Schlumberger

Sonic Scanner

Anisotropic GeoMechanical Properties Advisor

6905 ft - 8390 ft

COMPANY: North East Natural Energy LLC
WELL: Boggess 17H
FIELD: Wildcat
COUNTY: Monongalia
STATE: West Virginia
COUNTRY: USA

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API No: 47-061-01812-00-00

Other Services:

Location
Field: Lat and Long: 39:40:12.6 N
Sec: Clay Township: Core Range:Blacksville
Lat: 39° 41' 15" N
Long: 80° 6' 27.1" W

Elevations:
K.B. 1296 ft
D.F. 1296 ft
G.L. 1268 ft

Permanent Datum:	GL Elev: 1268 ft
Log Measured From:	KB 28 ft above Perm. Datum
Drilling Measured From:	KB
Magnetic Dec: -9.072007	Magnetic Inc: 66.55547 Magnetic Intensity:

Date	15-Apr-2019
Run No.	1A
Depth Driller	8400 ft
Depth Logger (Schl)	8400 ft
Btm. Log Interval	8400 ft
Top Log Interval	2543 ft
Casing-Driller	9.625 in @ 2538 ft
Casing-Logger	2543 ft
Bit Size	8.5 in
Type Fluid in Hole	WATER
Dens. | Visc.	9.5 lbm/gal | -999.25 s
pH | Fluid loss	-999.25 | -999.25 cm3
Source of Sample	Active Tank
Rm @ Meas. Temp.	0.04 ohm.m @ 103 degF
Rmf @ Meas. Temp.	0.0255 ohm.m @ 103 degF
Rmc @ Meas. Temp.	0.04 ohm.m @ 102 degF
Source: Rmf | Rmc	Pressed | Calculated
Rm @ BHT	0.04 ohm.m @ 158 degF
Circulation Stopped	23:00:00
Logger on Bottom	09:04:00
Max Rec. Temp.	158 degF
Equipment | Location	3703 | Bradford, PA
Recorded by:	Elizabeth Morrone
Witnessed by:	BJ Varney

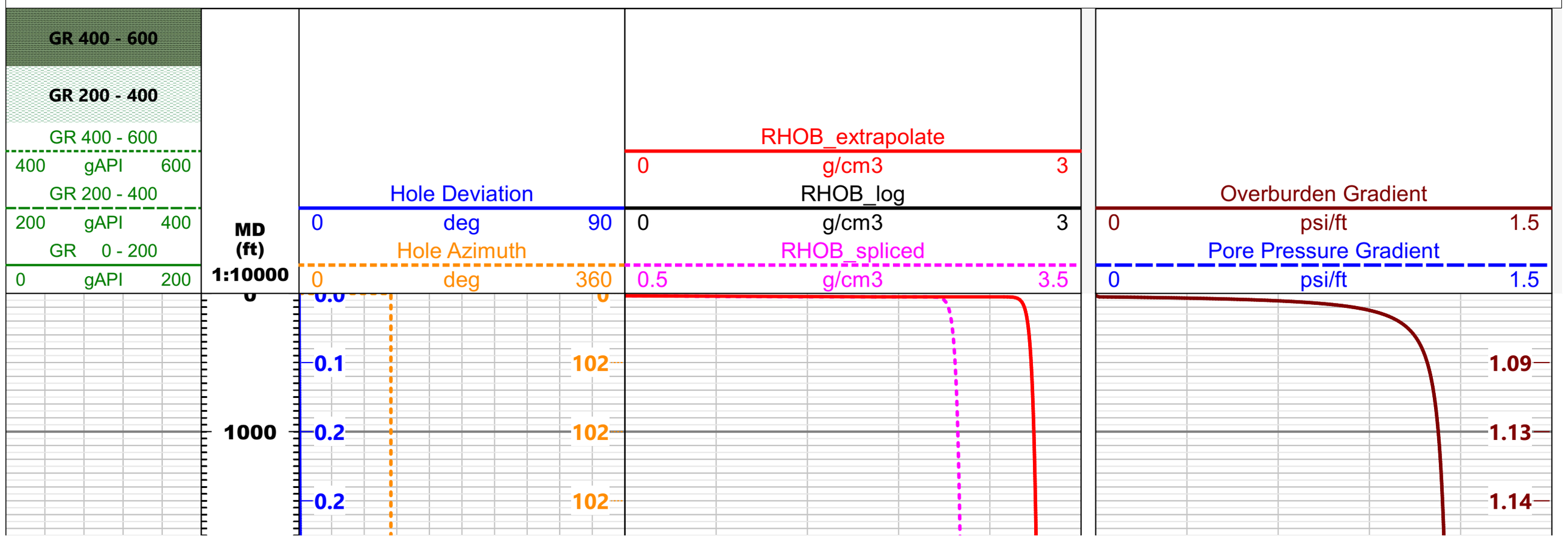
FOLD HERE

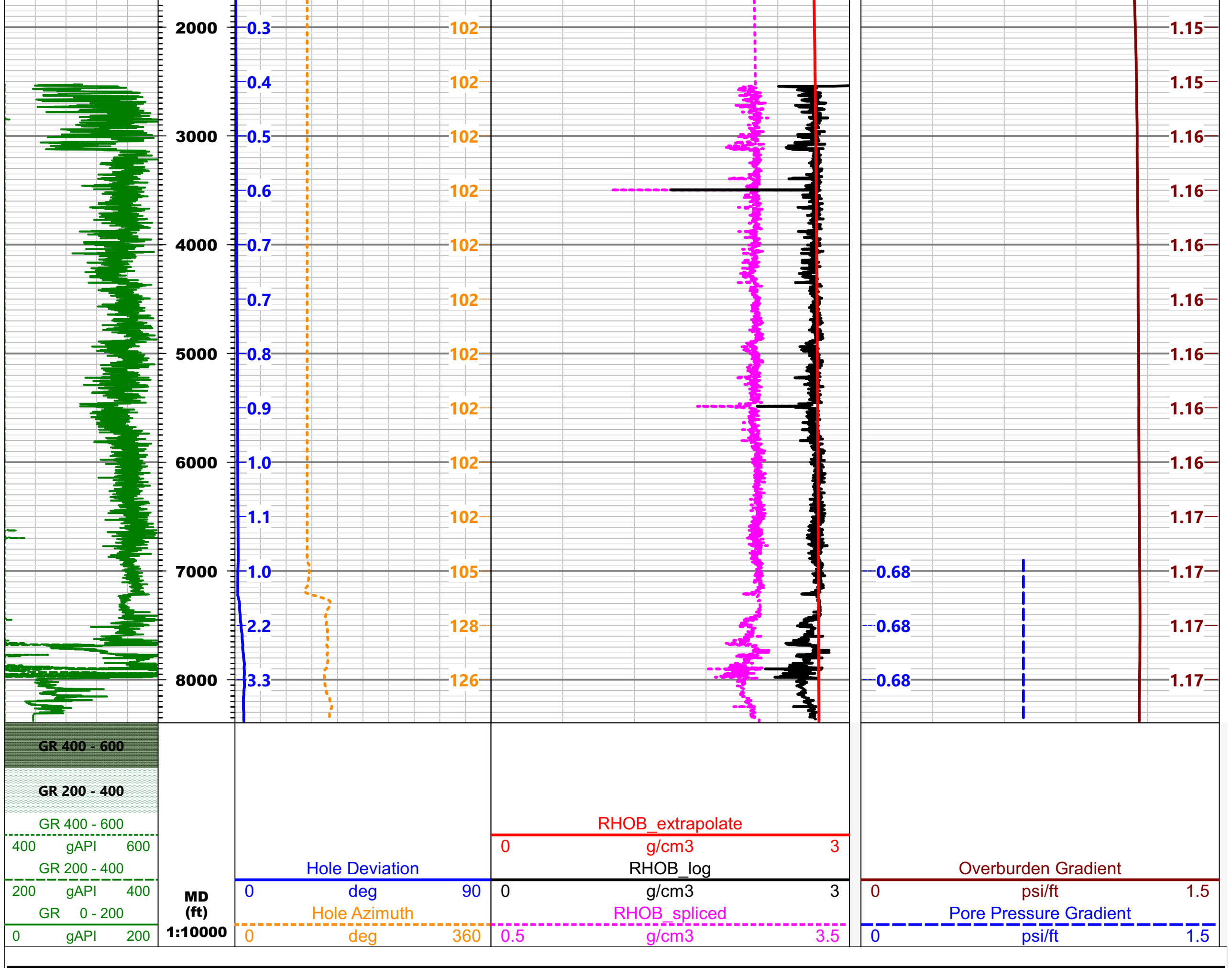
The well name, location and borehole reference data were furnished by the customer

Ser. Order #	OP Vers.: 20C0-999	Process Date: 30-APR-2019	Center: PIT-PTS	Baseline: Techlog 2018.2 on DELFI	Log Analyst: Seun Magbagbeola

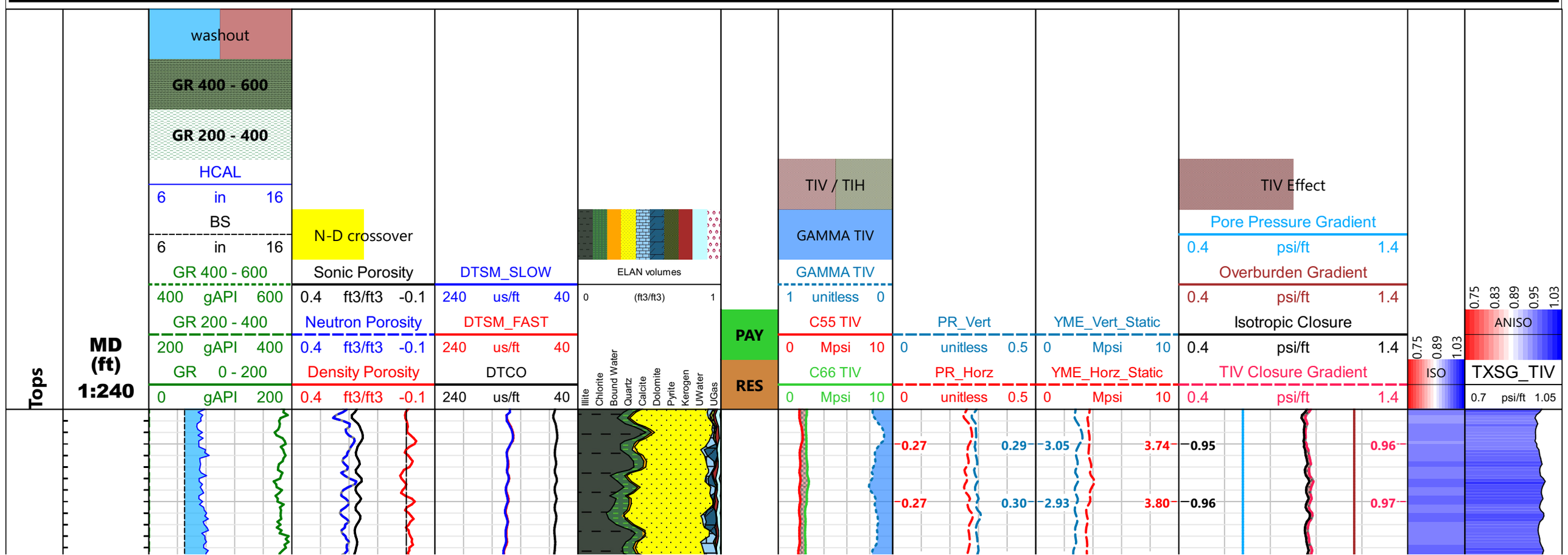
Remarks:

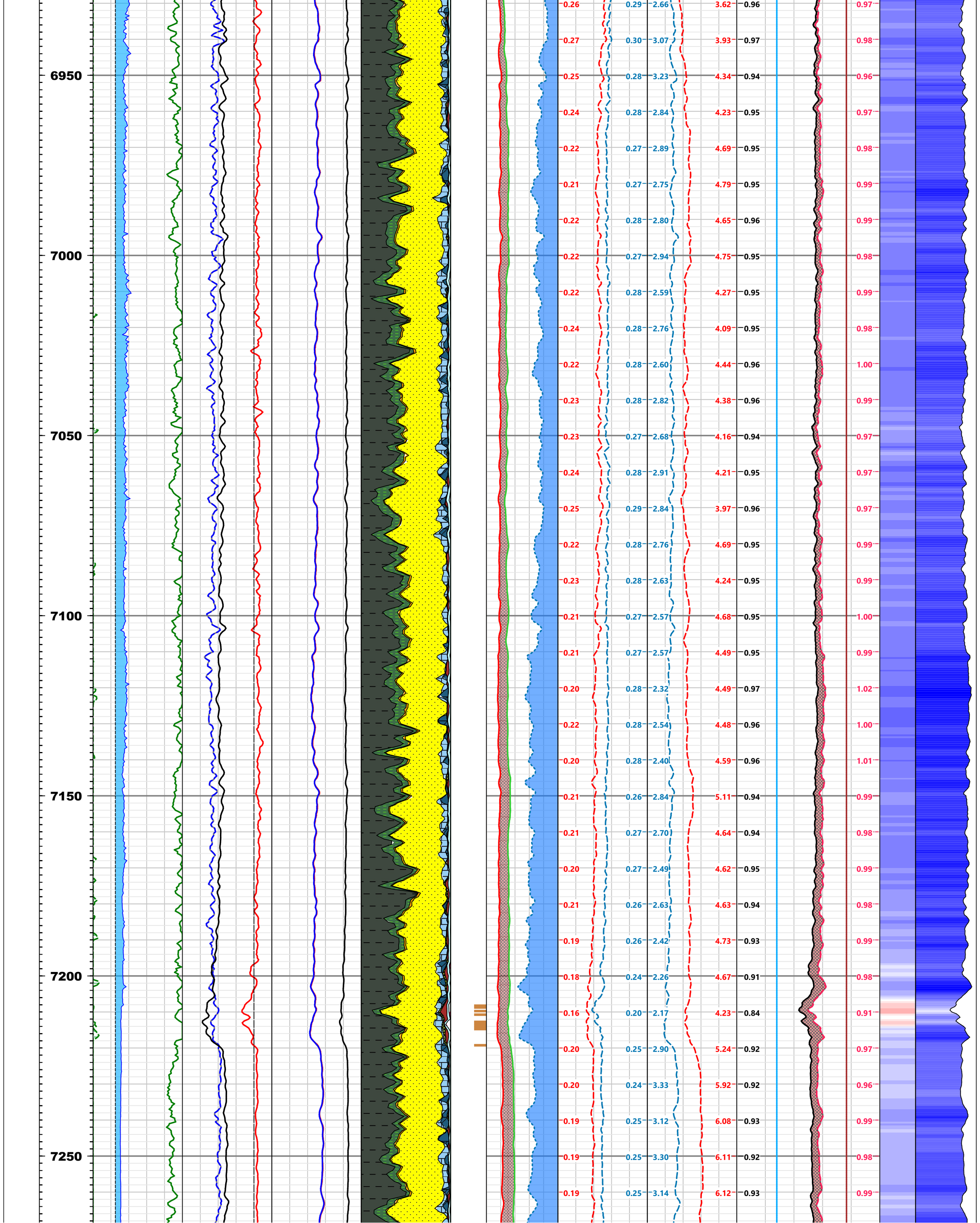
Sonic data depth matched to neutron porosity.
Pore pressure gradient = 0.68 psi/ft.
DT_mud = 172.5 us/ft.
Zimmerman correlation was used for dynamic to static Young's modulus conversion.
UCS was computed using the static Young's modulus correlation.




2000
3000
4000
5000
6000
7000
8000
0.3
0.4
0.5
0.6
0.7
0.7
0.8
0.9
1.0
1.1
1.0
2.2
3.3
102
102
102
102
102
102
102
102
102
105
128
126
0.68
0.68
0.68
1.15
1.15
1.16
1.16
1.16
1.16
1.16
1.16
1.17
1.17
1.17
GR 400 - 600
GR 200 - 400
GR 400 - 600
400 gAPI 600
GR 200 - 400
200 gAPI 400
GR 0 - 200
0 gAPI 200
MD (ft)
1:10000
Hole Deviation
0 deg 90
Hole Azimuth
0 deg 360
RHOB_extrapolate
0 g/cm3 3
RHOB_log
0 g/cm3 3
RHOB_spliced
0.5 g/cm3 3.5
Overburden Gradient
0 psi/ft 1.5
Pore Pressure Gradient
0 psi/ft 1.5

Scale 1:240


Tops
MD (ft) 1:240
washout
GR 400 - 600
GR 200 - 400
HCAL
6 in 16
BS
6 in 16
GR 400 - 600
400 gAPI 600
GR 200 - 400
200 gAPI 400
GR 0 - 200
0 gAPI 200
N-D crossover
Sonic Porosity
0.4 ft3/ft3 -0.1
Neutron Porosity
0.4 ft3/ft3 -0.1
Density Porosity
0.4 ft3/ft3 -0.1
DTSM_SLOW
240 us/ft 40
DTSM_FAST
240 us/ft 40
DTCO
240 us/ft 40
ELAN volumes
0 (ft3/ft3) 1
Illite
Chlorite
Bound Water
Quartz
Calcite
Dolomite
Pyrite
Kerogen
UWater
UGas
PAY
RES
TIV / TIH
GAMMA TIV
GAMMA TIV
1 unitless 0
C55 TIV
0 Mpsi 10
C66 TIV
0 Mpsi 10
PR_Vert
0 unitless 0.5
PR_Horz
0 unitless 0.5
YME_Vert_Static
0 Mpsi 10
YME_Horz_Static
0 Mpsi 10
TIV Effect
Pore Pressure Gradient
0.4 psi/ft 1.4
Overburden Gradient
0.4 psi/ft 1.4
Isotropic Closure
0.4 psi/ft 1.4
TIV Closure Gradient
0.4 psi/ft 1.4
0.27
0.27
0.29
0.30
3.05
2.93
3.74
3.80
0.95
0.96
0.96
0.97
0.75 0.83 0.89 0.95 1.03
ANISO
0.75 0.89 1.03
ISO
TXSG_TIV
0.7 psi/ft 1.05


6950
7000
7050
7100
7150
7200
7250
0.26 0.29 2.66 3.62 0.96 0.97
0.27 0.30 3.07 3.93 0.97 0.98
0.25 0.28 3.23 4.34 0.94 0.96
0.24 0.28 2.84 4.23 0.95 0.97
0.22 0.27 2.89 4.69 0.95 0.98
0.21 0.27 2.75 4.79 0.95 0.99
0.22 0.28 2.80 4.65 0.96 0.99
0.22 0.27 2.94 4.75 0.95 0.98
0.22 0.28 2.59 4.27 0.95 0.99
0.24 0.28 2.76 4.09 0.95 0.98
0.22 0.28 2.60 4.44 0.96 1.00
0.23 0.28 2.82 4.38 0.96 0.99
0.23 0.27 2.68 4.16 0.94 0.97
0.24 0.28 2.91 4.21 0.95 0.97
0.25 0.29 2.84 3.97 0.96 0.97
0.22 0.28 2.76 4.69 0.95 0.99
0.23 0.28 2.63 4.24 0.95 0.99
0.21 0.27 2.57 4.68 0.95 1.00
0.21 0.27 2.57 4.49 0.95 0.99
0.20 0.28 2.32 4.49 0.97 1.02
0.22 0.28 2.54 4.48 0.96 1.00
0.20 0.28 2.40 4.59 0.96 1.01
0.21 0.26 2.84 5.11 0.94 0.99
0.21 0.27 2.70 4.64 0.94 0.98
0.20 0.27 2.49 4.62 0.95 0.99
0.21 0.26 2.63 4.63 0.94 0.98
0.19 0.26 2.42 4.73 0.93 0.99
0.18 0.24 2.26 4.67 0.91 0.98
0.16 0.20 2.17 4.23 0.84 0.91
0.20 0.25 2.90 5.24 0.92 0.97
0.20 0.24 3.33 5.92 0.92 0.96
0.19 0.25 3.12 6.08 0.93 0.99
0.19 0.25 3.30 6.11 0.92 0.98
0.19 0.25 3.14 6.12 0.93 0.99

Middlesex

7300	0.19	0.26	2.98	6.02	0.94	1.01
	0.20	0.25	3.33	5.82	0.92	0.97
	0.20	0.25	3.24	6.02	0.93	0.98
	0.20	0.25	3.29	6.09	0.93	0.98
	0.19	0.25	3.31	6.11	0.92	0.98
	0.19	0.24	3.16	6.03	0.92	0.98
	0.18	0.25	2.96	6.18	0.93	0.99
	0.19	0.24	3.19	6.16	0.92	0.97
7350	0.18	0.24	2.97	6.33	0.92	1.00
	0.17	0.25	2.86	6.35	0.93	1.00
	0.18	0.25	3.00	6.31	0.93	1.00
	0.19	0.24	3.15	5.92	0.91	0.97
	0.17	0.25	2.81	6.18	0.93	1.00
7400	0.18	0.24	2.94	6.30	0.91	0.99
	0.17	0.23	2.84	6.09	0.90	0.98
	0.17	0.24	2.86	6.33	0.91	0.99
	0.18	0.24	2.79	5.78	0.91	0.97
	0.15	0.21	2.17	5.27	0.86	0.96
7450	0.16	0.20	2.44	5.17	0.85	0.93
	0.15	0.19	2.30	4.68	0.83	0.90
	0.15	0.19	2.25	4.92	0.84	0.92
	0.15	0.18	2.43	4.92	0.82	0.90
	0.15	0.19	2.19	5.04	0.83	0.92
7500	0.15	0.18	2.17	4.66	0.82	0.91
	0.14	0.17	2.20	4.51	0.80	0.88
	0.17	0.20	3.12	5.47	0.85	0.90
	0.17	0.21	3.00	5.55	0.86	0.92
	0.17	0.21	2.97	5.68	0.87	0.93
7550	0.17	0.20	3.19	5.69	0.86	0.91
	0.17	0.20	3.05	5.43	0.85	0.91
	0.16	0.19	2.99	5.48	0.84	0.90
	0.17	0.20	2.94	5.58	0.85	0.91
	0.17	0.18	3.55	5.20	0.83	0.86
7600	0.15	0.16	3.08	4.84	0.80	0.84

Middlesex

Geneseo

Tully

Mahantango (Hamilton)

Marcellus

7650

7700

7750

7800

7850

7900

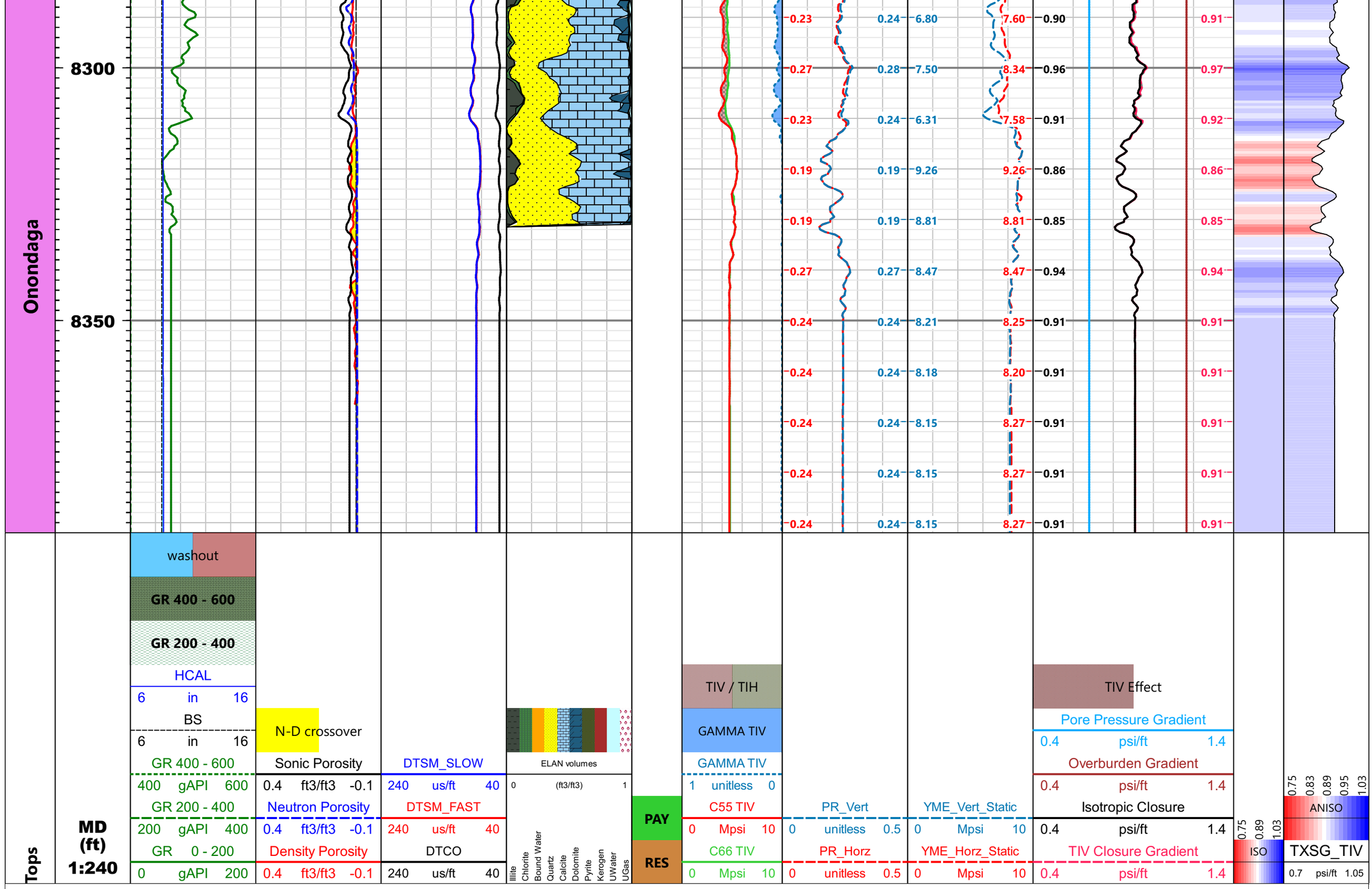
0.16 0.17 3.36 5.12 0.82 0.86
0.16 0.18 3.21 5.16 0.83 0.87
0.16 0.17 3.06 4.67 0.81 0.85
0.14 0.16 2.87 4.56 0.80 0.84
0.16 0.20 2.18 4.76 0.85 0.93
0.18 0.22 2.72 5.15 0.88 0.94
0.15 0.18 2.09 3.97 0.81 0.88
0.17 0.20 1.61 3.11 0.84 0.91
0.26 0.28 5.04 6.09 0.95 0.96
0.27 0.29 5.62 6.53 0.97 0.97
0.28 0.28 6.22 6.59 0.95 0.96
0.23 0.25 4.80 6.30 0.92 0.94
0.21 0.24 3.77 5.77 0.91 0.94
0.20 0.23 3.62 5.70 0.89 0.93
0.19 0.22 3.52 5.71 0.88 0.92
0.17 0.22 2.96 5.96 0.88 0.94
0.16 0.20 2.82 5.55 0.85 0.92
0.17 0.21 2.93 5.55 0.87 0.93
0.14 0.18 1.89 4.81 0.81 0.92
0.18 0.22 3.24 5.58 0.88 0.92
0.15 0.20 2.01 4.75 0.85 0.94
0.15 0.20 2.00 4.54 0.84 0.93
0.16 0.21 2.12 4.72 0.85 0.94
0.15 0.21 2.06 4.91 0.86 0.95
0.14 0.18 1.98 4.70 0.80 0.91
0.16 0.21 1.95 4.44 0.86 0.94
0.15 0.18 1.83 3.84 0.81 0.89
0.14 0.19 1.39 3.30 0.82 0.92
0.20 0.21 2.05 2.84 0.85 0.87
0.16 0.17 1.75 2.25 0.80 0.82
0.17 0.20 1.57 2.92 0.84 0.89
0.17 0.22 1.81 3.76 0.87 0.94
0.14 0.17 1.51 3.57 0.79 0.89
0.14 0.17 1.72 3.37 0.80 0.86

Target Base

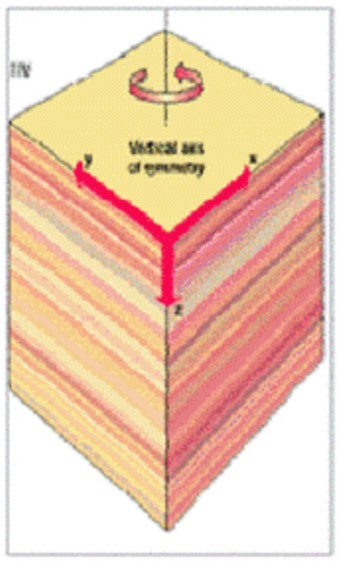
Onondaga

7950
8000
8050
8100
8150
8200
8250

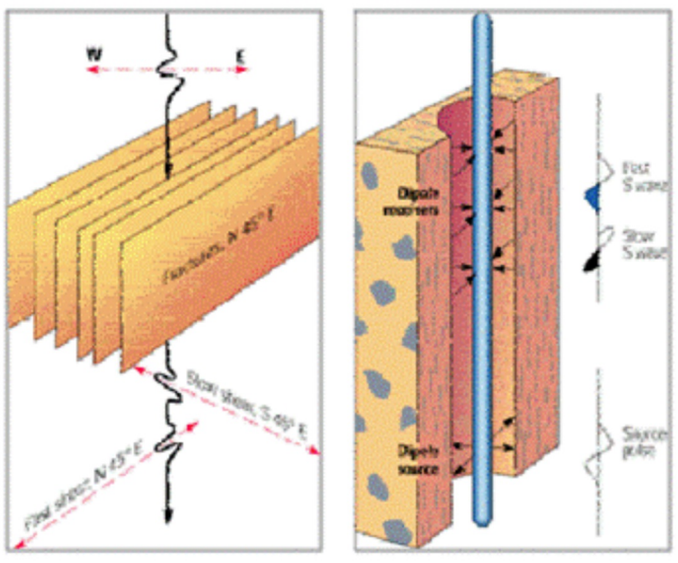
0.16 0.19 1.84 3.50 0.83 0.89
0.15 0.18 1.81 3.45 0.81 0.88
0.19 0.21 1.69 2.76 0.85 0.89
0.23 0.24 4.53 5.30 0.89 0.90
0.18 0.18 7.26 7.26 0.84 0.84
0.17 0.17 7.15 7.15 0.82 0.82
0.17 0.17 7.15 7.15 0.83 0.83
0.20 0.20 6.89 6.89 0.86 0.86
0.14 0.14 6.66 6.81 0.80 0.80
0.17 0.17 7.47 7.57 0.83 0.83
0.16 0.16 6.10 6.10 0.81 0.81
0.16 0.16 6.58 6.76 0.81 0.82
0.13 0.13 5.86 5.86 0.78 0.78
0.19 0.19 6.29 6.40 0.84 0.85
0.20 0.20 6.42 6.42 0.85 0.85
0.19 0.20 4.69 5.68 0.85 0.86
0.20 0.20 6.41 6.55 0.85 0.86
0.17 0.17 6.86 7.24 0.83 0.83
0.19 0.20 6.26 6.56 0.85 0.85
0.17 0.17 5.83 6.33 0.82 0.83
0.19 0.19 5.50 6.11 0.84 0.85
0.19 0.20 6.15 6.81 0.85 0.86
0.22 0.22 6.81 7.71 0.89 0.89
0.19 0.20 6.42 6.97 0.85 0.86
0.27 0.28 7.99 8.54 0.96 0.96
0.18 0.18 8.45 8.83 0.84 0.85
0.16 0.16 8.67 8.82 0.83 0.83
0.15 0.15 8.64 8.84 0.82 0.82
0.18 0.18 9.10 9.43 0.85 0.85
0.19 0.19 8.62 9.00 0.86 0.86
0.20 0.21 8.27 8.68 0.87 0.87
0.24 0.24 8.03 8.37 0.91 0.91
0.24 0.25 7.66 8.20 0.91 0.92
0.21 0.21 7.49 7.94 0.88 0.88



TIV ANISOTROPY



TIH ANISOTROPY



From the Promise of Elastic Anisotropy, Schlumberger Oilfield Review, Oct 1994

Poro Elastic Horizontal Strain Model with isotropy

$$\sigma_h - \alpha\sigma_{pp} = \frac{\nu}{1-\nu}\left(\sigma_V - \alpha\sigma_{pp}\right) + tectonics$$

Poro Elastic Horizontal Strain Model for TIV anisotropy

$$\sigma_h - \alpha\sigma_{PP} = \frac{E_h}{E_v}\frac{\nu_v}{1-\nu_h}\left(\sigma_V - \alpha\sigma_{pp}\right) + tectonics$$

σ_h = Minimum horizontal stress

σ_{PP} = Pore Pressure

σ_V = Overburden stress

α = Poro – Elastic constant

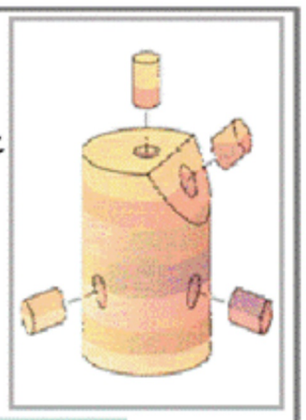
E_h = Horizontal Young's Modulus

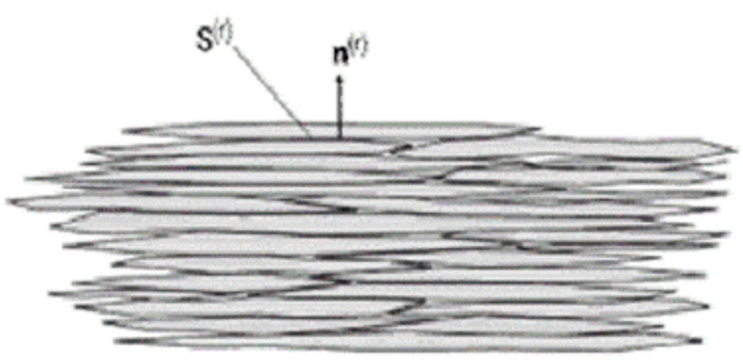
E_V = Vertical Young's Modulus

ν_H = Horizontal Poisson's Ratio

ν_V = Vertical Poisson's Ratio

Layered media often exhibts TIV anisotropy. Properties measured in the vertical direction are different than properties measured in the horizontal direction.





Figures courtsey of Sayers and Suarez-Rivera

ν = Vertical Poisson's Ratio

From Thiercelin and Plumb, SPE 21847

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