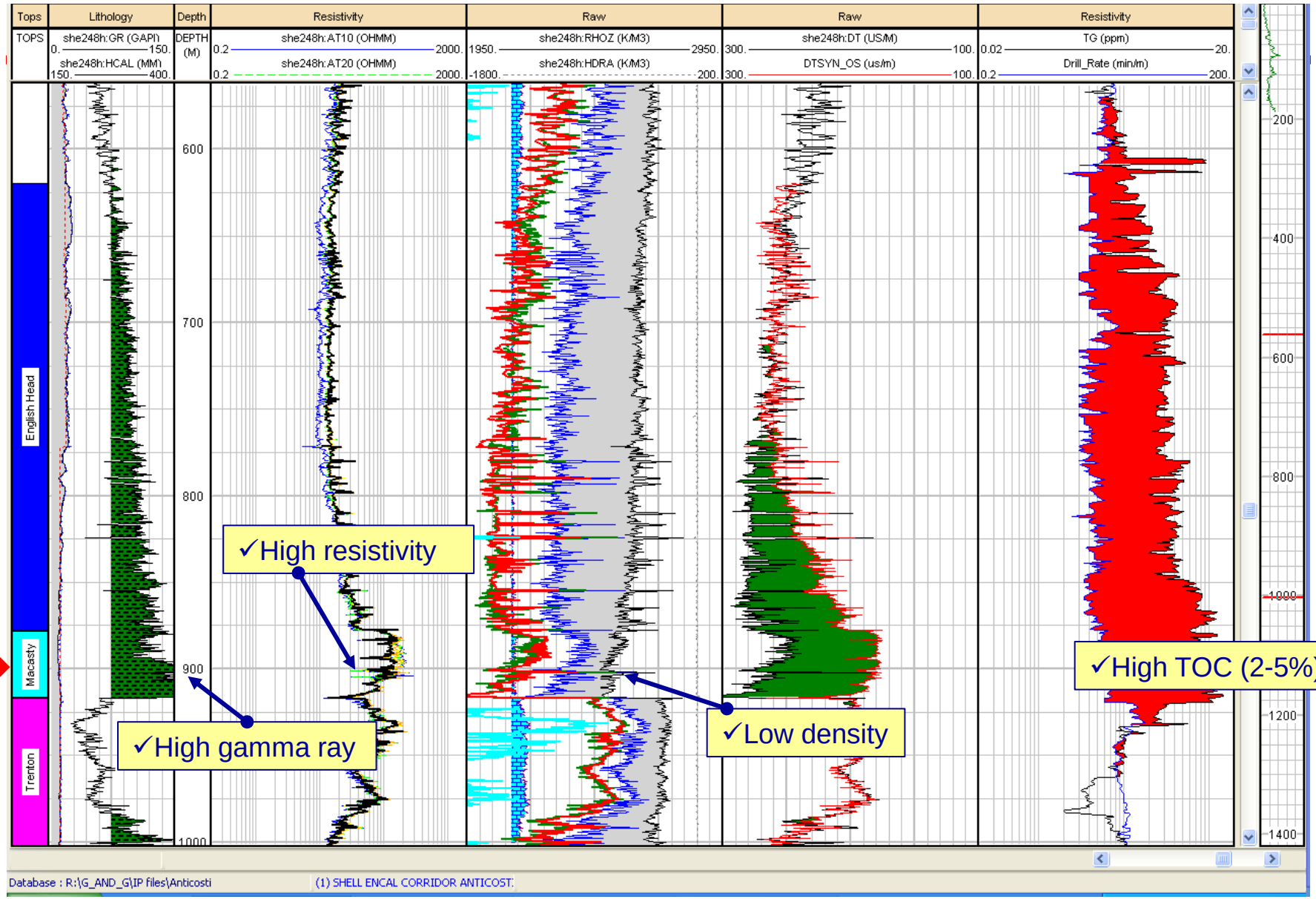
- High Total Organic Carbon (TOC)
  - Organic carbon generates hydrocarbons
  - Provides porosity for hydrocarbon storage
- Shales are screened using wireline logs

In Marine Shales the Log Indicators to Look for are:

- High gamma ray values
  - Organic carbon extracts uranium from seawater to produce high gamma shales
- Low rock densities
  - Organic shale low densities due to the low density of organics (1.0 vs 2.6 g/cm^3)
- High resistivities
  - Resistivities increase with organic carbon and free hydrocarbon content (insulators)

MARINE SHALE EXAMPLE

Utica/Macasty Fm, Anticosti Island

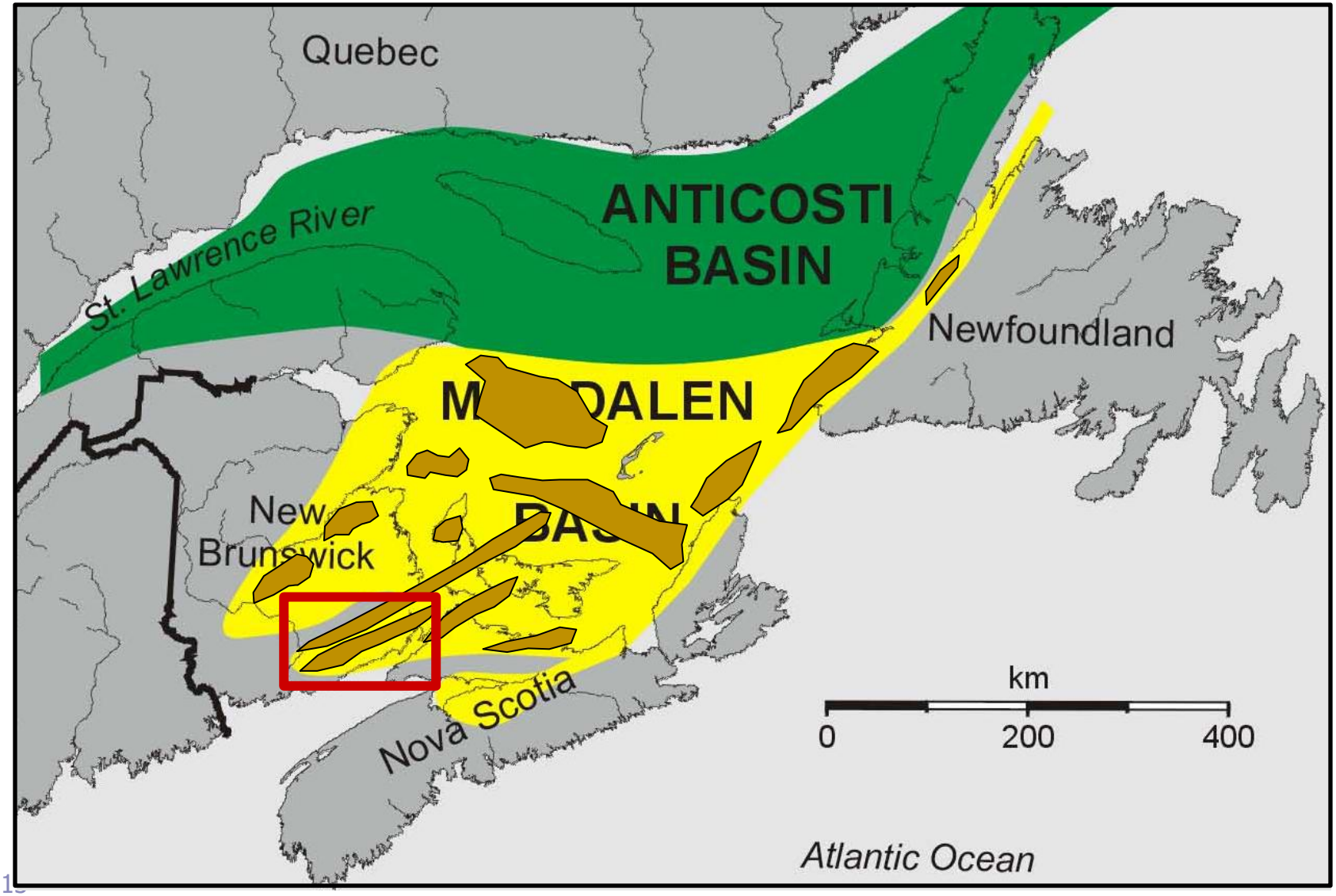


LACUSTRINE ORGANIC SHALES

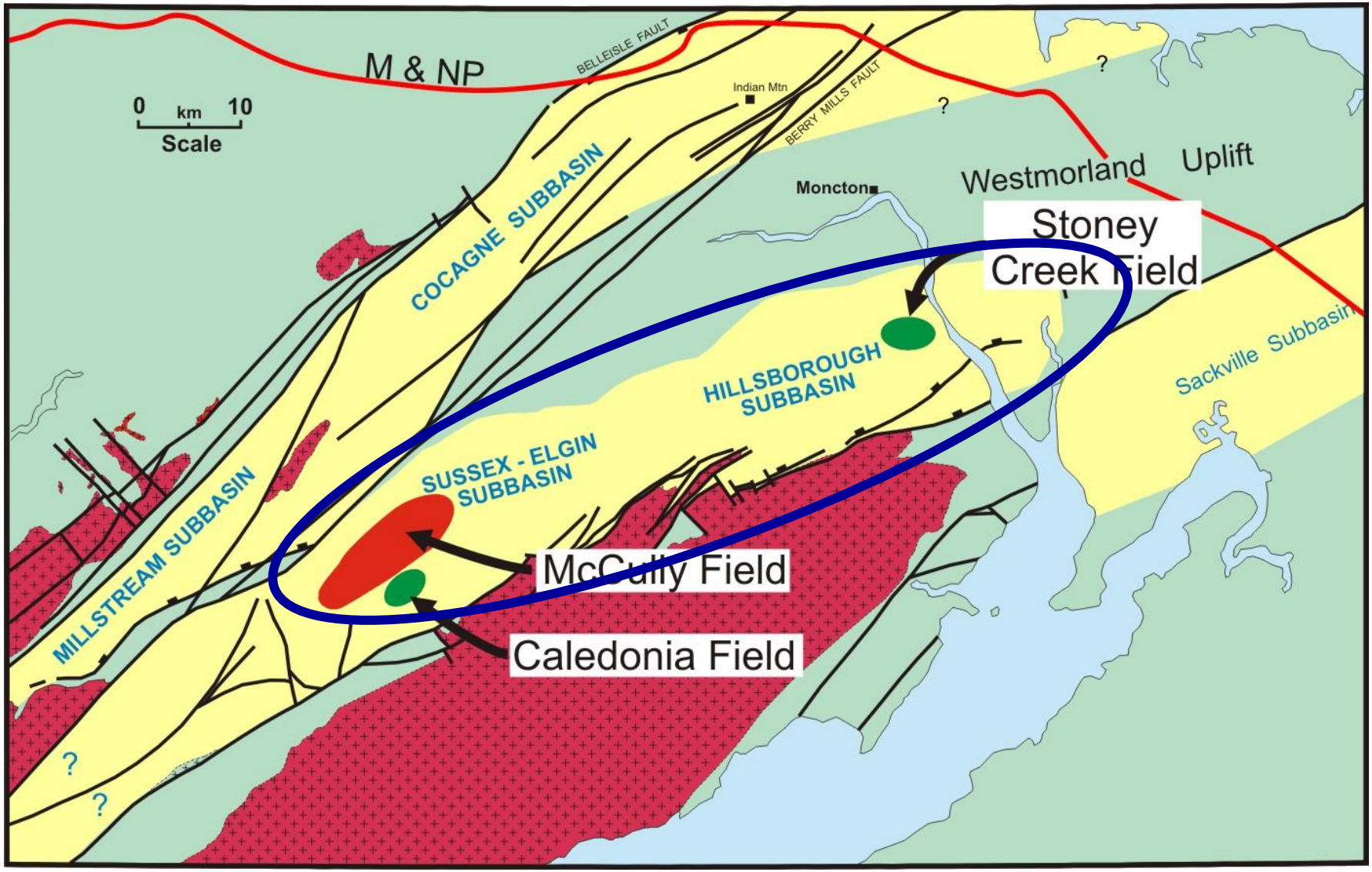
FREDERICK BROOK FM

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011

Magdalen Basin



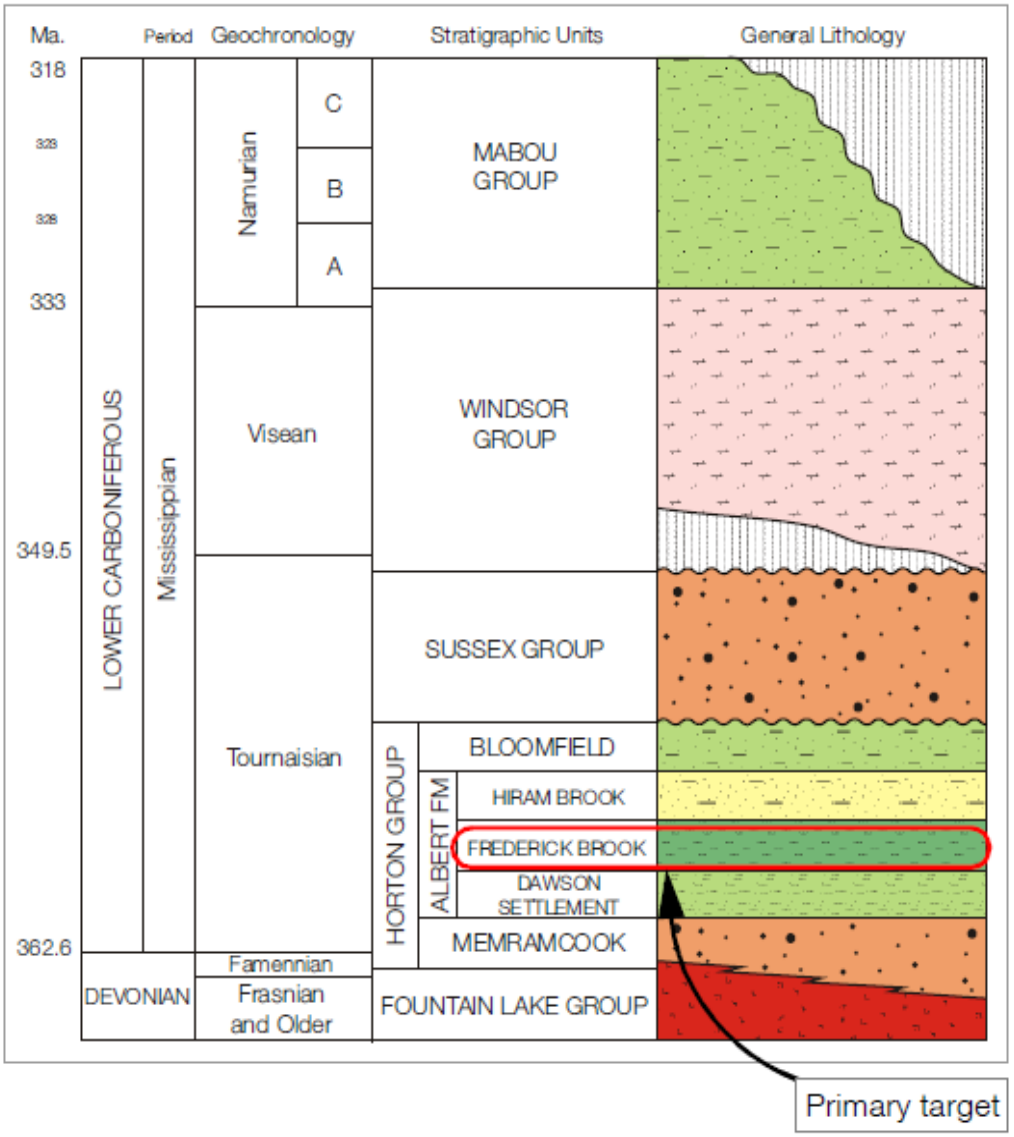
Deep Horton Basins in Southern New Brunswick



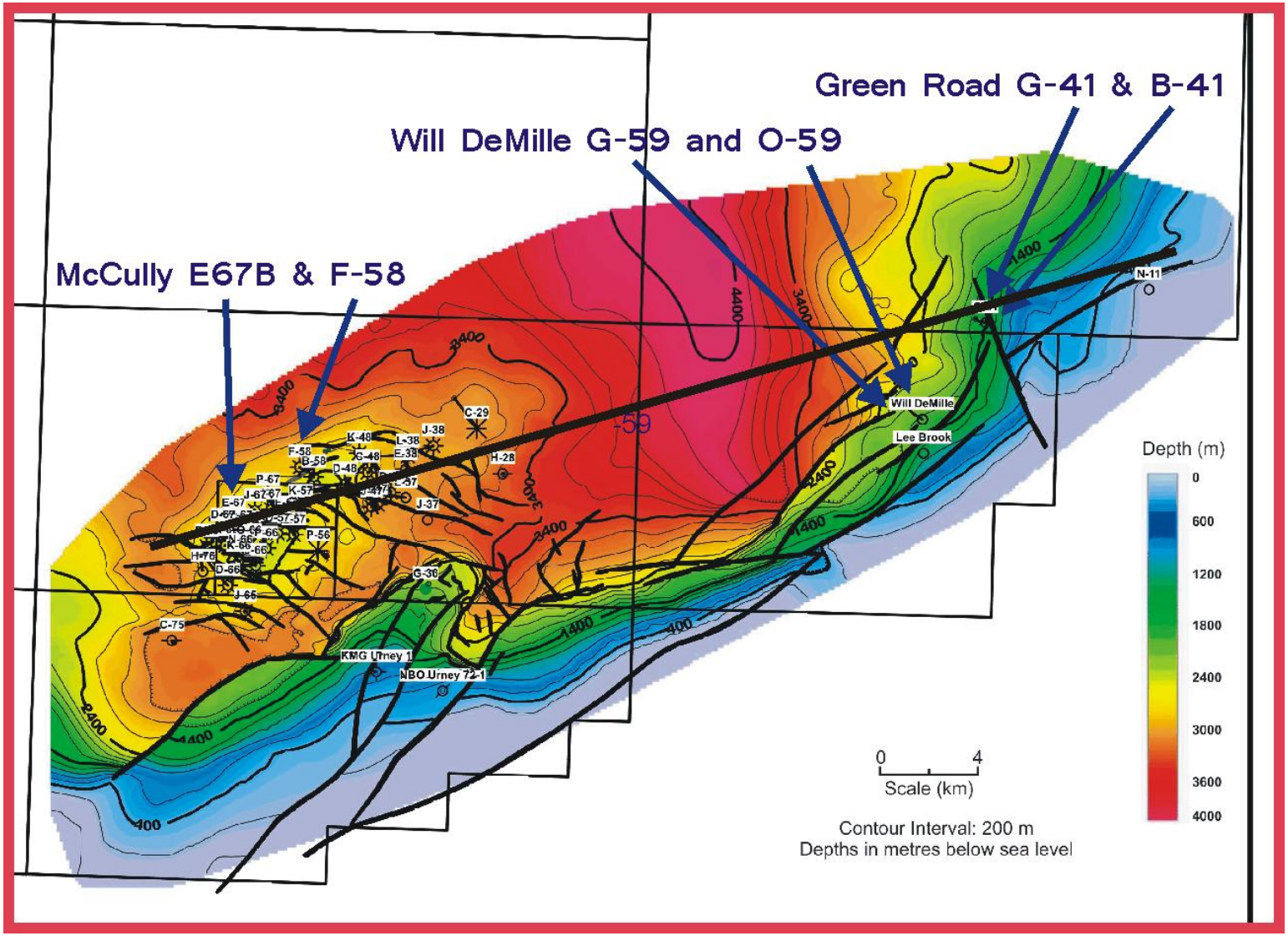
New Brunswick Carboniferous Frederick Brook Shale

Deposition in widespread regional basins

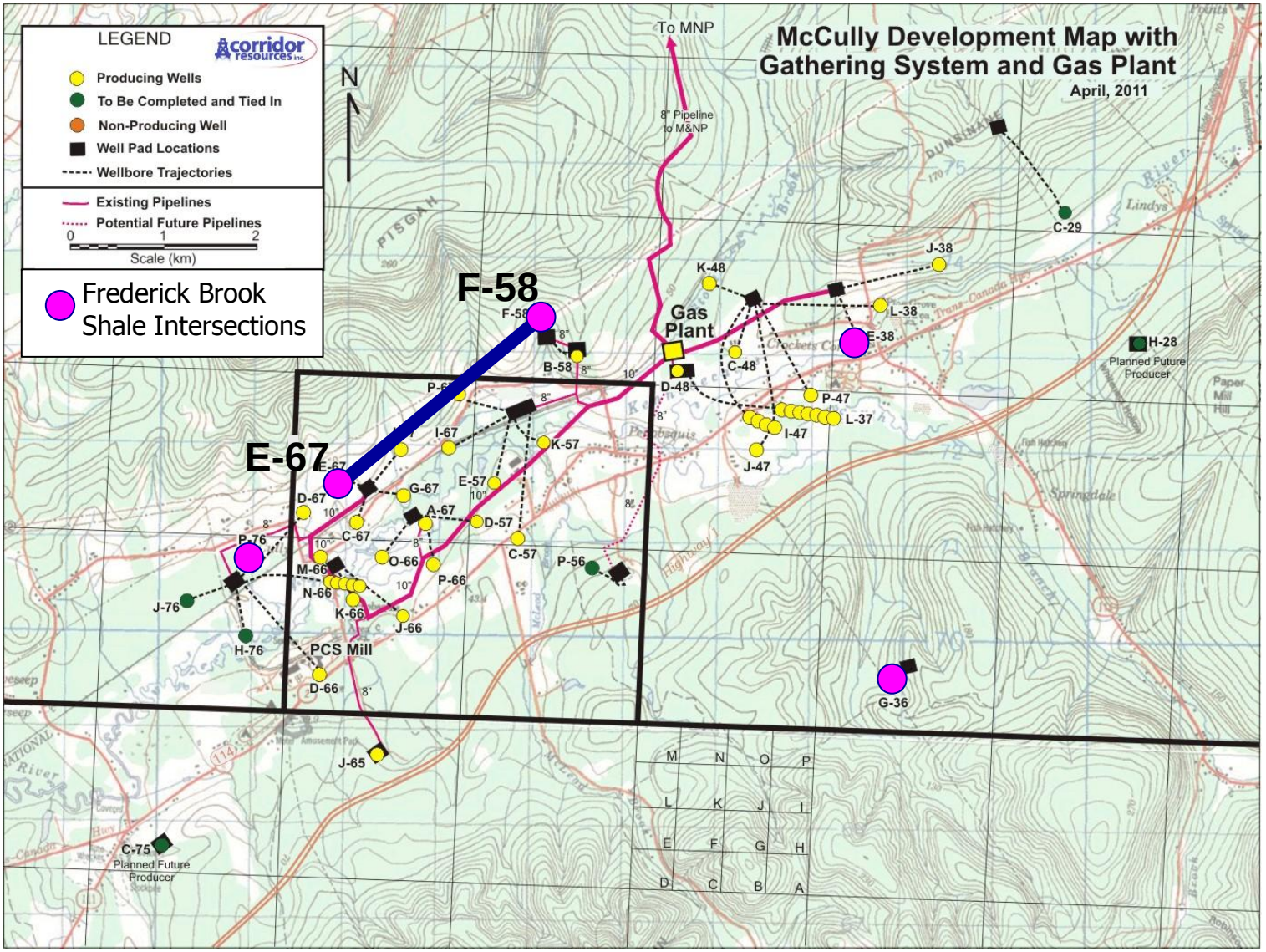
Deposition in restricted deep strike-slip basins

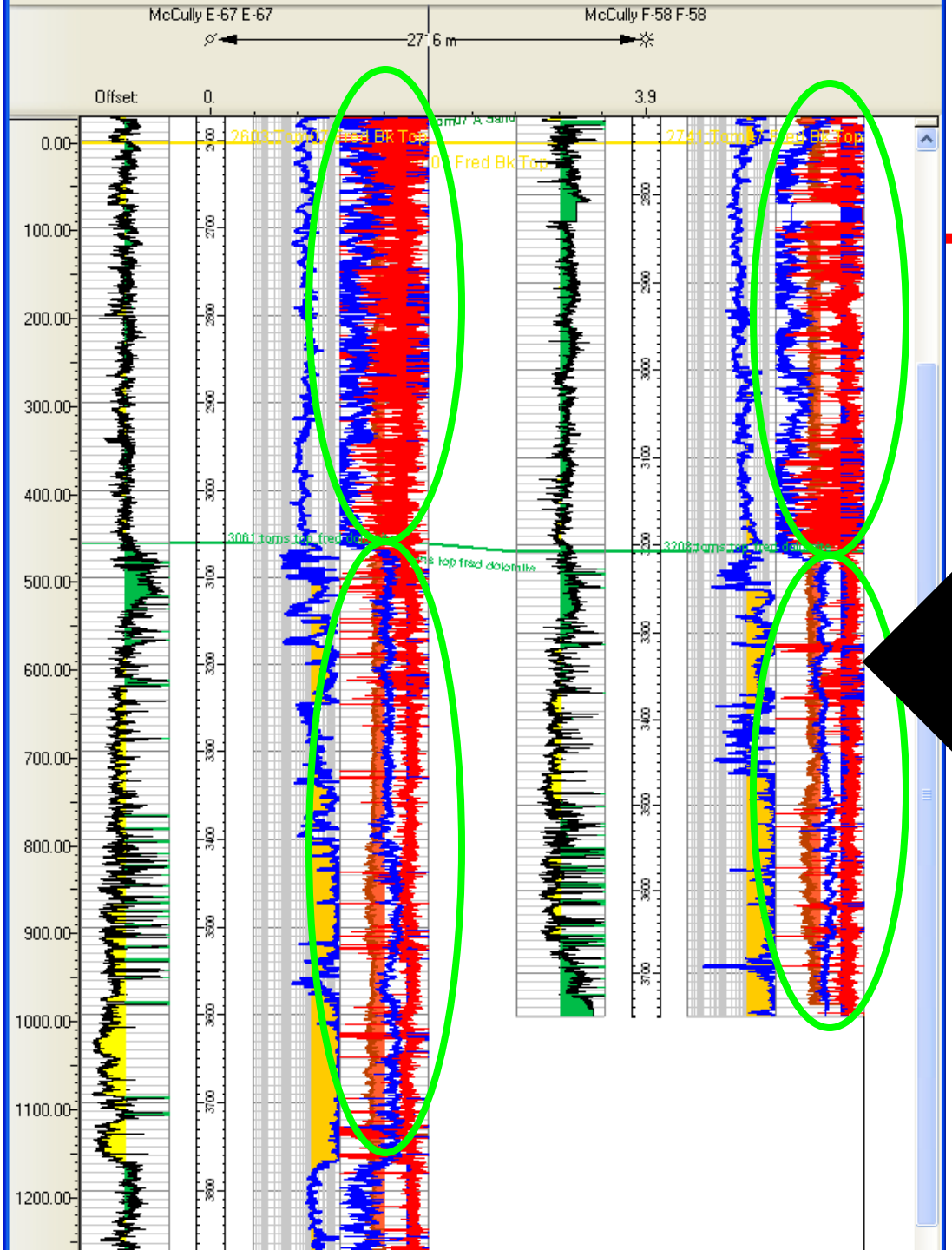


Depth to Top Frederick Brook



Frederick Brook Shale Wells





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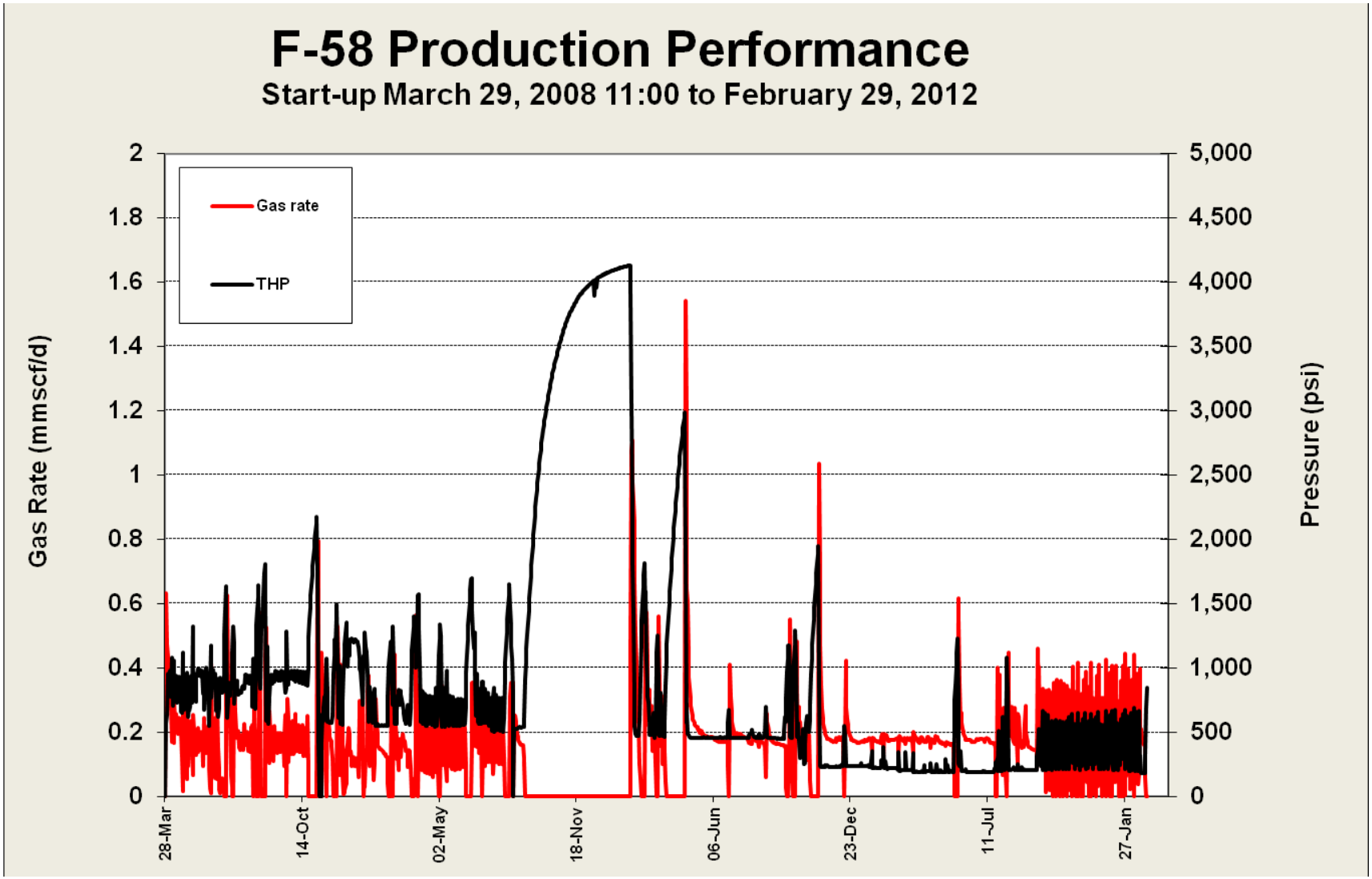
Upper Frederick Brook

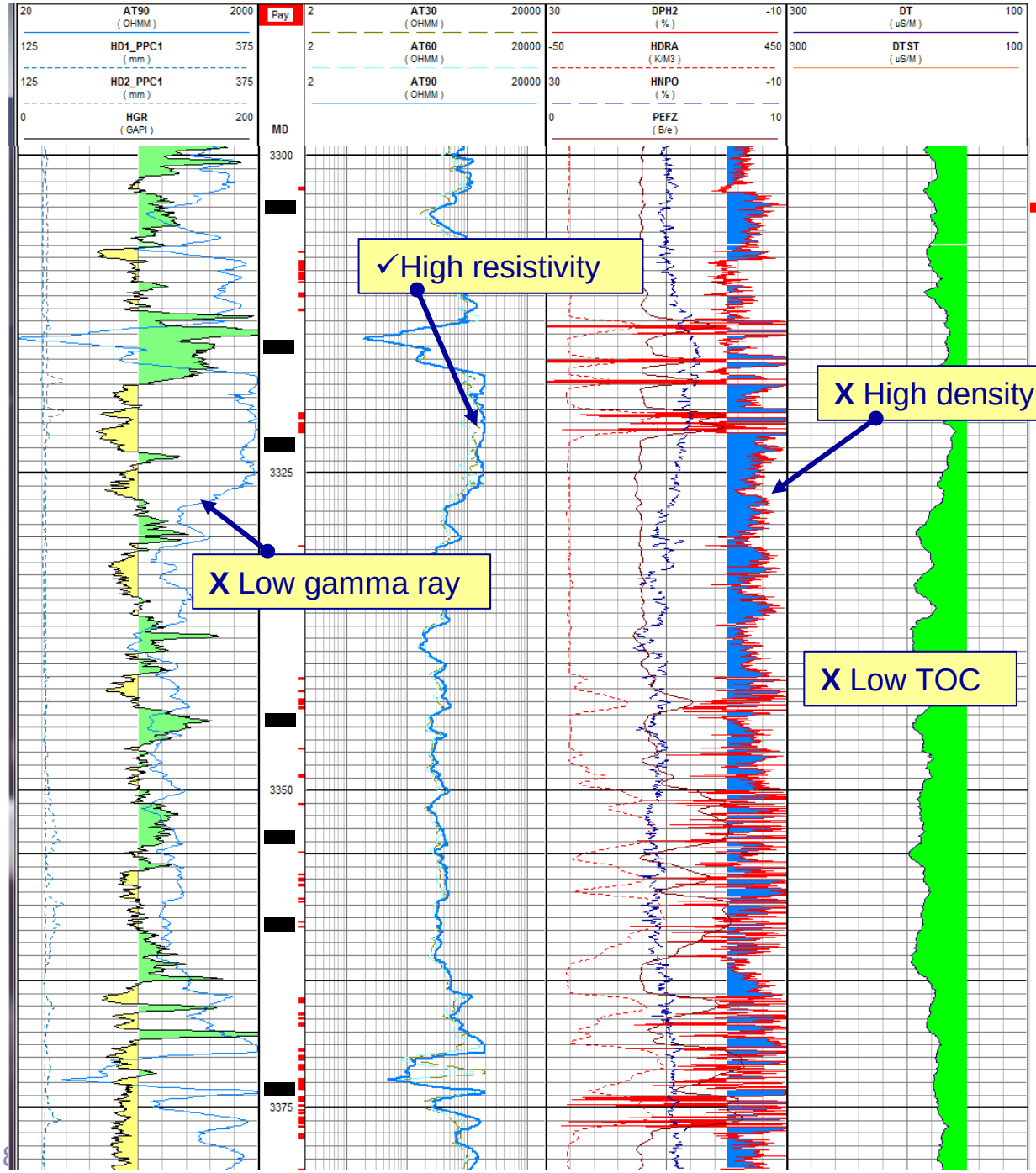
- 450 m thick
- Composed of clay, quartz and dolomite
-Tested gas in G-41

9 tonne frac

- 700 m thick
- Composed of albite, dolomite quartz and clay
-Producing gas in F-58

F-58 Production History





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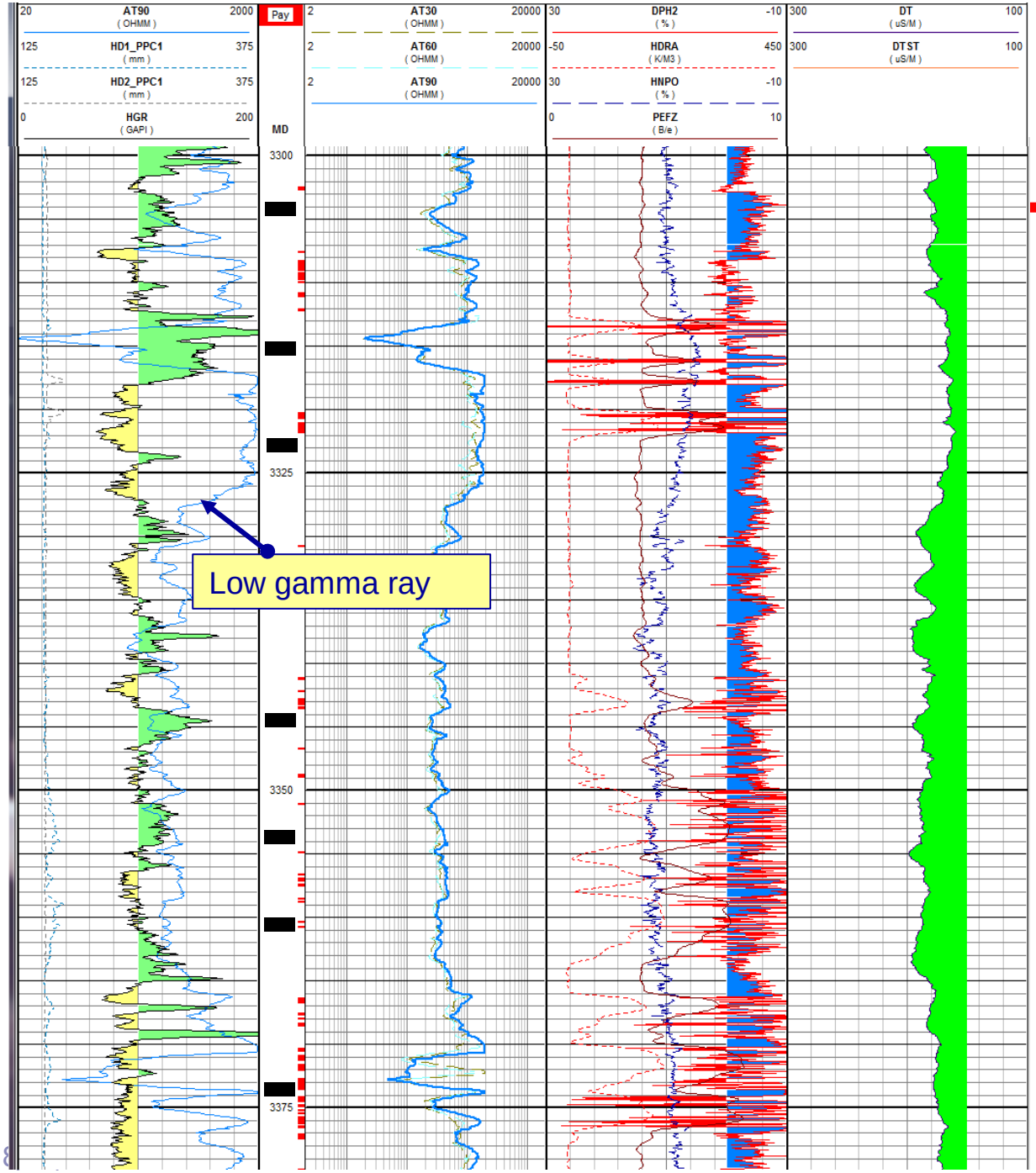
F-58 Producing Interval

These shales have:

- Low gamma ray
- High resistivity
- High density
- Low TOC
- One BCF EUR

Gamma Ray Counts

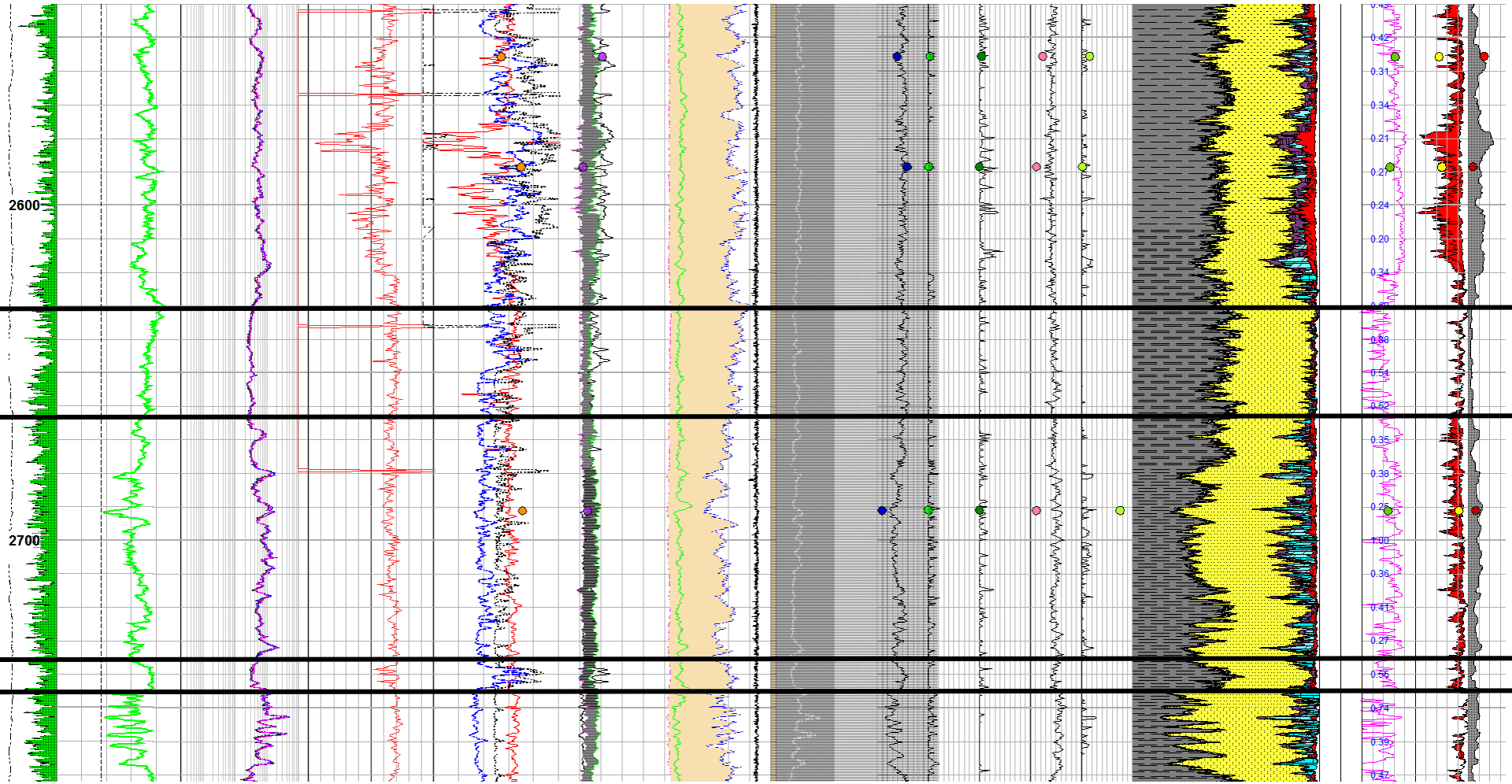
- High gamma ray values (marine)
  - Organic carbon extracts uranium from seawater = high gamma shales
- Low gamma ray values (lake)
  - Lake waters usually low in radioactive components, drainage basin dependant
  - Therefore, gamma does not correlate to TOC



F-58 Producing Interval

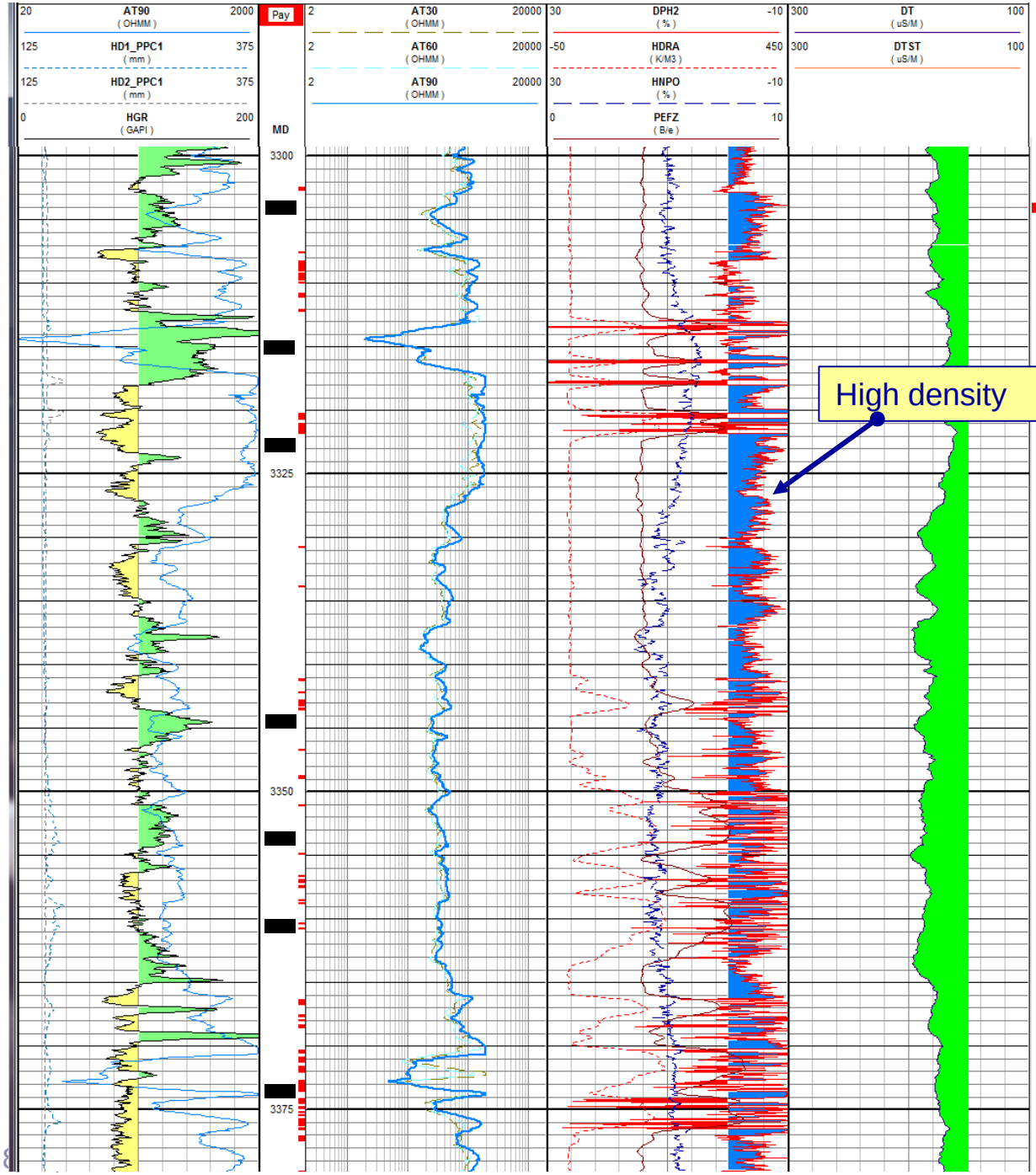
- Low gamma ray

Will DeMille O-59
Frederick Brook Shale



Rock Density

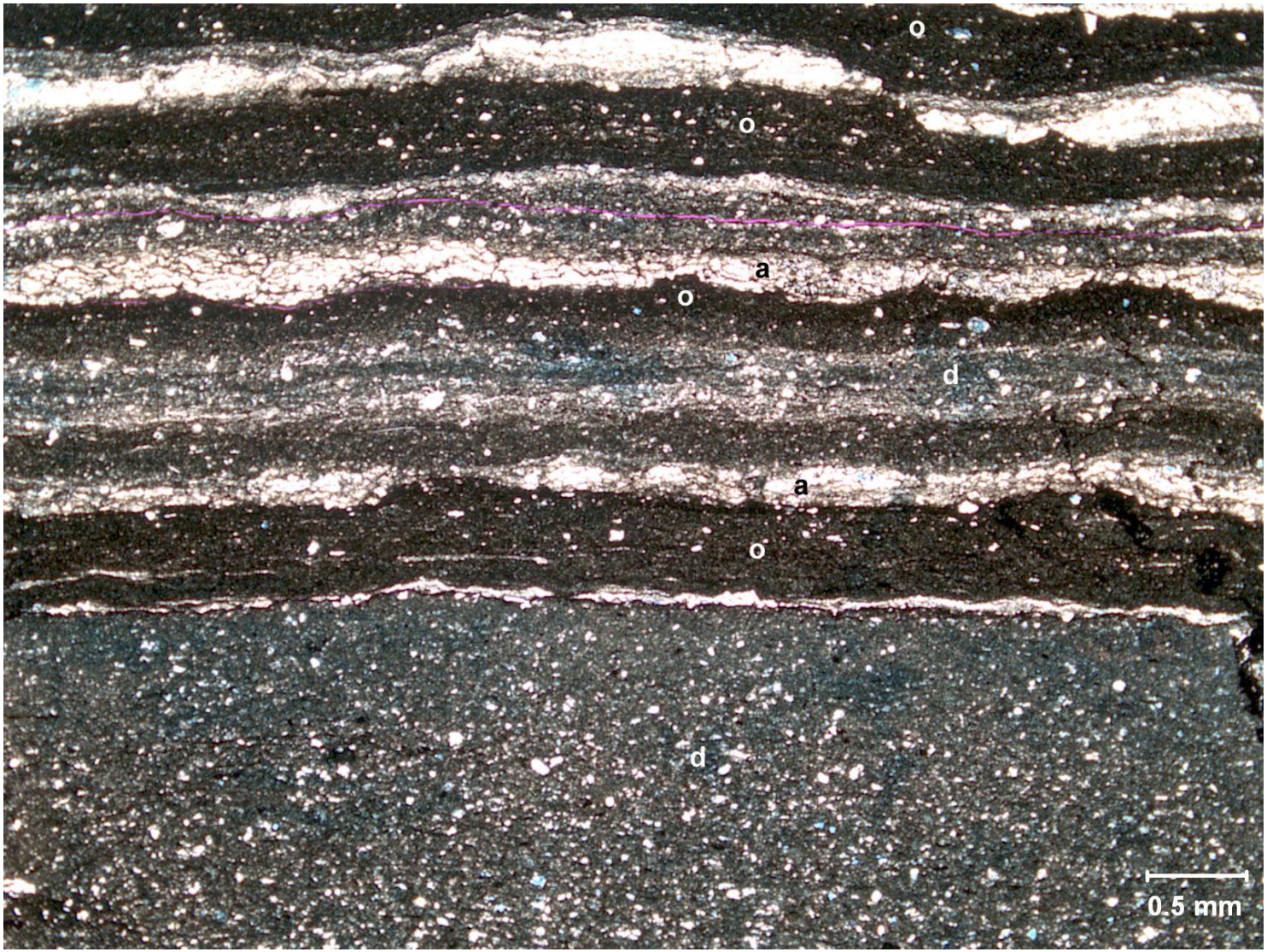
- Low rock densities (marine)
  - Organic shale low densities due to low-density organic matter
- High rock densities (lake)
  - Some Frederick Brook shales have abundant (dense) feldspar and iron dolomite precipitates
  - These precipitates are associated with organic deposition
  - Despite organic content, results in high density



F-58 Producing Interval

- High density

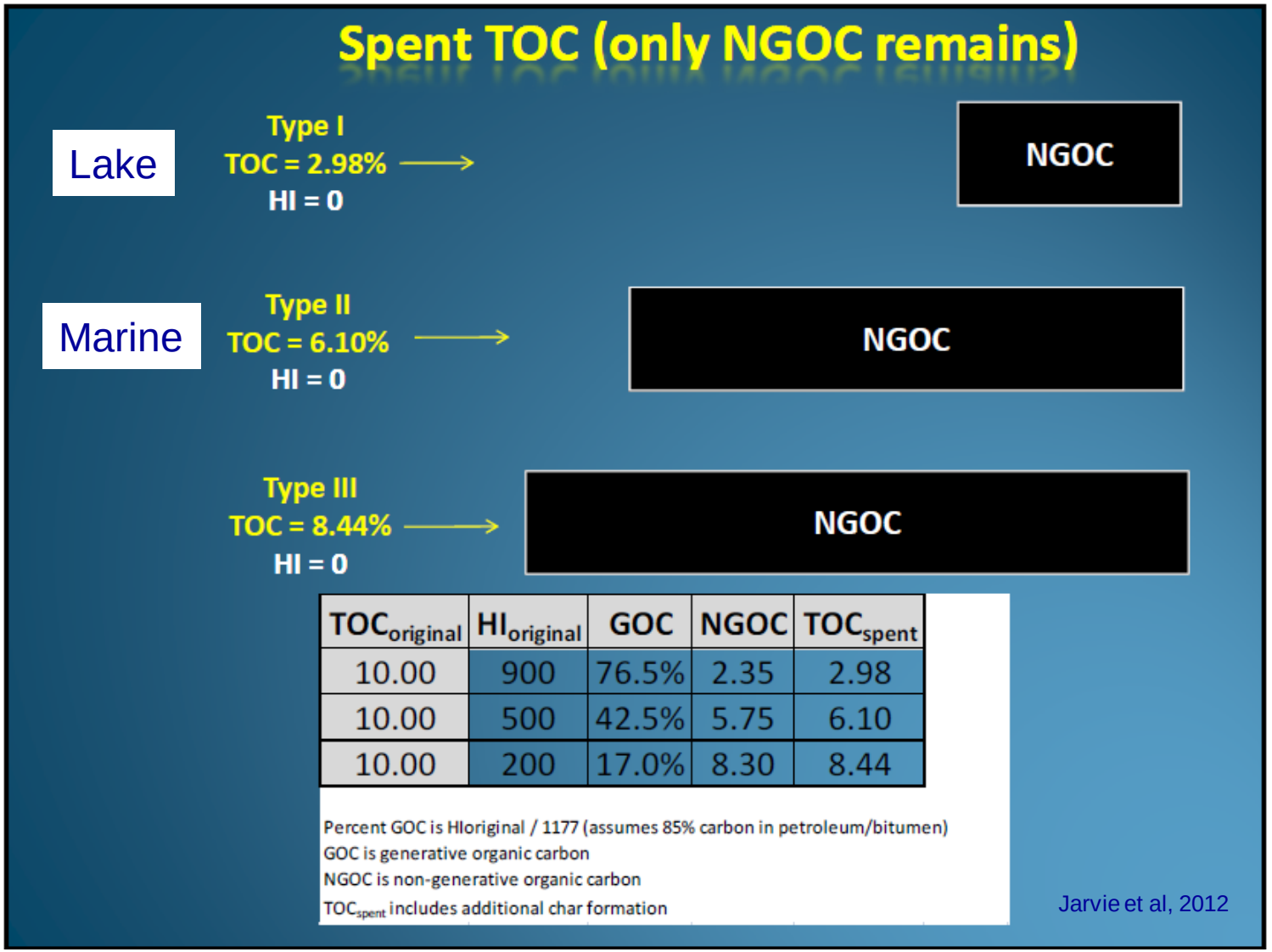
McCully P-76 2583.3 m



Measured TOC

- High TOC percentages (marine)
  - Prospective shales generally have > 2% of Type II TOC remaining in the rock
- Low to high TOC percentages (lake)
  - Lakes mainly Type I organic carbon
  - More generative capacity (higher quality)
  - More organic carbon is transformed to hydrocarbon leaving less in the rock

Frederick Brook is Type I

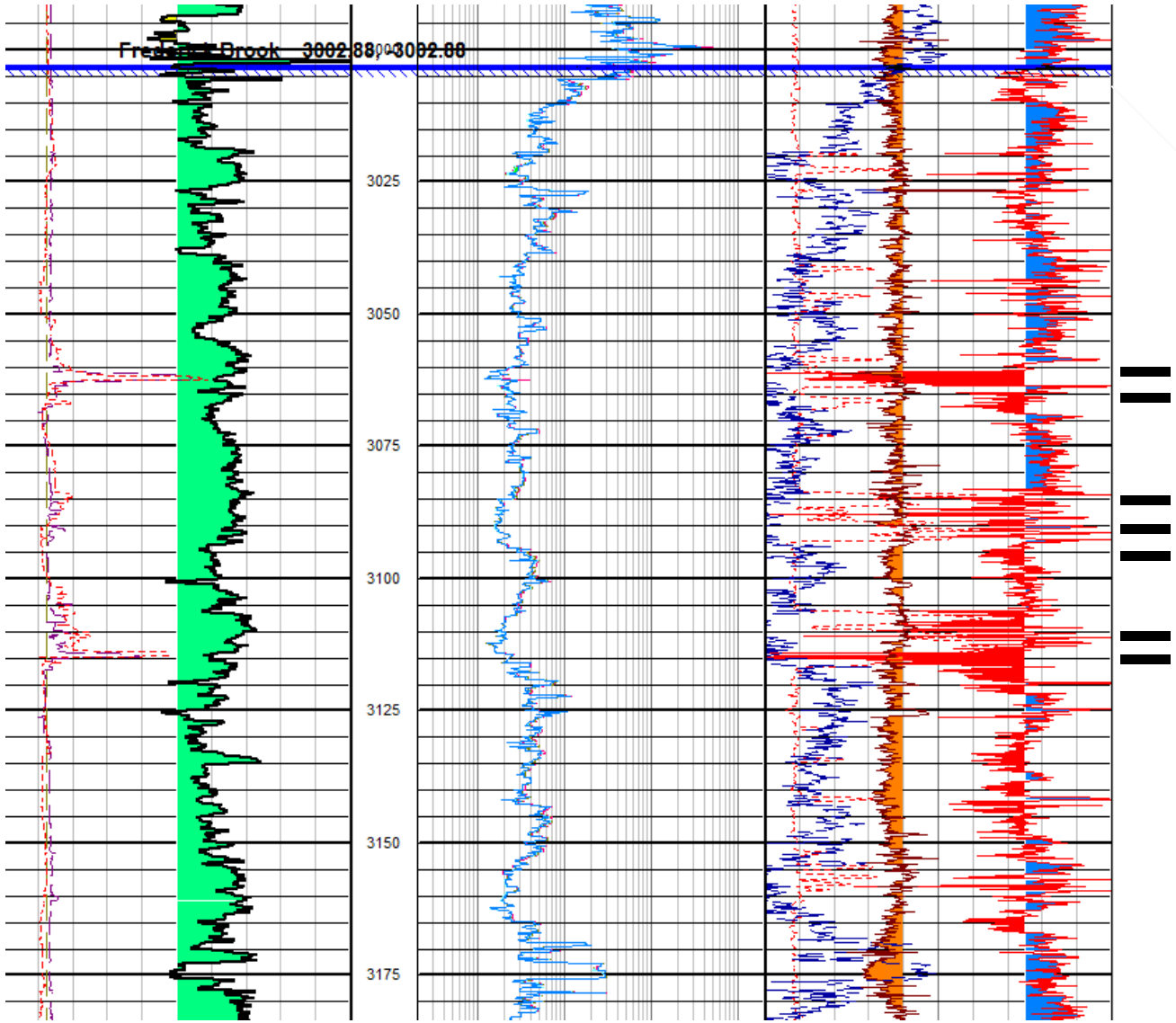


$TOC_{original}$	$HI_{original}$	GOC	NGOC	TOC_{spent}
10.00	900	76.5%	2.35	2.98
10.00	500	42.5%	5.75	6.10
10.00	200	17.0%	8.30	8.44

Percent GOC is HIoriginal / 1177 (assumes 85% carbon in petroleum/bitumen)
GOC is generative organic carbon
NGOC is non-generative organic carbon
TOC_{spent} includes additional char formation

Jarvie et al, 2012

What Did Not Work



Interpretation

- Albite and dolomite precipitates are result of solute concentration during reduced water influx
- Organics may be elevated as a result of additional nutrients/less dilution.
- Result: Low gamma, high density, higher TOC
- Higher clay contents may result from increased water influx
- Result: Higher gamma, lower density, lower TOC

Conclusions

- Shale gas screening in marine shales does not translate to lacustrine shales
- This is because:
  - High gamma and high TOC are not correlatable in lacustrine shales
  - Very heavy minerals can mask TOC content
  - Lacustrine rocks with low TOC values may have generated significant hydrocarbons and porosity
- A more detailed evaluation is required to assess lacustrine shale potential

Acknowledgements

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