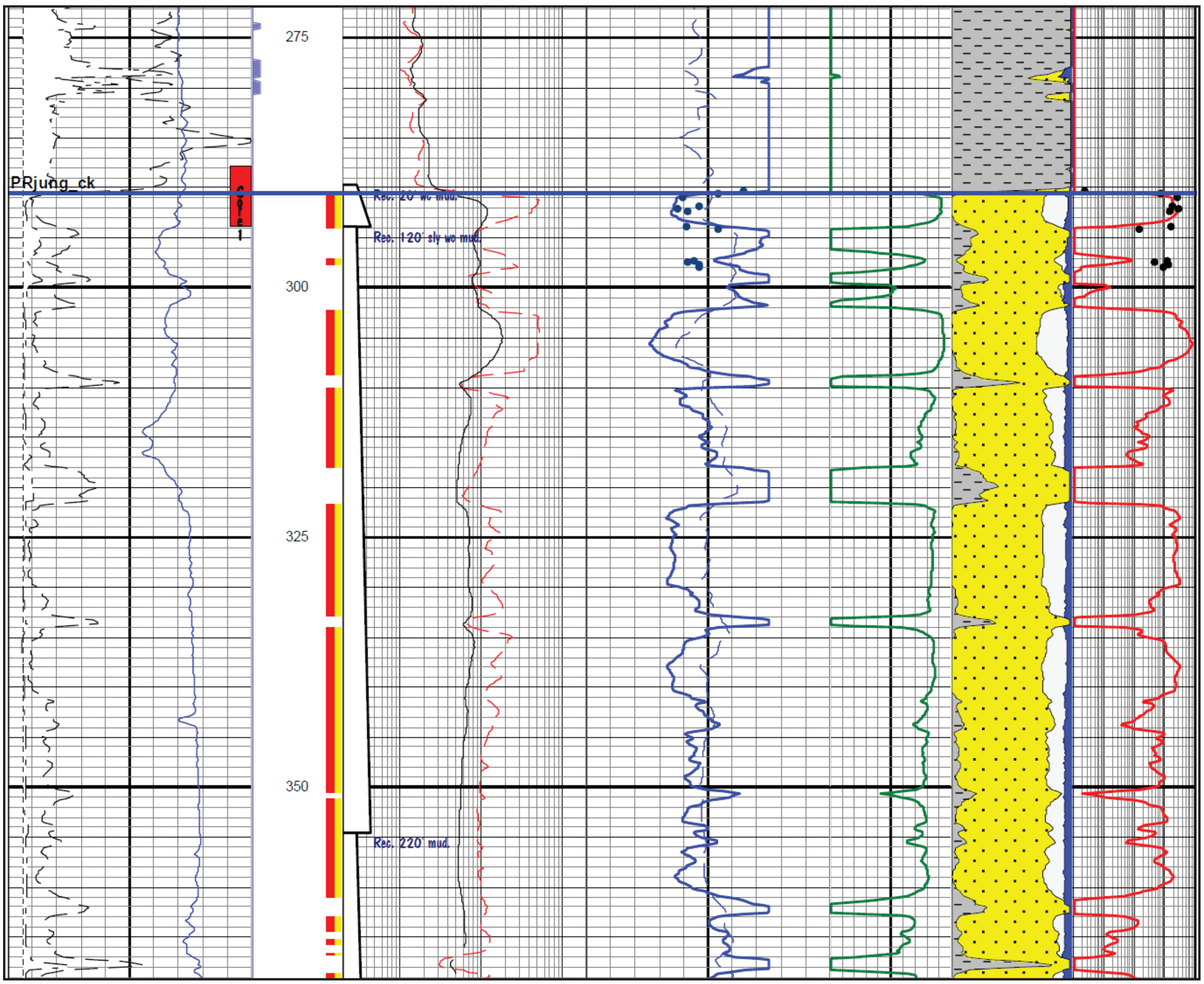
YGS Open File 2015-22

Conventional reservoir petrophysical property assessment for 34 wells, Eagle Plain, Yukon (65°45′ to 67°30′ N; 135°50′ to 138°45′ W)

Petrel Robertson Consulting Ltd. and T.A. Fraser



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Cover photo. Well log and petrophysical interpretation from the top of the Birch Y.T. B-34 well (300B346610136450), drilled in 1965.

EXECUTIVE SUMMARY

In late 2010, Petrel Robertson Consulting Ltd. was contracted by the Yukon Geological Survey through the Geological Survey of Canada (Natural Resources Canada) to undertake a quantitative petrophysical assessment of the petroleum exploration wells drilled in the Eagle Plain Basin of Yukon. The study was initiated to enhance the research of the Yukon Basins Project, a collaborative research effort among the Geological Survey of Canada, the Yukon Geological Survey and university partners, and funded by the Geo-Mapping for Energy and Minerals (GEM) 2008-2013 initiative. The purpose of the assessment was to highlight prospective conventional hydrocarbon accumulations, and generate input for use in future resource assessments.

The data necessary to undertake the assessment were provided by the Yukon Geological Survey, Geological Survey of Canada and public data repositories. Thirty-one of the 34 wells drilled in the Eagle Plain Basin were deemed to have sufficient data to perform a meaningful analysis, and were subsequently interpreted with a consistent methodology and set of input parameters. Average values of shale volume, porosity, permeability and water saturation were generated.

More than 60 000 m of strata were analyzed in the study. Based on three sets of cutoff criteria, reservoir and pay intervals were identified. The results identify hydrocarbons in 19 stratigraphic intervals, in 29 of the 31 wells analyzed. The best conventional hydrocarbon potential, assessed by net pay thickness, proportion of total net pay, proportion of net pay to formation/member thickness, and proportion of reservoir rock filled with net pay, was identified in the Carboniferous stable platform tectonostratigraphic succession followed in order by a Lower Paleozoic platform carbonate horizon and Permian sedimentary rocks of the Ancestral Aklavik Arch. Less prospective are the Jurassic-Cretaceous Cordilleran and Devonian-Carboniferous Ellesmerian orogenic successions. Studies of the conventional hydrocarbon potential of the Carboniferous Hart River Formation (including its Canoe River, Alder and Chance Sandstone members) and Ettrain Formation, Devonian Ogilvie Dolomite member of the Ogilvie Formation and the Permian Jungle Creek Formation are to be prioritized.

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INTRODUCTION

In 2010, the Yukon Geological Survey (YGS) through the Geological Survey of Canada (GSC; a department of Natural Resources Canada) contracted Petrel Robertson Consulting Ltd. (PRCL) to undertake a conventional reservoir petrophysical assessment of wireline geophysical logs from 34 oil and gas exploration wells in the Eagle Plain region of the northern Yukon Territory. Of these 34 wells, drilled between 1957 and 2005, 31 were deemed to have sufficient well log data to conduct a meaningful conventional petrophysical assessment. Using three sets of cutoff variables of porosity, permeability, shale volume and water saturation, conventional reservoir and hydrocarbon pay intervals were identified from 66 575 m of measured strata. The data derived from this assessment are intended to highlight the petroleum prospectivity of the Eagle Plain basin, and to conduct future resource assessments.

EAGLE PLAIN BASIN

Study area and exploration history

The Eagle Plain exploration region is situated in north central Yukon between latitudes 65 and 67.5°N, longitudes 136 and 140°W (Fig. 1). The region covers an area of approximately 20 800 km^2, and is flanked by the Richardson Mountains to the east, the Ogilvie Mountains to the south and west, and by the Dave Lord Range to the north (Fig. 2). Many indications of an active petroleum system are present in Eagle Plain, including proven source rocks, surface seeps, bitumen staining and positive flow and drill-stem test results from previously drilled hydrocarbon exploration wells (Osadetz *et al.*, 2005; National Energy Board, 2000; Morrell, 1995; Hamblin, 1990). The entire Cretaceous through Lower Paleozoic section is deemed to be prospective, and includes successful penetrations of both gas and oil reservoirs (Osadetz *et al.*, 2005). Petroleum fields were discovered in the Chance Y.T. No. 1 M-08 (*aka* L-08), Blackie No. 1 Y.T. M-59 and Birch Y.T. B-34 wells (a detailed discovery summary is offered in Osadetz *et al.*, 2005 and Hannigan, 2014).

The 34 wells assessed as part of this study are listed in Table 1. Figure 2 shows the distribution of the wells in the Eagle Plain basin. Note that the map shows four wells (yellow dots, and yellow labels) drilled in 2012 or 2013 which were not assessed for this study.

Sedimentary setting

Eagle Plain basin is in the northern Canadian Cordillera and is a northern extension of the Mesozoic Western Canadian Sedimentary Basin (Mossop *et al.*, 2004). Its surface geology is defined by a central area of flat-lying Cretaceous strata, rimmed by uplifts of folded and faulted Paleozoic and Precambrian bedrock (Norris 1981a,b,c, 1982a,b). In the subsurface, Phanerozoic sedimentary rocks range up to 5800 m in thickness, and lie unconformably on mid-Proterozoic successions that form the basin's economic basement (Osadetz *et al.*, 2005).

Eagle Plain basin lies within the Yukon Stable Block or Yukon Block, a stratigraphically, structurally and geophysically distinctive part of northwestern Laurentia (ancestral North American craton; Lenz, 1972; Norris, 1985; Fritz, 1997; Lane, 2007, 2010; Nelson *et al.*, 2013). Cambrian strata are preserved in southeastern Eagle Plain and include the Illtyd, Slats Creek and Taiga formations, which consist of silt and carbonate, sandstone, and bright orange-weathering dolomite and grey limestone, respectively. Throughout the late Cambrian to Middle Devonian, the Yukon Stable Block was in part characterized by shallow water carbonate deposition (Lenz, 1972) that transitioned into, or was drowned by deepwater facies of the Richardson trough and Selwyn basin, to the present day east and south respectively (Morrow and Geldsetzer, 1988). Carbonate platform successions include the Cambrian-Ordovician

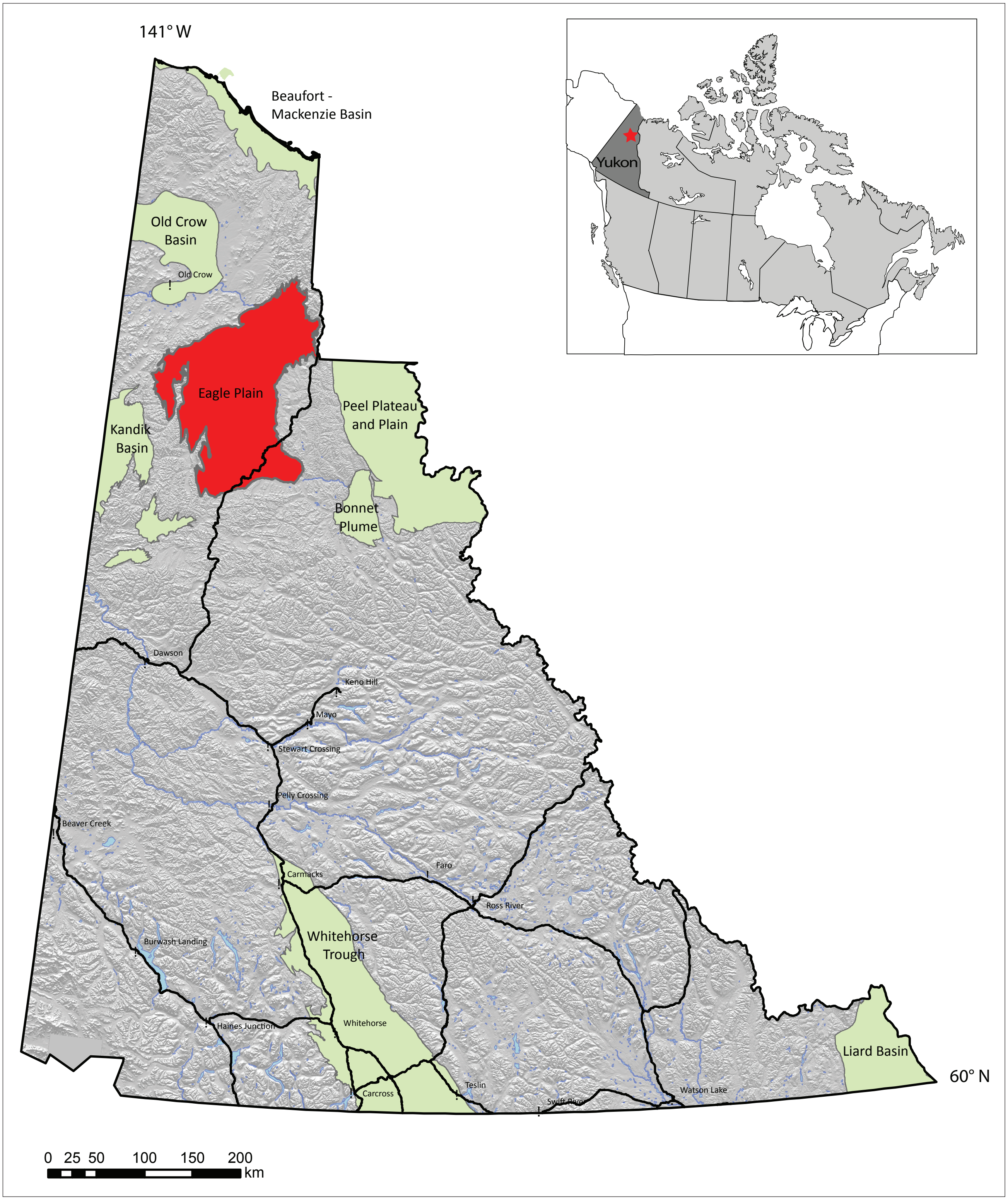


Figure 1. *Map of Yukon highlighting its hydrocarbon exploration regions. Eagle Plain is located in north Yukon and highlighted in red. All other exploration regions are in green. Inset map shows the location of Yukon within Canada and the Eagle Plain region identified by a red star.*

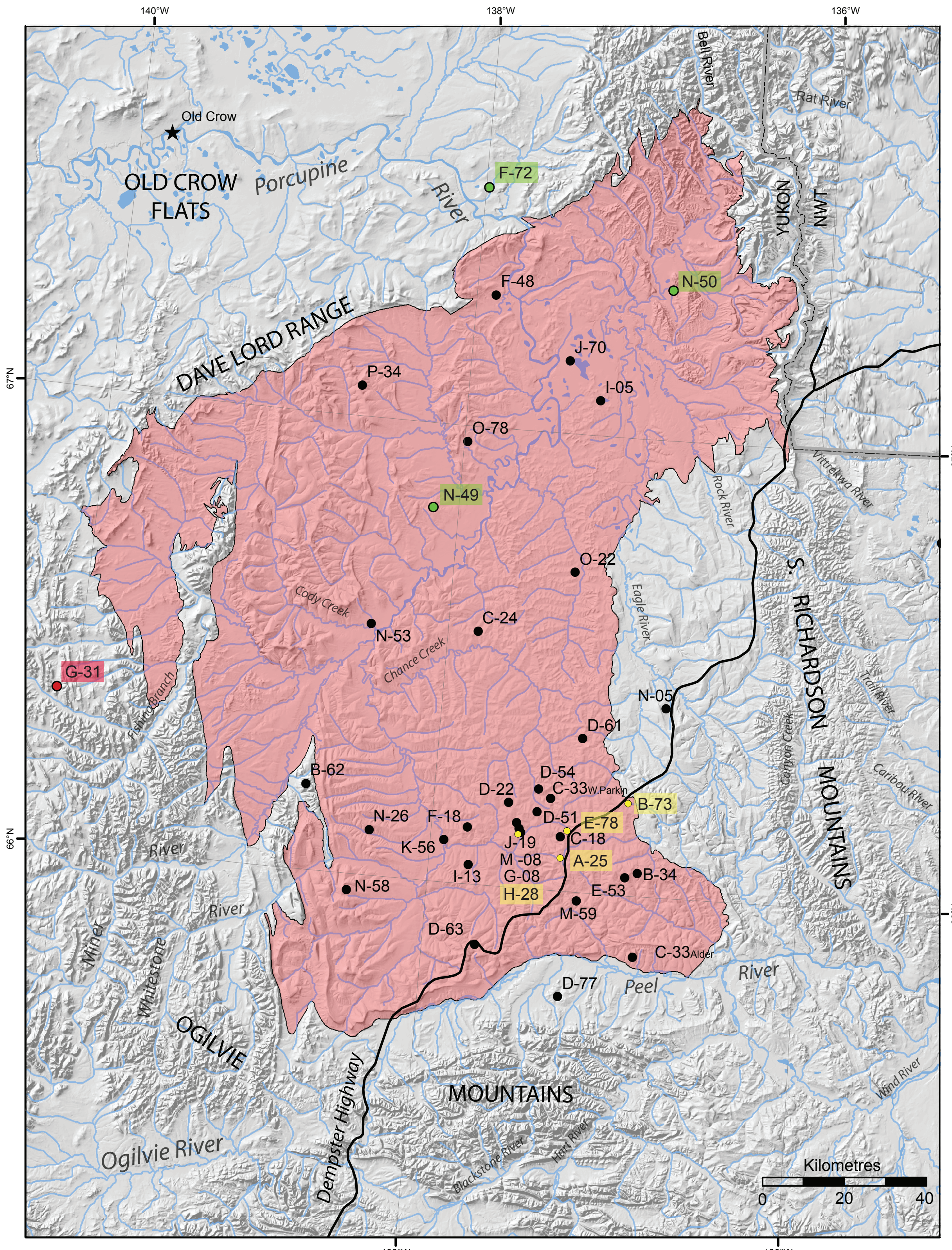


Figure 2. *Map of Eagle Plain basin with oil and gas well locations. Black dots represent wells that were analyzed as part of this study. Green dots represent wells with insufficient well log data to analyze. The red dot in the west represents a well that was outside the scope of this assessment. Wells, indicated by yellow, in east were drilled in 2012 and 2013, postdating this study.*

Table 1. *List of wells in Eagle Plain that were analyzed for this study. Wells with insufficient data are shaded grey. UWI is the unique well identifier. KB is the elevation of the Kelly Bushing in metres. TD is the total measured depth of the well in metres. Fm@TD is the lithological formation that was encountered at the bottom of the well.*

No.	UWI	Well Long Name	Well Short Name	Latitude	Longitude	KB (m)	TD (m)	Fm@TD
1	300C336620137150	W. Parkin Y.T. C-33	C-33 [W. Parkin]	66.201111	-137.365556	520.0	1257.7	Hart River
2	300D616630137000	N. Parkin Y.T. D-61	D-61	66.336667	-137.216944	489.2	3352.8	Ogilvie
3	300E536610136450	Birch Y.T. E-53	E-53	66.039167	-136.934722	621.5	684.3	Blackie
4	300F186610137450	E. Porcupine Y.T. F-18	F-18	66.123611	-137.804444	523.0	2050.7	Hart River
5	300F486720137450	Ridge Y.T. F-48	F-48	67.289722	-137.893056	321.3	1868.7	Imperial
6	300I056710137150	Whitefish Y.T. I-05	I-05	67.076944	-137.256944	348.1	1498.4	Tuttle
7	300I136610137450	E. Porcupine Y.T. I-13	I-13	66.043056	-137.782778	507.5	2439.3	Chance Sandstone
8	300O226650137150	Shaeffer Creek Y.T. O-22	O-22	66.698333	-137.327778	352.0	3161.7	Ogilvie
9	300O786700137452	E. Pine Creek O-78	O-78	66.964722	-137.982700	389.2	947.7	Imperial
10	300B346610136451	Birch Y.T. B-34	B-34	66.050872	-136.854864	667.5	1649.9	Ford Lake Shale
11	300D776550137000	Blackstone Y.T. D-77	D-77	65.769658	-137.248550	645.0	4028.5	Bouvette
12	300G086610137303	Chance Y.T. G-08	G-08	66.121694	-137.513889	524.3	1579.8	Chance Sandstone
13	300J196610137301	Chance Y.T. J-19	J-19	66.142000	-137.541117	518.8	1446.3	Chance Sandstone
14	300J706710137150	Whitefish Y.T. J-70	J-70	67.158889	-137.445556	330.7	2127.5	Porcupine River
15	300M086610137301	Chance Y.T. No. 1 M-08	M-08	66.128333	-137.528333	539.2	2635.9	Ford Lake Shale
16	300M596600137000	Blackie No. 1 Y.T. M-59	M-59	65.981922	-137.186353	562.1	1931.8	Ford Lake Shale
17	300B626620138300	N. Cathedral Y.T. B-62	B-62	66.187083	-138.698056	540.1	2138.5	Bouvette
18	300C186610137150	East Chance Y.T. C-18	C-18	66.119150	-137.299283	535.2	1540.8	Chance Sandstone
19	300C246640137450	Ellen Y.T. C-24	C-24	66.552464	-137.835597	414.5	2174.4	Tuttle
20	300C336600136451	Alder Y.T. C-33	C-33 [Alder]	65.867108	-136.919444	530.0	3714.0	Carboniferous
21	300D226620137300	North Chance Y.T. D-22	D-22	66.185028	-137.592470	536.0	1830.0	Carboniferous
22	300D516620137150	West Parkin Y.T. D-51	D-51	66.169028	-137.434583	475.5	1508.8	Chance Sandstone
23	300D546620137151	West Parkin Y.T. D-54	D-54	66.218750	-137.433589	506.8	1811.0	Ogilvie
24	300D636600137300	South Chance Y.T. D-63	D-63	65.869167	-137.714167	707.4	2020.8	Carboniferous
25	300F726740137450	Porcupine Y.T. F-72	F-72	67.523100	-137.985000	349.3	2251.9	Bouvette
26	300K566610137450	E. Porcupine R. Y.T. K-56	K-56	66.092617	-137.925597	498.0	2286.0	Ford Lake Shale
27	300K586610136450	Devon Eagle Plains Y.T. K-58	K-58	66.126333	-136.924333	604.2	1278.0	Ford Lake Shale
28	300N056630136450	South Tuttle Y.T. N-05	N-05	66.414222	-136.772972	504.7	3513.4	Bouvette
29	300N266610138150	Whitestone Y.T. N-26	N-26	66.099722	-138.333333	696.5	2464.3	Ford Lake Shale
30	300N496650138002	Eagle Plains Y.T. No.1 N-49	N-49	66.815000	-138.141667	447.8	2922.7	Bouvette
31	300N506720136450	Crown Bell River Y.T.-A No.1 N-50	N-50	67.329167	-136.891389	317.6	2439.6	Imperial
32	300N536640138150	North Hope Y.T. N-53	N-53	66.548333	-138.425000	350.5	4280.3	Bouvette
33	300N586600138150	Whitestone Y.T. N-58	N-58	65.963889	-138.425000	889.4	2131.5	Ettrain
34	300P346710138300	Molar Y.T. P-34	P-34	67.066389	-138.600000	803.5	2649.6	Imperial

Bouvette Formation and Devonian Ogilvie Formation, with basinal and transitional facies assigned to the Road River Group and/or Michelle Formation (Fig. 3; Morrow, 1999). In the northwest part of the basin, the Lower Devonian Mount Dewdney Formation unconformably overlies the Bouvette Formation and occurs in outcrops as a distinctive band of yellow/orange silty dolomite (Morrow, 1999).

In the Middle to Upper Devonian, a sea-level rise resulted in the deposition of siliceous shale and chert of the Canol Formation and correlative strata throughout north Yukon, northwestern NWT and east-central Alaska (Fig. 3; Bassett 1961; Norris, 1968; Churkin and Brabb, 1965). These deepwater conditions were interrupted by siliciclastic deposition sourced from the Ellesmerian orogenic event in the Canadian Arctic Islands in the Late Devonian and Early Carboniferous (Pugh, 1983; Lane, 2007). Strata from this event comprise the silty shale and sandstone of the Imperial Formation, sandstone and conglomerate of the Tuttle Formation (in the northeast) and the basinal Ford Lake Shale Formation (Fig. 3).

During Middle to Late Carboniferous time, a stable carbonate platform re-established itself in the region as the Hart River Formation and two of its informal members (Canoe River and Alder) and the Ettrain Formation (Fig. 3). Platformal conditions were interrupted by episodic sand and shale deposition assigned to the Chance Sandstone Member of the Hart River Formation and Blackie Formation, respectively. During the Late Carboniferous and Early Permian, the northeast-trending Ancestral Aklavik Arch (or Eagle Arch) developed in northern Eagle Plain, resulting in a regional sub-Permian unconformity and the erosion of Carboniferous and upper Devonian sedimentary rocks (Richards *et al*., 1997). Permian strata interpreted to be eroded from the Ancestral Aklavik Arch occur locally within the basin as the Jungle Creek Formation (*see* Richards *et al*., 1997, Fig. 8.1). No Triassic rocks are preserved in the region.

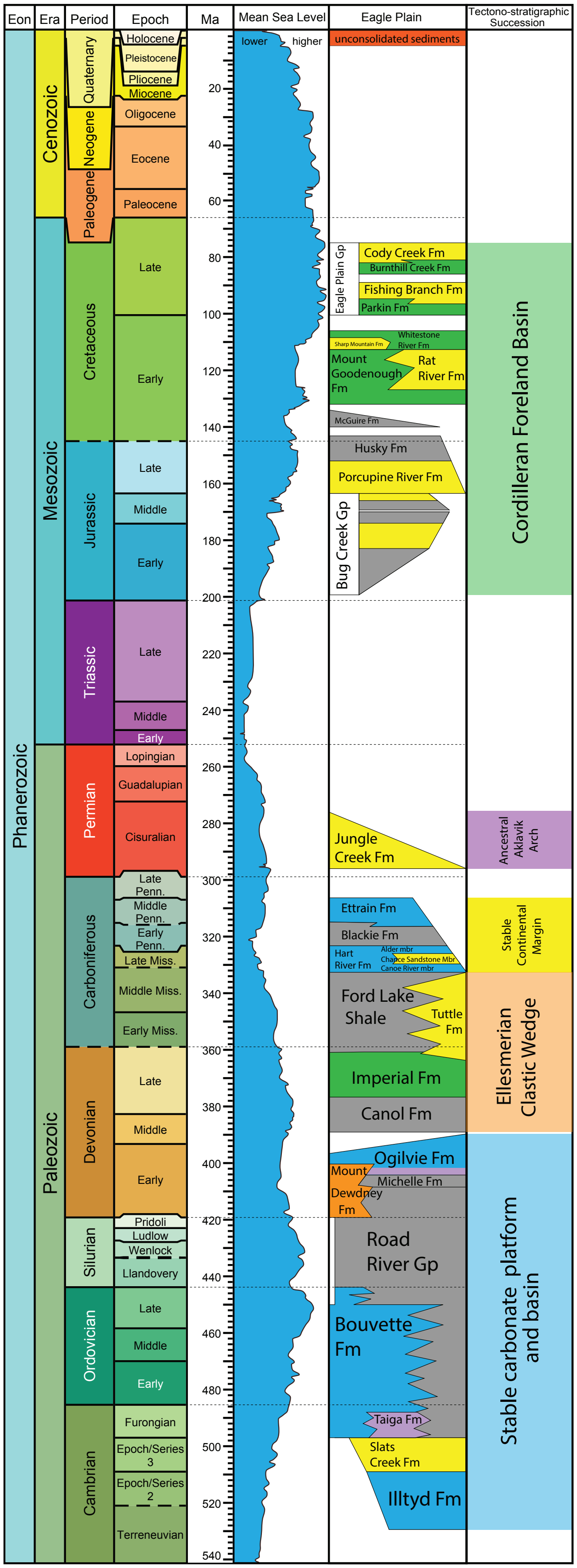
Mesozoic and Cenozoic Cordilleran orogenesis south of, and across the region, and initial rifting of the Canada Basin to the north (Dixon and Dietrich, 1990; Lane, 2010) effected first-order tectonic controls on sedimentation in the north Yukon. From the Jurassic onward, up to 2500 m of siliciclastic sediments were deposited in Eagle Plain as northerly prograding wedges into the Cordilleran foreland basin (Dixon, 1992). The Mesozoic succession includes the Jurassic Bug Creek Group, Porcupine River and Husky formations, Lower Cretaceous Mount Goodenough, Rat River, Sharp Mountain and Whitestone River formations, and the Upper Cretaceous Eagle Plain Group which includes the Parkin, Fishing Branch, Burnthill Creek and Cody Creek formations (Fig. 3). Tertiary folds and thrust faults thickened the Phanerozoic successions.

ASSESSMENT METHODOLOGY

Data quality and availability

Of the 34 wells analyzed in the project area (Table 1), only 31 were deemed to have sufficient log data to perform a meaningful petrophysical evaluation. The wells Porcupine Y.T. F-72, Eagle Plains Y.T. N-49 and Crown Bell River Y.T. N-50 were not analyzed, due to a lack of requisite data. No resistivity logs were run in the F-72 well, and no porosity logs were run in either the N-49 or N-59 wells. As is common in many older wells, the types of logs and intervals over which they were acquired varies. For this reason, not every formation in the remainder of the wells could be analyzed in this study.

Digital log data in *.LAS format was supplied by the Yukon Geological Survey (YGS) and Natural Resources Canada (NRCan). In a small number of instances, missing curves were obtained commercially through data vendors (GeoScout™ or IHS Accumap®). While every effort was made to acquire as complete a set of digital logs as possible, there is a possibility that additional data may exist that PRCL and YGS were unaware of at the time the study was completed.



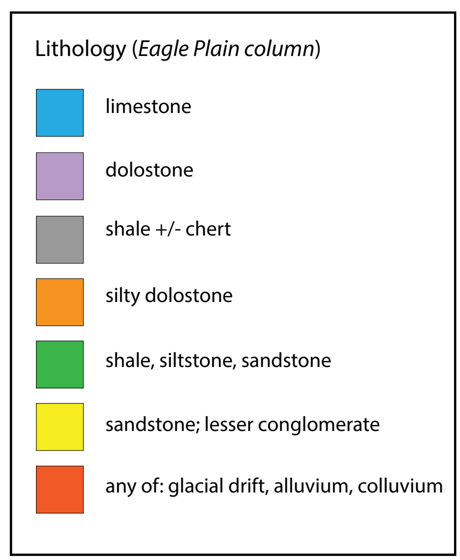


Figure 3. *Generalized Phanerozoic stratigraphy for Eagle Plain basin (modified from Pigage, 2009). The mean sea level curve is from Haq and Schutter (2008). The tectonostratigraphic setting is distilled from Pugh (1983), Norris (1997), Morrow (1999) and Nelson et al. (2013).*

Ancillary data such as routine core analyses, drill-stem test results and perforation intervals were obtained through GeoScout™. Raster images of well log headers, containing relevant borehole environmental data, were also obtained through MJ Systems (accessed via Geoscout™).

A list of the wells, with available core analysis data, is presented in Table 2. These data have been used in this study in the form it in which it was exported from GeoScout™. No further quality control was performed.

Drill-stem test (DST) results were used qualitatively to verify the assignment of "pay" zones, and a summary of tested intervals by well is presented in Appendix A. DST results are not included, but have been annotated on the individual, interpreted log plots.

Overall, the quality of the available log data can be considered fair. Due to the vintage of the wells and prevailing borehole conditions at the time of logging, a meaningful number of project log curves contain some spurious data values. Remediation, as appropriate, has been attempted, however there has been no manual editing of log curve data.

A "badhole flag" (FBH) has been included, to indicate where recorded data may be suspect, and by extension the interpreted curves calculated using this data as input. For various reasons, this curve may not be definitive; it is possible some data in intervals flagged as badhole may be, at least partially, valid. Conversely, in some instances it was not possible to generate a badhole flag because the required curves were not available. Interpreted curves should be used in the context of a qualitative assessment of the validity of the raw data from which it was calculated.

Further, logs do not provide direct measurements of the physical properties they are used to calculate. For this reason, their signatures are sometimes ambiguous; this is especially so with older logs. Some notable examples in this study were observed in the F-48 (Porcupine River Fm) and G-08 (Chance Sandstone) wells, where log analysis indicated nothing of interest, but the interval gave a positive DST result.

Table 2. *Wells with core analysis data used in this assessment. Core analysis intervals and lithological Formation or Member is indicated. 'm MD' = metres measured depth from Kelly Bushing.*

UWI	Well Short Name	Core Analysis Intervals (m MD)	Formation/Member
300C336620137150	C-33	(691.28-695.85) (876.9-894.74)	Parkin-SS, Chance-SS
300D616630137000	D-61	(312.11-334.67)	Parkin-SS
300E536610136450	E-53	(416.96-418.18)	Jungle Creek
300F186610137450	F-18	(1894.02-1910.79)	Hart River
300F486720137450	F-48	(1416.4-1432.04)	Porcupine River
300I056710137150	I-05	(1431.34-1434.69)	Mount Goodenough SS Mbr
300I136610137450	I-13	(1114.95-1133.91)	Fishing Branch
300O226650137150	O-22	(2731.05-2758.92)	Ogilvie
300O786700137452	O-78	(772.97-787.9)	Porcupine River
300B346610136451	B-34	(290.41-293.49) (392.88-395.66)	Jungle Creek
300D776550137000	D-77	(3304.03-3322.59) (3900.83-3903.30)	Bouvette
300G086610137303	G-08	(1299.36-1302.19) (1340.2-1342.88) (1388.79)	Chance-SS
300J196610137301	J-19	(1243.27-1293.26) (1337.46-1391.71)	Chance-SS
300J706710137150	J-70	(2046.42-2048.4)	Mount Goodenough SS Mbr
300M086610137301	M-08	(1296.92-1339.29) (1384.4-1401.92) (1854.7-1858.97)	Chance-SS, Canoe River
300M596600137000	M-59	(644.65-660.74) (718.41-724.14)	Jungle Creek

Log response should be considered in conjunction with all other available data.

Raw, open-hole wireline logs in *.LAS format were loaded into the petrophysical software application HDS2000™ (HDS). Digital logs were validated against service company raster files, and where appropriate, depth shifts and environmental corrections were applied.

Assumptions

Formation tops used in this study were provided by YGS (Fraser and Hogue, 2007). The formation list is shown in Table 3, and includes abbreviations used on the graphical log plots in Appendix C.

Interpretation of lithology was restricted to identification of the primary constituent (sandstone/limestone/dolomite), and calculation of shale. Determinations were made based on a combination of an understanding of Yukon stratigraphy, core data and logs. Clarifications were provided by YGS staff. Lithology was ultimately used to determine cutoff parameters.

Table 3. *List of formations used in this study, and their abbreviated names which are used to annotate interpreted logs in Appendix C.*

Age	Formation/Member Name	Abbreviation
Cretaceous	Cody Creek Fm	Kcody_ck
Cretaceous	Burnthill Creek Fm	Kbrnhl_ck
Cretaceous	Fishing Branch Fm	Kfish_brth
Cretaceous	Parkin Fm	Kprkin
Cretaceous	Parkin Sandstone mbr	Kprkin_ss
Cretaceous	Whitestone River Fm	Kwhstn_rv
Cretaceous	Sharp Mountain Fm	Ksharpmtn
Cretaceous	Rat River Fm	Krat_rv
Cretaceous	Mount Goodenough Fm	Kmt_godng
Cretaceous	Mount Goodenough Sandstone Mbr	Kmt_godng_ss
Jurassic	Porcupine River Fm	Jporcup_rv
Permian	Jungle Creek Fm	PRjung_ck
Pennsylvanian	Ettrain Fm	PNettrain
Pennsylvanian	Blackie Fm	PNblk
Mississippian	Alder mbr	Malder_mbr
Mississippian	Hart River Fm	Mhart_rv
Mississippian	Chance Sandstone Mbr	Mchanc_ss
Mississippian	Canoe River mbr	Mcanoe_rv
Mississippian	Ford Lake Shale Fm	Mford_lk
Mississippian	Tuttle Fm	Mtuttle
Devonian	Imperial Fm	Dimperial
Devonian	Canol Fm	Dcanol
Devonian	Ogilvie Fm	Dogl_road
Devonian	Ogilvie Dolomite mbr	Dogl_road_dol
Devonian	Michelle Fm	Dmichelle
Devonian	Mount Dewdney Fm	Dmt_dedn
Devonian	Road River Gp	Droad_rv
Ordovician	Bouvette Fm	Obvtt

Determination of reservoir and pay

For the purposes of this evaluation, “reservoir” has been defined as that volume of rock with sufficient pore space to host petroleum, and with sufficient permeability to contribute flow to the wellbore. Reservoir intervals with more than a defined volume fill of hydrocarbon are considered to be “pay”. Reservoir and pay intervals have been defined based on cutoff values of shale volume (V_{sh}), effective porosity ($Ø_E$), water saturation (S_w) and permeability (K_I), as calculated from logs. Measurement of both gross and net reservoir/pay were made in this assessment. Gross reservoir/pay is an interval of rock, defined by the petrophysicist, which exhibits zone of reservoir/pay interspersed with zones of non-reservoir/pay strata. It is used as a first approximation to identify zones of interest. Net reservoir/pay is the sum of those gross reservoir/pay intervals that have actually reservoir/pay properties. Net reservoir/pay, therefore, is a subset of gross reservoir/pay.

Because the cutoffs used to define pay are sensitive to a number of economic factors, the consideration of which are beyond the scope of this project, PRCL, in consultation with YGS staff, identified three sets of cutoff criteria meant to identify prospective accumulations that might be considered on a continuum of conventional to unconventional reservoirs. These cutoff variables are shown in Table 4. Table 4a is the most conservative set of criteria, whereas 4b and 4c are increasingly less conservative, respectively. More conservative cutoff criteria put the most restrictions on determining pay and thus will result in lower payoff values than less conservative criteria.

Table 4. *List of cutoff values for Reservoir and Pay used in this analysis. 4a are the most conservative values, and 4b and 4c are increasingly less conservative, respectively.* V_{sh} *is the volume of shale (ratio).* $Ø_E$ *is effective porosity (ratio). K_I is permeability (millidarcies), and* S_w *is water saturation (ratio).*

a

Rock type	**V_{sh} (V/V)**	**$Φ_E$ (V/V)**	**K_I (mD)**	**Sw (V/V)**
Siliciclastic	≤0.3	≥0.08	≥2	≤0.5
Limestone	≤0.3	≥0.06	≥1	≤0.5
Dolostone	≤0.3	≥0.04	≥1	≤0.5

b

Rock type	**V_{sh} (V/V)**	**$Φ_E$ (V/V)**	**K_I (mD)**	**Sw (V/V)**
Siliciclastic	≤0.3	≥0.06	≥1	≤0.55
Limestone	≤0.3	≥0.04	≥0.1	≤0.55
Dolostone	≤0.3	≥0.03	≥0.1	≤0.55

c

Rock type	**V_{sh} (V/V)**	**$Φ_E$ (V/V)**	**K_I (mD)**	**Sw (V/V)**
Siliciclastic	≤0.3	≥0.05	≥1	≤0.6
Limestone	≤0.3	≥0.03	≥0.1	≤0.6
Dolostone	≤0.3	≥0.02	≥0.1	≤0.6

Calculations

The following section discusses the overall calculation procedure and rationale for selection of various relevant parameters. Detailed equations and parameters can be found in Appendix B.

Shale Volume (V_{sh})

Shale volume was calculated from the gamma-ray log, using the "Larionov Equation for Older Rocks" (Larionov, 1969). Gamma-ray values of shale and clean rock were chosen by the analyst, individually for each well and stratigraphic interval.

Porosity (Ø)

Porosities were derived from the density, neutron and/or sonic logs, or a combination thereof. Where possible, the density/neutron crossplot technique was used, as it provides a robust estimate of porosity. Over intervals where poor borehole conditions adversely affected the density log response, porosity was generally computed from the sonic log, if available, using the Raymer-Hunt-Gardner equation (Raymer *et al.*, 1980).

It should be noted that borehole conditions can adversely affect the sonic log, and that a caliper log for generation of a badhole flag was not always available. In some instances use of the sonic log as a badhole porosity device may have been over-ridden by the analyst, where it appeared to generate porosity values even more spurious than the density. Certain intervals contain qualitatively suspect-looking sonic porosity data, with no indication of badhole. As previously stated, no log curves were manually edited.

Calculated porosities were corrected for the presence of shale, to arrive at an estimate of effective porosity.

Log-derived effective porosity values were further calibrated to core. Available routine core analyses were used to generate stratigraphically specific correction transforms, which were applied on a well-by-well basis. The correction transforms have been tabulated in Appendix B.

Permeability (K)

A preliminary attempt was made to calculate permeability from stratigraphically specific core-derived porosity-permeability transforms. This proved unsuccessful for most intervals as a scarcity of data points resulted in transforms generating unrealistically high values at higher porosities. Therefore, permeability values for this study were calculated using industry standard porosity-permeability transforms. The Wyllie-Rose equation (Wyllie and Rose, 1950) was used for clastic intervals, and the Coates and Dumanoir (1974) equation for carbonates.

Saturation (S_w)

Saturations were derived using lithology-specific equations. Water saturation (S_w) for carbonate intervals was computed using the industry-standard Archie Equation (Archie, 1942).

In clastic intervals, PRCL used a modified version of the Simandoux Equation (Simandoux, 1963), referred to informally as the "Silty Simandoux" Equation. This equation, as it exists in HDS, was originally used by Schlumberger in the early 1970s, and was referred to internally as the "V-Shale Squared" equation (L. Wells, personal communication).

As no special core analyses were available, industry-standard Archie parameter values for tortuosity, cementation and saturation exponents in clastic and carbonate environments were employed.

A formation water resistivity (R_w) database for Eagle Plain was provided to PRCL by YGS.

Formation temperature data were obtained from temperature readings recorded during wireline logging runs. Measured temperatures were corrected using the Horner Method (Horner, 1951), when sufficient data were available.

The older vintage logs available for this project were generally inadequate to resolve whether calculated hydrocarbon was oil or gas. However, gas was recovered on test from three Cretaceous (Fishing Branch [C-33; D-54; G-08; L-08], Jungle Creek [I-13; M-56], Chance [B-34; C-18; L-08]) and three Upper Paleozoic (Canoe River [C-18; I-13; J-19; L-08; M-59], Tuttle [B-34; F-28; L-08; N-26], Ogilvie [N-05]) intervals. Oil was recovered from the Chance sandstone [G-08; J-19; L-08] and Canoe River member [D-51; L-08]. A test of the Canoe River in the C-18 well yielded condensate (Osadetz *et al.*, 2005).

PRESENTATION OF RESULTS

Project results are presented digitally in Appendix C. The digital deliverables are contained in two separate folders:

- *Data Unique to Each Well*; and
- *Summary Data*

Data Unique to Each Well

The folder "Data Unique to Each Well" contains 34 subfolders, named by Unique Well Identifier (UWI). Each subfolder contains a series of five files and two subfolders.

Files

- UWI_1.LAS
- UWI_1_int.LAS
- UWI_LAT.pdf
- UWI_BHTC.pdf
- UWI_Geoscout.txt

UWI_1.LAS and UWI_1_int.LAS are *"Log ASCII Standard"* files containing both raw and interpreted curves, respectively. An explanation of the curve names is included in Appendix D.

UWI_LAT.pdf is a graphical depiction of which logs were run in the well, and what formations they cover.

UWI_BHTC.pdf shows the Horner correction (Horner, 1951) to bottom-hole temperature, if such was calculated.

UWI_Geoscout.txt is an export of the publicly available Geoscout™ well ticket information for the well.

Subfolders

- Log Plots
  - UWI_CPI.pdf
- Log Analysis Tables

- UWI_CutOffs-1.xls
- UWI_CutOffs-2.xls
- UWI_CutOffs-3.xls

UWI_CPI.pdf contains the interpreted log plot, or "Computer Processed Interpretation", for the well.

UWI_CutOffs-1.xls contains the well-specific analytical results obtained using cutoff set 1.

UWI_CutOffs-2.xls contains the well-specific analytical results obtained using cutoff set 2.

UWI_CutOffs-3.xls contains the well-specific analytical results obtained using cutoff set 3.

Summary Data

The "Summary Data" folder contains the following three files:

- Summary Table_CutOffs-1.xls
- Summary Table_CutOffs-2.xls
- Summary Table_CutOffs-3.xls

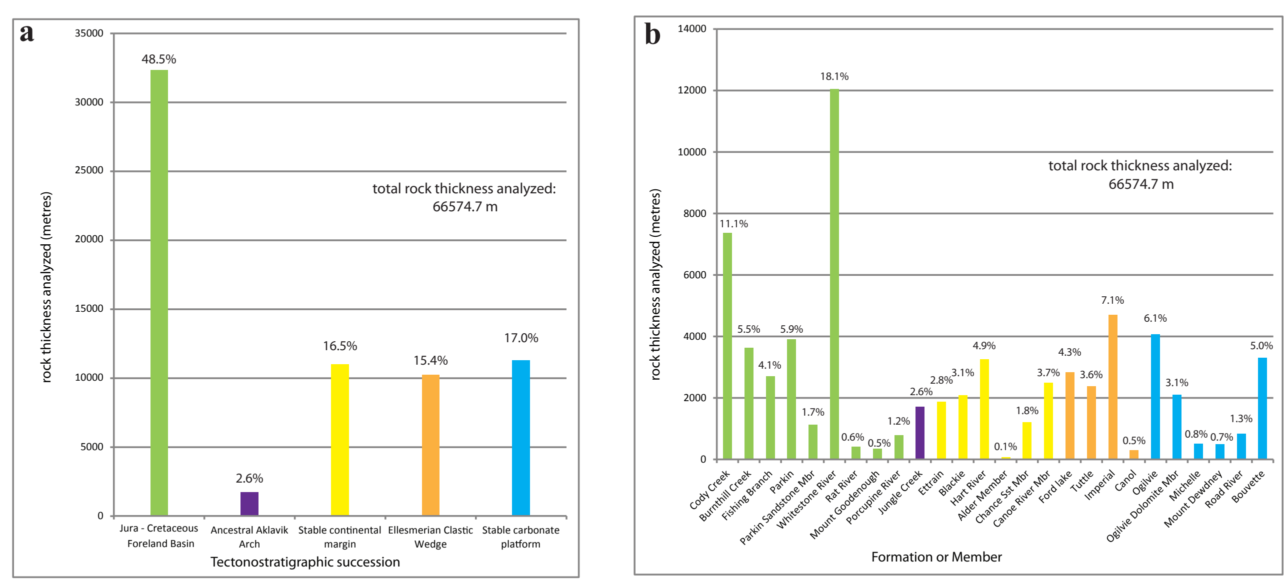
These files are compilations of the results for every project well, organized into a single spreadsheet, which have been organized by well and formation. They contain formation thickness, reservoir and pay data, as well as the cutoff values employed to arrive at these numbers. A separate file has been included for each set of cutoffs.

RESULTS

Analysis of results was conducted on a formation/member basis, and by tectonostratigraphic succession as identified in Fig. 2. The Jurassic-Cretaceous foreland basin succession includes the Cody Creek Formation, Burnthill Creek Formation, Fishing Branch Formation, Parkin Formation and its Parkin Sandstone Member, Whitestone River Formation, Rat River Formation, Mount Goodenough Formation and Porcupine River Formation. The Permian Jungle Creek Formation comprises the sediments shed from the Ancestral Aklavik Arch. The Carboniferous stable continental margin includes the Ettrain, Blackie and Hart River formations, and the Alder, Chance Sandstone, and Canoe River members of the Hart River Formation. The Ellesmerian orogenic clastic wedge includes the Ford Lake Shale, Tuttle, Imperial and Canol formations. The Canol Formation is not part of the clastic wedge, however, its overall inclusion in this tectonostratigraphic succession has a negligible effect on conventional hydrocarbon assessment and does not warrant its identification as a separate succession in this study[1]. The lower Paleozoic stable carbonate platform includes the Ogilvie Formation, the Ogilvie Dolomite Member, the Michelle Formation, Mount Dewdney Formation, Road River Group and Bouvette Formation.

[1] Reservoir and pay zones are identified in the Canol Formation in one well: 300N056630136450, South Tuttle Y.T., N-05 between 1433.9 and 1439.4 m below KB, using cutoff #3. This interval occurs at the contact between the Canol Formation and the underlying Ogilvie Formation. The nature of this contact is uncertain, and is currently the focus of study by Yukon Geological Survey petroleum geologists (Fraser, T., pers. comm.). Based on log-derived lithology, this interval is likely not part of the Canol Formation, as the base of the Canol is better placed at 1427 m below KB rather than 1439.9 m which was used in the assessment (from Fraser and Hogue, 2007). The 1427-1439.9 interval is different lithologically from the shale of the Canol strata above and the Ogilvie limestone below. It is unclear whether it would be part of the Ogilvie Formation, for example as an altered or eroded limestone surface, or as a separate unit altogether. Because of the uncertainty, the formation tops were left unchanged from Fraser and Hogue (2007), resulting in up to 4.1 m of pay strata falling within the Canol Formation. This small thickness does not impact or change the results of the study.

A total of 66 575 m of strata were analyzed in this assessment, 48.6% of which comprises Jurassic-Cretaceous foreland basin sedimentary rocks, 2.6% Permian strata shed from the Ancestral Aklavik Arch, 16.5% from the Carboniferous stable continental margin, 15.4% Ellesmerian orogeny clastic wedge succession and 17.0% lower Paleozoic stable carbonate platform sedimentary rocks (Fig. 4). Results used to compare unit hydrocarbon prospectivity include net reservoir and pay thickness, proportion of pay rock to non-pay formation rock, and proportion of reservoir rock filled with pay.



Percentages represent each succession's proportion of the total thickness analyzed.

Percentages represent each Formation/Member's proportion of the total thickness analyzed.

Figure 4. *Graph of rock thickness analyzed in this study per tectonostratigraphic succession (4a) and per Formation/Member (4b).*

Most conservative results

Most conservative analytical results are in Table 5. Using cutoff #1 criteria from Table 4a, the total reservoir thickness identified is 2845.5 m, or 4.3% of the total strata assessed (Fig. 5). The Carboniferous stable continental margin sedimentary rocks have the greatest net reservoir thickness (1068 m or 37.5% of total), followed closely by the Jura-Cretaceous foreland basin sedimentary rocks (993.0 m or 34.9%; Fig. 5a). Significantly thinner net reservoir thicknesses were identified in the Paleozoic stable carbonate succession (381.6 m or 13.4%), Ancestral Aklavik Arch (254.7 m or 9.0%) and the Ellesmerian clastic wedge (148.2 m or 5.2%). The Canoe River member, Fishing Branch and Cody Creek formations, and Ogilvie Dolomite member all contain >300 m of net reservoir thickness, with the Canoe River member containing the thickest value at 501.4 m, representing 17.6% of the total (Fig. 5b). Net reservoir thicknesses are also notable from the Hart River, Jungle Creek, and Ettrain formations (280.4 m, 254.7 m and 150.3 m respectively). All other formations are have <150 m net reservoir identified.

Total net pay thickness identified is 1899.9 m, or 2.9% of the total strata assessed (Fig. 6). The Carboniferous stable continental margin sedimentary rocks comprise over half of the total net pay thickness (1016.8 m or 53.5%; Fig. 6a), mainly in the Canoe River member of the Hart River Formation (500.3 m), and in the Hart River Formation itself (275.1 m), followed by the Ettrain and the Chance Sandstone Member of the Hart River Formation (109.0 and 99.9 m respectively; Fig. 6b). A total net pay thickness of 18.7% (355.9 m) is identified in the Lower Paleozoic stable carbonate platform succession, dominated by 292.9 m in the Ogilvie Dolomite Member. The Ancestral Aklavik Arch sedimentary rocks (Jungle Creek Formation) and Jura-Cretaceous foreland basin succession comprise 13.0% (246.6 m) and 12.5% (237.5 m) of the total net pay thickness, and the Ellesmerian clastic wedge only 2.3%, dominated by 25.5 m in the Tuttle Formation.

Table 5. *Analytical results of the petrophysical study using cutoff parameters #1 (most conservative).*

Formation or Member	Total rock thickness analyzed (m)	% of Total Thickness	Net Reservoir thickness (m)	Individual Formation proportion of total net reservoir (%)	Net Pay thickness (m)	Individual Formation proportion of total net pay (%)	Proportion of individual Formation filled with pay (%)	Proportion of individual Formation's reservoir rock filled with pay (%)	Dominant Lithology
Cody Creek	7364.6	11.1	350.9	12.3	86.6	4.6	1.2	24.7	SST
Burnthill Creek	3629.2	5.5	43.9	1.5	6.9	0.4	0.2	15.6	SH
Fishing Branch	2700.8	4.1	419.6	14.7	83.8	4.4	3.1	20.0	SST
Parkin	3914.4	5.9	15.7	0.6	0.0	0.0	0.0	0.0	SH
Parkin Sandstone Mbr	1126	1.7	54.3	1.9	18.8	1.0	1.7	34.7	SST
Whitestone River	12049.8	18.1	8.7	0.3	0.3	0.0	negligible	3.5	SH
Rat River	418.2	0.6	0.4	0.0	0.0	0.0	0.0	0.0	SST
Mount Goodenough	343.3	0.5	17.1	0.6	0.0	0.0	0.0	0.0	SST
Porcupine River	790.3	1.2	82.5	2.9	41.1	2.2	5.2	49.7	SST
Jungle Creek	1714.7	2.6	254.7	9.0	246.6	13.0	14.38	96.8	SST
Ettrain	1876.9	2.8	150.3	5.3	109.0	5.7	5.8	72.6	LIM
Blackie	2088.6	3.1	14.3	0.5	11.9	0.6	0.6	83.0	SH
Hart River	3259.4	4.9	280.4	9.9	275.1	14.5	8.4	98.1	LIM
Alder Member	67.6	0.1	20.6	0.7	20.6	1.1	30.4	100.0	LIM
Chance Sst Mbr	1217.8	1.8	101.0	3.5	99.9	5.3	8.2	98.9	SST
Canoe River Mbr	2486.7	3.7	501.4	17.6	500.3	26.3	20.1	99.8	LIM
Ford lake	2845.5	4.3	14.3	0.5	2.3	0.1	0.1	16.1	SH
Tuttle	2383.5	3.6	104.2	3.7	25.5	1.3	1.1	24.4	SST
Imperial	4702.4	7.1	27.1	1.0	12.7	0.7	0.3	47.0	SH
Canol	301.3	0.5	2.6	0.1	2.6	0.1	0.9	100.0	SH
Ogilvie	4065.5	6.1	16.7	0.6	16.7	0.9	0.4	100.0	LIM
Ogilvie Dolomite Mbr	2095	3.1	313.8	11.0	292.9	15.4	14.0	93.3	DOL
Michelle	505.1	0.8	1.2	0.0	1.2	0.1	0.2	100.0	SH
Mount Dewdney	492.6	0.7	22.4	0.8	17.8	0.9	3.6	79.6	LIM
Road River	833	1.3	0.0	0.0	0.0	0.0	0.0	0.0	SH
Bouvette	3302.5	5.0	27.4	1.0	27.3	1.4	0.8	99.4	LIM
Total	66574.7	100.0	2845.5	100.0	1899.9	100.0	2.9	66.8	

Tectonostratigraphic successions	Total rock thickness analyzed (m)	% of Total thickness	Net Reservoir thickness (m)	Proportion of total net reservoir thickness (%)	Net Pay thickness (m)	Proportion of total net pay thickness (%)	Proportion of succession filled with pay (%)	Proportion of succession's reservoir rock filled with pay (%)	Lithology
Cretaceous Foreland Basin	32336.6	48.57	993	34.90	237.5	12.5	0.73	23.91	SST, SH
Ancestral Aklavik Arch	1714.7	2.58	254.7	8.95	246.6	13.0	14.38	96.8	SST
Stable continental margin	10997	16.52	1068	37.53	1016.8	53.5	9.25	95.21	LIM, SH, SST
Ellesmerian Clastic Wedge	10232.7	15.37	148.2	5.21	43.1	2.3	0.42	29.05	SH, SST
Stable carbonate platform	11293.7	16.96	381.6	13.41	355.9	18.7	3.15	93.27	LIM, DOL, SH
Total	66574.7	100.00	2845.5	100.00	1899.9	100.0	2.9	66.8	

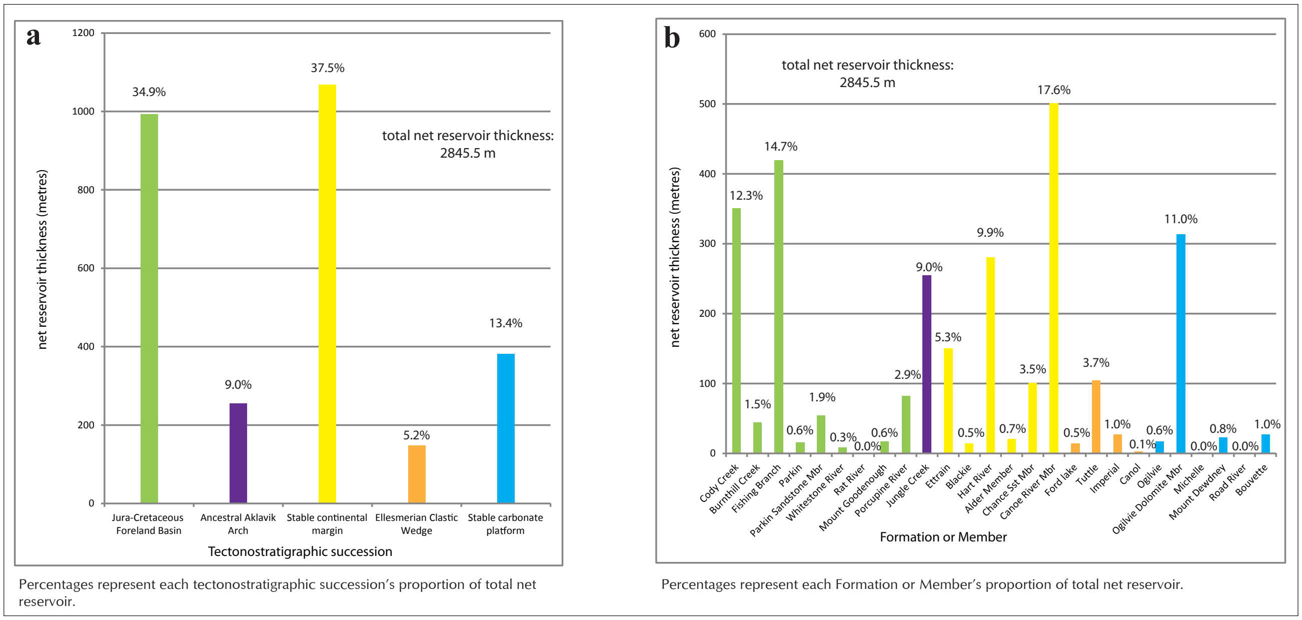


Figure 5. *Graph of net reservoir thickness using cutoff parameters #1 (most conservative) per tectonostratigraphic succession (5a) and per Formation/Member (5b).*

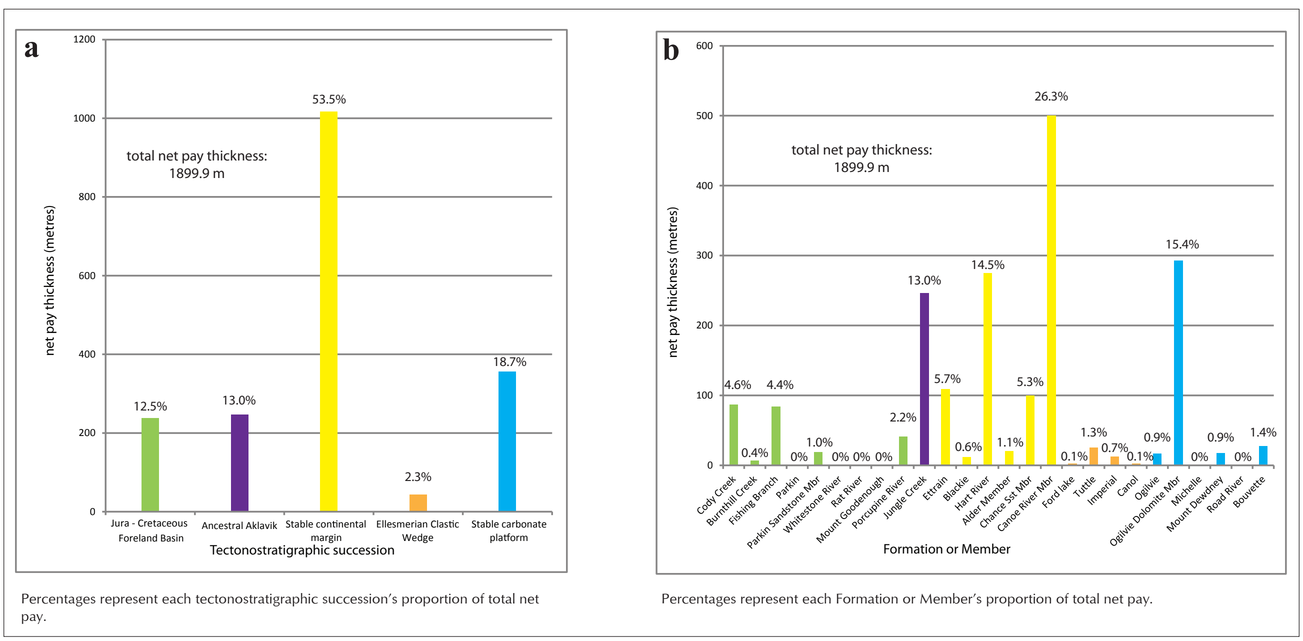


Figure 6. *Graph of net pay thickness using cutoff parameters #1 (most conservative) per tectonostratigraphic succession (6a) and per Formation/Member (6b).*

The Ancestral Aklavik Arch sedimentary rocks have the highest proportion of pay rock thickness/non-pay tectonostratigrahic succession thickness (14.4%) followed by the Carboniferous stable continental margin (9.3%), Lower Paleozoic stable carbonate platform (3.2%) and Jura-Cretaceous foreland basin and Ellesmerian clastic wedge sedimentary rocks (<1%; Fig. 7a).The largest proportion of pay rock thickness to non-pay formation/member thickness is in the Carboniferous stable continental margin succession (Fig. 7b), notably the Alder and Canoe River members of the Hart River Formation, where 30.4% and 20.1% of the units are filled with pay, respectively. The Jungle Creek Formation and Ogilvie Dolomite Member are almost equal with 14.4% and 14.0% of each formation, respectively, identified as pay.

The Ancestral Aklavik Arch, Carboniferous stable continental margin and Lower Paleozoic stable carbonate platform sedimentary rocks have >90% pay enrichment of reservoir rock with pay compared to the Ellesmerian clastic wedge and Jura-Cretaceous foreland basin sedimentary rocks which are only 29.1% and 23.9% enriched, respectively (Fig. 8).

Least conservative results

Least conservative analytical results are in Table 6. Using cutoff criteria #3 from Table 4c, the total reservoir thickness identified is 4629.6 m, or 7.0% of all strata assessed (Fig. 9). Of the total reservoir rock identified 1842.4 m or 39.8% is present in the Carboniferous stable continental margin succession (Fig. 9a), with the majority from the Canoe River member of the Hart River Formation (805.6 m or 17.4% of total), the Hart River Formation (514.3 m or 11.1%) and the Ettrain Formation (350.8 m or 7.6% of total; Fig. 9b). Approximately one-quarter of the reservoir rock is present in both the Paleozoic carbonate platform (1162.4 m or 25.1% of total) and the Jurassic-Cretaceous foreland basin succession (1104.6 m or 23.9% of total). The Ogilvie Dolomite member dominates the lower Paleozoic succession with 20.2% of the total net reservoir (936.8 m) and the Fishing Branch and Cody Creek formations host the most reservoir rock in the Cretaceous succession with 9.5% (439.4 m) and 8.9% (412.8 m) of the total net reservoir thickness respectively.

Total net pay thickness identified is 3691.8 m, or 5.5% of the total strata assessed (Fig. 10). Almost half of the total net pay thickness is identified in the Carboniferous stable continental margin succession (1779.7 m or 48.2% of total; Fig. 10a) with the majority in the Canoe River member of the Hart River Formation (803.9 m or 21.8% of total), the Hart River (507.1 m or 13.7% of total) and Ettrain formations (303.5 m 8.2% of total; Fig. 10b). A net pay thickness of 28.6% (1056.3 m) is identified in the Paleozoic stable carbonate platform succession, dominated by the Ogilvie Dolomite Member of the Ogilvie Formation (841.1 m or 22.8% of total). The Jura-Cretaceous foreland basin succession hosts 12.9% (478 m) of the total net pay thickness, dominated equally by the Cody Creek (194.5 m or 5.3% of total) and Fishing Branch formations (183.8 m or 5.0% of total). The Permian Jungle Creek Formation representing eroded Ancestral Aklavik Arch sedimentary rocks hosts 7.7% (284.2 m) of the total net pay thickness, followed by the Ellesmerian clastic sedimentary rocks which comprise 2.5% (93.1 m) of net pay thickness, predominantly in the Tuttle Formation (54.6 m or 1.5% of total).

The Ancestral Aklavik Arch sedimentary rocks have the largest proportion of pay rock thickness to non-pay tectonostratigraphic succession thickness (16.6%), followed closely by the stable continental margin (16.2%) and the stable carbonate platform (9.4%; Fig. 11a). The Jura-Cretaceous foreland basin and Ellesmerian clastic wedge sedimentary rocks have relatively poorer proportions of pay rock thickness to non-pay succession thicknesses (7.7% and 2.5%, respectively). The largest proportion of pay rock thickness to non-pay formation/member thickness is in the Ogilvie Dolomite Member (40.2%), followed by the Alder member and the Canoe River member of the Hart River Formation (38.1% and 32.3% respectively; Fig. 11b).

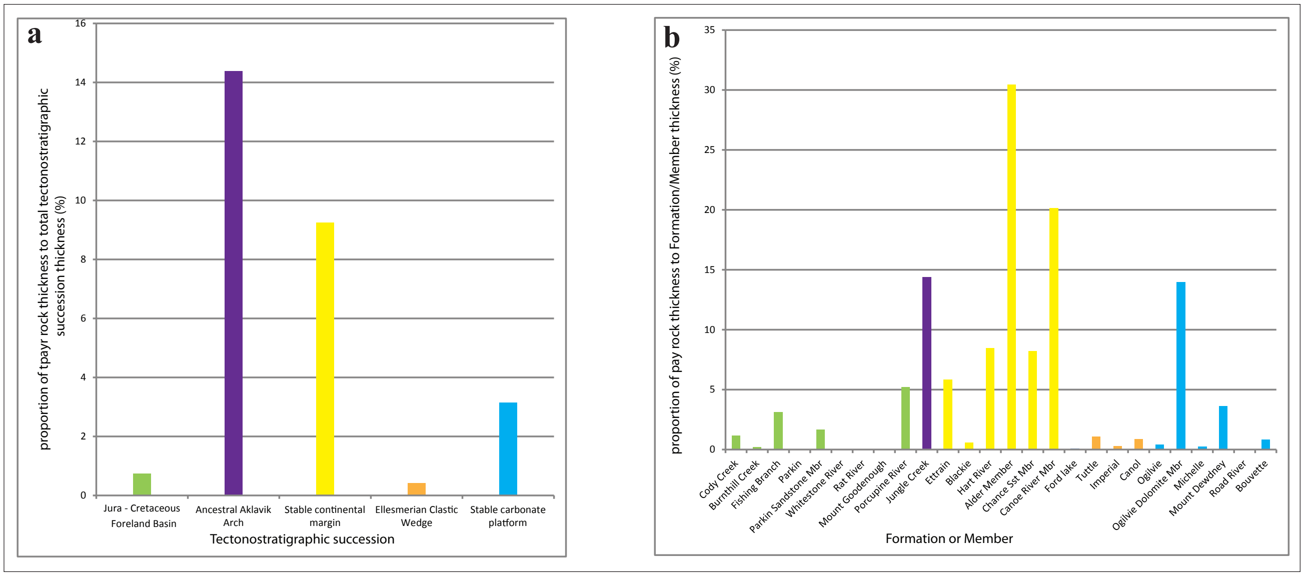


Figure 7. *Graph of proportion of pay rock thickness to total tectonostratigraphic succession thickness (7a) and Formation/Member thickness (7b) using cutoff parameters #1 (most conservative).*

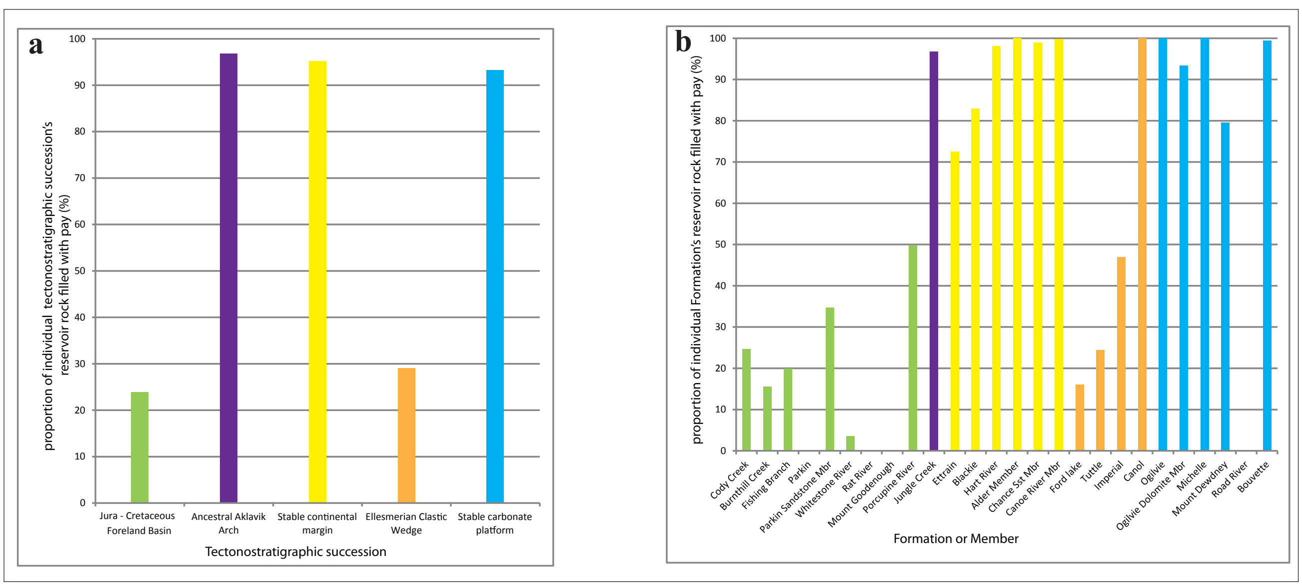
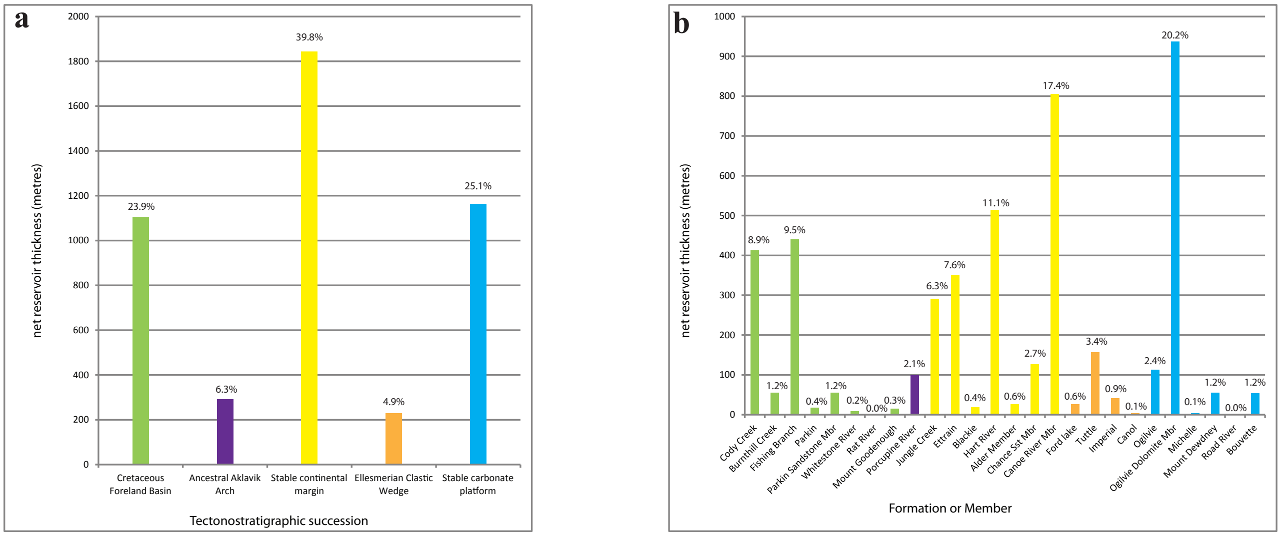


Figure 8. *Graph of proportion of reservoir rock filled with pay rock for each stratigraphic succession (8a) and Formation/Member thickness (8b) using cutoff parameters #1 (most conservative).*

Table 6. *Analytical results of the petrophysical study using cutoff parameters #3 (least conservative).*

Formation or Member	Total rock thickness analyzed (m)	% of Total Thickness	Net Reservoir thickness (m)	Individual Formation proportion of total net reservoir (%)	Net Pay thickness (m)	Individual Formation proportion of total net pay (%)	Proportion of individual Formation filled with pay (%)	Proportion of individual Formation's reservoir rock filled with pay (%)	Dominant Lithology
Cody Creek	7364.6	11.1	412.8	8.9	194.5	5.3	2.6	47.1	SST
Burnthill Creek	3629.2	5.5	55.4	1.2	8.8	0.2	0.2	15.9	SH
Fishing Branch	2700.8	4.1	439.4	9.5	183.8	5.0	6.8	41.8	SST
Parkin	3914.4	5.9	17.2	0.4	0.0	0.0	0.0	0.0	SH
Parkin Sandstone Mbr	1126	1.7	55.5	1.2	29.7	0.8	2.6	53.5	SST
Whitestone River	12049.8	18.1	8.8	0.2	1.5	0.0	0.0	17.0	SH
Rat River	418.2	0.6	0.7	0.0	0.0	0.0	0.0	0.0	SST
Mount Goodenough	343.3	0.5	15.4	0.3	0.0	0.0	0.0	0.0	SST
Porcupine River	790.3	1.2	99.3	2.1	59.7	1.6	7.6	60.1	SST
Jungle Creek	1714.7	2.6	291.3	6.3	284.2	7.7	16.58	97.6	SST
Ettrain	1876.9	2.8	350.8	7.6	303.5	8.2	16.2	86.5	LIM
Blackie	2088.6	3.1	18.9	0.4	14.0	0.4	0.7	74.1	SH
Hart River	3259.4	4.9	514.3	11.1	507.1	13.7	15.6	98.6	LIM
Alder Member	67.6	0.1	25.9	0.6	25.8	0.7	38.1	99.6	LIM
Chance Sst Mbr	1217.8	1.8	126.9	2.7	125.8	3.4	10.3	99.1	SST
Canoe River Mbr	2486.7	3.7	805.6	17.4	803.9	21.8	32.3	99.8	LIM
Ford lake	2845.5	4.3	26.2	0.6	8.5	0.2	0.3	32.4	SH
Tuttle	2383.5	3.6	156.8	3.4	54.6	1.5	2.3	34.8	SST
Imperial	4702.4	7.1	41.8	0.9	25.9	0.7	0.6	62.0	SH
Canol	301.3	0.5	4.1	0.1	4.1	0.1	1.4	100.0	SH
Ogilvie	4065.5	6.1	112.5	2.4	110.7	3.0	2.7	98.4	LIM
Ogilvie Dolomite Mbr	2095	3.1	936.8	20.2	841.1	22.8	40.2	89.8	DOL
Michelle	505.1	0.8	4.0	0.1	4.0	0.1	0.8	100.0	SH
Mount Dewdney	492.6	0.7	55.6	1.2	47.1	1.3	9.6	84.7	LIM
Road River	833	1.3	0.0	0.0	0.0	0.0	0.0	0.0	SH
Bouvette	3302.5	5.0	53.5	1.2	53.5	1.4	1.6	100.0	LIM
Total	66574.7	100.0	4629.5	100.0	3691.8	100.0	5.5	79.7	

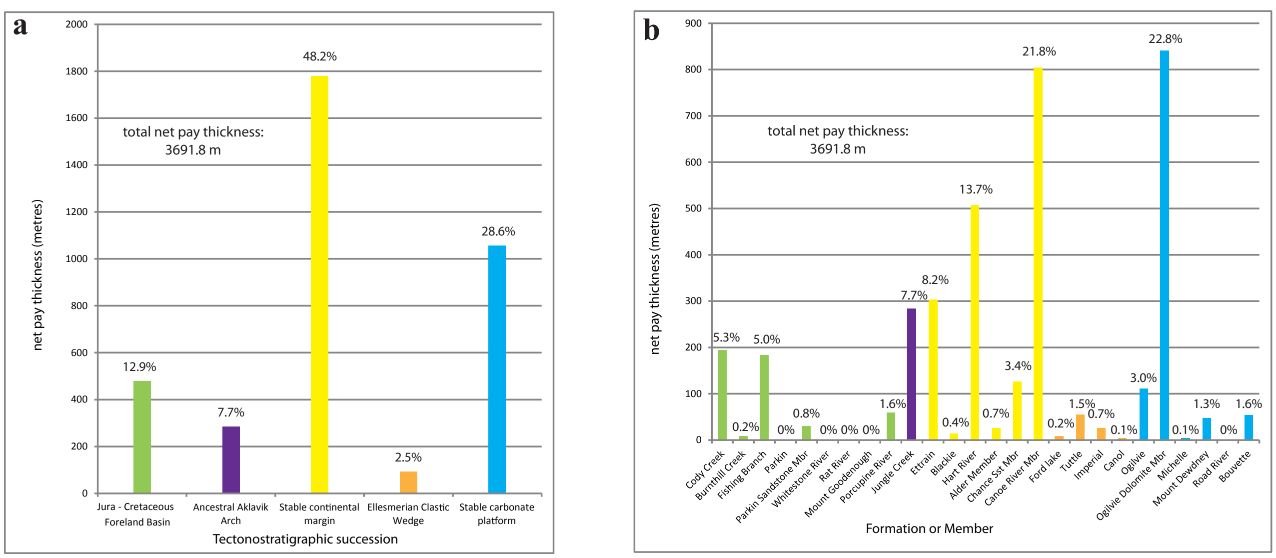
Tectonostratigraphic successions	Total rock thickness analyzed (m)	% of total thickness	Net Reservoir thickness (m)	Proportion of total net reservoir thickness (%)	Net Pay thickness (m)	Proportion of total net pay thickness (%)	Proportion of succession filled with pay (%)	Proportion of succession's reservoir rock filled with pay (%)	Lithology
Cretaceous Foreland Basin	32336.6	48.6	1104.6	23.9	478	12.9	1.48	43.28	SST, SH
Ancestral Aklavik Arch	1714.7	2.6	291.3	6.3	284.2	7.7	16.58	97.57	SST
Stable continental margin	10997	16.5	1842.4	39.8	1779.7	48.2	16.18	96.59	LIM, SH, SST
Ellesmerian Clastic Wedge	10232.7	15.4	228.9	4.9	93.1	2.5	0.91	40.65	SH, SST
Stable carbonate platform	11293.7	17.0	1162.4	25.1	1056.3	28.6	9.35	90.87	LIM, DOL, SH
Total	66574.7	100.0	4629.6	100.0	3691.3	100.0	5.5	79.7	



Percentages represent each tectonostratigraphic succession's proportion of total net reservoir.

Percentages represent each Formation or Member's proportion of total net reservoir.

Figure 9. *Graph of net reservoir thickness using cutoff parameters #3 (least conservative) per tectonostratigraphic succession (9a) and per Formation/Member (9b).*



Percentages represent each tectonostratigraphic succession's proportion of total net pay.

Percentages represent each Formation or Member's proportion of total net pay.

Figure 10. *Graph of net pay thickness using cutoff parameters #3 (least conservative) per tectonostratigraphic succession (10a) and per Formation/Member (10b).*

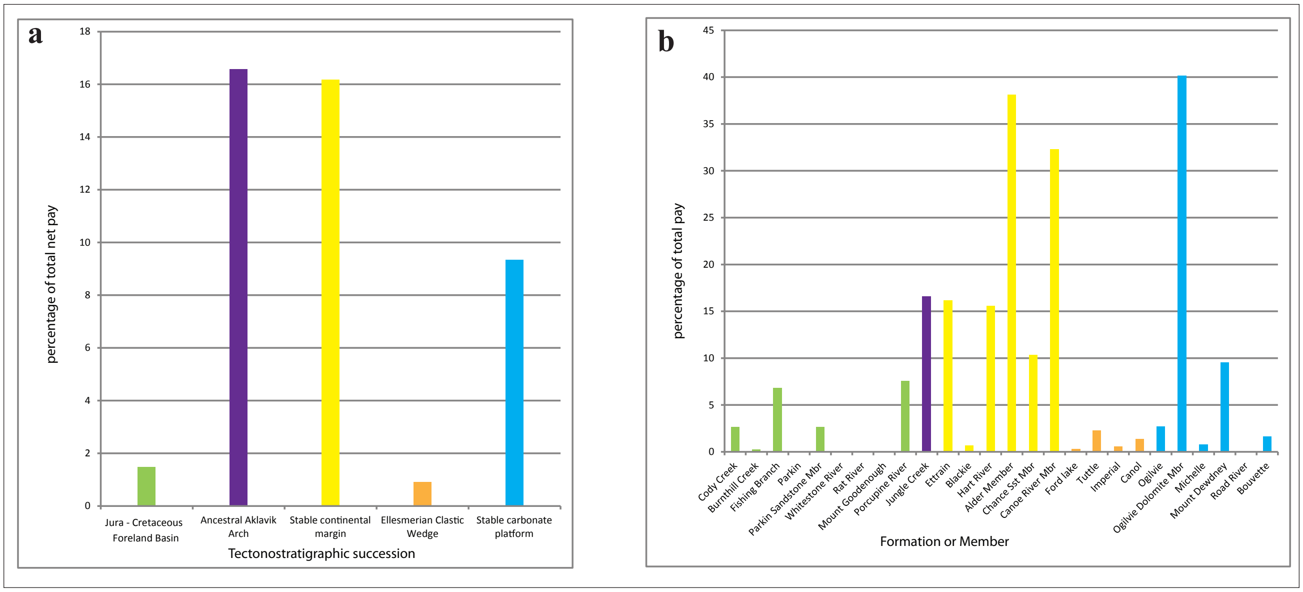


Figure 11. *Graph of proportion of pay rock thickness to total tectonostratigraphic succession thickness (11a) and Formation/Member thickness (11b) using cutoff parameters #3 (least conservative).*

Several formations/members have in excess of 90% pay-filled reservoir rock (Fig. 12). Ancestral Aklavik Arch, stable continental margin and stable carbonate platform sedimentary rocks have notable enrichment of reservoir rock with pay (all >90%) compared to the Jura-Cretaceous foreland basin and Ellesmerian clastic wedge sedimentary rocks which are only 43.3% and 40.7% enriched respectively (Fig. 12a).

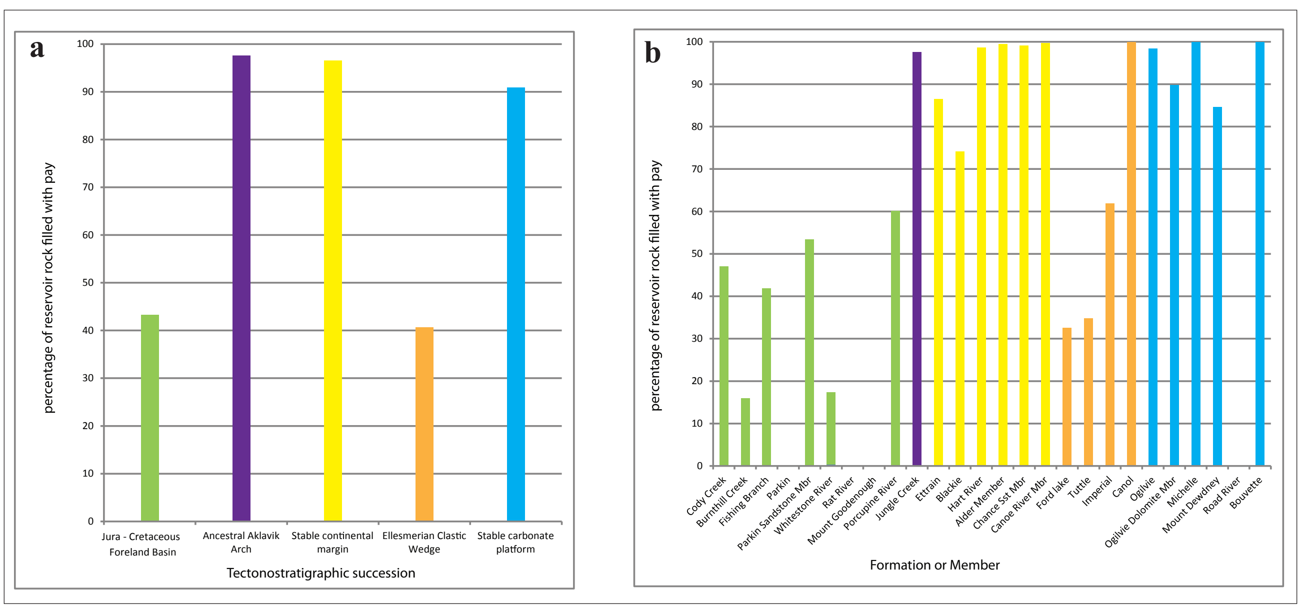


Figure 12. *Graph of proportion of pay rock thickness to total tectonostratigraphic succession thickness (12a) and Formation/Member thickness (12b) using cutoff parameters #3 (least conservative).*

CONCLUSIONS

The petrophysical analysis of well logs has revealed that conventional reservoir rocks with hydrocarbon-bearing intervals are present in both Paleozoic and Mesozoic rocks in Eagle Plain basin, in 19 stratigraphic intervals and in 29 of 31 wells analyzed. Table 7 summarizes the wells and formations/members in which hydrocarbons were identified from logs, based on the least restrictive set of cutoff criteria employed (cutoff 3; see Table 4c). Using a variety of cutoff values for porosity, permeability, water saturation and shale volume, net reservoir thickness ranges between 2845.5 and 4629.6 m, and net pay thickness between 1899.9 and 3691.8 m. At a minimum, this study has shown that ~1900 m of pay strata was identified in the basin.

Over the range of cutoff values, the Carboniferous stable platform succession is the most prospective for hydrocarbon accumulations. Although ranking third (of five) tectonostratigraphic successions in terms of total strata analyzed, it ranks first in net reservoir and net pay thicknesses, has the second highest proportion of net pay to formation thickness, and has >90% of reservoir rock filled with pay. The most prospective units in this succession are the Canoe River member of the Hart River Formation, the Hart River Formation, and the Ettrain Formation, with the Alder member of the Hart River Formation notable for its net pay to formation thickness ratio.

Table 7. *Prospective hydrocarbon-bearing strata identified from well logs in Eagle Plain basin.*

Age	Tectonostratigraphic succession	Formation/Member	Lithology	Prospective Wells
Cretaceous	Cordilleran Foreland Basin	Cody Creek Fm	Sandstone	C-18, C-24, C-33 [W.Parkin], D-22, D-51, F-18, G-08, I-13, J-19, K-56, N-26
Cretaceous		Burnthill Creek Fm	Shaley Sand	I-05, I-13, M-08
Cretaceous		Fishing Branch Fm	Sandstone	C-18, C-24, D-22, D-54, D-61, D-63, G-08, I-05, I-13, J-19, K-56, M-08, N-58
Cretaceous		Parkin Sandstone mbr	Sandstone	C-33 [W. Parkin], D-54, D-61
Jurassic		Porcupine River Fm	Sandstone	F-48, J-70
Permian	Ancestral Aklavik Arch	Jungle Creek Fm	Sandstone	B-34, D-77, E-53, I-13, M-59, N-58
Pennsylvanian	Stable Continental Margin	Ettrain Fm	Limestone	B-34, C-18, C-33 [Alder], D-63, E-53, N-58
Pennsylvanian		Blackie Fm	Shaley Sand	D-77, K-58
Mississippian		Hart River Fm	Limestone	B-34, C-18, C-33 [Alder], D-22, D-51, D-54, D-77, F-18, G-08, K-56, K-58, M-08, M-59, N-26
Mississippian		Chance Sandstone Mbr	Sandstone	B-34, C-18, C-33 [W. Parkin], G-08, J-19, K-58, M-08, M-59, N-26
Mississippian		Canoe River mbr	Limestone	B-34, C-33 [W. Parkin], D-51, F-18, G-08, K-56, M-08, M-59, N-26
Mississippian	Ellesmerian Clastic Wedge	Ford Lake Shale Fm	Shaley Sand	C-33 [Alder], D-77, M-08, N-26
Mississippian		Tuttle Fm	Sandstone	F-48, N-53, O-22
Devonian		Imperial Fm	Shaley Sand	B-62, C-24, C-33 [Alder], M-08, N-05, N-53
Devonian	Stable carbonate platform and basin	Ogilvie Fm	Limestone	B-62, C-33 [Alder], D-77, N-53, O-22
Devonian		Ogilvie Dolomite mbr	Dolomite	B-62, C-33 [Alder], D-77, N-53, O-22
Devonian		Michelle Fm	Shaley Sand	D-77
Devonian		Mount Dewdney Fm	Limestone	N-53
Ordovician		Bouvette Fm	Limestone	D-77, N-53

The second most prospective succession is the Lower Paleozoic stable carbonate platform rocks, with the Ogilvie Dolomite Member the main, if only, viable target identified, given the depth of these successions from surface.

The Ancestral Aklavik Arch complex consists of the Jungle Creek Formation which comprises only 2.6% of all strata analyzed, however, its net pay thickness, proportion of net pay rock thickness to formation thickness and proportion of reservoir filled with pay values are notable. The overall volume of pay, however, is restricted by the overall amount of rock in this stratigraphic succession.

Cretaceous and Jurassic rocks are the dominant rock in the basin, comprising almost 50% of the total rock analyzed. Unlike the Carboniferous stable platform, Aklavik Arch and Lower Paleozoic carbonate successions, the proportion of Jura-Cretaceous reservoir rock filled with pay and the proportion of pay rock to total rock thickness is small. Of this succession, the Fishing Branch and Cody Creek formations are the most prospective formations with more than 400 m of reservoir thickness each (cutoff #3), however, net pay is <200 m thick in these formations as the pay-filled reservoir is <50%, unlike the more prospective successions mentioned above.

The Ellesmerian succession is the overall lowest performer in net reservoir and pay thicknesses, proportion of net pay to formation thickness, and in the proportion of reservoir rock filled with pay (except using cutoff #1 where proportion of reservoir filled with pay is slightly higher than the Jura-Cretaceous succession). Within this succession the Tuttle Formation is the most prospective, however, its overall contribution to hydrocarbons in the basin is considered low.

Based on this study, the number one tectonostratigraphic succession that should be explored for conventional hydrocarbons is the Carboniferous stable platform, followed by the Lower Paleozoic carbonate platform and the Ancestral Aklavik Arch sedimentary rocks. The Jura-Cretaceous and Ellesmerian successions, while in part hydrocarbon-bearing, are found to be the least prospective in this basin.

Specific formations/members worthy of further investigation include, in order of importance, the Canoe River member of the Hart River Formation, the Hart River Formation, the Ogilvie Dolomite Member, the Jungle Creek Formation, the Ettrain Formation and the Alder member of the Hart River Formation. Also noteworthy is the Chance Sandstone Member of the Hart River Formation, based on previously discovered hydrocarbons (oil and gas) in the basin (Osadetz *et al.*, 2005).

Successions of lower priority for exploration include the Jura-Cretaceous foreland basin and Ellesmerian orogenic successions, which while contributing to the overall abundance of rock in the basin, are underperformers in terms of hydrocarbon presence.

The results of this study are very encouraging for future conventional exploration in the basin, and highlight strata that were not previously identified as exploration targets in the past. While this study did not assess the unconventional hydrocarbon potential of the well logs (*e.g.*, shale and tight reservoirs), the presence of conventional hydrocarbons identified in this study throughout the basin is encouraging for the presence of unconventional units as well.

Recommendations for further study include:

- Subsurface mapping of geological units and reservoir and pay intervals using data from this study, newer wells drilled in the basin that were not included in this study (*see* Figure 2), available seismic data and field studies. Updated mapping will geographically delineate the basin "sweet spots" for hydrocarbons, convert two dimensional 'thickness' data to volumes, and will augment the understanding of basin evolution;

- Targeted geological field studies focusing primarily on the Carboniferous stable platform succession and Permian Ancestral Aklavik Arch succession to characterize the sedimentology, stratigraphy and petroleum potential of conventional source and reservoir rocks;
- A refinement of the regional stratigraphy is required in Eagle Plain basin, particularly in the Upper Devonian and Carboniferous section. For example, the Hart River Formation is divided formally and informally in a number of members that are, in-part, poorly-defined. Also, the Ogilvie Formation to Canol Formation transition also requires examination as its age and lithology are varied in the outcrops surrounding the basins (*e.g.*, Richardson and Ogilvie mountains);
- Detailed bedrock mapping of NTS map sheets 106 L, and 116 F, G, H, I, J, K and P. The most recent bedrock maps of the region were published in 1981 and 1982, with fieldwork conducted in the decades prior. Since this time, there has been a refinement of the regional stratigraphy which should be updated on the regional bedrock maps and cross sections;
- Although conventional hydrocarbon targets have been identified in this study, further work is required to characterize the unconventional reservoir potential (*i.e.*, shale and tight reservoirs). Data from existing wells, including well logs, core and cuttings can be used to assess a number of unconventional reservoir characteristics including organic content, geochemistry, mineralogy, porosity, permeability, natural fracture patters, and mechanical properties, as examples; and
- Subsurface data are critical to understanding any sedimentary basin and its hydrocarbon evolution. Frontier areas are expensive to work in and new subsurface data are not made available on a regular basis. At present, subsurface data are acquired through two main means: exploratory drilling and seismic acquisition. In order to understand the potential that may or may not exist within any jurisdiction, the ability to collect, interpret and share these types of data must be enhanced and ensured, which will ultimately result in more accurate estimations of hydrocarbon resources in the territory.

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APPENDIX A. DRILL-STEM TEST INTERVALS FOR EAGLE PLAIN BASIN WELLS

UWI	Well Short Name	Drill-Stem Test Interval (m MD)	Formation/Member	Age
300B346610136450	B-34	289.6 – 293.8	Jungle Creek	Permian
		293.8 – 354.5	Jungle Creek	Permian
		354.5 – 405.1	Jungle Creek	Permian
		487.7 – 509.9	Jungle Creek	Permian
		701 – 707.1	Ettrain	Pennsylvanian
		1350.3 – 1371.9	Hart River	Mississippian
		453.5 – 464.8	Jungle Creek	Permian
		458.7 – 463.3	Jungle Creek	Permian
		1583.4 – 1649.9	Hart River	Mississippian
300B626620138300	B-62	–	–	–
300C186610137150	C-18	925.1 – 934.8	Jungle Creek	Permian
		1524 – 1540.8	Jungle Creek	Mississippian
		1496.6 – 1517.9	Hart River	Mississippian
300C246640137450	C-24	1649 – 1676.7	Tuttle	Mississippian
		1886.7 – 1912.9	Tuttle	Mississippian
300C336600136450	C-33 [Alder]	–	–	–
300C336620137150	C-33 [W.Parkin]	669.3 – 691	Parkin SS	Cretaceous
		691.3 – 696.8	Whitestone River	Cretaceous
		874.8 – 895.2	Hart River	Mississippian
		969.3 – 979.6	Hart River	Mississippian
		1005.8 – 1066.5	Hart River	Mississippian
		481.6 – 498	Fishing Branch	Cretaceous
300D226620137300	D-22	1807.5 – 1829.4	Ford Lake	Mississippian
		1433 – 1436	Hart River	Mississippian
		1538 – 1554	Hart River	Mississippian
		717.8 – 749.8	Burnthill Creek	Cretaceous
		1538 - 1554	Hart River	Mississippian
		717.8 – 749.8	Burnthill Creek	Cretaceous
		786 – 789	Fishing Branch	Cretaceous
		719.6 – 748	Burnthill Creek	Cretaceous
300D516620137150	D-51	1336.5 – 1358.2	Hart River	Mississippian
		1323.4 – 1333.8	Hart River	Mississippian
		1124.7 – 1136.9	Hart River	Mississippian
		1109.5 – 1135.7	Hart River	Mississippian
		685.8 – 718.1	Fishing Branch	Cretaceous
300D546620137150	D-54	1060 – 1065	Hart River	Mississippian
		700 – 750	Parkin SS	Cretaceous
		742 – 747	Parkin SS	Cretaceous
		1042 – 1047	Hart River	Mississippian
		1038 – 1048	Hart River	Mississippian
300D616630137000	D-61	2325.6 – 2404.9	Ogilvie	Devonian
		459 – 464.5	Whitestone River	Cretaceous

APPENDIX A continued

UWI	Well Short Name	Drill-Stem Test Interval (m MD)	Formation/Member	Age
300D636600137300	D-63	1639.2 – 1793.7	Blackie	Pennsylvanian
		1674 – 1712.1	Jungle Creek	Permian
300D776550137000	D-77	1494.7 – 1616.4	Gossage	Devonian
		1737.7 – 1774.5	Gossage	Devonian
		2011.7 – 2061.7	Gossage	Devonian
		2499.4 – 2514.9	Road River	Devonian
		2650.8 – 2660	Road River	Devonian
		2889.5 – 3021.5	Franklin Mountain	Ordovician
		2807.2 – 2852.9	Franklin Mountain	Ordovician
		3811.2 – 3859.4	Franklin Mountain	Ordovician
		3974 – 4028.5	Franklin Mountain	Ordovician
		3974 – 4028.5	Franklin Mountain	Ordovician
		3974.6 – 4028.5	Franklin Mountain	Ordovician
300E536610136450	E-53	496.5 – 516.6	Jungle Creek	Permian
		403.9 – 419.4	Jungle Creek	Permian
300F186610137450	F-18	1885.8 – 1911.7	Hart River	Mississippian
		1174.1 – 1198.5	Fishing Branch	Cretaceous
		1210.1 – 1241.8	Fishing Branch	Cretaceous
		283.5 – 315.8	Cody Creek	Cretaceous
300F486720137450	F-48	1404.8 – 1432.3	Porcupine River	Jurassic
		1204 – 1289.3	Porcupine River	Jurassic
		1289.3 – 1327.4	Porcupine River	Jurassic
300F726740137450	F-72	--	--	--
300G086610137300	G-08	673.6 – 688.8	Fishing Branch	Cretaceous
		691.9 – 710.2	Fishing Branch	Cretaceous
		1194.8 – 1207	Hart River	Mississippian
		1295.4 – 1299.1	Hart River	Mississippian
		1289.3 – 1302.4	Hart River	Mississippian
		1333.5 – 1340.2	Hart River	Mississippian
		1302.4 – 1333.5	Hart River	Mississippian
		1340.2 – 1343.3	Hart River	Mississippian
		1340.2 – 1346.3	Hart River	Mississippian
		1345.1 – 1379.2	Hart River	Mississippian
		1379.2 – 1384.4	Hart River	Mississippian
		1385.9 – 1392.9	Hart River	Mississippian
		1417.3 – 1434.4	Hart River	Mississippian
		1435 – 1462.1	Hart River	Mississippian
		1462.1 – 1506.9	Hart River	Mississippian
		1495.3 – 1530.7	Hart River	Mississippian
300I056710137150	I-05	1415.8 – 1450.2	Mount Goodenough	Cretaceous
		1421.9 – 1450.2	Mount Goodenough	Cretaceous
		1426.5 – 1450.2	Mount Goodenough	Cretaceous
		668.1 – 671.2	Fishing Branch	Cretaceous

APPENDIX A continued

UWI	Well Short Name	Drill-Stem Test Interval (m MD)	Formation/Member	Age
300I136610137450	I-13	1103.4 – 1115	Fishing Branch	Cretaceous
		1109.2 – 1162.2	Fishing Branch	Cretaceous
		1106.1 – 1162.2	Fishing Branch	Cretaceous
		1821.8 – 1845	Ettrain	Pennsylvanian
		2377.4 – 2439.6	Hart River	Mississippian
		758 – 781.8	Burnthill Creek	Cretaceous
		1823.3 – 1847.1	Ettrain	Pennsylvanian
		758 – 781.8	Burnthill Creek	Cretaceous
		757.7 – 776.6	Cody Creek	Cretaceous
300J196610137300	J-19	726.6 – 744	Fishing Branch	Cretaceous
		1239.3 – 1260.7	Hart River	Mississippian
		1264.9 – 1279.2	Hart River	Mississippian
		1278.9 – 1329.8	Hart River	Mississippian
		1330.1 – 1356.1	Hart River	Mississippian
		1356.1 – 1372.8	Hart River	Mississippian
		1409.7 – 1446.3	Hart River	Mississippian
		1377.7 – 1392.9	Hart River	Mississippian
		1396 – 1446.3	Hart River	Mississippian
300J706710137150	J-70	2053.7 – 2076.3	Mount Goodenough	Cretaceous
		2098.5 – 2127.5	Porcupine River	Jurassic
		2098.5 – 2127.5	Porcupine River	Jurassic
300K566610137450	K-56	286.2 – 291.7	Cody Creek	Cretaceous
		621.8 – 651.1	Burnthill Creek	Cretaceous
		735.5 – 754.7	Burnthill Creek	Cretaceous
		1036.6 – 1051.3	Fishing Branch	Cretaceous
		1966 – 1973	Hart River	Mississippian
300K586610136450	K-58	427 – 453	Hart River	Mississippian
		985 – 995	Hart River	Mississippian
		997 – 1007	Chance	Mississippian
		1041 – 1051	Chance	Mississippian
		1193 – 1203	Chance	Mississippian
300M086610137300	M-08	413.6 – 423.7	Cody Creek	Cretaceous
		612.3 – 620.3	Burnthill Creek	Cretaceous
		615.4 – 620.3	Burnthill Creek	Cretaceous
		607.2 – 620.3	Burnthill Creek	Cretaceous
		697.7 – 709	Fishing Branch	Cretaceous
		707.7 – 713.8	Fishing Branch	Cretaceous
		719.3 – 735.8	Fishing Branch	Cretaceous
		734.6 – 740.7	Fishing Branch	Cretaceous
		741.3 – 773.3	Fishing Branch	Cretaceous
		1226.8 – 1240.5	Hart River	Mississippian
		1240.5 – 1267.4	Hart River	Mississippian

APPENDIX A continued

UWI	Well Short Name	Drill-Stem Test Interval (m MD)	Formation/Member	Age
300M086610137300	M-08	1289 – 1304.2	Chance	Mississippian
		1289.3 – 1314.9	Chance	Mississippian
		1314.3 – 1327.1	Chance	Mississippian
		1327.1 – 1334.1	Chance	Mississippian
		1326.8 – 1337.2	Chance	Mississippian
		1337.2 – 1345.7	Chance	Mississippian
		1345.4 – 1401.2	Chance	Mississippian
		1487.4 – 1540.5	Chance	Mississippian
		1540.5 – 1581.9	Chance	Mississippian
		1565.1 – 1586.5	Chance	Mississippian
		1400.6 – 1487.4	Chance	Mississippian
		1325.9 – 1335	Chance	Mississippian
		1581.9 – 1586.5	Chance	Mississippian
		1563.6 – 1581.9	Chance	Mississippian
		1540.5 – 1563.6	Chance	Mississippian
		1548.4 – 1563.6	Chance	Mississippian
		1540.5 – 1548.4	Chance	Mississippian
		1555.7 – 1563.6	Chance	Mississippian
		1550.2 – 1553	Chance	Mississippian
		1586.5 – 1621.5	Chance	Mississippian
		1586.5 – 1621.5	Chance	Mississippian
		1586.5 – 1621.5	Chance	Mississippian
		1667 – 1685.8	Chance	Mississippian
		1667 – 1685.8	Chance	Mississippian
		1726.4 – 1738.6	Chance	Mississippian
		1754.1 – 1776.4	Chance	Mississippian
		1849.5 – 1860.2	Chance	Mississippian
		1927.9 – 1953.8	Chance	Mississippian
300M596600137000	M-59	640.7 – 649.8	Jungle Creek	Permian
		649.8 – 656.5	Jungle Creek	Permian
		656.5 – 669	Jungle Creek	Permian
		655.3 – 724.8	Jungle Creek	Permian
		749.8 – 759	Jungle Creek	Permian
		749.8 – 759	Jungle Creek	Permian
		749.8 – 759	Jungle Creek	Permian
		1770.9 – 1783.1	Hart River	Mississippian
		1895.2 – 1931.8	Hart River	Mississippian
300N056630136450	N-05	1478.3 – 1542.9	Hume	Devonian
		2046.7 – 2062.3	Gossage	Devonian
		2042.2 – 2116.5	Gossage	Devonian
		2530.1 – 2542.3	Gossage	Devonian
		2530.1 – 2542.3	Gossage	Devonian
		3499.7 – 3513.4	Franklin Mountain	Ordovician

APPENDIX A continued

UWI	Well Short Name	Drill-Stem Test Interval (m MD)	Formation/Member	Age
300N056630136450	N-05	3493 – 3513.4	Franklin Mountain	Ordovician
		3483.6 – 3513.4	Franklin Mountain	Ordovician
		3379.6 – 3393	Franklin Mountain	Ordovician
300N266610138150	N-26	1935.8 – 1939.4	Hart River	Mississippian
		1937 – 1941.9	Hart River	Mississippian
		2406.4 – 2464.3	Hart River	Mississippian
		2406.4 – 2464.3	Hart River	Mississippian
		2406.4 – 2464.3	Hart River	Mississippian
		2406.4 – 2464.3	Hart River	Mississippian
		2406.4 – 2464.3	Hart River	Mississippian
300N496650138000	N-49	1091.2 – 1194.2	Ogilvie	Devonian
		1071.4 – 1194.2	Ogilvie	Devonian
		1431 – 1438.7	Gossage	Devonian
		1447.8 – 1458.5	Gossage	Devonian
		1356.4 – 1429.5	Gossage	Devonian
		1466.1 – 1508.8	Gossage	Devonian
		2104.3 – 2145.8	Ronning	Silurian
		2069.6 – 2104.3	Ronning	Silurian
		1903.8 – 1976.6	Gossage	Devonian
		2145.8 – 2214.1	Mount Kindle	Silurian
		2214.1 – 2296.1	Mount Kindle	Silurian
		2331.7 – 2343.3	Mount Kindle	Silurian
		2327.5 – 2345.7	Mount Kindle	Silurian
		2294.2 – 2353.4	Franklin Mountain	Ordovician
		2541.4 – 2563.1	Franklin Mountain	Ordovician
		1245.1 – 1348.1	Ogilvie	Devonian
300N506720136450	N-50	–	–	–
300N536640138150	N-53	2453.6 – 2475	Landry	Devonian
		2505.5 – 2529.8	Landry	Devonian
		3305.6 – 3343.7	Franklin Mountain	Ordovician
		3305.6 – 3343.7	Franklin Mountain	Ordovician
		2952 – 3026.7	Mount Kindle	Silurian
		1161.9 – 1165.6	Imperial	Devonian
300N586600138150	N-58	–	–	–
300O226650137150	O-22	2744.4 – 2763.9	Landry	Devonian
		2534.1 – 2565.5	Ogilvie	Devonian
		2534.1 – 2565.5	Ogilvie	Devonian
		150.9 – 212.4	Eagle Plain	Cretaceous
		136.9 – 338	Eagle Plain	Cretaceous
		152.1 – 338	Eagle Plain	Cretaceous
300O786700137450	O-78	768.4 – 792.5	Imperial	Devonian
300P346710138300	P-34	2420.4 – 2434.4	Porcupine River	Jurassic

APPENDIX B. EQUATIONS AND PARAMETERS

SHALE VOLUME

Larionov Equation for Older Rocks (Larionov, 1969):

$$\mathbf{V_{sh} = 0.33 * (2^{(2*(IGR)} - 1)}$$

Where, IGR = $GR_{log} - GR_{min} / GR_{max} - GR_{min}$

V_{sh} = Shale Volume (V/V)

IGR = Gamma Ray Index

GR_{log} = Gamma Ray log reading (API)

GR_{max} = Gamma Ray maximum reading [or "shale" reading] (API)

GR_{min} = Gamma Ray minimum reading [or "clean" reading] (API)

GR "clean" and "shale" values were selected individually by well, and stratigraphic interval, by the analyst.

POROSITY

Sonic Porosity, Raymer-Hunt-Gardner (Raymer et al., 1980):

$$\mathbf{\Phi_S = 0.625 * ((\Delta T_{log} - \Delta T_{ma})/\Delta T_{log})}$$

Φ_S = Sonic Porosity (V/V)

ΔT_{log} = Log Interval Transit Time (μs/ft; μs/m)

ΔT_{ma} = Matrix Interval Transit Time (μs/ft; μs/m)

- $\Delta T_{Sandstone}$ = 180 μs/m
- $\Delta T_{Limestone}$ = 155 μs/m
- $\Delta T_{Dolomite}$ = 140 μs/m
- ΔT_{Fluid} = 620 μs/m

In Paleozoic shaly-sand intervals, matrix travel-time was selected by the analyst.

Density Porosity:

$$\mathbf{\Phi_D = (\rho_{ma} - \rho_b)/(\rho_{ma} - \rho_f)}$$

Φ_D = Density Porosity (V/V)

ρ_{ma} = Matrix Density (g/c^3; kg/m^3)

- $\rho_{Sandstone}$ = 2650 kg/m^3
- $\rho_{Limestone}$ = 2710 kg/m^3
- $\rho_{Dolomite}$ = 2870 kg/m^3
-

ρ_b = Bulk Density (g/c^3; kg/m^3) [log reading]

ρ_f = Fluid Density (g/c^3; kg/m^3)

- ρ_{oil} = 800 kg/m^3
- ρ_{water} = 1000 kg/m^3

In Paleozoic shaly-sand intervals, matrix density values were selected by the analyst.

Density/Neutron Crossplot Porosity:

Crossplot porosity methods are mathematical interpretations of published service company charts. Interpretations are based on the service company and neutron porosity type (Hydrocarbon Data Systems, 2000).

Effective Porosity:

$$\Phi_E = \Phi_T - (V_{sh} * \Phi_{sh})$$

Φ_E = Effective Porosity (V/V)

Φ_T = Total Porosity (V/V)

V_{sh} = Shale Volume (V/V)

Φ_{sh} = Shale Porosity (V/V)

Porosity Calibration to Core:

The following transforms were used to calibrate log-derived effective porosity values to routine core analysis data:

Age	Lithology	Correction Transform
Cretaceous	Clastic	Φ_{E}_cor = 0.0038 + 0.768 * Φ_E
Jurassic	Clastic	Φ_{E}_cor = -0.012 + 0.856 * Φ_E
Permian	Clastic	Φ_{E}_cor = 0.0038 + 0.768 * Φ_E
Mississippian	Clastic	Φ_{E}_cor = 0.0061 + 0.892 * Φ_E
Mississippian	Carbonate	Φ_{E}_cor = 0.0193 + 0.899 * Φ_E
Devonian	Carbonate	Φ_{E}_cor = -0.0191 + 1.394 * Φ_E
Ordovician	Carbonate	Φ_{E}_cor = 0.0016 + 0.582 * Φ_E
Φ_{E}_cor: core corrected log porosity (V/V); Φ_E: log porosity (V/V)		

PERMEABILITY

Wyllie and Rose (1950)

For Gas: $K = (79 * \Phi^3/S_{wirr})^2$

For Oil: $K = (250 * \Phi^3/S_{wirr})^2$

Coates and Dumanoir (1974)

$K = (C*\Phi^{2W}/W^4*(R_w/R_t))^2$

Where:

$C = 23 + 45 * \rho_h - (188 * \rho_h^2)$

$W^2 = (3.75 - \Phi) + [\log (R_w/R_t) + 2.2/2.0]^2$

K = permeability (mD)

C = a Coates and Dumanoir Constant

ρ_h = Hydrocarbon density in g/c^3

Φ = Porosity

R_t = Deep resistivity

W = Coates and Dumanoir constant

R_w = Formation water resistivity

S_{wirr} = Irreducible water saturation

WATER & HYDROCARBON SATURATION

Archie Equation (Archie, 1942):

$S_w = [(a * R_w / \Phi_t^m * R_t)]^{1/n}$

Silty Simandoux Equation (unpublished; modified after Simandoux, 1963):

$1/R_t = (V_{sh}^2 / R_{sh}) * S_w + (1 / F * R_w * (1 - V_{sh}^2)) * S_w^n$

Where:

$F = a / \Phi_t^m$

S_w = Water Saturation (V/V)

R_w = Formation Water Resistivity (Ωm @ Formation Temperature)

R_t = Formation Resistivity (Ωm) [log reading]

Φ_t = Total Porosity (V/V)

V_{sh} = Shale Volume (V/V)

a = tortuosity factor

m = Cementation exponent

n = Saturation exponent

Archie Parameters	Clastics	Carbonates
a	0.62	1.0
m	2.15	2.0
n	2.0	2.0

Age	Lithology	R_w @ 25°C (Ωm)
Cretaceous	Clastic	0.97
Jurassic	Clastic	0.38
Permian	Clastic	0.24
Carboniferous	Clastic/Carbonate	0.24
Devonian	Clastic/Carbonate	0.13
Ordovician	Clastic/Carbonate	0.13

Hydrocarbon Saturation :

$$S_o = 1 - S_w$$

Where:

S_o = Hydrocarbon Saturation (V/V)
S_w = Water Saturation (V/V)

APPENDIX C. TABULATED PROJECT RESULTS

Appendix C contains data unique to each well and summary data for cutoff values. These data are only available in digital format.

APPENDIX D. WIRELINE LOG ABBREVIATIONS

Raw Curves	
DEPT	Measured Depth
GR; GRS	Gamma Ray
BS; BS2	Bit Size
CALI; CALS; HCAL	Caliper
SP; SP01	Spontaneous Potential
AHT90	Array Induction; 2′ resolution; 90″ depth-of-investigation
AHT60	Array Induction; 2′ resolution; 60″ depth-of-investigation
AHT30	Array Induction; 2′ resolution; 30″ depth-of-investigation
RLA5	Laterolog Array; Borehole Corrected Resistivity 5
RLA4	Laterolog Array; Borehole Corrected Resistivity 4
RLA3	Laterolog Array; Borehole Corrected Resistivity 3
ILD	Induction Log - Deep
ILM	Induction Log - Medium
SFL	Spherically Focused Log
LL8	Laterolog 8
LN64	Long Normal - 64″
SN16	Short Normal - 16″
SN	Short Normal - 16″
RHOB; RHOZ	Bulk Density
DRHO; HDRA	Density Correction
PEFZ	PhotoElectric Factor
NPHI; NPHI01	Neutron Porosity
NEUT	Neutron Count Rate
DT; DT2	Compressional Sonic Travel Time
Interpreted Curves	
VSH	Shale Volume
PHIE	Effective Porosity
SW	Water Saturation
BVW	Bulk Volume Water
K_I	Permeability Index
SAND	Volume of Sandstone
LIME	Volume of Limestone
DOLO	Volume of Dolomite
Core Data	
PhiCor	Core Analysis Porosity
Kmax	Core Permeability - Maximum