



CMS-300 CONVENTIONAL PLUG ANALYSIS

Sohio & McCulloch

Oswald-Wilcox "A" #25 & Ruthuen 1-25

Russell County, Kansas

CL File Number: DEN-130033

Date: 05/20/2013

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CMS-300 CONVENTIONAL PLUG ANALYSIS

Sample Number	Depth (ft)	Net Confining Stress (psig)	Porosity (%)	Permeability		b(air) psi	Beta ft(-1)	Alpha (microns)	Grain Density (g/cm3)	Footnote
				Klinkenberg	Kair					
				(md)	(md)					
Sohio-Oswald-Wilcox "A" #25										
1	2359.30	800	18.52	5.23	5.55	1.04	1.16E+10	1.94E+02	2.680	
2	2360.80	800	20.34	10.1	12.3	3.63	1.33E+08	4.32E+00	2.682	
3	2363.40	Ambient	19.69	***	***	***	***	***	2.740	(5)
4	2444.85	Ambient	23.54	***	***	***	***	***	2.769	(5)
5	2445.35	Ambient	20.55	***	***	***	***	***	2.711	(5)
6	2447.60	800	14.19	6.24	7.62	3.76	2.53E+08	5.09E+00	2.689	
7	2449.50	800	25.62	109	123	1.74	7.22E+08	2.55E+00	2.683	(1)
8	2451.80	Ambient	27.79	***	***	***	***	***	2.695	(5)
McCulloch-Ruthuen 1-25										
9	2441.00	800	3.29	.001	.005	136.56	8.09E+15	2.61E+04	2.706	
10	2446.20	800	24.33	114	124	1.32	2.94E+07	1.08E+01	2.675	
11	2479.30	800	4.44	.001	.003	171.42	2.87E+18	4.74E+04	2.720	
12	2502.30	800	19.34	.315	.606	21.84	2.96E+11	2.97E+02	2.684	
13	2510.10	800	21.77	6.67	8.56	4.76	7.69E+09	1.66E+02	2.681	
14	2512.10	800	4.74	.073	.090	5.95	4.29E+13	9.75E+03	2.702	
15	2516.50	800	19.31	7.65	9.08	3.10	1.50E+10	3.89E+02	2.705	(1)

Footnotes :

- (1) : Denotes fractured or chipped sample. Permeability and/or porosity may be optimistic.
 - (2) : Sample permeability below the measurement range of CMS-300 equipment at indicated net confining stress (NCS). Data unavailable.
 - (3) : Denotes very short sample, porosity may be optimistic due to lack of conformation of boot material to plug surface.
 - (4) : Sample contains bitumen or other solid hydrocarbon residue.
 - (5) : Denotes sample unsuitable for measurement at stress. Porosity determined using Archimedes bulk volume at ambient conditions.
- Permeability greater than 0.1 mD measured using helium gas. Permeability less than 0.1 mD measured using nitrogen gas. All b values converted to b (air)

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Date: 05/20/2013
Analyst(s): JK, NR

CMS-300 CONVENTIONAL PLUG ANALYSIS PROTOCOL

Sample Preparation

1.0" diameter plugs were drilled with liquid nitrogen and trimmed into right cylinders with a diamond-blade trim saw.

Core Extraction

Plugs selected for routine core analysis were placed in Soxhlet extraction cycling between a chloroform /methanol (87:13) azeotrope and methanol.

Sample Drying

Samples were oven dried at 240° F to weight equilibrium (+/- 0.001 g).

Porosity

Porosity was determined using Boyle's Law technique by measuring grain volume at ambient conditions & pore volume at indicated net confining stresses (NCS)

Grain Density

Grain density values were calculated by direct measurement of grain volume and weight on dried plug samples.

Grain volume was measured by Boyle's Law technique.

Permeability

Klinkenberg permeability was measured on each sample using unsteady-state method at indicated NCS.



APPENDIX A: EXPLANATION OF CMS-300 TERMS "b", "Beta, and "Alpha"

K_{∞}	=	Equivalent non-reactive liquid permeability, corrected for gas slippage, mD
K_{air}	=	Permeability to Air, calculated using K_{∞} and b, mD
b	=	Klinkenberg slip factor, psi
β (Beta)	=	Forcheimer inertial resistance factor, ft^{-1}
α (Alpha)	=	A factor equal to the product of Beta and K_{∞} . This factor is employed in determining the pore level heterogeneity index, H_i .
H_i	=	$\log_{10} (\alpha \phi / RQI)$ α , microns = $3.238E^{-9} \beta K_{\infty}$
ϕ	=	Porosity, fraction
RQI	=	Reservoir Quality Index, microns
RQI	=	$0.0314(K/\phi)^{0.5}$

For further information please refer to:

Jones, S.C.: "Two-Point Determination of Permeability and PV vs. Net Confining Stress" SPE Formation Evaluation (March 1988) 235-241.

Jones S.C.: "A Rapid Accurate Unsteady-State Klinkenberg Permeameter," Soc. Pet. Eng. J. (Oct. 1972) 383-397.

Jones, S.C.: "Using the Inertial Coefficient, β , To Characterize Heterogeneity in Reservoir Rock: SPE 16949 (September 1987).

Amaefule, J.O.; Kersey, D.G.; Marschall, D.M.; Powell, J.D.; Valencia, L.E.; Keelan, D.K.: "Reservoir Description: A Practical Synergistic Engineering and Geological Approach Based on Analysis of Core Data,: SPE Technical Conference (Oct. 1988) SPE 18167.



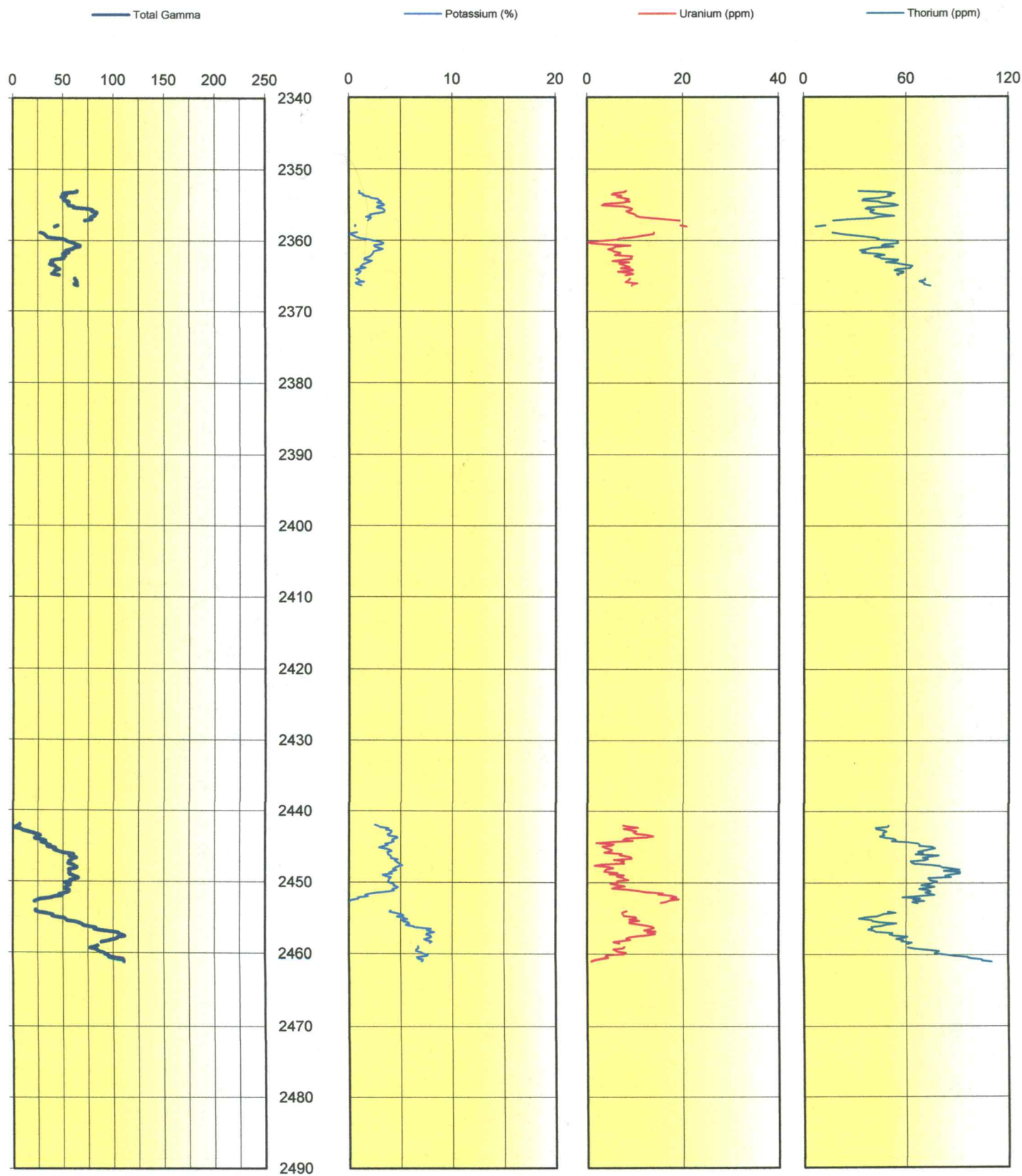
TGF Exploration

Oswald Wilcox

CL File No.: DEN-130033

Spectral Core Gamma

Scale 5" = 100'



TGF Exploration
Oswald Wilcox
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Spectral Core Gamma

Depth (Feet)	Gamma	Th	U	K	Remarks
2353.07	64.09	32.19	8.17	0.99	
2353.23	63.45	48.93	7.64	1.06	
2353.40	50.92	53.26	5.52	0.98	
2353.57	49.94	49.33	5.14	1.39	
2353.73	53.45	51.12	7.17	1.39	
2353.90	48.64	48.46	6.30	1.96	
2354.07	51.91	44.43	7.54	2.15	
2354.23	51.42	35.19	8.78	2.81	
2354.40	51.07	34.28	8.08	2.92	
2354.57	56.05	43.82	8.91	3.12	
2354.73	54.54	45.43	6.96	2.77	
2354.90	55.65	52.19	3.62	3.29	
2355.07	55.73	55.11	3.07	3.43	
2355.23	60.91	49.67	7.53	2.86	
2355.40	60.83	37.93	8.74	2.73	
2355.57	74.07	36.30	9.42	3.26	
2355.73	79.56	41.23	9.18	3.47	
2355.90	78.69	39.06	8.18	3.44	
2356.07	83.43	39.04	8.60	3.39	
2356.23	83.23	41.51	9.48	2.69	
2356.40	81.08	47.30	10.11	2.04	
2356.57	81.65	52.96	10.21	2.10	
2356.73	77.62	43.42	11.07	1.66	
2356.90	78.26	40.71	13.63	2.11	
2357.07	78.42	25.08	16.72	1.99	
2357.23	71.71	17.36	19.32	1.83	
2357.90	44.81	12.77	19.50	0.63	
2358.07	41.72	7.07	20.83	0.60	
2358.90	27.63	17.10	13.99	0.79	
2359.07	31.15	21.58	13.92	0.05	
2359.57	34.76	40.94	9.06	0.77	
2359.57	34.76	40.94	9.06	0.77	
2359.73	43.96	43.90	6.79	1.13	
2359.90	52.06	43.10	6.08	1.95	
2360.07	53.70	53.93	2.89	2.34	
2360.23	57.24	55.17	0.01	3.06	
2360.40	60.99	54.99	0.80	3.34	
2360.57	63.43	47.44	4.13	3.20	
2360.73	66.75	45.71	9.06	2.46	
2360.90	66.35	52.48	5.87	2.49	

2361.07	60.63	39.89	5.54	2.86
2361.23	59.74	37.17	4.38	3.27
2361.40	53.71	32.92	5.26	2.94
2361.57	52.71	36.16	5.80	2.39
2361.73	55.79	34.19	6.96	2.38
2361.90	50.13	43.51	6.80	2.30
2362.07	51.04	47.35	5.76	2.21
2362.23	52.44	41.49	9.46	2.13
2362.40	49.89	44.58	9.18	1.83
2362.57	50.60	45.53	9.32	1.52
2362.73	41.47	55.20	7.32	1.53
2362.90	38.12	54.71	5.28	2.23
2363.07	39.55	48.18	8.86	1.95
2363.23	38.60	55.07	6.71	1.73
2363.40	37.17	58.18	7.30	1.34
2363.57	41.80	63.54	8.16	1.25
2363.73	42.97	62.70	8.94	1.12
2363.90	43.92	62.42	7.08	1.62
2364.07	46.48	55.15	9.36	0.92
2364.23	42.39	53.06	9.61	0.64
2364.40	41.62	58.36	6.44	1.14
2364.57	41.75	58.04	9.04	1.06
2364.73	39.12	54.59	9.59	0.87
2364.90	46.13	55.46	8.01	0.79

2365.40	61.84	70.84	8.98	0.75
2365.57	62.16	71.08	8.65	0.97
2365.73	63.48	67.75	8.50	1.00
2365.90	63.40	69.13	8.02	1.47
2366.07	64.00	70.65	10.52	0.66
2366.23	61.38	70.44	9.50	0.78
2366.40	64.43	74.10	9.30	1.21

2442.00	6.80	49.69	7.46	2.52
2442.17	6.16	49.11	8.61	2.85
2442.33	3.44	42.00	10.62	3.01
2442.50	1.92	42.47	7.58	3.82
2442.67	7.94	46.99	8.99	3.59
2442.83	9.35	48.31	10.23	4.11
2443.00	14.18	46.60	9.64	4.10
2443.17	18.80	46.33	10.18	3.99
2443.33	22.43	47.14	12.60	3.73
2443.50	26.84	44.51	13.75	3.82
2443.67	25.98	47.29	12.41	4.63
2443.83	23.99	52.43	7.99	4.68
2444.00	21.99	53.88	7.54	4.26
2444.17	29.40	51.56	9.50	4.17
2444.33	32.31	61.49	5.28	4.33
2444.50	28.08	66.77	1.90	4.13
2444.67	32.94	67.79	5.55	3.51
2444.83	33.71	67.62	5.17	3.74
2445.00	37.56	75.24	3.17	3.40
2445.17	34.59	76.84	3.90	2.93
2445.33	42.25	73.29	4.68	3.56

2445.50	40.78	70.10	5.19	3.92
2445.67	43.15	66.89	4.74	4.12
2445.83	46.86	69.63	3.57	3.75
2446.00	51.01	65.43	7.20	3.78
2446.17	60.18	78.96	6.77	3.80
2446.33	56.62	73.99	8.18	4.01
2446.50	56.95	69.66	9.19	4.10
2446.67	63.13	72.67	9.28	4.10
2446.83	59.66	70.75	5.56	4.72
2447.00	58.10	62.64	7.67	4.42
2447.17	55.82	63.39	7.12	4.61
2447.33	56.97	64.88	7.76	4.83
2447.50	55.05	74.56	2.84	4.91
2447.67	59.92	79.89	1.58	5.15
2447.83	61.55	80.76	4.41	4.77
2448.00	63.59	86.93	5.45	4.45
2448.17	62.38	91.28	4.04	4.28
2448.33	55.83	81.97	3.81	4.59
2448.50	56.31	91.42	3.59	4.21
2448.67	56.55	91.34	6.37	3.90
2448.83	55.94	85.81	4.64	4.16
2449.00	56.58	82.75	7.66	3.27
2449.17	59.97	86.20	6.27	3.60
2449.33	62.21	72.89	7.52	4.05
2449.50	65.15	73.62	7.68	3.91
2449.67	62.20	73.96	8.58	3.88
2449.83	56.86	78.01	6.25	3.81
2450.00	57.82	75.24	6.47	3.85
2450.17	51.91	73.38	4.85	4.12
2450.33	55.56	68.93	6.06	4.41
2450.50	56.91	76.39	7.81	4.37
2450.67	53.96	72.65	6.07	4.73
2450.83	52.96	67.53	5.18	4.62
2451.00	51.58	72.65	8.30	4.23
2451.17	55.81	74.26	10.78	4.37
2451.33	56.10	71.14	12.34	3.76
2451.50	55.26	73.59	15.76	2.72
2451.67	51.31	76.38	14.89	1.97
2451.83	46.00	67.85	17.60	1.58
2452.00	48.94	57.74	18.67	1.83
2452.17	40.77	68.02	17.47	0.89
2452.33	37.42	64.12	19.15	0.92
2452.50	27.72	70.52	17.07	0.32
2452.67	24.46	63.57	16.64	0.04
2452.83	21.59	66.50	15.33	0.01

2454.00	23.02	49.22	8.24	4.04
2454.17	22.87	53.72	7.42	3.95
2454.33	25.84	47.14	7.32	4.49
2454.50	33.58	44.66	7.50	5.05
2454.67	39.56	42.57	7.62	5.29
2454.83	39.32	35.36	10.11	4.66
2455.00	43.50	32.31	10.28	5.22

2455.17	51.32	39.26	8.77	5.65
2455.33	52.92	40.46	10.91	5.09
2455.50	53.92	44.15	8.84	5.29
2455.67	62.24	54.25	8.85	5.78
2455.83	65.80	48.73	10.30	5.85
2456.00	68.88	45.21	12.34	5.51
2456.17	70.36	39.78	13.42	6.18
2456.33	75.94	40.31	13.98	6.42
2456.50	82.34	37.79	13.08	7.93
2456.67	80.99	41.10	11.92	7.56
2456.83	86.65	42.22	14.29	7.82
2457.00	96.51	51.88	12.57	8.27
2457.17	104.73	50.35	14.18	7.55
2457.33	105.20	52.75	12.85	7.51
2457.50	108.64	60.78	10.53	7.90
2457.67	111.07	58.27	8.80	7.97
2457.83	104.73	54.15	8.18	7.74
2458.00	103.46	58.19	9.05	7.29
2458.17	98.36	57.23	7.29	7.59
2458.33	94.45	63.32	5.49	8.02
2458.50	88.22	60.64	6.77	7.84

2459.00	84.53	60.96	7.81	6.71
2459.17	81.33	65.44	7.53	6.75
2459.33	77.26	73.11	5.47	6.62
2459.50	83.26	79.12	5.90	6.51
2459.67	84.59	77.60	6.48	6.53
2459.83	86.22	76.79	8.10	7.02
2460.00	90.64	83.43	7.79	7.22
2460.17	91.85	87.92	4.11	7.67
2460.33	95.05	95.75	3.86	7.56
2460.50	95.42	97.74	4.43	6.61
2460.67	101.23	104.25	2.95	6.73
2460.83	109.47	104.64	1.65	7.18
2461.00	110.46	110.25	0.91	7.04