Quick Look Determination of Oil-in-Place in Oil Shale Resource Plays*

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Abstract

Quantitative measurements of gas-in-place volumes for coal gas and shale gas resource plays have been important and powerful starting points for planning optimized economic gas extraction. Quantitative desorption measurements of gas-in-place have strongly assisted investor confidence in the exploitation of coal gas and shale gas plays. Gas-in-place measurements provide the resource target that can justify on-going technical and business investments in gas shale resource plays.

With recent successes in apparent commercial extraction of oil from shale, such as in the Eagle Ford Shale of South Texas and the Woodford Shale of southern Oklahoma, the question arises as to the efficiency of oil recovery using current completion and drilling technologies. Given the high likelihood that these plays will prove to be long-term endeavors, it is a strategic and economic imperative that recovery efficiency be optimized, the starting point being the reliable definition of the size of the oil-in-place resource. While this approach does not determine how much oil can be recovered, it provides a measurement of the maximum amount of oil-in-place, the target volume of the play area.

We propose a quantitative measure of oil-in-place from measurements of the distillable oil in an oil shale, specifically from the S1 measurements of a standard Rock-Eval analysis. The measurements obtained may then be up-scaled to calculate oil-in-place for a given formation, trend or basin. By comparing these estimates to estimates of ultimate recovery per well-bore based on decline curve analysis, operators may glean greater insight into their recovery efficiency, and as a result determine the need for, and lay plans to carry out the minimum amount of drilling and formation fracturing to ensure the maximum amount of oil extraction. The ultimate recovery efficiency will be determined over time by iterative applications of technology.

In testing the technique, measurements were made in the Eagle Ford Shale of South Texas and in the Woodford Shale of southern Oklahoma. Comparisons were made between immature, mature and over-mature source rocks and between core derived measurements and those obtained from drill cuttings. Guidelines are proposed for a simplified quick-look approach with pointers to avoid potential pitfalls and ensure accuracy.

A QUICKLOOK DETERMINATION OF OIL-IN-PLACE IN OIL SHALE RESOURCE PLAYS

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  - Justin Bagley
  - Bo Henk

DISCUSSION TOPICS

- Gas-in-place measurements in the Coal and Shale Gas Industry
  - Gas desorption methodology
- Importance of Hydrocarbon Target Volumes in Unconventional Resource Plays
  - Measure amount of Hydrocarbons available
  - Application of RockEval Pyrolysis for S1 values

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GAS DESORPTION METHODOLOGY

- Standard analytical technique over 20 years
  - Measures total gas contained in coal cores or shale cores.
  - Allows the determination of the total gas resource in place in a given area.

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HYDROCARBON TARGET VOLUMES

- Focus on application of hydrocarbon distillation from Rock-Eval.
  - Requires rock samples, preferably whole core, properly collected.
  - Determines volumes of distillable hydrocarbons in the rock in mg of hydrocarbon/g of dry rock.
  - Relatively simple and cheap to do.
  - Results can be obtained early in exploration campaign.
  - Easily up-scaled to reflect total rock potential.

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HYDROCARBON TARGET VOLUMES

- **Emphasis on S1 measurement of distillable hydrocarbons.**

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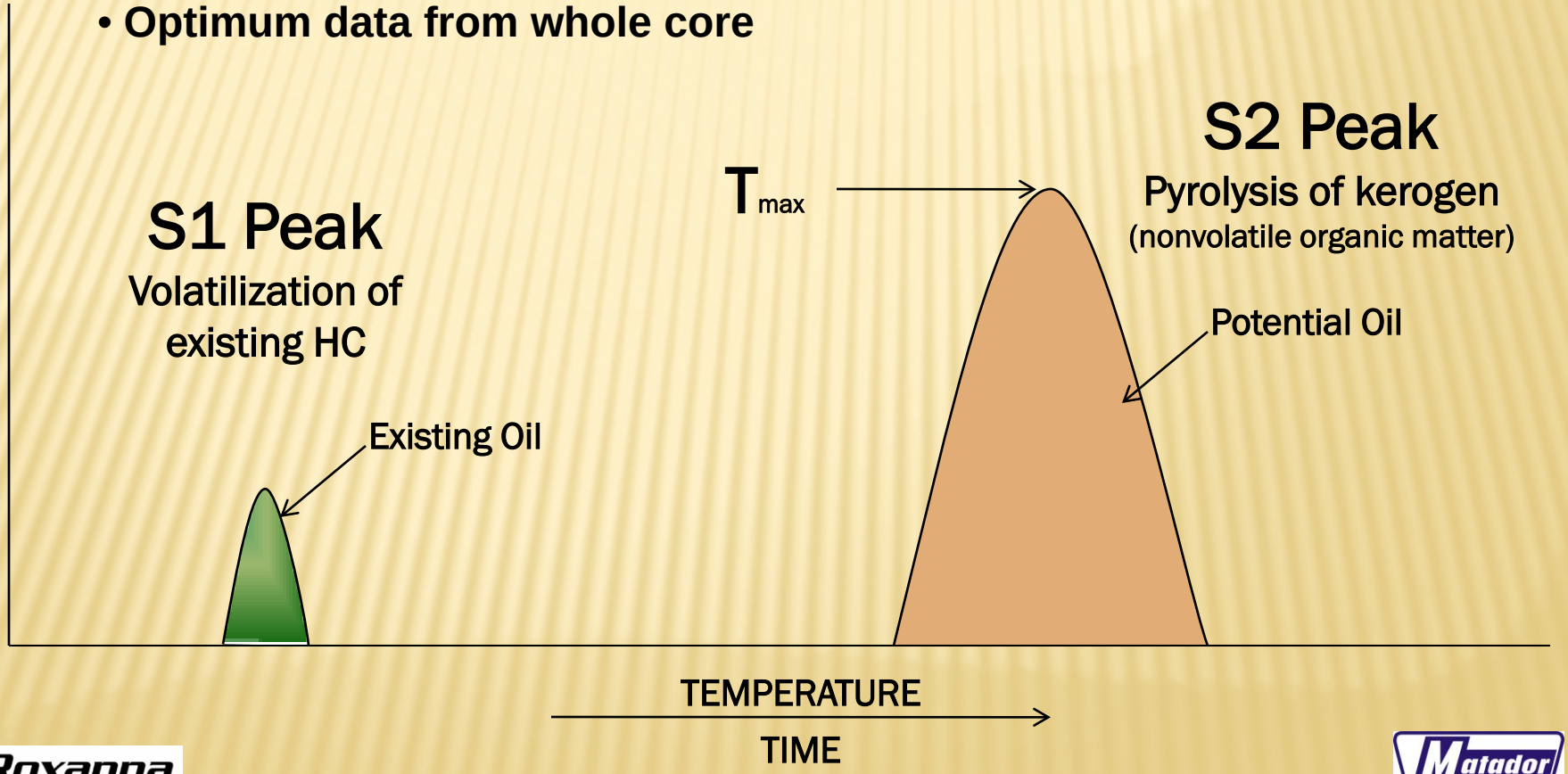
Rock Eval Pyrolysis

S1 represents the free hydrocarbons in a rock

- Primarily indicates generated free oil (liquid hydrocarbons)
- The greater the S1 value, the greater amount of free oil
- Optimum data from whole core



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APPLICATION PROCEDURE

- Establish S1 values, preferably from whole core, preferably every foot. This represents measured oil-in-place per unit volume of rock.
- Upscale oil-in-place to Acre-feet or “Section-feet” (i.e. one square mile of surface area x one foot thick x hydrocarbon richness).
- Resulting volume from core measurements is a minimum value for the oil-in-place volume.

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METHODOLOGY: OIL IN PLACE FROM S1

Step 1: grams of oil per section

$$M_{S1HC} = Ah\ (\rho_{Av})\ (S1_{Av})(.001) \div 8.11E\text{-}10\ acre\text{-}ft/cc$$

Where:

M_{S1HC} = *Mass of S1 hydrocarbons per section (g)*

A = Area of interest in acres (sectional area – 640 acres)

h = Reservoir height (ft)

ρ_{Av} = *Average bulk density (g/cc)*

$S1_{Av}$ =*Average S1 (mg/g)*

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METHODOLOGY (CONT.)

Step 2: volume of oil per section (cc)

$$V_{S1HC} = M_{S1HC} \div \rho_{oil}$$

Where:

V_{S1HC} = *Volume of S1 hydrocarbons per section (cc)*

M_{S1HC} = *Mass of S1 hydrocarbons per section (g)*

ρ_{oil} = *Density of oil (g/cc)*

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METHODOLOGY (CONT.)

Step 3: barrels of oil per section

Oil in Place per section (Bbl)

=

V_{S1HC} *x 6.29E-6 bbl/cc*

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OIL IN PLACE FROM S1

Simplified Equation

$$\textit{Oil in Place per 640 acre/ft} = 4965.36 \times (\rho_{Av})\,(S1_{Av})(\rho_{oil})$$

Where:

ρ_{Av} = *Average bulk density (g/cc)*

$S1_{Av}$ =*Average S1 (mg/g)*

ρ_{oil} = *Density of oil (g/cc)*

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OIL IN PLACE FROM S1

Simplified Equation

$$\textit{Oil in Place per 640 acre/ft} = 9677.48 \times (S1_{Av})$$

Where:

$S1_{Av}$ *=Average S1 (mg/g)*

Assumes:

2.5 g/cc Bulk Density

50° API Oil Gravity

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CONVERSIONS

1 section = 640 Acres

1 cc = 8.10713194 E-10 Acre-ft

1 cc = 6.28981077E-6 Bbl

Specific gravity = 141.5/(131.5 + API gravity)

Specific gravity 1 =1 g/cc

1 mg = .001 g

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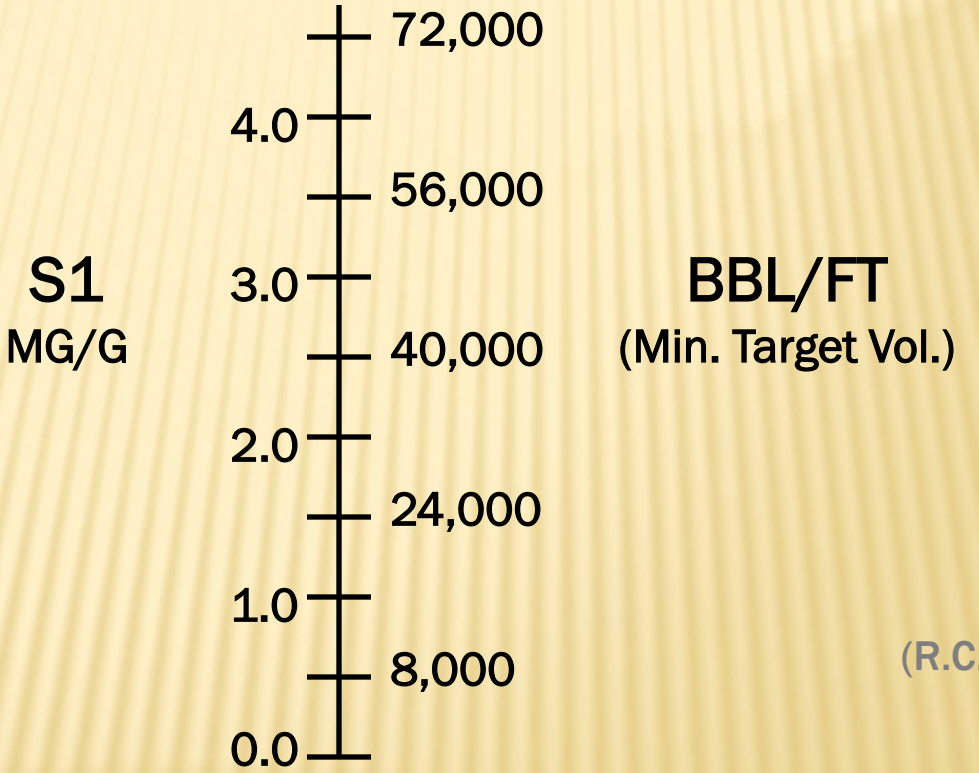
QUICKLOOK CONVERSION OF S1 TO OIL

Using S1 in mg/g to BBL of Oil in 640 acres/foot



(R.C. Lagomarsino)

Assumes:
2.5 g/cc Bulk Density
50° API Oil Gravity

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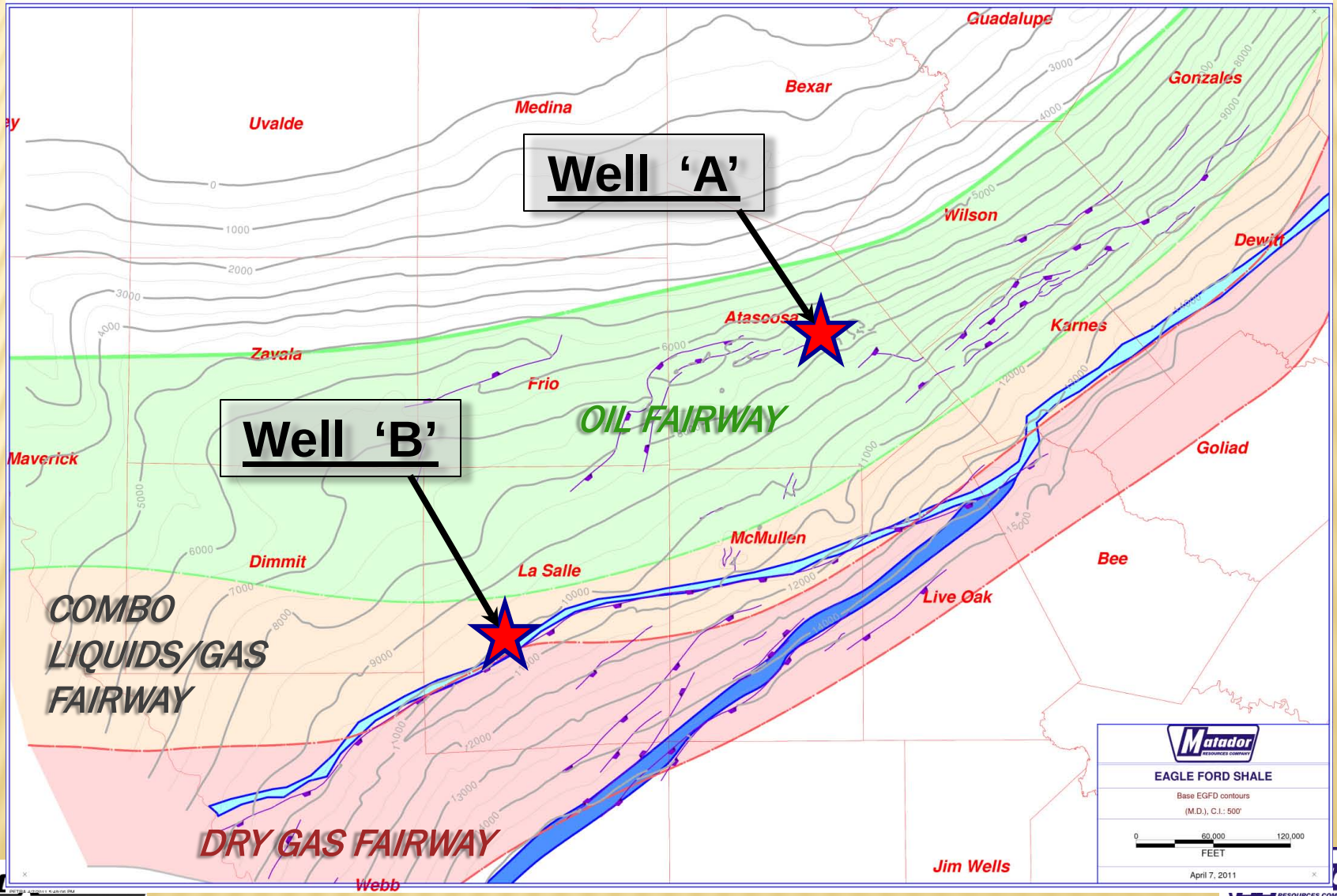
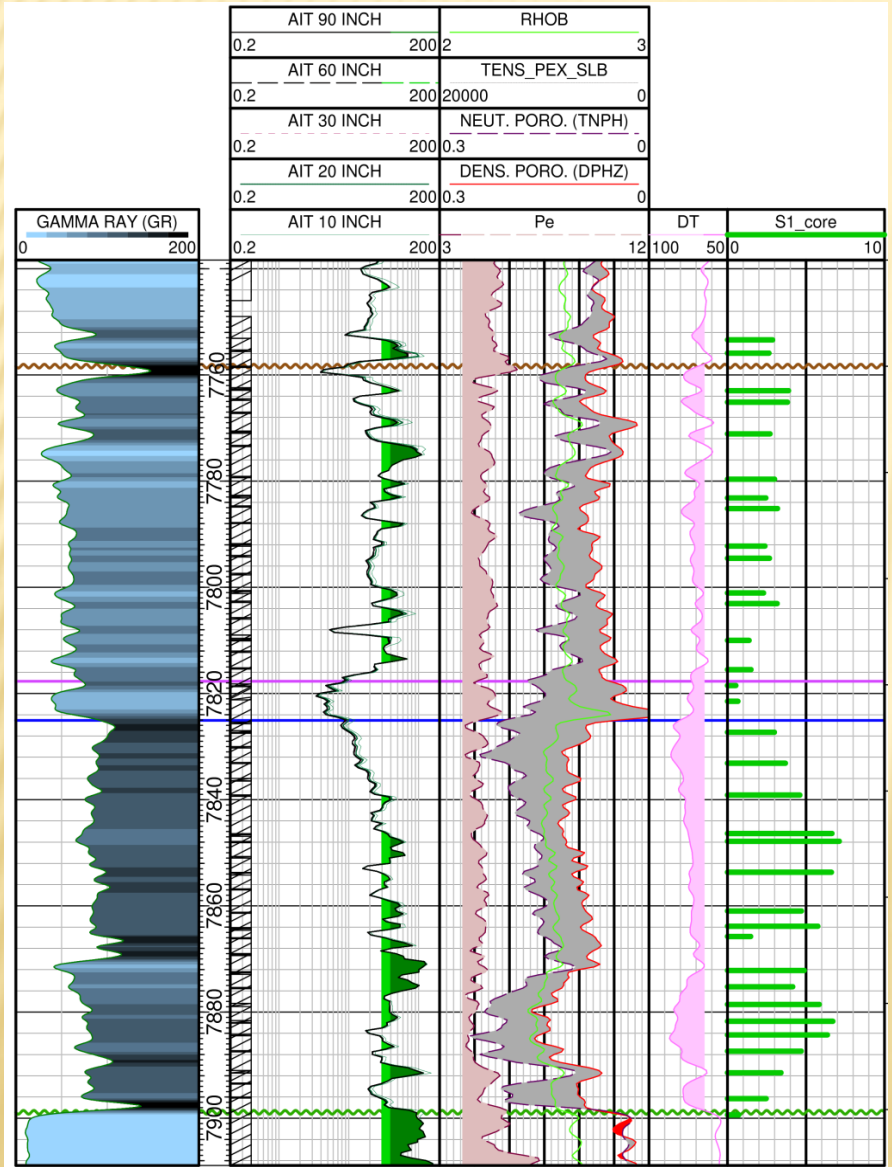
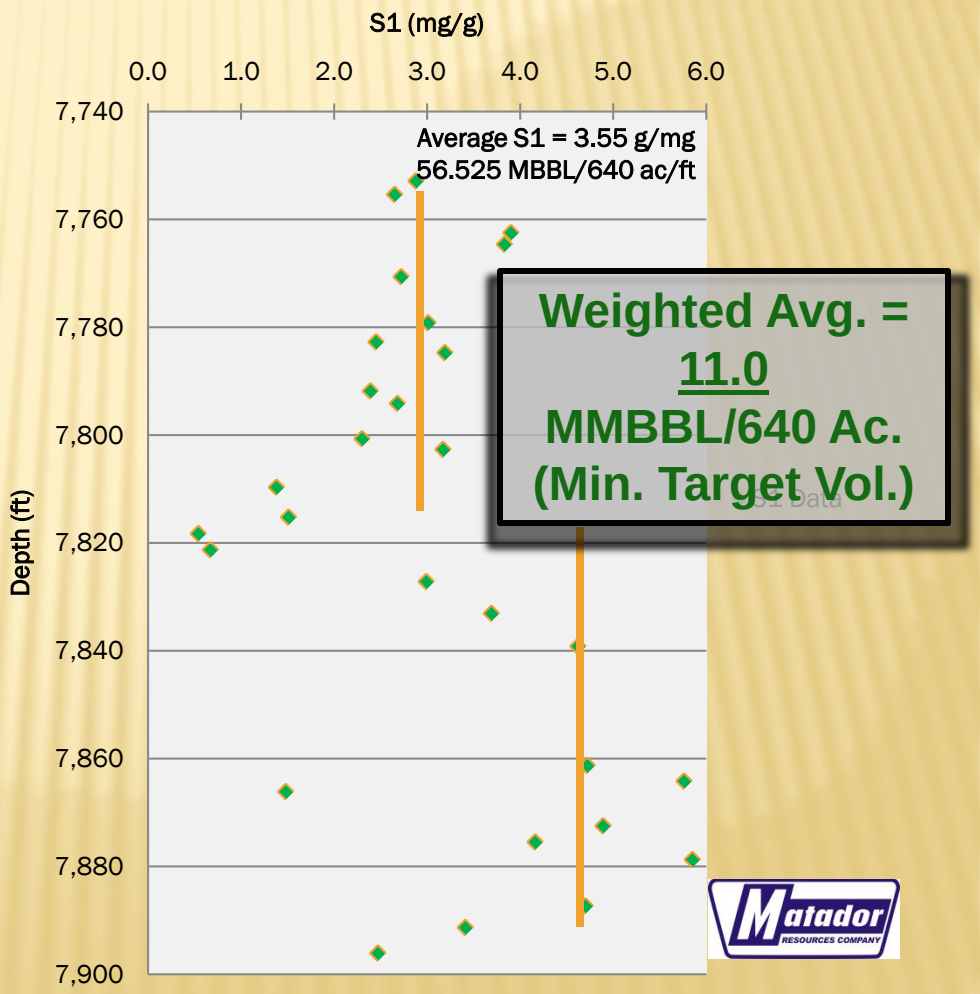
EAGLE FORD SHALE – STUDY WELLS



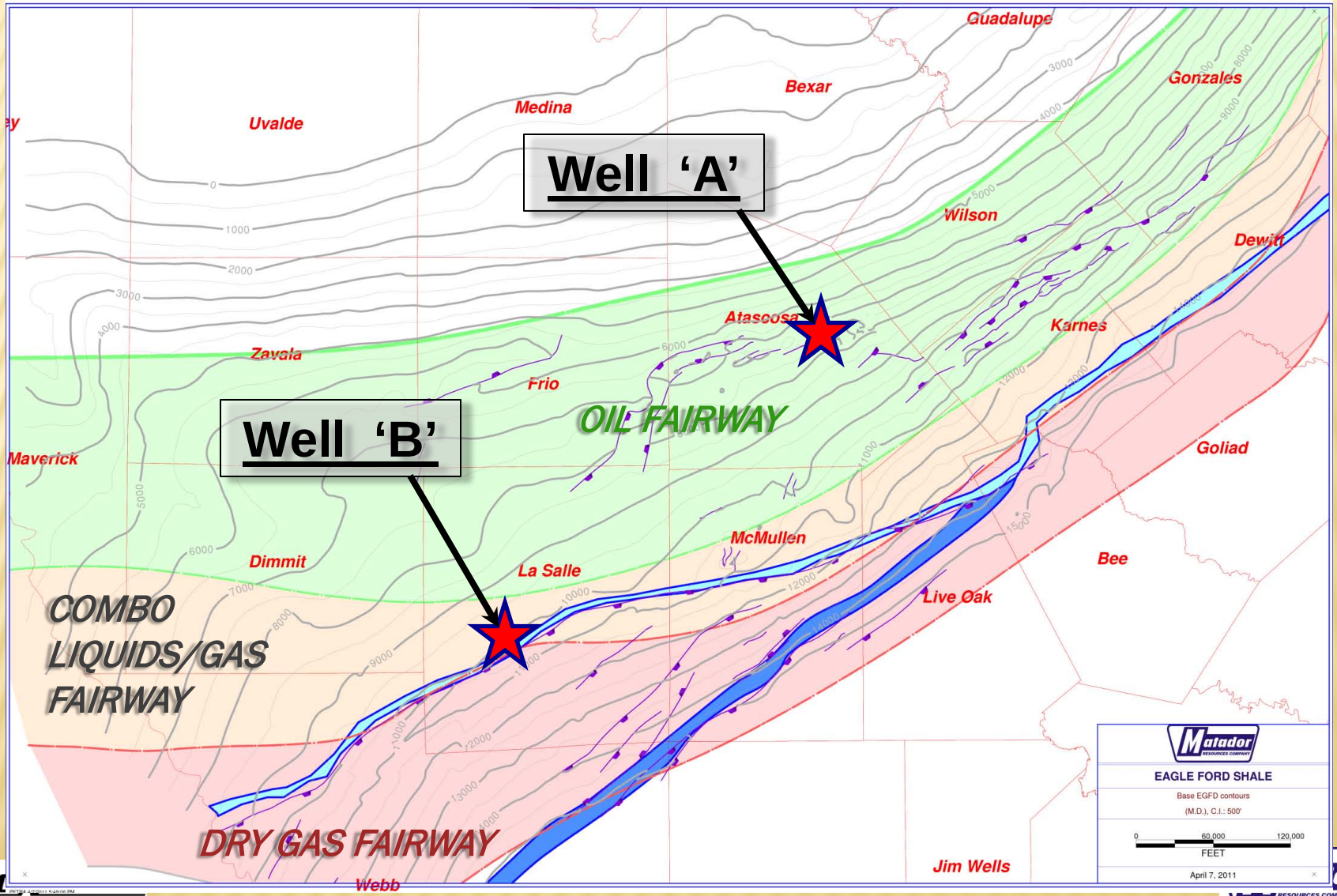
VERTICAL VARIATIONS IN S1 VALUES FOR EAGLE FORD, WELL 'A'

(Less Thermally Mature)



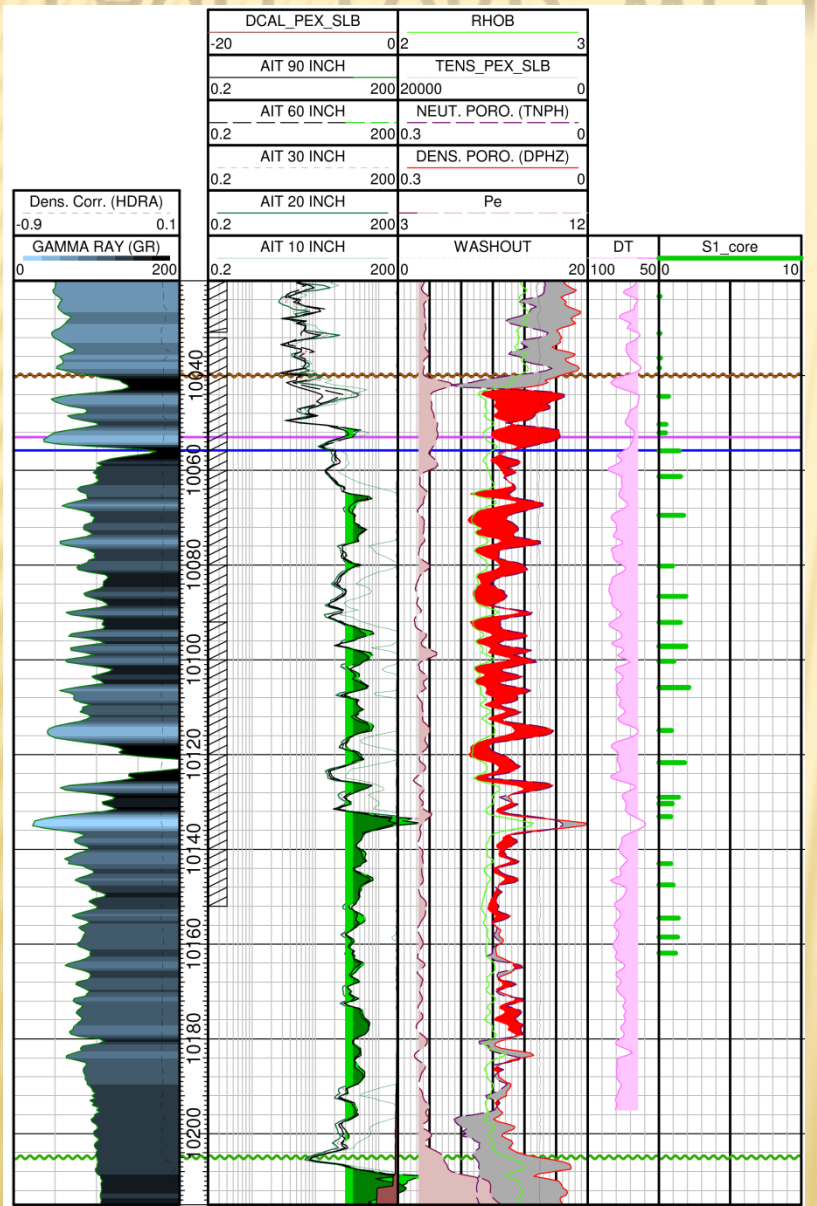


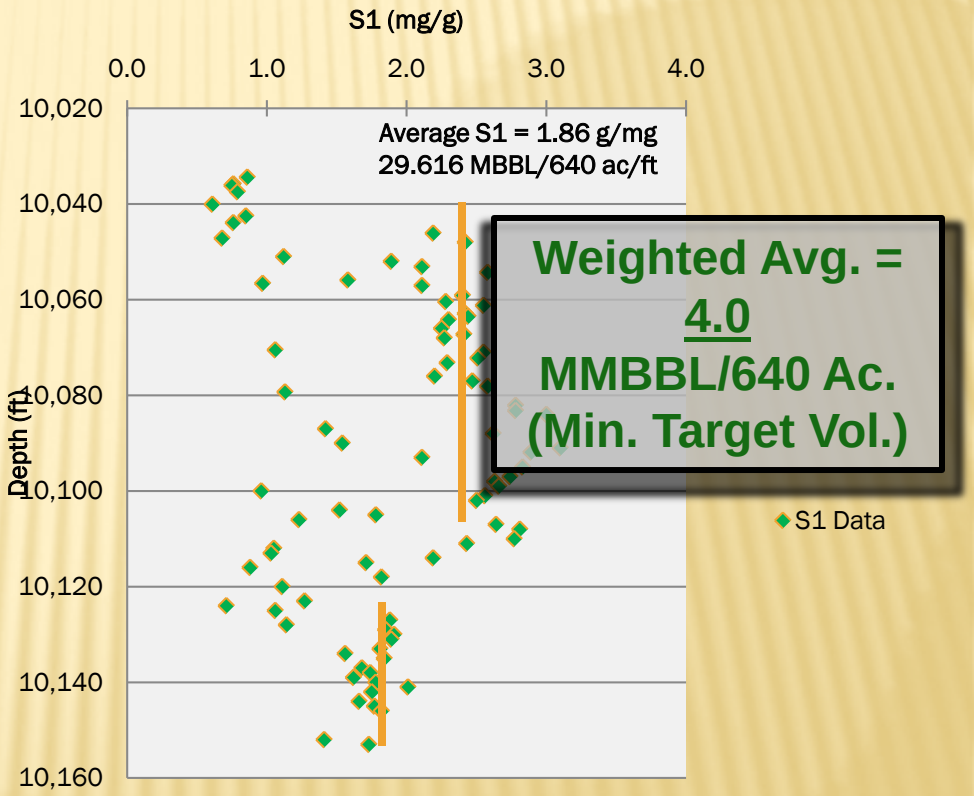
EAGLE FORD SHALE – STUDY WELLS



VERTICAL VARIATIONS IN S1 VALUES FOR EAGLE FORD, WELL 'B'

(More Thermally Mature)





CONCLUSIONS

- **Rock-Eval S1 value provides early measurement of oil in place.**
- **Can be up-scaled easily for various thicknesses for quantified values of oil-in-place.**
- **Measurements of oil-in-place compared to production decline analysis will provide improved measures of recovery efficiency.**
- **For further information, check out:**

www.roxannaoil.com

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