Central Petroleum
CBM 93-002 Well
Purni Formation
Perdika Basin
June 2010
Water Injection-Falloff Test Analysis Summary

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Summary

Weatherford Laboratories (WFT Labs) conducted one water injection-falloff test between June 2, 2010 and June 3, 2010, of Purni Formation penetrated by Central Petroleum's CBM 93-002 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 the test. Therefore, estimates of permeability to water were equivalent to the absolute permeability.

Table 1. CBM 93-002 Pressure and Temperature Conditions

Test Interval	Coal Top Depth	Coal Bottom Depth	Static Pressure	Pressure Depth	Pressure Gradient*	Temperature	Temperature Gradient**
	m	m	kPaa	m	kPa/m	°C	°C/m
Purni Formation	701.5	712.0	6,889.8	702.0	9.67	56.7	0.045

* Pressure gradient computed with a surface pressure of 101.325 kPaa.
** Temperature gradient computed with a mean annual surface temperature of 25 °C.

Table 2. CBM 93-002 Reservoir Property Summary

Test Interval	Coal Thickness	Effective Conductivity to Water	Effective Permeability to Water	Fracture Skin Factor	Fracture Half Length
	m	md-m	md	-	m
Purni Formation	10.5	5.78	0.55	0	5.87

The test was evaluated with a single porosity model with an indefinite conductivity fracture. The permeability estimate of 0.55 md was moderate. There is an indefinite fracture with a half-length of 5.87 m. The static pressure estimate indicated that the tested interval was slightly under pressured relative to the hydrostatic head of water to surface.

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

Test Analysis Details

The water injection-falloff test was performed between June 2, 2010 and June 3, 2010. The test interval was Purni Formation at depths between 701.5 and 712.0 m. This test was an open-hole test. The upper packer was placed at a depth of 701.5 m. 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 702 m. The test consisted of an 7.9-hour injection period that started approximately 3.6 hours after the transducers were initialized followed by a 16-hour falloff period with no injection.

Figure 1. Pressure and Temperature Data

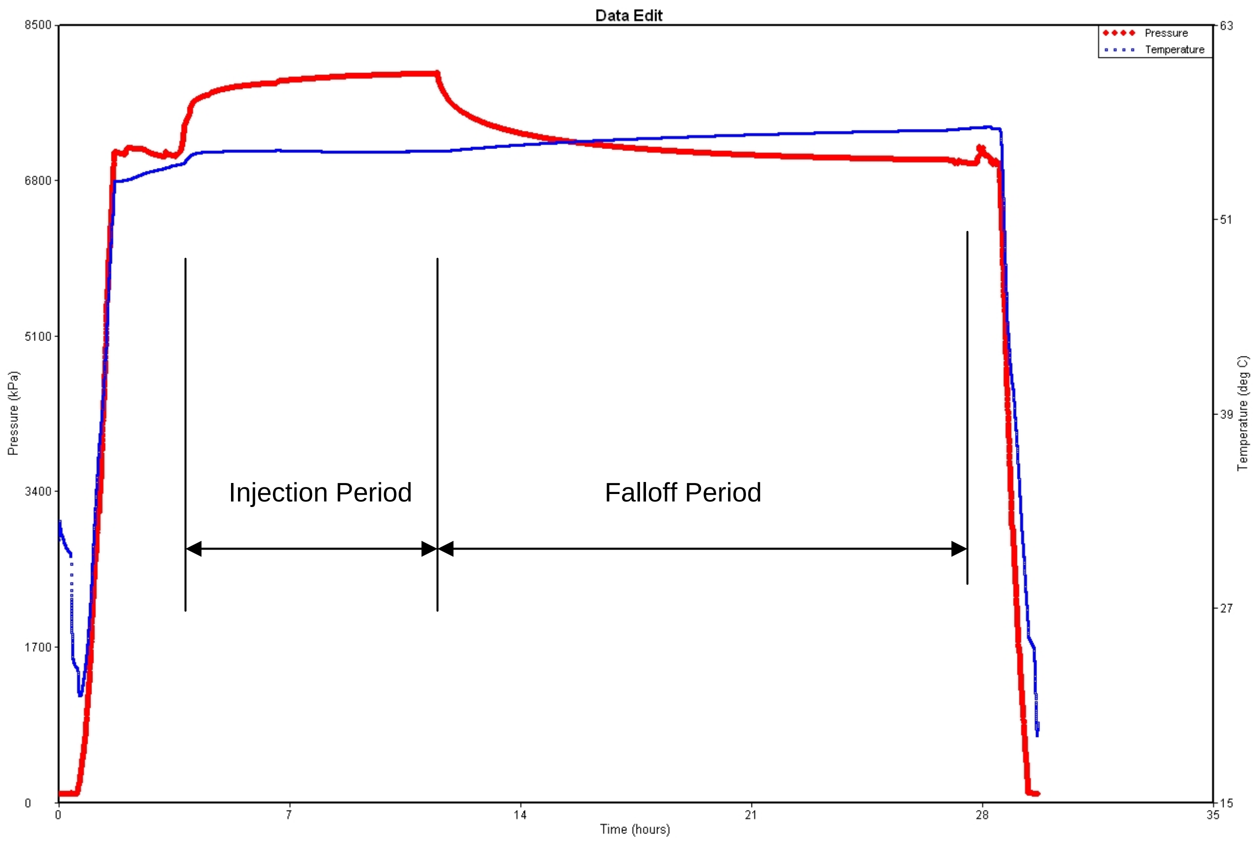


Figure 3 illustrates the surface water injection rate data. The injection rate data were simplified to the test history summarized in Table 3 for analysis.

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

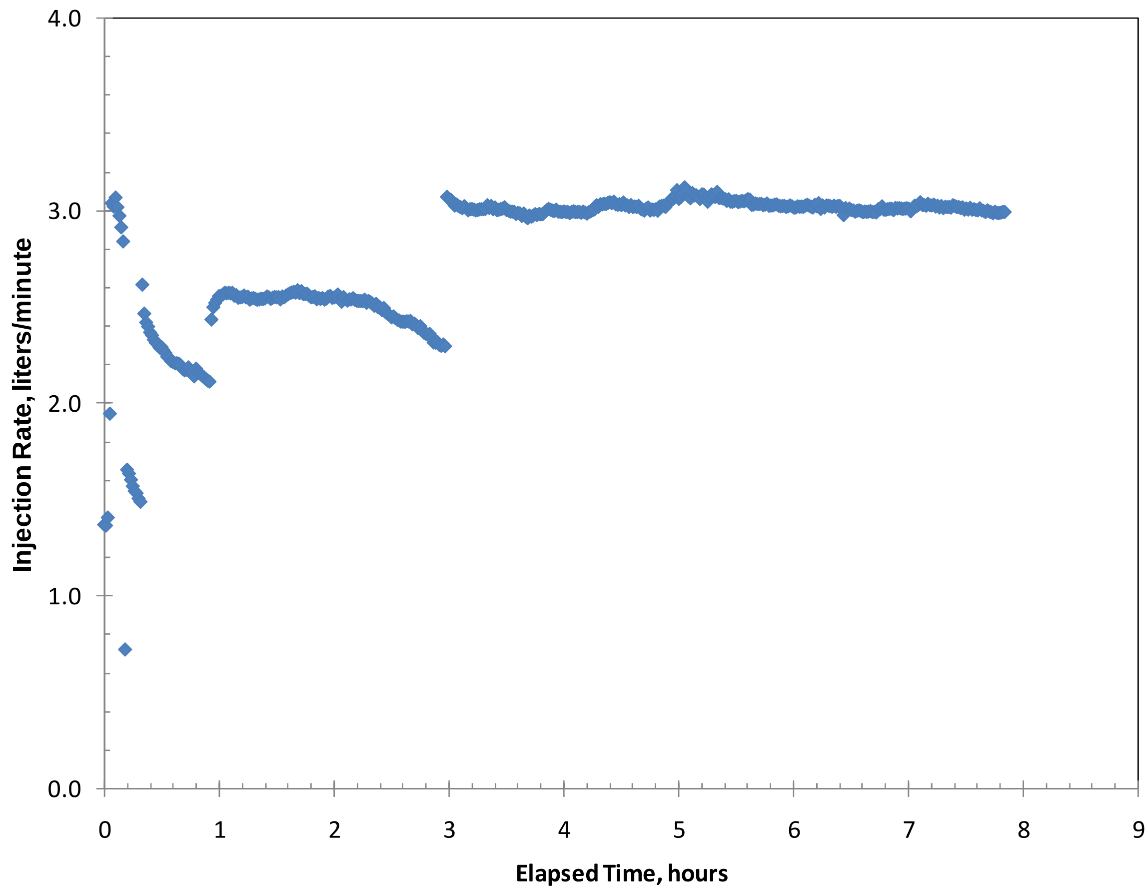


Table 3. **Injection-Falloff Test Times**

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	3.001	2.30	7,079.2	7,859.1
Injection 2	3.001	7.880	3.00	7,859.1	7,967.2
Falloff	7.880	23.522	0.00	7,967.2	7,018.7

Table 4 summarizes the test analysis parameters. The coal thickness was determined by visual observation during drilling and coring. The values for Young's Modulus, Poisson's Ratio, and the natural fracture porosity were typical values for coal and were used to compute the pore volume compressibility. These values affect the fracture half-length and the 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.

Table 4. **Analysis Parameter**

Parameter	Units	Value
Geometry		
Top Depth	m	701.5
Bottom Depth	m	712.0
Coal Thickness	m	10.5
Wellbore Radius	m	0.089
Coal Matrix Properties		
Temperature	°C	56.7
Young's Modulus	kPaa	$3.65(10^{6})$
Poisson's Ratio	-	0.25
Natural Fracture Properties		
Porosity	vol. fraction	0.01
Total Compressibility	kPa^{-1}	$4.15\ (10^{-5})$
Water Properties		
Viscosity	cp	0.475
Formation Volume Factor	res. vol./surface vol.	1.013

The data were evaluated with a wellbore storage and infinite fracture model[2]. Table 5 summarizes the analysis results that resulted from matching the infinite fracture model to the observed test behavior. Considering the relatively high permeability, the infinite fracture may not be created by the injection but is a pre-existing one. The pre-existing fracture might be opened during the injection period. The fracture effect can be converted into a negative pseudo-skin factor of -3.50. The model matched the falloff period well as illustrated in Figure 3 and Figure 4, which is a semilog graph of the falloff period data. Figure 5 illustrates the match with the fall-off period. The computed behavior generally matched the measured data throughout the test.

Table 5. **Test Analysis Results**

Property	Unit	Value
Model	-	single porosity infinite conductivity fracture model with wellbore storage effect
Static Pressure	kPaa	6,889.8
Temperature	°C	56.7
Pressure and Temperature Depth	m	702.0
Pressure Gradient to Surface	kPa/m	9.67
Temperature Gradient to Surface	°C/m	0.045
Effective Conductivity to Water	md-m	5.78
Effective Permeability to Water	md	0.55
Wellbore Storage Coefficient	m^3/kPa	$2.73(10^{-5})$
Fracture Skin Factor	-	0
Pseudo-Skin Factor	-	-3.50
Flow Efficiency	%	92.8
Fracture Half-Length	m	5.87

Figure 3. **Falloff Period Diagnostic Graph**

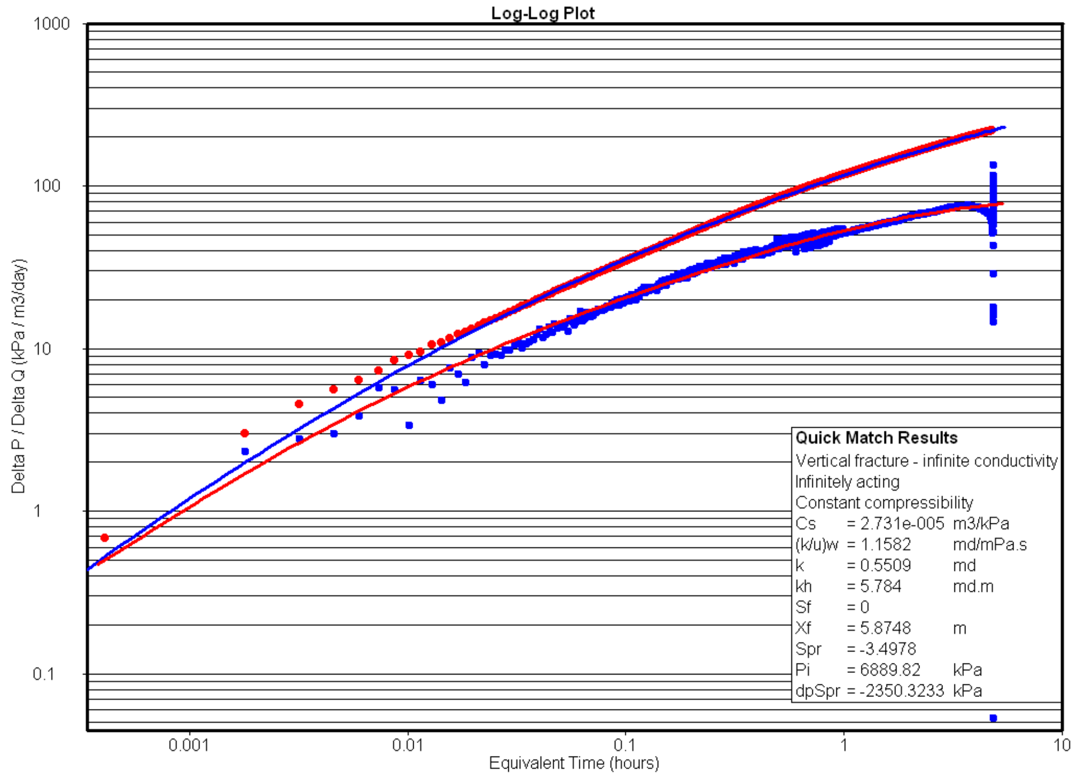


Figure 4. **Falloff Period Semilog Graph**

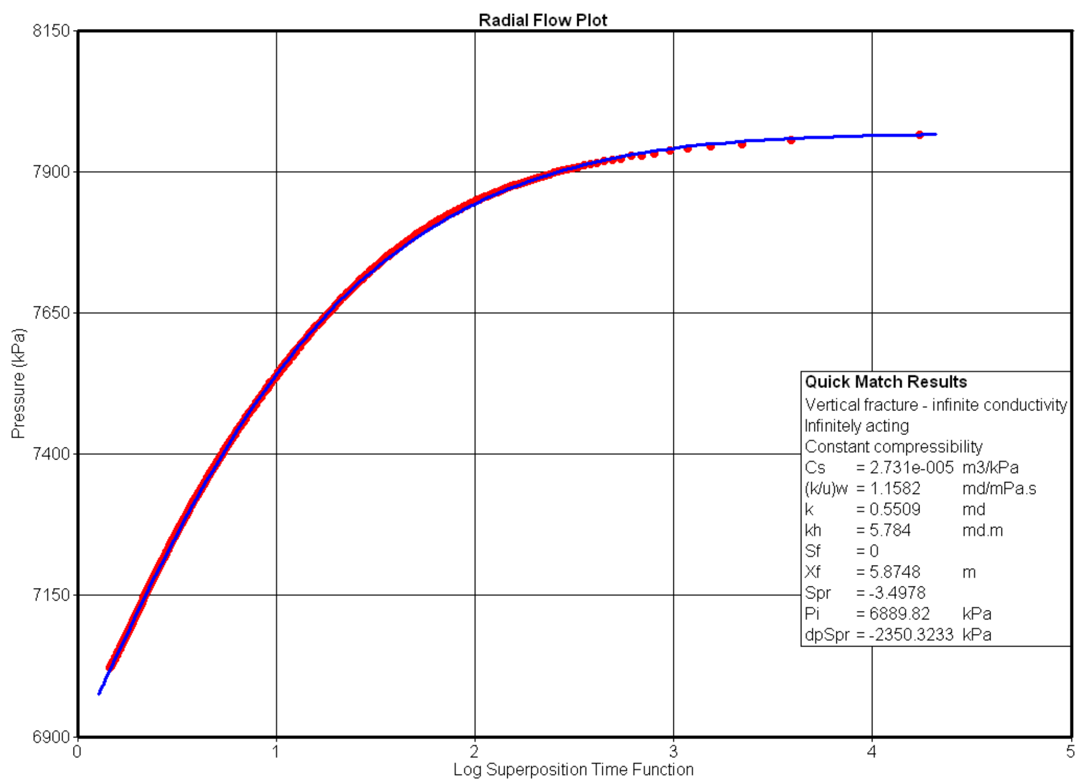
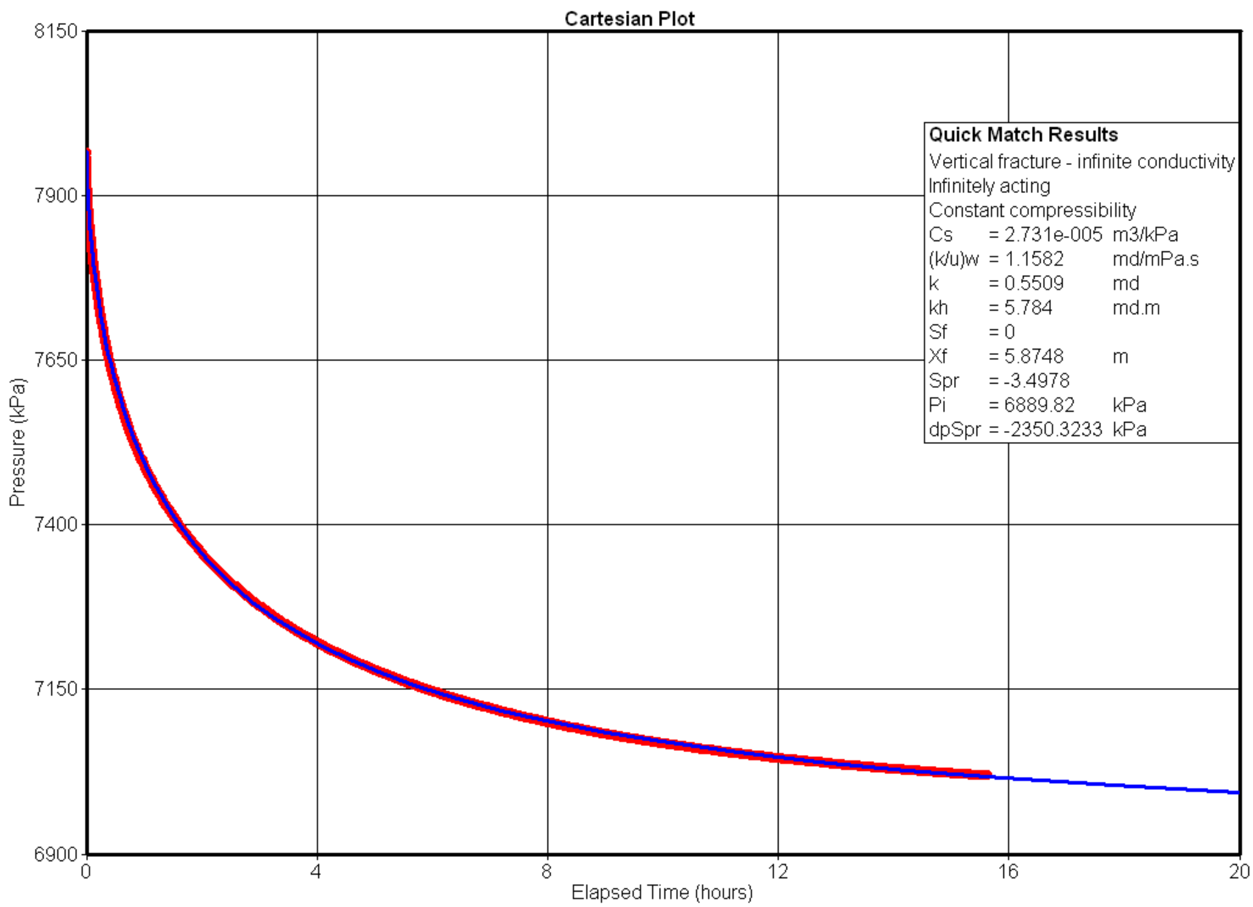


Figure 5. **History Match**



References

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. Horne, N.R.: *Modern Well Test Analysis: A Computer-Aided Approach*, Petroway, Inc., 1995, pp. 36-40.