Jamison 1 Interpretive Summary

Kyalla Interval

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INTRODUCTORY NOTE

A geochemical investigation has been conducted to assess hydrocarbon prospectivity of the Kyalla, Formation in the Jamison 1 well located in the Beetaloo Sub-Basin, Northern Territories, Australia. Thirty-three (33) core chip samples from this well were analyzed by a variety of geochemical techniques, including total organic carbon (TOC, LECO®), programmed pyrolysis (SRA) and organic petrology with measured maceral reflectance (R_o). In addition, client supplied published geochemical data for 103 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
Jamison 1	Kyalla	***Estimated Original*** ⟶		*Very Good (2.37% TOC)*	*Oil-prone Type II*	**Low**
Measured Currently ⟶		Oil Wet Gas	Late Oil Window	Good (1.65% TOC)	Gas-prone Type III	

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

Table 1. Geochemical Summary

KYALLA

Thirty-three (33) samples from the Kyalla Formation were analyzed for LECO TOC content and programmed pyrolysis, with the remaining data set (103 samples) composed of client supplied public data (Fig. 1). TOC contents ranged from 0.03 to 8.97 wt.% and averaged 1.65 wt.% (good). Eighty-five (85) samples have TOC content above the minimum requirement of 1 wt.% for *effective* petroleum source rocks, while forty-seven (47) of these samples have TOC content above the minimum requirement of 2 wt.% for *economic* petroleum source rocks. Six (6) samples have > 4 wt. % TOC and would be considered excellent quality source rocks. Highest TOC content was found near the base of the designated Kyalla interval (1580.3 & 1649.5 m depth) (Fig. 1). The basal portion of the Kyalla in this well between 1454−1665 m depths has a thick zone of elevated TOC with many values > 2 wt.% (Fig. 1). There is also an upper portion of the Kyalla between 995−1051 m depths that also has elevated TOC generally > 2 wt. % (Fig. 1).

The S1 values of the Kyalla source rock samples average 0.73 mg HC/g rock (16 bbl oil/acre-ft) and the S2 values average 2.25 mg HC/g rock (49 bbl oil/acre-ft). The S1 and S2 values imply fair in-situ hydrocarbon saturation and poor remaining generative potential (Fig. 1). The normalized oil contents (NOC) in the Kyalla samples, (S1/TOC) x 100, average 40 (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 represent zones with good potential for containing producible hydrocarbon saturation (or zones of possible contamination). In the present study, there are multiple samples where S1 crosses over TOC in the Kyalla interval, generally in the upper and lower zones which contain elevated TOC (Fig. 1). This suggests possible producible hydrocarbons are present at these depths. It is also of interest to note that the overlying Chambers River Formation has an NOC of 115 consistent with a conventional oil reservoir.

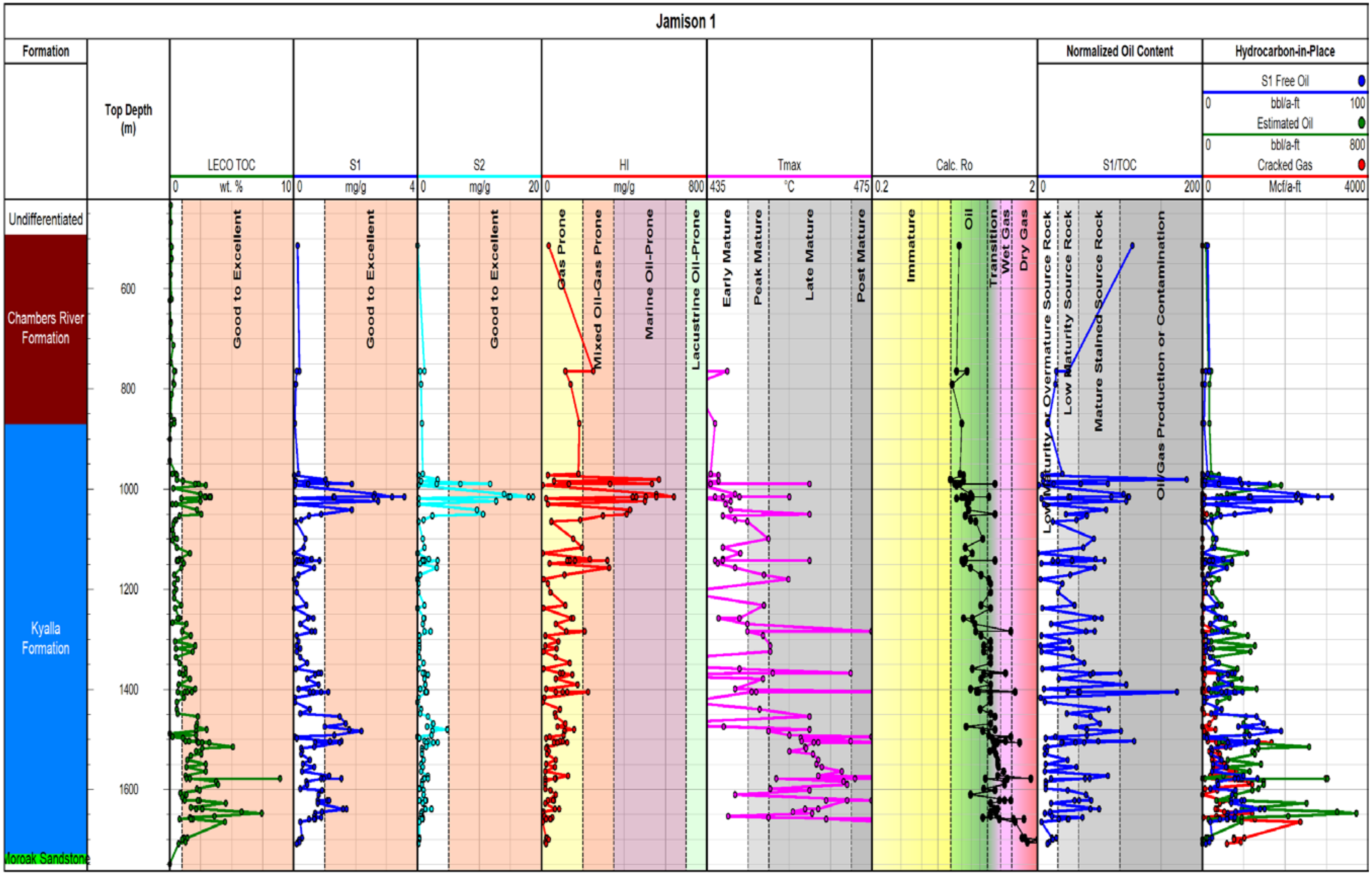

Figure 1. Geochemical depth plots for the Jamison 1 well. Note Tmax values plot off scale on depth plot beyond post-mature field.

The measured Hydrogen Index (HI) values in the Kyalla average 123 mg HC/g TOC, indicating gas-prone Type III kerogen quality in these source rocks at present day. This is consistent with elemental analysis of a kerogen sample from the Kyalla that has an H/C ratio of 0.96, which is typical for Type III kerogen. Original HI_o of these samples are estimated to average 465 mg HC/g rock, which indicate oil-prone Type II kerogen. Transformation Ratios (TR) based upon HI are average 82%, which suggest late oil window thermal maturity. The T_{max} values in the Kyalla samples average is 456°C. T_{max} between 445 and 450°C typically indicate late oil window, while values between 450 and 470°C typically indicate condensate/wet gas 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 early condensate/wet 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 measured T_{max} value of 456°C is equivalent to a Calc. $\%R_o$ value of 1.05%. 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. Also, the average T_{max} values and other thermal maturity ratios summarized in this report can potentially be misleading with regard to intervals such as the Kyalla Formation in this well, which is ~745 m thick. It is apparent from the Calc. % R_o depth trend in this well that thermal maturity is variable from the top of the interval to the base (Fig. 1), apparently ranging from the early oil window to early wet gas/condensate window.

The Production Index (PI) values in the Kyalla samples average 0.32. These elevated PI values are consistent with source rocks in the late oil window, which typically have PI values in the range of 0.25 to 0.35, while post mature samples in the gas window tend to have values > 0.40.

Organic petrology was performed on three samples from the Kyalla interval (1018, 1515, 1629 m). The results from these analyses show similarities in all three samples with a distribution that consists of macerals identified as either low reflectance solid bitumen or high reflectance solid bitumens (Figs. 2 through 4). The low reflectance solid bitumen population has average reflectance values that range between 0.48% in the shallowest sample to 1.04-1.09% R_o in the deeper samples. These values are generally considered the most representative indigenous kerogen population for thermal maturity assessment in this study. However, caution should be applied for interpretation of the shallow sample from 1018 m depth as reflectance may be “suppressed” due to the high in-situ hydrocarbon saturations (S1 is 3.20 mg HC/g rock). The high reflecting solid bitumen populations have average reflectance values that range between 0.75% in the shallow sample to 1.50-1.54% R_o in the deeper samples. The solid bitumens are thought to possibly represent fine grained migrabitumen, although they could also represent preserved original cyanobacterial kerogen that has subsequently undergone thermal conversion to form a dispersed solid bitumen network within these Kyalla Formation source rocks.

Published solid bitumen conversions were applied to these reflectance values (Figs. 2 through 4). The conversion formula published by Landis and Castaño (1995) for bitumen in lenses/layers (Eq. R_o = (Bitumen R_o +0.41)/1.09) was applied to the low reflectance bitumen populations and resulted in 0.82-1.38% Eq. R_o. The conversion formula published by Jacob (1985) equation (Eq. R_o = (Bitumen R_o $\times$ 0.618) + 0.4) for 'angular-like' pyrobitumen trapped in mineral pore spaces was applied to the high reflecting populations and resulted in values that range from 0.86% in the shallow sample to 1.33-1.35% Eq. R_o in the deeper samples. The Landis and Castaño (1995) and Jacob (1985) conversions both appear to provide a possible correction back to a more suitable thermal maturity that is in general generally higher compared to the population of low reflectance solid bitumens. Evaluation with other samples examined in the current study suggest that the high reflectance solid bitumen reflectance readings can be corrected using the Jacob (1985) formula and often these “corrected” values compare favorably to “uncorrected” readings from the population of low reflectance solid bitumen within the same sample. This was not observed in the Jamison 1 well. The calculated 0.86% Eq. R_o value is significantly higher than the measured 0.48% R_o value in the shallow Kyalla (as noted previously this may be due to “suppression” effects caused by high in-situ hydrocarbon saturation). The calculated ~1.34% Eq. R_o value and measured ~1.07% R_o values in the deeper Kyalla samples are also somewhat divergent, but in general these values suggest the deeper Kyalla samples in this well are within the late oil to early wet gas/condensate window.

The thermal maturity of the Kyalla source 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). Ten (10) samples from the Kyalla Formation (avg. 70% clays) have an average measured Kübler Index of 0.270, which is equivalent to a measured vitrinite reflectance of ~3.5% (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.

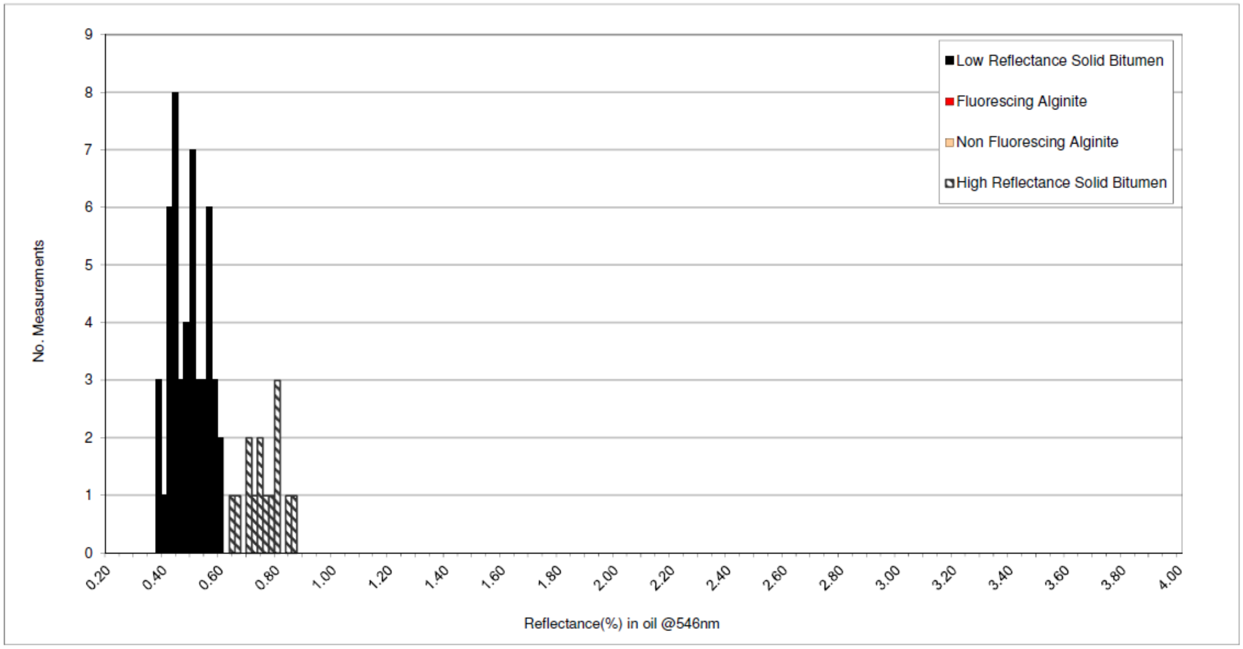

Figure 2. Organic petrology of the Kyalla (1018 m) in the Jamison 1 well. Mean maceral reflectance of low reflecting solid bitumen is 0.48% R_o (possibly "suppressed"). The high reflecting solid bitumen has mean reflectance of 0.75% R_o, which equates to calculated Eq. R_o of 0.86% R_o using the conversion of Jacob (1985).

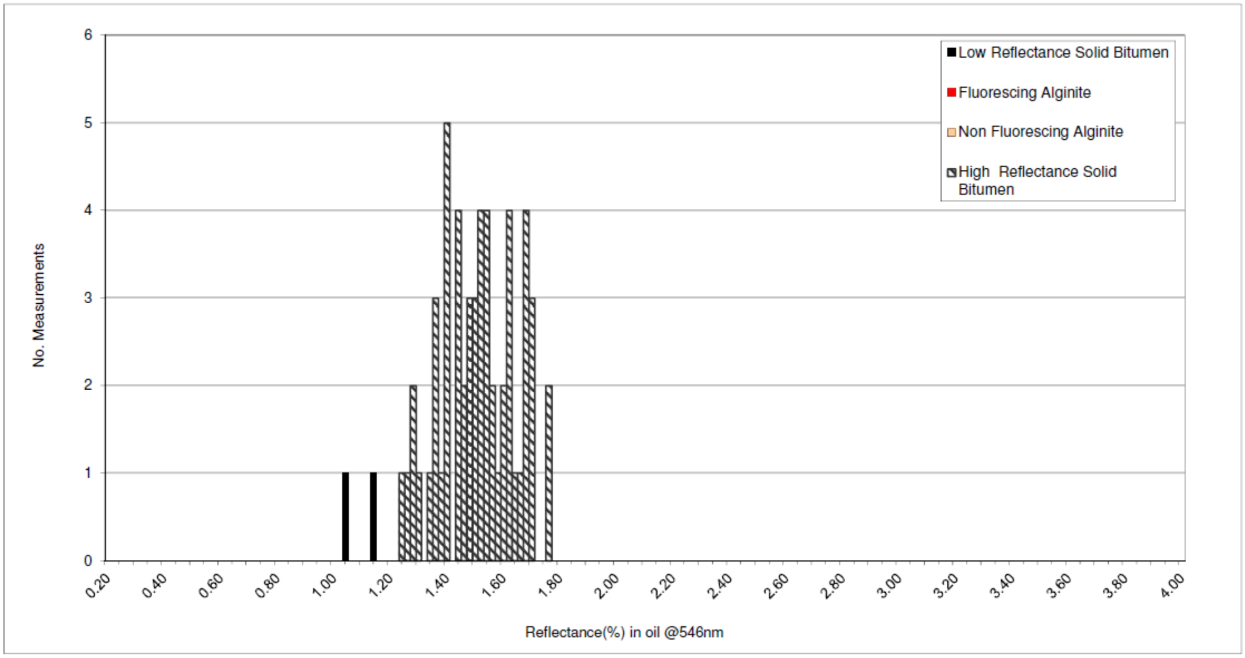

Figure 3. Organic petrology of the Kyalla (1515 m) in the Jamison 1 well. Mean maceral reflectance of low reflecting solid bitumen is 1.09% R_o. The high reflecting solid bitumen has mean reflectance of 1.50% R_o, which equates to calculated Eq. R_o of 1.33% R_o using the conversion of Jacob (1985).

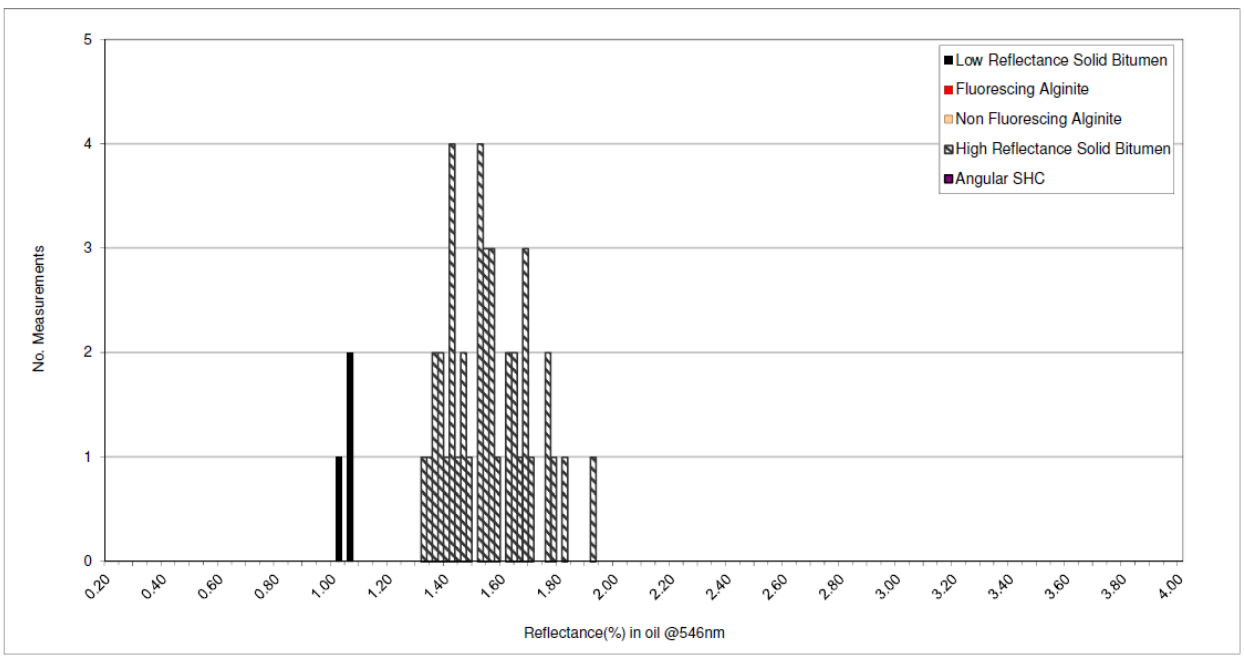

Figure 4. Organic petrology of the Kyalla (1629 m) in the Jamison 1 well. Mean maceral reflectance of low reflecting solid bitumen is 1.04% R_o. The high reflecting solid bitumen has mean reflectance of 1.54% R_o, which equates to calculated Eq. R_o of 1.35% R_o using the conversion of Jacob (1985).

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 source rocks 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):

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

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	5	95	0	0	465

Table 2. Average Kerogen Estimations for Jamison 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 an average HI_o values of 465 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 is 0.82 (Table 3), i.e., on average an estimated 82% 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 estimated original TOC_o for the Kyalla source rock samples in this well before petroleum generation average 2.37 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 Kyalla source rocks examined in the Jamison 1 well, the average $S2_o$ values are 11.1 mg HC/g rock or approximately 243 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 estimated generated oil yields average 147 bbl/acre-ft (Table 3). Oil cracking is estimated to have averaged 19% and resulted in 277 Mcf/acre-ft of secondary cracked gas generation, which is higher in the basal portion of this thick interval at depths > 1500 m (Fig. 1).

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	1.83	123	49	465	0.82	2.37	243	16	147	277

Table 3. Hydrocarbon Yields average data for Jamison 1 well.

For shale oil systems, 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 Kyalla interval is 92%, which is consistent with a source rock in the peak to late oil generation window.

The Kyalla source rock interval in the Jamison 1 well is interpreted to be in the late oil window and hydrocarbon yield calculations suggest significant amounts of generation have occurred (predominantly oil with some 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 5). 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 Kyalla Formation, original generation potential ($S2_o$) averages 243 bbl oil/acre-ft, this is below all of the other formations on the list of unconventional US Shale plays shown below, but is nearly as high as the Utica Shale play in the Appalachian Basin. Given the thickness of the Kyalla Formation in the Jamison 1 well (~745 m), it would appear that this source rock may have similar prospectivity as the Utica Shale.

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	465	0.82	2.37	11.09	49	243	0.19	16	147	277

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

HYDROCARBON SATURATIONS

A comparison was made between oil saturations based upon shale rock properties (SRP) analyses and those determined via programmed pyrolysis for a single sample from the Jamison 1 well. The measured SRP oil saturations are lower than those determined by SRA methods using the S1 yields. In a sample from the basal Kyalla Formation (1637.27 m depth) with elevated 4.53 wt.% TOC, the saturation determined by SRP was 0.22 mg oil/g AR Rock (5 bbl oil/acre-ft), while that determined from S1 yields on the same sample is 0.80 mg oil/g AR Rock (18 bbl oil/acre-ft). This observation is rather unusual, because the S1 usually underestimates the total hydrocarbons extracted using Dean-Stark methods (toluene) due to the inclusion of non-volatile polar and asphaltene components of the extracted in-situ oil/bitumen saturation. Further evaluation of the extractable hydrocarbons by liquid chromatography and gas chromatography is warranted to fully evaluate the nature of these apparent discrepancies between SRP and S1 saturations.

UNCONVENTIONAL OIL & GAS RISK ASSESSMENT

The Mesoproterozoic Kyalla Formation source rocks in the Jamison 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. 5) based upon published results from the Barnett Shale in the Fort Worth Basin. The data illustrated in the star plot represents average values for all four of the diagnostic ratios. 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.

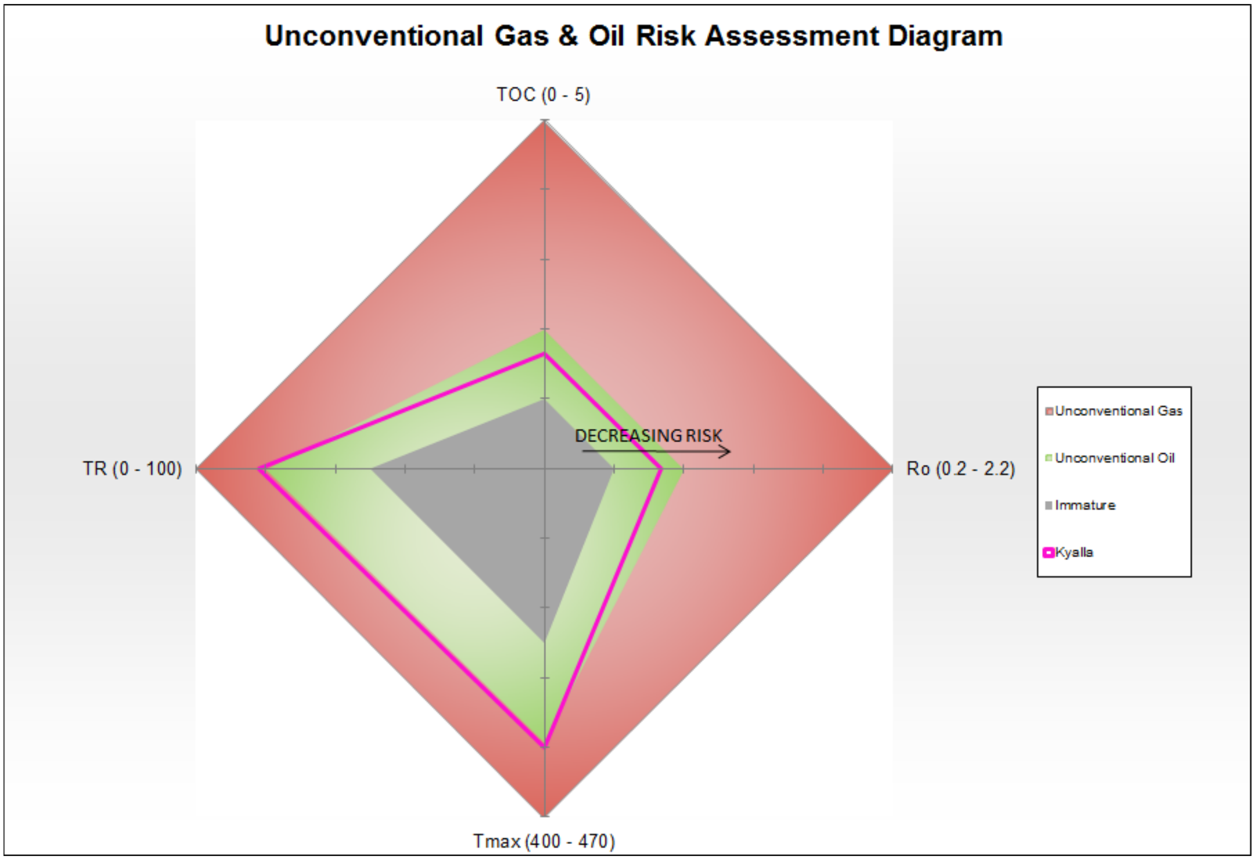

Figure 5. Geochemical Risk Assessment diagram for Mesoproterozoic Kyalla Formation source rocks in the Jamison 1 well.

The Kyalla source rock interval in the Jamison 1 well is interpreted to represent a low geochemical risk for in-situ shale oil production. The average measured TOC content of 1.65 wt.% is above the generally accepted minimum value of 1 wt.% TOC to be considered an *effective* source rock for hydrocarbon generation/expulsion (Fig. 5). The large numbers of samples that exceed this threshold are located predominantly in two horizons near the top and basal portions of the Kyalla interval (Fig. 1), and these zones could represent lower risk targets. There are also a large number of these samples that are above the minimum requirements of 2 wt.% for *economic* petroleum source rocks, which is also the minimum threshold for prospective shale gas. Original organic matter type is interpreted to be predominantly oil-prone Type I/II marine algal kerogen. Thermal maturity parameters from programmed pyrolysis generally place the Kyalla source interval in late oil window. The average Tmax value of 456°C is above recommended minimum value of 435°C for shale oil and just above the minimum of 455°C for shale gas

(Fig. 5). 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 82% and fall above the recommended minimum of 50% for shale oil and just above the 80% threshold for shale gas systems (Fig. 5). Measured maceral reflectance values in the Kyalla give a mean for low reflectance solid bitumen that range from 0.48% in the shallow sample to 1.09% in the deeper samples and average 0.87% R_o, which is in between the recommended minimum thresholds of 0.5% R_o for shale oil and 1.0% R_o for shale gas (Fig. 5).

In the Kyalla source interval, measured in-situ oil saturation determined by programmed pyrolysis S1 yields is generally fair (avg. 16 bbl oil/acre-ft), which is a potential concern regarding risk assessment for unconventional oil (Fig. 6). This is also supported by the low in-situ hydrocarbon saturations determined from SRP analysis (5 bbl oil/acre-ft), although this single sample may not be representative of the entire interval, it was taken from a sample that had excellent organic richness. S1 Free Oil depth trends (Fig. 1) do show that in-situ oil saturations tend to be higher near the upper and basal sections where TOC is elevated. However, a calculated expulsion factor of 92% could indicate that most of the generated oil has migrated upwards into adjacent reservoir units (which is supported by high NOC values in the overlying Chambers River Formation).

Hydrocarbon yield calculations on as-received samples show estimates of average generated oil from the Kyalla at 147 bbl oil/acre-ft, along with moderate amounts of secondary cracked gas (277 Mcf/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 (Fig.6). These values are somewhat higher compared to the average values for the Kyalla Formation, which is primarily due to differences in organic richness (Barnett Shale oil example has 4.70 wt. % TOC). However, samples within the two zones of elevated TOC have fairly comparable yields between the Kyalla and Barnett Shale considering slight differences in thermal maturity and extent of secondary oil cracking.

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 source interval in this well is in the late oil window and hydrocarbon saturation is likely to be fairly light and mobile. However, the presence of solid 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 Kyalla 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.

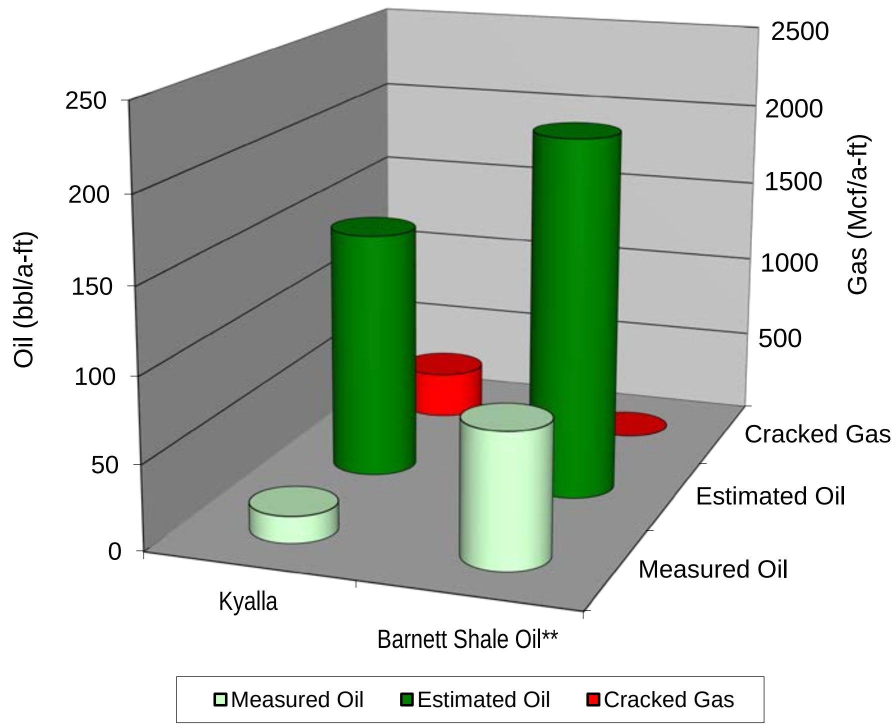

Figure 6. Hydrocarbon yield estimates for the Mesoproterozoic source rocks in the Jamison 1 well compared to Barnett Shale in the oil window.

GEOCHEMICAL SUMMARY

The Kyalla source interval in the Jamison 1 well is interpreted to represent low geochemical risk for unconventional shale oil development. The average measured TOC content of 1.65 wt.% is above the generally accepted minimum value of 1 wt.% TOC for unconventional shale oil and both the upper and basal sections of this source rock interval have zones of even higher relatively higher TOC values that are generally > 2 wt.%. The Kyalla source rock is thought to contain dominantly oil-prone Type I/II kerogen. Thermal maturity parameters indicate that this source interval is in the late oil window, average 1.05% Calc. R_o and 0.87% Eq. R_o from solid bitumen reflectance and 82% Transformation Ratio. All of these key thermal maturity risk ratios are above recommended minimum thresholds for shale oil systems and near the minimums for shale gas. Depth trends in thermal maturity for this thick interval further suggest that it brackets the main oil window from the upper portion to the base. While the Kyalla has likely generated significant amounts of oil and secondary cracked gas (avg. 147 bbl oil/acre-ft; 277 Mcf gas/acre-ft), comparison to other systems such as the Barnett Shale show in-situ oil saturations are lower for the Kyalla. Risk criteria like the S1 versus TOC show multiple samples exhibiting oil cross-over within this unit, also supporting a low risk assessment. Further evaluation of in-situ oil characteristics would be required to fully evaluate potential oil mobility and recovery risk.

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Appendix I

Hydrocarbon Yield Calculation
Beetaloo Sub-Basin Group
Jamison 1

McArthur Basin Integrated Petroleum Geochemistry, 2016

Northern Territory Geological Survey - Australia

Weatherford® LABORATORIES

Jamison 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
Jamison 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
2831903	515	0.13	38	0.15	0.05	0.68	0.75	0	0	100	0	450	0.95	0.18	0.80	1	18	0.00	3	16	0
1396096	766	0.49	253	0.19	1.24	**0.65**	0.13	0	0	100	0	450	0.56	0.58	2.62	27	57	0.00	4	30	0
2831909	766	0.42	119	0.10	0.50	**0.76**	0.17	0	0	100	0	450	0.82	0.54	2.44	11	53	0.00	2	42	0
1396097	791	0.40	145	0.09	0.58	**0.62**	0.13	0	0	100	0	450	0.77	0.51	2.28	13	50	0.00	2	37	0
1396099	870	0.43	184	0.06	0.79	**0.71**	0.07	0	0	100	0	450	0.70	0.53	2.37	17	52	0.00	1	35	0
Chambers River (Avg)		**0.37**	**148**	**0.12**	**0.63**	**0.68**	**0.25**	**0**	**0**	**100**	**0**	**450**	**0.76**	**0.47**	**2.10**	**14**	**46**	**0.00**	**3**	**32**	**0**
1396100	972	0.52	181	0.16	0.94	**0.69**	0.15	0	0	100	0	450	0.71	0.65	2.91	21	64	0.00	4	43	0
TN14DJR015	975	0.64	34	0.04	0.22	**0.72**	0.15	0	0	100	0	450	0.95	0.86	3.87	5	85	0.00	1	80	0
1396101	982	0.58	569	1.05	3.30	**0.60**	0.24	0	0	25	75	675	0.41	0.71	4.77	72	104	0.00	23	32	0
TN14DJR016	985	1.07	64	0.08	0.68	**0.72**	0.11	0	0	100	0	450	0.91	1.41	6.35	15	139	0.00	2	124	0
1329809	992	2.18	539	1.88	11.74	**0.63**	0.14	0	0	50	50	600	0.25	2.41	14.46	257	317	0.00	41	60	0
1396102	992	2.37	135	0.47	3.20	**0.69**	0.13	0	0	100	0	450	0.79	2.99	13.45	70	295	0.00	10	225	0
2872411	992	2.09	335	1.10	7.00	**1.12**	0.14	0	0	100	0	450	0.38	2.36	10.62	153	233	0.20	24	64	95
TN14DJR017	995	2.91	8	0.06	0.23	**0.65**	0.21	0	0	100	0	450	0.99	3.92	17.63	5	386	0.00	1	381	0
1396104	1012	2.51	559	2.64	14.03	**0.80**	0.16	0	0	25	75	675	0.39	2.90	19.60	307	429	0.00	58	122	0
1329808	1018	2.91	641	3.20	18.66	**0.74**	0.15	0	0	0	100	750	0.39	3.38	25.33	409	555	0.00	70	146	0
1396105	1018	3.23	558	3.59	18.02	**0.81**	0.17	0	0	25	75	675	0.39	3.75	25.28	395	554	0.00	79	159	0
2872414	1018	2.89	509	2.60	14.70	**1.03**	0.15	0	0	50	50	600	0.32	3.25	19.52	322	428	0.11	57	95	67
TN14DJR007	1018	3.28	459	1.34	15.05	**0.71**	0.08	0	0	75	25	525	0.23	3.51	18.45	330	404	0.00	29	74	0
TN14DJR008	1018	3.38	445	1.29	15.05	**0.71**	0.08	0	0	75	25	525	0.26	3.64	19.13	330	419	0.00	28	89	0
TN14DJR018	1020	0.98	23	0.05	0.22	**0.65**	0.19	0	0	100	0	450	0.97	1.32	5.93	5	130	0.00	1	125	0
1396106	1025	2.55	503	2.75	12.82	**0.78**	0.18	0	0	50	50	600	0.35	2.92	17.52	281	384	0.00	60	103	0
TN14DJR019	1032	0.57	32	0.05	0.18	**0.75**	0.22	0	0	100	0	450	0.95	0.76	3.43	4	75	0.00	1	71	0
1396108	1044	2.25	431	1.89	9.70	**0.78**	0.16	0	0	75	25	525	0.33	2.54	13.34	212	292	0.00	41	80	0
2831917	1051	2.56	414	0.90	10.60	**1.12**	0.08	0	0	75	25	525	0.34	2.81	14.77	232	323	0.20	20	73	109
1396109	1054	0.84	298	0.51	2.50	**0.74**	0.17	0	0	100	0	450	0.47	0.98	4.42	55	97	0.00	11	42	0
DI000022	1063	0.53	189	0.25	1.00	**0.80**	0.20	0	0	100	0	450	0.70	0.66	2.97	22	65	0.00	6	43	0
1396110	1067	0.41	51	0.08	0.21	**0.85**	0.28	0	0	100	0	450	0.93	0.55	2.48	5	54	0.00	2	50	0
2831918	1102	0.58	155	0.40	0.90	**0.94**	0.31	0	0	100	0	450	0.76	0.75	3.36	20	74	0.03	9	52	10
1396115	1119	0.62	197	0.35	1.22	**0.74**	0.22	0	0	100	0	450	0.68	0.77	3.48	27	76	0.00	8	50	0
TN14DJR020	1131	1.66	7	0.02	0.12	**0.82**	0.14	0	0	100	0	450	0.99	2.25	10.13	3	222	0.00	0	219	0
1329807	1142	0.81	236	0.58	1.91	**0.74**	0.23	0	0	100	0	450	0.61	0.99	4.47	42	98	0.00	13	56	0
TN14DJR005	1143	0.73	164	0.19	1.20	**0.71**	0.14	0	0	100	0	450	0.74	0.92	4.13	26	90	0.00	4	64	0
TN14DJR006	1143	0.58	141	0.11	0.81	**0.74**	0.12	0	0	100	0	450	0.78	0.73	3.28	18	72	0.00	2	54	0
1396116	1143	1.03	321	0.84	3.31	**0.74**	0.20	0	0	100	0	450	0.43	1.20	5.40	72	118	0.00	18	46	0
2831919	1143	0.71	127	0.30	0.90	**1.12**	0.25	0	0	100	0	450	0.81	0.92	4.13	20	91	0.20	7	57	85
TN14DJR021	1151	1.20	41	0.07	0.49	**0.72**	0.13	0	0	100	0	450	0.94	1.60	7.21	11	158	0.00	2	147	0
1396117	1158	0.97	330	0.68	3.20	**0.80**	0.18	0	0	100	0	450	0.40	1.12	5.02	70	110	0.00	15	40	0
1396118	1174	0.40	113	0.16	0.45	**0.92**	0.26	0	0	100	0	450	0.83	0.52	2.35	10	51	0.02	4	41	5
TN14DJR022	1181	0.69	10	0.03	0.07	**1.03**	0.30	0	0	100	0	450	0.99	0.94	4.25	2	93	0.10	1	82	57
1396119	1191	0.39	33	0.12	0.13	1.05	0.48	0	0	100	0	450	0.95	0.53	2.39	3	52	0.12	3	43	37
1396120	1208	0.43	47	0.11	0.20	1.05	0.35	0	0	100	0	450	0.93	0.58	2.61	4	57	0.12	2	46	39
1396121	1234	0.95	118	0.43	1.12	**0.92**	0.28	0	0	100	0	450	0.82	1.24	5.56	25	122	0.02	9	95	12
TN14DJR024	1240	0.44	11	0.03	0.05	1.05	0.38	0	0	100	0	450	0.98	0.60	2.71	1	59	0.12	1	51	43
1329806	1258	0.84	148	0.66	1.24	**0.81**	0.35	0	0	100	0	450	0.77	1.09	4.90	27	107	0.00	14	80	0
1396122	1259	0.70	157	0.49	1.10	**0.72**	0.31	0	0	100	0	450	0.76	0.90	4.05	24	89	0.00	11	65	0
TN14DJR025	1272	1.37	70	0.23	0.96	**0.85**	0.19	0	0	100	0	450	0.90	1.81	8.13	21	178	0.00	5	157	0
1396123	1285	1.02	213	0.71	2.17	**0.85**	0.25	0	0	100	0	450	0.65	1.27	5.70	48	125	0.00	16	77	0
2872562	1285	1.00	120	0.60	1.20	**1.39**	0.33	0	0	100	0	450	0.82	1.31	5.88	26	129	0.55	13	46	338
TN14DJR026	1295	1.77	21	0.10	0.37	**0.92**	0.21	0	0	100	0	450	0.97	2.38	10.73	8	235	0.02	2	223	24
1396124	1305	0.46	83	0.18	0.38	1.05	0.32	0	0	100	0	450	0.88	0.61	2.75	8	60	0.12	4	45	39
TN14DJR027	1313	2.07	18	0.10	0.38	**0.95**	0.21	0	0	100	0	450	0.97	2.79	12.54	8	275	0.04	2	256	61
1396125	1320	0.52	73	0.22	0.38	1.05	0.37	0	0	100	0	450	0.89	0.70	3.13	8	68	0.12	5	53	45
TN14DJR028	1325	1.86	13	0.10	0.25	**0.95**	0.29	0	0	100	0	450	0.98	2.52	11.32	5	248	0.04	2	233	56
1396126	1338	0.51	73	0.22	0.37	1.05	0.37	0	0	100	0	450	0.89	0.68	3.07	8	67	0.12	5	52	44
1396127	1348	0.80	138	0.46	1.10	1.05	0.29	0	0	100	0	450	0.79	1.04	4.66	24	102	0.12	10	68	58
TN14DJR029	1360	1.30	13	0.09	0.17	**0.82**	0.35	0	0	100	0	450	0.98	1.77	7.94	4	174	0.00	2	170	0
1329805	1370	0.81	106	0.82	0.86	**0.96**	0.49	0	0	100	0	450	0.84	1.08	4.86	19	106	0.04	18	84	24
2872567	1370	1.33	90	0.90	1.20	**1.30**	0.43	0	0	100	0	450	0.87	1.77	7.96	26	174	0.43	20	85	379
1396128	1371	1.11	153	0.72	1.70	1.05	0.30	0	0	100	0	450	0.76	1.43	6.42	37	141	0.12	16	90	77

Jamison 1

Hydrocarbon Yield Calculation

																S2 (meas)	S2 (orig)				
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	Remaining Potential	Original Potential	Oil Cracked	S1 Free Oil	Estimated Oil	Cracked Gas
Jamison 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
TN14DJR030	1380	1.70	72	0.45	1.22	**0.92**	0.27	0	0	100	0	450	0.89	2.25	10.11	27	221	0.02	10	191	20
1396129	1392	0.76	176	0.82	1.34	1.05	0.38	0	0	100	0	450	0.73	0.98	4.41	29	97	0.12	18	59	50
TN14DJR032	1400	2.07	25	0.18	0.51	**0.79**	0.26	0	0	100	0	450	0.96	2.78	12.52	11	274	0.00	4	263	0
2831920	1407	1.79	73	0.90	1.30	**1.48**	0.41	0	0	100	0	450	0.89	2.38	10.72	28	235	0.67	20	69	826
TN14DJR003	1408	1.45	106	0.54	1.54	**0.87**	0.26	0	0	100	0	450	0.84	1.89	8.50	34	186	0.00	12	152	0
TN14DJR004	1408	1.26	126	0.65	1.59	**0.89**	0.29	0	0	100	0	450	0.81	1.63	7.35	35	161	0.00	14	126	0
1396130	1408	0.66	227	1.12	1.50	1.05	0.43	0	0	100	0	450	0.64	0.85	3.81	33	83	0.12	25	44	38
TN14DJR033	1418	1.15	14	0.05	0.16	1.05	0.24	0	0	100	0	450	0.98	1.56	7.02	4	154	0.12	1	132	112
1396131	1428	0.63	8	0.06	0.05	1.05	0.55	0	0	100	0	450	0.99	0.86	3.88	1	85	0.12	1	73	63
DI000023	1440	0.61	91	0.53	0.56	**0.90**	0.49	0	0	100	0	450	0.87	0.82	3.70	12	81	0.01	12	68	4
1396132	1451	0.66	67	0.24	0.44	1.05	0.35	0	0	100	0	450	0.90	0.88	3.97	10	87	0.12	5	68	58
2831921	1455	2.33	73	1.50	1.70	**1.12**	0.47	0	0	100	0	450	0.89	3.10	13.96	37	306	0.20	33	215	321
1396133	1469	2.22	118	1.69	2.62	1.05	0.39	0	0	100	0	450	0.82	2.90	13.07	57	286	0.12	37	200	171
TN14DJR034	1475	2.14	78	1.01	1.66	**0.75**	0.38	0	0	100	0	450	0.89	2.83	12.75	36	279	0.00	22	243	0
2831928	1482	2.98	161	1.80	4.80	**1.12**	0.27	0	0	100	0	450	0.75	3.77	16.97	105	372	0.20	39	213	318
DI000024	1483	2.16	115	2.20	2.49	**0.94**	0.47	0	0	100	0	450	0.83	2.85	12.82	55	281	0.03	48	219	44
1396134	1493	2.18	108	1.32	2.36	**1.03**	0.36	0	0	100	0	450	0.84	2.85	12.83	52	281	0.11	29	205	145
DI000025	1496	0.27	42	0.06	0.11	**1.39**	0.35	0	0	100	0	450	0.94	0.36	1.61	2	35	0.55	1	15	108
TN14DJR035	1500	1.09	26	0.12	0.28	**1.08**	0.30	0	0	100	0	450	0.96	1.47	6.63	6	145	0.16	3	117	132
2831923	1504	1.62	105	1.20	1.70	**1.30**	0.41	0	0	100	0	450	0.84	2.14	9.62	37	211	0.43	26	99	445
DI000026	1505	1.33	91	1.56	1.21	**1.08**	0.56	0	0	100	0	450	0.87	1.78	8.02	26	176	0.16	34	125	143
2831924	1507	3.23	80	1.50	2.60	**1.57**	0.37	0	0	100	0	450	0.88	4.24	19.10	57	418	0.78	33	81	1683
TN14DJR001	1507	2.38	64	0.70	1.52	**1.16**	0.32	0	0	100	0	450	0.91	3.15	14.18	33	310	0.24	15	210	401
TN14DJR002	1507	2.33	64	0.71	1.50	**1.14**	0.32	0	0	100	0	450	0.91	3.09	13.88	33	304	0.22	16	212	358
1396135	1507	2.64	127	1.51	3.34	**1.14**	0.31	0	0	100	0	450	0.81	3.41	15.33	73	336	0.22	33	205	347
TN14DJR036	1515	5.10	28	0.67	1.41	**1.10**	0.32	0	0	100	0	450	0.96	6.74	30.32	31	664	0.18	15	520	677
TN14DJR037	1520	2.63	26	0.26	0.69	**1.10**	0.27	0	0	100	0	450	0.96	3.52	15.85	15	347	0.18	6	272	361
TN14DJR038	1525	2.19	37	0.27	0.82	**1.03**	0.25	0	0	100	0	450	0.95	2.92	13.16	18	288	0.11	6	241	176
TN14DJR039	1530	2.60	28	0.25	0.73	**1.13**	0.26	0	0	100	0	450	0.96	3.48	15.65	16	343	0.22	5	256	424
1396136	1543	1.44	71	0.53	1.02	**1.16**	0.34	0	0	100	0	450	0.90	1.91	8.61	22	189	0.24	12	126	241
TN14DJR040	1550	2.94	22	0.31	0.66	**1.15**	0.32	0	0	100	0	450	0.97	3.94	17.73	14	388	0.24	7	286	529
1396137	1557	1.40	69	0.67	0.96	**1.17**	0.41	0	0	100	0	450	0.90	1.87	8.41	21	184	0.26	15	120	258
TN14DJR041	1564	2.92	22	0.27	0.64	**1.26**	0.30	0	0	100	0	450	0.97	3.91	17.60	14	386	0.38	6	232	839
1396138	1574	1.33	129	1.15	1.71	**1.16**	0.40	0	0	100	0	450	0.81	1.74	7.85	37	172	0.24	25	102	195
1329804	1580	1.70	66	0.99	1.13	**0.98**	0.47	0	0	100	0	450	0.90	2.28	10.24	25	224	0.06	22	188	70
1396139	1580	8.97	20	1.54	1.81	**1.32**	0.46	0	0	100	0	450	0.97	11.65	52.41	40	1148	0.45	34	608	3000
2872297	1580	1.41	71	0.90	1.00	**1.84**	0.47	0	0	100	0	450	0.90	1.89	8.50	22	186	0.99	20	2	973
TN14DJR042	1585	3.80	19	0.41	0.73	**1.27**	0.36	0	0	100	0	450	0.97	5.08	22.84	16	500	0.39	9	297	1123
TN14DJR043	1590	3.90	19	0.44	0.73	**1.28**	0.38	0	0	100	0	450	0.97	5.21	23.43	16	513	0.40	10	296	1208
TN14DJR044	1600	2.21	18	0.23	0.40	**0.95**	0.37	0	0	100	0	450	0.97	2.98	13.41	9	294	0.04	5	274	66
1396140	1604	2.47	45	0.92	1.11	**1.12**	0.45	0	0	100	0	450	0.94	3.31	14.88	24	326	0.20	20	242	360
1396141	1612	1.40	72	0.83	1.01	**0.80**	0.45	0	0	100	0	450	0.90	1.87	8.43	22	185	0.00	18	162	0
1329813	1623	2.31	58	1.17	1.35	**1.28**	0.46	0	0	100	0	450	0.92	3.09	13.89	30	304	0.40	26	164	664
1396142	1623	2.42	62	1.10	1.49	**1.19**	0.42	0	0	100	0	450	0.91	3.22	14.50	33	318	0.29	24	204	489
2872295	1623	1.22	33	0.80	0.40	**1.39**	0.67	0	0	100	0	450	0.95	1.66	7.47	9	164	0.55	18	70	510
TN14DJR045	1629	4.53	19	0.80	0.86	1.05	0.48	0	0	100	0	450	0.97	6.04	27.16	19	595	0.12	18	504	430
DI000027	1641	2.14	65	1.61	1.38	**1.16**	0.54	0	0	100	0	450	0.91	2.86	12.89	30	282	0.24	35	191	365
1396143	1641	2.67	87	1.72	2.33	**1.10**	0.42	0	0	100	0	450	0.87	3.53	15.86	51	347	0.18	38	243	318
TN14DJR047	1645	5.82	12	0.93	0.69	**1.05**	0.57	0	0	100	0	450	0.98	7.72	34.72	15	760	0.12	20	655	539
TN14DJR048	1650	7.43	8	0.72	0.58	**1.13**	0.55	0	0	100	0	450	0.99	9.76	43.93	13	962	0.21	16	748	1207
TN14DJR049	1655	3.68	15	0.68	0.55	1.05	0.55	0	0	100	0	450	0.98	4.94	22.21	12	486	0.12	15	415	354
1396144	1658	1.65	53	0.91	0.87	**0.94**	0.51	0	0	100	0	450	0.92	2.22	9.99	19	219	0.03	20	193	39
1329812	1660	1.76	44	0.68	0.77	**1.19**	0.47	0	0	100	0	450	0.94	2.37	10.66	17	233	0.29	15	155	371
1396145	1660	1.89	44	0.71	0.84	**1.44**	0.46	0	0	100	0	450	0.94	2.54	11.43	18	250	0.62	16	88	863
2872293	1660	1.91	26	0.50	0.50	**1.66**	0.50	0	0	100	0	450	0.96	2.58	11.61	11	254	0.87	11	32	1271
TN14DJR050	1665	4.50	6	0.23	0.28	**1.49**	0.45	0	0	100	0	450	0.99	6.01	27.06	6	593	0.67	5	191	2373
1396146	1698	1.47	26	0.27	0.38	**1.70**	0.42	0	0	100	0	450	0.96	1.99	8.95	8	196	0.90	6	18	1015
1396147	1699	1.21	27	0.28	0.33	**1.62**	0.46	0	0	100	0	450	0.96	1.64	7.38	7	162	0.83	6	25	773
2831925	1701	1.04	38	0.20	0.40	**2.02**	0.33	0	0	100	0	450	0.94	1.40	6.30	9	138	1.00	4	0	776
1396148	1707	1.29	19	0.20	0.25	**1.75**	0.44	0	0	100	0	450	0.97	1.75	7.88	5	173	0.94	4	10	945

Weatherford LABORATORIES

Jamison 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
Jamison 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
2831926	1709	0.78	26	0.10	0.20	**2.38**	0.33	0	0	100	0	450	0.96	1.06	4.76	4	104	1.00	2	0	599
Kyalla (Avg)		**1.83**	**123**	**0.73**	**2.25**	**1.05**	**0.32**	**0**	**0**	**95**	**5**	**465**	**0.82**	**2.37**	**11.09**	**49**	**243**	**0.19**	**16**	**147**	**277**
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)