Central Petroleum
CBM 107-001 Well
Purni Formation
Perdika Basin
February 2010
Water Injection-Falloff Test Analysis Summary

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Summary

Weatherford Laboratories (WFT Labs) conducted one water injection-falloff test between February 14th, 2010 and February 15th, 2010, of Purni Formation penetrated by Central Petroleum's CBM 107-001 well. Table 1 summarizes the pressure and temperature conditions of tested interval. Table 2 summarizes the test analysis results.

This well is a core hole that was not produced before testing and the coal natural fracture (cleat) systems were water filled during each test. Therefore, estimates of permeability to water were equivalent to the absolute permeability.

Table 1. CBM 107-001 Pressure and Temperature Conditions

Tested Interval	Tested Interval Top Depth	Tested Interval Bottom Depth	Static Pressure	Pressure Depth	Pressure Gradient*	Temperature	Temperature Gradient**
	m	m	kPaa	m	kPa/m	°C	°C/m
Purni Formation	831.4	838.9	8,130	832.0	9.65	63.8	0.0466

* Pressure gradient computed with a surface pressure of 101.325 kPaa.
** Temperature gradient computed with a mean annual surface temperature of 25 °C.
*** All depths are to ground level.

Table 2. CBM 107-001 Reservoir Property Summary

Tested Interval	Coal Thickness	Near-Well Effective Permeability to Water	Far-Region Effective Permeability to Water	Skin Factor	Radius from Well to Far-Region	Radius of Investigation
	m	md	md	-	m	m
Purni Formation	7.4	1.65	36.7	0	9.4	52.0

The data from test were analyzed by application of a composite reservoir model that accounted for a reduced permeability region near the well. This region was likely caused by interactions with drilling and test fluids. The permeability was reduced to approximately 0.045 of the original permeability to a distance of approximately 9.4 m from the well. The permeability beyond the near-well region, which is the permeability that would control production after stimulation, was 36.7 md. The estimated skin factor at the well was 0. The static pressure estimate indicated that the tested interval was slightly under pressured relative to the hydrostatic head of water to surface (9.65 kPa/m).

The estimated radius of investigation during the test was 52.0 m due to the extended falloff test.

The remainder of this report discusses the test data and the analysis thereof.

Test Analysis Details

The water injection-falloff test was performed between February 14th, 2010 and February 15th, 2010. The test interval was Purni Formation at depths between 831.4 and 838.9 m. The upper and lower packers were set at 831.5 and 838.9 m, respectively. Two transducers were placed at a depth of 832.0 meters between the two packers. This section discusses the analysis of the data collected during this test.

Figure 1 illustrates pressure and temperature measured by a transducer at a depth of 832.0 m. The test consisted of an 8-hour injection period that started approximately 10 hours after the transducers were initialized followed by a 16-hour falloff period with no injection.

Figure 1. Pressure and Temperature Data

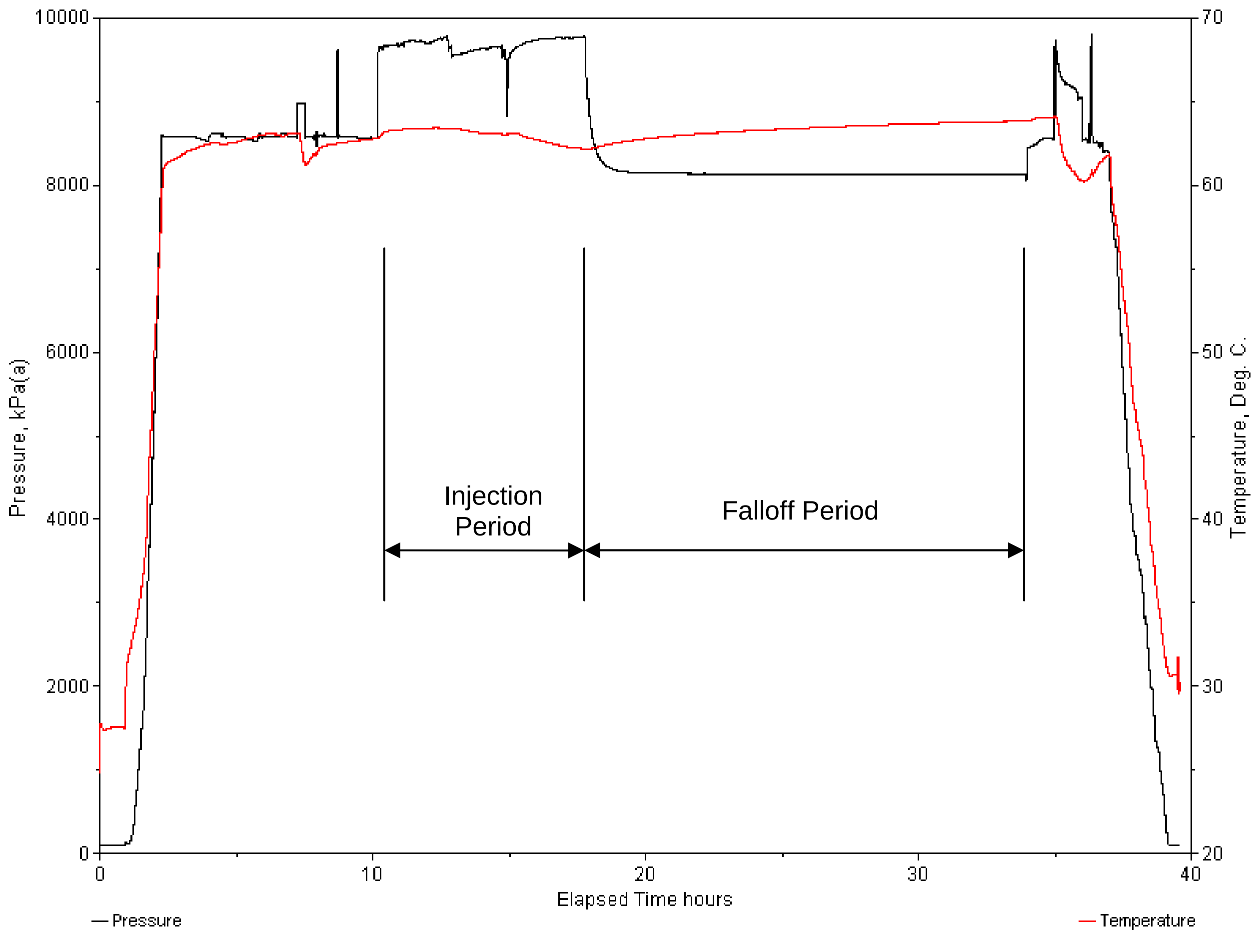


Figure 3 illustrates the surface water injection rate data. The injection rate data were simplified to the test history summarized in Table 3 for analysis.

Figure 2. **Surface Water Injection Rate Data**

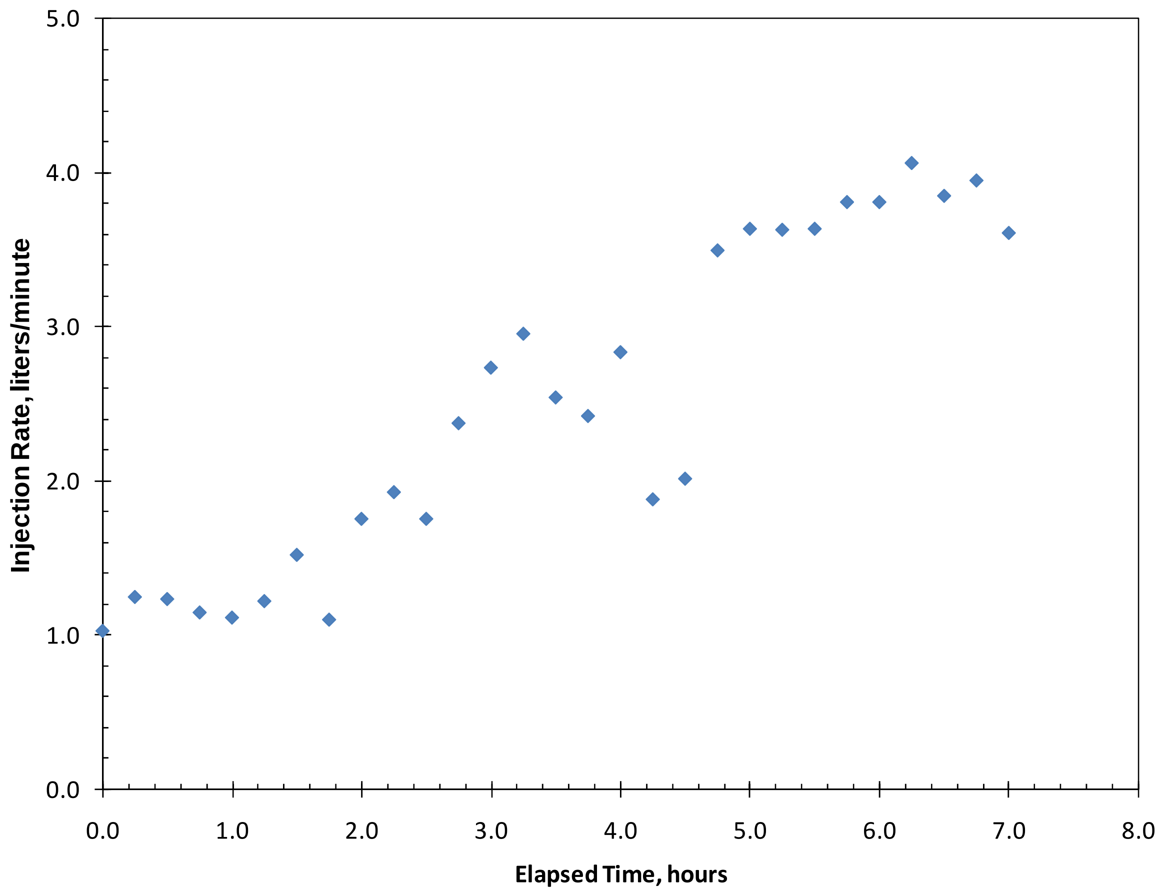


Table 3. **Injection-Falloff Test Times**

Test Period	Elapsed Time at Period Start	Elapsed Time at Period End	Surface Water Injection Rate	Pressure at Period Start	Pressure at Period End
	hours	hours	liters/min	kPaa	kPaa
Injection 1	0.000	2.578	1.35	8570.9	9783.5
Injection 2	2.578	4.593	2.51	9783.5	9673.3
Injection 3	4.593	7.627	3.44	9673.3	9752.3
Falloff	7.627	23.778	0	9752.3	8130.3

Table 4 summarizes the test analysis parameters. The tested interval thickness was determined by the distance between the two packers as both packers were set in the coal seam that was continuous in this interval. The values for Young's Modulus and Poisson's Ratio were typical values for coal and were used to compute the pore volume compressibility. These values affect the radius of investigation and skin factor estimates but do not affect the conductivity or permeability estimates. Water properties were estimated from correlations[1] for fresh water at the reservoir temperature.

Figure 3 illustrates a diagnostic graph of the falloff period data. A diagnostic graph presents the log of the pressure change and the log of the derivative of the pressure change versus the log of the elapsed time during the period. The derivative was computed with respect to a multirate superposition function.[2]

The data were evaluated with a composite reservoir model[3] with two concentric permeability regions each

each of constant permeability. Figure 4 illustrates a plan view of the model geometry.

Table 4. Analysis Parameters

Parameter	Units	Value
Geometry		
Top Depth	m	831.4
Bottom Depth	m	838.9
Coal Thickness	m	7.4
Wellbore Radius	m	0.09
Coal Matrix Properties		
Temperature	°C	63.8
Young's Modulus	kPaa	$3.47(10^{6})$
Poisson's Ratio	-	0.25
Natural Fracture Properties		
Porosity	vol. fraction	0.01
Total Compressibility	kPa^{-1}	$2.46(10^{-5})$
Water Properties		
Viscosity	cp	0.443
Formation Volume Factor	res. vol./surface vol.	1.017

Table 5 summarizes the analysis results that resulted from matching the composite model to the observed test behavior. The model matched the falloff period well as illustrated in Figure 3 and Figure 5, which is a semilog graph of the falloff period data. Figure 6 illustrates the match with the entire test history.

Table 5. Test Analysis Results

Property	Unit	Value
Model	-	variable permeability model with wellbore storage and skin effects
Static Pressure	kPaa	8130.0
Temperature	°C	63.8
Pressure and Temperature Depth	m	832
Pressure Gradient to Surface	kPa/m	9.65
Temperature Gradient to Surface	°C/m	0.0466
Near-Well Region Effective Conductivity to Water	md-m	12.21
Near-Well Region Effective Permeability to Water	md	1.65
Radius to Far Region	m	9.45
Far-Region Effective Conductivity to Water	md-m	271.3
Far-Region Effective Permeability to Water	md	36.7
Dimensionless Wellbore Storage Coefficient	-	150
Skin Factor	-	0
Flow Efficiency	%	100
Radius of Investigation	m	52.5

Figure 3. **Falloff Period Diagnostic Graph**

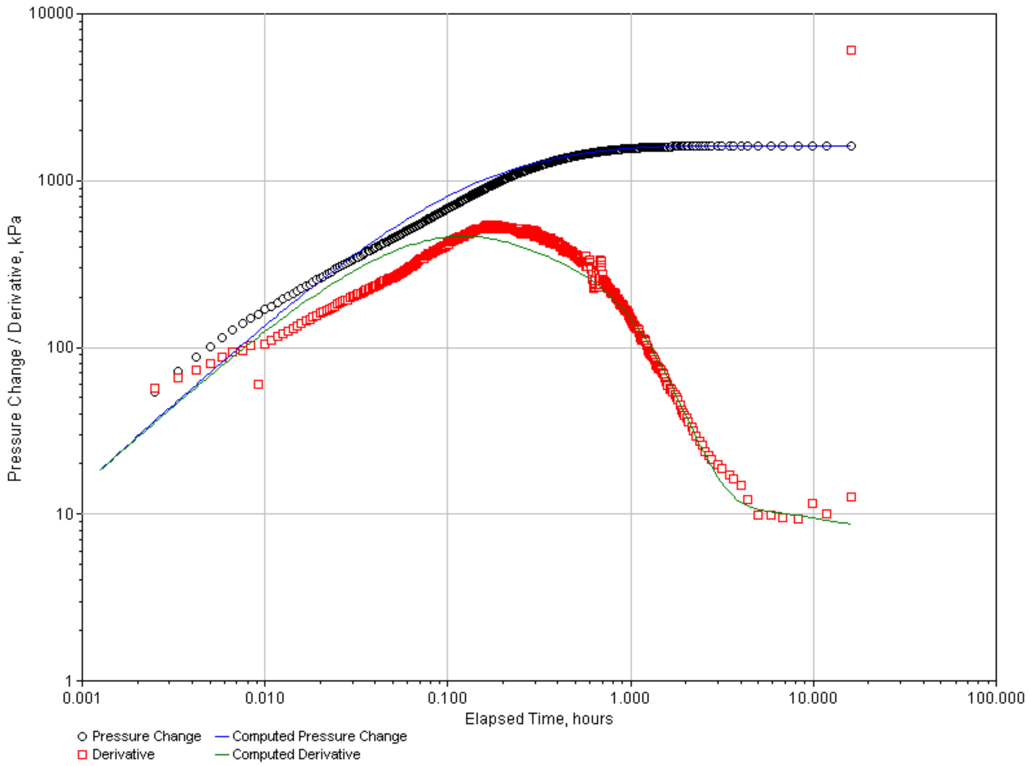


Figure 4. **Composite Reservoir Model Geometry**

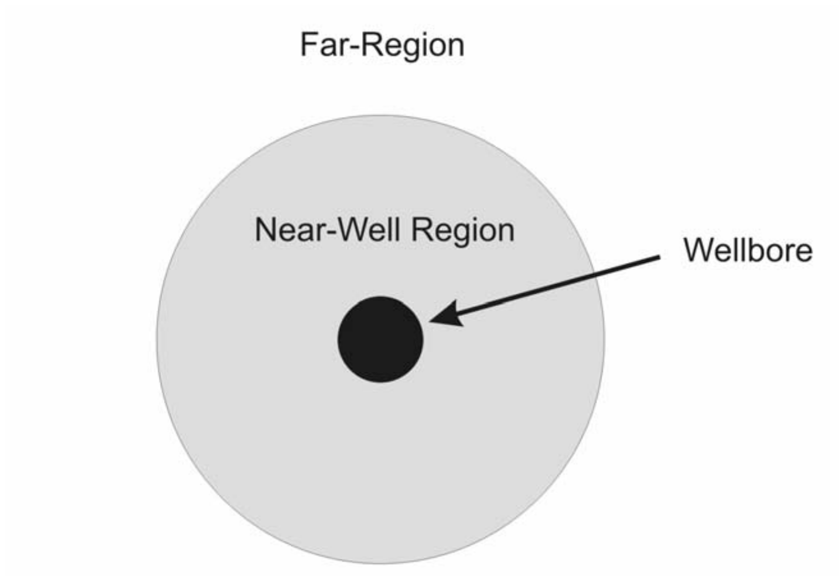


Figure 5. **Falloff Period Semilog Graph**

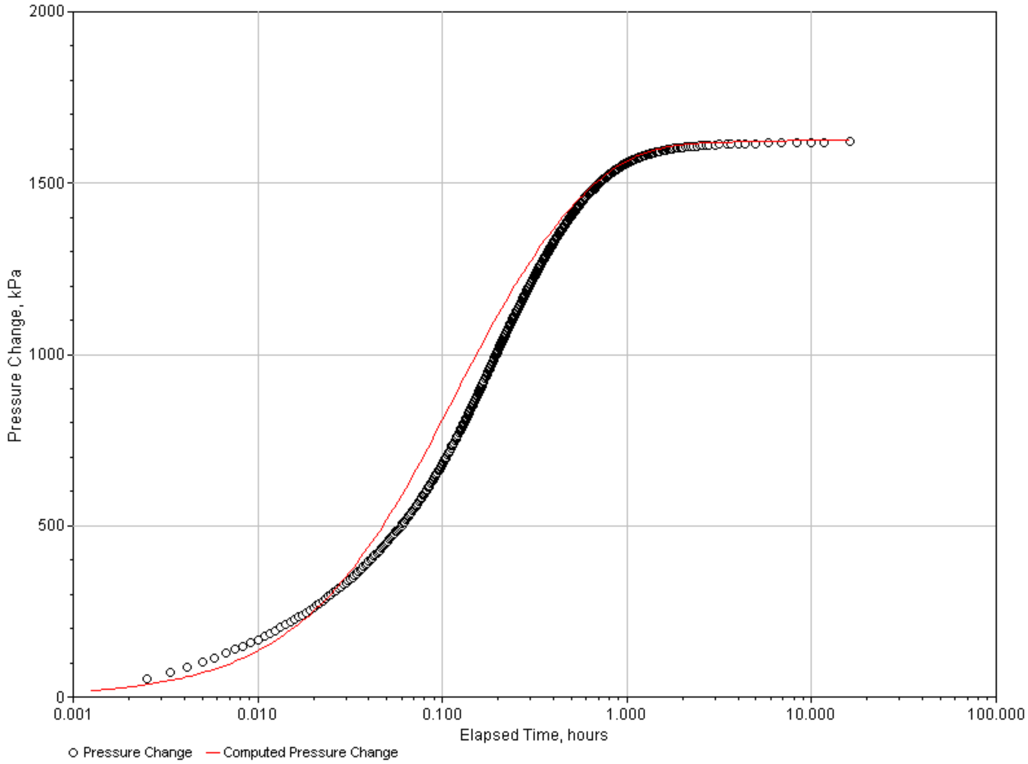
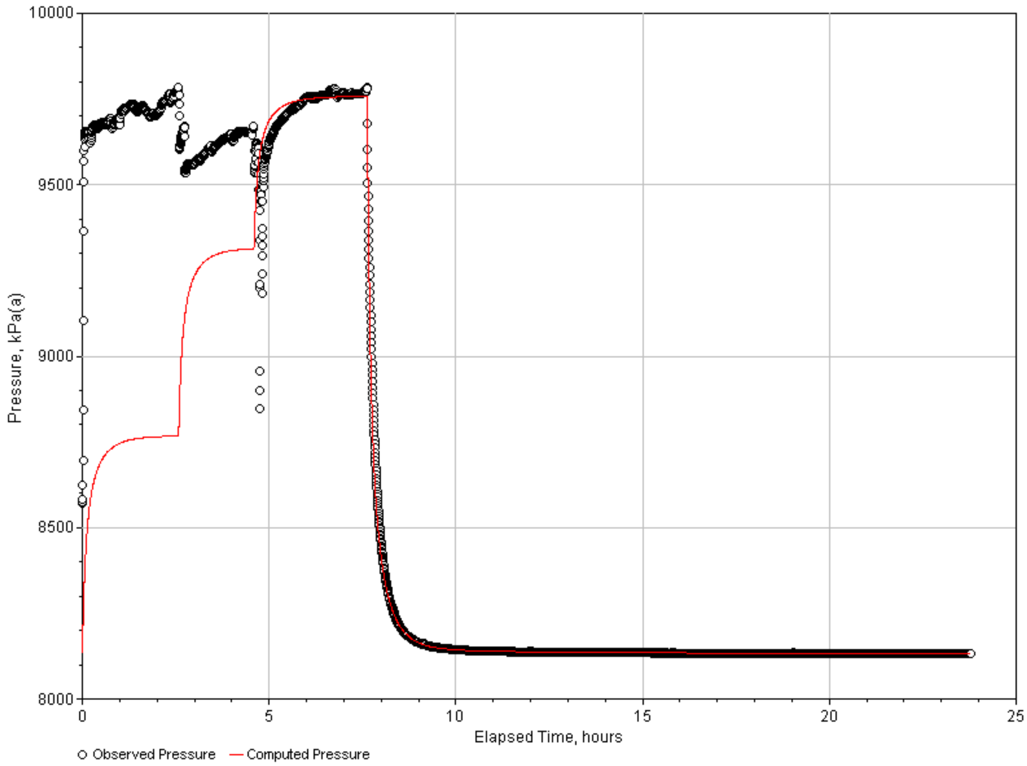


Figure 6. **History Match**



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1. Whitson, C.H., and Brule, M.R.: *Phase Behavior*, Monograph Volume 20, Henry L. Doherty Series, Society of Petroleum Engineers, Richardson, Texas (2000).

2. Mavor, M.J. and Robinson, J.R.: “Analysis of Coal Gas Reservoir Interference and Cavity Well Tests,” Paper SPE 25860 presented at the 1993 Joint Rocky Mountain Regional and Low Permeability Reservoirs Symposium held in Denver, Colorado (April 26-28, 1993).

3. Satman, A., Eggenschwiller, M., and Ramey, H.J., Jr.: “Interpretation of Injection Well Pressure Transient Data in Thermal Oil Recovery,” paper SPE 8908 presented at the 1980 California Regional Meeting of the Society of Petroleum Engineers, Los Angeles, California (April 9-11, 1980).