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Scarborough 1 Interpretive Summary

Kyalla – Corcoran Interval

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INTRODUCTORY NOTE

A geochemical investigation has been conducted to assess hydrocarbon prospectivity of the Kyalla, Upper, Middle and Lower Velkerri, and Corcoran Formations in the Scarborough 1 well located in the McArthur Basin, Northern Territories, Australia. Nineteen (19) 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 73 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
Scarborough 1	Kyalla	**Estimated Original →**		Very Good (2.22% TOC)	Oil-prone Type II	Moderate
Measured Currently →		Oil	Peak Oil Window	Very Good (2.06% TOC)	Gas-prone Type III	
Scarborough 1	Upper Velkerri	**Estimated Original →**		Good (1.45% TOC)	Oil-prone Type II	Low
Measured Currently →		Oil	Peak Oil Window	Good (1.02% TOC)	Gas-prone Type III	
Scarborough 1	Middle Velkerri	**Estimated Original →**		Very Good (3.80% TOC)	Oil-prone Type II	Low
Measured Currently →		Oil	Peak Oil Window	Very Good (2.85% TOC)	Gas-prone Type III	
Scarborough 1	Lower Velkerri	**Estimated Original →**		Very Good (3.32% TOC)	Oil-prone Type II	High
Measured Currently →		Oil	Late Oil Window	Fair (0.87% TOC)	Gas-prone Type III	
Scarborough 1	Corcoran	**Estimated Original →**		Fair (0.69% TOC)	Oil-prone Type II	High
Measured Currently →		Minor Oil Wet Gas	Wet Gas Window	Poor (0.34% 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

KYALLA FORMATION

Three samples (3) from the Kyalla Formation were analyzed for LECO TOC content and programmed pyrolysis (Fig. 1). TOC contents ranged from 0.67 to 3.35 wt.% and averaged 2.06 wt.% (very good). Two (2) samples have TOC content that is above the minimum requirement of 1 wt.% for *effective* petroleum source rocks, while these same samples also have TOC content above the minimum requirement of 2 wt.% for *economic* petroleum source rocks. Highest TOC content was found near the base of the designated Kyalla interval (49.4 m depth) (Fig. 1) and there is a progressive trend of decreasing TOC toward the surface contact, which could indicate some weathering artifacts.

The S1 values of the Kyalla source rock samples average 0.16 mg HC/g rock (3 bbl oil/acre-ft) and S2 values average 3.22 mg HC/g rock (71 bbl oil/acre-ft). The S1 and S2 values imply poor in-situ hydrocarbon saturation and fair remaining generative potential (Fig. 1). The normalized oil content (NOC) in the Kyalla samples, (S1/TOC) x 100, averages 8 (Fig. 1). NOC values of 20 to 50 are typical of low

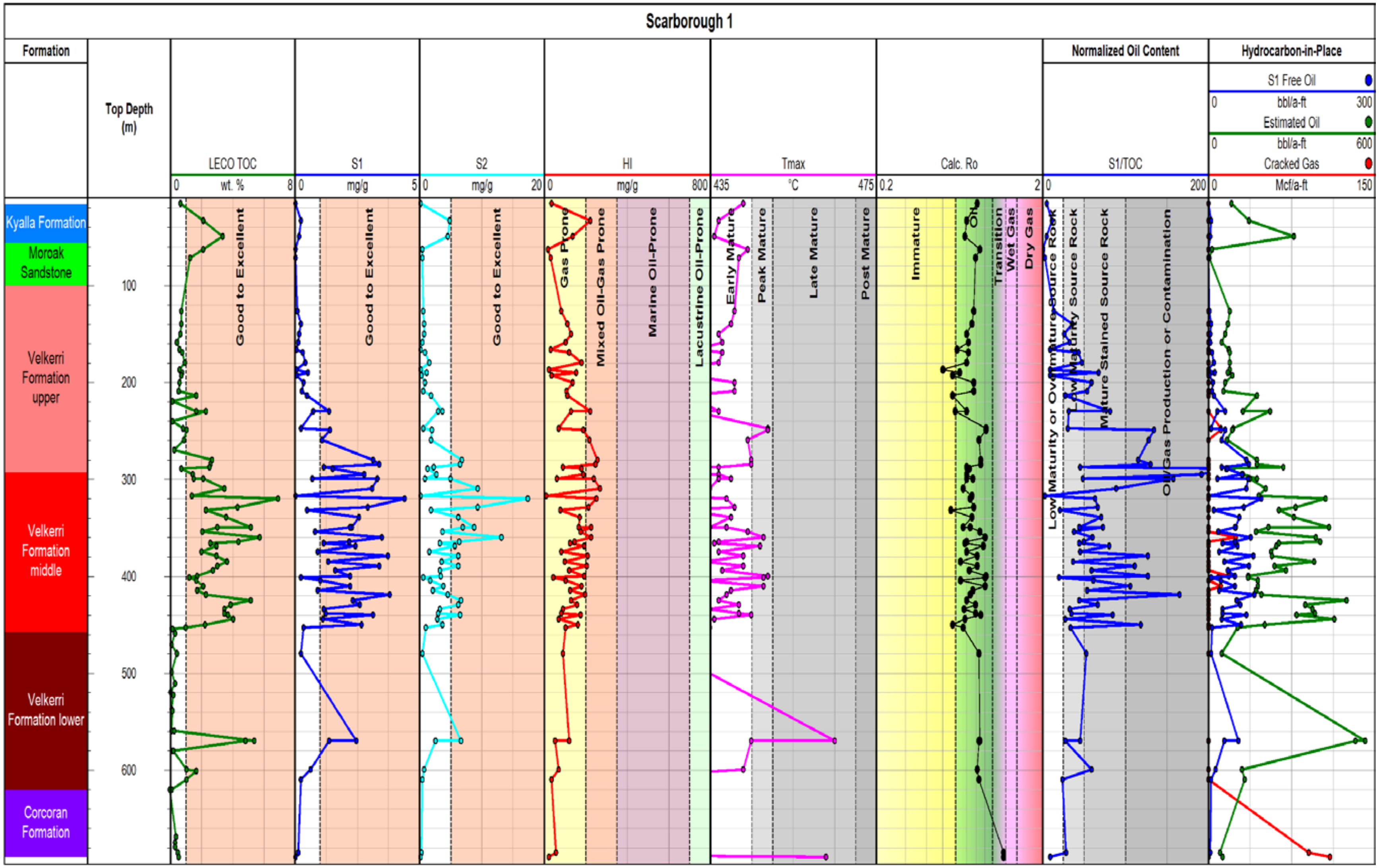

Figure 1. Geochemical depth plots for the Scarborough 1 well.

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. Very low NOC values < 20 are most likely related to post-mature source rocks that have likely generated and expelled most of their in-situ hydrocarbon saturation or source rocks with poor original hydrocarbon generation capacity. 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 represent zones with good potential for containing producible hydrocarbon saturation (or zones of possible contamination). In the present study, there is no S1 cross over TOC in any of the Kyalla samples analyzed (Fig. 1).

Measured Hydrogen Index (HI) values in the Kyalla average 133 mg HC/g TOC, indicating gas-prone Type III kerogen quality in these source rocks at present day (Fig. 1). Original HI_o of these samples are estimated to average 450 mg HC/g rock, which indicate oil-prone Type I/II kerogen. Transformation Ratios (TR) based upon HI average 78%, which is consistent with an peak oil window thermal maturity. T_{max} values in the Kyalla samples average 438°C. T_{max} between 425 and 435°C typically indicate early oil window, while values between 435 and 445°C indicate peak oil window (Type II kerogen). On the basis of these guidelines, the average Kyalla T_{max} values in this well would be interpreted to be in the peak 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 438°C is equivalent to a Calc. %R_o value of 0.73%. 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.

Production Index (PI) values in these Kyalla samples average 0.07. These low PI values are consistent with immature source, which typically have PI values < 0.10. Samples in the early oil window tend to have PI values in the range of ~0.10 to 0.15.

The thermal maturity of the Kyalla Formation source rocks was also evaluated using 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 (1) sample from the base of the Kyalla at 49.4 m depth (69% clays) has a measured Kübler Index of 0.245, which is equivalent to a measured vitrinite reflectance of >4% (late stage metagenesis). This interpretation is inconsistent with the other geochemical data reported in this study and suggests the Kübler Index should be used with caution to evaluate thermal maturity in Mesoproterozoic aged source rocks.

UPPER VELKERRI FORMATION

No samples from the Upper Velkerri Formation were analyzed for LECO TOC content and programmed pyrolysis, so the entire data set (25 samples) is composed of client supplied public data (Fig. 1). The Upper Velkerri Formation in the Scarborough 1 well exhibits good generative potential for petroleum source rocks based on TOC content values (Fig. 1). TOC content ranges from 0.15 to 2.70 wt.% and averages 1.02 wt.% (good). Seven (7) samples have TOC content that is above the minimum requirement of 1 wt.% for *effective* petroleum source rocks, while four (4) samples analyzed exceed the minimum value of 2.0 wt.% for *economic* petroleum source rocks (Lewan, 1987). High TOC samples occur primarily in the lower portion of the sampled interval > 200 m depth and show an increasing trend into the underlying Middle Velkerri (Fig. 1).

The S1 values in the Upper Velkerri average 0.79 mg HC/g rock (17 bbl oil/acre-ft), indicating fair in-situ hydrocarbon saturation (Fig. 1) and appear to trend with TOC in this source rock interval. These 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. NOC values in the Upper Velkerri interval are much higher in comparison to the Kyalla Formation and average 70. Oil cross over (NOC > 100) was observed in in several samples from the lower portion of this interval > 250 m depth (Fig. 1), which suggests possible producible hydrocarbons. The S2 values in the Upper Velkerri average 1.75 mg HC/g rock (38 bbl oil/acre-ft), indicating poor remaining hydrocarbon generation potential.

Measured HI values in these samples average 134 mg HC/g TOC, which indicate gas-prone Type III 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 79%, which is consistent with a peak to late oil window thermal maturity.

The organic-matter in the Upper Velkerri interval in the Scarborough 1 well is thermally mature and is interpreted to be in the peak oil window. Programmed pyrolysis T_{max} values average 438°C (Fig. 1). 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 438°C is equivalent to a Calc. %R_o value of 0.73%. 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.

Production Index (PI) values in these Upper Velkerri samples average 0.28. These elevated PI values are consistent with source rocks in the late oil window, which tend to have values between ~0.25 to 0.35. The PI values tend to increase toward the base of the Upper Velkerri interval and are generally elevated in the same zone where NOC values are also highest. This suggests possible producible in-situ oil saturation within this horizon.

MIDDLE VELKERRI FORMATION

Thirteen (13) samples from the Middle Velkerri Formation were analyzed for LECO TOC content and programmed pyrolysis, with the remaining data set (24 samples) composed of client supplied public data (Fig. 1). TOC contents ranged from 0.10 to 6.90 wt.% and averaged 2.85 wt.% (very good). Twenty-seven (27) of these samples exceed the minimum requirement of 2 wt.% for *economic* petroleum source rocks. There are three distinct cycles of TOC within this interval with maxima occurring at depths of 320, 360 and 425 m (Fig. 1). These three organic rich intervals have been previously recognized within the Middle Velkerri (Lanigan et al, 1994) and could be associated with the base of transgressive systems tracts (TST) in a series of platform/ramp parasequences (Bohacs et al., 2013). These stepwise changes in TOC and corresponding minimal change in Hydrogen Index values (HI) suggests that production was the major control on organic richness along with auto-dilution by pelagic carbonate (Bohacs et al., 2013).

The S1 values in the Middle Velkerri source rock samples average 2.03 mg HC/g rock (45 bbl oil/acre-ft) and S2 values are moderate with an average 4.92 mg HC/g rock (108 bbl oil/acre-ft). The S1 and S2 values imply very good in-situ hydrocarbon saturation and fair remaining generative potential (Fig. 1). The normalized oil content (NOC) in the Middle Velkerri samples average 68 and there are multiple samples exhibiting oil “cross-over”, notably in the very top and basal sections of this source rock interval (Fig. 1). This would be interpreted to represent zones with high potential for containing producible hydrocarbon saturation.

Measured Hydrogen Index (HI) values in the Middle Velkerri average 152 mg HC/g TOC, indicating gas-prone Type III kerogen quality in these source rocks at present day (Fig. 1). 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 76%, which is consistent with a peak to late oil window thermal maturity. T_{max} values in the Middle Velkerri samples average 439°C. T_{max} between 435 and 445°C indicate peak oil window (Type II kerogen), so these samples would be interpreted to be within the middle of the peak 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 439°C is equivalent to a Calc. %R_o value of 0.75%. 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.

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

LOWER VELKERRI FORMATION

One (1) sample from the Lower Velkerri Formation was analyzed for LECO TOC content and programmed pyrolysis, with the remaining data set (19 samples) composed of client supplied public data (Fig. 1). TOC contents ranged from 0.05 to 5.04 wt.% and averaged 0.87 wt.% (fair). Five (5) of these samples have TOC contents above the minimum requirement of 1 wt.% for *effective* petroleum source rocks, while two (2) samples exceed the minimum requirement of 2 wt.% for *economic* petroleum source rocks . Elevated TOC appears to occur in a narrow interval of ~20 m that maximizes at a depth of 570 m (Fig. 1), while most of the upper section of this interval has poor organic richness.

The S1 values in the Lower Velkerri source rock samples average 0.99 mg HC/g rock (22 bbl oil/acre-ft) for the select samples chosen for programmed pyrolysis analysis. The S2 values for these five samples average 2.17 mg HC/g rock (47 bbl oil/acre-ft). The S1 and S2 values imply generally fair in-situ hydrocarbon saturation and poor remaining generative potential (Fig. 1). The normalized oil content (NOC) in the Lower Velkerri samples average 38 (Fig. 1) and there is no oil "cross-over" observed in any of these samples.

Measured Hydrogen Index (HI) values in the Lower Velkerri average 76 mg HC/g TOC, indicating gas-prone Type III kerogen quality in these source rocks at present day (Fig. 1). 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 89%, which is consistent with a wet gas/condensate window thermal maturity.

The organic-matter in the Lower Velkerri interval in the Scarborough 1 well is thermally mature and is interpreted to be in the late oil window. T_{max} values from select data deemed reliable gives an average 444°C. T_{max} between 435 and 445°C typically indicate peak oil window, while values between 445 and 450°C suggest late 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 later part of the peak oil gas 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 444°C is equivalent to a Calc. $\%R_o$ value of 0.83%. 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.

Production Index (PI) values in the Lower Velkerri samples average 0.36. These elevated PI values are generally consistent with source rocks in the late oil window, which typically have PI values between ~0.25 and 0.35.

CORCORAN FORMATION

No samples from the Corcoran Formation were analyzed for LECO TOC content and programmed pyrolysis, so the remaining data set (5 samples) is composed of client supplied public data (Fig. 1). TOC contents ranged from 0.31 to 0.54 wt.% and averaged 0.34 wt.% (poor). None of these samples exceeds the minimum requirement of 1 wt.% for *effective* petroleum source rocks. Highest TOC was found at the base of the sampled interval at a depth of 690 m (Fig. 1).

The S1 values in the Corcoran source rock samples average only 0.10 mg HC/g rock (2 bbl oil/acre-ft) and S2 values are very low with an average 0.21 mg HC/g rock (5 bbl oil/acre-ft). The S1 and S2 values imply poor in-situ hydrocarbon saturation and poor remaining generative potential (Fig. 1). The normalized oil content (NOC) in the Corcoran samples average 18 (Fig. 1) and there no samples exhibiting oil "cross-over".

Measured Hydrogen Index (HI) values in the Corcoran Formation average only 42 mg HC/g TOC, indicating inert Type IV kerogen quality in these source rocks at present day (Fig. 1). 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 94%, which is consistent with dry gas window thermal maturity.

The organic-matter in the Corcoran interval in the Scarborough 1 well is thermally mature and is interpreted to be in the condensate/wet gas window. Programmed pyrolysis T_{max} value for one sample considered reliable is 463°C (Fig. 1). Using the formula published by Jarvie et al. (2007) for Type II kerogen (Calculated R_o = (0.0180)(T_{max}) – 7.16), the measured T_{max} value of 463°C is equivalent to a Calc. %R_o value of 1.17%. 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 limited number of samples analyzed from this interval makes the interpretation of thermal maturity somewhat speculative and given the context of the overlying strata this interval could still be within the late oil window.

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

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 Kyalla, 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
Kyalla	0	100	0	0	450
Upper Velkerri	0	100	0	0	450
Middle Velkerri	0	100	0	0	450
Lower Velkerri	0	100	0	0	450
Corcoran	0	100	0	0	450

Table 2. Average Kerogen Estimations for Scarborough 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):

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

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 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 0.78 to 0.94 (Table 3), i.e., on average an estimated 78 to 94% 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):

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

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 1.45 to 3.80 wt.% (Table 3).

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

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

For the Kyalla, Velkerri and Corcoran source rocks examined in the Scarborough 1 well, the average $S2_o$ values vary from 3.1 to 17.1 mg HC/g rock or approximately 68 to 375 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).

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

Using this methodology for the Kyalla samples analyzed in the current study, the generated oil yields average 179 bbl/acre-ft (Table 3). The generated oil yield from underlying Upper Velkerri was lower with an average value of 104 bbl/acre-ft. The average generated oil yield from the Middle Velkerri averaged 267 bbl/acre-ft and it would be considered the most prospective interval within the Scarborough 1 well. The Lower Velkerri averaged 280 bbl/acre-ft oil generation, but this elevated value represents only select samples with high TOC and thus this interval is considered less prospective than the Middle Velkerri. The leas prospective horizon is the Corcoran, in which the generated oil yield is only 47 bbl/acre-ft along with 100 Mcf/acre-ft of secondary cracked gas.

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
Kyalla	2.06	133	71	450	0.78	2.53	249	3	179	0
Upper Velkerri	1.13	134	38	450	0.79	1.45	143	17	104	1
Middle Velkerri	3.01	152	108	450	0.76	3.80	375	45	267	2
Lower Velkerri	2.55	76	47	450	0.89	3.32	327	22	280	0
Corcoran	0.52	42	5	450	0.94	0.69	68	2	47	100

Table 3. Hydrocarbon Yields average data for Scarborough 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 intervals varies from 98% in the Kyalla, 83% in the Upper and Middle Velkerri, 92% in the Lower Velkerri and 97% in the Corcoran.

The Kyalla and Velkerri source rock intervals in the Scarborough 1 well are interpreted to be in the peak to late oil window and hydrocarbon yield calculations suggest moderate to significant amounts of generation have occurred (predominantly oil with some presumed associated gas). The Corcoran source interval in this well is interpreted to be in the early wet gas window and has likely generated minor amounts of oil and secondary cracked gas. From an exploration risk perspective, this is generally 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 Middle Velkerri original generation potential ($S2_o$) averages 375 bbl oil/acre-ft, this compares favorably to the list of unconventional US Shale plays shown below. Original generation potential for the Lower Velkerri is 327 bbl oil/acre-ft, but this elevated value is somewhat misleading because it represents only the relatively few samples with elevated TOC. For the Kyalla and Upper Velkerri, original generation potential is much lower from 143 to 249 bbl oil/acre-ft and these two units do not compare favorably with other unconventional US Shale plays. Likewise, the Corcoran original generation potential is only 68 bb oil/acre-ft and this unit also does not compare well against other 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
Kyalla	450	0.78	2.53	11.39	71	249	0.00	3	179	0
Upper Velkerri	450	0.79	1.45	6.52	38	143	0.00	17	104	1
Middle Velkerri	450	0.76	3.80	17.11	108	375	0.00	45	267	2
Lower Velkerri	450	0.89	3.32	14.94	47	327	0.00	22	280	0
Corcoran	450	0.94	0.69	3.13	5	68	0.26	2	47	100

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

UNCONVENTIONAL OIL & GAS RISK ASSESSMENT

The Mesoproterozoic Kyalla, Velkerri and Corcoran Formation source rocks in the Scarborough 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 (no measured R_o data available). 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.

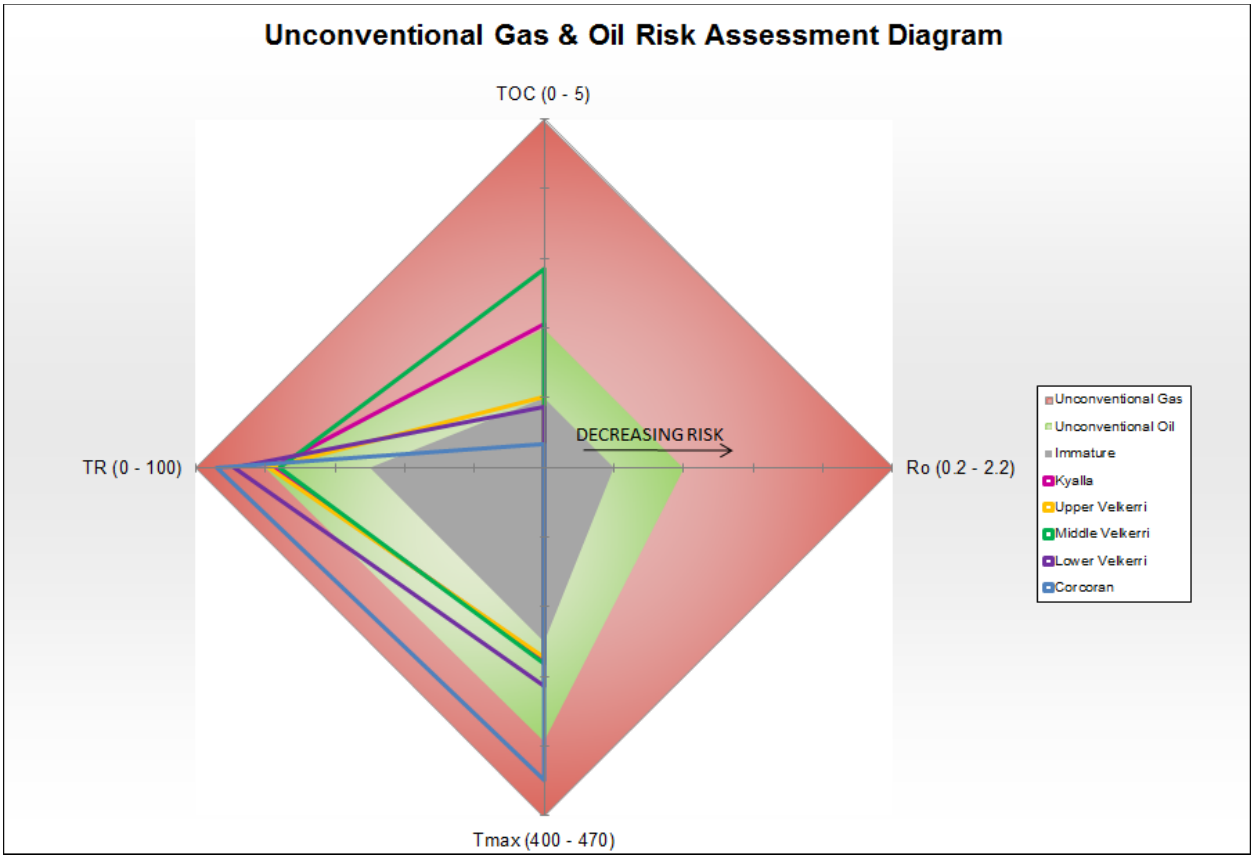

Figure 2. Geochemical Risk Assessment diagram for Mesoproterozoic source rocks in the Scarborough 1 well.

The Middle Velkerri source rock interval in the Scarborough 1 well is interpreted to represent a low geochemical risk for in-situ shale oil production and is considered the most prospective unit within this well. The average TOC content of 2.85 wt.% is well above the generally accepted minimum value of 1% TOC to be considered an *effective* source rock for hydrocarbon generation/expulsion (Fig. 2). It is also above the minimum requirements of 2 wt.% for *economic* petroleum source rocks. Original organic matter type is interpreted to be predominantly oil-prone Type II marine algal kerogen. Thermal maturity parameters from programmed pyrolysis place the Middle Velkerri source interval in peak oil window. The average Tmax value of 439°C is above the recommended minimum value of 435°C for shale oil, but below the minimum of 455°C for shale gas (Fig. 2). This amount of conversion would likely be sufficient to generate/expel significant amounts of hydrocarbons from this organic-rich, oil prone source facies. Transformation Ratios (TR), the least constrained risk parameter, average 76% and fall above the recommended minimum of 50% for shale oil systems but well below the 80% threshold for shale gas (Fig. 2). On the basis of all of these measured geochemical risk parameters, the Middle Velkerri source interval would be considered a low risk for shale oil since all of the risk parameters fall above recommended minimum thresholds (Fig. 2).

The overlying Upper Velkerri source interval in the Scarborough 1 well is also interpreted to represent a low geochemical risk for shale oil production, but in particular the basal zone below 230 m depth where measured S1 oil saturations are highest (Fig. 1). The average TOC content in this formation is 1.02 wt.%, which is just above the recommended minimum threshold of 1% TOC for shale oil systems. Original organic matter type is interpreted to be predominantly oil-prone Type II marine algal kerogen. Thermal maturity parameters place the Middle Velkerri source interval in peak oil window. The average Tmax value of 438°C and the Transformation Ratio of 79% are both above recommended minimum values for shale oil (Fig. 2). On the basis of all of these measured parameters, the Upper Velkerri source interval would be considered a low risk for shale oil since all of the risk parameters fall above recommended minimum thresholds (Fig. 2). Given its proximity to the underlying Middle Velkerri, it would be logical to conclude that any contribution to the overall resource potential from this horizon would simply be included within the evaluation of the Middle Velkerri, since fracture stimulation would likely connect both horizons, especially when considering the most prospective zone with elevated NOC values is the basal section of the Upper Velkerri.

The other formations examined in the current study are considered to represent moderate to high risk for in-situ shale oil/gas production. This is primarily related to organic richness and in-situ hydrocarbon saturations. The Kyalla samples have an average TOC of 2.06 wt.% and thermal maturity indicators suggest peak oil window maturity. On the risk assessment diagram, average Tmax value of 438°C is above the recommended minimum value of 435°C for shale oil and the Transformation Ratio of 78% is also above the minimum threshold (Fig. 2). However, measured in-situ oil saturation from S1 yields in this interval is very low (avg. 3 bbl/acre-ft) and for this reason the Kyalla is considered a moderate risk for shale oil production.

The Lower Velkerri samples have an average TOC of 0.87 wt.%, which is below the minimum threshold for shale oil (Fig. 2). Thermal maturity indicators suggest a late oil window maturity and the average Tmax value of 444°C and Transformation Ratio of 89% are both above at the minimum threshold for shale oil (Fig. 2). While low organic richness is the primary reason for the Lower Velkerri to be considered a high risk for shale oil development, there is a narrow zone ~20 m thick between 560-580 m depth that does contain elevated TOC (up to 5.40 wt.%). These samples were included in the few select samples analyzed by programmed pyrolysis and hydrocarbon yield determinations, which would appear to show the Lower Velkerri as a highly prospective interval (Fig. 3). Certainly, the zone with elevated TOC does have some potential as an unconventional target and might be considered in the overall resource potential since fracture stimulation might connect this zone with the much more prospective overlying Middle Velkerri interval.

The Corcoran Formation samples have an average TOC of only 0.34 wt.%, which is well below the minimum threshold for shale oil (Fig. 2). Thermal maturity indicators suggest a late oil to early condensate/wet gas window maturity and the average Tmax value of 463°C and Transformation Ratio of 94% are both above at the minimum threshold for shale gas (Fig. 2). Maximum measured TOC content within this horizon is only 0.54 wt.% and thus this entire interval would be considered a poor source rock and a high risk for either unconventional shale oil or shale gas production.

In the Middle Velkerri source interval, measured in-situ oil saturation determined by programmed pyrolysis S1 yields is very good (avg. 45 bbl oil/acre-ft), suggesting low risk for shale oil development (Fig. 3). Hydrocarbon yield calculations on as-received samples show estimates of average generated oil from the Middle Velkerri at 267 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 comparable to the Middle Velkerri and minor differences in-situ hydrocarbon saturations could be cause by variations in retention/expulsion efficiency possibly related to differences in geologic age of these formations.

As noted previously, in the Kyalla source interval measured in-situ oil saturation from S1 yields is very low (avg. 3 bbl oil/acre-ft), although estimated generated oil yields are moderately high (avg. 179 bbl oil/acre-ft) (Fig. 3). This could be a consequence of weathering/expulsion of hydrocarbons from this shallow interval that only extends from the surface down to a depth of 52 m (Fig. 1). As a consequence of low in-situ hydrocarbon saturation source rock interval is considered a moderate risk for shale oil development.

In the Upper Velkerri source interval measured in-situ oil saturation from S1 yields is generally fair (avg. 17 bbl oil/acre-ft), but is more elevated in the basal section of this interval (up to 74 bbl/acre-ft at 285 m depth) (Fig. 1). Estimated generated oil yields are only moderate (avg. 104 bbl oil/acre-ft) due to lower average organic richness (Fig. 3). However, basal samples have much higher values (up to 271 bbl/acre-ft at 288 m depth) and thus this portion of the source interval is considered a low risk for shale oil development.

The Lower Velkerri source interval was selectively sampled for programmed pyrolysis and the average results from hydrocarbon yield calculations show measured in-situ oil saturation is generally fair (avg. 22 bbl/acre-ft) (Fig. 3). Estimated generated oil yield from this interval is 280 bbl oil/acre-ft, which is actually higher than determined for the Middle Velkerri interval (Fig. 3), but this is not representative of the entire interval and serves to illustrate only that that there are some horizons within the Lower Velkerri and do have some prospectivity for shale oil development.

The Corcoran interval has the lowest measured in-situ oil saturation (2 bbl oil/acre-ft), but this could be a partial consequence of elevated thermal maturity and loss of volatile oil saturation. Estimated generated oil yield is low (47 bbl oil/acre-ft) along with some minor amounts of secondary cracked gas (100 Mcf/acre-ft). These low values suggest a high risk for shale oil and shale gas within the Corcoran Formation.

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 Kyalla and Velkerri source intervals in this well is in the peak to late oil window and hydrocarbon saturation is likely to be light and mobile. The Corcoran source interval is interpreted to be in the late oil to early condensate/wet gas window and also would be expected to have very light in-situ hydrocarbon saturation. However, the presence of solid bitumen in these samples 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 samples would 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.

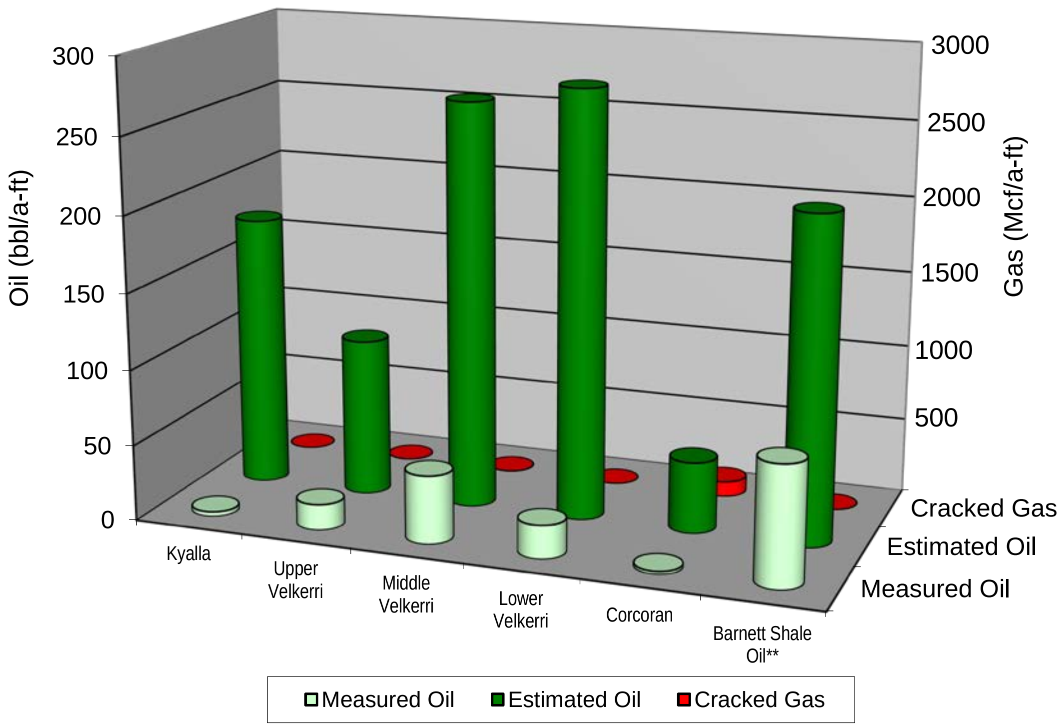

Figure 3. Hydrocarbon yield estimates for the Mesoproterozoic source rocks in the Scarborough 1 well compared to Barnett Shale in the oil window.

GEOCHEMICAL SUMMARY

The Middle Velkerri source interval in the Scarborough 1 well is interpreted to represent low geochemical risk for unconventional shale oil development. It clearly has elevated organic richness (avg. 2.85 wt.% TOC) and is considered a very good source rock with dominantly oil-prone Type II kerogen. Thermal maturity parameters indicate that the source interval is in the peak oil window, 0.75% Calc. R_o and key risk ratios are at or above recommended minimum thresholds for shale oil systems. The Middle Velkerri has likely generated significant amounts of oil (avg. 267 bbl oil/acre-ft) and comparison to other systems such as the Barnett Shale show in-situ oil saturations are generally comparable. Risk criteria like the S1 versus TOC show oil cross-over for several samples in this unit, notably in the basal section. Further evaluation of in-situ oil characteristics would be required to fully evaluate potential oil mobility and recovery risk.

The other source rock intervals evaluated in the Scarborough 1 well generally have higher risk in comparison to the Middle Velkerri. The Upper Velkerri Formation has good organic richness (avg. 1.02 wt% TOC) and is also in the peak oil window. It is considered a low risk for shale oil development primarily within the basal section where TOC and in-situ oil saturations are elevated. The Kyalla (avg. 2.06 wt. % TOC) exceeds the minimum threshold for TOC and is also in the peak oil window, but low measured in-situ oil saturations (avg. 3 bbl/acre-ft) suggest a moderate risk for shale oil. The Lower Velkerri and Corcoran intervals have overall low organic richness (avg. 0.87 & 0.34 wt.% TOC) and would be considered high risk for shale oil/gas development. However, within the Lower Velkerri there are zones with much higher TOC and hydrocarbon yield calculations suggest these horizons do have some prospectivity as contributors to in-situ oil reserves.

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Appendix I

Hydrocarbon Yield Calculation
Shelf Group
Scarborough 1

McArthur Basin Integrated Petroleum Geochemistry, 2016

Northern Territory Geological Survey - Australia

Scarborough 1

Hydrocarbon Yield Calculation

																S2 (meas)	S2 (orig)				
Sample	Top Depth	TOC*	HI*	S1*	S2*	Calc.Ro	PI*	%Type IV 50 HI°	% Type III 125 HI°	%Type II 450 HI°	%Type I 750 HI°	HI°	TR	TOC°	S2°	Remaining Potential	Original Potential	Oil Cracked	S1 Free Oil	Estimated Oil	Cracked Gas
Scarborough 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
HD14DJR046	16	0.67	37	0.04	0.25	**0.81**	0.14	0	0	100	0	450	0.95	0.90	4.03	5	88	0.00	1	83	0
HD14DJR047	34	2.15	223	0.26	4.79	**0.70**	0.05	0	0	100	0	450	0.62	2.54	11.45	105	251	0.00	6	146	0
HD14DJR048	49	3.35	138	0.17	4.62	**0.69**	0.04	0	0	100	0	450	0.78	4.15	18.69	101	409	0.00	4	308	0
Kyalla (Avg)		**2.06**	**133**	**0.16**	**3.22**	**0.73**	**0.07**	**0**	**0**	**100**	**0**	**450**	**0.78**	**2.53**	**11.39**	**71**	**249**	**0.00**	**3**	**179**	**0**
HD14DJR049	63	2.10	21	0.03	0.45	**0.84**	0.06	100	0	0	0	50	0.58	2.15	1.08	10	24	0.00	1	14	0
HD14DJR050	73	1.27	33	0.04	0.42	**0.80**	0.09	100	0	0	0	50	0.35	1.29	0.65	9	14	0.00	1	5	0
Moroak Sandstone (Avg)		**1.69**	**27**	**0.04**	**0.44**	**0.82**	**0.07**	**100**	**0**	**0**	**0**	**50**	**0.47**	**1.72**	**0.86**	**10**	**19**	**0.00**	**1**	**9**	**0**
	127	0.70	86	0.10	0.60	**0.78**	0.14	0	0	100	0	450	0.87	0.92	4.12	13	90	0.00	2	77	0
1408931	140	0.69	112	0.25	0.77	**0.76**	0.25	0	0	100	0	450	0.83	0.90	4.04	17	89	0.00	5	72	0
1408932	150	0.63	132	0.17	0.83	**0.71**	0.17	0	0	100	0	450	0.80	0.81	3.63	18	79	0.00	4	61	0
1408933	160	0.46	104	0.15	0.48	**0.72**	0.24	0	0	100	0	450	0.84	0.60	2.71	11	59	0.00	3	49	0
	166	0.60	33	0.06	0.20	**0.62**	0.23	0	0	100	0	450	0.95	0.81	3.64	4	80	0.00	1	75	0
1408934	170	0.76	122	0.33	0.93	**0.72**	0.26	0	0	100	0	450	0.81	0.99	4.44	20	97	0.00	7	77	0
1408935	180	0.92	179	0.44	1.65	**0.71**	0.21	0	0	100	0	450	0.71	1.15	5.19	36	114	0.00	10	78	0
	187	0.60	23	0.06	0.14	**0.51**	0.30	0	0	100	0	450	0.97	0.81	3.66	3	80	0.00	1	77	0
1408936	190	0.77	155	0.52	1.19	**0.63**	0.30	0	0	100	0	450	0.76	0.99	4.46	26	98	0.00	11	72	0
	194	0.70	39	0.07	0.27	**0.58**	0.21	0	0	100	0	450	0.94	0.94	4.23	6	93	0.00	2	87	0
1408937	200	0.62	139	0.37	0.86	**0.78**	0.30	0	0	100	0	450	0.79	0.80	3.62	19	79	0.00	8	60	0
1408938	210	0.52	108	0.28	0.56	**0.78**	0.33	0	0	100	0	450	0.84	0.68	3.08	12	67	0.00	6	55	0
	213	1.70	112	0.48	1.90	**0.58**	0.20	0	0	100	0	450	0.83	2.19	9.87	42	216	0.00	11	175	0
1408940	230	1.70	222	1.39	3.77	**0.71**	0.27	0	0	100	0	450	0.64	2.11	9.48	83	208	0.00	30	125	0
	231	2.30	132	0.73	3.03	**0.60**	0.19	0	0	100	0	450	0.80	2.93	13.18	66	289	0.00	16	222	0
	248	0.80	70	0.25	0.56	**0.92**	0.31	0	0	100	0	450	0.90	1.07	4.79	12	105	0.02	5	91	12
1408942	250	1.04	189	1.40	1.97	**0.92**	0.42	0	0	100	0	450	0.71	1.34	6.04	43	132	0.02	31	87	11
1408943	260	0.86	217	1.10	1.87	**0.83**	0.37	0	0	100	0	450	0.66	1.09	4.92	41	108	0.00	24	67	0
1408945	280	2.70	256	3.13	6.90	**0.85**	0.31	0	0	100	0	450	0.58	3.32	14.93	151	327	0.00	69	176	0
1408946	285	2.60	250	3.39	6.51	**0.85**	0.34	0	0	100	0	450	0.59	3.22	14.51	143	318	0.00	74	175	0
	288	2.50	94	1.15	2.35	**0.71**	0.33	0	0	100	0	450	0.86	3.27	14.73	51	323	0.00	25	271	0
1408947	290	0.70	180	1.53	1.26	0.73	0.55	0	0	100	0	450	0.73	0.93	4.17	28	91	0.00	34	64	0
Upper Velkerri (Avg)		**1.13**	**134**	**0.79**	**1.75**	**0.73**	**0.28**	**0**	**0**	**100**	**0**	**450**	**0.79**	**1.45**	**6.52**	**38**	**143**	**0.00**	**17**	**104**	**1**
1408948	295	1.45	190	2.78	2.75	**0.71**	0.50	0	0	100	0	450	0.71	1.90	8.53	60	187	0.00	61	127	0
1408949	300	2.10	240	3.31	5.03	**0.71**	0.40	0	0	100	0	450	0.62	2.65	11.92	110	261	0.00	72	151	0
HD14DJR051	300	1.48	64	0.72	0.95	**0.76**	0.43	0	0	100	0	450	0.91	1.98	8.91	21	195	0.00	16	174	0
1408950	310	3.50	269	3.12	9.43	**0.67**	0.25	0	0	100	0	450	0.54	4.20	18.91	207	414	0.00	68	208	0
	317	1.40	12	0.05	0.17	0.76	0.23	0	0	100	0	450	0.98	1.90	8.54	4	187	0.00	1	183	0
1408951	320	6.90	252	4.41	17.41	**0.74**	0.20	0	0	100	0	450	0.57	8.16	36.73	381	804	0.00	97	423	0
1408952	330	4.35	217	2.92	9.43	**0.78**	0.24	0	0	100	0	450	0.65	5.31	23.91	207	524	0.00	64	317	0
	332	2.30	80	0.49	1.83	**0.56**	0.21	0	0	100	0	450	0.88	3.01	13.53	40	296	0.00	11	256	0
1408953	340	3.60	173	2.56	6.24	**0.76**	0.29	0	0	100	0	450	0.73	4.53	20.39	137	447	0.00	56	310	0
1408954	350	3.05	227	2.22	6.92	**0.74**	0.24	0	0	100	0	450	0.63	3.73	16.79	152	368	0.00	49	216	0
HD14DJR052	350	5.15	170	2.29	8.74	**0.67**	0.21	0	0	100	0	450	0.73	6.37	28.67	191	628	0.00	50	437	0
HD14DJR053	355	2.07	177	0.80	3.67	**0.84**	0.18	0	0	100	0	450	0.72	2.57	11.58	80	254	0.00	18	173	0
1408955	360	5.75	230	3.51	13.21	**0.90**	0.21	0	0	100	0	450	0.62	6.91	31.10	289	681	0.01	77	388	25
HD14DJR054	365	4.39	147	2.20	6.45	**0.71**	0.25	0	0	100	0	450	0.77	5.54	24.92	141	546	0.00	48	404	0
	366	2.60	127	1.17	3.30	**0.69**	0.26	0	0	100	0	450	0.81	3.34	15.02	72	329	0.00	26	257	0
1408956	370	3.00	192	2.42	5.75	**0.89**	0.30	0	0	100	0	450	0.70	3.76	16.93	126	371	0.00	53	245	0
HD14DJR055	375	2.02	82	0.92	1.66	**0.70**	0.36	0	0	100	0	450	0.88	2.67	12.01	36	263	0.00	20	227	0
1408957	380	2.95	212	3.76	6.26	**0.81**	0.38	0	0	100	0	450	0.66	3.72	16.76	137	367	0.00	82	230	0
HD14DJR056	385	3.63	99	1.34	3.61	**0.65**	0.27	0	0	100	0	450	0.85	4.69	21.12	79	463	0.00	29	384	0
1408958	390	3.05	207	3.39	6.30	**0.81**	0.35	0	0	100	0	450	0.67	3.84	17.27	138	378	0.00	74	240	0
HD14DJR057	395	2.77	122	1.64	3.37	**0.73**	0.33	0	0	100	0	450	0.82	3.59	16.13	74	353	0.00	36	280	0
1408959	400	1.75	194	2.22	3.40	**0.92**	0.40	0	0	100	0	450	0.70	2.24	10.09	74	221	0.02	49	143	18
	402	1.20	48	0.24	0.57	**0.90**	0.30	0	0	100	0	450	0.93	1.61	7.23	12	158	0.01	5	144	9
HD14DJR058	405	1.69	106	1.04	1.79	**0.64**	0.37	0	0	100	0	450	0.84	2.22	9.99	39	219	0.00	23	180	0
1408960	410	2.10	181	2.23	3.81	**0.90**	0.37	0	0	100	0	450	0.72	2.69	12.08	83	265	0.01	49	179	12
HD14DJR059	415	1.71	125	0.93	2.13	**0.77**	0.30	0	0	100	0	450	0.81	2.22	9.98	47	219	0.00	20	172	0
1408961	420	2.30	198	3.81	4.55	**0.74**	0.46	0	0	100	0	450	0.69	2.97	13.34	100	292	0.00	83	193	0
HD14DJR060	425	5.17	129	2.33	6.68	**0.70**	0.26	0	0	100	0	450	0.80	6.55	29.47	146	645	0.00	51	499	0

Scarborough 1

Hydrocarbon Yield Calculation

																S2 (meas)	S2 (orig)				
Sample	**Top Depth**	**TOC***	**HI***	**S1***	**S2***	**Calc.Ro**	**PI***	**%Type IV 50 HI°**	**% Type III 125 HI°**	**%Type II 450 HI°**	**%Type I 750 HI°**	**HI°**	**TR**	**TOC°**	**S2°**	**Remaining Potential**	**Original Potential**	**Oil Cracked**	**S1 Free Oil**	**Estimated Oil**	**Cracked Gas**
Scarborough 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**
1408962	430	3.90	160	2.61	6.23	**0.80**	0.30	0	0	100	0	450	0.75	4.93	22.19	136	486	0.00	57	350	0
HD14DJR061	435	3.50	94	1.17	3.29	**0.68**	0.26	0	0	100	0	450	0.86	4.54	20.41	72	447	0.00	26	375	0
	439	3.50	85	1.22	2.98	**0.80**	0.29	0	0	100	0	450	0.87	4.56	20.52	65	449	0.00	27	384	0
1408963	440	3.70	175	3.15	6.49	**0.85**	0.33	0	0	100	0	450	0.73	4.68	21.04	142	461	0.00	69	319	0
HD14DJR062	445	4.04	72	1.14	2.90	**0.68**	0.28	0	0	100	0	450	0.89	5.27	23.73	64	520	0.00	25	456	0
1408964	450	2.25	165	2.68	3.71	**0.58**	0.42	0	0	100	0	450	0.75	2.91	13.10	81	287	0.00	59	206	0
HD14DJR063	454	1.00	105	0.34	1.04	***0.67***	0.25	0	0	100	0	450	0.84	1.30	5.84	23	128	0.00	7	105	0
Middle Velkerri (Avg)		**3.01**	**152**	**2.03**	**4.92**	**0.75**	**0.30**	**0**	**0**	**100**	**0**	**450**	**0.76**	**3.80**	**17.11**	**108**	**375**	**0.00**	**45**	**267**	**2**
1408967	480	0.45	93	0.24	0.42	0.83	0.36	0	0	100	0	450	0.86	0.60	2.69	9	59	0.00	5	50	0
1408972	570	5.40	123	2.46	6.63	0.83	0.27	0	0	100	0	450	0.81	6.86	30.86	145	676	0.00	54	531	0
HD14DJR064	570	4.82	54	1.36	2.62	**0.85**	0.34	0	0	100	0	450	0.92	6.32	28.46	57	623	0.00	30	566	0
1408974	600	1.05	71	0.62	0.75	**0.81**	0.45	0	0	100	0	450	0.90	1.41	6.33	16	139	0.00	14	122	0
1408975	610	1.05	39	0.26	0.41	0.83	0.39	0	0	100	0	450	0.94	1.42	6.37	9	140	0.00	6	131	0
Lower Velkerri (Avg)		**2.55**	**76**	**0.99**	**2.17**	**0.83**	**0.36**	**0**	**0**	**100**	**0**	**450**	**0.89**	**3.32**	**14.94**	**47**	**327**	**0.00**	**22**	**280**	**0**
1408980	685	0.49	59	0.14	0.29	1.17	0.33	0	0	100	0	450	0.91	0.66	2.96	6	65	0.26	3	43	91
1408981	690	0.54	24	0.05	0.13	**1.17**	0.28	0	0	100	0	450	0.97	0.73	3.30	3	72	0.26	1	51	110
Corcoran (Avg)		**0.52**	**42**	**0.10**	**0.21**	**1.17**	**0.30**	**0**	**0**	**100**	**0**	**450**	**0.94**	**0.69**	**3.13**	**5**	**68**	**0.26**	**2**	**47**	**100**
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)