



**Advanced Rock Properties
Study using Pulsed Decay
Permeametry on the
Duvernay Formation, East
Shale Basin: Client Report
to ERCB**

AER/AGS Special Report 106

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Core Laboratories Canada Ltd.

September 2017

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ISBN 978-1-4601-1677-7

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If you use information from this publication in other publications or presentations, please acknowledge the AER/AGS. We recommend the following reference format:

Core Laboratories Canada Ltd. (2017): Advanced rock properties study using Pulsed Decay Permeametry on the Duvernay Formation, East Shale Basin: client report to ERCB; Alberta Energy Regulator, AER/AGS Special Report 106, 8 p.

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Published September 2017 by:

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Acknowledgements

This report includes data generated to support the AGS report “Summary of Alberta's shale- and siltstone-hosted hydrocarbon resource potential” (2012) and subsequent unconventional resource evaluations. Funding was provided in part by Alberta Energy. The authors thank B. Fildes and M. Grobe for their technical editing, comments and advice during the preparation of this release.

Abstract

This report publishes a summary report from Core Laboratories on ‘Air Permeability at Net Overburden Pressure’ using a pulsed decay permeameter on selected core samples from the Duvernay Formation in the East Shale Basin of Alberta, as part of the Alberta Geological Survey study on shale and siltstone hosted hydrocarbons.

1 Introduction

In 2012, the Alberta Geological Survey (AGS) published a report that determined the quantity and spatial extent of shale- and siltstone-hosted hydrocarbons (oil, gas, and natural gas liquids) in the province (Rokosh et al., 2012). The AGS is releasing client reports and digital data to disseminate knowledge from the project. These data and reports can be accessed from the AGS website (<http://ags.aer.ca>).

This report disseminates results of a study on permeability using a pulsed decay permeameter on the Duvernay Formation of the East Shale Basin (Rokosh et al., 2012).

2 Sample Locations and Descriptions

Table 1 lists the samples and sites examined in the study.

Table 1. Samples collected for permeability analysis.

AGS Sample_ID	UWI	Units	Depth	Lithology	Formation
13701	00/07-29-038-19W4/0	m	1769.8	mudstone	Duvernay
13702	00/07-29-038-19W4/0	m	1778.0	shale	Duvernay
13703	00/02-19-039-26W4/0	m	2275.9	shale	Duvernay
13704	00/02-19-039-26W4/0	m	2282.3	shale	Duvernay
13705	00/02-19-039-26W4/0	m	2285.5	shale	Duvernay
13706	00/05-16-038-02W5/0	m	2774.2	lime mudstone	Duvernay
13707	00/05-16-038-02W5/0	m	2785.6	lime mudstone	Duvernay

References

Rokosh, C.D., Lyster, S., Anderson, S.D.A., Beaton, A.P., Berhane, H., Brazzoni, T., Chen, D., Cheng, Y., Mack, T., Pana, C. and Pawlowicz, J.G. (2012): Summary of Alberta's shale- and siltstone-hosted hydrocarbon resource potential; Energy Resources Conservation Board, ERCB/AGS Open File Report 2012-06, 327 p., URL < http://ags.aer.ca/publications/OFR_2012_06.html > [March 2017].

**ADVANCED ROCK PROPERTIES STUDY
For
ENERGY RESOURCES CONSERVATION BOARD.**

**7-29-38-19 W4M
2-19-39-26 W4M
5-16-38-2 W5M**

April 30, 2013

52132-13-6030



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Effective Overburden Air Permeability Results



SUMMARY OF RESULTS

At the request of Energy Resources Conservation Board, Core Laboratories Canada Ltd. has conducted effective overburden air permeability testing on core samples from 7-29-38-19 W4M, 2-19-39-26 W4M, and 5-16-38-2 W5M, Duv. E. Basin formation in Alberta.

Sample Preparation

Six (6) 25.4 mm diameter and one (1) 38.1 mm diameter plug samples were trimmed at Core Laboratories Canada Ltd. Samples were preserved with plastic film and tin foil before the effective overburden air permeability measurements began.

Effective Air Permeability at Net Overburden Pressure

The hydrostatic net confining stress used for the effective overburden air permeability measurements was 13435 kPa for Samples 13701 and 13702 from 7-29-38-19 W4M well, 18950 kPa for Samples 13703, 13704, and 13705 from 2-19-39-26 W4M well, and 22574 kPa for Samples 13706 and 13707 from 5-16-38-2 W5M well.

Samples were loaded individually in a hydrostatic core holder and connected to Pulse Decay Permeameter (PDP) for effective overburden air permeability measurements. The air permeability ranged from 4.00×10^{-7} md to 1.80×10^{-6} md for 7-29 well, 1.40×10^{-6} md to 2.11×10^{-5} md for 2-19 well, and 5.60×10^{-6} md to 7.80×10^{-6} md for 5-16 well.

Upon completion of PDP measurements, samples were individually placed in a dean stark extractor and insitu water volume was extracted. No water was extracted from dean stark extraction. Samples weights before and after dean stark extraction are presented in Section 3. The sample weight difference is the other residual fluids in the sample, i.e., hydrocarbon or drill fluid.

The detailed test results are presented in Section 3.



CHRONOLOGICAL SEQUENCE OF EVENTS

Sample Preparation

1. Six (6) 25.4 mm diameter and one (1) 38.1 mm diameter core samples from 7-29-38-19 W4M, 2-19-39-26 W4M and 5-16-38-2 W5M wells were trimmed at Core Laboratories Canada Ltd. Samples represented the Duv. E. Basin formation in Alberta.

Overburden Air Permeability

2. Samples were individually loaded into a hydrostatic core holder and air (nitrogen gas) permeability was measured by Pulse Decay Permeameter (PDP) at ambient temperature and hydrostatic net confining pressure of 13435 kPa for 7-29-38-19 W4M well, 18950 kPa for 2-19-39-26 W4M well and 22574 kPa for 5-16-38-2 W5M well.
3. Samples weight were taken after PDP measurement and then individually placed in a dean stark extractor for insitu water volume determination. Samples weight were taken after dean stark water saturation and after they were dried in a vacuum oven at 100°C.

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:

$$\text{NOB Hydrostatic} = \left[\frac{1}{3} + \frac{2}{3} \left(\frac{\mu}{1-\mu} \right) \right] \times [(\text{Depth} \times \text{Pressure Gradient}) - \text{Reservoir Pressure}]$$

where:

- NOB Hydrostatic = Hydrostatic Net Confining Pressure, kPa
- 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
- Reservoir Pressure = kPa

Overburden Permeability by Pulse Decay Permeameter (PDP-200)

The Pulse Decay Permeameter (PDP-200) measures the permeability of rocks below 1 millidarcy. In the PDP-200 system only a portion of the pulse decay curve, after a smooth pressure gradient has been established, is investigated. The system is ideal for direct measurement of the permeability of cap rock, tight gas sands and other low permeability porous media.

The clean and dry sample is loaded into a hydrostatic core holder, which is connected to the upstream and downstream outlet ports of the PDP-200. A 1,000 psig pressure is supplied to the system by a nitrogen gas bottle. The gas supply is disconnected from the system before the test. A desired pressure drop (less than 50 psi) is established between the upstream and downstream, and then pressure decay is conducted and the upstream, downstream and mean pressures are monitored. Air permeability is automatically calculated based on the pressure decay data.

FILE: 52132-13-6030

COMPANY: Energy Resources Conservation Board
 WELL: Various
 LOCATION: Various PROVINCE: Alberta
 Duv. E. Basin
 NA

EFFECTIVE OVERBURDEN AIR PERMEABILITY RESULTS
 (PDP Results)

SAMPLE:	DEPTH, meters	CONFINING PRESSURE, kPa	EFFECTIVE PDP AIR PERMEABILITY millidarcies	DEAN STARK WATER VOLUME mL	SAMPLE	
					WEIGHT BEFORE DEAN STARK gram	WEIGHT AFTER DEAN STARK gram
<u>7-29-38-19 W4M</u>						
13701	1769.80	13435	1.80E-06	0.00	45.0963	45.0565
13702	1778.00	13435	4.00E-07	0.00	46.6215	46.5831
<u>2-19-39-26 W4M</u>						
13703	2275.90	18950	1.80E-06	0.00	27.6510	27.6495
13704	2282.30	18950	1.40E-06	0.00	33.6204	33.6114
13705	2285.45	18950	2.11E-05	0.00	36.1620	36.1582
<u>5-16-38-2 W5M</u>						
13706	2774.15	22574	7.80E-06	0.00	158.3740	158.3310
13707	2785.58	22574	5.60E-06	0.00	33.1314	33.1280