Prince of Wales 1 Interpretive Summary

Lower Velkerri – Corcoran Interval

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PETROLEUM GEOCHEMISTRY

INTRODUCTORY NOTE

A geochemical investigation has been conducted to assess hydrocarbon prospectivity of the Upper Velkerri and Corcoran Formations in the Prince of Wales 1 well located in the McArthur Basin, Northern Territories, Australia. Thirteen (13) core chip samples from this well were analyzed by a variety of geochemical techniques, including total organic carbon (TOC, LECO®) and programmed pyrolysis (SRA). In addition, client supplied published geochemical data for 58 samples were also incorporated into the interpretive evaluation. The complete results of these analyses are documented in this report along with an integrated geochemical interpretation that is summarized in the following table.

Well Name	Formation	Main Product	Thermal Maturity	Source Rock Richness	Organic Matter Type	Shale Oil Risk
Prince of Wales 1	Lower Velkerri	**Estimated Original →**		Very Good (2.64% TOC)	Oil-prone Type II	Low
Measured Currently →		Oil	Early Oil Window	Good (1.79% TOC)	Gas-prone Type III	
Prince of Wales 1	Corcoran	**Estimated Original →**		Fair (0.74% TOC)	Oil-prone Type II	High
Measured Currently →		Oil	Late Oil Window	Poor (0.24% TOC)	Inert Type IV	

Current TOC averages represent all data available; Original TOC averages are only high graded samples that have PPy data

Table 1. Geochemical Summary

LOWER VELKERRI FORMATION

Eight (8) samples from the Lower Velkerri Formation were analyzed for LECO TOC content and programmed pyrolysis, with the remaining data set (42 samples) composed of client supplied public data (Fig. 1). The Lower Velkerri in the Prince of Wales 1 well exhibits good generative potential for petroleum source rocks based on TOC content values (Fig. 1). TOC contents ranged from 0.04 to 5.84 wt.% and averaged 1.79 wt.% (good). Twenty-eight (28) of these samples have TOC contents above the minimum requirement of 1 wt.% for *effective* petroleum source rocks, while eighteen (18) samples have TOC content above the minimum requirement of 2 wt.% for *economic* petroleum source rocks. Highest TOC content is in the basal portion the designated Lower Velkerri interval (166 m depth) and the TOC depth trends in this unit are very unique and distinctive (Fig. 1). There are two zones of elevated TOC near the top and base of the formation, while the middle section between ~50-130 m depth has much lower organic richness (generally < 0.50 wt.% TOC). The reasons for this depth trend are not know and need to be properly assessed within the context of additional geologic information.

The S1 values of the Lower Velkerri source rock samples average 0.96 mg HC/g rock (21 bbl oil/acre-ft) and S2 values average 3.01 mg HC/g rock (66 bbl oil/acre-ft). The S1 and S2 values imply fair in-situ hydrocarbon saturation and fair remaining generative potential (Fig. 1). These S1 values should be considered a minimum for in-situ oil saturation since they do not account for potential loss of volatile components during sample collection and analysis. The normalized oil content (NOC) in the Lower Velkerri samples, (S1/TOC) x 100, averages 46 (Fig. 1). NOC values of 20 to 50 are typical of low maturity source rocks, whereas values of 50 to 100 indicate possible oil staining or shows in thermally mature, tight petroleum source rocks. NOC > 100 are often associated with conventional oil reservoirs and indicate good prospectivity in unconventional shale oil plays. Jarvie (2012) has utilized a depth comparison of TOC versus programmed pyrolysis S1 yields as a potential indicator of producible hydrocarbon saturation in unconventional source rocks. When the S1 yields (reported as mg HC/g rock) exceed or "cross-over" the measured TOC content (reported as wt.%), this would be interpreted to

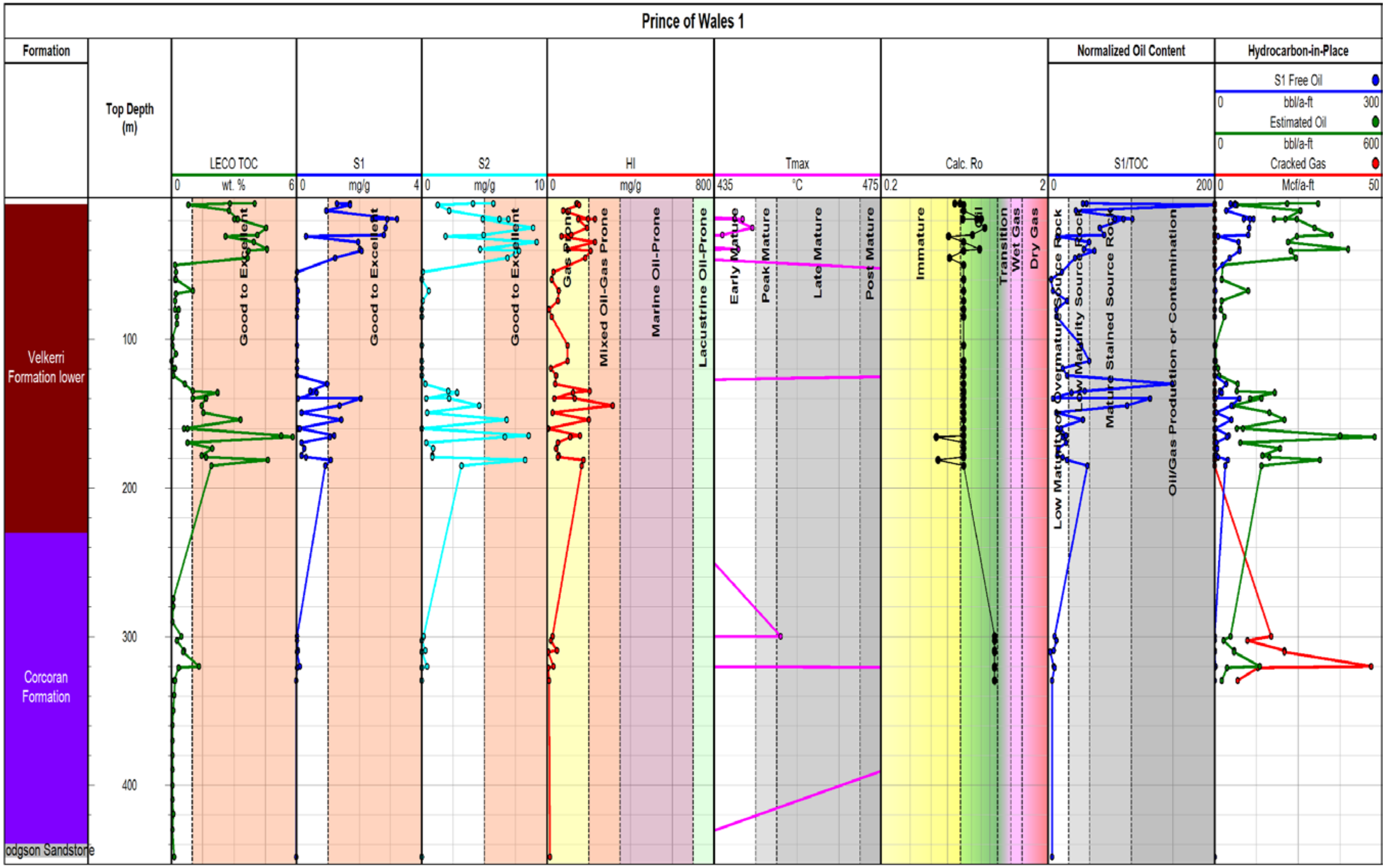

Figure 1. Geochemical depth plots for the Prince of Wales 1 well. Note Tmax values plot off scale on depth plot beyond post-mature field.

represent zones with good potential for containing producible hydrocarbon saturation (or zones of possible contamination). In the present study, there are three samples where S1 crosses over TOC within the Lower Velkerri Formation, one in the upper section at 10 m depth and two in the basal section at 130 and 140 m depth (Fig. 1), this would suggest possible producible hydrocarbons at these depths.

Measured Hydrogen Index (HI) values in the Lower Velkerri average 110 mg HC/g TOC, indicating gas-prone Type III kerogen quality in these source rocks at present day. Original HI_o of these samples are estimated to average 450 mg HC/g rock, which indicate oil-prone Type II kerogen. Transformation Ratios (TR) based upon HI average 83%, which is more consistent with a condensate/wet gas window thermal maturity. Programmed pyrolysis T_{max} values in many of these samples are quite low (< 420°C) and are considered invalid for thermal maturity assessment. T_{max} values in the Lower Velkerri samples average 433°C, on the basis of select samples determined to have reliable S2 peak shape. T_{max} between 435 and 445°C typically indicate peak oil window, while values between 425 and 435°C indicate early oil window (Type II kerogen). On the basis of these guidelines, the average Lower Velkerri T_{max} values in this well would be interpreted to be in the early oil window. Using the formula published by Jarvie et al. (2007) for Type II kerogen (Calculated $R_o = (0.0180)(T_{max}) - 7.16$), the average measured T_{max} value of 433°C is equivalent to a Calc. $\%R_o$ value of 0.63%. It is important to note that T_{max} is only a crude measure of thermal maturation (Peters, 1986) and it can be compromised by a variety of pyrolysis artifacts and caveats. In this case, pyrograms were available to visually assess S2 peaks in select samples and in several instances the peak shapes suggest possible contamination issues. No measured organic petrology data was performed on any samples from this well and thus maturity assessments on the basis of T_{max} should be considered very speculative.

Production Index (PI) values in these Lower Velkerri samples average 0.30. These elevated PI values are consistent with source rocks in the late oil window, which typically have PI values between ~0.25 to 0.35.

The thermal maturity of the Lower Velkerri source rocks was also evaluated by measured Kübler Index values from XRD, which are based upon illite crystallinity. These values can be used as maturity indicator when samples contain sufficient high quality clays (Abad, 2008). One sample from the Lower Velkerri Formation (63% clays) has a measured Kübler Index of 0.128, which is equivalent to a measured vitrinite reflectance of > 4% (late stage metagenesis). This interpretation is inconsistent with other geochemical maturity ratios evaluated in this study and suggests the Kübler Index should be used with caution to evaluate thermal maturity in Mesoproterozoic aged source rocks.

CORCORAN FORMATION

Four samples (4) from the Corcoran Formation were analyzed for LECO TOC content and programmed pyrolysis, with the remaining data set (17 samples) composed of client supplied public data (Fig. 1). The TOC content ranges from 0.05 to 1.35 wt.% and averages 0.24 wt.% (poor). None of these samples analyzed exceed the minimum value of 2.0 wt.% for *economic* petroleum source rocks (Lewan, 1987). The highest TOC occurs near the middle of the sampled interval at a depth of 320 m (Fig. 1) and samples below this depth generally have very low organic richness (< 0.10 wt.% TOC).

The S1 values in the Corcoran average only 0.04 mg HC/g rock (1 bbl oil/acre-ft), indicating poor in-situ hydrocarbon saturation (Fig. 1) and are consistent with the poor organic richness in this unit. NOC values in the Corcoran interval are much lower in comparison to the overlying strata and average only 7. Oil cross over (NOC > 100) was not observed in any of these samples. The S2 values in the Corcoran Formation average 0.14 mg HC/g rock (3 bbl oil/acre-ft), which indicates poor remaining generative potential and is consistent with an interpreted late oil window thermal maturity.

Measured HI values in these samples average 22 mg HC/g TOC, which indicate inert Type IV kerogen quality in these source rocks at present day. Estimated original HI_o values in these samples average 450 mg HC/g TOC, which indicate oil-prone Type II kerogen quality. Transformation Ratios (TR) based upon HI average 97%, which is generally more consistent with a dry gas window thermal maturity.

The organic-matter in the Corcoran interval in the Prince of Wales 1 well is thermally mature and is interpreted to be in the late oil window. Programmed pyrolysis T_{max} values average 451°C (Fig. 1), but this is based upon only a single sample where values were considered reliable. Using the formula published by Jarvie et al. (2007) for Type II kerogen (Calculated $R_o = (0.0180)(T_{max}) - 7.16$), the average measured T_{max} value of 451°C is equivalent to a Calc. %R_o value of 0.96%. It is important to note that T_{max} is only a crude measure of thermal maturation (Peters, 1986) and it can be compromised by a variety of pyrolysis artifacts and caveats. The pyrograms from samples evaluated in this study suggest possible contamination issues in this well and thus T_{max} determined maturity should be considered very speculative.

Production Index (PI) values in these Corcoran samples average 0.31. These elevated PI values are consistent with source rocks in the late oil window. The PI values are determined on samples with very low S1 and S2 yields and should also be interpreted with caution.

The thermal maturity of the Corcoran source rocks was also evaluated by measured Kübler Index values from XRD, which are based upon illite crystallinity. These values can be used as maturity indicator when samples contain sufficient high quality clays (Abad, 2008). One sample from the Corcoran Formation (69% clays) has a measured Kübler Index of 0.281, which is equivalent to a measured vitrinite reflectance of ~3.5% (early stage metagenesis). This interpretation is inconsistent with other geochemical maturity ratios evaluated in this study and suggests the Kübler Index should be used with caution to evaluate thermal maturity in Mesoproterozoic aged source rocks.

ORIGINAL GENERATIVE POTENTIAL AND HYDROCARBON YIELD CALCULATIONS

Petroleum generative capacity depends on the original quantity of organic matter (TOC_o) and the original type of organic matter (HI_o) (Peters et al., 2005, p. 97). The petroleum generation process has likely decreased the remaining generative potential as measured by TOC_{pd} and HI_{pd} in the Lower Velkerri and Corcoran source rock samples examined in this study. We can estimate the extent of the petroleum generation process, the volume of expelled oil and the expulsion efficiency by making some reasonable assumptions based on the core geochemical data and published regional information (Jarvie et al., 2007; Peters et al., 2005).

HI_o values can be computed from visual kerogen assessments and assigned kerogen-type HI_o average values using the following equation (Jarvie et al., 2007):

$$HI_o = \left(\frac{\%\text{Type I}}{100} \times 750\right) + \left(\frac{\%\text{Type II}}{100} \times 450\right) + \left(\frac{\%\text{ Type III}}{100} \times 125\right) + \left(\frac{\%\text{Type IV}}{100} \times 50\right) \quad (1)$$

This equation requires the input of maceral percentages from visual kerogen assessment of a source rock. For the present study, only limited kerogen data were available. Where available, these kerogen data sets were used. In the absence of other measured kerogen data original kerogen type were interpreted in the context of measured present day TOC, HI and OI values to arrive at an appropriate kerogen mix for each sample examined in this investigation. All samples were modeled using appropriate kerogen mix to maintain an appropriate transformation ratio consistent with the interpreted thermal maturity. The average maceral percentage in the various formations evaluated in the current study are shown in Table 2, along with the resultant average original HI_o values calculated using equation (1) above. The kerogen estimations used in this study are generally in agreement with other published values that suggest Type II to a mixed Type I/II kerogen assemblage (Law et al., 2010; Crick et al., 1988; Taylor et al., 1994).

Formation	%Type I 750 HI_o	%Type II 450 HI_o	%Type III 125 HI_o	%Type IV 50 HI_o	HI_o
Lower Velkerri	0	100	0	0	450
Corcoran	0	100	0	0	450

Table 2. Average Kerogen Estimations for Prince of Wales 1 well.

The extent of the petroleum-generation process, or transformation ratio (TR) which is also called fractional conversion, is calculated as follows (Jarvie et al., 2007, p. 497):

$$TR_{HI} = 1 - \frac{HI_{pd}[1200 - HI_o(1 - PI_o)]}{HI_o[1200 - HI_{pd}(1 - PI_{pd})]} \quad (2)$$

HI_{pd} and PI_{pd} are the measured HI and PI values for the various source rock samples in this well. The average HI_{pd} and PI_{pd} for the formations evaluated in the current study are shown in Table 3. HI_o and PI_o are the original HI and PI values for immature organic matter in the rocks. For this calculation using the assumptions described previously results in an average HI_o values of 450 mg HC/g TOC (Table 2). We assume a PI_o of 0.02 (see Peters et al., 2005). Using these values in equation 2, the extent of fractional conversion of HI_o to petroleum varies from 0.83 to 0.97 (Table 3), i.e., on average an estimated 83 to 97% of the petroleum generation process has been completed.

The original TOC_o in the source rocks before burial and thermal maturation is constrained by mass balance considerations as follows (corrected from Jarvie et al., 2007):

$$TOC_o = \frac{HI_{pd}\left(\frac{TOC_{pd}}{1+k}\right)(83.33)}{\left[HI_o(1 - TR_{HI})\left(83.33 - \left(\frac{TOC_{pd}}{1+k}\right)\right)\right] + \left[HI_{pd}\left(\frac{TOC_{pd}}{1+k}\right)\right]} \quad (3)$$

In this equation k is a correction factor based on residual organic carbon being enriched in carbon over original values at high maturity (Jarvie et al., 2007, p. 497). For Type II kerogen the increase in residual carbon C_R at high maturity is assigned a value of 15% (whereas for Type I, it is 50%, and for Type III, it is 0%) and the correction factor k is then $TR_{HI} \times C_R$. The kerogen mix for each individual sample was used in this calculation.

Using equation 3, the average estimated original TOC_o for the source rock samples in this well before petroleum generation varies from 0.74 to 2,64 wt.% (Table 3).

The original generation potential $S2_o$ can be calculated using the following equation:

$$S2_o = \left(\frac{HI_o \times TOC_o}{100}\right) \quad (4)$$

For the Lower Velkerri and Corcoran source rocks examined in the Prince of Wales 1 well, the average $S2_o$ values vary from 3.3 to 11.9 mg HC/g rock or approximately 73 to 260 bbl/acre-ft (multiply $S2_o$ by 21.89 to calculate barrels/acre-ft, Jarvie and Tobey, 1999) (Table 3).

Knowing the measured remaining generation potential S2 from programmed pyrolysis and using the calculated original generation potential $S2_o$ enables a determination of the amounts of hydrocarbons generated. A VR_o algorithm can then be applied to estimate fractional oil cracking thereby converting yields to estimated oil and cracked gas (reported as Mcf/acre-ft or thousand cubic feet/acre-ft).

$$\text{Original }(S2_o)\ -\ \text{Remaining }(S2) = \ \text{Generated HCs} \tag{5}$$

Using this methodology for the Lower Velkerri samples analyzed in the current study, the generated oil yields average 194 bbl/acre-ft (Table 3). The generated oil yield from underlying Corcoran Formation was lower with an average value of 67 bbl/acre-ft and there is a minor amount of secondary cracked gas that averages 19 Mcf/acre-ft.

Formation	TOC_{pd}	HI_{pd}	$S2_{pd}$ bbl/a-ft	HI_o	TR	TOC_o	$S2_o$ bbl/a-ft	S1 Free Oil bbl/a-ft	Est. Oil bbl/a-ft	Cracked Gas Mcf/a-ft
Lower Velkerri	2.08	110	66	450	0.83	2.64	260	21	194	0
Corcoran	0.55	22	3	450	0.97	0.74	73	1	67	19

Table 3. Hydrocarbon Yields average data for Prince of Wales 1 well.

The amount of hydrocarbons (oil + gas) expelled from the rocks can be estimated as the difference between the amount of residual oil measured via programmed pyrolysis (S1) and the amount of estimated generated hydrocarbon yields determined above (equation 5). The expulsion efficiency (ExEf) can then be calculated as a direct proportion of the measured retained oil saturations and the average generated hydrocarbon yields. Thus, the resulting expulsion efficiency for the Lower Velkerri interval is 89%, while it is 99% in the Corcoran interval.

The Lower Velkerri and Corcoran source rock intervals in the Prince of Wales 1 well are interpreted to be in the early and late oil window and hydrocarbon yield calculations suggest significant to minor amounts of generation have occurred (predominantly oil with some associated and secondary cracked gas). From an exploration risk perspective, this is favorable. However, it is useful to relate these hydrocarbon yields to other productive unconventional US Shale plays (Table 4). In doing so, the potential critical value is not necessarily the generated oil and gas yields, but also the original ($S2_o$) generation potential of the source rocks. These values related to the ultimate volumes of hydrocarbon that could be generated at depth in the basin. For the Lower Velkerri original generation potential ($S2_o$) averages 260 bbl oil/acre-ft, this is just slightly below the examples shown on the list of unconventional US Shale plays below. For the Corcoran Formation, original generation potential is much lower 67 bbl oil/acre-ft and this unit does not compare favorably with other unconventional US Shale plays.

Sample Database Averages TOC >1%	HI° mg/g TOC	TR	TOC° wt%	S2° mg/g Rock	Remaining Potential bbl/a-ft	Original Potential bbl/a-ft	Oil Cracked %	S1 Free Oil bbl/a-ft	Estimated Oil bbl/a-ft	Cracked Gas Mcf/a-ft
Barnett Shale Ft. Worth Basin	435	0.84	5.38	23.40	94	513	0.40	33	251	1005
Barnett Shale Delaware Basin	435	0.91	5.25	22.84	52	500	0.80	32	90	2149
Woodford Shale Delaware Basin	480	0.89	6.41	30.79	139	674	0.89	46	60	2854
Haynesville Shale E. Texas Basin	400	0.98	3.93	15.73	7	344	1.00	3	0	2022
Fayetteville Shale Arkoma Basin	435	0.95	3.34	14.53	15	318	1.00	10	0	1820
Woodford Shale Arkoma Basin	520	0.87	5.15	26.80	12	587	0.70	87	170	2431
Eagle Ford Shale Gulf Coast Basin	520	0.85	3.19	16.61	61	364	0.47	22	161	848
Marcellus Shale Appalachian Basin	600	0.97	6.44	38.66	34	847	1.00	24	0	4875
Utica Shale Appalachian Basin	450	0.98	2.74	12.32	6	270	1.00	12	0	1585
Barnett Shale Oil	450	0.47	5.47	24.64	326	540	0.00	79	213	0
Barnett Shale Gas	450	0.96	5.58	25.13	23	550	0.87	7	68	2751
Lower Velkerri	450	0.83	2.64	11.86	66	260	0.00	21	194	0
Corcoran	450	0.97	0.74	3.34	3	73	0.05	1	67	19

Table 4. Geochemical Properties and Generation Potential for US Shale plays and current study.

UNCONVENTIONAL OIL & GAS RISK ASSESSMENT

The Mesoproterozoic Lower Velkerri and Corcoran Formation source rocks in the Prince of Wales 1 well have been evaluated for unconventional oil and gas potential. These source rock samples are presented in a modified geochemical risk assessment diagram (Fig. 2) based upon published results from the Barnett Shale in the Fort Worth Basin. The data illustrated in the star plot represents average values for three of the four diagnostic ratios (measured R_o data was unavailable). Also shown are the recommended areas for unconventional oil (in green) and gas (in red). Data that lies above the minimum threshold and within the shaded areas indicates samples with low geochemical risk for either thermogenic oil or gas production. Data that lie below the minimum threshold and fall in the immature region (in gray) indicate a high risk for commercial shale oil or gas production. Transformation ratios (TR) were calculated based upon HI_o estimates using measured and interpreted fractional composition of kerogen macerals.

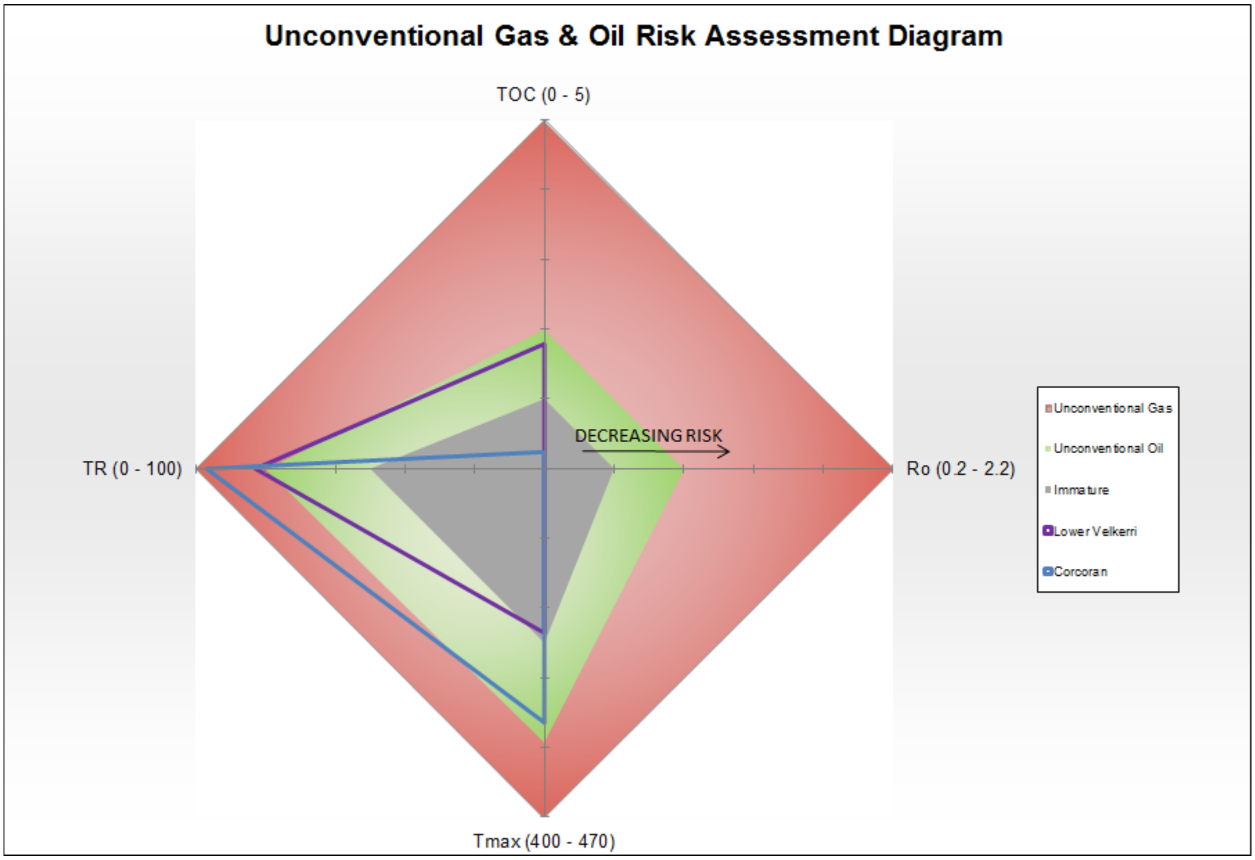

Figure 2. Geochemical Risk Assessment diagram for Mesoproterozoic Lower Velkerri and Corcoran Formation source rocks in the Prince of Wales 1 well.

The Lower Velkerri source rock interval in the Prince of Wales 1 well is interpreted to represent a low geochemical risk for in-situ shale oil production. The average TOC content of 1.79 wt.% is above the generally accepted minimum value of 1% TOC to be considered an *effective* source rock for hydrocarbon generation/expulsion (Fig. 2). It is somewhat below the minimum requirements of 2 wt.% for *economic* petroleum source rocks, however, depth trends show two horizons in both the upper and lower sections of this interval where TOC values do generally exceed 2 wt.% (Fig. 1). Original organic matter type is interpreted to be predominantly oil-prone Type II marine algal kerogen. Thermal maturity parameters from programmed pyrolysis are considered speculative but place the Lower Velkerri source interval in the early oil window. The average Tmax value of 433°C is just below the recommended minimum value of 435°C for shale oil and well below the minimum of 455°C for shale gas (Fig. 2). However, as noted previoiusly this value is based upon a few select samples where Tmax was assessed to be somewhat reliable and thus it is not considered to be as much of a risk for this well. Even this amount of conversion would likely be sufficient to generate/expel significant amounts of hydrocarbons from this organic-rich, oil prone source facies, especially in the upper/lower zones where TOC is elevated. Transformation Ratios (TR), the least constrained risk parameter, average 83% and fall above the recommended minimum of 50% for shale oil systems and the 80% threshold for shale gas (Fig. 2). On the basis of all of these measured geochemical risk parameters, the Lower Velkerri source interval would be considered a low risk for shale oil and a high risk for shale gas.

In contrast, the underlying Corcoran Formation source rock interval in the Prince of Wales 1 well is interpreted to represent a high geochemical risk for in-situ shale oil production. The Corcoran samples have an average TOC of only 0.24 wt.% (Fig. 2) and only one sample exceeds the recommended minimum threshold of 1% TOC for shale oil systems (Fig. 1) Thermal maturity indicators suggest late window maturity. On the risk assessment diagram, average Tmax value of 451°C is above the recommended minimum value of 435°C for shale oil and the Transformation Ratio of 97% is also above the minimum threshold for shale oil and shale gas (Fig. 2). On the basis of all of these measured geochemical risk parameters, the Corcoran source interval would be considered a high risk for shale oil because despite having sufficient thermal maturity it has insufficient organic richness (Fig. 2).

In the Lower Velkerri source interval, measured in-situ oil saturation determined by programmed pyrolysis S1 yields is fair (avg. 21 bbl oil/acre-ft) (Fig. 3), but zones in both the upper and lower intervals have generally higher saturations (20-70 bbl oil/acre-ft) suggesting low risk for shale oil development. Hydrocarbon yield calculations on as-received samples show estimates of average generated oil from the Lower Velkerri at 194 bbl oil/acre-ft. As a comparison, a representative example from the core area of Barnett Shale oil production in the Fort Worth Basin has an estimated generated oil yield of 213 bbl/a-ft with a measured in-situ oil saturation of 79 bbl/a-ft. These values are somewhat higher in comparison to the Lower Velkerri due primarily to differences in organic richness (Barnett Shale oil example has avg. 4.70 wt.% TOC).

In the Corcoran source interval, measured in-situ oil saturation determined by programmed pyrolysis S1 yields is poor (avg. 1 bbl oil/acre-ft), suggesting high risk for shale oil development (Fig. 3). Hydrocarbon yield calculations on as-received samples show estimates of average generated oil from the Corcoran at 67 bbl oil/acre-ft along with 19 Mcf/acre-ft of secondary cracked gas. These low values suggest a high risk for shale oil and shale gas within the Corcoran interval.

It is important to note that the quantity of oil generated from a potential source rock is only one geochemical factor to consider in regard to risk assessment. Equally important is the quality of the oil generated, since this factor can be a critical element in assessing the movability and ultimate recovery. The interpreted thermal maturity of the Lower Velkerri and Corcoran source intervals in this well is tentatively interpreted to be in the early to late oil window and hydrocarbon saturation is likely to vary from relatively heavy to light and mobile with increasing depth/thermal maturity. The presence of heavy oil and/or bitumen could also indicate a source interval with restricted microporosity. Such microporosity is considered necessary for recovery of in-situ oil saturation and can be better assessed using scanning electron microscopy (SEM). Source rock extract fingerprints and bulk fractional compositional analyses from select Velkerri samples would also aid in the determination of the quality of the in-situ hydrocarbon saturation and provide a better assessment of their movability and ultimate recovery potential.

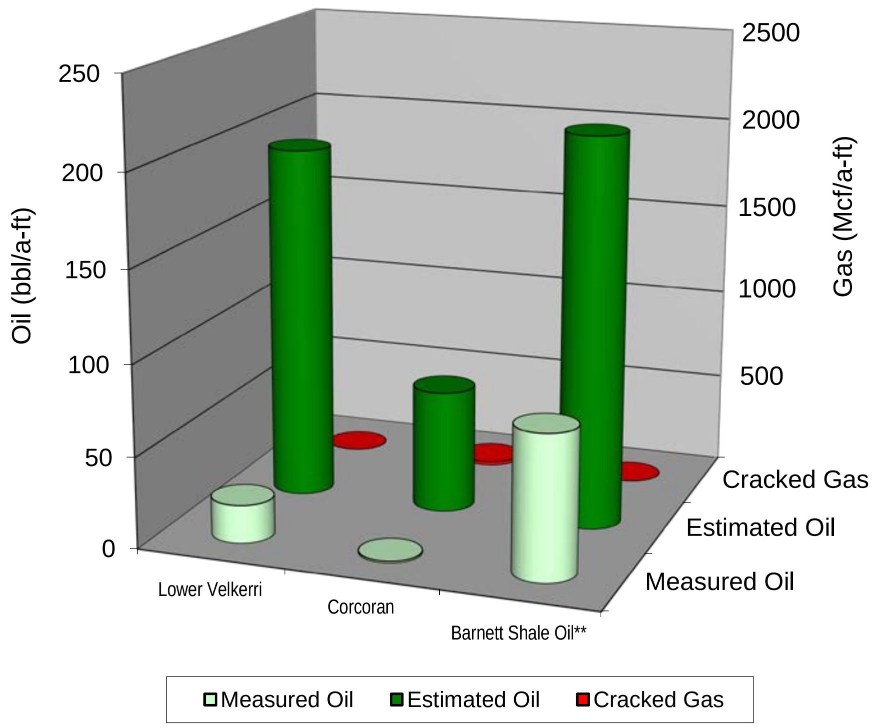

Figure 3. Hydrocarbon yield estimates for the Mesoproterozoic source rocks in the Prince of Wales 1 well compared to Barnett Shale in the oil window.

GEOCHEMICAL SUMMARY

The Lower Velkerri source interval in the Prince of Wales 1 well is interpreted to represent low geochemical risk for unconventional shale oil development. It clearly has elevated organic richness (avg. 1.79 wt.% TOC) and is considered a good source rock with dominantly oil-prone Type II kerogen. Thermal maturity parameters are considered somewhat speculative but they indicate that the source interval is in the early oil window, 0.63% Calc. R_o, and key risk ratios like the Transformation Ratio of 83% are above recommended minimum thresholds for shale oil systems. The Lower Velkerri has likely generated significant amounts of oil (avg. 194 bbl oil/acre-ft) and comparison to other systems such as the Barnett Shale show in-situ oil saturations (avg. 21 bbl oil/acre-ft) are much lower for the Lower Velkerri. Risk criteria like the S1 versus TOC show some oil cross-over and generally more elevated values of hydrocarbon saturation in both the upper and lower zones of this unit. Further evaluation of in-situ oil characteristics would be required to fully evaluate potential oil mobility and recovery risk.

The Corcoran Formation source rock interval evaluated in the Prince of Wales 1 well generally has higher risk in comparison to the Lower Velkerri. This horizon has poor organic richness, with the average 0.24 wt% TOC being well below the minimum threshold for shale oil. The estimated generated oil is low (avg. 67 bbl oil/acre-ft) in the Corcoran and measured in-situ oil saturation determined by S1 yields is also very low (avg. 1 bbl oil/acre-ft). Thus, the Corcoran Formation in this well is considered a high risk for shale oil development.

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Appendix I

Hydrocarbon Yield Calculation
Shelf Group
Prince of Wales 1

McArthur Basin Integrated Petroleum Geochemistry, 2016

Northern Territory Geological Survey - Australia

Weatherford®
LABORATORIES

Prince of Wales 1

Hydrocarbon Yield Calculation

Sample	Top Depth	TOC*	HI*	S1*	S2*	Calc.Ro	PI*	%Type IV 50 HIº	% Type III 125 HIº	%Type II 450 HIº	%Type I 750 HIº	HIº	TR	TOCº	S2º	S2 (meas) Remaining Potential	S2 (orig) Original Potential	Oil Cracked	S1 Free Oil	Estimated Oil	Cracked Gas
Prince of Wales 1	(m)	wt%	mg/g TOC	mg/g Rock	mg/g Rock	%						mg/g TOC		wt%	mg/g Rock	bbl/a-ft	bbl/a-ft	%	bbl/a-ft	bbl/a-ft	Mcf/a-ft
	9	4.02	143	1.73	5.76	**0.60**	0.23	0	0	100	0	450	0.78	5.07	22.83	126	500	0.00	38	374	0
	9	2.82	145	1.31	4.10	**0.56**	0.24	0	0	100	0	450	0.77	3.58	16.11	90	353	0.00	29	263	0
1329852	10	0.83	157	1.71	1.30	0.63	0.57	0	0	100	0	450	0.77	1.11	4.98	28	109	0.00	37	80	0
UR14DJR029	14	2.76	80	0.95	2.21	0.63	0.30	0	0	100	0	450	0.88	3.62	16.29	48	357	0.00	21	308	0
1329874	20	3.20	153	2.92	4.91	**0.76**	0.37	0	0	100	0	450	0.77	4.11	18.49	108	405	0.00	64	298	0
	20	3.03	230	2.44	6.97	**0.62**	0.26	0	0	100	0	450	0.62	3.71	16.72	153	366	0.00	53	213	0
	20	3.15	197	3.22	6.21	**0.80**	0.34	0	0	100	0	450	0.69	3.97	17.86	136	391	0.00	71	255	0
UR14DJR030	25	4.57	195	2.86	8.89	**0.84**	0.24	0	0	100	0	450	0.69	5.64	25.37	195	556	0.00	63	361	0
1329873	30	4.15	120	2.81	4.96	**0.71**	0.36	0	0	100	0	450	0.82	5.36	24.10	109	528	0.00	62	419	0
	31	2.63	73	0.32	1.91	**0.51**	0.14	0	0	100	0	450	0.89	3.43	15.43	42	338	0.00	7	296	0
UR14DJR031	35	3.95	233	1.97	9.21	0.63	0.18	0	0	100	0	450	0.61	4.74	21.32	202	467	0.00	43	265	0
1329872	40	4.60	102	2.03	4.71	**0.78**	0.30	0	0	100	0	450	0.85	5.93	26.67	103	584	0.00	44	481	0
	40	3.70	211	2.08	7.82	0.63	0.21	0	0	100	0	450	0.65	4.52	20.34	171	445	0.00	46	274	0
UR14DJR032	45	3.68	186	1.23	6.85	**0.52**	0.15	0	0	100	0	450	0.70	4.51	20.28	150	444	0.00	27	294	0
UR14DJR034	55	0.23	35	0.04	0.08	0.63	0.33	0	0	100	0	450	0.95	0.31	1.40	2	31	0.00	1	29	0
	60	0.21	24	0.01	0.05	0.63	0.17	0	0	100	0	450	0.97	0.28	1.28	1	28	0.00	0	27	0
	68	1.04	59	0.07	0.61	0.63	0.10	0	0	100	0	450	0.91	1.37	6.19	13	135	0.00	2	122	0
	75	0.21	52	0.05	0.11	0.63	0.31	0	0	100	0	450	0.92	0.28	1.27	2	28	0.00	1	25	0
	80	0.18	11	0.02	0.02	0.63	0.50	0	0	100	0	450	0.98	0.25	1.11	0	24	0.00	0	24	0
UR14DJR035	85	0.27	22	0.03	0.06	0.63	0.33	0	0	100	0	450	0.97	0.37	1.65	1	36	0.00	1	35	0
	105	0.05	100	0.02	0.05	0.63	0.29	0	0	100	0	450	0.85	0.07	0.30	1	6	0.00	0	5	0
	115	0.04	100	0.02	0.04	0.63	0.33	0	0	100	0	450	0.85	0.05	0.24	1	5	0.00	0	4	0
	120	0.11	18	0.02	0.02	0.63	0.50	0	0	100	0	450	0.97	0.15	0.68	0	15	0.00	0	14	0
	125	0.13	46	0.03	0.06	0.63	0.33	0	0	100	0	450	0.93	0.18	0.79	1	17	0.00	1	16	0
1329723	130	0.67	42	1.00	0.28	0.63	0.78	0	0	100	0	450	0.94	0.92	4.13	6	90	0.00	22	84	0
	135	1.04	208	0.46	2.16	0.63	0.18	0	0	100	0	450	0.66	1.28	5.75	47	126	0.00	10	79	0
UR14DJR036	136	2.22	128	0.64	2.84	0.63	0.18	0	0	100	0	450	0.80	2.83	12.74	62	279	0.00	14	217	0
1329718	140	1.68	133	2.06	2.23	0.63	0.48	0	0	100	0	450	0.80	2.22	9.97	49	218	0.00	45	169	0
	140	1.03	38	0.07	0.39	0.63	0.15	0	0	100	0	450	0.95	1.38	6.21	9	136	0.00	2	127	0
	145	1.45	319	1.38	4.62	0.63	0.23	0	0	100	0	450	0.44	1.70	7.67	101	168	0.00	30	67	0
1329722	150	1.57	30	0.17	0.47	0.63	0.27	0	0	100	0	450	0.96	2.11	9.50	10	208	0.00	4	198	0
	155	3.33	204	1.43	6.80	0.63	0.17	0	0	100	0	450	0.67	4.06	18.27	149	400	0.00	31	251	0
1329719	160	0.77	1	0.12	0.01	0.63	0.92	0	0	100	0	450	1.00	1.05	4.74	0	104	0.00	3	104	0
	160	0.60	7	0.07	0.04	0.63	0.64	0	0	100	0	450	0.99	0.82	3.70	1	81	0.00	2	80	0
	165	5.29	161	1.21	8.54	0.63	0.12	0	0	100	0	450	0.74	6.49	29.21	187	640	0.00	26	453	0
UR14DJR037	166	5.84	115	1.06	6.69	**0.43**	0.14	0	0	100	0	450	0.82	7.33	33.00	147	723	0.00	23	576	0
1329720	170	0.77	52	0.17	0.40	0.63	0.30	0	0	100	0	450	0.92	1.03	4.64	9	102	0.00	4	93	0
	174	1.96	47	0.26	0.92	0.63	0.22	0	0	100	0	450	0.93	2.61	11.73	20	257	0.00	6	237	0
	179	1.46	59	0.17	0.86	0.63	0.17	0	0	100	0	450	0.91	1.93	8.69	19	190	0.00	4	172	0
1329721	180	1.66	53	0.31	0.88	0.63	0.26	0	0	100	0	450	0.92	2.21	9.94	19	218	0.00	7	198	0
	181	4.66	178	1.10	8.29	**0.44**	0.12	0	0	100	0	450	0.71	5.68	25.55	182	560	0.00	24	378	0
1329821	185	1.92	168	0.92	3.22	0.63	0.22	0	0	100	0	450	0.74	2.42	10.87	71	238	0.00	20	168	0
Lower Velkerri (Avg)		**2.08**	**110**	**0.96**	**3.01**	**0.63**	**0.30**	**0**	**0**	**100**	**0**	**450**	**0.83**	**2.64**	**11.86**	**66**	**260**	**0.00**	**21**	**194**	**0**
1408230	300	0.49	31	0.04	0.15	**0.96**	0.21	0	0	100	0	450	0.96	0.66	2.98	3	65	0.04	1	59	17
UR14DJR038	303	0.28	18	0.03	0.05	0.96	0.38	0	0	100	0	450	0.97	0.38	1.69	1	37	0.05	1	34	10
1408231	310	0.62	48	0.05	0.30	0.96	0.14	0	0	100	0	450	0.93	0.83	3.72	7	82	0.05	1	72	21
UR14DJR039	310	0.56	5	0.02	0.03	0.96	0.40	0	0	100	0	450	0.99	0.77	3.47	1	76	0.05	0	72	21
1408232	320	1.35	31	0.10	0.42	0.96	0.19	0	0	100	0	450	0.96	1.81	8.16	9	179	0.05	2	162	47
UR14DJR040	321	0.35	9	0.03	0.03	0.96	0.50	0	0	100	0	450	0.99	0.48	2.16	1	47	0.05	1	44	13
UR14DJR041	330	0.20	10	0.01	0.02	0.96	0.33	0	0	100	0	450	0.99	0.27	1.21	0	26	0.05	0	25	7
Corcoran (Avg)		**0.55**	**22**	**0.04**	**0.14**	**0.96**	**0.31**	**0**	**0**	**100**	**0**	**450**	**0.97**	**0.74**	**3.34**	**3**	**73**	**0.05**	**1**	**67**	**19**
Barnett Shale Oil**		4.70	300	3.60	14.90	0.86	0.20	0	0	100	0	450	0.47	5.47	24.64	326	540	0.00	79	213	0
Barnett Shale**		4.21	26	0.33	1.07	1.66	0.24	0	0	100	0	450	0.96	5.58	25.13	23	550	0.87	7	68	2751

Notes: Calc.Ro values in **bold** are calculated from measured Tmax. Calc.Ro values in red font are intrepreted from other geochemical maturity data because Tmax was considered unreliable. All other Calc.Ro values are formation specific averages because Tmax was considered unreliable.

Kerogen Type in **bold** have visual kerogen data for estimates TR = Transformation Ratio (fractional conversion) (Original Potential - Remaining Potential) = (Estimated Oil + Cracked Gas)

Estimated Oil and Cracked Gas yield data assume complete conversion and no expulsion of hydrocarbon products and the proportion between each is based on empirical Ro calculated % cracking.

Yields do not represent recoverable products and are intended primarily for comparison purposes, yield calculations based on carbon mass balance are likely to be overestimations. **Estimated parameters for productive Barnett Shale in the Ft. Worth Basin

Hydrocarbon yield calculations and formulas are fully documented in the appendix section of Jarvie et al. (2007)