

NATIONAL ENERGY BOARD
ENERGY RESEARCH BRANCH
OCT 25 2001

**ADVANCED ROCK PROPERTIES STUDY
for
CANADIAN NATURAL RESOURCES LIMITED**

**PCI CANTERRA TWEED LAKE A-67
66° 56' 11" N LAT. 126° 56' 18" W LOG**

2001-08-30

52132-01-1032

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RELEASE DATE
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Core Laboratories

PROGRAM PARTICIPANTS

Laboratory Measurements and Data Review



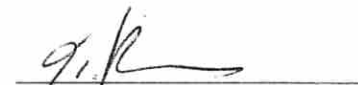
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EXECUTIVE SUMMARY

Dynamic overbalance mud leakoff/gas regain tests were conducted on four (4) samples, and Mercury Injection Capillary Pressure on two (2) sample from the PCI Canterra Tweed Lake A-67 well, representing the Mount Clark formation in the Tweed Lake field. The porosity and air permeability of the samples ranged from 8.8% to 12%, and from 0.43 mD to 13.4 mD, respectively. Three mud systems, i.e., Viscom Polymer mud, Salt Saturated mud and Gel Chem mud were evaluated. Detailed discussion of results is presented under "Results and Discussion". Summary of the main findings is as follows.

- Viscom Polymer mud leakoff/gas regain testing was conducted on sample #1 (Porosity = 0.088, K_{air} = 0.43mD) at an initial water saturation of 22.0%. A threshold pressure of 3,034 kPa was measured as the breakthrough pressure during regain permeability measurement. Final regain permeability was 0.022 mD, which was 25.9% of the original baseline gas permeability.
- Salt saturated mud leakoff/gas regain testing was conducted on sample #2 (Porosity = 0.114, K_{air} = 0.84mD) at an average initial water saturation of 23.4%. A threshold pressure of 1,930 kPa was measured as the breakthrough pressure during regain permeability measurement. Final regain permeability was 0.055 mD, which was 28.1% of the original baseline gas permeability.
- Gel Chem mud leakoff/gas regain testing was conducted on sample #3 (Porosity = 0.118, K_{air} = 5.66 mD) at an average initial water saturation of 33.7%. A threshold pressure of 172 kPa was measured as the breakthrough pressure during regain permeability measurement. Final regain permeability was 0.038 mD, which was 79.8% of the original baseline gas permeability.
- Viscom Polymer mud leakoff/gas regain testing was conducted on sample #4 (Porosity = 0.120, K_{air} = 13.4 mD) at an average initial water saturation of 26.0%. A threshold pressure of 3,170 kPa was measured as the breakthrough pressure during regain permeability measurement. Final regain permeability was 0.055 mD, which was 22.0% of the original baseline gas permeability.
- Gel Chem mud had the lowest filtrate loss and the highest percentages of regain permeability.

- Mercury injection capillary pressure tests conducted on the end trims of sample #2 and #4 indicated that these two samples have different pore structure. Sample #2 has a unimodal pore system with good connectivity and little micro-porosity, whereas sample #4 has a bimodal pore system and high percentage of micro-porosity. The reservoir rock represented by sample #2 will have lower connate water saturation than sample #4.

RESULTS AND DISCUSSION

At the request of Canadian Natural Resources Limited, Core Laboratories Canada Ltd. has conducted an Advanced Rock Properties Study on core samples from the PCI Canterra Tweed Lake A-67 well.

The testing program included Dynamic Mud Leakoff and Gas Regain Permeability on four (4) small plug samples and Mercury Injection Capillary Pressure on two (2) small plug samples. Results of the Mud Leakoff and regain permeability are summarized in Table 2.1 and those of the mercury injection tests in Table 2.2 in this section. A detailed discussion of the test results is provided below.

Simulated formation brine, used in the testing, was from the Mobil Balot Hills M-63-N.W.T. well.

Three mud systems, i.e., Viscom Polymer mud, Salt Saturated mud and Gel Chem mud, were evaluated in the tests. These muds were provided by Concord Drilling Fluids Ltd. Humidified methane was used to measure effective gas permeability and regain permeability in the tests.

Dynamic Mud Leakoff/Gas Regain Permeability

Dynamic mud leakoff/gas regain permeability tests were conducted on Samples 1, 2, 3 and 4 from the PCI Canterra Tweed Lake A-67 well representing the Mount Clark formation. The porosity and air permeability of the samples as well as the mud used for each sample are as follows:

<i>Sample</i>	<i>Porosity</i>	<i>Air Permeability</i>	<i>Mud</i>
#1	8.80%	0.43 mD	Viscom Polymer
#2	11.4%	0.84mD	Salt Saturated
#3	11.8%	5.66 mD	Gel Chem
#4	12.0%	13.4mD	Viscom Polymer

Testing Procedure

To commence a test, the selected samples were first vacuum saturated with simulated formation brine. The samples were then de-saturated in a centrifuge under the same capillary pressure to irreducible water saturation. One sample was loaded into a hydrostatic coreholder and stressed to equivalent reservoir overburden pressure and pore pressure and placed in an oven heated to reservoir temperature. Baseline permeability of the sample to humidified methane gas was measured at initial water saturation. The mud

was then circulated for two (2) hours at 10 mL/min in D2 direction (See Figure B in Section 3) at an overbalance pressure dictated by the density of the mud and reservoir pressure. During the mud leakoff test, the filtrate leak off volume was measured against time. Mud circulation was followed by regain permeability measurements using humidified methane gas. Threshold pressure for the first gas break through and regain permeabilities at three increasing drawdown pressures were measured. The data are summarized in Table 2.1 at the end of this section.

Dynamic Mud Leakoff/Gas Regain Test Results

Sample #1 had a baseline permeability of 0.085 mD at an initial water saturation of 22.0%. During the two (2) hours of circulation at an overbalance pressure of 2,700 kPa, the mud (Viscom Polymer) had a total leakoff volume of 0.28 ml, or 6% of the pore volume, collected at the downstream end in D2 direction. A threshold pressure of 3,034 kPa was measured as the breakthrough pressure to initiate gas flow. The regain permeability after the first drawdown pressure of 4,895 kPa was 0.014 mD, or 16.5% of the baseline permeability of 0.085 mD. After the highest drawdown pressure of 9,653 kPa the regain permeability increased to 0.022 mD, or 26% of the baseline permeability. The final water saturation measured after regain testing was 39%.

Salt Saturated mud was tested on Sample #2, which had a baseline permeability of 0.196 mD at an initial water saturation of 23.4%. During the two (2) hours of circulation at an overbalance pressure of 5,500 kPa, total filtrate loss of 6.06 mL (0.97 pore volumes) and spurt loss of 0.60 mL (0.096 pore volumes) were observed. This suggests non-effective filter cake buildup. A threshold pressure of 1,930 kPa was measured as the breakthrough pressure to initiate gas flow. Regain permeability after the first drawdown pressure of 3,075 kPa was 0.052 mD, or 26.5% of the original baseline permeability. After the highest drawdown pressure of 9,653 kPa the regain permeability was 0.055 mD, or 28.1% of the original baseline permeability. The final water saturation in the sample was 26%.

Gel Chem mud was tested on Sample #3, which had a baseline permeability of 0.471 mD at an initial water saturation of 33.7%. During the two (2) hours of circulation at an overbalance pressure of 2,700 kPa, total filtrate loss of 0.20mL (0.030 pore volumes) and no spurt loss were observed. This suggests effective filter cake buildup. A threshold pressure of 172 kPa was measured as the breakthrough pressure to initiate gas flow. Regain permeability after the first drawdown pressure of 274 kPa was 0.074 mD, or 15.7% of the original baseline permeability and after the highest drawdown pressure of 9,653 kPa it was 0.376 mD, or 79.8% of the original baseline permeability. The final water saturation in the sample was 33.5%.

Viscom Polymer mud was tested on Sample #4, which had a baseline permeability of 0.25 mD at an initial water saturation of 26.0%. During the two (2) hours of circulation at an overbalance pressure of 2,700 kPa, total filtrate loss of 3.22 mL (0.50 pore volumes) and spurt loss of 0.89 ml (0.141 pore volumes) were observed. This suggests non-effective filter cake buildup. A threshold pressure of 3,170 kPa was measured as the breakthrough pressure to initiate gas flow. Regain permeability after the first drawdown pressure of 3,172 kPa was 0.034 mD, or 13.6% of the original baseline permeability and after the highest drawdown pressure of 9,653 kPa it was 0.055 mD, or 22.0% of the original baseline permeability.

The results indicated that Gel Chem mud outperformed Viscom Polymer mud and Salt saturated mud. The Gel Chem mud was able to form effective filter cake without incurring significant permeability reduction.

Mercury Injection Capillary Pressure

Two (2) small plug end pieces from samples #2 and #4 were drilled to 25.4-mm diameter plugs and were subjected to drainage mercury injection capillary pressure measurements.

The porosity and air permeability of the plugs #2 and #4 were 11.6% and 13.2% and 0.85 mD and 2.43 mD, respectively. Note that these values are slightly different from those of samples #2 and #4.

Table 1.2 summarizes mercury injection capillary pressure results with respect to minimum wetting phase saturation, threshold pressure, median pore throat radius and macro-pores versus sample porosity and permeability. Minimum wetting phase saturations are reported at an arbitrary laboratory air-mercury capillary pressure of 14 MPa.

Plug #2 displayed unimodal pore throat size distributions with median throat size of 0.556 micron. Plug #2 displayed uniform and well connected pore system with small amount of micro-porosity. Plug #4 displayed bimodal pore throat size distribution with median throat size of 0.058 micron. Plug #4 has higher percentage of micro-porosity than Plug #2. As a result, initial water saturation in sample #4 was higher than that of sample #2, even though the porosity and permeability of sample #4 was higher than those of sample #2.

The mercury injection data is corrected for conformance. Conformance is defined as that apparent injection that occurs as mercury fills in around the irregular surfaces of the sample prior to actual injection. These data are removed from the injected volumes, otherwise the median pore throat size would be erroneously large and the reported saturations would be less than actual. The wetting phase refers to mercury vapour.

FILE:

52132-01-1032

COMPANY:

Canadian Natural Resources

WELL:

PCI Canterra Tweed Lake A-67

LOCATION:

66° 56'11" N LAT, 126 56'18" W LOG

FORMATION:

Mount Clark

FIELD:

Tweed Lake

PROVINCE:

Northwest Territories

**TABLE 2.1: SUMMARY OF MUDLEAKOFF/GAS REGAIN PERMEABILITY RESULTS
EVALUATION OF VISCOM POLYMER, SALT SATURATED MUD & GEL CHEM**

38.1 mm Diameter Sample

SAMPLE	DEPTH meters	AMBIENT POROSITY fraction	AMBIENT Ka (mD)	Swi fraction Vp	Kg * @ Swi, RESERVOIR		THRESHOLD PRESSURE (kPa)	1st 2nd 3rd 4th 5th				
					TEMP. AND NOB (mD)	@ 185 kPa		REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)
1	1280.65	0.088	0.43	0.220	0.085		3034	0.014 After	0.019 After	0.022 After		
Total Measured Leakoff Vol = 0.28 mL (0.058 of PV)												
Spurt Loss = 0 mL (0 of PV)												
(Viscom Polymer)												
Percent Regain (Compared to Baseline Permeability) =												
2	1282.3	0.114	0.84	0.234	0.196	@ 168 kPa	1930	0.052 After	0.046 After	0.0551 After		
Total Measured Leakoff Vol = 6.06 mL (0.973 of PV)												
Spurt Loss = 0.60 mL (0.096 of PV)												
(Salt Saturated Mud)												
Percent Regain (Compared to Baseline Permeability) =												
3	1283	0.118	5.66	0.337	0.471	@ 53.1 kPa	172	0.074 @ 274 kPa (15.7%)	0.129 After	0.168 After	0.228 After	0.376 After
Total Measured Leakoff Vol = 0.20 mL (0.0303 of PV)												
Spurt Loss = 0 mL (0 of PV)												
(Gel Chem)												
Percent Regain (Compared to Baseline Permeability) =												
Total Measured Leakoff Vol = 0.20 mL (0.0303 of PV)												
Spurt Loss = 0 mL (0 of PV)												
(Gel Chem)												
Percent Regain (Compared to Baseline Permeability) =												

52132-01-1032

FILE:

Mount Clark
Tweed Lake
Northwest Territories

COMPANY: Canadian Natural Resources
WELL: PCI Canterra Tweed Lake A-67
LOCATION: 66° 56'11" N LAT, 126 56'18" W LOG

FORMATION:
FIELD:
PROVINCE:

TABLE 2.1: SUMMARY OF MUDLEAKOFF/GAS REGAIN PERMEABILITY RESULTS
EVALUATION OF VISCOM POLYMER, SALT SATURATED MUD & GEL CHEM

38.1 mm Diameter Sample

SAMPLE	DEPTH meters	AMBIENT		Swi fraction Vp	Kg * @ Swi, RESERVOIR		THRESHOLD PRESSURE (kPa)	1st		2nd		3rd		4th		5th		
		POROSITY fraction	Ka (mD)		TEMP. AND NOB (mD)	NOB (mD)		REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)			
4	1292.20	0.120	13.4	0.260	0.250	0.250	3170	0.034	0.031	0.055	0.031	0.055	0.031	0.055	0.031	0.055	0.031	0.055

Total Measured Leakoff Vol = 3.22 mL (0.509 of PV)
Spurt Loss = 0.89 mL (0.141 of PV)
(Viscom Polymer)

Percent Regain (Compared to Baseline Permeability) =

* Kg - Gas permeability was measured using humidified Methane Gas

TEST/RESERVOIR CONDITIONS

Res. Temperature = 18 °C
Res. Pore Pressure = 13000 kPa
Res. NOB Pressure = 16200 kPa

CHRONOLOGICAL SEQUENCE OF EVENTS

Sample Preparation

1. Five (5), 38.1 mm diameter samples from the zone under investigation, representing the PCI Canterra Tweed Lake A-67 wells, were received at Core Laboratories Canada Ltd. for dynamic overbalance mud leakoff/gas regain permeability and mercury injection capillary pressure testing.
2. All five (5), 38.1 mm diameter samples were trimmed under tap water and cleaned with toluene and methanol, and dried in a vacuum oven at 85° C for a period of twenty-four (24) hours.
3. Petrophysical properties of porosity, permeability and grain density were measured at ambient conditions and a lithological description provided.
4. Samples 1, 2, 3 and 4 from the PCI Canterra Tweed Lake A-67 well were selected for dynamic overbalance mud leakoff/gas regain permeability testing.
5. End pieces of samples 2 and 4 from the PCI Canterra Tweed Lake A-67 well were selected for mercury injection capillary pressure testing.
6. Simulated formation brine (168,580 mg/L total dissolved solids) was prepared based on a compositional analysis of formation water from the Mobil Balot Hills M-63-N.W.T. well.

Dynamic Overbalance Mud Leakoff/Gas Regain Permeability Test

7. The selected samples were evacuated and pressure saturated with the simulated formation brine.
8. The samples were then centrifuged under air to initial water saturation (S_{wi}).
9. Sample 1 was mounted in a hydrostatic core holder at reservoir net overburden pressure of 16,160 kPa and reservoir temperature of 18° C. A back pressure of 13,000 kPa was applied on the downstream and a baseline permeability was measured to humidified methane gas.

10. A dynamic overbalance mud leakoff/circulation was conducted along the D2 face of the sample using Viscom Polymer. The mud was circulated at a rate of 10 mL/min for a two (2) hour time period at a prescribed overbalance pressure.
11. Threshold inflow pressure was determined followed by regain permeability measurements at three (3) increasing drawdown pressures across the sample.
12. Following final regain permeability measurements, pressure drop across the core was dropped and regain permeability was re-measured again to confirm last regain permeability value. This was done to check for turbulence at high-pressure drops across the sample.
13. Following testing, the plug was placed in a Dean Stark extractor to determine residual fluid saturations.
14. Tests described in Steps 7-13 above was repeated on Sample 2, 3 and 4 using Salt Saturated mud, Gel Chem mud and Viscom Polymer mud.
15. Data are presented in tabular and graphical format.

Mercury Injection Capillary Pressure

16. All selected samples were cleaned with toluene and methanol in a soxhlet extractor and dried in a vacuum oven at 85° C for a period of twenty-four (24) hours.
17. Petrophysical properties of permeability, porosity and grain density were measured and a lithological description provided.
18. Two (2) samples were selected for mercury injection testing.
19. The samples were loaded into an Autopore 9220 (automated mercury injection apparatus). Mercury was injected into the samples at incrementally increasing pressures. The volume of mercury injected at each pressure was monitored and recorded and used to determine the capillary pressure of each sample.
20. The data are presented in tabular and graphical format.

ADVANCED ROCK PROPERTIES PROCEDURES

Net Overburden Pressure

Tests performed under overburden conditions are loaded under hydrostatic conditions in the laboratory. Because laboratory loading is hydrostatic, more strain results than under typical reservoir loading conditions. In order to obtain a hydrostatic net confining pressure that is equivalent to the reservoir loading conditions, the following formula is used:

NOB Hydrostatic =

$$\left[\frac{1}{3} + \frac{2}{3} \left(\frac{\mu}{1-\mu} \right) \right] * [(Depth * PressureGradient) - ReservoirPressure]$$

Where:

μ	= Poisson's Ratio (Assumed to be 0.26 for Sandstones) (Assumed to be 0.35 for Carbonates)
Depth	= Reservoir True Vertical Depth, meters
Pressure Gradient	= 22.62 kPa/meter (1.0 psi/ft)
Reservoir Pressure	= kPa

Dynamic Leakoff/Threshold Inflow Pressure/Regain Permeability at Overbalance Conditions

Testing is typically performed on fresh-state or restored-state core samples. Once initial water saturation is achieved the core sample is mounted under reservoir conditions of temperature, pressure and net overburden pressure. A base permeability to crude oil or methane gas, at irreducible water saturation, is measured in the forward (D1) direction (see Figure A).

Drilling fluid (or "Frac" fluid) is then circulated, for a specified time, over the D2 face of the core at overbalance conditions as dictated by the reservoir depth, pressure and fluid density, or by the fracture pressure of the reservoir rock. Filtrate leakoff through the sample, in the D2 direction, is monitored after passing through a back pressure regulator (BPR). A constant pressure delivery pump supplies fluid to the face of the core, at the desired overbalance pressure, while a second pump receives the fluid while maintaining a specified circulation rate (see Figure B). A 0.25 to 0.50-inch spacer ring is utilized,

between the face of the core and the flow head, to establish a void space for filter cake build-up (see Figure C).

After circulation, a flow of crude oil or gas is re-established in the D1 direction by applying a ramped pressure differential across the core at a rate of 1.0 kPa per minute. Any evidence of inflow is detected by fluid production from the downstream end of the core, as monitored by the production pump. The pressure at which fluid inflow first occurs is recorded as the threshold inflow pressure.

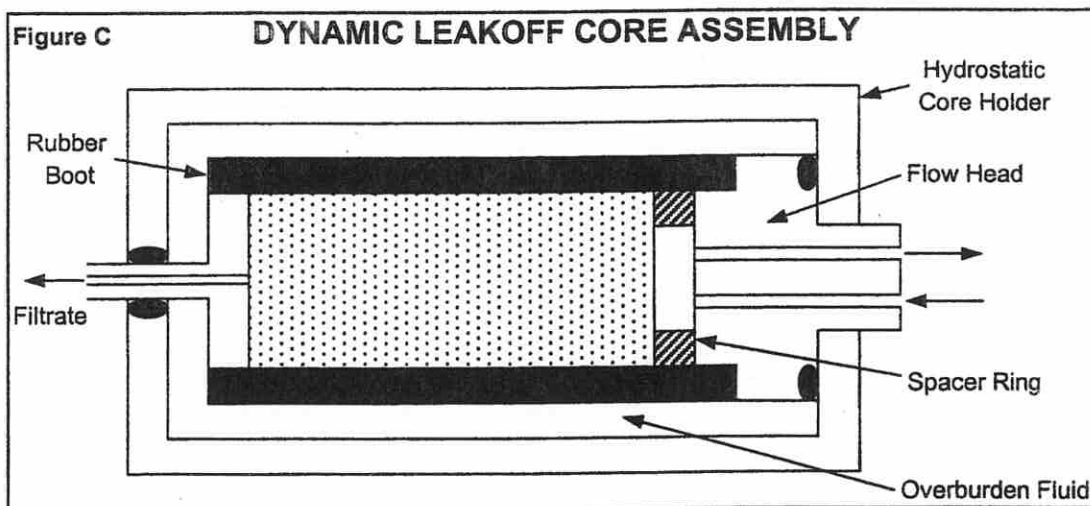
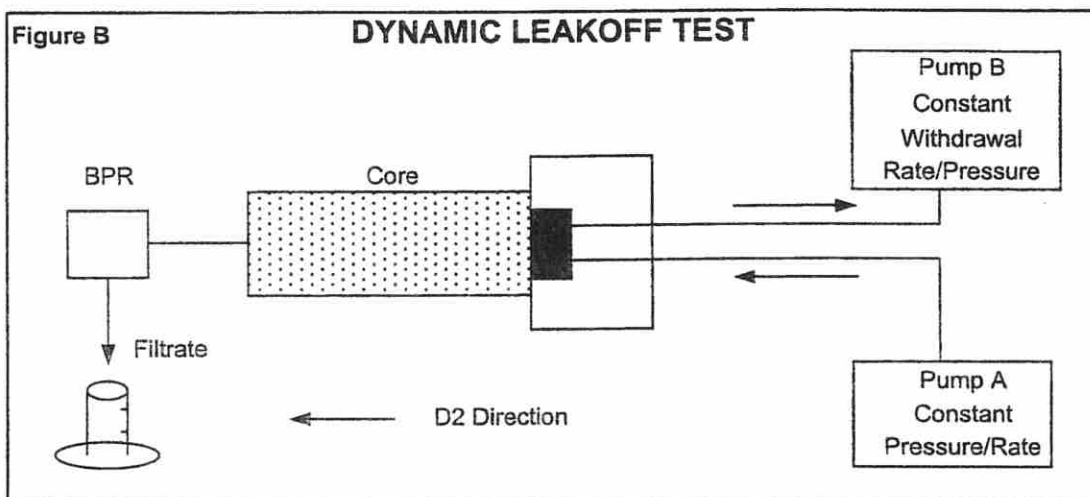
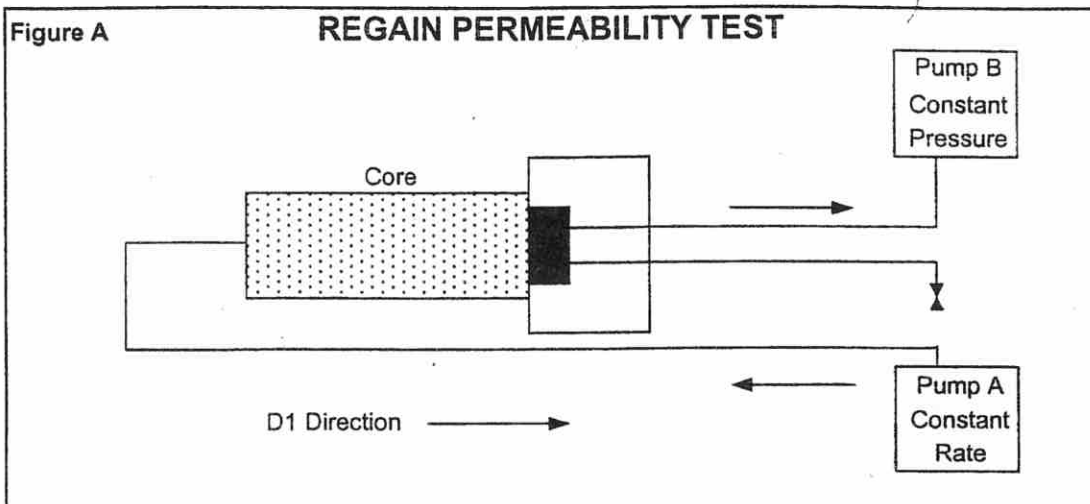
Following the inflow pressure measurement, regain permeability is monitored as a function of throughput, at varying target pressure differentials designed to span the maximum expected operating pressure of the well, until stable or to a maximum of twenty (20) pore volumes. Note: if Frac fluid is being tested, the sample is shut in for a minimum eight (8) hour period, prior to the threshold inflow pressure measurement, to allow the fluid to break.

Mercury Injection Capillary Pressure

Prior to testing, the core sample is cleaned, dried and routine petrophysical properties of porosity, grain density and permeability to air are measured.

The sample is loaded into an Autopore 9220 (Automated Mercury Injection Apparatus), sealed in a mercury-filled cell and evacuated. Mercury is injected at increasing pressures from 20 to 405,000 kPa absolute for the drainage cycle, wetting phase saturation decreasing. The volume of mercury saturating the sample at each pressure is accurately determined by a calibrated "penetrometer". As mercury is injected into the sample, the volume of mercury remaining in the penetrometer decreases, causing a precise change in capacitance within the penetrometer. Equilibration at each pressure is verified by minimum injection rate equilibrium (0.001 $\mu\text{l/gm/sec}$), monitored via the system software.

The data are presented in both a tabular and graphical format. Graphical presentation of data includes: air-mercury capillary pressure versus wetting phase saturation, of both drainage and imbibition cycles, pore volume fraction versus pore entry radius, percent bulk volume mercury divided by capillary pressure versus percent bulk volume mercury (Swanson's parameter), height above free water versus wetting phase saturation, and permeability fraction, k_f , versus pore throat radius.



**SUMMARY OF FLUIDS USED
CANADIAN NATURAL RESOURCES LTD.
TWEED LAKE MUD EVALUATION STUDY**

FLUIDS	SUPPLIER
Simulated Mount Clark Formation Brine (see next page for details)	Core Laboratories Canada Limited
Viscom Polymer mud Salt Saturated mud Gel Chem mud	Concord Drilling Fluids Ltd.

SIMULATED FORMATION BRINE COMPOSITION

<u>CONSTITUENT</u>	<u>CONCENTRATION, mg/L</u>
Sodium Chloride (NaCl)	166 667
Calcium Chloride (CaCl ₂ +2H ₂ O)	914
Magnesium Chloride (MgCl ₂ +6H ₂ O)	811
Sodium Sulfate (Na ₂ SO ₄)	467
Sodium Bicarbonate (NaHCO ₃)	151

The brine composition was prepared from the following analysis:

COMPANY: Canadian Natural Resources Limited
WELL: Mobil Balot Hills M-63-N.W.T.
FORMATION: Mount Clark

CONSTITUENT	CONCENTRATION, mg/L
Sodium	65 755
Calcium	330
Magnesium	97
Chloride	102 000
Bicarbonate	110
Sulfate	316

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11' N LAT, 126°56'18' W LOG

PROVINCE:

Northwest Territories

SAMPLE IDENTIFICATION - 1.5 INCH

38.1 mm Diameter Samples

SAMPLE	DEPTH, meters	AMBIENT CONDITION			LITHOLOGICAL DESCRIPTION
		POROSITY, fraction	AIR PERMEABILITY, millidarcies	GRAIN DENSITY, kg/m ³	
1	1280.65	0.088	0.43	2650	ss: gr, f-m, wl srt, lam
2	1282.30	0.114	0.84	2650	ss: lt gr, f-m, wl srt
3	1283.00	0.118	5.66	2650	ss: lt gr, f-m, wl srt
4	1292.20	0.120	13.4	2670	ss: gr, m-c, ind-bd, p srt
5	1292.50	0.139	102	2690	ss: gr, m-c, ind-bd, p srt

SMALL PLUG ANALYSIS

COMPANY: anadian Natural Resources Limited

FILE:

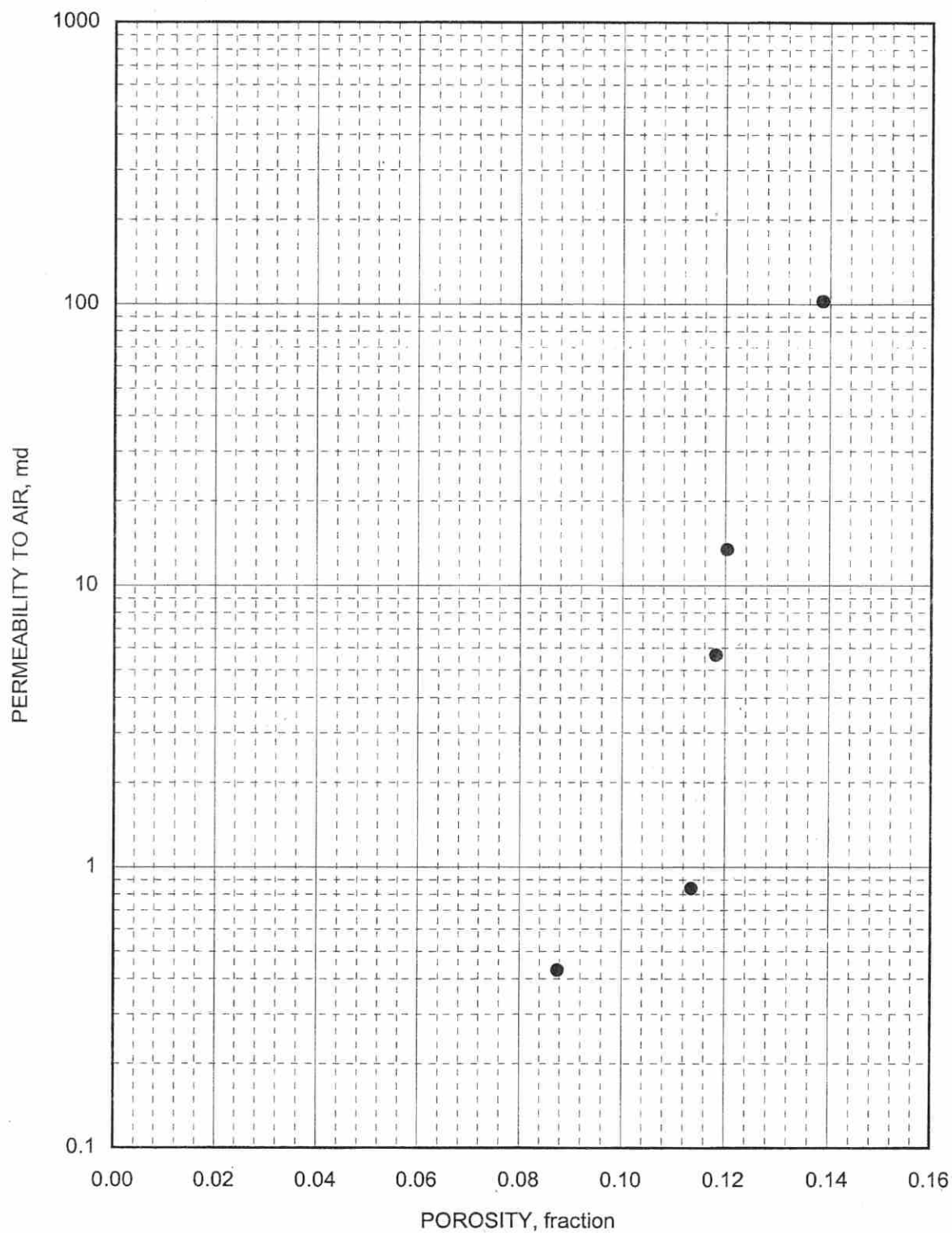
52132-01-1032

WELL: PCI Canterra Tweed Lake A-67

FORMATION:

Mount Clark

38.1 mm Diameter Samples



FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11' N LAT, 126°56'18' W LOG

PROVINCE:

Northwest Territories

SAMPLE IDENTIFICATION - 1.0 INCH

25.4 mm Diameter Samples

SAMPLE	DEPTH, meters	AMBIENT CONDITION			LITHOLOGICAL DESCRIPTION
		POROSITY, fraction	AIR PERMEABILITY, millidarcies	GRAIN DENSITY, kg/m ³	
2	1282.30	0.116	0.85	2640	ss: lt gry, f-m, wl srt
4	1292.20	0.132	2.43	2670	ss: lt gry, f-m, wl srt

52132-01-1032

FILE:

COMPANY:

Canadian Natural Resources

WELL:

PCI Canterra Tweed Lake A-67

LOCATION:

66° 56'11" N LAT, 126 56'18" W LOG

FORMATION:

Mount Clark

FIELD:

Tweed Lake

PROVINCE:

Northwest Territories

SUMMARY OF MUDLEAKOFF/GAS REGAIN PERMEABILITY RESULTS EVALUATION OF VISCOM POLYMER, SALT SATURATED MUD & GEL CHEM

38.1 mm Diameter Sample

SAMPLE	DEPTH meters	AMBIENT POROSITY fraction	AMBIENT Ka (mD)	Swi fraction Vp	Kg * @ Swi, RESERVOIR		THRESHOLD PRESSURE (kPa)	1st 2nd 3rd 4th 5th				
					TEMP. AND NOB (mD)	@ 185 kPa		REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)

1

1280.65

0.088

0.43

0.220

0.085

3034

0.014

0.019

0.022

5th

Total Measured Leakoff Vol = 0.28 mL (0.058 of PV)

Spurt Loss = 0 mL (0 of PV)

(Viscom Polymer)

Percent Regain (Compared to Baseline Permeability) =

(16.5%)

After

4895 kPa

@ 3916 kPa

@ 3903 kPa

@ 2937 kPa

(25.9%)

2

1282.3

0.114

0.84

0.234

0.196

1930

0.052

0.046

0.0551

5th

Total Measured Leakoff Vol = 6.06 mL (0.973 of PV)

Spurt Loss = 0.60 mL (0.096 of PV)

(Salt Saturated Mud)

Percent Regain (Compared to Baseline Permeability) =

(26.5%)

After

3075 kPa

@ 367 kPa

@ 352 kPa

@ 399 kPa

(28.1%)

3

1283

0.118

5.66

0.337

0.471

172

0.074

0.129

0.168

5th

Total Measured Leakoff Vol = 0.20 mL (0.0303 of PV)

Spurt Loss = 0 mL (0 of PV)

(Gel Chem)

Percent Regain (Compared to Baseline Permeability) =

(15.7%)

After

@ 274 kPa

548 kPa

@ 259 kPa

@ 250 kPa

@ 181 kPa

@ 193 kPa

(48.4%)

(35.7%)

(79.8%)

52132-01-1032

Mount Clark
Tweed Lake
Northwest Territories

FILE:

FORMATION:
FIELD:
PROVINCE:

COMPANY: Canadian Natural Resources
WELL: PCI Canterra Tweed Lake A-67
LOCATION: 66° 56'11" N LAT, 126 56'18" W LOG

SUMMARY OF MUDLEAKOFF/GAS REGAIN PERMEABILITY RESULTS
EVALUATION OF VISCOM POLYMER, SALT SATURATED MUD & GEL CHEM

38.1 mm Diameter Sample

		Kg * @ Swi,		RESERVOIR		TEMP. AND		THRESHOLD		1st		2nd		3rd		4th		5th	
SAMPLE	DEPTH meters	AMBIENT POROSITY fraction	AMBIENT Ka (mD)	Swi	fraction Vp	NOB (mD)	PRESSURE (kPa)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)	REGAIN (mD)
4	1292.20	0.120	13.4	0.260	0.250	3170	0.034	0.031	0.055	After	6206 kPa	9653 kPa	@ 2096 kPa	(22.0%)	@ 1448 kPa	(12.4%)	@ 3172 kPa	(13.6%)	@ 187 kPa
Total Measured Leakoff Vol = 3.22 mL (0.509 of PV)																			
Spurt Loss = 0.89 mL (0.141 of PV)																			
(Viscom Polymer)																			
Percent Regain (Compared to Baseline Permeability) =																			

* Kg - Gas permeability was measured using humidified Methane Gas

TEST/RESERVOIR CONDITIONS

Res. Temperature = 18 °C
Res. Pore Pressure = 13000 kPa
Res. NOB Pressure = 16200 kPa

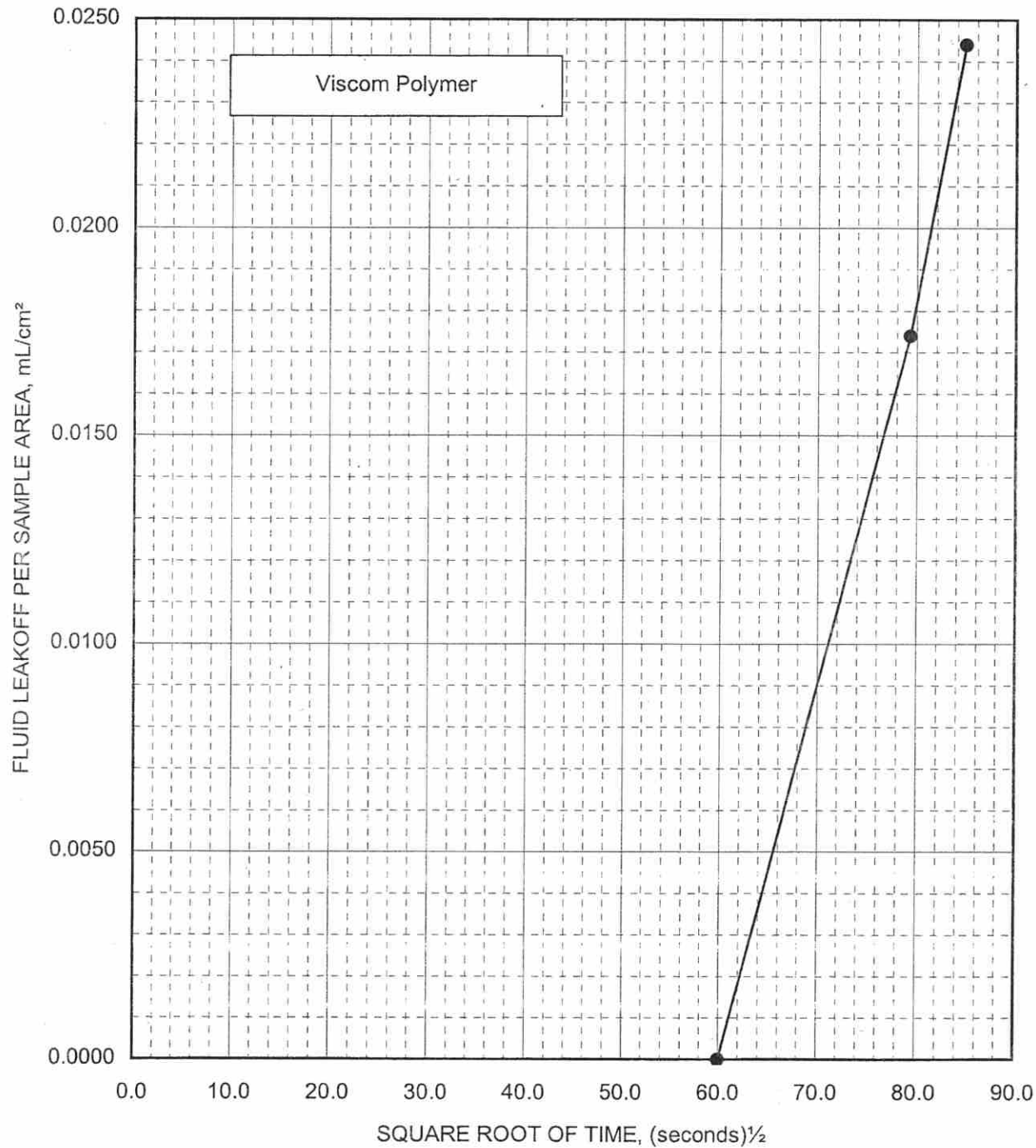
DYNAMIC LEAKOFF TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 1 Ambient Condition Air Permeability, md: 0.430
Depth, meters: 1280.65 Ambient Condition Porosity, fraction: 0.0880



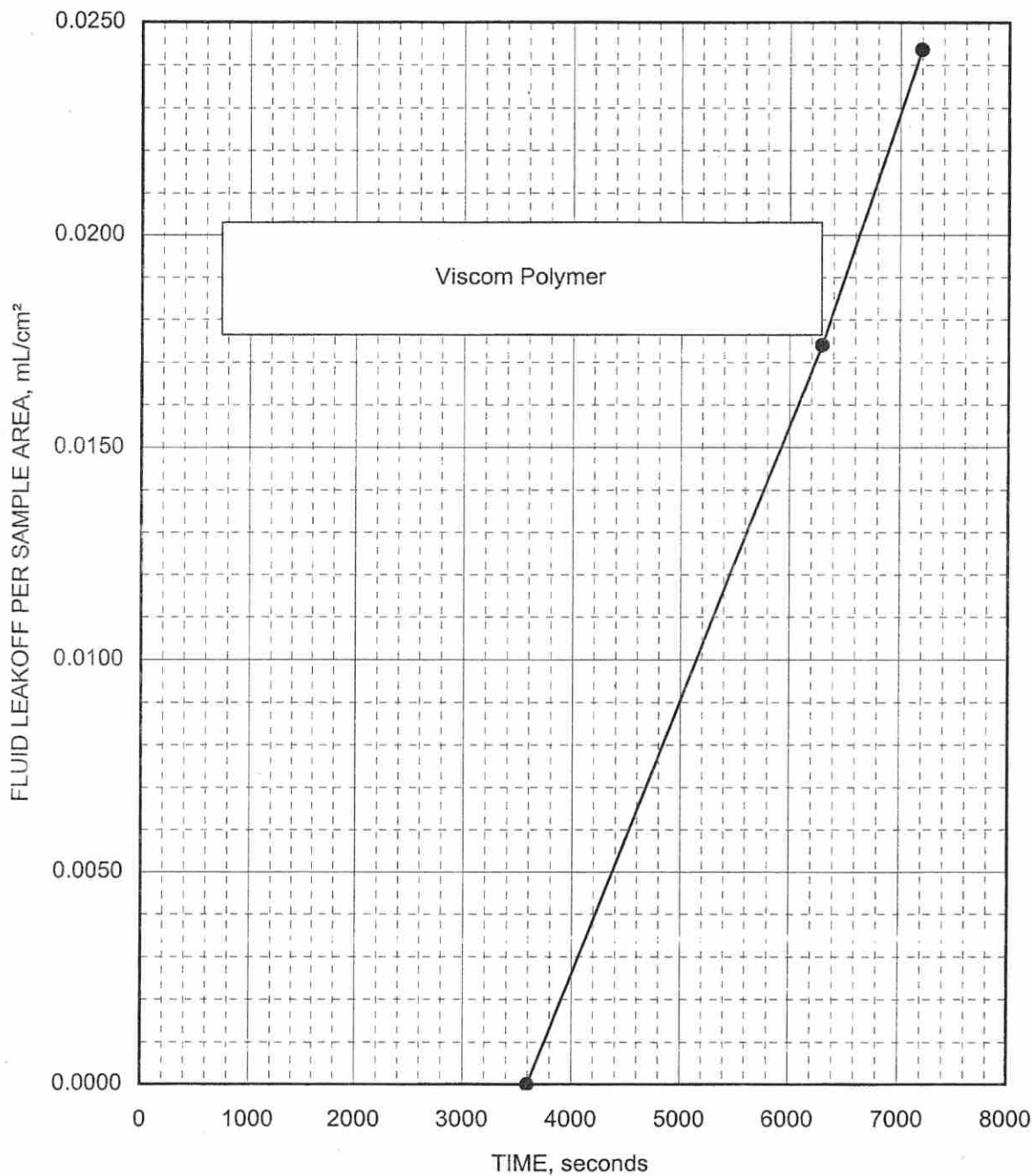
DYNAMIC LEAKOFF TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 1 Ambient Condition Air Permeability, md: 0.430
Depth, meters: 1280.65 Ambient Condition Porosity, fraction: 0.0880



GAS REGAIN PERMEABILITY TEST

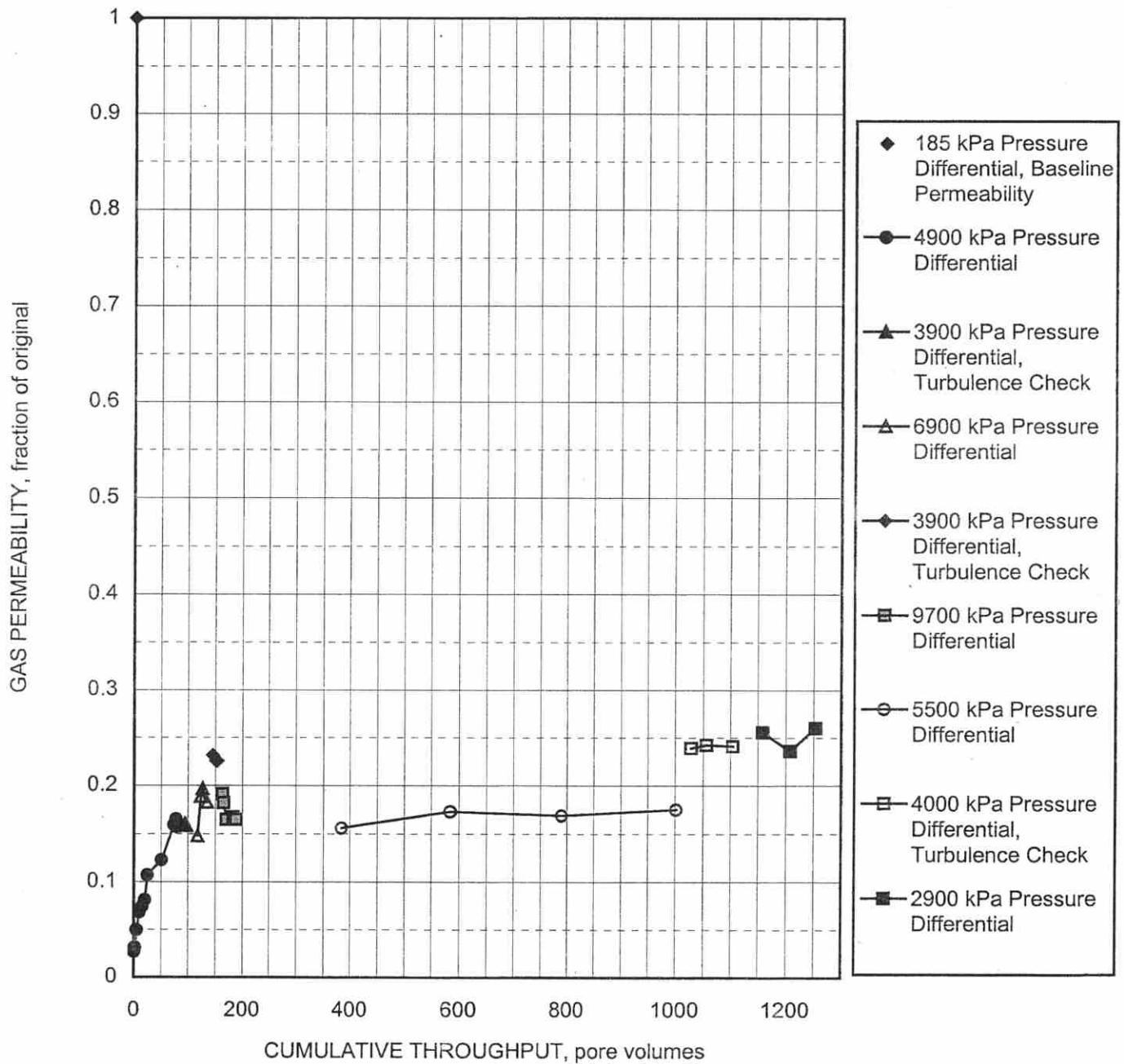
COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 1 Ambient Condition Air Permeability, md: 0.430
Depth, meters: 1280.65 Ambient Condition Porosity, fraction: 0.0880

Viscom Polymer



FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

DYNAMIC LEAKOFF TEST

Sample: 1 Sample State: Restored
 Depth, meters: 1280.65 Test Method: Dynamic Circulation
 Ambient Condition Air Permeability, md: 0.430 Test Conditions: Reservoir
 Ambient Condition Porosity, fraction: 0.0880 Temperature, °C: 18.0
 Sample Diameter, cm: 3.825 Pore Pressure, kPa: 13000
 Leakoff Fluid Used: Reservoir NOB Pressure, kPa: 16200
 Viscom Polymer

Circulation Rate, mL/min: 10.0 Net Overbalance Pressure, kPa: 2700

TIME, seconds	SQUARE ROOT OF TIME, (seconds) ^{1/2}	CUMULATIVE FLUID LEAKOFF VOLUME, mL	FLUID LEAKOFF VOLUME PER SAMPLE AREA, mL/cm ²
3600	60.0	0.000	0.0000
6300	79.4	0.200	0.0174
7200	84.9	0.280	0.0244

Total Leakoff Volume (collected at outlet) = 0.28 mL

Total Leakoff Volume (filtrate accumulated in the sample, as compared to pore volume [pv]) = 0.058 pv

Spurt Loss (Loss of fluid during the first 30 minutes of leakoff) = 0 mL

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11' N LAT, 126°56'18' W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	1	Test Conditions:	Reservoir
Depth, meters:	1280.65	Temperature, °C:	18.0
Ambient Condition Air Permeability, md:	0.430	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.0880	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.220	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.0850
---	-------	---	--------

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Base Permeability to humidified Methane Gas

1.6 kPa Pressure Differential

(D1 Direction)

17

0.0850

1.00

Circulate Viscom Polymer for 2 Hours, Net Overbalance Pressure = 2700 kPa

(D2 Direction)

Threshold Inflow Pressure = 3034 kPa

(D1 Direction)

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	1	Test Conditions:	Reservoir
Depth, meters:	1280.65	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.430	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.0880	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.220	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.0850
---	-------	---	--------

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Regain Permeability to humidified Methane Gas

4895 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 1.42 cm³/min To 8.37 cm³/min

(D1 Direction)

0.609	0.00230	0.0271
1.83	0.00267	0.0314
5.48	0.00424	0.0499
10.3	0.00580	0.0682
15.2	0.00632	0.0743
20.1	0.00689	0.0811
25.0	0.00910	0.107
51.7	0.0104	0.123
74.9	0.0135	0.159
78.5	0.0140	0.165
79.7	0.0134	0.157
83.4	0.0135	0.159

Regain Permeability to humidified Methane Gas

3916 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 7.34 cm³/min To 7.41 cm³/min

(D1 Direction)

94.7	0.0136	0.160
97.2	0.0135	0.158

Core Laboratories

Advanced Rock Properties

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

PROVINCE:

Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	1	Test Conditions:	Reservoir
Depth, meters:	1280.65	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.430	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.0880	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.220	and Reservoir NOB Pressure, md:	0.0850

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Regain Permeability to humidified Methane Gas

6895 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 10.7 cm³/min To 13.3 cm³/min

(D1 Direction)

118	0.0126	0.148
124	0.0160	0.189
127	0.0167	0.197
135	0.0155	0.183

Regain Permeability to humidified Methane Gas

3903 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 9.32 cm³/min To 9.56 cm³/min

(D1 Direction)

145	0.0197	0.232
151	0.0192	0.226
154	0.0192	0.226

*Core Laboratories**Advanced Rock Properties*

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	1	Test Conditions:	Reservoir
Depth, meters:	1280.65	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.430	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.0880	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.220	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.0850
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CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

9653 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 16.4 cm³/min To 19.0 cm³/min

(D1 Direction)

163	0.0163	0.191
165	0.0155	0.182
171	0.0140	0.165
183	0.0142	0.167
189	0.0140	0.165

Regain Permeability to humidified Methane Gas

5516 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 9.47 cm³/min To 10.6 cm³/min

(D1 Direction)

384	0.0133	0.156
585	0.0147	0.173
790	0.0144	0.169
1002	0.0149	0.175

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	1	Test Conditions:	Reservoir
Depth, meters:	1280.65	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.430	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.0880	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.220	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.0850
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CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

3958 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 10.2 cm³/min To 10.4 cm³/min

(D1 Direction)

1029	0.0203	0.239
1056	0.0206	0.243
1104	0.0205	0.241

Regain Permeability to humidified Methane Gas

2937 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 7.54 cm³/min To 8.34 cm³/min

(D1 Direction)

1159	0.0217	0.256
1208	0.0201	0.236
1254	0.0221	0.260

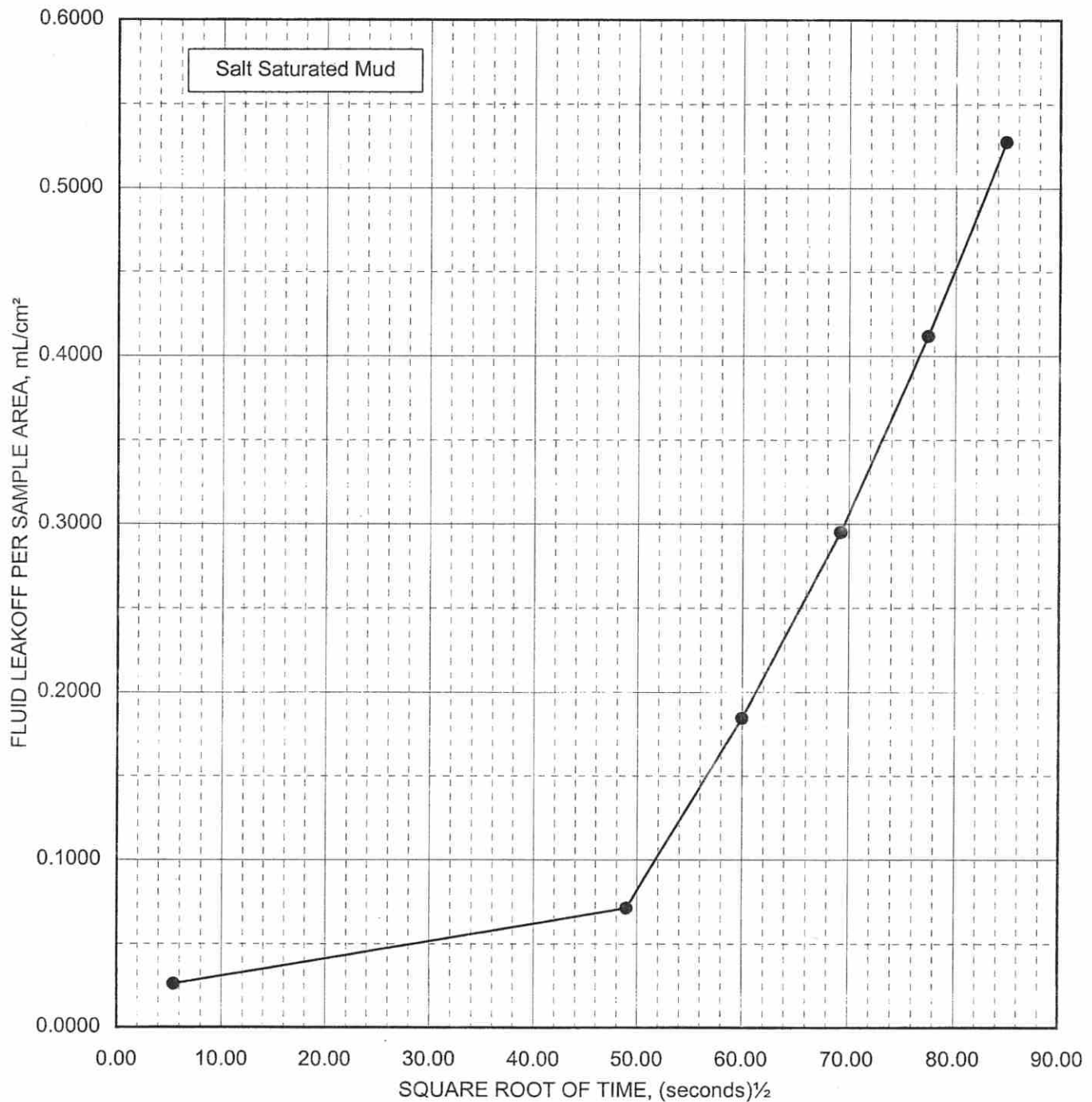
DYNAMIC LEAKOFF TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 2 Ambient Condition Air Permeability, md: 0.840
Depth, meters: 1282.3 Ambient Condition Porosity, fraction: 0.114



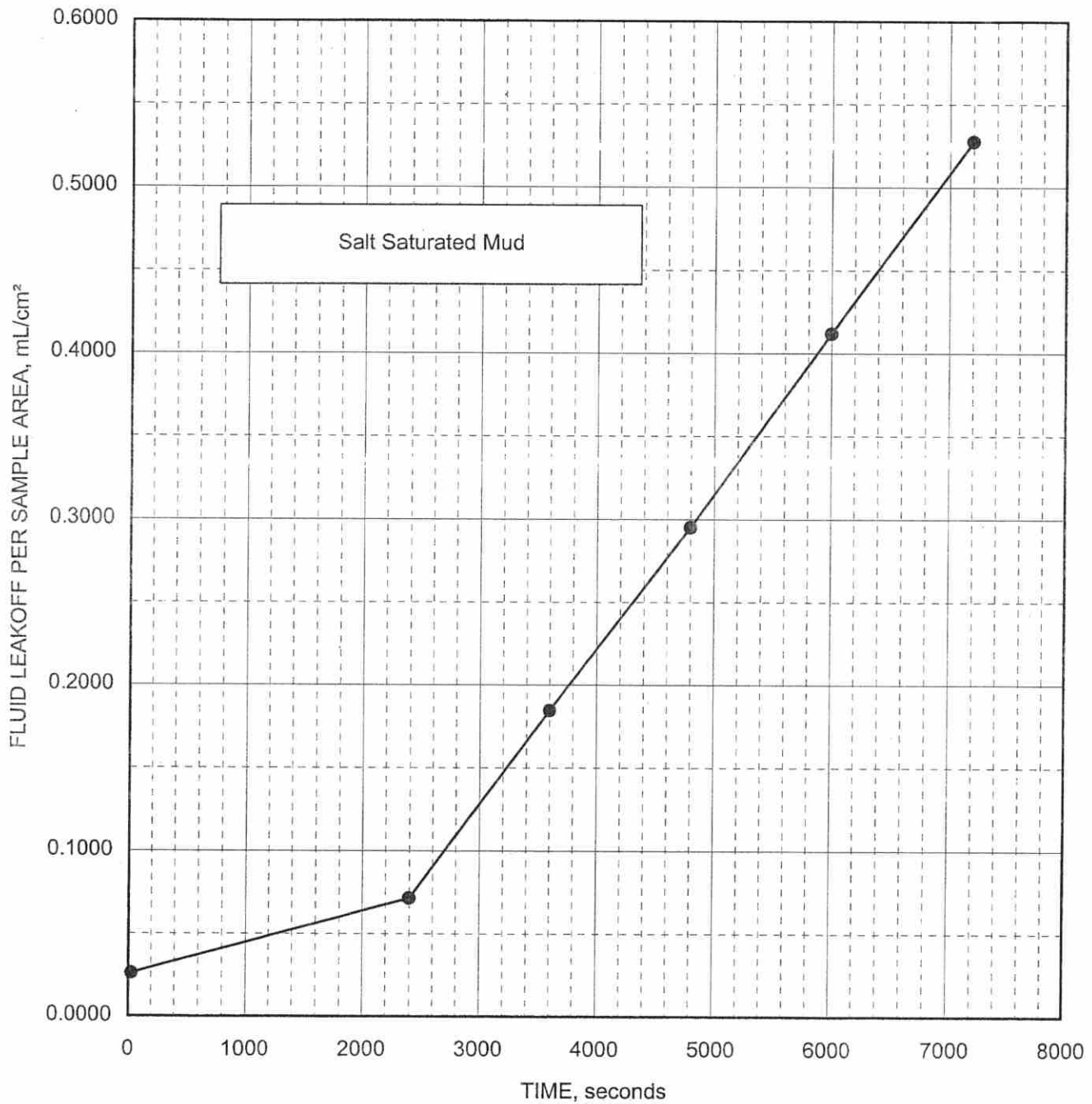
DYNAMIC LEAKOFF TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 2 Ambient Condition Air Permeability, md: 0.840
Depth, meters: 1282.3 Ambient Condition Porosity, fraction: 0.114



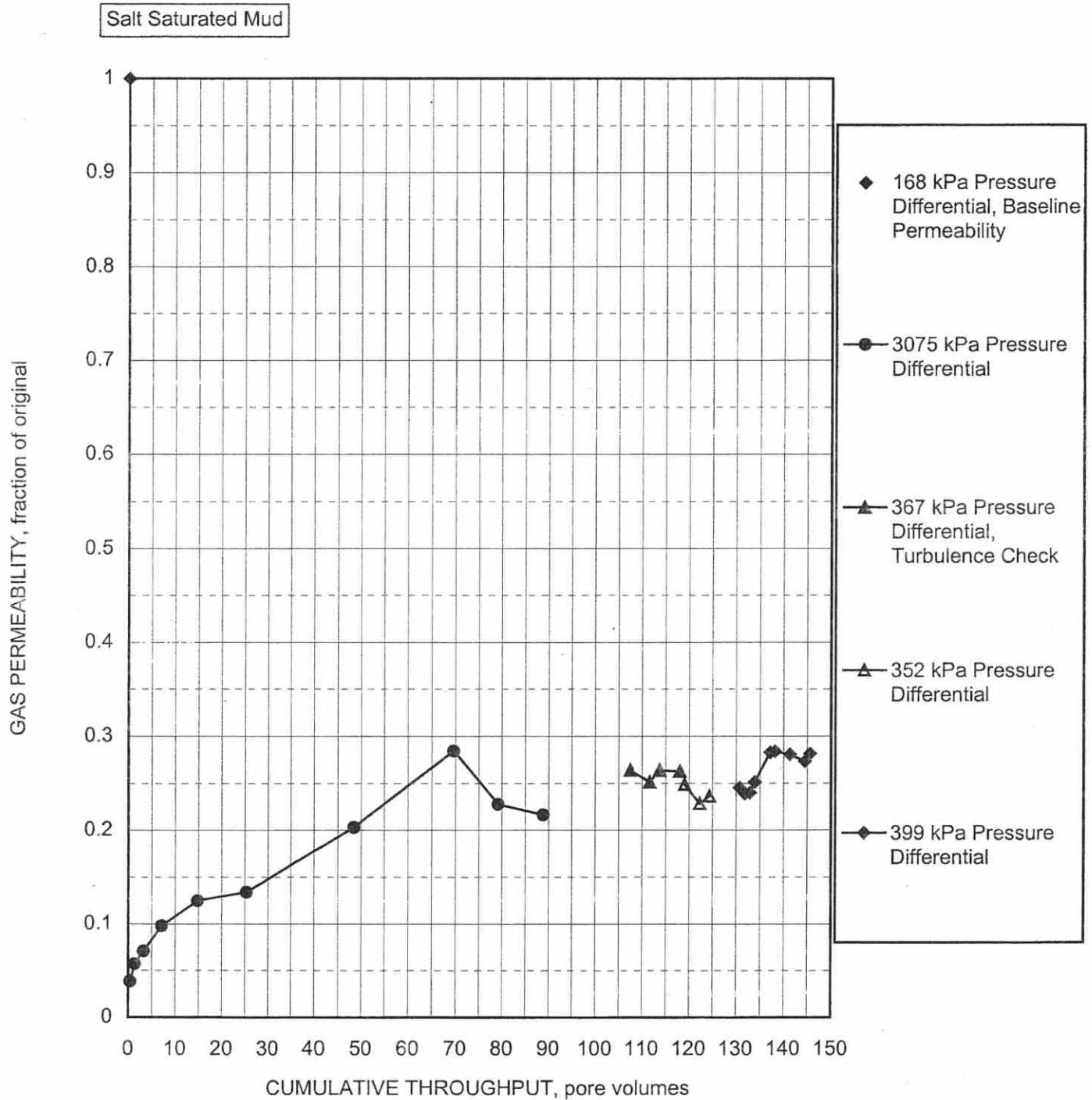
GAS REGAIN PERMEABILITY TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 2 Ambient Condition Air Permeability, md: 0.840
Depth, meters: 1282.3 Ambient Condition Porosity, fraction: 0.114



COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION:
 FIELD:
 PROVINCE:

Mount Clark
 Tweed Lake
 Northwest Territories

DYNAMIC LEAKOFF TEST

Sample: 2 Sample State: Restored
 Depth, meters: 1282.3 Test Method: Dynamic Circulation
 Ambient Condition Air Permeability, md: 0.840 Test Conditions: Reservoir
 Ambient Condition Porosity, fraction: 0.114 Temperature, °C: 18.0
 Sample Diameter, cm: 3.824 Pore Pressure, kPa: 13000
 Leakoff Fluid Used: Reservoir NOB Pressure, kPa: 16200
 Salt Saturated Mud

Circulation Rate, mL/min: 10.0 Net Overbalance Pressure, kPa: 5500

TIME, seconds	SQUARE ROOT OF TIME, (seconds) ^{1/2}	CUMULATIVE FLUID LEAKOFF VOLUME, mL	FLUID LEAKOFF VOLUME PER SAMPLE AREA, mL/cm ²
30	5.48	0.00	0.000
2400	49.0	0.820	0.0714
3600	60.0	2.12	0.185
4800	69.3	3.39	0.295
6000	77.5	4.73	0.412
7200	84.9	6.06	0.528

Total Leakoff Volume (collected at outlet) = 6.06 mL

Total Leakoff Volume (filtrate accumulated in the sample, as compared to pore volume [pv]) = 0.973 pv

Spurt Loss (Loss of fluid during the first 30 minutes of leakoff) = 0.60 mL

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG
 FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample: 2
 Depth, meters: 1282.3
 Ambient Condition Air Permeability, md: 0.840
 Ambient Condition Porosity, fraction: 0.114
 Test Conditions: Reservoir
 Temperature, °C: 18.0
 Pore Pressure, kPa: 13000
 Reservoir NOB Pressure, kPa: 16200

Initial Water Saturation (Swi),
 fraction Vp: 0.234
 Base Permeability at Swi
 and Reservoir NOB Pressure, md: 0.196

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Base Permeability to humidified Methane Gas

1.6 kPa Pressure Differential

(D1 Direction)

14.9

0.196

1.00

Circulate Salt Saturated Mud for 2 Hours, Net Overbalance Pressure = 5500 kPa

(D2 Direction)

Threshold Inflow Pressure = 1931 kPa

(D1 Direction)

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	2	Test Conditions:	Reservoir
Depth, meters:	1282.3	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.840	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.114	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.234	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.196
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CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

3075 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 3.13 cm³/min To 22.5 cm³/min

(D1 Direction)

0.480	0.00759	0.0387
1.44	0.0112	0.0572
3.36	0.0139	0.0710
7.20	0.0192	0.0980
14.9	0.0245	0.125
25.4	0.0263	0.134
48.5	0.0398	0.203
69.7	0.0557	0.284
79.3	0.0446	0.227
88.9	0.0424	0.216

Regain Permeability to humidified Methane Gas

367 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 2.54 cm³/min To 6.79 cm³/min

(D1 Direction)

108	0.0517	0.264
112	0.0492	0.251
114	0.0516	0.263
118	0.0515	0.263

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	2	Test Conditions:	Reservoir
Depth, meters:	1282.3	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.840	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.114	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.234	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.196
---	-------	---	-------

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Flow at 6895 kPa Pressure Differential for 5 minutes, with Humidified Methane Gas

Regain Permeability to humidified Methane Gas

352 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 2.16 cm³/min To 2.33 cm³/min

(D1 Direction)

119	0.0487	0.248
122	0.0447	0.228
124	0.0463	0.236

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	2	Test Conditions:	Reservoir
Depth, meters:	1282.3	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	0.840	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.114	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.234	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.196
---	-------	---	-------

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Flow at 9653 kPa Pressure Differential for 5 minutes, with Humidified Methane Gas

Regain Permeability to humidified Methane Gas

399 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 9.32 cm³/min To 9.56 cm³/min

(D1 Direction)

131	0.0481	0.245
133	0.0470	0.240
134	0.0492	0.251
137	0.0554	0.283
138	0.0556	0.284
141	0.0550	0.281
145	0.0536	0.273
146	0.0551	0.281

DYNAMIC LEAKOFF TEST

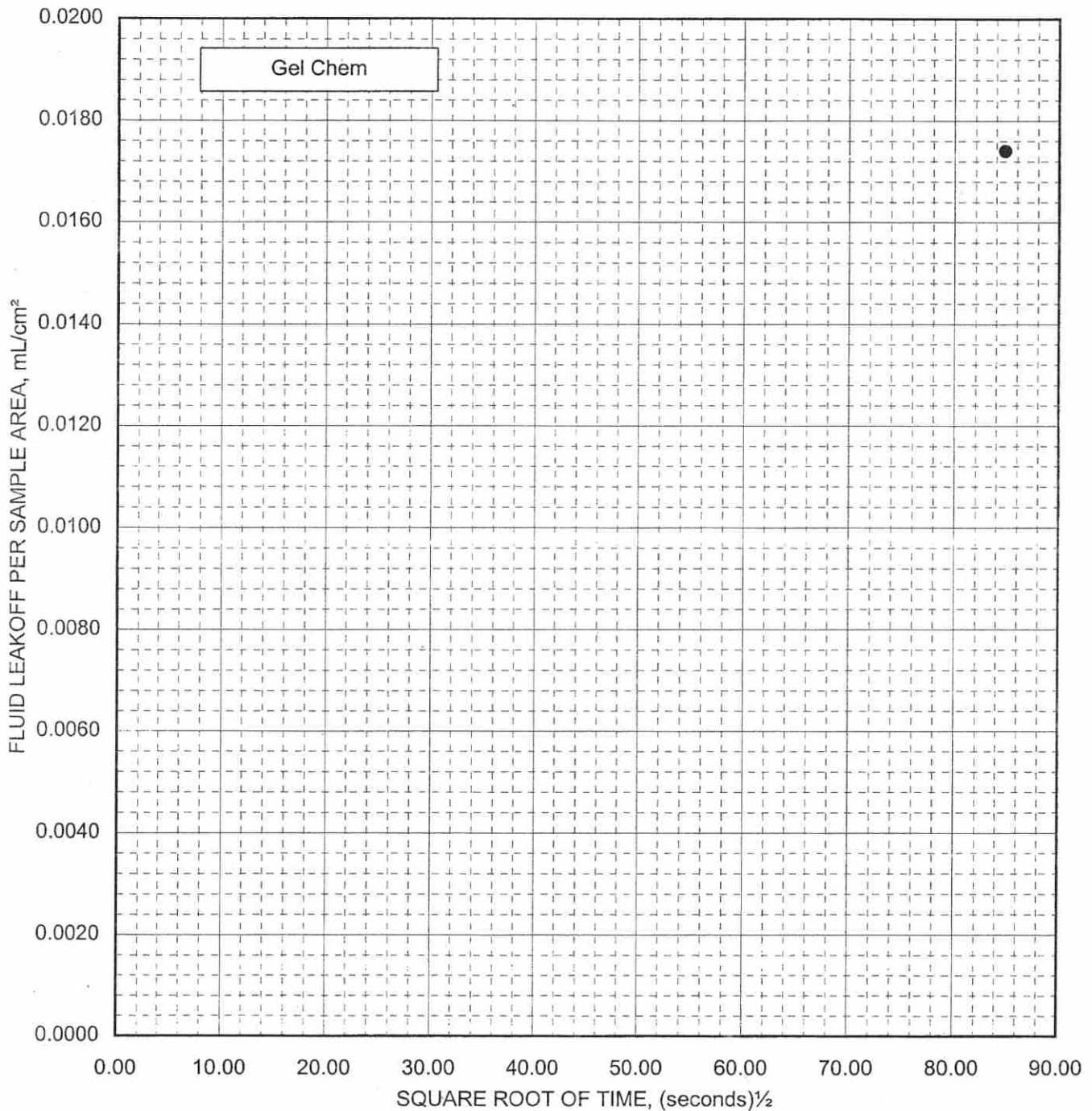
COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 3
Depth, meters: 1283

Ambient Condition Air Permeability, md: 5.66
Ambient Condition Porosity, fraction: 0.118

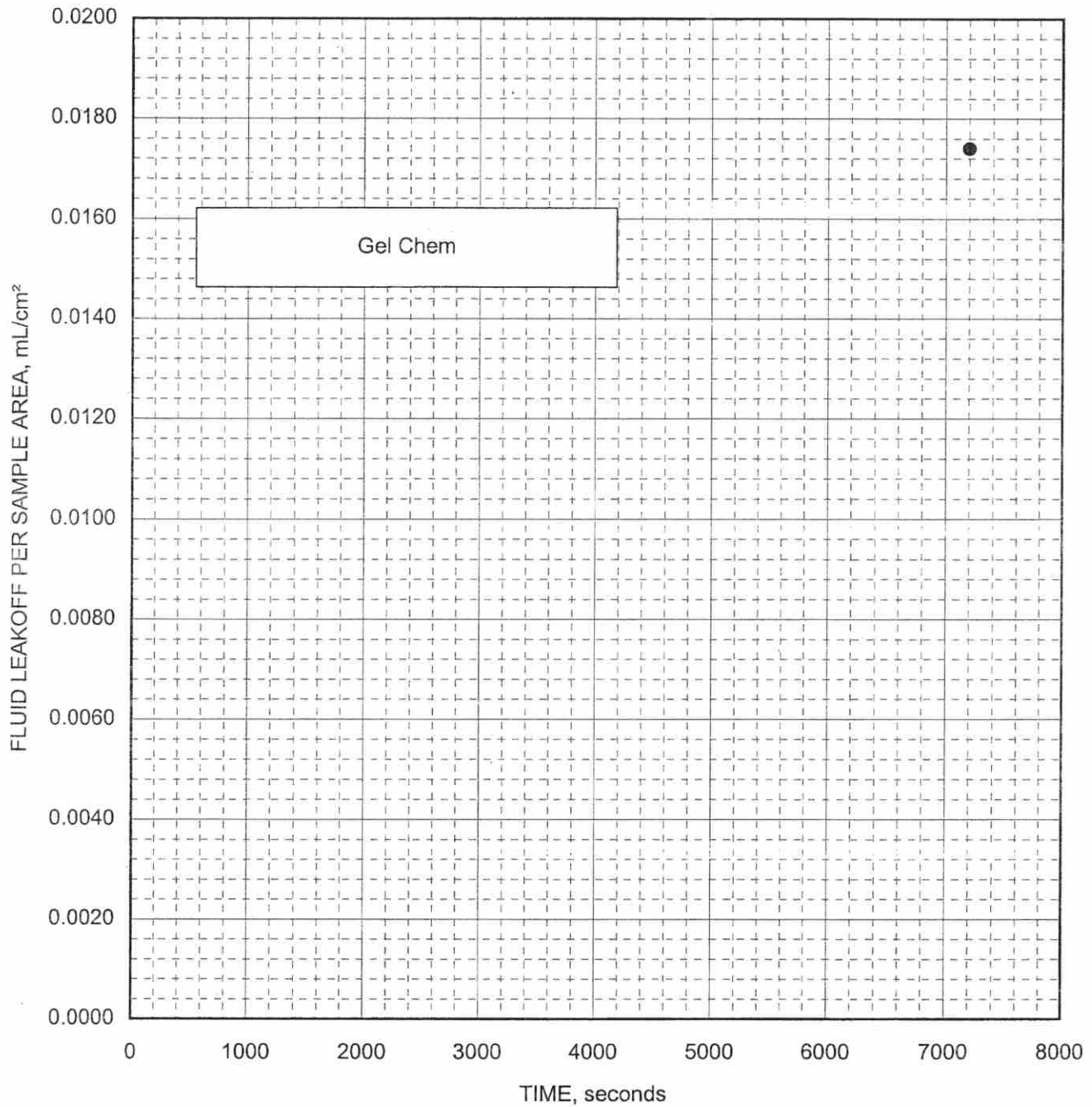


DYNAMIC LEAKOFF TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

Sample: 3 Ambient Condition Air Permeability, md: 5.66
Depth, meters: 1283 Ambient Condition Porosity, fraction: 0.118



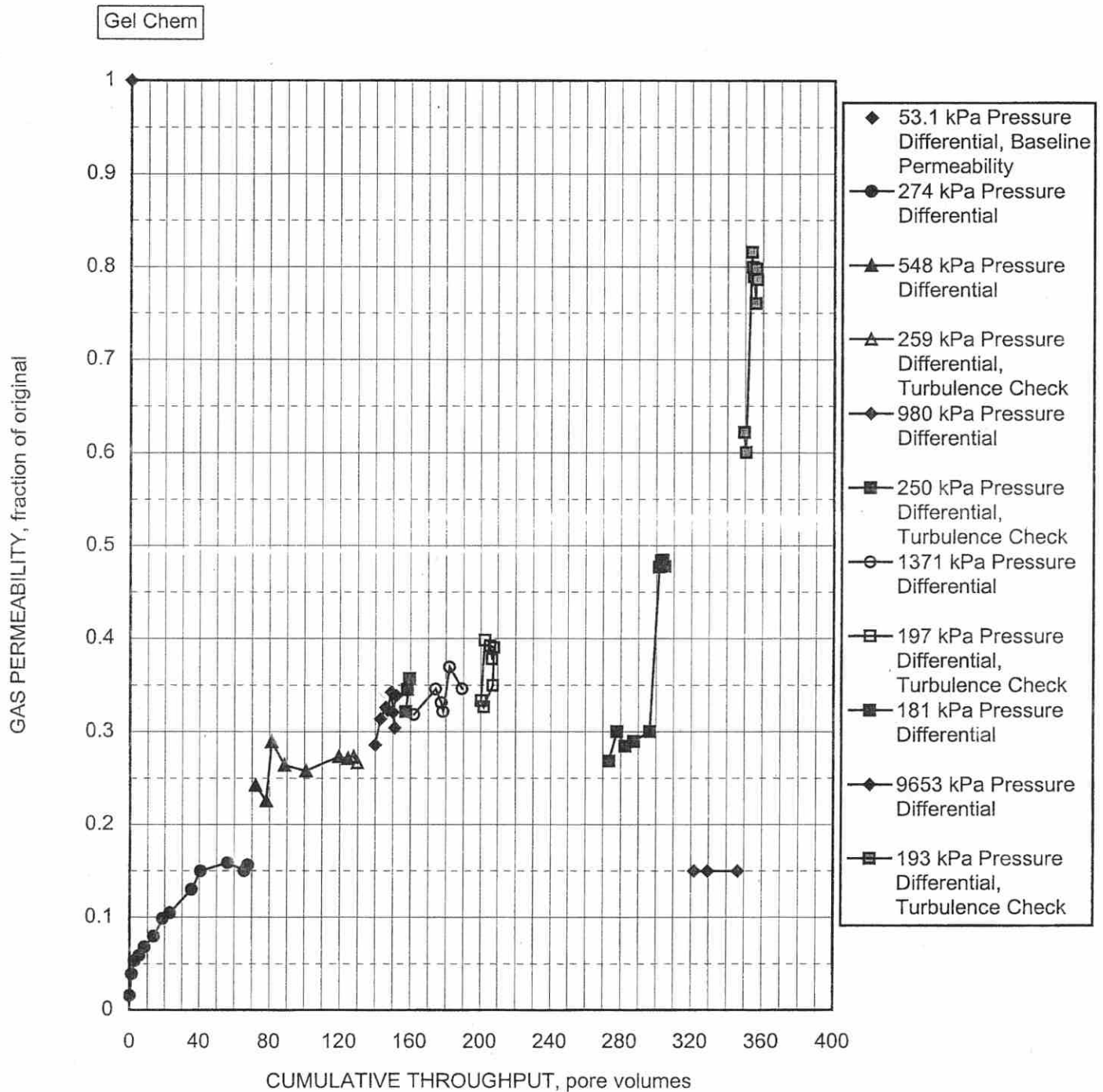
GAS REGAIN PERMEABILITY TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

52132-01-1032
Mount Clark

Sample: 3 Ambient Condition Air Permeability, md: 5.66
Depth, meters: 1283 Ambient Condition Porosity, fraction: 0.118



COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11' N LAT, 126°56'18' W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

DYNAMIC LEAKOFF TEST

Sample: 3 Sample State: Restored
 Depth, meters: 1283 Test Method: Dynamic Circulation
 Ambient Condition Air Permeability, md: 5.66 Test Conditions: Reservoir
 Ambient Condition Porosity, fraction: 0.118 Temperature, °C: 18.0
 Sample Diameter, cm: 3.825 Pore Pressure, kPa: 13000
 Leakoff Fluid Used: Reservoir NOB Pressure, kPa: 16200
 Gel Chem

Circulation Rate, mL/min: 10.0 Net Overbalance Pressure, kPa: 2700

TIME, seconds	SQUARE ROOT OF TIME, (seconds) ^{1/2}	CUMULATIVE FLUID LEAKOFF VOLUME, mL	FLUID LEAKOFF VOLUME PER SAMPLE AREA, mL/cm ²
7200	84.9	0.200	0.0174

Total Leakoff Volume (collected at outlet) = 0.20 mL

Total Leakoff Volume (filtrate accumulated in the sample, as compared to pore volume [pv]) = 0.0303 pv

Spurt Loss (Loss of fluid during the first 30 minutes of leakoff) = 0 mL

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.337	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.471
---	-------	---	-------

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Base Permeability to humidified Methane Gas

53.1 kPa Pressure Differential

(D1 Direction)

8.49

0.471

1.00

Circulate Gel Chem for 2 Hours, Net Overbalance Pressure = 2700 kPa

(D2 Direction)

Threshold Inflow Pressure = 172 kPa

(D1 Direction)

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

PROVINCE:

Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.337	and Reservoir NOB Pressure, md:	0.471

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Regain Permeability to humidified Methane Gas

274 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 0.330 cm³/min To 2.79 cm³/min

(D1 Direction)

0.208	0.00746	0.0158
1.25	0.0184	0.0392
2.81	0.0251	0.0532
5.42	0.0277	0.0588
8.54	0.0321	0.0681
13.8	0.0375	0.0796
19.0	0.0464	0.0986
23.1	0.0493	0.105
35.6	0.0611	0.130
40.8	0.0705	0.150
56.5	0.0747	0.159
65.8	0.0706	0.150
67.9	0.0736	0.156

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.337	and Reservoir NOB Pressure, md:	0.471

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Regain Permeability to humidified Methane Gas

548 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 8.17 cm³/min To 10.2 cm³/min

(D1 Direction)

72	0.114	0.242
78	0.106	0.226
81	0.136	0.289
89	0.124	0.264
101	0.121	0.258
119	0.129	0.273
125	0.128	0.271

Regain Permeability to humidified Methane Gas

259 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 4.46 cm³/min To 4.72 cm³/min

(D1 Direction)

128	0.129	0.273
130	0.126	0.267

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.337	and Reservoir NOB Pressure, md:	0.471

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

980 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 18.3 cm³/min To 21.4 cm³/min

(D1 Direction)

140	0.135	0.286
143	0.148	0.314
146	0.153	0.326
147	0.152	0.323
149	0.161	0.342
151	0.143	0.304
150	0.151	0.321
152	0.159	0.339

Regain Permeability to humidified Methane Gas

250 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 5.20 cm³/min To 5.78 cm³/min

(D1 Direction)

158	0.162	0.345
159	0.168	0.357
157	0.151	0.321

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi), fraction Vp:	0.337	Base Permeability at Swi and Reservoir NOB Pressure, md:	0.471
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CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

1371 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 28.1 cm³/min To 32.8 cm³/min

(D1 Direction)

162	0.150	0.318
174	0.163	0.346
177	0.156	0.331
178	0.152	0.322
182	0.174	0.370
189	0.163	0.346

Regain Permeability to humidified Methane Gas

197 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 4.43 cm³/min To 5.3 cm³/min

(D1 Direction)

203	0.188	0.398
200	0.157	0.334
202	0.154	0.327
207	0.165	0.350
208	0.184	0.390
206	0.185	0.392
207	0.178	0.378

Core Laboratories

Advanced Rock Properties

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.337	and Reservoir NOB Pressure, md:	0.471

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

181 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 4.43 cm³/min To 5.3 cm³/min

(D1 Direction)

273	0.126	0.268
278	0.141	0.300
283	0.134	0.284
287	0.136	0.289
297	0.141	0.300
302	0.225	0.477
303	0.228	0.484
304	0.228	0.485
305	0.225	0.478

Regain Permeability to humidified Methane Gas

9653 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 85.7 cm³/min To 85.7 cm³/min

(D1 Direction)

322	0.0704	0.150
330	0.0704	0.150
346	0.0704	0.150

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

PROVINCE:

Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	3	Test Conditions:	Reservoir
Depth, meters:	1283	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	5.66	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.118	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.337	and Reservoir NOB Pressure, md:	0.471

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

193 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 4.76 cm³/min To 10.1 cm³/min

(D1 Direction)

350	0.293	0.622
351	0.283	0.600
354	0.384	0.816
354	0.377	0.800
355	0.372	0.789
356	0.358	0.760
356	0.376	0.798
357	0.370	0.786

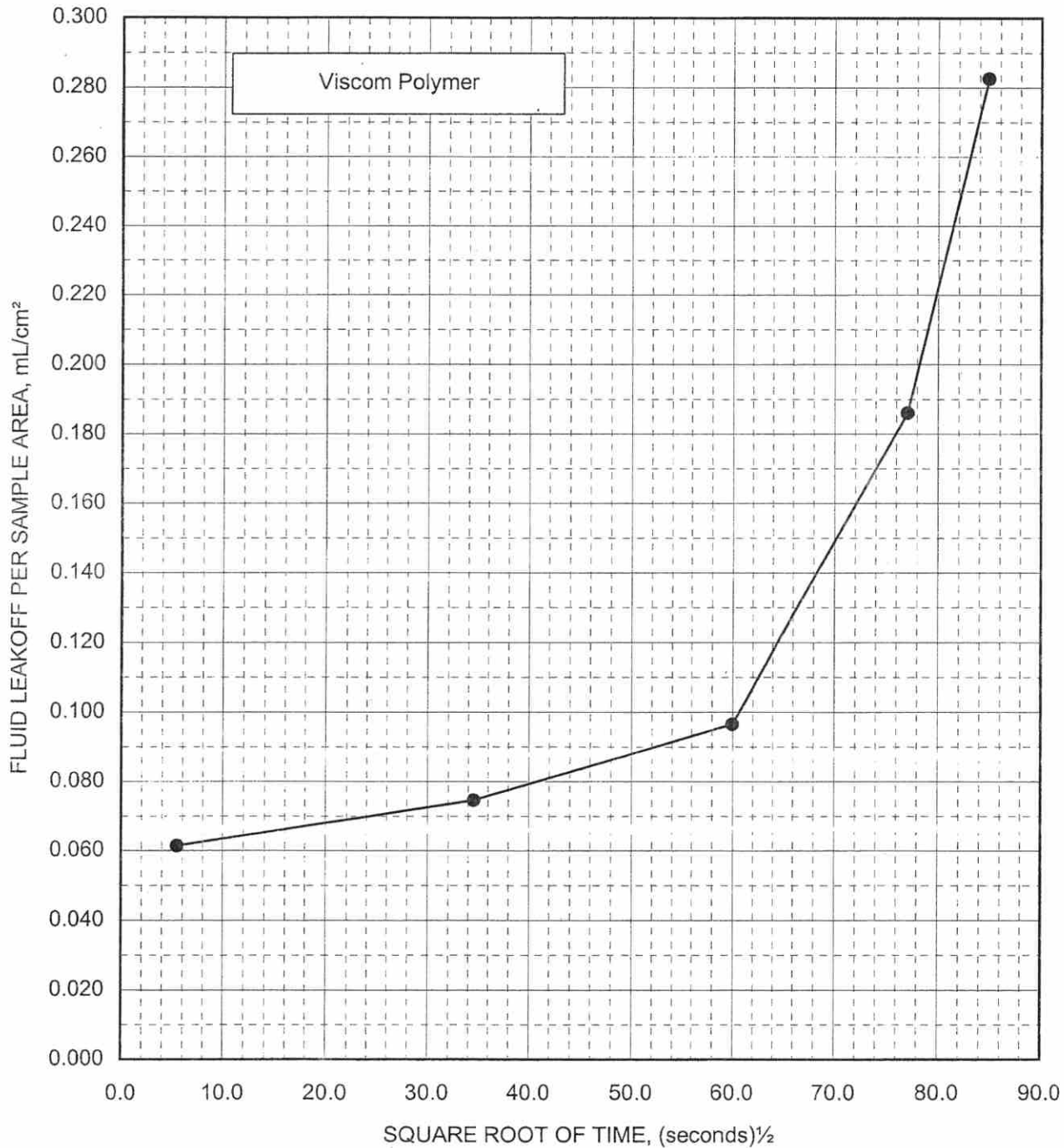
DYNAMIC LEAKOFF TEST

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE:
FORMATION:

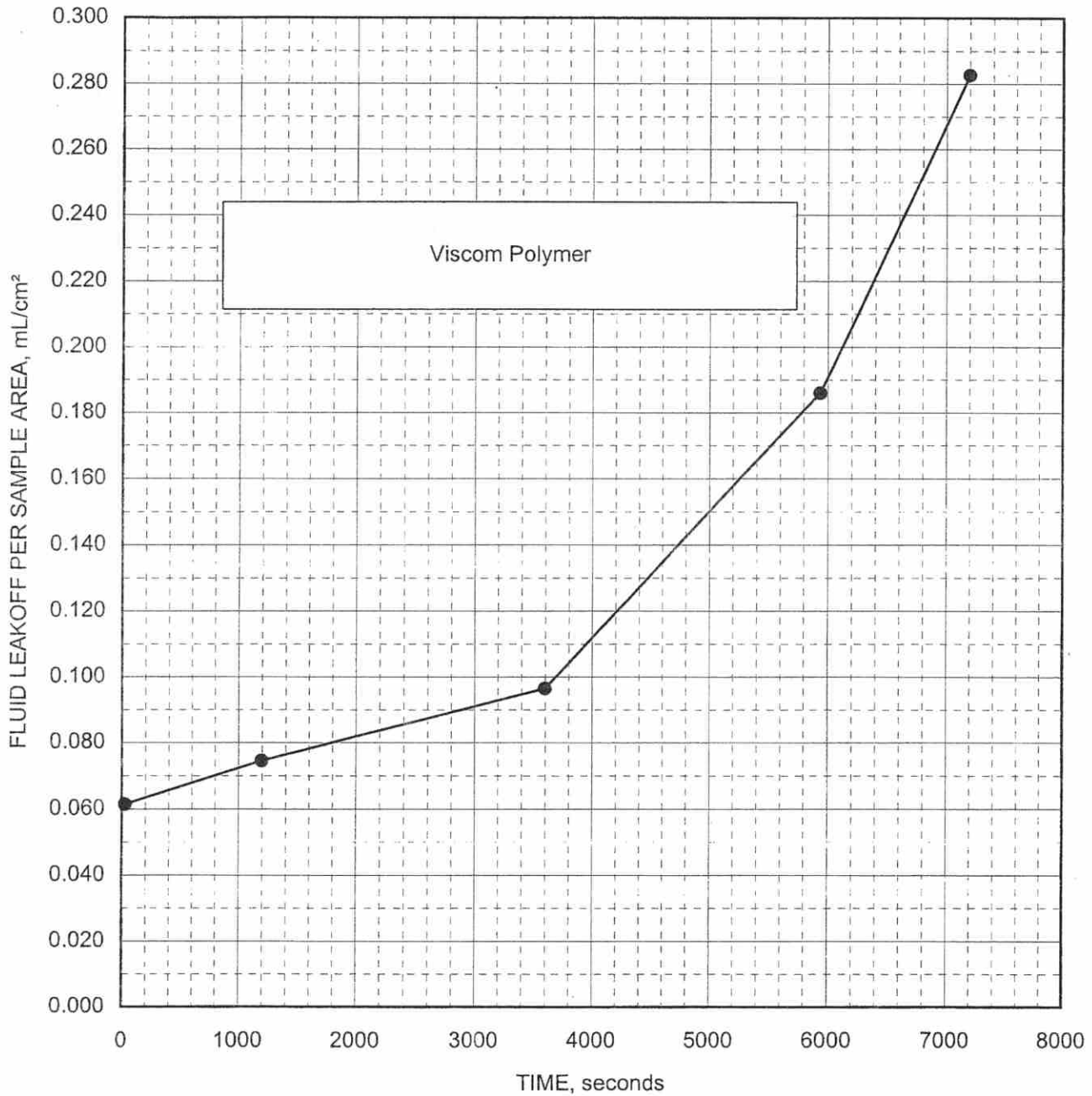
52132-01-1032
Mount Clark

Sample: 4 Ambient Condition Air Permeability, md: 13.4
Depth, meters: 1292.2 Ambient Condition Porosity, fraction: 0.120



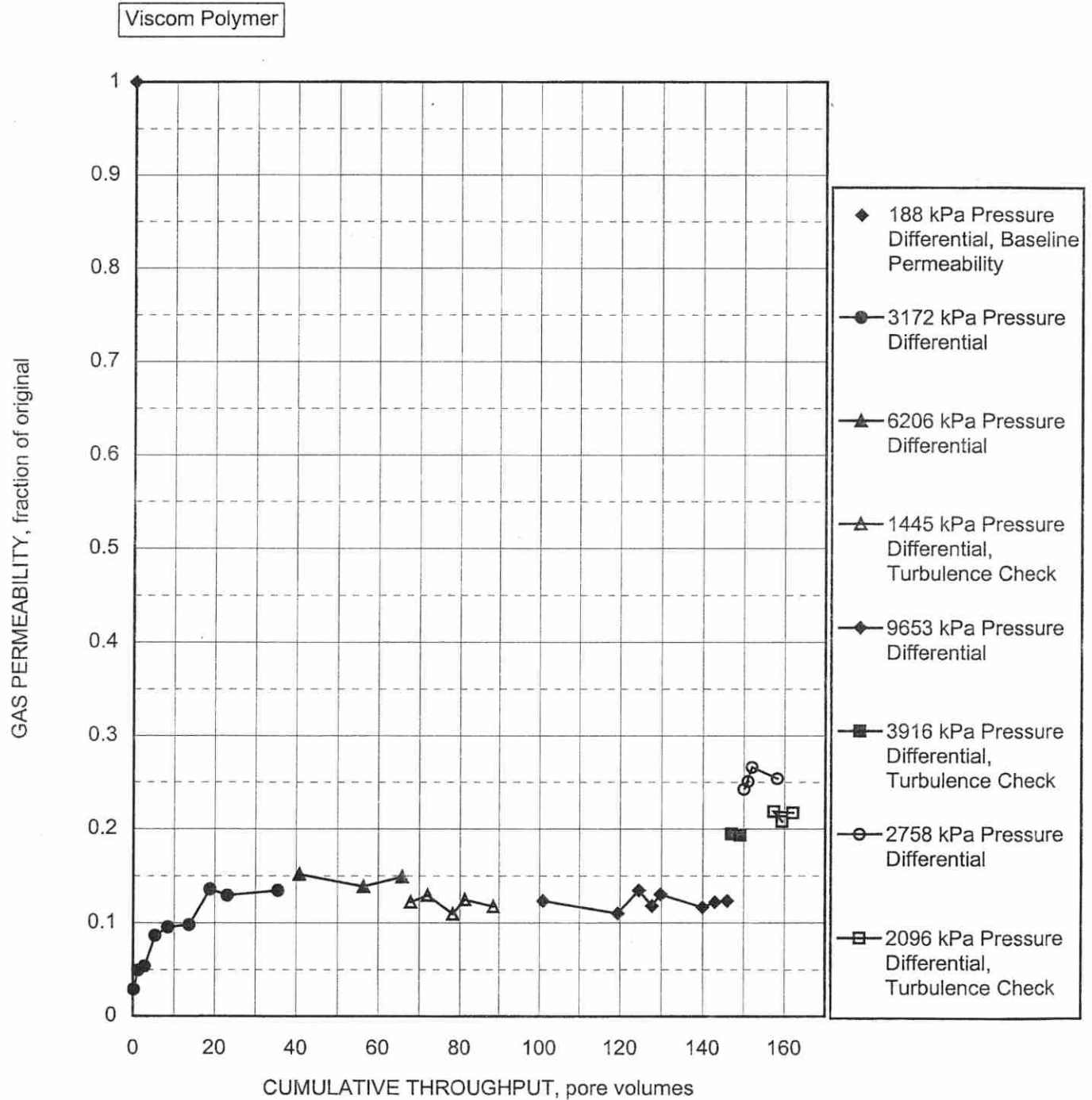
DYNAMIC LEAKOFF TEST

COMPANY:	Canadian Natural Resources Limited	FILE:	52132-01-1032
WELL:	PCI Canterra Tweed Lake A-67	FORMATION:	Mount Clark
Sample:	4	Ambient Condition Air Permeability, md:	13.4
Depth, meters:	1292.2	Ambient Condition Porosity, fraction:	0.120



GAS REGAIN PERMEABILITY TEST

COMPANY:	Canadian Natural Resources Limited	FILE:	52132-01-1032
WELL:	PCI Canterra Tweed Lake A-67	FORMATION:	Mount Clark
Sample:	4	Ambient Condition Air Permeability, md:	13.4
Depth, meters:	1292.2	Ambient Condition Porosity, fraction:	0.120



FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION:
 FIELD:
 PROVINCE:

Mount Clark
 Tweed Lake
 Northwest Territories

DYNAMIC LEAKOFF TEST

Sample: 4 Sample State: Restored
 Depth, meters: 1292.2 Test Method: Dynamic Circulation
 Ambient Condition Air Permeability, md: 13.4 Test Conditions: Reservoir
 Ambient Condition Porosity, fraction: 0.120 Temperature, °C: 18.0
 Sample Diameter, cm: 3.809 Pore Pressure, kPa: 13000
 Leakoff Fluid Used: Reservoir NOB Pressure, kPa: 16200
 Viscom Polymer

Circulation Rate, mL/min: 10.0 Net Overbalance Pressure, kPa: 2700

TIME, seconds	SQUARE ROOT OF TIME, (seconds) ^{1/2}	CUMULATIVE FLUID	FLUID LEAKOFF
		LEAKOFF VOLUME, mL	VOLUME PER SAMPLE AREA, mL/cm ²
30	5.48	0.20	0.0174
1200	34.6	0.85	0.0746
3600	60.0	1.10	0.0965
5940	77.1	2.12	0.186
7200	84.9	3.22	0.283

Total Leakoff Volume (collected at outlet) = 3.22 mL

Total Leakoff Volume (filtrate accumulated in the sample, as compared to pore volume [pv]) = 0.509 pv

Spurt Loss (Loss of fluid during the first 30 minutes of leakoff) = 0.89 mL

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

PROVINCE:

Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	4	Test Conditions:	Reservoir
Depth, meters:	1292.2	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	13.4	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.120	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.260	and Reservoir NOB Pressure, md:	0.250

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
---	--------------------------------------	--

Base Permeability to humidified Methane Gas

187 kPa Pressure Differential

(D1 Direction)

21.8

0.250

1.00

Circulate Viscom Polymer for 2 Hours, Net Overbalance Pressure = 2700 kPa

(D2 Direction)

Threshold Inflow Pressure = 3172 kPa

(D1 Direction)

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	4	Test Conditions:	Reservoir
Depth, meters:	1292.2	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	13.4	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.120	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.260	and Reservoir NOB Pressure, md:	0.250

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

3172 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 2.86 cm³/min To 13.4 cm³/min

(D1 Direction)

0.208	0.00721	0.0288
1.25	0.0123	0.0491
2.81	0.0134	0.0537
5.42	0.0217	0.0867
8.54	0.0239	0.0955
13.8	0.0245	0.0980
19.0	0.0340	0.136
23.1	0.0323	0.129
35.6	0.0336	0.134

Regain Permeability to humidified Methane Gas

6206 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 26.2 cm³/min To 28.7 cm³/min

(D1 Direction)

41	0.0379	0.151
56	0.0346	0.138
66	0.0372	0.149

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	4	Test Conditions:	Reservoir
Depth, meters:	1292.2	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	13.4	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.120	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.260	and Reservoir NOB Pressure, md:	0.250

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

1448 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 5.401 cm³/min To 6.16 cm³/min

(D1 Direction)

68	0.0305	0.122
72	0.0323	0.129
78	0.0273	0.109
81	0.0312	0.125
89	0.0293	0.117

Regain Permeability to humidified Methane Gas

9653 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 31.4 cm³/min To 38.4 cm³/min

(D1 Direction)

101	0.0309	0.123
119	0.0275	0.110
125	0.0336	0.134
128	0.0295	0.118
130	0.0326	0.130
140	0.0292	0.117
143	0.0305	0.122
146	0.0309	0.123

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

PROVINCE:

Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	4	Test Conditions:	Reservoir
Depth, meters:	1292.2	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	13.4	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.120	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.260	and Reservoir NOB Pressure, md:	0.250

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

3916 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 23.5 cm³/min To 23.6 cm³/min

(D1 Direction)

147	0.0486	0.195
149	0.0483	0.193

Regain Permeability to humidified Methane Gas

2758 kPa Pressure Differential

Reservoir Condition Flow Rate Ranged From 20.9 cm³/min To 22.9 cm³/min

(D1 Direction)

151	0.0627	0.251
150	0.0606	0.243
152	0.0666	0.266
158	0.0635	0.254

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited

FORMATION:

Mount Clark

WELL: PCI Canterra Tweed Lake A-67

FIELD:

Tweed Lake

LOCATION: 66°56'11' N LAT, 126°56'18' W LOG

PROVINCE:

Northwest Territories

GAS REGAIN PERMEABILITY TEST

Sample:	4	Test Conditions:	Reservoir
Depth, meters:	1292.2	Temperature, °C:	18.0
Ambient Condition Air Permeability, md	13.4	Pore Pressure, kPa:	13000
Ambient Condition Porosity, fraction:	0.120	Reservoir NOB Pressure, kPa:	16200

Initial Water Saturation (Swi),		Base Permeability at Swi	
fraction Vp:	0.260	and Reservoir NOB Pressure, md:	0.250

CUMULATIVE THROUGHPUT, pore volumes	GAS PERMEABILITY, millidarcies	GAS PERMEABILITY, fraction of original
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Regain Permeability to humidified Methane Gas

2096 kPa Pressure Differential, Turbulence Check

Reservoir Condition Flow Rate Ranged From 4.43 cm³/min To 5.3 cm³/min

(D1 Direction)

159	0.0520	0.208
157	0.0547	0.219
162	0.0543	0.217

52132-01-1032

FILE:

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG
 FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

SUMMARY OF MERCURY INJECTION CAPILLARY PRESSURE RESULTS

— AMBIENT CONDITION —		MINIMUM		MEDIAN		MACRO-		MESO-		MICRO-	
SAMPLE	DEPTH, meters	AIR		WETTING PHASE		PORE		PORES		PORES	
		fraction	permeability, MPa	THRESHOLD	SATURATION	THROAT	RADIUS	(> 1.5 µm), percent Vp	(0.5 - 1.5 µm), percent Vp	(< 0.5 µm), percent Vp	BIMODAL, yes/no
2	1282.30	0.116	0.85	0.612	0.078	0.556	0.556	0.0	55.8	44.2	no
4	1283.00	0.132	2.43	0.202	0.412	0.058	0.058	10.9	22.4	66.6	yes

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE TEST DATA

Sample: 2 Depth, meters: 1282.30

ROUTINE LAB MEASURED DATA

Length, cm:	2.295	Ambient Condition Air Permeability, mD:	0.85
Diameter, cm:	2.522	Weight, grams:	26.917
Calip. Bulk Volume (Vb), cm ³ :	11.465	Grain Density, kg/m ³ :	2644
Ambient Immersed Vb, cm ³ :	11.520	Bulk Density*, kg/m ³ :	2337
Vacuum Immersed Vb, cm ³ :	11.569	Surface Volume*, cm ³ :	-0.104
Grain Volume, cm ³ :	10.180	Surface Volume*, percent Vp:	-7.75
Pore Volume (Vp)*, cm ³ :	1.340	Surface Area (SA), cm ² :	28.17
Ambient Condition Porosity*, fraction:	0.116	SA/Vb Ratio*, 1/cm:	2.446

* Calculated using ambient immersed bulk volume.

MERCURY INJECTION CAPILLARY PRESSURE CALCULATED DATA

VOLUMES USED FOR CAPILLARY PRESSURE CURVE CONSTRUCTION

Pore Volume, cm ³ :	1.281	Mercury Constant, cm ³ :	0.140
Porosity, fraction:	0.111	Bulk Volume, cm ³ :	11.520
Total Pore Surface Area, m ² :	10.44	Pore Volume, cm ³ :	1.340

CONVERSIONS USED FOR CALCULATION OF PORE SIZE, RESERVOIR CAPILLARY PRESSURE AND HEIGHT ABOVE WATER

Mercury IFT, dynes/cm:	480
Mercury Contact Angle, degrees:	140
Ratio of Reservoir/Lab IFTxCOS(Contact Angle):	0.196
Hydrocarbon Density Gradient, kPa/meter:	0.553
Water Density Gradient, kPa/meter:	9.857

COMPANY: Canadian Natural Resources Limited FORMATION: Mount Clark
 WELL: PCI Canterra Tweed Lake A-67 FIELD: Tweed Lake
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
 Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

WETTING PHASE	LABORATORY AIR-MERCURY	RESERVOIR HC-WATER	HEIGHT ABOVE FREE WATER
SATURATION, fraction Vp	CAPILLARY PRESSURE (Pc), MPa	CAPILLARY PRESSURE, MPa	LEVEL, meters
1.000	0.612	0.120	12.88
0.986	0.763	0.149	16.05
0.831	0.954	0.187	20.08
0.566	1.19	0.232	24.98
0.434	1.49	0.293	31.45
0.347	1.86	0.365	39.22
0.285	2.33	0.456	49.00
0.235	2.93	0.573	61.56
0.197	3.64	0.712	76.53
0.164	4.56	0.892	95.91
0.142	5.68	1.11	119.5
0.122	7.08	1.39	149.0
0.104	8.86	1.74	186.5
0.090	11.1	2.17	233.2
0.078	13.9	2.72	292.1
0.068	17.3	3.39	364.8
0.062	21.7	4.24	455.7
0.056	27.1	5.31	570.6
0.052	33.8	6.63	712.2
0.050	42.6	8.33	895.6
0.048	52.9	10.3	1112
0.046	65.8	12.9	1385
0.046	82.4	16.1	1735
0.044	102.9	20.2	2166
0.044	129.3	25.3	2721
0.044	161.6	31.6	3400
0.044	202.4	39.6	4260
0.044	241.1	47.2	5074

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67
LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
FIELD: Tweed Lake
PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

WETTING PHASE	LABORATORY AIR-MERCURY	RESERVOIR HC-WATER	HEIGHT ABOVE FREE WATER
SATURATION, fraction Vp	CAPILLARY PRESSURE, MPa	CAPILLARY PRESSURE, MPa	LEVEL, meters
0.044	275	53.8	5787
0.044	309	60.6	6510
0.044	343	67.2	7224
0.044	378	74.1	7961
0.044	406	79.4	8535

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
 Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

WETTING PHASE SATURATION, fraction Vp	PORE THROAT RADIUS, microns	PERMEABILITY, fraction of original	MERCURY SATURATION (Sb), percent Vb	SWANSON PARAMETER (Sb/Pc), percent Vb/MPa
1.000	1.20	0.000	0.00	0.000
0.986	0.964	0.049	0.16	0.214
0.831	0.771	0.397	1.96	2.057
0.566	0.619	0.779	5.05	4.252
0.434	0.492	0.902	6.59	4.409
0.347	0.394	0.952	7.59	4.074
0.285	0.316	0.976	8.32	3.573
0.235	0.251	0.988	8.90	3.043
0.197	0.202	0.994	9.35	2.570
0.164	0.161	0.997	9.72	2.133
0.142	0.130	0.998	9.98	1.758
0.122	0.104	0.999	10.2	1.442
0.104	0.083	1.000	10.4	1.176
0.090	0.066	1.000	10.6	0.955
0.078	0.053	1.000	10.7	0.773
0.068	0.042	1.000	10.8	0.625
0.062	0.034	1.000	10.9	0.504
0.056	0.027	1.000	11.0	0.405
0.052	0.022	1.000	11.0	0.326
0.050	0.017	1.000	11.1	0.260
0.048	0.014	1.000	11.1	0.210
0.046	0.011	1.000	11.1	0.169
0.046	0.009	1.000	11.1	0.135
0.044	0.007	1.000	11.1	0.108
0.044	0.006	1.000	11.1	0.086
0.044	0.005	1.000	11.1	0.069
0.044	0.004	1.000	11.1	0.055
0.044	0.003	1.000	11.1	0.046

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67
LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
FIELD: Tweed Lake
PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

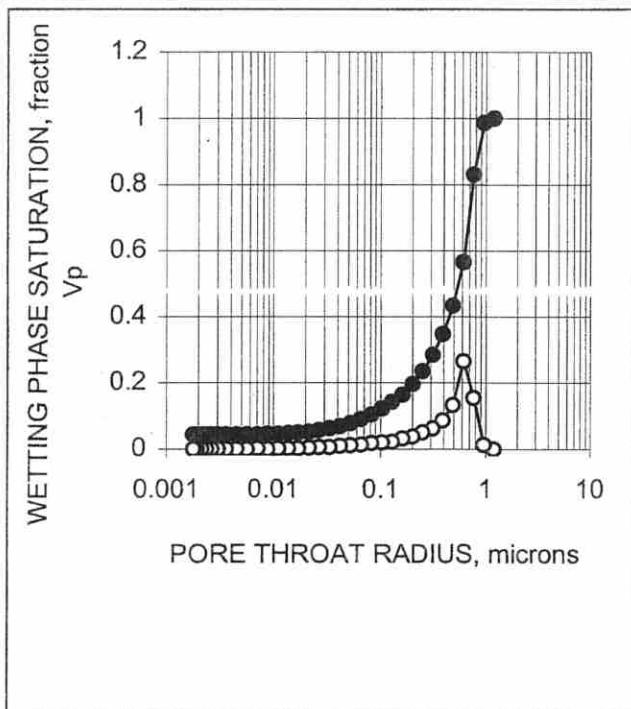
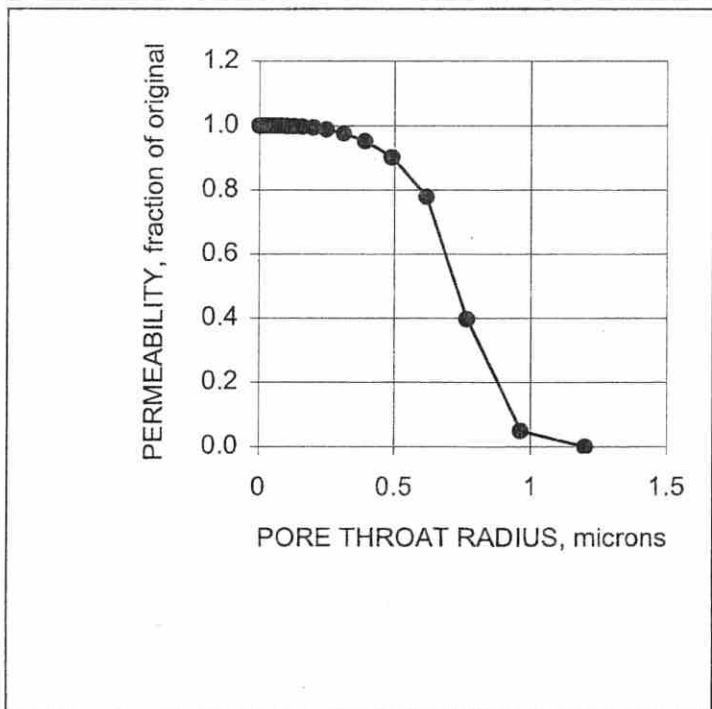
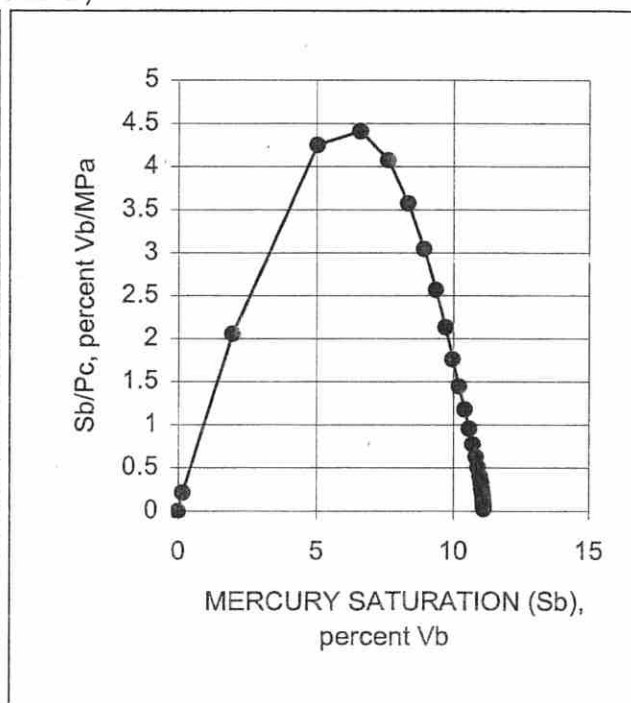
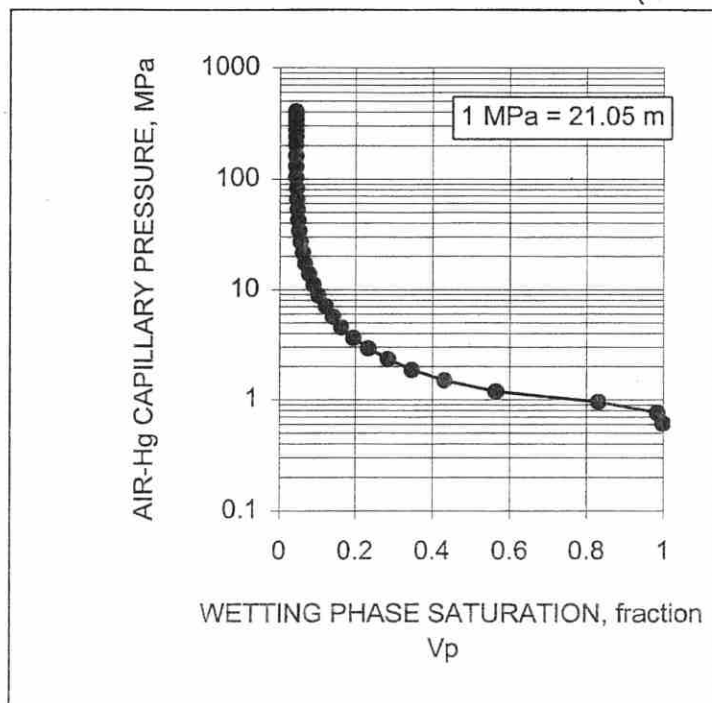
WETTING PHASE SATURATION, fraction Vp	PORE THROAT RADIUS, microns	PERMEABILITY, fraction of original	MERCURY SATURATION (Sb), percent Vb	SWANSON PARAMETER (Sb/Pc), percent Vb/MPa
0.044	0.003	1.000	11.1	0.040
0.044	0.002	1.000	11.1	0.036
0.044	0.002	1.000	11.1	0.032
0.044	0.002	1.000	11.1	0.029
0.044	0.002	1.000	11.1	0.027

MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited FILE: 52132-01-1032
WELL: PCI Canterra Tweed Lake A-67 FORMATION: Mount Clark

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

(0 - 400 MPa)



Median Pore Throat Radius, μm : 0.556
Reservoir Quality Index, μm : 0.085

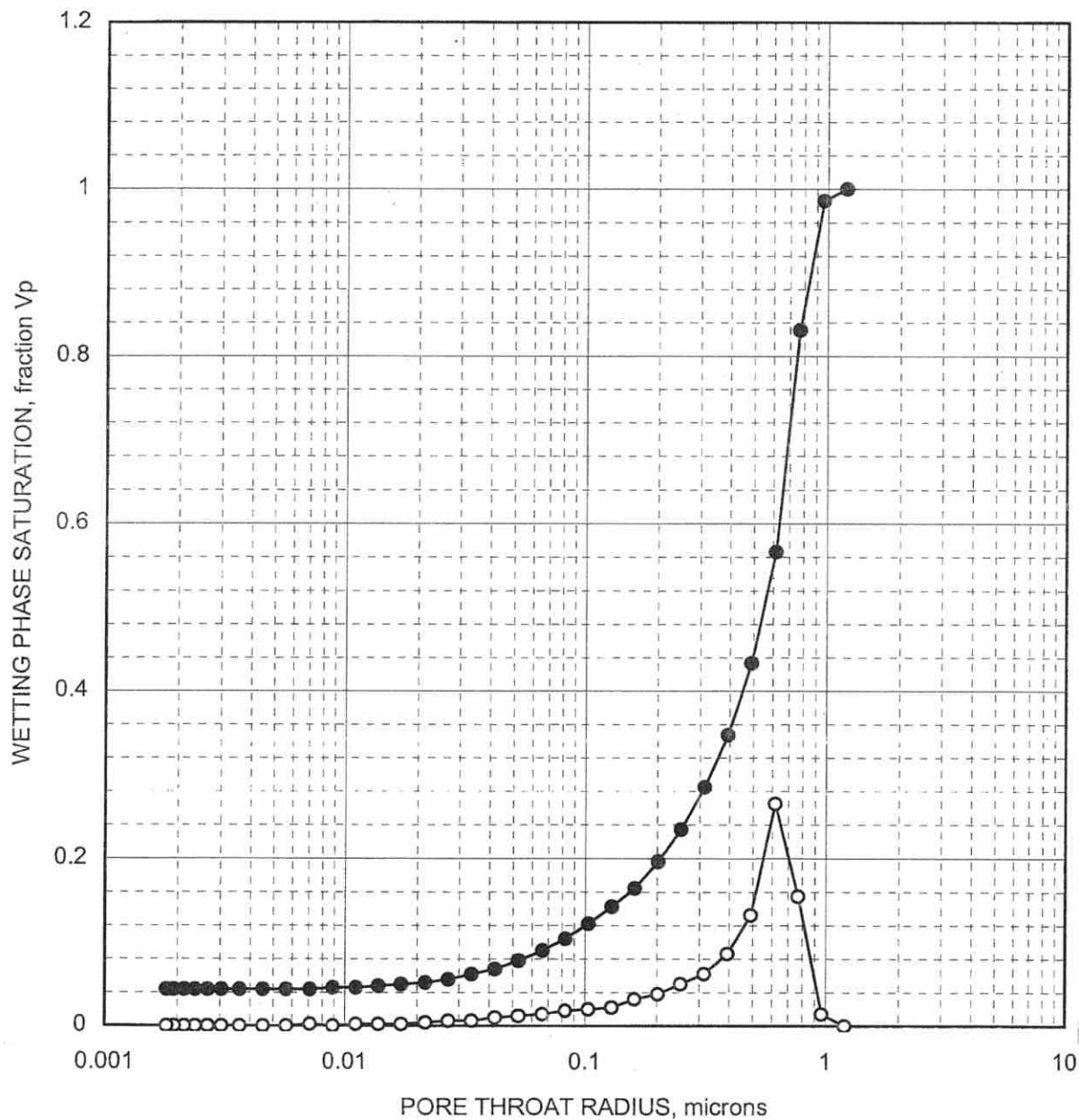
Mean Hydraulic Radius, μm : 0.334

MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited FILE: 52132-01-1032
WELL: PCI Canterra Tweed Lake A-67 FORMATION: Mount Clark

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

(0 - 400 MPa)



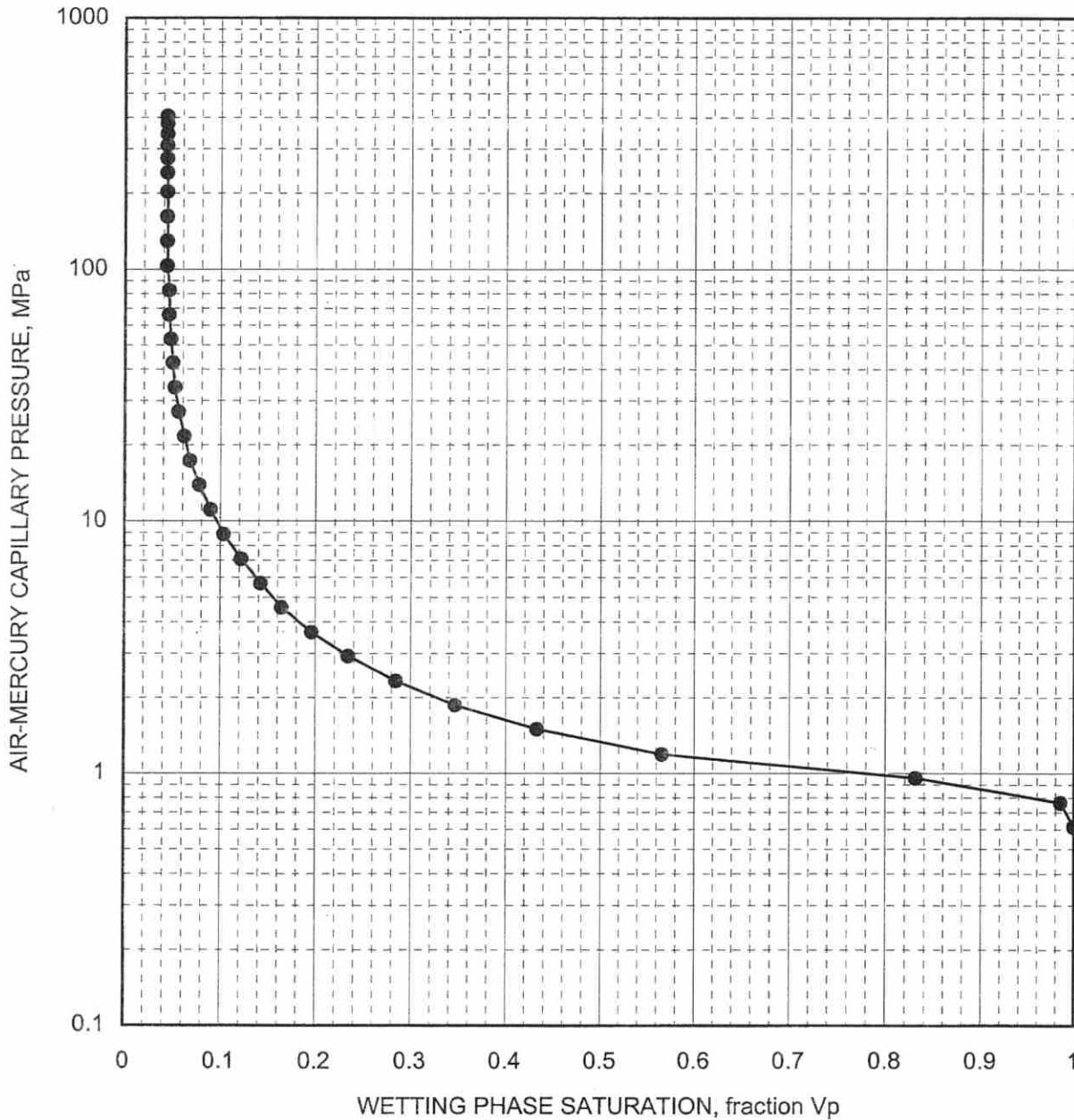
Median Pore Throat Radius, μm : 0.556 Mean Hydraulic Radius, μm : 0.334
Reservoir Quality Index, μm : 0.085

MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited FILE: 52132-01-1032
WELL: PCI Canterra Tweed Lake A-67 FORMATION: Mount Clark

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

(0 - 400 MPa)



Median Pore Throat Radius, μm : 0.556 Mean Hydraulic Radius, μm : 0.334
Reservoir Quality Index, μm : 0.085

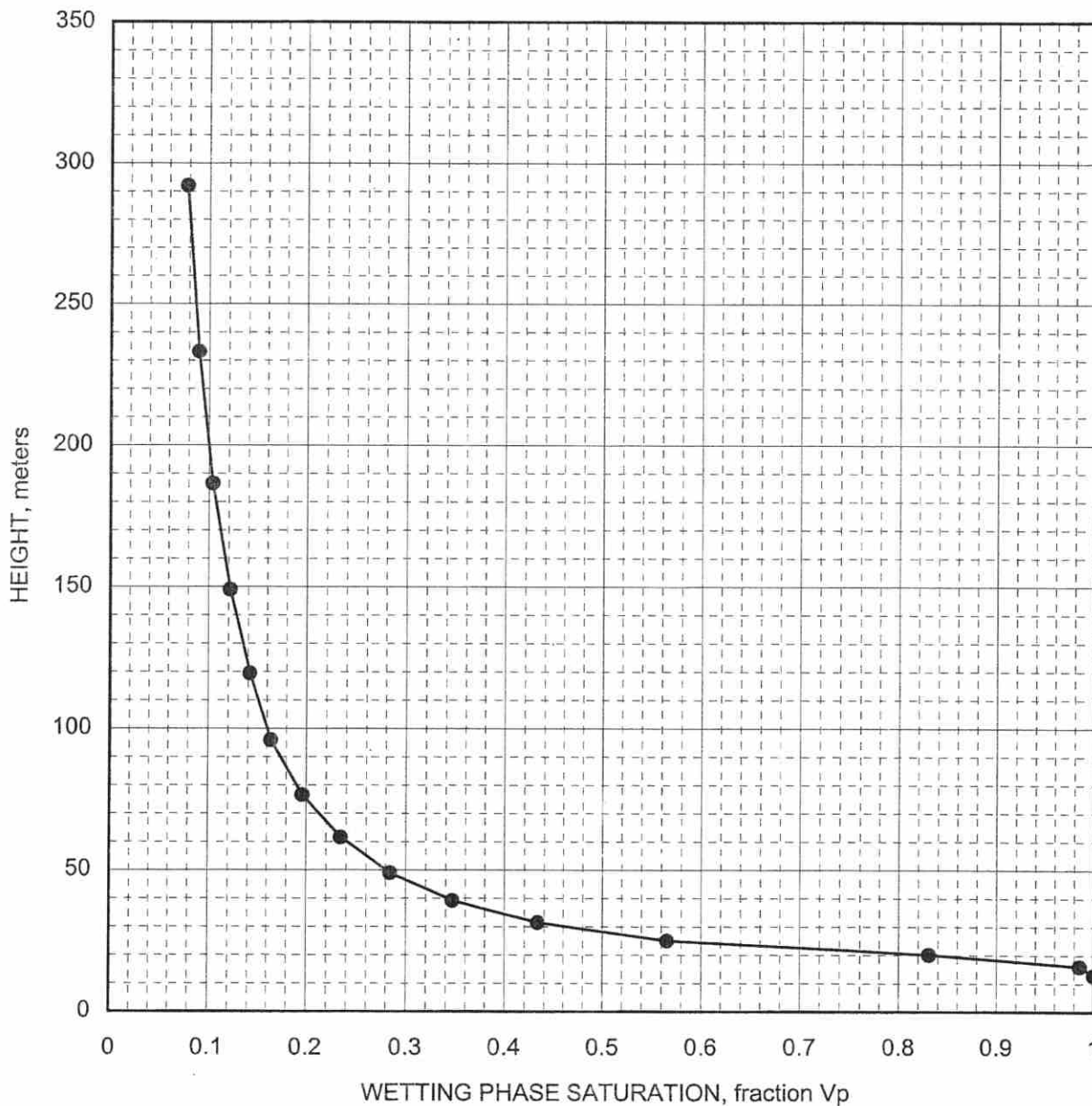
MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

(0 - 14 MPa)



Median Pore Throat Radius, μm : 0.556 Mean Hydraulic Radius, μm : 0.334
Reservoir Quality Index, μm : 0.085

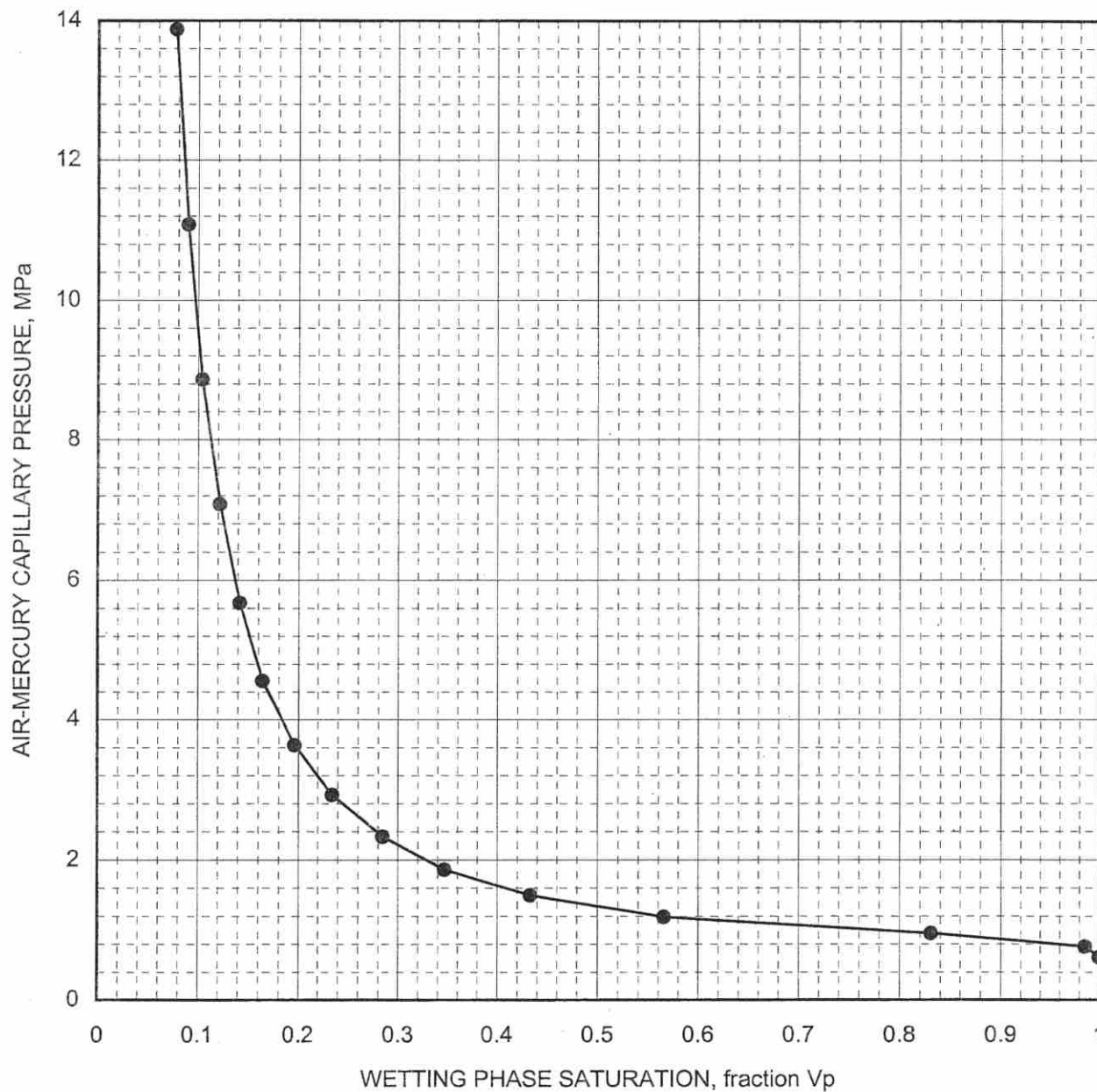
MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

(0 - 14 MPa)



Median Pore Throat Radius, μm : 0.556 Mean Hydraulic Radius, μm : 0.334
Reservoir Quality Index, μm : 0.085

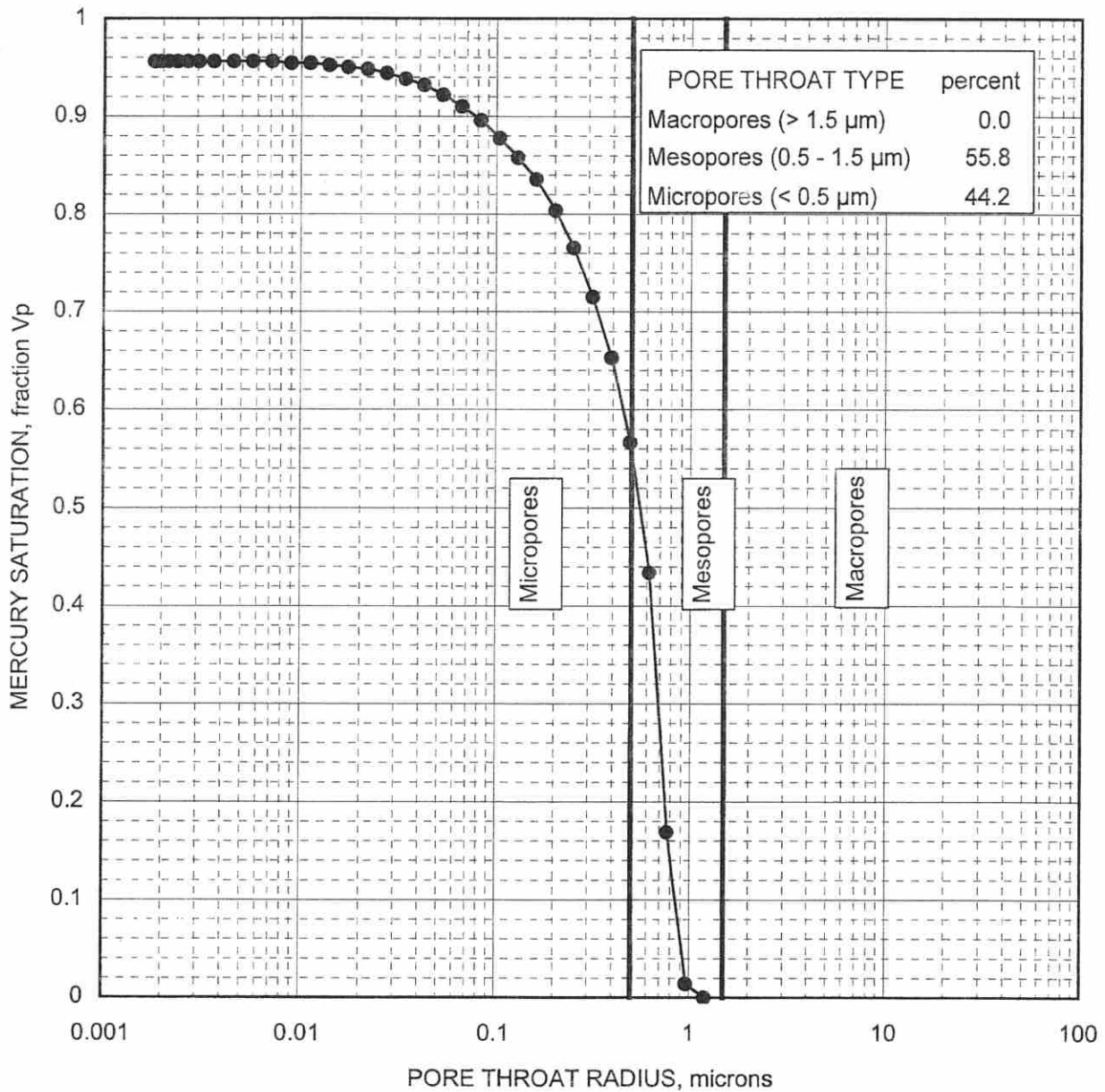
MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

Sample: 2 Ambient Condition Air Permeability, mD: 0.85
Depth, meters: 1282.30 Ambient Condition Porosity, fraction: 0.116

(0 - 400 MPa)



Median Pore Throat Radius, μm : 0.556 Mean Hydraulic Radius, μm : 0.334
Reservoir Quality Index, μm : 0.085

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE TEST DATA

Sample: 4 Depth, meters: 1292.20

ROUTINE LAB MEASURED DATA

Length, cm:	1.521	Ambient Condition Air Permeability, mD:	2.43
Diameter, cm:	2.425	Weight, grams:	15.388
Calip. Bulk Volume (Vb), cm ³ :	7.025	Grain Density, kg/m ³ :	2673
Ambient Immersed Vb, cm ³ :	6.633	Bulk Density*, kg/m ³ :	2320
Vacuum Immersed Vb, cm ³ :	6.627	Surface Volume*, cm ³ :	0.398
Grain Volume, cm ³ :	5.757	Surface Volume*, percent Vp:	45.40
Pore Volume (Vp)*, cm ³ :	0.876	Surface Area (SA), cm ² :	20.82
Ambient Condition Porosity*, fraction:	0.132	SA/Vb Ratio*, 1/cm:	3.140

* Calculated using ambient immersed bulk volume.

MERCURY INJECTION CAPILLARY PRESSURE CALCULATED DATA

VOLUMES USED FOR CAPILLARY PRESSURE CURVE CONSTRUCTION

Pore Volume, cm ³ :	0.728	Mercury Constant, cm ³ :	0.092
Porosity, fraction:	0.110	Bulk Volume, cm ³ :	6.633
Total Pore Surface Area, m ² :	31.85	Pore Volume, cm ³ :	0.876

CONVERSIONS USED FOR CALCULATION OF PORE SIZE, RESERVOIR CAPILLARY PRESSURE AND HEIGHT ABOVE WATER

Mercury IFT, dynes/cm:	480
Mercury Contact Angle, degrees:	140
Ratio of Reservoir/Lab IFTxCOS(Contact Angle):	0.196
Hydrocarbon Density Gradient, kPa/meter:	0.553
Water Density Gradient, kPa/meter:	9.857

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 4 Ambient Condition Air Permeability, mD: 2.43
 Depth, meters: 1292.20 Ambient Condition Porosity, fraction: 0.132

WETTING PHASE	LABORATORY AIR-MERCURY	RESERVOIR HC-WATER	HEIGHT ABOVE FREE WATER
SATURATION, fraction Vp	CAPILLARY PRESSURE (Pc), MPa	CAPILLARY PRESSURE, MPa	LEVEL, meters
1.000	0.202	0.040	4.25
0.984	0.252	0.049	5.29
0.958	0.314	0.061	6.60
0.928	0.390	0.076	8.20
0.891	0.488	0.096	10.28
0.849	0.610	0.120	12.85
0.805	0.761	0.149	16.01
0.752	0.955	0.187	20.10
0.705	1.19	0.234	25.12
0.663	1.50	0.294	31.64
0.631	1.87	0.367	39.45
0.608	2.34	0.458	49.24
0.587	2.94	0.575	61.82
0.570	3.65	0.715	76.80
0.552	4.57	0.895	96.19
0.536	5.69	1.11	119.8
0.517	7.09	1.39	149.3
0.491	8.88	1.74	186.8
0.455	11.1	2.17	233.5
0.412	13.9	2.72	292.3
0.373	17.3	3.40	365.1
0.340	21.7	4.24	455.9
0.311	27.1	5.31	570.9
0.287	33.9	6.63	712.5
0.264	42.6	8.34	895.8
0.245	52.9	10.4	1113
0.229	65.8	12.9	1385
0.210	82.5	16.1	1735

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited FORMATION: Mount Clark
 WELL: PCI Canterra Tweed Lake A-67 FIELD: Tweed Lake
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 4 Ambient Condition Air Permeability, mD: 2.43
 Depth, meters: 1292.20 Ambient Condition Porosity, fraction: 0.132

WETTING PHASE	LABORATORY AIR-MERCURY	RESERVOIR HC-WATER	HEIGHT ABOVE FREE WATER
SATURATION, fraction Vp	CAPILLARY PRESSURE, MPa	CAPILLARY PRESSURE, MPa	LEVEL, meters
0.192	103	20.2	2167
0.181	129	25.3	2721
0.174	162	31.6	3401
0.171	202	39.6	4260
0.171	241	47.2	5074
0.169	275	53.8	5787
0.169	309	60.6	6510
0.169	343	67.2	7225
0.169	378	74.1	7961
0.169	406	79.4	8536

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 4 Ambient Condition Air Permeability, mD: 2.43
 Depth, meters: 1292.20 Ambient Condition Porosity, fraction: 0.132

WETTING PHASE SATURATION, fraction Vp	PORE THROAT RADIUS, microns	PERMEABILITY, fraction of original	MERCURY SATURATION (Sb), percent Vb	SWANSON PARAMETER (Sb/Pc), percent Vb/MPa
1.000	3.64	0.000	0.00	0.000
0.984	2.92	0.210	0.21	0.830
0.958	2.34	0.435	0.56	1.774
0.928	1.89	0.600	0.95	2.441
0.891	1.51	0.731	1.44	2.945
0.849	1.20	0.827	2.00	3.269
0.805	0.966	0.890	2.58	3.385
0.752	0.770	0.939	3.27	3.425
0.705	0.616	0.967	3.90	3.265
0.663	0.489	0.983	4.45	2.962
0.631	0.392	0.991	4.87	2.599
0.608	0.314	0.994	5.17	2.211
0.587	0.250	0.996	5.45	1.856
0.570	0.201	0.998	5.68	1.558
0.552	0.161	0.998	5.92	1.294
0.536	0.129	0.999	6.12	1.076
0.517	0.104	0.999	6.38	0.899
0.491	0.083	0.999	6.73	0.758
0.455	0.066	1.000	7.19	0.648
0.412	0.053	1.000	7.77	0.559
0.373	0.042	1.000	8.28	0.477
0.340	0.034	1.000	8.72	0.403
0.311	0.027	1.000	9.09	0.335
0.287	0.022	1.000	9.42	0.278
0.264	0.017	1.000	9.72	0.228
0.245	0.014	1.000	9.98	0.189
0.229	0.011	1.000	10.2	0.155
0.210	0.009	1.000	10.4	0.127

FILE:

52132-01-1032

COMPANY: Canadian Natural Resources Limited
 WELL: PCI Canterra Tweed Lake A-67
 LOCATION: 66°56'11" N LAT, 126°56'18" W LOG

FORMATION: Mount Clark
 FIELD: Tweed Lake
 PROVINCE: Northwest Territories

MERCURY INJECTION CAPILLARY PRESSURE

Sample: 4 Ambient Condition Air Permeability, mD: 2.43
 Depth, meters: 1292.20 Ambient Condition Porosity, fraction: 0.132

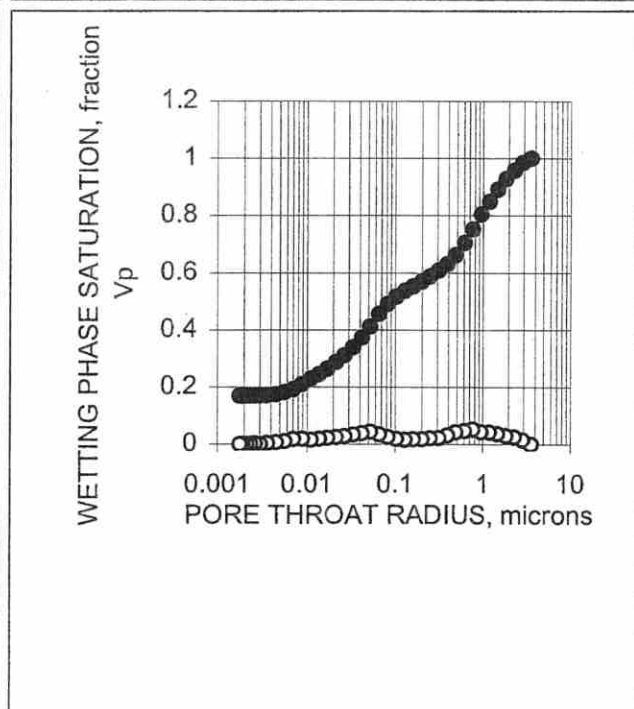
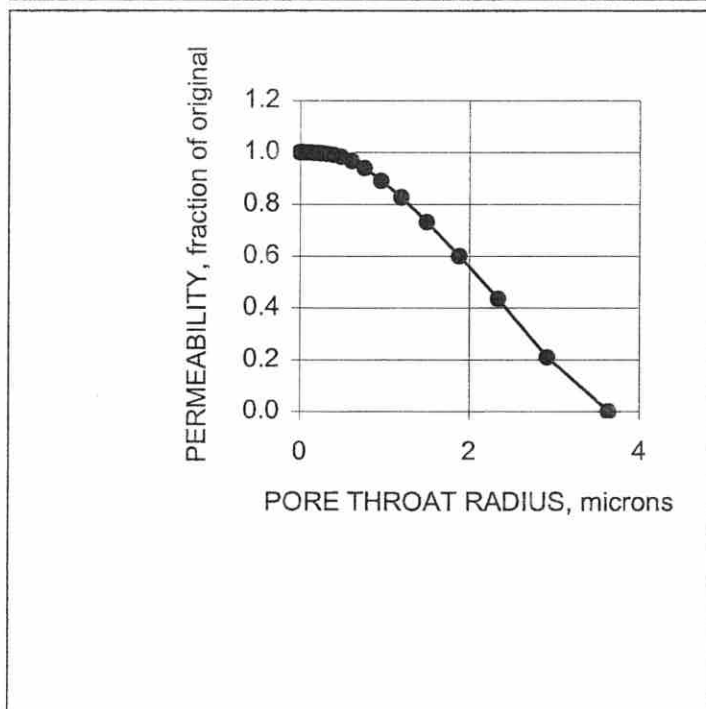
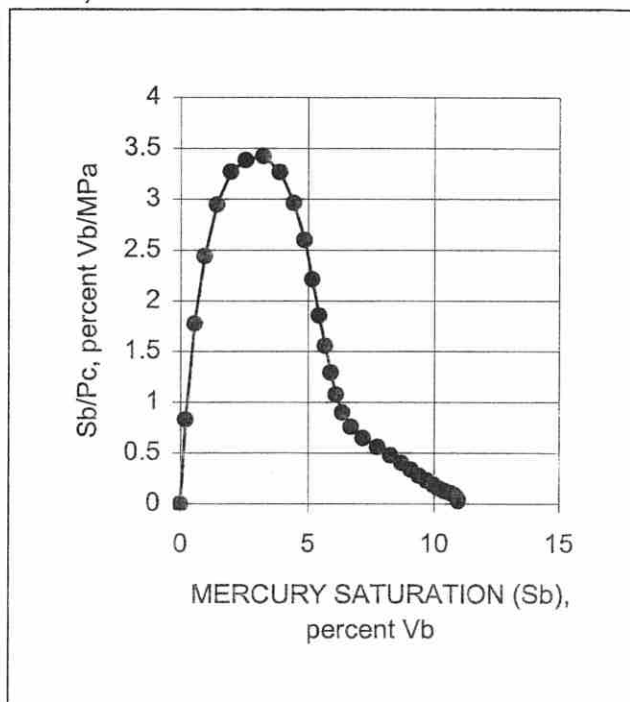
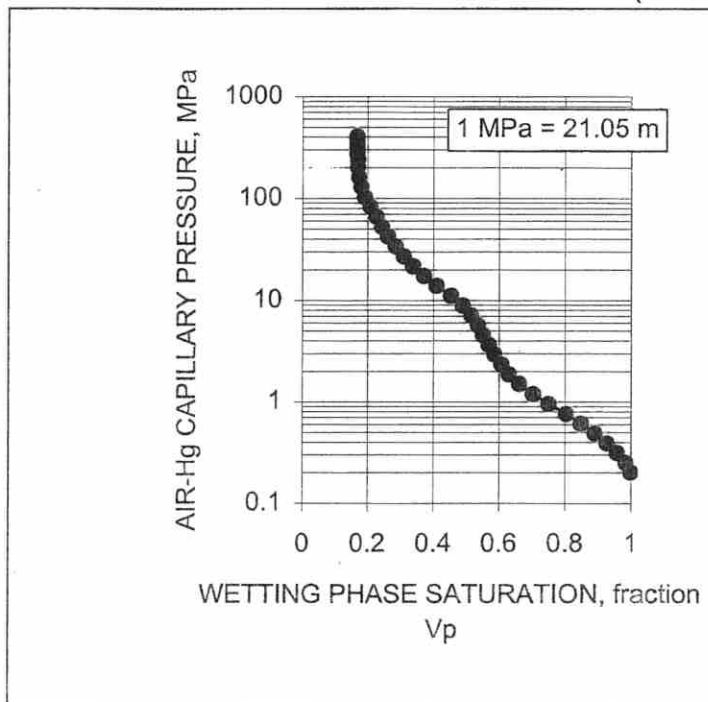
WETTING PHASE SATURATION, fraction Vp	PORE THROAT RADIUS, microns	PERMEABILITY, fraction of original	MERCURY SATURATION (Sb), percent Vb	SWANSON PARAMETER (Sb/Pc), percent Vb/MPa
0.192	0.007	1.000	10.7	0.104
0.181	0.006	1.000	10.8	0.084
0.174	0.005	1.000	10.9	0.067
0.171	0.004	1.000	11.0	0.054
0.171	0.003	1.000	11.0	0.045
0.169	0.003	1.000	11.0	0.040
0.169	0.002	1.000	11.0	0.035
0.169	0.002	1.000	11.0	0.032
0.169	0.002	1.000	11.0	0.029
0.169	0.002	1.000	11.0	0.027

MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

Sample: 4 Ambient Condition Air Permeability, mD: 2.43
Depth, meters: 1292.20 Ambient Condition Porosity, fraction: 0.132
(0 - 400 MPa)



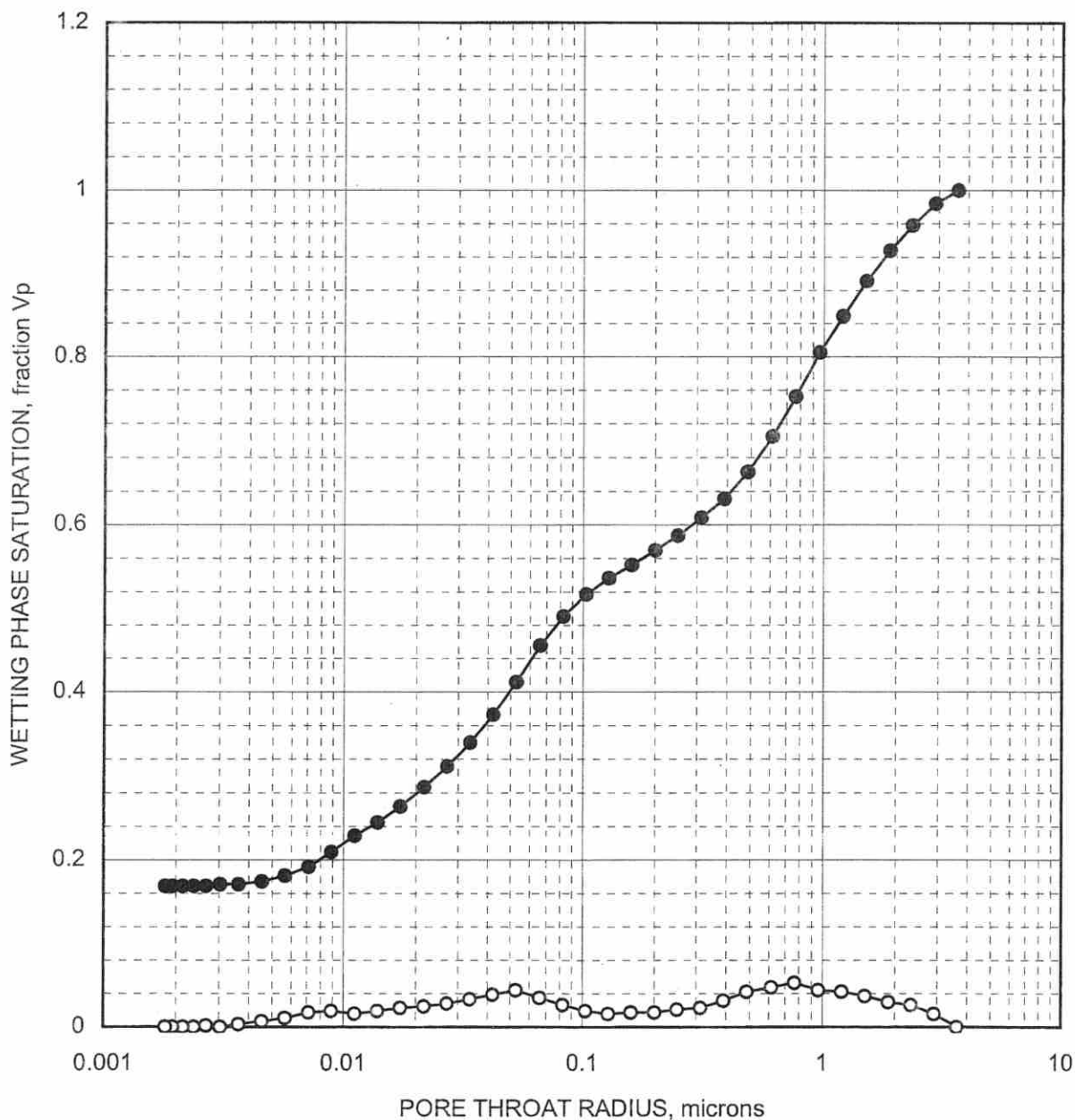
Median Pore Throat Radius, μm : 0.058
Reservoir Quality Index, μm : 0.135

Mean Hydraulic Radius, μm : 0.809

MERCURY INJECTION CAPILLARY PRESSURE

COMPANY:	Canadian Natural Resources Limited	FILE:	52132-01-1032
WELL:	PCI Canterra Tweed Lake A-67	FORMATION:	Mount Clark
Sample:	4	Ambient Condition Air Permeability, mD:	2.43
Depth, meters:	1292.20	Ambient Condition Porosity, fraction:	0.132

(0 - 400 MPa)



Median Pore Throat Radius, μm :	0.058	Mean Hydraulic Radius, μm :	0.809
Reservoir Quality Index, μm :	0.135		

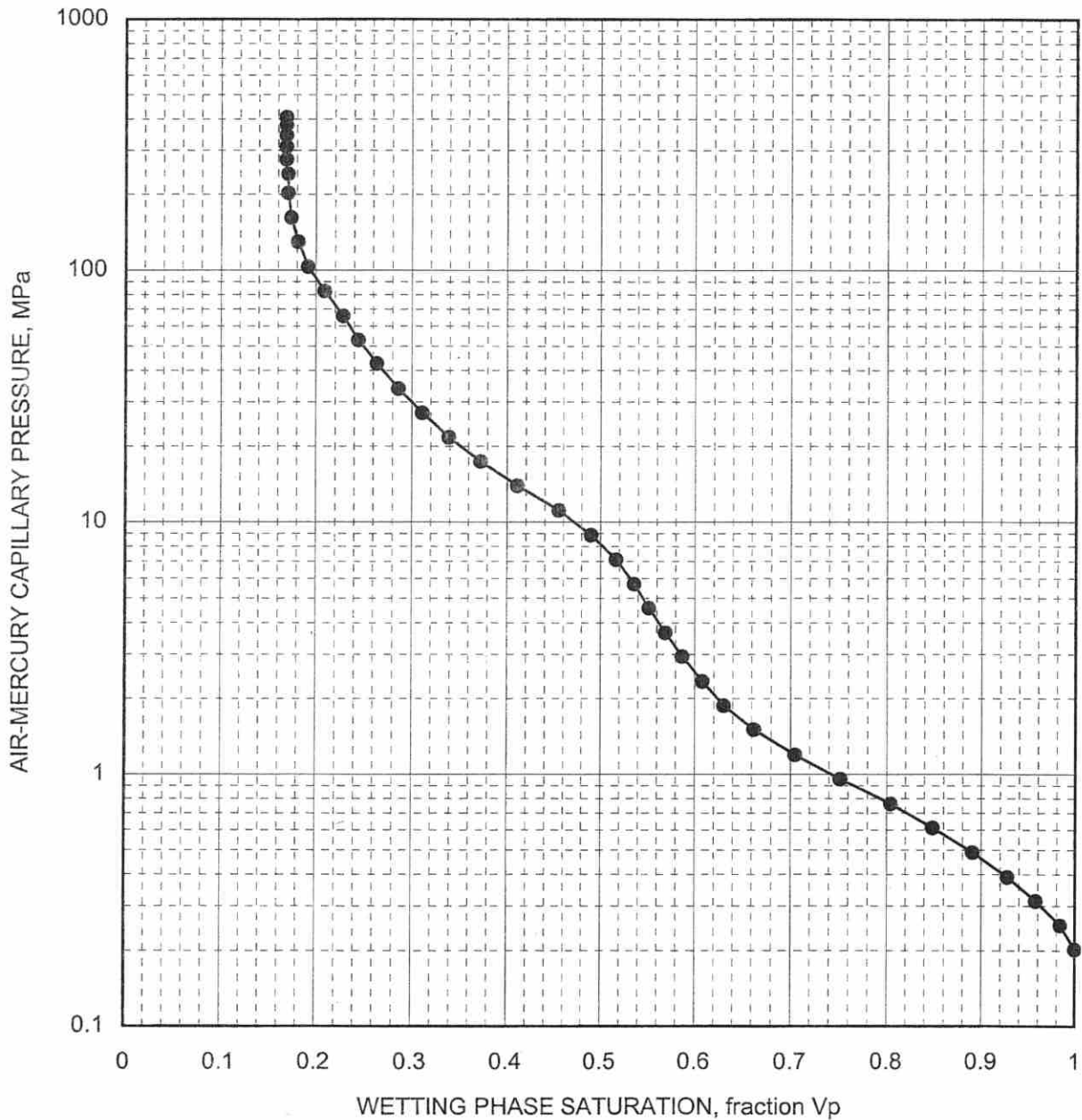
MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

Sample: 4 Ambient Condition Air Permeability, mD: 2.43
Depth, meters: 1292.20 Ambient Condition Porosity, fraction: 0.132

(0 - 400 MPa)

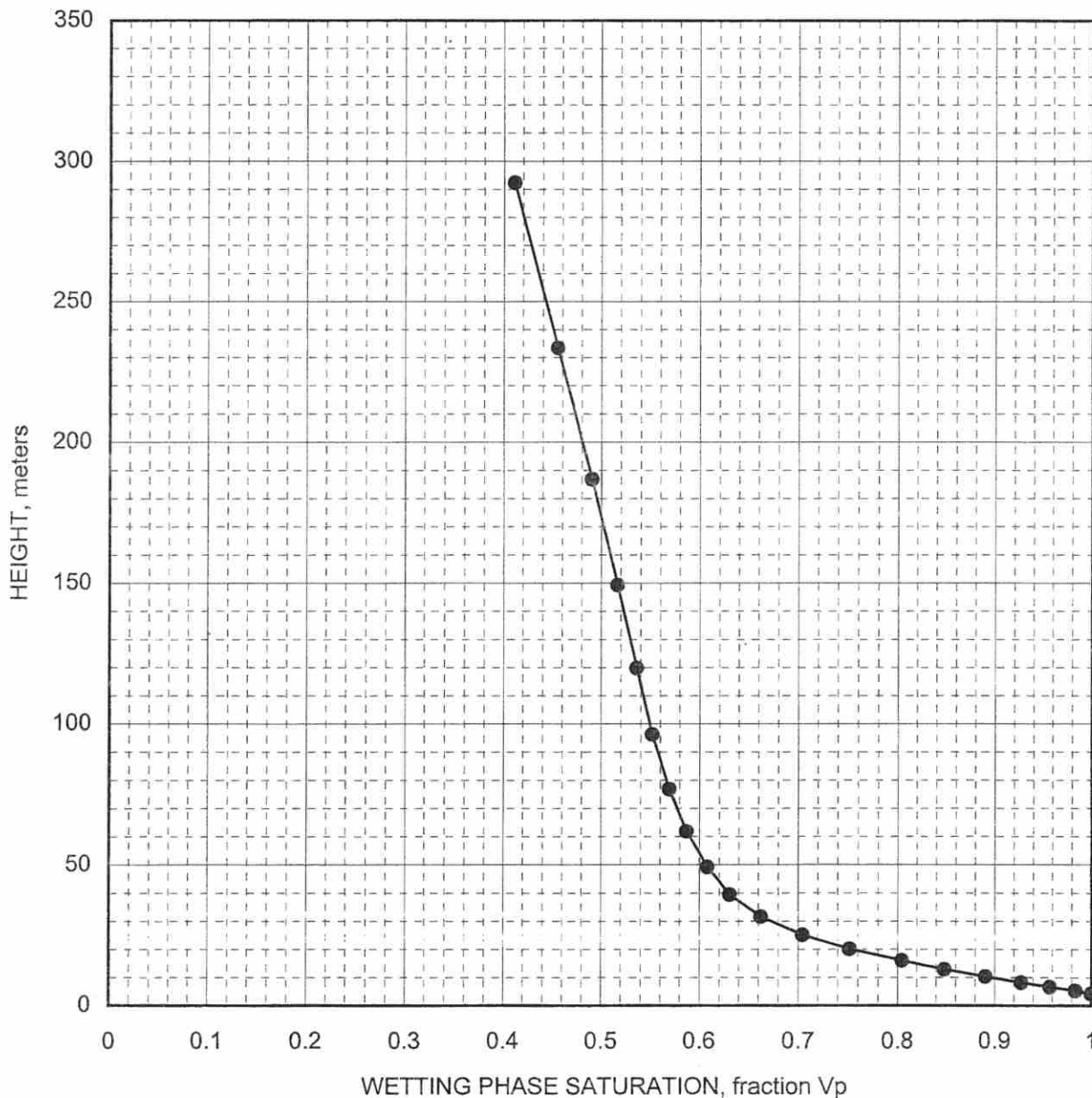


Median Pore Throat Radius, μm : 0.058 Mean Hydraulic Radius, μm : 0.809
Reservoir Quality Index, μm : 0.135

MERCURY INJECTION CAPILLARY PRESSURE

COMPANY:	Canadian Natural Resources Limited	FILE:	52132-01-1032
WELL:	PCI Canterra Tweed Lake A-67	FORMATION:	Mount Clark
Sample:	4	Ambient Condition Air Permeability, mD:	2.43
Depth, meters:	1292.20	Ambient Condition Porosity, fraction:	0.132

(0 - 14 MPa)



Median Pore Throat Radius, μm :	0.058	Mean Hydraulic Radius, μm :	0.809
Reservoir Quality Index, μm :	0.135		

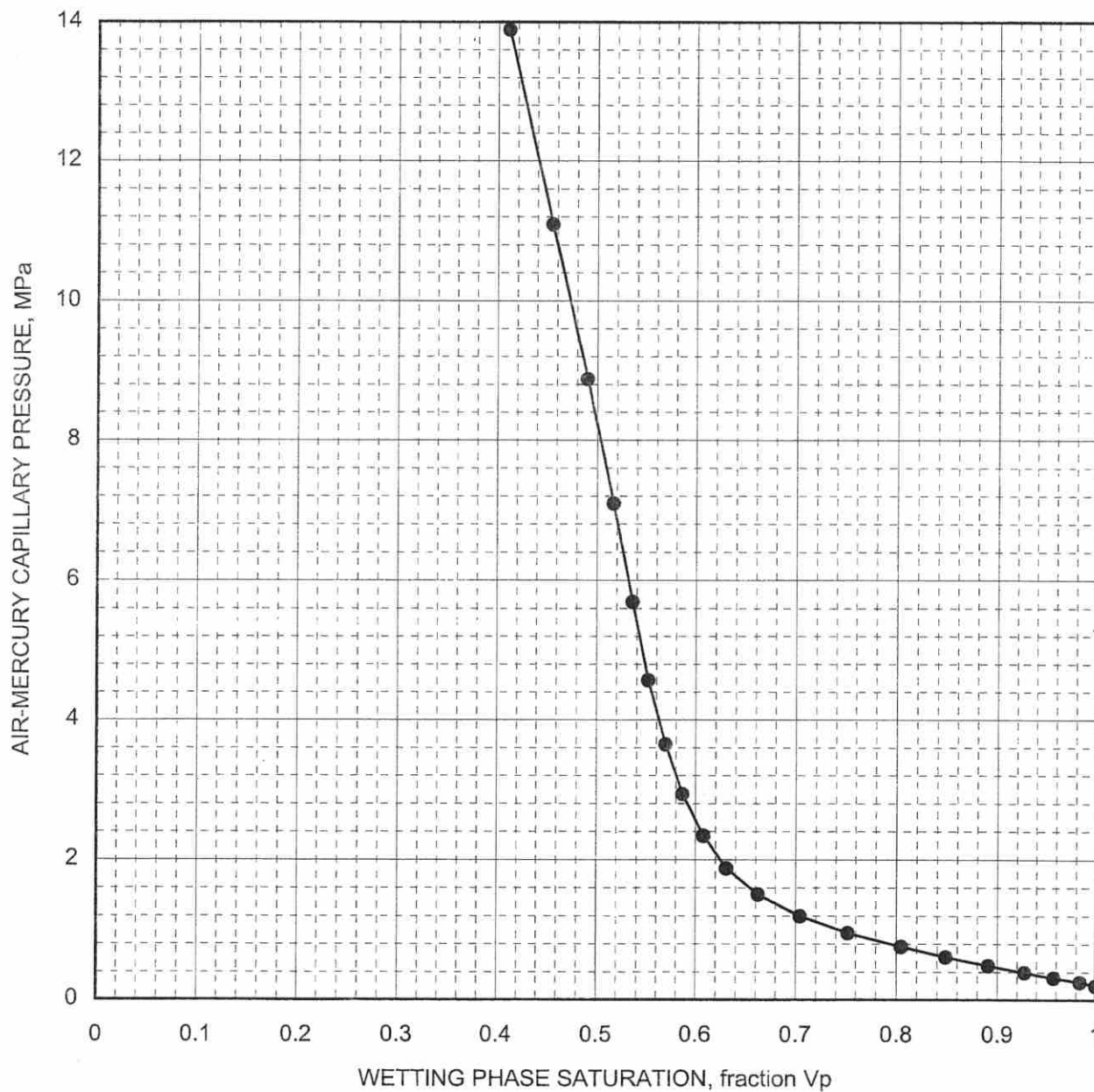
MERCURY INJECTION CAPILLARY PRESSURE

COMPANY: Canadian Natural Resources Limited
WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
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Sample: 4 Ambient Condition Air Permeability, mD: 2.43
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(0 - 14 MPa)



Median Pore Throat Radius, μm : 0.058 Mean Hydraulic Radius, μm : 0.809
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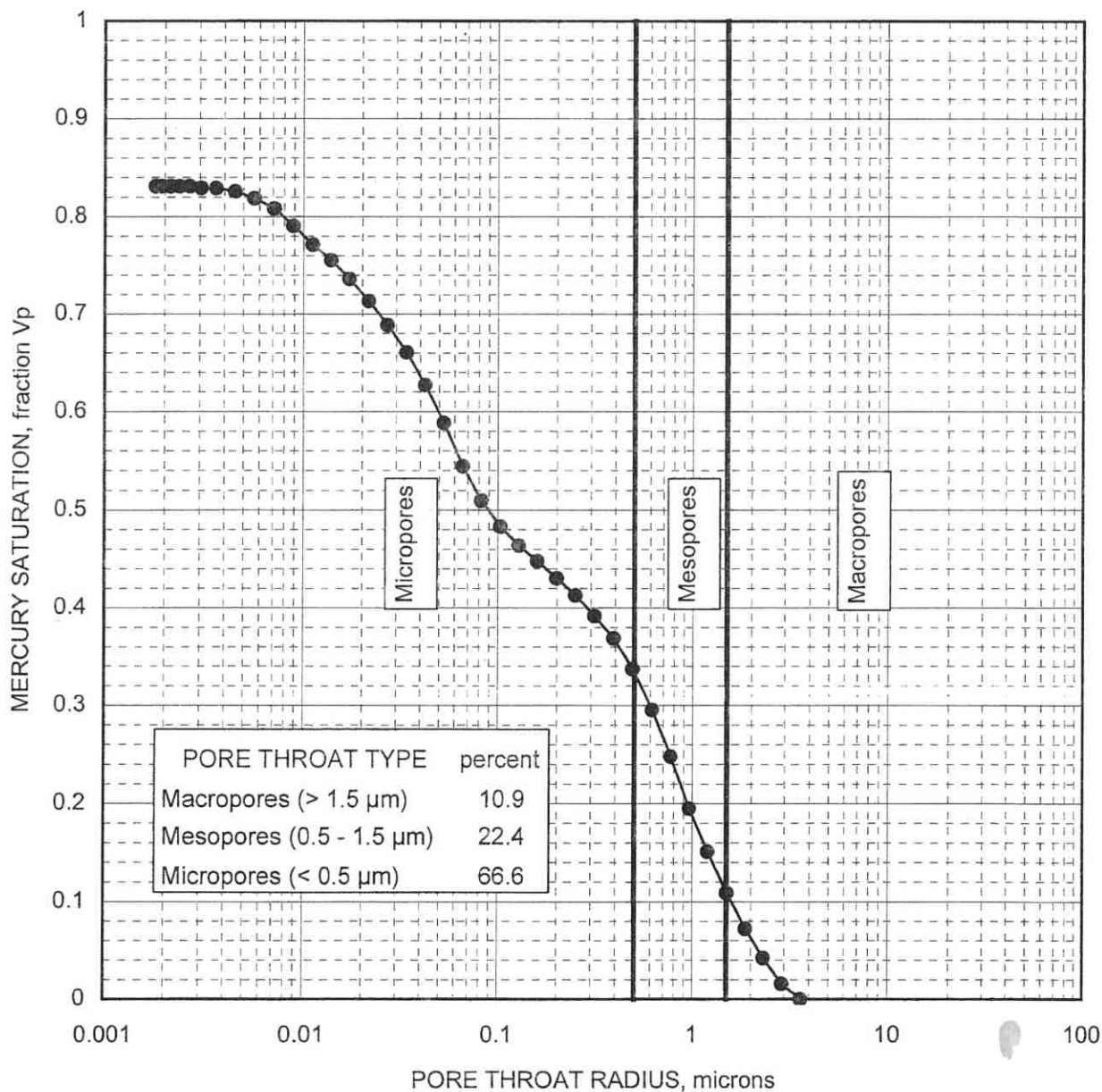
MERCURY INJECTION CAPILLARY PRESSURE

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WELL: PCI Canterra Tweed Lake A-67

FILE: 52132-01-1032
FORMATION: Mount Clark

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(0 - 400 MPa)



Median Pore Throat Radius, μm : 0.058 Mean Hydraulic Radius, μm : 0.809
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Core Laboratories Canada Ltd.



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Signature	<i>Syle Hahn</i>
Date	<i>Dec 31, 2001</i>
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