



Elliott 1 Interpretive Summary

Kyalla Interval

As a part of:

Northern Territory Geological Survey - Australia
McArthur Basin Integrated Petroleum Geochemistry, 2016

Submitted to:

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Study Project No. AB-74329

June 29, 2016

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PETROLEUM GEOCHEMISTRY

INTRODUCTORY NOTE

A geochemical investigation has been conducted to assess hydrocarbon prospectivity of the Kyalla, Formation in the Elliott 1 well located in the Beetaloo Sub-Basin, Northern Territories, Australia. Five (5) 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 81 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
Elliott 1	Kyalla	<i>Estimated Original</i> →		Good (1.46% TOC)	Oil-prone Type II	High
		<i>Measured Currently</i> →	Oil	Fair (0.87% 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

Five (5) samples from the Kyalla Formation were analyzed for LECO TOC content and programmed pyrolysis, with the remaining data set (81 samples) composed of client supplied public data (Fig. 1). TOC contents ranged from 0.17 to 3.80 wt.% and averaged 0.87 wt.% (fair). Twenty-six (26) samples have TOC content above the minimum requirement of 1 wt.% for *effective* petroleum source rocks, while five (5) of these samples have TOC content above the minimum requirement of 2 wt.% for *economic* petroleum source rocks. Highest TOC content occurs near the base of the designated Kyalla interval (1120.05 m depth) and the basal portion of the Kyalla in this well has a much thicker zone of elevated TOC (Fig. 1).

The S1 values of the Kyalla source rock samples average 0.59 mg HC/g rock (13 bbl oil/acre-ft) and the S2 values average 1.99 mg HC/g rock (44 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 51 (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 three samples which exhibit S1 cross over TOC in the Kyalla interval, all within the basal section that contains elevated TOC (Fig. 1).

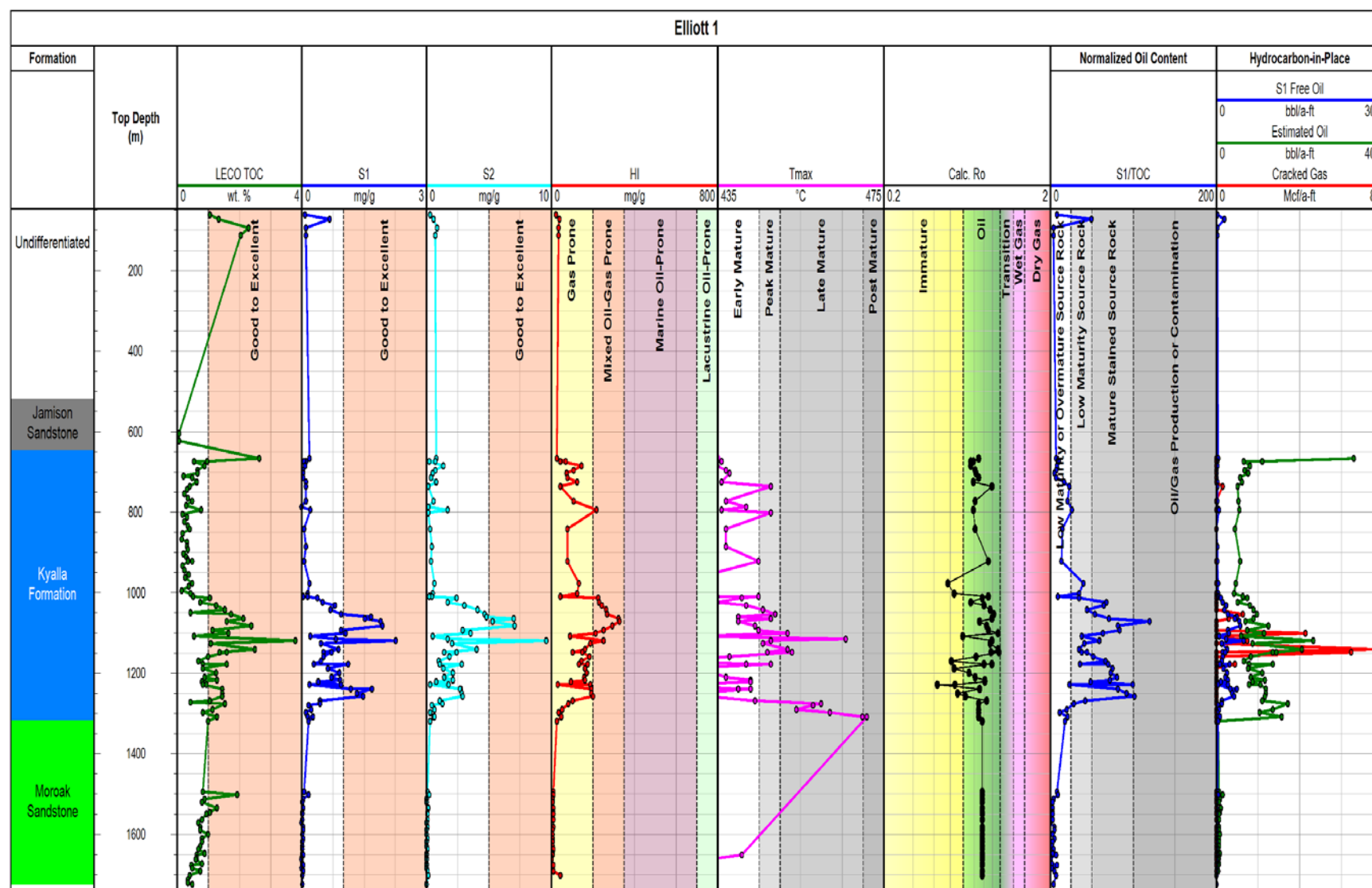


Figure 1. Geochemical depth plots for the Elliott 1 well.

The measured Hydrogen Index (HI) values in the Kyalla average 151 mg HC/g TOC, indicating gas-prone Type III kerogen quality in these source rocks at present day. Original HI_o of these samples are estimated to average 450 mg HC/g rock, which indicate oil-prone Type II kerogen. Transformation Ratios (TR) based upon HI are average 76%, which suggest peak oil window thermal maturity. The T_{max} values in the Kyalla samples average is 439°C. T_{max} between 435 and 445°C typically indicate peak oil window, while values between 445 and 450°C typically indicate late 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 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.

The Production Index (PI) values in the Kyalla samples average 0.23. These elevated PI values are consistent with source rocks in the peak oil window, which typically have PI values in the range of 0.15 to 0.25, while samples in the late oil window tend to have values in the range of 0.25 to 0.35.

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). Six (6) samples from the Kyalla Formation (avg. 60% clays) have an average measured Kübler Index of 0.218, which is equivalent to a measured vitrinite reflectance of > 4% (late stage metagenesis). This interpretation is inconsistent with other geochemical maturity ratios evaluated in this study and suggests the Kübler Index should be used with caution to evaluate thermal maturity in Mesoproterozoic aged source rocks.

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):

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

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

Table 2. Average Kerogen Estimations for Elliott 1 well.

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

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

HI_{pd} and PI_{pd} are the measured HI and PI values for the various source rock samples in this well. The average HI_{pd} and PI_{pd} for the formations evaluated in the current study are shown in Table 3. HI_o and PI_o are the original HI and PI values for immature organic matter in the rocks. For this calculation using the assumptions described previously results in an average HI_o values of 450 mg HC/g TOC (Table 2). We assume a PI_o of 0.02 (see Peters et al., 2005). Using these values in equation 2, the extent of fractional conversion of HI_o to petroleum is 0.76 (Table 3), i.e., on average an estimated 76% 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} × 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 1.46 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 Elliott 1 well, the average S2_o values are 6.6 mg HC/g rock or approximately 144 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).

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

Using this methodology for the Kyalla samples analyzed in the current study, the estimated generated oil yields average 100 bbl/acre-ft (Table 3), along with a very minor amount (5 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	1.16	151	44	450	0.76	1.46	144	13	100	5

Table 3. Hydrocarbon Yields average data for Elliott 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 87%, which is consistent with a source rock in the peak to late oil generation window.

The Kyalla source rock interval in the Elliott 1 well is interpreted to be in the peak oil window and hydrocarbon yield calculations suggest minor to moderate amounts of generation have occurred (predominantly oil with minor 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 Kyalla Formation, original generation potential (S2_o) averages 144 bbl oil/acre-ft, this is below all of the other formations on the list of unconventional US Shale plays shown below.

Sample Database Averages TOC >1%	HI ^o mg/g TOC	TR	TOC ^o wt%	S2 ^o 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	0.76	1.46	6.57	44	144	0.00	13	100	5

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 Elliott 1 well. The measured SRP oil saturations are lower than those determined by SRA methods using the S1 yields. In a sample from the Kyalla Formation (1176.57 m depth), the saturation determined by SRP was 0.09 mg oil/g AR Rock (2 bbl oil/acre-ft), while that determined from S1 yields on the same sample is 0.20 mg oil/g AR Rock (4 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 Elliott 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). 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 Hl_o estimates using measured and interpreted fractional composition of kerogen macerals.

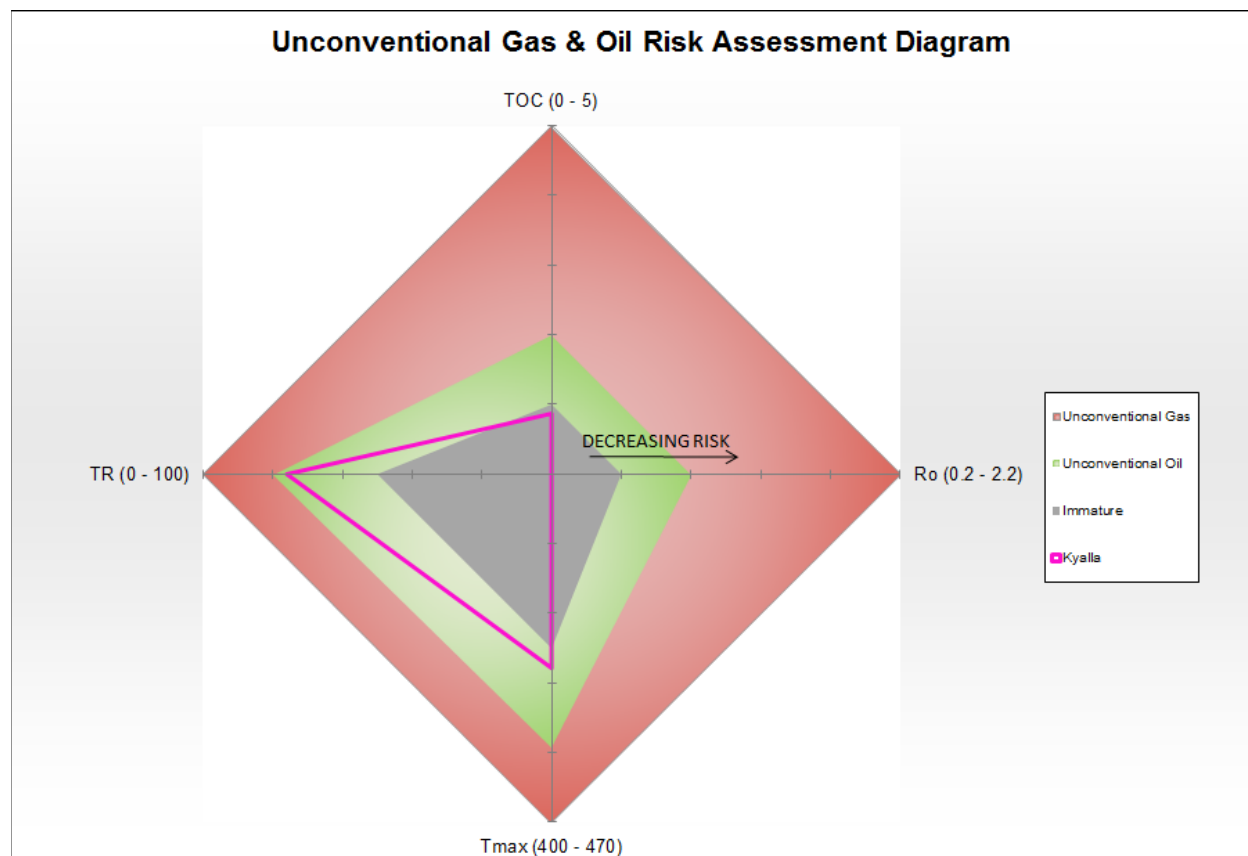


Figure 2. Geochemical Risk Assessment diagram for Mesoproterozoic Kyalla Formation source rocks in the Elliott 1 well.

The Kyalla source rock interval in the Elliott 1 well is interpreted to represent a high geochemical risk for in-situ shale oil production. The average measured TOC content of 0.87 wt.% is below the generally accepted minimum value of 1% TOC to be considered an *effective* source rock for hydrocarbon generation/expulsion (Fig. 2). Some samples do exceed this threshold, predominantly in the basal portion of the Kyalla interval, and this zone could represent a somewhat lower risk target. However, the overall average organic richness is considered marginal and thus the designation of high risk. Most of these

source rocks are below 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 II marine algal kerogen. Thermal maturity parameters from programmed pyrolysis generally place the Kyalla source interval in peak oil window. The average Tmax value of 439°C is above recommended minimum value of 435°C for shale oil and well below the minimum of 455°C for shale gas (Fig. 2). This amount of conversion would likely be sufficient to generate/expel moderate amounts of hydrocarbons from this 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 and just below the 80% threshold for shale gas systems (Fig. 2).

In the Kyalla source interval, measured in-situ oil saturation determined by programmed pyrolysis S1 yields is generally fair to poor (avg. 13 bbl oil/acre-ft), which is a significant concern regarding risk assessment for unconventional oil (Fig. 3). This is also supported by the low in-situ hydrocarbon saturations determined from SRP analysis (2 bbl oil/acre-ft), although this single sample may not be representative of the entire interval. Hydrocarbon yield calculations on as-received samples show estimates of average generated oil from the Kyalla at 100 bbl oil/acre-ft, along with a very minor amount of secondary cracked gas (5 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.3). These values are significantly higher compared to the Kyalla, primarily due to differences in TOC (Barnett Shale oil example has 4.70 wt. % TOC).

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 peak 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.

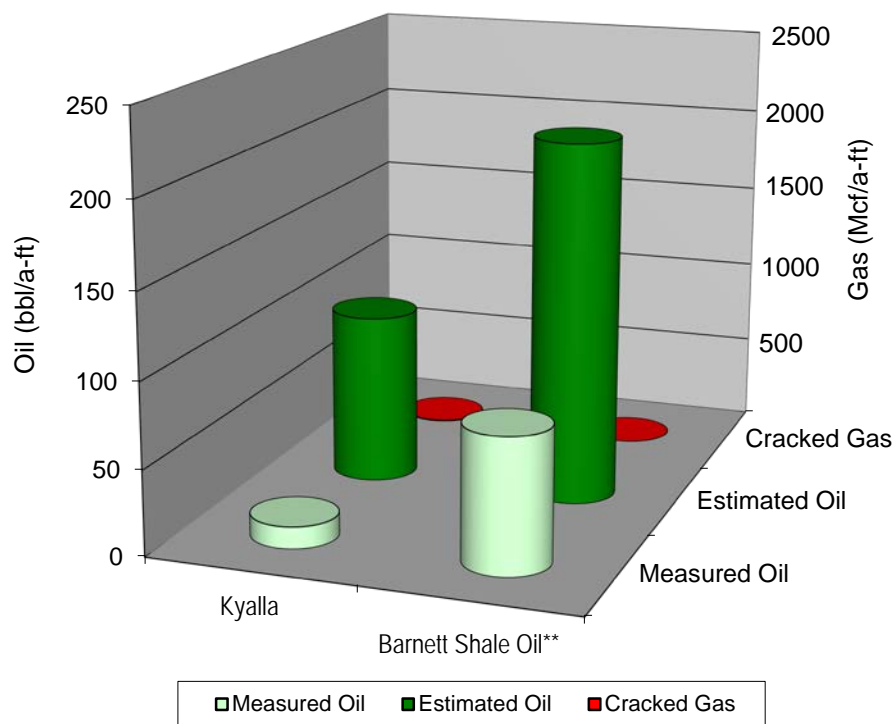


Figure 3. Hydrocarbon yield estimates for the Mesoproterozoic source rocks in the Elliott 1 well compared to Barnett Shale in the oil window.

GEOCHEMICAL SUMMARY

The Kyalla source interval in the Elliott 1 well is interpreted to represent high geochemical risk for unconventional shale oil development. The average measured TOC content of 0.87 wt.% is below the generally accepted minimum value of 1% TOC for unconventional shale oil, although the basal section of this source rock interval does have relatively higher TOC values. The Kyalla source rock is thought to contain dominantly oil-prone Type II kerogen. Thermal maturity parameters indicate that this source interval is in the peak oil window, 0.75% Calc. R_o . All key thermal maturity risk ratios are above recommended minimum thresholds for shale oil systems. While the Kyalla has likely generated minor to moderate amounts of oil (avg. 100 bbl oil/acre-ft), comparison to other systems such as the Barnett Shale show in-situ oil saturations are much lower for the Kyalla. Risk criteria like the S1 versus TOC show only limited oil cross-over for the samples within this unit, also supporting a high risk assessment. Further evaluation of in-situ oil characteristics would be required to fully evaluate potential oil mobility and recovery risk.

REFERENCES CITED

- Crick I. H., Boreham, C. J., Cook, A. C. and Powell, T.G., 1988, Petroleum geology and geochemistry of Upper Proterozoic McArthur Basin, Northern Territory II: Assessment of source rock potential. American Association of Petroleum Geologists, Bulletin 72(12), 1495–1514.
- Jarvie, D. M., 2012, Shale resource systems for oil and gas: Part 2 – shale-oil resource systems, *in* Breyer, J.A., ed., Shale reservoirs—giant resources for the 21st century: AAPG Memoir 97, CD-ROM Material, p. 89-119.
- Jarvie, D. M., Hill, R.J., Ruble, T.E., and Pollastro, R.M., 2007, Unconventional shale gas systems: the Mississippian Barnett Shale of north-central Texas as one model for thermogenic shale-gas assessment, American Association of Petroleum Geologists Bulletin, v. 91, p. 475-499.
- Jarvie, D. M. and Tobey, M H., 1999, TOC, Rock-Eval, or SR Analyzer Interpretive Guidelines: Application Note 99-4: Weatherford Laboratories, 16 p.
- Law, B. E., Ahlbrandt, T. and Hoyer, D., 2010, Source and reservoir rock attributes of Mesoproterozoic shale, Beetaloo Basin, Northern Territory, Australia. Search and Discovery Article #110130 (14 June 2010). Adapted from oral presentation at session: Genesis of shale gas – physicochemical and geochemical constraints affecting methane adsorption and desorption, at AAPG Annual Convention, New Orleans, Louisiana, April 11–14, 2010.
http://www.searchanddiscovery.com/documents/2010/110130law/ndx_law.pdf
- Lewan, M. D., 1987, Petrographic study of primary petroleum migration in the Woodford Shale and related rock units, *in* B. Doligez, ed., Migration of hydrocarbons in sedimentary basins, 2nd Edition, IFP Exploration Research Conference, Carcans, France, June 15-19, 1987, p. 113-130.
- Peters, K. E., 1986, Guidelines for evaluating petroleum source rocks using programmed pyrolysis, AAPG Bulletin, v 70, p. 318-329.
- Peters, K. E., C. C. Walters, and M. Moldowan, 2005, The biomarker guide, 2nd Edition, Volumes 1 and 2, Cambridge University Press, 1155 p.
- Taylor, D. P., Kontorovich, A. E., Larichev, A. I. and Glikson, M., 1994. Petroleum source rocks in the Roper Group of the McArthur Basin: Source characterisation and maturity determinations using physical and chemical methods. APEA Journal 34, 279 –296.

Appendix I

Hydrocarbon Yield Calculation
Beetaloo Sub-Basin Group
Elliott 1

McArthur Basin Integrated Petroleum Geochemistry, 2016
Northern Territory Geological Survey - Australia



Elliot 1
Hydrocarbon Yield Calculation

Sample	Top Depth	TOC*	HI*	S1*	S2*	Calc.Ro	PI*	%Type IV 50 HIº	% Type III 125 HIº	%Type II 450 HIº	%Type I 750 HIº	HIº	TR	TOCº	S2º	S2 (meas) Remaining Potential	S2 (orig) Original Potential	Oil Cracked	S1 Free Oil	Estimated Oil	Cracked Gas
	(m)	wt%	mg/g TOC	mg/g Rock	mg/g Rock	%						mg/g TOC		wt%	mg/g Rock	bb/a-ft	bb/a-ft	%	bb/a-ft	bb/a-ft	Mcf/a-ft
Elliot 1	667	2.65	30	0.20	0.80	0.75	0.20	0	0	100	0	450	0.96	3.54	15.91	18	348	0.00	4	331	0
	677	0.98	72	0.10	0.71	0.69	0.12	0	0	100	0	450	0.89	1.29	5.79	16	127	0.00	2	111	0
BE14DJR001	677	0.55	44	0.06	0.24	0.67	0.20	0	0	100	0	450	0.94	0.74	3.32	5	73	0.00	1	67	0
	688	0.90	149	0.08	1.34	0.67	0.06	0	0	100	0	450	0.76	1.12	5.05	29	111	0.00	2	81	0
	698	0.66	108	0.05	0.71	0.71	0.07	0	0	100	0	450	0.83	0.85	3.81	16	83	0.00	1	68	0
	705	0.68	74	0.04	0.50	0.72	0.07	0	0	100	0	450	0.89	0.89	4.01	11	88	0.00	1	77	0
	716	0.51	78	0.04	0.40	0.75	0.09	0	0	100	0	450	0.88	0.67	3.01	9	66	0.00	1	57	0
	726	0.65	128	0.11	0.83	0.69	0.12	0	0	100	0	450	0.80	0.83	3.73	18	82	0.00	2	63	0
	737	0.42	45	0.10	0.19	0.90	0.34	0	0	100	0	450	0.93	0.57	2.55	4	56	0.01	2	51	3
	774	0.51	110	0.11	0.56	0.71	0.16	0	0	100	0	450	0.83	0.66	2.97	12	65	0.00	2	53	0
	795	0.78	221	0.21	1.72	0.69	0.11	0	0	100	0	450	0.63	0.94	4.23	38	93	0.00	5	55	0
	844	0.40	80	0.06	0.32	0.71	0.16	0	0	100	0	450	0.88	0.53	2.37	7	52	0.00	1	45	0
	925	0.51	78	0.07	0.40	0.85	0.15	0	0	100	0	450	0.88	0.67	3.02	9	66	0.00	2	57	0
	977	0.49	135	0.20	0.66	0.49	0.23	0	0	100	0	450	0.79	0.63	2.84	14	62	0.00	4	48	0
	1003	0.43	128	0.15	0.55	0.53	0.21	0	0	100	0	450	0.80	0.55	2.50	12	55	0.00	3	43	0
BE14DJR005	1010	0.53	45	0.05	0.24	0.85	0.17	0	0	100	0	450	0.93	0.71	3.19	5	70	0.00	1	65	0
	1014	1.07	226	0.38	2.42	0.78	0.14	0	0	100	0	450	0.62	1.29	5.81	53	127	0.00	8	74	0
	1025	0.74	232	0.50	1.72	0.67	0.23	0	0	100	0	450	0.62	0.91	4.09	38	89	0.00	11	52	0
	1034	1.25	246	0.81	3.08	0.80	0.21	0	0	100	0	450	0.59	1.51	6.81	67	149	0.00	18	82	0
	1045	1.55	266	0.70	4.12	0.87	0.15	0	0	100	0	450	0.54	1.83	8.23	90	180	0.00	15	90	0
	1054	1.75	269	0.95	4.71	0.92	0.17	0	0	100	0	450	0.53	2.07	9.32	103	204	0.02	21	99	13
	1065	2.15	326	1.52	7.00	0.90	0.18	0	0	100	0	450	0.41	2.47	11.13	153	244	0.01	33	90	6
	1074	1.60	331	1.91	5.30	0.76	0.26	0	0	100	0	450	0.42	1.89	8.50	116	186	0.00	42	70	0
	1084	2.40	295	1.95	7.07	0.83	0.22	0	0	100	0	450	0.49	2.83	12.76	155	279	0.00	43	125	0
	1093	1.15	254	0.96	2.92	0.85	0.25	0	0	100	0	450	0.58	1.40	6.31	64	138	0.00	21	74	0
	1102	1.65	217	1.06	3.58	0.98	0.23	0	0	100	0	450	0.65	2.03	9.15	78	200	0.06	23	115	43
	1110	0.55	93	0.21	0.51	0.60	0.29	0	0	100	0	450	0.86	0.73	3.27	11	72	0.00	5	60	0
	1120	3.80	253	2.26	9.61	0.90	0.19	0	0	100	0	450	0.57	4.53	20.39	210	446	0.01	49	233	15
	1128	1.10	191	0.46	2.10	0.87	0.18	0	0	100	0	450	0.69	1.36	6.14	46	134	0.00	10	88	0
	1142	2.50	163	0.89	4.08	0.98	0.18	0	0	100	0	450	0.74	3.13	14.07	89	308	0.06	19	206	77
DI000019	1149	1.37	106	0.52	1.45	0.89	0.26	0	0	100	0	450	0.84	1.79	8.04	32	176	0.00	11	144	0
	1151	1.60	150	0.72	2.40	0.99	0.23	0	0	100	0	450	0.77	2.04	9.16	53	201	0.07	16	137	65
	1160	1.00	185	0.52	1.85	0.72	0.22	0	0	100	0	450	0.70	1.25	5.64	41	123	0.00	11	83	0
	1171	0.70	146	0.47	1.02	0.51	0.32	0	0	100	0	450	0.78	0.91	4.08	22	89	0.00	10	67	0
BE14DJR008	1178	0.83	135	0.30	1.12	0.80	0.21	0	0	100	0	450	0.79	1.06	4.79	25	105	0.00	7	80	0
	1180	1.60	177	1.13	2.83	0.90	0.29	0	0	100	0	450	0.72	2.03	9.12	62	200	0.01	25	136	9
	1189	0.85	162	0.64	1.38	0.53	0.32	0	0	100	0	450	0.75	1.09	4.91	30	108	0.00	14	77	0
	1200	1.25	173	0.91	2.16	0.65	0.30	0	0	100	0	450	0.73	1.59	7.16	47	157	0.00	20	110	0
	1210	0.90	159	0.73	1.43	0.71	0.34	0	0	100	0	450	0.76	1.16	5.23	31	114	0.00	16	83	0
	1220	1.30	165	0.94	2.14	0.81	0.31	0	0	100	0	450	0.74	1.66	7.48	47	164	0.00	21	117	0
BE14DJR012	1222	0.81	96	0.40	0.78	0.81	0.34	0	0	100	0	450	0.86	1.07	4.81	17	105	0.00	9	88	0
	1229	0.95	189	0.95	1.80	0.54	0.35	0	0	100	0	450	0.70	1.21	5.46	39	120	0.00	21	80	0
BE14DJR010	1231	0.85	33	0.20	0.28	0.42	0.42	0	0	100	0	450	0.95	1.15	5.18	6	113	0.00	4	107	0
	1240	1.45	192	1.19	2.79	0.76	0.30	0	0	100	0	450	0.70	1.83	8.24	61	180	0.00	26	119	0
	1250	1.45	194	1.34	2.82	0.56	0.32	0	0	100	0	450	0.69	1.84	8.27	62	181	0.00	29	119	0
	1259	1.45	201	1.48	2.91	0.62	0.34	0	0	100	0	450	0.68	1.84	8.27	64	181	0.00	32	117	0
	1270	1.05	107	0.45	1.12	0.83	0.29	0	0	100	0	450	0.84	1.37	6.18	25	135	0.00	10	111	0
	1279	1.55	84	0.44	1.30	0.75	0.25	0	0	100	0	450	0.88	2.04	9.16	28	201	0.00	10	172	0
	1292	1.15	56	0.23	0.64	0.75	0.26	0	0	100	0	450	0.92	1.53	6.90	14	151	0.00	5	137	0
	1300	0.85	39	0.10	0.33	0.75	0.23	0	0	100	0	450	0.94	1.14	5.14	7	113	0.00	2	105	0
	1311	1.30	52	0.28	0.67	0.75	0.29	0	0	100	0	450	0.93	1.74	7.82	15	171	0.00	6	157	0
Kyalla (Avg)		1.16	151	0.59	1.99	0.75	0.23	0	0	100	0	450	0.76	1.46	6.57	44	144	0.00	13	100	5
	1322	1.00	28	0.18	0.28	0.78	0.39	100	0	0	0	50	0.46	1.03	0.51	6	11	0.00	4	5	0
	1495	0.85	12	0.07	0.10	0.78	0.41	100	0	0	0	50	0.77	0.88	0.44	2	10	0.00	2	7	0
	1505	1.95	13	0.18	0.26	0.78	0.41	100	0	0	0	50	0.74	2.02	1.01	6	22	0.00	4	16	0
	1514	0.90	6	0.04	0.05	0.78	0.44	100	0	0	0	50	0.89	0.94	0.47	1	10	0.00	1	9	0
	1523	0.80	6	0.03	0.05	0.78	0.38	100	0	0	0	50	0.88	0.83	0.42	1	9	0.00	1	8	0
	1537	1.30	12	0.05	0.16	0.78	0.24	100	0	0	0	50	0.76	1.34	0.67	4	15	0.00	1	11	0
	1547	1.05	11	0.03	0.12	0.78	0.20	100	0	0	0	50	0.78	1.09	0.54	3	12	0.00	1	9	0
	1551	0.95	13	0.03	0.12	0.78	0.20	100	0	0	0	50	0.76	0.98	0.49	3	11	0.00	1	8	0

Elliot 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
Elliot 1	(m)	wt%	mg/g TOC	mg/g Rock	mg/g Rock	%						mg/g TOC		wt%	mg/g Rock	bbbl/a-ft	bbbl/a-ft	%	bbbl/a-ft	bbbl/a-ft	Mcf/a-ft
	1564	0.80	10	0.03	0.08	0.78	0.27	100	0	0	0	50	0.81	0.83	0.41	2	9	0.00	1	7	0
	1582	0.75	12	0.04	0.09	0.78	0.31	100	0	0	0	50	0.77	0.78	0.39	2	9	0.00	1	7	0
	1593	0.75	5	0.04	0.04	0.78	0.50	100	0	0	0	50	0.90	0.78	0.39	1	9	0.00	1	8	0
	1602	1.00	6	0.03	0.06	0.78	0.33	100	0	0	0	50	0.88	1.04	0.52	1	11	0.00	1	10	0
	1615	0.80	9	0.04	0.07	0.78	0.36	100	0	0	0	50	0.83	0.83	0.41	2	9	0.00	1	8	0
	1621	0.80	6	0.03	0.05	0.78	0.38	100	0	0	0	50	0.88	0.83	0.42	1	9	0.00	1	8	0
	1633	0.75	5	0.02	0.04	0.78	0.33	100	0	0	0	50	0.90	0.78	0.39	1	9	0.00	0	8	0
	1640	0.70	10	0.03	0.07	0.78	0.30	100	0	0	0	50	0.81	0.73	0.36	2	8	0.00	1	6	0
	1650	0.90	7	0.03	0.06	0.78	0.33	100	0	0	0	50	0.87	0.93	0.47	1	10	0.00	1	9	0
DI000020	1655	0.65	9	0.05	0.06	0.78	0.45	100	0	0	0	50	0.82	0.67	0.34	1	7	0.00	1	6	0
	1659	0.65	5	0.01	0.03	0.78	0.25	100	0	0	0	50	0.91	0.68	0.34	1	7	0.00	0	7	0
	1665	0.60	3	0.01	0.02	0.78	0.33	100	0	0	0	50	0.94	0.62	0.31	0	7	0.00	0	6	0
	1675	0.80	5	0.02	0.04	0.78	0.33	100	0	0	0	50	0.90	0.83	0.42	1	9	0.00	0	8	0
DI000021	1679	0.46	11	0.04	0.05	0.78	0.45	100	0	0	0	50	0.79	0.48	0.24	1	5	0.00	1	4	0
	1693	0.75	13	0.04	0.10	0.78	0.29	100	0	0	0	50	0.74	0.78	0.39	2	8	0.00	1	6	0
	1704	0.40	45	0.03	0.18	0.78	0.14	100	0	0	0	50	0.11	0.40	0.20	4	4	0.00	1	0	0
Moroak Sandstone (Avg)		0.85	11	0.05	0.09	0.78	0.33	100	0	0	0	50	0.79	0.88	0.44	2	10	0.00	1	8	0
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)