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LESA
Coalbed Methane Log Analysis

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LESA Coalbed Methane Log Analysis

The attached extract from the equation and methodology documentation for ***LESA*** describes the techniques used to analyze coalbed methane using wireline logs.

One example is shown, from Fruitland Coal Field, Rio Arriba County, New Mexico (Northeast Blanco Unit).

- Raw data
- Interpretations involving the various analytic techniques showing:
    - ash content
    - moisture content
    - volatile matter
    - fixed carbon
    - productivity – MCFD
    - gas content – cubic feet per ton
    - gas in place – MMCF

Included in the interpretive depth plot are regular deterministic outputs of ***LESA*** (porosity, shale, water saturation profile of the non-coal sections) using the in-depth module.

Procedures to follow using the ***LESA*** program are:

a) Edit the file for standard in-depth analysis. Choose petrophysical input for the non-coal intervals.

b) Run the **Coalbed Methane** module, with suitable edits for:

	Default Value
Maximum Rhob for coal	2.0
Minimum neutron for coal	35
Minimum sonic delta t for coal	95
Minimum resistivity for coal	10
Tons per acre	1800
Well spacing, acres	160

Digital LAS files, including interpretations, are included.

Coalbed Methane

A. The program first checks for "generic" coal:

- $R > 10\Omega M$
- $\rho_B < 2.0$
- $\Delta_t > 95$
- $\Phi_N > 35\%$

If more than one log exists, go to density log preferentially. If $\rho_B > 2$, cannot be coal, no matter what. The interpreter can define the inequalities.

B. Then, if more than one porosity log is available, determines different types of coal.

Coal Matrix properties are as follows:

	ρ_B	Φ_N	Δ_t	Δ_{tma}	Pe
Anthracite	1.47	38	105	48	0.16
Bituminous	1.24	60	120	44	0.17
Lignite	1.19	52	160	50	0.20

From Density Neutron

Anthracite	ρ_B Φ_N	1.3 to 1.9 35 - 45
Lignite	ρ_B Φ_N	1.0 to 1.22 45 – 55
Sub-bituminous	ρ_B Φ_N	1.22 to 2.0 55 – 60
Bituminous	ρ_B Φ_N	1.22 to 2.0 > 60

From Neutron Sonic

Anthracite		Can not distinguish
Lignite	Δ_t Φ_N	140 – 170 45 – 55
Sub-bituminous	Δ_t Φ_N	110 – 140 55 – 60
Bituminous	Δ_t Φ_N	95 – 110 > 60

From Sonic / Density

Anthracite	Δ_t ρ_B	80 – 95 1.3 – 2.0
Lignite	Δ_t ρ_B	140 – 170 1.0 – 1.22
Sub-bituminous	Δ_t ρ_B	110 – 140 1.22 – 2.0
Bituminous	Δ_t ρ_B	95 – 110 1.22 – 2.0

C. The program then determines a series of calculations relative to coal components.

- Ash Content $V_A = 64.94 \times \rho_B - 66.27$

- Fixed Carbon $V_{FC} = -0.517V_{ASH} + 51.2$
- Moisture $V_M = -0.10V_{ASH} + 4.61$
- Volatile Matter $V_{VM} = 100 - V_A - V_{FC} - V_M$

D. Using the data calculated in item (C), the program then calculates gas volumes according to several published equations. Basic references used are:

- Olszewski and Schranfnagel, "Development of Formation Evaluation Technology for Coalbed Methane Development," Methane from Coal Series, October, 1992.
- Mavor, Close and McBane, "Formation Evaluation of Exploration Coalbed Methane Wells," paper SPE 90-101, Calgary, 1990.
- Mullen, "Log Evaluation in Wells Drilled for Coal-bed Methane," RMAG, 1988.

Original Kim Equation

$$g = \frac{(1 - w - a) \times V_w}{V_d \times (k_0 p^{n_0} - bT)}$$

where,

g = adsorbed gas volume, cc/g

a = ash content, weight fraction = V_A

b = constant = 0.14

$$k_0 = 0.8 \times \left(V_{FC} / V_M \right) + 5.6$$

$$n_0 = 0.39 - 0.1 \times \left(V_{FC} / V_M \right)$$

p = pressure, atmospheres

T = temperature, ºC

V_d = gas volume, dry coal

V_w = gas volume, moist coal

w = moisture content, weight fraction = V_M

$V_w/V_d = 0.75$

Modified Kim Equation

$$V = (1 - V_M - V_A) \times 0.75 \times \left\{ k_0 \times 0.96h^{n_0} - 0.14\left(\frac{1.8h}{100} \right) + 11 \right\}$$

V = Gas content Ft^3 gas / ton

h = Depth in meters

All other terms defined under "Kim Equation".

Langmuir

$$\log G_L = k_1 \log \left(V_{FC} / V_{VM} \right) + k_2$$

$$\log P_L = k_3 \log \left(V_{FC} / V_{VM} \right) + k_4$$

T = temperature, ºC

$K_2 = -0.00268T + 2.82873$

$K_3 = 0.00259T + 0.50899$

$K_4 = 0.00402T + 2.20342$

G_L = gas volume (Langmuir) SCF/T (infinite pressure)

P_L = Langmuir pressure, at which sample's gas content is ½ G_L

Mullen

Average Gas Content = $-542\rho_B + 1053$ ft^3 per ton

Mavor, Close, McBane

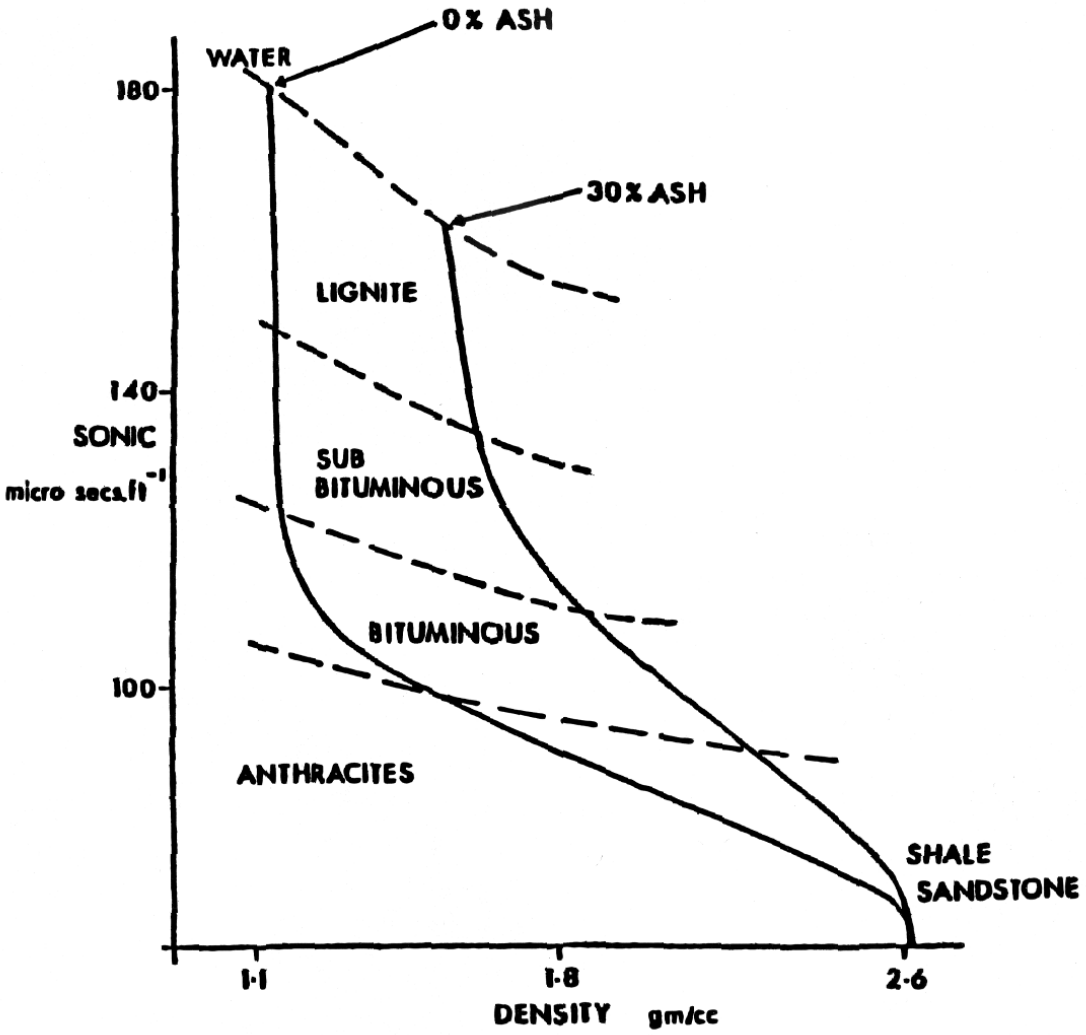
$g = 601.4 - 751.8a_d$

$$a_d = \frac{a}{(1-w)} = \frac{V_A}{(1-V_M)}$$

g = gas content, SCF per ton

Prensky

By comparisons between sonic and density logs, coal rank and ash content is available. A look-up table is a numeric solution to the following graph (Prensky):



Graph showing the relationship between acoustic log travel-time, bulk density, and coal rank 9from BPB, 1981, by permission).

A. Gas in Place is calculated using the equation:

Gas in place MCF = $g \times h \times c \times area$

g = gas content, ft^3 per ton

h = coal be thickness, ft.

c = tons of coal per acre foot of coal (average 1800)

(Area in acres)

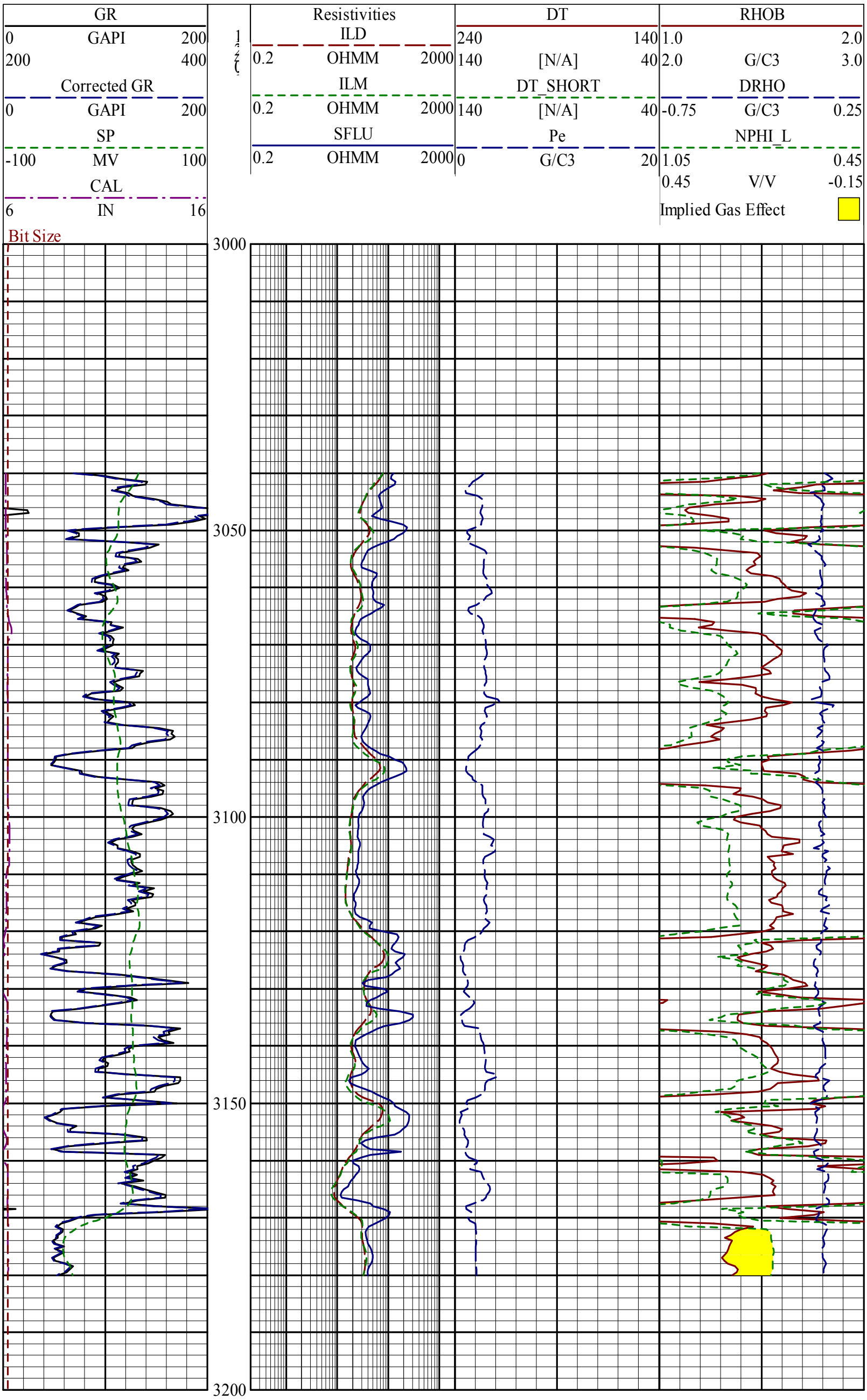
B. Deliverability

Using Mullen's correlation between SP development and deliverability:

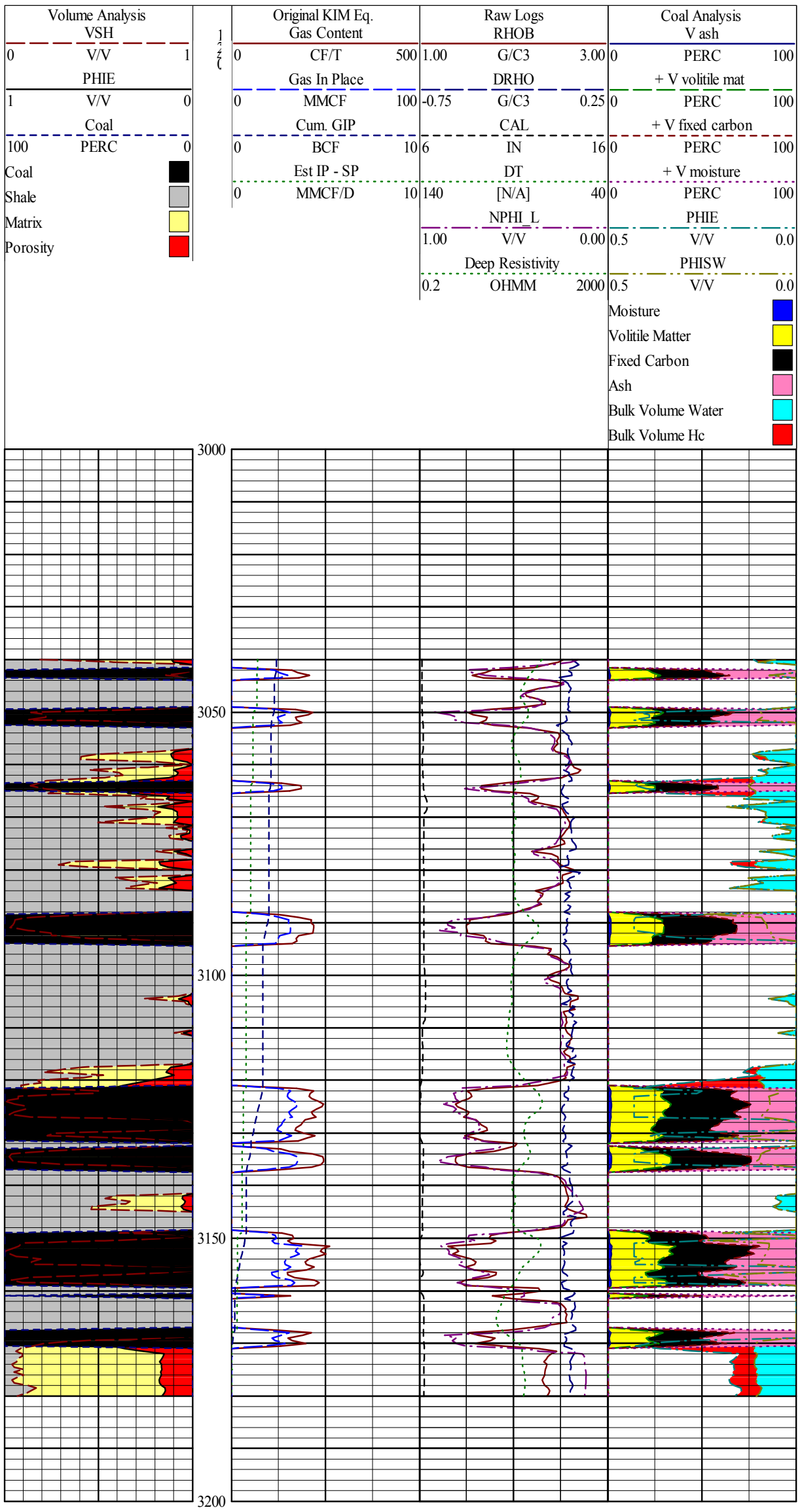
Productivity (MMCFD) = $4.3 \times 10^{-3} \times SPM$

SPM = Maximum SP deflection in coal (MV) × Coal thickness (ft.)

LESA 2.2, © 1992-2000 Digital Formation, Inc.
File: Nbu495.las Well Name: Northeast Blanco Unit #495
Plot: L-RAW-U.PLT Plot Name: Raw Data Log (US and Canada)
Gross Interval: 3040 to 3180 by 0.5 F
Ranges: 3040-3180
Time: 02:57 PM Date: Tue, Jul 25, 2000



LESA 2.2, © 1992-2000 Digital Formation, Inc.
File: Nbu495.las Well Name: Northeast Blanco Unit #495
Plot: L-CBM-S.PLT Plot Name: Coal Bed Methane (Schlumberger)
Gross Interval: 3040 to 3180 by 0.5 F
Ranges: 3040-3180
Time: 03:12 PM Date: Tue, Jul 25, 2000



Coal Bed Methane Analysis Parameters

Gross Range: [3040] - [3180] Interval Analyzed: [3040] - [3180]

Num Beds:	9		Mullen Ave. Gc:	175.399	CF/T
Thickness:	43	ft	Mullen Cum. GIP:	2.172	BCF
Tons/Acre-ft:	1800		Mavor et al. Ave. Gc:	261.59	CF/T
Acres:	160		Mavor et al. Cum. GIP:	3.24	BCF
Density Max.:	2	gm/cc	Original KIM Ave. Gc:	192.678	CF/T
Neutron Min.:	0.35	fractions	Original KIM Cum. GIP:	2.386	BCF
Sonic Min.:	95	us/ft	Modified KIM Ave. Gc:	295.222	CF/T
Resistivity Min.:	10	ohm-m	Modified KIM Cum. GIP:	3.656	BCF
SP PP:	-603.374	mV-ft	Langmuir Ave. Gc:	274.818	CF/T
SP IP:	1.397	MMCF/Day	Langmuir Cum. GIP:	3.403	BCF

Pressures:

[3040] - [3180] FRUITLAND COALS1000 psi

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