T32S R14E, Sec.10
R. COPENHAVER 15-10
15-125-30124

CMS-300 CONVENTIONAL PLUG ANALYSIS

Layne Energy

Various Wells

15-049-22397 Fuqua 10-36 28-9
T28S R09E, Sec. 36

CL File Number: DEN-120035

Date: 5.9.2012

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Analyst(s): SK

CMS-300 CONVENTIONAL PLUG ANALYSIS

Sample Number		Well Name	Depth (ft)	Net Confining Stress (psig)	Porosity (%)	Permeability Klinkenberg (md)	Permeability Kair (md)	b(air) psi	Beta ft(-1)	Alpha (microns)	Grain Density (g/cm3)	Footnote
1	15-049-22397	Fuqua 10-36 28-9 T28S R09E, Sec. 36	2234.60	800	6.25	0.007	0.0147	30.65	8.90E+13	2.05E+03	2.589	
2	15-125-30117	E. McCabe 2-16 T31S R14E, Sec. 16	1411.50	Ambient	15.70	***	***	***	***	***	2.672	(5)
3	15-125-30124	R. Copenhaver 15-10 T32S R14E, Sec. 10	1416.70	800	8.40	6.73	7.68	6.79	9.58E+09	2.08E+02	2.584	(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)

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	=	$\log_{10}(\alpha ø/RQI)$ α, microns = $3.238E^{-9}\,\beta K_\infty$
Ø	=	Porosity, fraction
RQI	=	Reservoir Quality Index, microns
RQI	=	$0.0314(K/ø)^{0.5}$

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.

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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 were cleaned in a Soxhlet extraction unit, cycling in a chloroform/methanol (87:13) azeotrope.

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
Permeability to air was measured on each sample using unsteady-state method at indicated NCS.

Fluid Saturations
Fluid saturations were determined by the Dean Stark technique using the following fluid properties:

Brine	1.032 g/cc (50000 ppm TDS)
Oil	0.845 g/cc (36° API)