Technical Report

Title: ***Laboratory Petrophysical Testing of DGR-5 and DGR-6 Core***

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DGR Site Characterization Document
Geofirma Engineering Project 08-200

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Geofirma Engineering DGR Site Characterization Document		
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

Geofirma Engineering Ltd. (formerly Intera Engineering Ltd.) has been contracted by the Nuclear Waste Management Organization (NWMO) to implement the Geoscientific Site Characterization Plan (GSCP) for the Bruce nuclear site located in the municipality of Kincardine, Ontario. The purpose of this site characterization work is to assess the suitability of the geological formations beneath the Bruce nuclear site to host a Deep Geologic Repository (DGR) to store low-level and intermediate-level radioactive waste. The GSCP is described by Intera Engineering Ltd. (2006, 2008).

As part of the GSCP, Geofirma Engineering Ltd. contracted with Core Laboratories, Houston, Texas to complete petrophysical testing of samples of core collected from boreholes DGR-5 and DGR-6. This report summarizes the results of the petrophysical testing of vertical sub-cores of DGR-5 and DGR-6 core samples collected from Ordovician shales and limestones. Petrophysical testing included characterization of bulk and grain density, total porosity and residual fluid saturations. Fluid saturation testing was undertaken using two methods - Nuclear Magnetic Resonance (NMR)/helium (He) gas testing and Dean Stark/He gas testing. Testing was completed on "as received" and 'clean and dried" samples.

Work described in this Technical Report was completed with data generated from Test Plan TP-09-02 – DGR-5 and DGR-6 Core Sampling and Distribution for Laboratory Testing (Intera Engineering Ltd., 2010a) and Test Plan TP-09-08 – Laboratory Petrophysical Testing of DGR-5 and DGR-6 Core (Intera Engineering Ltd., 2009a), which were prepared following the general requirements of the DGR Project Quality Plan (Intera Engineering Ltd., 2009b).

2 Petrophysical Testing Program

Core samples of 76 mm diameter for petrophysical testing were collected during diamond coring of inclined boreholes DGR-5 and DGR-6 at the Bruce nuclear site during 2009 and 2010. All core samples were vacuum sealed within nitrogen flushed polyethylene and aluminum foil/polyethylene bags following core retrieval and the general preservation and handling requirements of TP-09-02 (Intera Engineering Ltd., 2010a). A total of ten preserved core samples from borehole DGR-5 and nine preserved core samples from DGR-6 were shipped to Core Laboratories under chain of custody procedures (following procedure DGR P4). Because DGR-5 and DGR-6 were inclined boreholes, core samples are identified based on depth along the borehole axis (i.e., metres length below ground surface, mLBGS).

The principal objective of the petrophysical testing program described in this Technical Report was to assess the reliability of porosities and residual gas saturations in the Ordovician shale and limestone formations that overly and surround the proposed DGR. Previous testing of porosities and residual fluid (i.e., oil, brine, gas) saturations in these rocks (Intera Engineering Ltd., 2010b; 2010c) and an assessment of the evidence for presence of gas phase (Geofirma Engineering Ltd., 2011, Intera Engineering Ltd, 2011) has noted the limitations of determining gas saturations in these rocks, especially within the low-porosity (<3%) Ordovician limestones. In such low porosity formations, uncertainty in estimation of gas phase presence is created by drying and stress relaxation of the cores prior to testing, measurement errors in the small weights of liquids removed from cores during drying, release of mineralogically-bound water during drying and sample size effects. In addition, the fissile nature of some of the shales as well as laminations and de-stressing of the cores lead to disking, especially in the horizontal orientation, which hampered the machining of some cylindrical core plugs.

During petrophysical testing of DGR-4 cores, liquid and gas saturations in three cores were estimated using two methods – NMR/He gas testing and Dean Stark/He gas testing. The similarity of the reported liquid and gas saturations from testing of these three cores (TR-08-28, Intera Engineering Ltd., 2010c) prompted additional comparative testing of DGR-5 and DGR-6 cores. In addition to fluid saturation testing, wet bulk densities, grain densities and total porosities were measured as part of the DGR-5 and DGR-6 petrophysical testing program.

Table 1 (DGR-5) and Table 2 (DGR-6) list the DGR sample numbers, the corresponding geologic formations and sample descriptions for the cores selected for petrophysical testing.

Core samples collected for petrophysical testing by Core Laboratories comparatively assessed Dean Stark and NMR/He methods for quantification of porosity and fluid saturations in Ordovician shales and limestones from the Georgian Bay Formation to the Sherman Fall Formation. Each core sample listed in Tables 1 and 2 underwent five petrophysical tests, in the same order. These tests, undertaken at ambient stress conditions, included: 1) bulk density, 2) NMR liquid saturation + He gas saturation (as received), 3) Dean Stark fluid saturation analysis, 4) grain density (clean and dry), and 5) He porosity (clean and dry). The laboratory procedures for these tests are discussed in detail in Section 3 below.

Table 1 Summary of DGR-5 Core Samples Submitted for Petrophysical Testing

Sample ID	*Formation*	*Sample Description*
DGR5-583.69	Georgian Bay	Grey fossiliferous limestone -siltstone hard bed
DGR5-612.31	Georgian Bay	Green-grey shale
DGR5-643.19	Georgian Bay	Dark grey shale
DGR5-678.52	Blue Mountain	Dark grey-green shale
DGR5-695.00	Blue Mountain	Dark grey shale
DGR5-697.54	Blue Mountain	Dark grey shale
DGR5-705.36	Collingwood Member - Cobourg	Calcareous grey-black shale
DGR5-712.74	Lower Member - Cobourg	Brownish -grey argillaceous limestone
DGR5-725.12	Lower Member - Cobourg	Brownish -grey argillaceous limestone
DGR5-757.54	Sherman Fall	Grey fossiliferous limestone with shale

Table 2 Summary of DGR-6 Core Samples Submitted for Petrophysical Testing

Sample ID	*Formation*	*Sample Description*
DGR6-647.39	Queenston	Grey shale
DGR6-664.58	Georgian Bay	Green-grey shale
DGR6-699.62	Georgian Bay	Dark grey shale
DGR6-717.68	Blue Mountain	Dark grey shale
DGR6-736.57	Blue Mountain	Dark grey shale
DGR6-750.55	Lower Member - Cobourg	Brownish -grey argillaceous limestone
DGR6-762.01	Lower Member - Cobourg	Brownish -grey argillaceous limestone
DGR6-768.31	Lower Member - Cobourg	Brownish -grey argillaceous limestone
DGR6-797.31	Sherman Fall	Grey fossiliferous limestone with abundant shale

3 Laboratory Test Procedures

Core plug sub-samples (5.1 x 3.8 cm) were drilled along the axis of the DGR core samples using humidified nitrogen as the bit lubricant. After being drilled and shaped into right cylinders, samples were analysed for "as received" petrophysical properties, i.e., bulk density, nuclear magnetic resonance (NMR) liquid and He gas saturation measurements, all at room temperature and pressure. NMR analysis of core plugs was undertaken to measure the total liquid – oil + brine – saturation, i.e., $S_W + S_O$, after which the gas saturation, S_G, was estimated on the same core plug by Boyle's Law gas expansion using He gas.

Dean Stark analysis was then completed. Dean Stark analysis is a distillation method used to directly determine the water content of a sample and also to indirectly determine its oil and gas contents, expressed as 'saturations', i.e. percentage of pore volume occupied by a particular fluid. Toluene was used as the solvent, and the distilled water removed from the sample was condensed into a calibrated trap where the volume was directly measured. Core plug weights were measured at each step of the process. Following water extraction, toluene was used as a reflux solvent to remove oil and the sample re-weighed. Any salts remaining in the sample from evaporation during distillation were extracted by refluxing methanol. The sample was then dried (now "clean and dry" or "convection dry") and the pore volume was measured by the Boyle's Law gas expansion method to yield the total or physical porosity. The grain density was also measured as a consequence of this test.

The sequence of petrophysical tests completed by Core Laboratories for each DGR-5 and DGR-6 core sample is summarized below.

3.1 Basic Analysis – As Received

1. Samples were drilled from the whole core with humidified nitrogen and trimmed as necessary to shape them into right cylinders.

2. Wet bulk density was measured on each sample.

3. Direct pore volume was determined using Boyle's law of gas expansion with He.

4. Nuclear Magnetic Resonance (NMR) liquid saturation was determined using NMR T_2 - measurements.

5. Porosity was calculated for each sample as liquid volumes plus He volume divided by bulk volume.

3.2 Dean Stark Analysis

1. Following 'as received" measurements, extraction of residual fluids was done using a Dean Stark apparatus. Toluene was used to extract residual hydrocarbons.

2. The distilled water removed from the sample was condensed into a calibrated trap where the volume was read directly. The oil removed from the sample remained in solution in the solvent.

3. Following toluene reflux, any salts remaining in the sample were extracted by refluxing methanol. Silver nitrate solution was used to confirm that all salts had been removed from the core sample.

4. After Dean-Stark core analysis the samples were dried to a stable dry weight (± 0.001g) in a vacuum oven at a temperature of 105ºC, and then were cooled to room temperature in a moisture-free environment.

5. After the sample was dried the pore volume was measured. The oil content was calculated by the difference of the weight of water recovered from the total weight loss after extraction and drying. The water and oil volumes are reported as a percentage of the sample pore volume. In the calculations, the salinity of the porewater was assumed to be 250 g/kg brine and the specific gravity of oil was assumed to be 0.83.

6. Clean and dry samples were then submitted for further basic property testing.

3.3 Basic Analysis – Clean and Dry

1. Grain volume was determined for each sample by placing it into a stainless steel matrix cup. It was injected with He from reference cells of known volume and pressure using the Core Lab Autoporosimeter. Grain volume (g/cm^3) was calculated using Boyle's law of gas expansion. Grain density was calculated by dividing sample dry weight by grain volume.

2. A direct pore volume was determined using Boyle's law of gas expansion with He.

3. Porosity was calculated for each sample as the pore volume fraction of the summation (grain volume + pore volume) bulk volume.

4 Results of Laboratory Testing

Ten DGR-5 and nine DGR-6 cores were tested for a uniform suite of petrophysical properties. Tables 3 and 4 summarize the results of the petrophysical testing of DGR-5 and DGR-6 cores, respectively. Tables 3 and 4 show sample identification, and "as received" and "convection dried" petrophysical properties. "As received" properties include liquid saturation (as % pore volume (PV)) total porosity at ambient or unstressed conditions (%), total, liquid (NMR) and He gas pore volumes (cm^3), wet bulk density (g/cm^3) and Dean Stark oil and water saturations (% pore volume). "Convection dried" properties include dry weight (g), grain volume (cm^3), grain density (g/cm^3) and total porosity (%) at ambient or unstressed conditions.

Summary statistics (arithmetic average and standard deviation of the petrophysical data given in Tables 3 and 4 are summarized in Table 5. Included in the calculated statistics for the Ordovician shales is the limestone-siltstone hard bed of the Georgian Bay Formation (sample DGR5-583.69). Included in the calculated statistics for the Ordovician limestones is the shale-rich core of the Sherman Fall Formation (sample DGR6-797.31).

4.1 Wet Bulk Densities and Grain Densities

Calculated "as received" wet bulk densities and calculated grain densities for 19 DGR-5 and DGR-6 core samples are listed in Tables 6 and 7. Calculated wet bulk densities range from 2.610 to 2.707 g/cm^3 with higher values reported for the lower porosity Ordovician limestones compared to the higher porosity Ordovician shales. The average wet bulk density of the DGR-5 and DGR-6 Ordovician shales and Ordovician limestones is 2.64 and 2.68 g/cm^3, respectively. These average results are comparable to average wet bulk densities determined from testing of DGR-1 to DGR-4 cores, which show average values of 2.65 and 2.68 g/cm^3 for Ordovician shales and limestones (Intera Engineering Ltd., 2011).

Calculated grain densities range from 2.664 to 2.812 g/cm^3 with higher values reported for the iron mineral-rich Queenston and Georgian Bay Formations and lower values reported for the calcite-rich limestones and calcareous shales (e.g., Collingwood Member). The average grain density of the DGR-5 and DGR-6 Ordovician shales and Ordovician limestones is 2.75 and 2.71 g.cm^3, respectively. These average results are comparable to average wet bulk densities determined from testing of DGR-1 to DGR-4 cores, which show average values of 2.76 and 2.72 g/cm^3 for Ordovician shales and limestones (Intera Engineering Ltd., 2011).

Table 3 Summary of As-Received and Convection-Dry Petrophysical Rock Properties, DGR-5

	As Received-Summation Technique								*Convection Dried*			
Sample ID	***Liquid Saturation (% PV)***	***Total (ambient) Porosity (%)***	***Pore Volume, cm³***			***Wet Bulk Density (g/cm³)***	***Dean Stark Saturation***		***Dry Weight (g)***	***Grain Volume (cm³)***	***Grain Density (g/cm³)***	***Ambient Porosity (%)***
			Total	***NMR (liquid)***	***He (gas)***		***Oil***	***Water***				
							(% Pore Volume)					
DGR5-583.69	78.3	2.2	1.269	0.994	0.275	2.707	6.2	91.3	156.790	57.631	2.721	1.4
DGR5-612.31	92.6	10.9	1.740	1.611	0.129	2.638	4.7	82.2	40.595	14.514	2.797	10.9
DGR5-643.19	96.4	10.2	2.596	2.502	0.094	2.634	3.7	82.8	64.371	23.109	2.786	9.0
DGR5-678.52	98.1	11.2	1.471	1.444	0.028	2.657	0.8	86.6	33.761	12.037	2.805	9.3
DGR5-695.00	94.9	9.9	1.810	1.718	0.092	2.616	6.1	74.5	46.759	17.005	2.750	8.0
DGR5-697.54	96.8	8.4	3.300	3.195	0.105	2.651	7.1	76.9	101.267	36.395	2.782	7.6
DGR5-705.36	83.6	3.3	1.590	1.329	0.261	2.652	10.5	77.4	126.990	47.661	2.664	1.8
DGR5-712.74	92.6	3.8	2.448	2.267	0.181	2.677	1.0	87.7	169.531	62.665	2.705	2.0
DGR5-725.12	96.1	4.5	2.949	2.833	0.116	2.671	1.3	83.5	173.329	63.919	2.712	3.6
DGR5-757.54	96.3	3.5	1.877	1.808	0.069	2.677	2.4	76.9	142.451	52.466	2.715	2.3

Note: Dean Stark data calculated with brine density of 250 g/kg (i.e., volume of brine/volume of water = 1.121) and oil density of 0.830 g/mL.

Table 4 Summary of As-Received and Convection-Dry Petrophysical Rock Properties, DGR-6

Sample ID	*As Received-Summation Technique*								*Convection Dried*			
	Liquid Saturation (% PV)	*Total (ambient) Porosity (%)*	*Pore Volume, cm^3*			*Wet Bulk Density (g/cm^3)*	*Dean Stark Saturation (% Pore Volume)*		*Dry Weight (g)*	*Grain Volume (cm^3)*	*Grain Density (g/cm^3)*	*Ambient Porosity (%)*
			Total	*NMR (liquid)*	*He (gas)*		*Oil*	*Water*				
DGR6-647.39	90.6	9.4	3.324	3.010	0.314	2.619	5.5	80.9	89.955	32.628	2.757	7.5
DGR6-664.58	87.3	8.7	3.690	3.220	0.469	2.630	2.5	83.2	108.119	39.015	2.771	7.3
DGR6-699.62	89.8	9.0	1.335	1.199	0.136	2.629	0.2	85.1	37.804	13.677	2.764	6.7
DGR6-717.68	84.9	7.7	1.996	1.695	0.300	2.610	0.8	81.6	65.536	24.054	2.725	5.9
DGR6-736.57	60.9	1.5	0.866	0.528	0.338	2.693	1.8	44.6	154.722	57.096	2.710	0.7
DGR6-750.55	77.9	2.1	1.106	0.862	0.244	2.689	1.1	66.5	141.230	52.453	2.692	0.5
DGR6-762.01	85.2	2.5	1.523	1.297	0.226	2.677	0.9	82.4	159.274	59.449	2.679	0.4
DGR6-768.31	83.4	1.7	1.023	0.853	0.170	2.701	7.1	77.6	157.664	58.115	2.713	0.5
DGR6-797.31	95.1	8.0	3.391	3.225	0.166	2.641	6.5	80.8	108.786	39.344	2.765	7.0

Note: Dean Stark data calculated with brine density of 250 g/kg (i.e., volume of brine/volume of water = 1.121) and oil density of 0.830 g/mL.

Table 5 Statistical Summary of Petrophysical Properties of DGR-5 and DGR-6 Cores by Ordovician Formations

Petrophysical Property	***All Ordovician Formations***		***Ordovician Shales***		***Ordovician Limestones***	
	Mean	***Std. Dev.***	***Mean***	***Std. Dev.***	***Mean***	***Std. Dev.***
Wet Bulk Density (g/cm^3)	2.66	0.03	2.64	0.03	2.68	0.02
Grain Density (g/cm^3)	2.74	0.04	2.75	0.04	2.71	0.03
Total Porosity - Convection Dry (%)	4.86	3.54	6.34	3.30	2.33	2.38
Total Porosity - NMR/He (%)	6.24	3.53	7.70	3.41	3.72	2.13
Liquid Saturation-Dean Stark (% PV)	82.8	10.4	83.1	12.3	82.2	7.1
Oil Saturation-Dean Stark (%PV)	3.7	2.9	6.3	3.3	2.3	2.4
Gas Saturation-Dean Stark (%PV)	16.8	10.5	17.1	12.2	16.3	7.4
Liquid Saturation-NMR/He (%PV)	88.5	9.2	87.9	10.5	89.5	7.3
Gas Saturation-NMR/He (%PV)	11.5	9.2	12.1	10.4	10.5	7.3

4.2 Total Porosities

Calculated total porosities determined from NMR/He gas testing on “as received” core and from He gas testing on “convection dried” core obtained from DGR-5 and DGR-6 are presented in Tables 6 and 7. All porosity determinations were made at ambient (i.e., non-confined) pressures. In previous total porosity testing of “convection dried” cores collected from DGR-2, DGR-3 and DGR-4, total porosity was measured with core samples brought to a depth-specific hydrostatic confining stress. Because the primary purpose of petrophysical testing described in this Technical Report was the quantitative comparison of porosities and residual fluid saturations by NMR/He gas testing and Dean Stark/He gas testing, and NMR testing can only be completed at unconfined pressures, all porosity and fluid saturation testing was completed at unconfined pressures.

As shown in Table 5, average total porosity determined from NMR/He gas testing is typically larger than average total porosity determined by Dean Stark/He gas testing by up to 1.3% to 1.4% total porosity. The average total porosities for Ordovician shales by NMR/He gas testing and by Dean Stark/He gas testing are 7.70% and 6.34%, respectively. The average total porosities for Ordovician limestones by NMR/He gas testing and by Dean Stark/He gas testing are 3.72% and 2.33%, respectively.

Figure 1 shows a cross plot of total porosity determined by these two analytical methods. As evident from Figure 1 there is increased total porosity determined by NMR/He gas testing over that determined by Dean Stark/He gas testing on the same sub-cores. This consistent relative overestimation of total porosity by NMR/He gas techniques compared to Dean Stark/He gas results suggests an experimental bias in one or both of these testing methods. Previous comparisons of liquid porosity by NMR and Dean Stark methods has shown comparable results (Kantzas et al., 2005) without the bias shown in Figure 1.

Given that total porosity measured by He gas equilibration following Dean Stark extractions is a direct method, it is difficult to believe that such methods would result in underestimation of total porosity. Consequently, it is most likely that the difference in total porosity between these two test methods is due to overestimation of total porosity by NMR/He gas methods. In particular the overestimation must be primarily due to overestimation of liquid volume by NMR techniques because the measured gas volumes are relatively small and these are measured directly by He gas expansion methods.

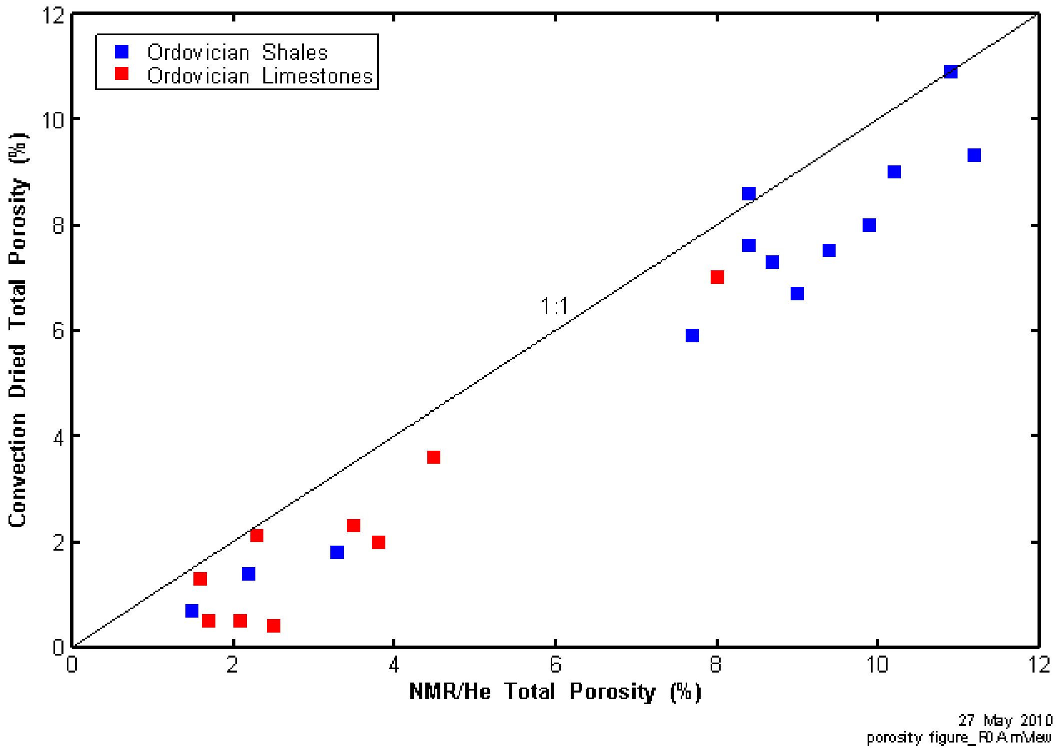

Figure 1 Cross Plot of Total Porosities Determined by NMR/He Gas Testing and Dean Stark/He Gas Testing of DGR-5 and DGR-6 Cores

Possible explanations for the overestimation of liquid volume by NMR methods include contributions of absorbed water and structural hydroxyl groups in clay minerals to the NMR response used to calculate in-core liquid volumes (Kitigawa, 1972), and/or inappropriate use of simplifications necessary to quantify liquid volumes from measured NMR relaxation amplitudes following exposure to low frequency magnetic fields.

4.3 Fluid Saturations

Calculated residual fluid saturations determined from NMR/He gas testing on “as received” core and from Dean Stark/He gas testing on “convection dried” core obtained from DGR-5 and DGR-6 are presented in Tables 6 and 7. For Dean Stark analyses the gas saturations are determined as1.0 minus the sum of oil and water saturations, and the calculations are performed assuming the brine is a 250g/kg solution and oil has density of 0.83 g/cm^3. Different assumptions concerning brine concentration and oil density will result in different Dean Stark estimates of water, oil and gas saturations.

NMR/He gas testing quantifies volumes of liquid (oil and water/brine) and gas in core based on two independent testing methods and then sums these volumes to determine total porosity. Liquid and gas saturations are then determined by the ratio of liquid and gas volumes to total volume. Fluid saturations are therefore expressed as a percentage of the pore volume. Liquid saturation includes both the oil saturation (S_O) and the water/brine saturation (S_W). Liquid saturations ($S_O + S_W$) and gas saturations (S_G), by definition equal 1.0 when summed.

Calculated NMR liquid saturations range from 60.9 to 98.1% with no clear pattern evident for Ordovician shales or limestones. The average NMR liquid saturations of the DGR-5 and DGR-6 Ordovician shales and Ordovician limestones is 87.9% and 89.5%, respectively. Calculated NMR/He gas saturations range from 1.9 to 39.1%, again with no clear pattern evident for Ordovician shales or limestones. The average NMR/He gas saturations of the DGR-5 and DGR-6 Ordovician shales and Ordovician limestones are12.1% and 10.5%, respectively.

Calculated Dean Stark liquid saturations range from 46.4 to 92.8% with no clear pattern evident for Ordovician shales or limestones. The average Dean Stark liquid saturation of the DGR-5 and DGR-6 Ordovician shales and Ordovician limestones is 83.1% and 82.2%, respectively. Calculated Dean Stark gas saturations range from 2.5% to 53.6%, again with no clear pattern evident for Ordovician shales or limestones. The average Dean Stark gas saturations of the DGR-5 and DGR-6 Ordovician shales and Ordovician limestones are 17.1% and 16.3%, respectively. Oil saturations were also reported from Dean Stark analyses at values of 0.2 to 10.5%. Ordovician shales show higher oil saturations with average values of 4.2% compared with Ordovician limestones with average values of 2.9%. The highest oil saturation of 10.5% was measured on a sample of Collingwood Member shale. The highest reported gas saturation occurred in a sample of Bleu Mountain Formation shale with values of 39.1% and 53.6% determined by NMR/He gas and Dean Stark/He gas testing, respectively.

Figure 2 shows a comparison of liquid (S_w + S_O) and gas saturations (S_G) determined from NMR/He gas testing and Dean Stark/He gas testing on identical sub-cores. Figure 2 shows that there is moderate comparability between liquid and gas saturations measured by both methods with most results falling within +/- 10% saturation of the 1:1 line of perfect correlation. There is also a clear overestimation of liquid saturation by NMR/He gas testing and clear underestimation of gas saturation by NMR/He gas testing compared to Dean Stark/He gas results. These biases in fluid saturation by NMR/He gas methods appear to due to the overestimation of liquid pore volume by NMR methods. Such overestimation of liquid pore volume also results in underestimation of gas saturations because the total pore volume is proportionally increased by the increase in liquid pore volume resulting in lower calculated gas saturations for a fixed gas pore volume.

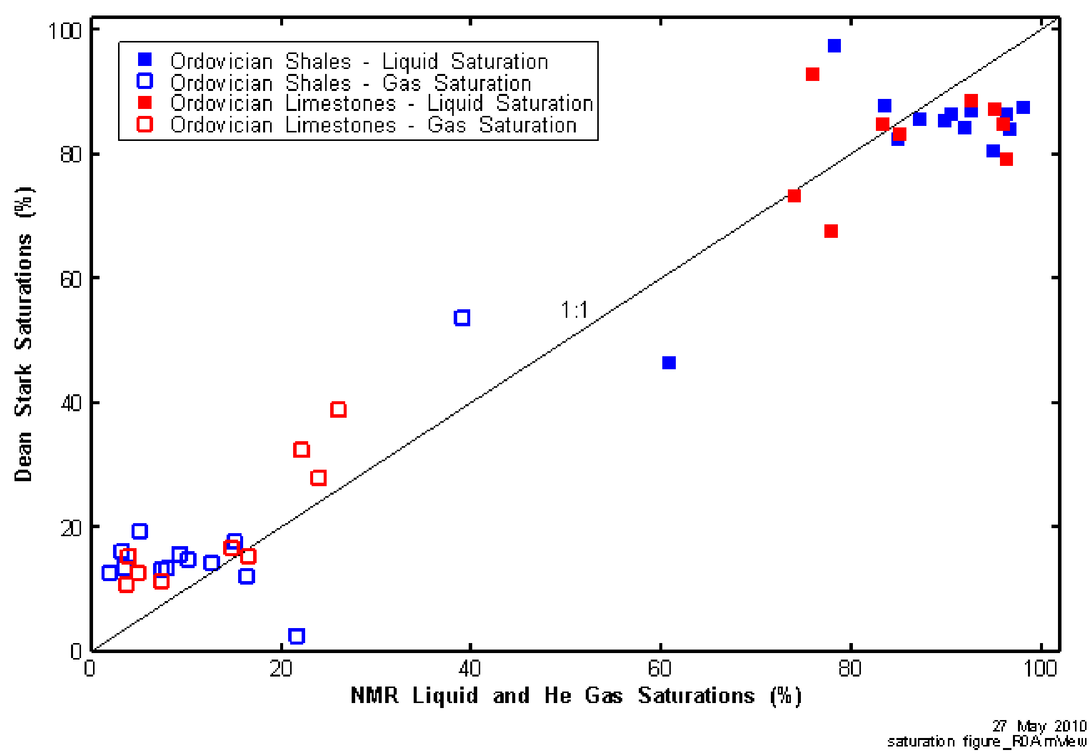

Figure 2 **Cross Plot of Liquid and Gas Saturations Determined by NMR/He Gas Testing and Dean Stark/He Gas Testing of DGR-5 and DGR-6 Cores**

5 Data Quality and Use

The reader is cautioned that the cores received at Core Labs will have undergone stress relaxation and thus certain petrophysical parameters will have changed relative to their in-situ values. This is especially important for data reported in this Technical Report as testing objectives precluded re-application of a depth-specific hydrostatic confining stress to approximate in-situ conditions and overcome core relaxation effects. This lack of confining stress will most notably affect estimates of total porosity and gas saturations resulting in overestimation of these petrophysical properties. The amount of overestimation due to core relaxation is difficult to quantify but based on total porosity testing on confined and unconfined cores (Intera Engineering Ltd., 2011), the overestimation of total porosity may be by up to 10 to 20% of reported values. The overestimation of gas saturations may be upwards of 100% meaning that actual confined gas saturations may be half of those reported in this Technical Report.

The number of DGR-5 and DGR-6 core samples with reported oil saturations (19 of 19 samples tested) is relatively large compared with results for testing of DGR-2, DGR-3 and DGR-4, which showed no oil saturations. The reasons for this discrepancy in testing results is not immediately known, but is explored further in TR-08-34 (Geofirma Engineering Ltd, 2011).

Dean Stark fluid saturations were also estimated on the basis of an assumed pore-water salinity of 250 g/kg brine. While this is a reasonable initial approximation based on available DGR pore water testing, a more accurate approach is to complete the Dean Stark calculations based on average formation salinity determined from review of all porewater and groundwater chemical testing. This more accurate approximation and others for determining fluid saturations are also considered further in TR-08-34 (Geofirma Engineering Ltd., 2011).

6 Conclusions

Petrophysical testing of 19 DGR-5 and DGR-6 cores was undertaken for comparative assessment of total porosity and fluid (oil, brine, gas) saturations by NMR/He gas testing and Dean Stark/He gas testing. In addition, basic properties of wet bulk density and grain density were determined.

The results of the testing show that there is overestimation of total porosity by NMR/He gas testing relative to Dean Stark/He gas testing by up to 1.3% to 1.4% total porosity, and that there is moderate comparability of liquid and gas saturations measured by both methods with most results falling within +/- 10% of the 1:1 line of perfect correlation. Basic rock property data of wet bulk density and grain density from DGR-5 and DGR-6 cores are very similar to those previously measured on DGR-1 to DGR-4 cores by different laboratories.

Petrophysical results reported here will be further analysed and assessed in TR-08-34 (Geofirma Engineering Ltd., 2011) and in the Descriptive Geosphere Site Model report (Intera Engineering Ltd., 2011).

7 References

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