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Relationships among mineralogy, geochemistry, and oil and gas production in the Tuscaloosa marine shale

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RELATIONSHIPS AMONG MINERALOGY, GEOCHEMISTRY, AND OIL AND GAS PRODUCTION IN THE TUSCALOOSA MARINE SHALE

by

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ABSTRACT

The Tuscaloosa Marine Shale (TMS) is an unconventional shale reservoir located in southeast Louisiana and southwest Mississippi. Limited mineralogical and geochemical data for the TMS have been published. The data that do exist indicate that the formation is heterogeneous. Consequently, previous investigators and oil and gas companies have not managed to effectively link mineralogical and chemical changes to oil and gas production in the TMS. These linkages are critical to establish for future exploration efforts. In this study, we attempt to establish these relationships by gathering all existing mineralogical and chemical data in the TMS, including newly acquired data from drill cuttings and comparing it to the volumes of oil, gas, and water production.

The TMS is dominated by clay minerals with various amounts of quartz and calcite and smaller amounts of other minerals. Organic geochemical results suggest the presence of mixed type II and III kerogen. The variability of depositional environments influenced by proximity to depocenters, clastic influx, and sea level fluctuations, has led to a great deal of physical and chemical heterogeneity within the TMS. In most cases, comparisons of the mineral and geochemical data to production/drilling information show no obvious correlations. However, weak relationships are found between oil production and regions with lower amounts of total clay and higher amounts of quartz, and areas of higher TOC. The results of this study, and continued evaluation of these trends with new data, including the consideration of mechanical features such as natural fracturing, will be needed to further the understanding of what factors control production success in this unit.

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NOMENCLATURE

Symbol	Description
LA	Louisiana
MS	Mississippi
TMS	Tuscaloosa Marine Shale
EIA	U.S. Energy Information Administration
OAE 2	Ocean Anoxic Event 2
HRZ	High resistivity zone
wt%	Weight percent
TOC	Total Organic Content
HI	Hydrogen Index
OI	Oxygen Index
PI	Production Index
VRo	Vitrinite Reflectance

1. INTRODUCTION

The "shale revolution" in the U.S. was born in the early 2000s through the development of hydraulic fracturing technology and the drive for domestic sources for oil and gas. The U.S. Energy Information Administration (EIA) estimates that tight oil resources contributed 63% of the total U.S. crude oil production in 2019. While major plays such as the Eagle Ford and Marcellus make up the majority of tight oil production, minor (less than 50,000 barrels per day production) and emerging plays were responsible for about 15% of the ~5 million barrels of oil produced per day from unconventional wells (Department of Energy; U.S. Energy Information Administration).

The Tuscaloosa Marine Shale (TMS) is one of these emerging unconventional plays which has gained attention in recent years because of its size and potential. Unfortunately, little published data exist regarding the mineralogy, geochemistry, and petrophysics of the TMS. This lack of data is a key factor in limiting the development of this potentially important oil and gas field. The TMS is extremely heterogeneous, so substantial amounts of data are required to understand the changes in facies distributions that control physical and geochemical properties. Further understanding of the mineralogy and organic content of the TMS can lead to significant commercial potential if these features can be effectively linked to success in oil and gas production.

The objectives of this investigation are (1) To compile newly available mineralogical and geochemical data for the TMS, and (2) To establish relationships among historical oil and gas production, mineralogy, and geochemistry in the TMS using all available data. This study builds on previous work by Borrok et al. (2019), where mineralogical and geochemical data from core from eleven wells were synthesized and interpreted to better understand the TMS. In this study, core data from three additional TMS wells and data from newly analyzed cuttings from the horizontal legs of seven more TMS wells are included. Counting the previous investigation, data for twenty-one wells were used in the study. Figure 1.1 illustrates the distribution of these sample locations across the TMS producing region.

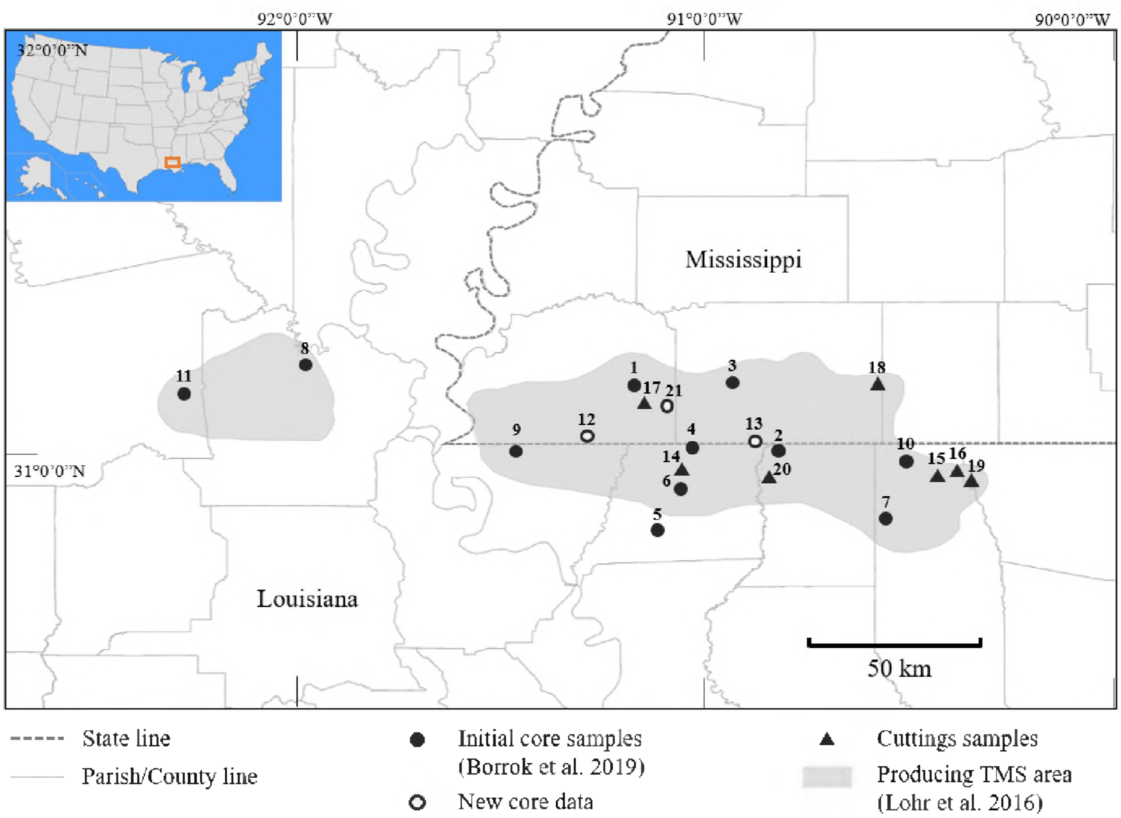


Figure 1.1 Regional map showing locations of wells with mineralogical and geochemical data used in this study. Shaded regions represent the general extent of the currently producing areas within the TMS.

2. THE TUSCALOOSA MARINE SHALE

2.1. GEOLOGY

The TMS is the middle unit of the Upper Cretaceous Tuscaloosa Group. The Tuscaloosa Group represents a complete marine depositional cycle (Spooner, 1964; John et al., 1997; Dubiel et al., 2012; Lowrey et al., 2017). The deepest unit of the Tuscaloosa Group is the Lower Tuscaloosa which consists of fluvial and deltaic sandstones, siltstones, and shales (Rouse et al., 2018). The Lower Tuscaloosa was deposited onto a mid-Cenomanian unconformity following a marine base level fall (Mancini and Puckett, 2003). The Lower Tuscaloosa was deposited as base levels began to rise and accommodation space increased. Therefore, the Lower Tuscaloosa represents the transgressional part of the cycle. The thickness and large amounts of sand indicate high rates of siliciclastic input (Enomoto et al., 2017). Sediment was sourced from the Tuscaloosa fluvial/deltaic system and a clastic depocenter in central Louisiana was present during the depositional period (Figure 2.1; Galloway, 2008). Conformably following the Lower Tuscaloosa, the TMS, or the Middle Tuscaloosa, is a gray to black, organic-rich shale that is highly laminated with thinly interbedded siltstones. The TMS was deposited in the inundated, or high-stand, phase of the depositional cycle (John et al., 1997). The maximum flooding surface was preserved within the TMS marking the end of the transgression (Mancini and Puckett, 2003). It is believed that the base of the TMS was deposited during the Cretaceous ocean anoxic event 2 (OAE 2; Liu, 2005). These OAEs were global events that led to the widespread deposition of organic-rich black shales (Allen et al., 2014). The transition from the Cenomanian and Turonian ages occurs within the TMS. Conformably overlaying the TMS is the Upper Tuscaloosa, which consists of fluvial and shallow marine sands and silts (Mancini and Puckett, 2003). The uppermost TMS and Upper Tuscaloosa record the regressive phase of the complete marine depositional cycle (Rouse et al., 2018).

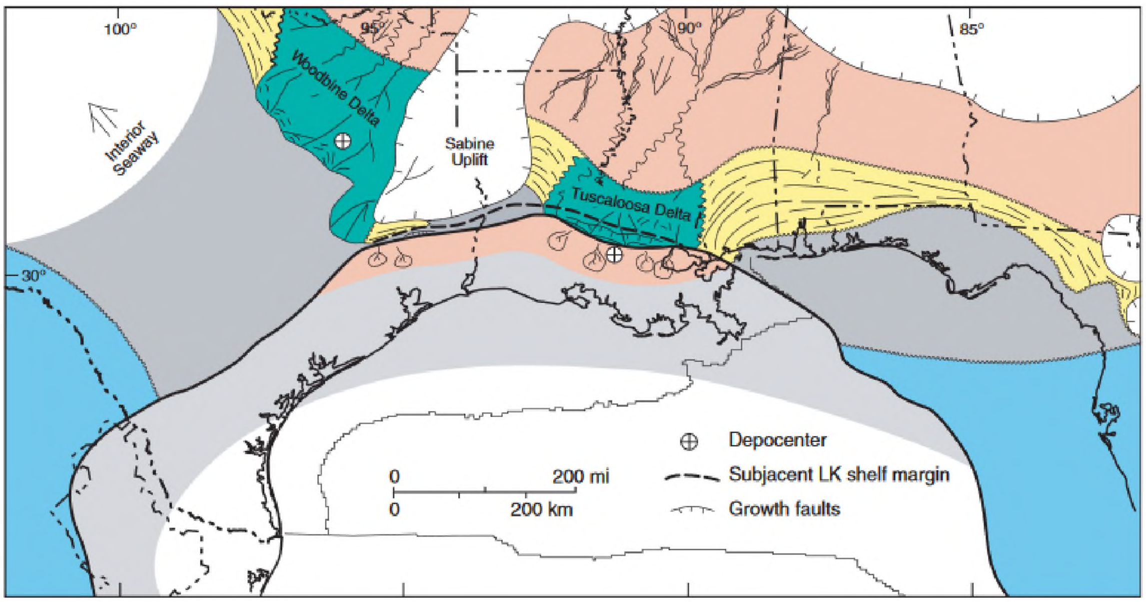


Figure 2.1 Map of paleogeography during the Upper Cretaceous Tuscaloosa—Woodbine depositional period. From Galloway, 2008.

From east to west, the TMS extends from the eastern border of Louisiana across southern Mississippi and Alabama to the panhandle of Florida (Hackley et. al, 2018). The TMS has a monoclinal dip from north to south and deepens in direct relation to the Sligo shelf margin of Early Cretaceous age. The TMS has a northern boundary in central Mississippi and Louisiana (and outcropping in Alabama) where it is unconformably overlayed by the Eutaw Formation and extends to the south into the Gulf of Mexico

(Hackley et al., 2018; Woolf, 2012). The area of interest for this study is the 46,000 km² producing region of the TMS which is shown in Figure 1.1 (Lohr et al., 2016). Within the producing area, the base of the TMS ranges from about 3000 m to 4500 m (Figure 2.2a). The thickness of the TMS ranges from about 70 m to 150 m with thickness increasing towards the southeast as seen in Figure 2.2b (Rouse et al. 2018). The western extent of the TMS is affected by the Sabine Uplift, as seen in Figure 2.1, a structural high where the Tuscaloosa Group is thinly deposited. The TMS thickens eastward and then is affected by other structural highs, the Wiggins Arch and Hancock County High in Central MS (Pair, 2017).

Werren et al. (1990) noted that the contact of the Lower Tuscaloosa and the TMS is distinguished on well logs by a high resistivity zone (HRZ). The HRZ extends into the TMS unit and is marked by a resistivity greater than 5 ohm-meters or a noticeable increase in resistivity by 3.5 ohm-meters or more (John et al., 1997). The HRZ generally thickens with depth of the TMS, with the maximum thickness (~67 m) correlating with the thickest areas of the TMS near the Lower Cretaceous shelf margin in the southwest of the main producing area. The lower TMS is chronostratigraphically equivalent to the lower Eagle Ford Shale in Texas and the upper part of the TMS is chronostratigraphically time equivalent to the upper part of the Eagle Ford Shale (Dubiel et al., 2012). After the analysis of electric logs and core data, a correlation was found by John et al., 1997 between the HRZ, the greatest occurrence of fracturing, and the presence of free hydrocarbons. Therefore, this zone, and the basal section of the TMS, is commonly the target for horizontal drilling.

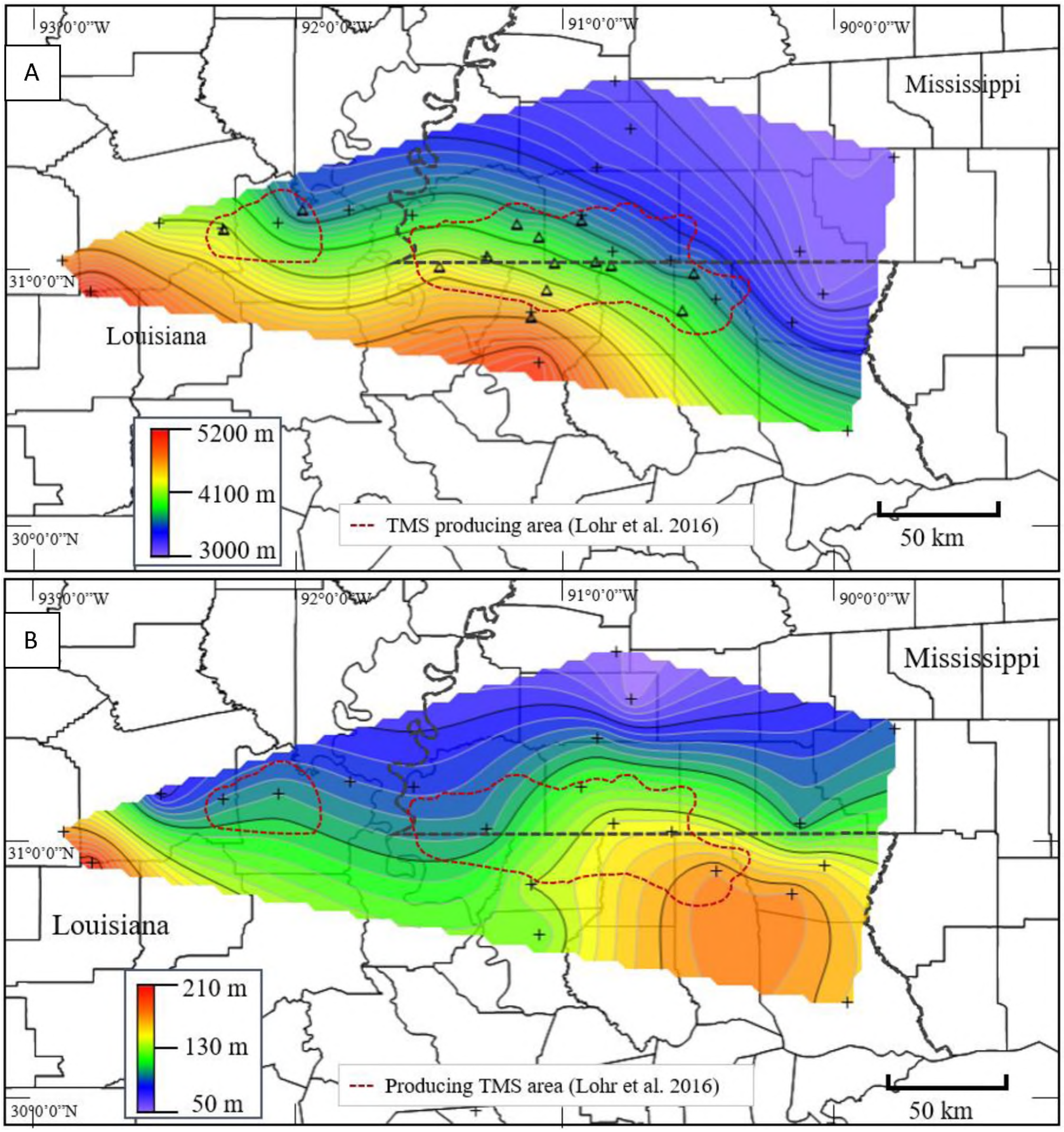


Figure 2.2 TMS structural maps a) Contour map of the base of the TMS. Depths of the TMS are determined by a high resistivity section in well logs that distinguishes the TMS from the Lower Tuscaloosa from Rouse et al., 2018 and from core from this study. Crosses represent wells from Rouse et al. (2018) and triangles represent wells from this study b) Isopach map showing the thickness of the TMS as determined from Rouse et al. (2018).

2.2. PRODUCTION HISTORY

An initial calculation by John et al. (1997) estimated that over 7 billion barrels of oil were potentially recoverable in the TMS. A more recent publication by the USGS in 2018 calculated the mean amounts of recoverable resources for the TMS to be 1.5 billion barrels of oil, 4.6 trillion cubic feet of gas, and 138 million barrels of natural gas liquids (Hackley et al., 2018). Since 2008, the TMS has produced approximately 11.9 million barrels of oil and 7.5 billion cubic feet of gas (DrillingInfo).

A few exploratory vertical wells were drilled in the TMS in the 1970s and 1980s, with two experiencing blowouts as they drilled through the over-pressured formation (Barrell, 2012). The first horizontal well in the TMS was drilled in 1998, however, the early horizontal wells were not hydraulically fractured and had relatively short lateral lengths. The first successful "modern" horizontal well drilled and completed with multi-stage fracking technology was in 2011 (Walkinshaw, 2020). It was around this time when Devon Energy commenced a large lease acquisition across the play with many companies such as Encana, Goodrich petroleum, EOG resources, Indigo Minerals, and Justiss Oil following suit (Barrell, 2012). Drilling activity peaked around 2014 and only a handful of wells were drilled more recently. The most recent wells were drilled in 2019 by Australis Oil & Gas. Figure 2.3 identifies the locations and time of well installation in the TMS. The three earliest wells included in this study were drilled along the Louisiana-Mississippi state line. Starting around 2011, activity extended westward into central Louisiana with 2 of the 5 wells drilled here in 2011-2012 along with 4 out of the 14 wells in 2013-2014 drilled in the western region of the study area. In 2014, most wells were drilled along the Louisiana-Mississippi north-south border again where a majority of the wells were located in southwest Mississippi (26 out of 35 wells).

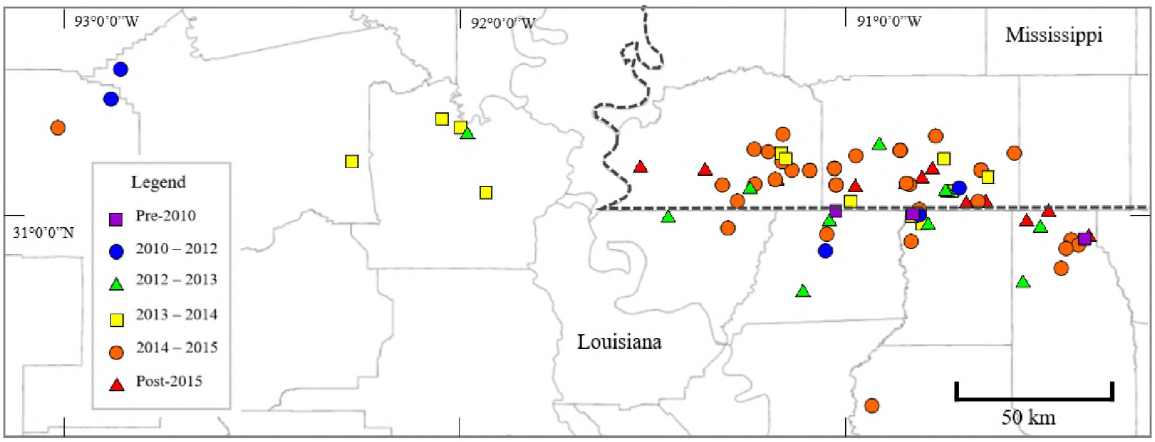


Figure 2.3 Completion date and location of TMS wells.

Figure 2.4 illustrates the total volume of oil production for each TMS well after 1 year relative to their completion dates. We chose the initial 12-month production period for comparison so we could normalize among wells completed at different times. The most productive wells in the TMS were drilled in 2013-2015. Drilling activity virtually halted in 2016 and Australis completed some additional wells, several with good production relative to other TMS wells, in 2019 (Walkinshaw, 2020). The amount of oil production in the TMS has been highly variable, however, there may be a general trend of increasing production relative to completion date. This could indicate improvement in the drilling, completion, and fracking processes over time, and/or it could indicate an improved focus on more productive regions within the TMS over time.

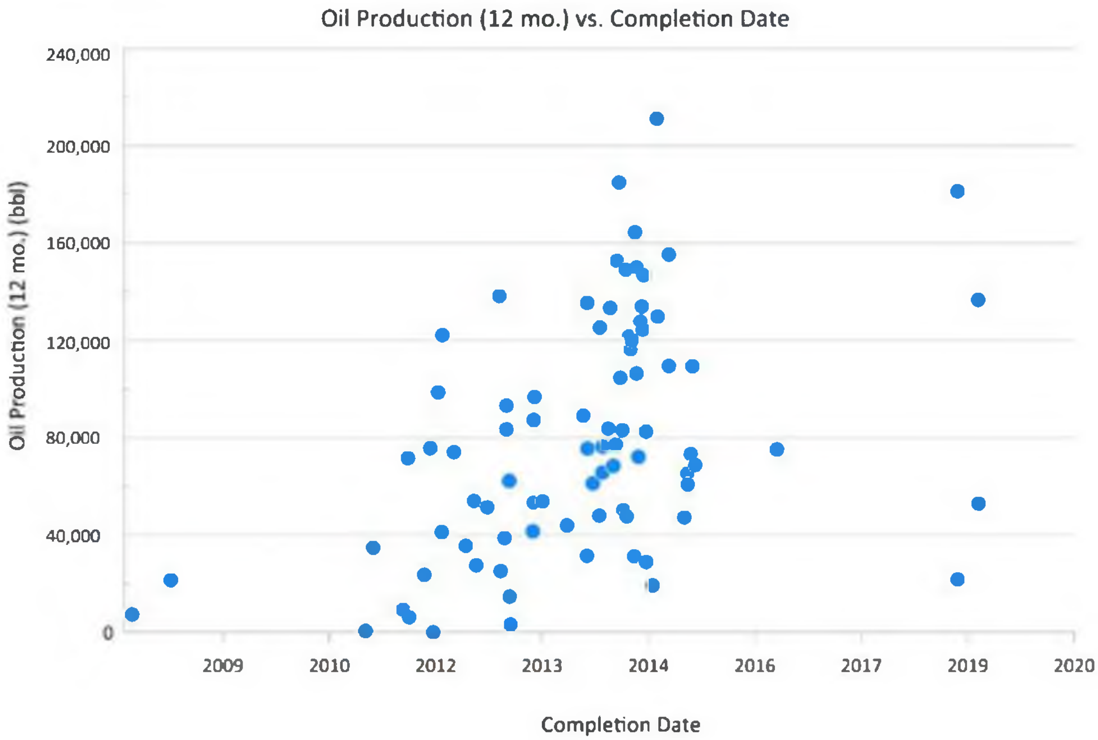


Figure 2.4 Cross-plot of oil production for the first 12 months of each well vs completion date.

2.3. EXISTING MINERALOGICAL AND GEOCHEMICAL INFORMATION

Previous studies have been helpful in identifying the general nature of the TMS, but differences among findings also highlight the heterogeneity of the unit and point to the need for more data and data synthesis. Early studies in the 1990s generally describe the TMS as a hydrocarbon laden, clay-dominated shale. John et al. (1997) describes the TMS shale as a "light to dark gray or brown, splintery, brittle, micaceous, calcareous silty shale with occasional stringers of white to light gray sand that, in most cases, has a yellow fluorescence indicating oil in the sample". Miranda and Walters (1992) performed the initial geochemical analysis on core from the No. 1 Spinks well located in Pike County, MS and found that the organic matter in the TMS (in the vicinity of the producing zone) was in the early stages of oil generation for Type II kerogen. Later studies by Lu et al. (2015) and Lowery et al. (2017) contributed more mineralogical and geochemical data from this core. Table 2.1 shows the major mineral and TOC averages from the available data from each source. The overall amount of data is still limited, and the results vary from each study. One challenge is that different studies report averages from different regions and areas within the TMS. Results from the Lu et al. (2015) study from the Spinks core consist of 8-19 wt% quartz, 0-28 wt% calcite, 40-65 wt% total clay and 0.75-2.85 wt% TOC with an average of 1.85 wt% TOC in the HRZ of the TMS. Lowery et al. (2017) reported an average 1.78 wt% TOC from the Spinks core in the HRZ section and a range from 0.5-4.6 wt% over the entire TMS unit. Besov et al. (2017) contributed data from an unnamed well. Results from Besov et al. (2017) have a larger clay content range of 25-81 wt% with a lower average TOC of 1.6 wt%, however, it is unclear if the samples are within the HRZ.

Enomoto et al. (2017) collected approximately 240 discrete samples from 70 different cores and cuttings samples in the TMS that were available in various repositories from the TMS. They found that, on average, the mineralogy and geochemistry of the total TMS unit was the same as that within the HRZ section of the TMS. In their study, they report an average composition of ~36 wt% quartz, ~4 wt% calcite, ~51 wt% total clay and 0.97 wt% TOC for the HRZ portion of the TMS. The TOC reported in the HRZ is considerably lower than other studies that focused on specific locations or sections of the TMS.

Borrok et al. (2019) compiled formerly unreleased mineralogical and geochemical data from oil and gas companies collected throughout the vertical sections of 11 wells in the TMS producing area. Their observations suggested that the basal section of the TMS contained higher concentrations of calcite and TOC as compared to the rest of the TMS. They also reported that the basal section of the TMS had a higher proportion of Type II kerogen as opposed to Type III kerogen. In order to make valid statistical comparisons among these wells, Borrok et al. (2019) averaged the data available in an 18 m basal section of the core for each of the 11 wells. They found that the basal section of the TMS averaged 22.8 wt% quartz, 17.2 wt% calcite, 47.6 wt% total clay and 1.65 wt% TOC. However, variation within wells and among the 11 wells was significant. For example, the average concentrations of quartz in the basal section of the TMS varied from a low of 7.0 wt% to a high of 54.9 wt% among the wells. Similarly, the concentrations of calcite ranged 0.6 to 74.0 wt%, total clay from 8.0 to 70.5 wt%, and TOC from 0.38 to 3.54 wt%. A more recent publication by the USGS (Lohr et al., 2020), using data previously reported by Enomoto et al. (2017) and Hackley et. al (2020), report an average TOC within the HRZ of the TMS of 1.03 wt%.

Table 2.1 Previous work and resulting averages of major minerals and TOC in the TMS. Averages for samples in the HRZ are separated if applicable.

	Source of sampling	Depth range	n samples	Avg. Quartz (wt%)	Avg. Calcite (wt%)	Avg. Total clay (wt%)	Avg. TOC (wt%)
Lu et al. (2015)	Core from Spinks well in Pike County, MS	3337-3361 m (within HRZ)	7- XRD 6- TOC	9.98	13.02	52.96	1.85
		3283-3361 m (total TMS)	14- XRD 13- TOC	12.14	9.14	55.69	1.39
Besov et al. (2017)	Core from 1 well in TMS	N/A	12 FTIR & TOC	7	11	63	1.6
Lowery et al. (2017)	Core from Spinks well in Pike County, MS	3361.3-3319.3 m (within HRZ)	65- TOC	-	-	-	1.78
		3276.6-3361.3 m (total TMS)	135- TOC				1.43
Enomoto et al. (2017)	70 wells in TMS (cuttings and core)	Various	96 (within HRZ) - XRD & TOC	36	4	51	0.97
			116 (TMS outside of HRZ) - XRD & TOC	32	16	44	1.24
Borrok et al. (2019)	11 wells in TMS (core)	Various (all within HRZ)	161- XRD 136- TOC	22.8	17.2	47.6	1.65
Lohr 2020 (data from Enomoto et al. (2017) & Hackley et al. (2020)	37 wells in TMS (cuttings and core)	Various within 3002-4215 m	154 from 37 wells- TOC	-	-	-	1.03 (within HRZ)
							0.85 (total TMS)

3. DATA AND METHODOLOGY

3.1. CORE & CUTTINGS DATA

Wells 1 through 11 were analyzed previously in the study by Borrok et al. (2019). The data obtained for these wells were provided by Goodrich Petroleum Company. Experimental analyses were performed by the following laboratories: Weatherford®, OMNI Laboratories (now Weatherford), Core Laboratories®, GeoMark®, and TerraTek Inc. (now Schlumberger). Additional data for well 11 and new core data for wells 12 and 13 were contributed by additional companies, including PetroQuest.

Data from wells 14 through 20 were collected from samples of cuttings from the horizontal sections of these wells, which were completed in the basal portion of the TMS. The cuttings samples were analyzed by the University of Louisiana at Lafayette using XRD, XRF, and Rock Eval™ Pyrolysis. The XRF data are not reported in this study, as not all wells have data available for comparison. Initial pyrolysis results indicated that the S1 peaks for the cuttings samples were anomalously high, suggesting that drilling oils had contaminated the rock. Therefore, these samples were reprocessed for a second pyrolysis run by first removing the free hydrocarbons using an extraction method that involves soaking the samples in a mixture of methanol and chloroform. This process also removes any naturally occurring free hydrocarbons and bitumen. After being subjected to the solvent mixture for several days, the samples were rinsed, dried, and disaggregated into powders before re-analysis. The mineralogical and organic content data for Well 21 was taken from the supplemental material provided in Enomoto et. al (2018).

3.2. PRODUCTION DATA

Well and production data were collected for ninety-five TMS wells, including those for which we have mineralogical and geochemical data, using the drilling info database from Enverus™ (drillinginfo.com). Additional data for the wells in Louisiana were collected from the Louisiana Department of Natural Resources (sonris.com). Additional data for the wells in Mississippi were collected from the Mississippi State Oil & Gas Board (www.ogb.state.ms.us/TMSDevelopment.php). It is important to note that of the ninety-five TMS wells that were used for data collection, two wells were dry holes. When creating contour maps based on production data, null values were used instead of zero, so as not to create outliers and skew the interpolations. Zero values were used for these wells when making any statistical comparisons. The dry holes are indicated on maps by a conventional dry hole symbol. In order to make valid comparisons of production for the wells, we chose to use total production amounts after 12 months. Wells that started producing after January 2019 did not meet the 12-month threshold prior to this compilation and were therefore not included.

The following attributes were recorded for our study and can be found in Tables 1 and 2 of Appendix C: operator, latitude and longitude, API number, first production day, total vertical depth, lateral length, upper and lower perforation, elevation, completion date, total fluid (bbl), total additive (lbs), and total proppant (lbs). Table 3 includes cumulative oil production(bbl), gas production (Mcf), and water production (bbl) over twelve-, twenty-four-, and thirty-six-month periods.

3.3. CONTOURING

Contour maps were constructed using the kriging gridding technique within Surfer by Golden Software™. Kriging is an interpolation method that estimates grid data from known data points by taking into consideration the distance between the known points (Golden Software Support). This method is helpful for filling in large data gaps in a reasonable way but poses a challenge to our ability to draw conclusions in regions with limited data. Afterall, information from only 21 wells is used to represent a large geographical area of 46,000 km^2 (the TMS producing region). Therefore, the areas with less data coverage where greater interpolation was required are suspect and should only be used for a coarse-level understanding. Data from more wells would aid in filling data gaps and improving the interpolations. All contour maps use the WGS 84 UTM zone 15N coordinate system.

4. RESULTS AND DISCUSSION

4.1. MINERALOGY

To directly compare the new mineralogical data to the averages established by Borrok et al. (2019), the samples from each well were averaged over the same 18-meter basal section of the TMS. A total of 241 samples across the 21 wells used for this study are located within this basal section. This section was determined by Borrok et al. (2019) because it lies within the HRZ and is the landing zone for lateral sections of most wells in the TMS. The cuttings samples are included in these comparisons because they were collected from the horizontal portion of each well and are assumed to be generally representative of the same basal section. However, the following discrepancies are important to note. Each sample of cuttings was assigned a drilling distance range of about 6 meters instead of an exact depth/horizontal location because the cuttings were collected in increments during drilling. Also, statistics from each well with cuttings samples apply to ~100 meters horizontally and therefore are subject to horizontal heterogeneity as well as inevitable vertical heterogeneity due to variations in elevation encountered during geosteering.

Table 4.1 displays the average values of the most abundant minerals in the TMS within the 18-meter basal section for each of the 21 wells. The total average mineral content for all the wells is 25.2 wt% quartz, 16.8 wt% calcite, 47.0 wt% total clay, 3.2 wt% plagioclase, and 3.7 wt% pyrite. As is congruent with the findings from Borrok et al. (2019), the additional data confirm that the TMS is dominated by clay minerals with various amounts of calcite and quartz, and minor amounts of plagioclase and pyrite. Traces of siderite and dolomite are also detected in a limited number of samples.

Table 4.1 Statistical compilation for major mineral data in the basal section of the TMS.

Well #	n samples	Avg. Quartz	1 Std Dev	Avg. Calcite	1 Std Dev	Avg. Total Clay	1 Std Dev	Avg. Plagio clase	1 Std Dev	Avg. Pyrite	1 Std Dev
		(%)		(%)		(%)		(%)		(%)	
1	13	23.0	2.9	10.6	7.0	56.9	7.0	4.6	1.4	3.7	2.3
2	12	27.8	9.0	24.1	16.0	37.5	11.3	4.3	1.4	4.1	1.6
3	5	33.2	7.5	7.2	4.1	38.6	16.4	12.2	6.1	5.4	1.8
4	9	20.9	5.6	17.8	17.4	52.2	14.0	4.4	2.1	5.1	3.2
5	19	19.2	4.5	15.3	16.8	48.5	13.8	5.4	3.1	4.1	1.4
6	28	22.2	5.5	17.0	11.4	45.4	8.0	4.1	2.1	3.8	1.5
7	22	16.1	4.6	24.0	22.4	48.0	16.4	2.2	0.8	4.9	2.5
8	18	25.3	3.6	12.0	10.3	50.0	10.2	3.5	0.9	5.1	2.9
9	9	25.0	4.8	20.8	11.1	46.6	6.6	2.2	0.4	3.1	1.2
10	17	21.8	4.8	19.2	15.3	48.5	12.3	2.8	0.8	5.1	2.8
11	9	32.1	2.8	14.1	6.4	46.6	5.0	2.2	0.5	3.8	2.2
12	18	27.1	10.3	13.0	9.8	45.8	9.4	3.8	2.6	3.4	1.4
13	2	24.5	4.5	15.0	10.0	52.5	4.5	3.5	0.5	3.5	0.5
14	6	31.5	4.5	11.7	1.7	50.8	5.3	1.1	0.9	1.2	0.8
15	10	28.1	6.9	23.3	15.6	42.2	9.1	1.1	1.7	1.1	1.2
16	6	29.9	4.5	13.1	3.1	48.8	3.8	0.5	1.2	1.8	1.9
17	8	37.6	4.3	10.7	4.0	45.2	5.0	1.5	1.2	2.2	0.9
18	8	33.1	5.2	18.2	8.9	40.1	5.6	1.2	0.8	1.9	0.5
19	10	26.7	3.6	18.7	5.9	48.7	5.0	0.0	1.4	1.5	1.0
20	8	35.5	2.3	12.9	2.6	45.8	3.7	1.6	0.7	0.8	1.4
21	4	28.8	5.5	13.0	5.7	50.0	2.7	1.25	0.4	5.6	0.4
Total	241	25.2	7.7	16.8	13.5	47.0	10.9	3.2	2.7	3.7	2.3

Table 4.2 displays the average values of individual clay minerals in the TMS within the 18-meter basal section for each of the 21 wells. Note that all clay mineral values were summed to calculate the “total clay” values in Table 4.1. The total clay is

comprised of 12.5 wt% illite, 10.9 wt% smectite, 16.4 wt% kaolinite, and 5.2 wt% chlorite. Because of the XRD analysis methodology, the average concentrations of smectite also include montmorillonite and bentonite values.

Table 4.2 Statistical compilation for individual clay mineral data in the basal section of the TMS.

Well #	n samples	Avg. Illite	1 Std Dev	Avg. Smectite	1 std dev	Avg. Kaolinite	1 Std Dev	Avg. Chlorite	1 Std Dev
		(%)		(%)		(%)		(%)	
1	13	18.2	3.4	14.3	2.6	15.0	2.0	9.4	1.3
2	12	9.2	3.1	10.7	3.4	12.3	4.5	5.3	1.7
3	5	9.8	3.8	7.4	3.4	12.0	5.2	9.4	4.0
4	9	18.7	8.7	4.6	1.9	16.4	8.0	9.5	4.1
5	19	18.3	7.6	12.9	6.8	12.1	5.0	6.4	2.1
6	28	16.0	4.3	11.9	5.4	10.7	2.4	6.7	1.7
7	22	6.5	2.2	16.2	8.4	23.2	8.3	3.1	1.3
8	18	12.7	5.7	13.8	6.2	20.6	4.9	3.9	1.6
9	9	12.8	2.4	12.7	2.6	18.6	3.8	2.6	0.7
10	17	14.0	5.4	10.6	3.7	21.1	7.1	2.8	1.5
11	9	19.1	3.2	3.9	0.6	13.6	1.7	9.2	1.0
12	18	16.5	6.0	11.6	9.0	8.8	4.0	9.0	6.0
13	2	17.5	3.5	16.0	2.0	14.5	1.5	4.5	0.5
14	6	7.4	6.4	14.1	6.3	18.7	5.6	2.5	1.4
15	10	5.2	6.1	10.0	4.6	18.6	4.5	1.7	0.6
16	6	5.1	1.8	13.6	6.4	23.2	5.0	1.6	0.8
17	8	6.4	5.7	10.8	2.5	17.1	4.3	2.8	1.4
18	8	7.7	4.5	4.9	2.7	17.3	3.7	3.2	1.1
19	10	4.9	5.9	13.2	3.4	25.3	3.6	1.8	1.0
20	8	4.1	4.9	9.5	3.4	19.9	4.5	2.5	1.4
21	4	24.8	3.3	1.3	1.6	16.5	0.9	6.8	1.5
Total	241	12.5	7.3	10.9	6.1	16.4	6.8	5.2	3.5

Figure 4.1 is a ternary diagram that presents the relative distributions of quartz, calcite, and total clay within the basal section of the TMS for each well. The samples previously presented by Borrok et al. (2019) are shown as gray circles. The locations of the new samples added in this investigation, shown in the colored symbols, are generally

like those in the previous study. Most of the samples plot in a range of 40 to 80 wt% total clay, 20 to 50 wt% quartz, and 20 to 70 wt% calcite. A global average calculated from all the samples is represented by the black outlined circle. Figure 4.1 illustrates the high degree of heterogeneity in the TMS formation. Some samples show a trend where calcite increases at the expense of clay. This is likely due to the presence of thin layers or stringers of shell fragments and/or calcite in fractures from variable depositional environments in the TMS. Wells that have samples that contain little to no calcite show variations in relative quartz and clay content.

To further evaluate vertical heterogeneity within each well, the quartz, calcite, and total clay values for each sample depth were plotted for wells 12, 13, and 21 in Figures 4.2, 4.3, and 4.4, respectively. In these figures, the gray zone denotes the selected 18-meter basal section for the samples that were averaged in Table 4.1. The cuttings samples (wells 14-20) are not plotted as a function of depth, as they were from horizontal well sections. In well 12, the concentrations of quartz are greater than 35 wt% in a few of the samples nearest the base, which could be reflective of the transition from the Lower Tuscaloosa sands to the TMS. The remaining samples in the basal section of the TMS have lower concentrations of quartz that generally increase with increasing elevation. Wells 13 and 21 have fewer samples and no trends were discernable. Wells 1 through 11 were similarly plotted by Borrok et al. (2019), who describe a trend of increasing concentrations of quartz with increasing elevation above the base of the TMS for eight of the eleven wells. This trend reflects an increase in sediment supply during regression immediately following the maximum flooding surface which occurs nearer to the base of the TMS.

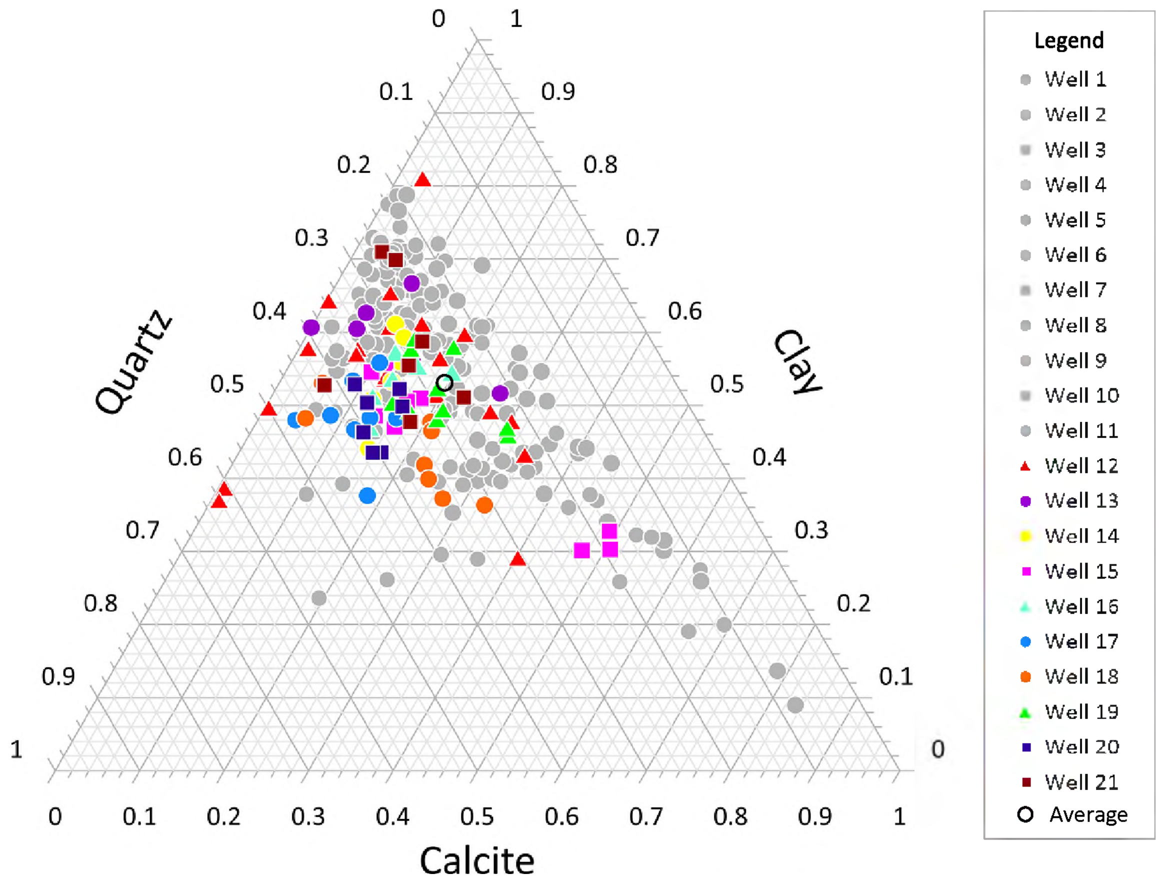


Figure 4.1 Ternary diagram of relative percentages of quartz, calcite, and total clay in the basal section of the TMS.

Samples with the highest calcite concentrations occurred at or near the base of the TMS in well 12 (Figure 4.3a). Vertical trends in the distribution of calcite were not identifiable in wells 13 and 21 because of the limited number of available samples. Higher calcite concentrations (on average) near the base of the TMS were similarly observed for most wells in the study by Borrok et al. (2019). It is also clear that the distribution of calcite is cyclical, most likely reflecting the presence of discrete thin layers of shell fragments that are intermittently sampled (e.g., Borrok et al., 2019). Limited petrographic analysis has shown that calcite in the TMS is both diagenetic (microcrystalline precipitants) and depositional (microfossils and shell fragments; Lu et al., 2015; Lohr et al., 2020).

The total clay content for wells 12, 13, and 21 does not vary in a consistent manner as a function of depth, as seen in Figure 4.4. Many of the original wells plotted by Borrok et al. (2019) displayed a cyclic pattern of deposition and about half of the wells had greater concentrations of clay nearer the base of the TMS. When the data for total clay content for wells 1-11 were plotted on a histogram in by Borrok et al. (2019), they showed a bimodal distribution with a primary peak at 50-55 wt% clay and a smaller peak at 35- 40 wt% clay indicating a depositional setting where cycles of sedimentation are influenced disproportionately by their distance from paleo-depositional centers.

The averages of all sample datapoints within the basal ~18 m section of the TMS wells were used to make contour maps of the major mineral distributions by using the kriging gridding technique (Figures 4.5, 4.7, 4.9). The degree of heterogeneity in these average mineral abundances is also important and could be reflective of different deposition environments. For this reason, we additionally constructed contour maps showing the interquartile range of the mineralogy data (Figures 4.6, 4.8, 4.10). The interquartile range is a statistical representation of the degree in variance of the middle 50% of the data. Interquartile ranges were only plotted for datasets with at least eight sample points.

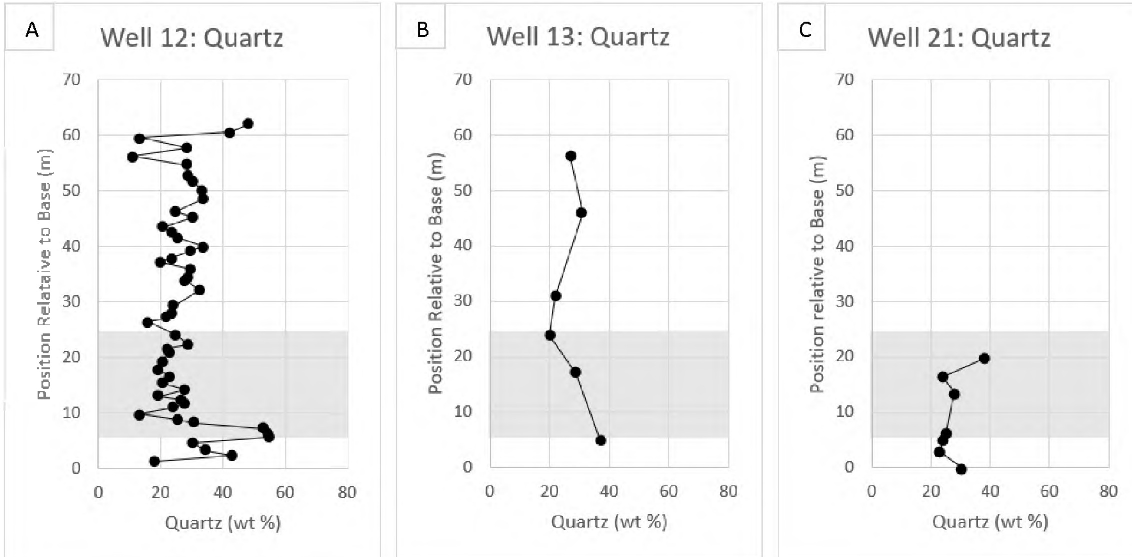


Figure 4.2 Quartz concentrations (wt%) vs depth: a) well 12, b) well 13, c) well 21.

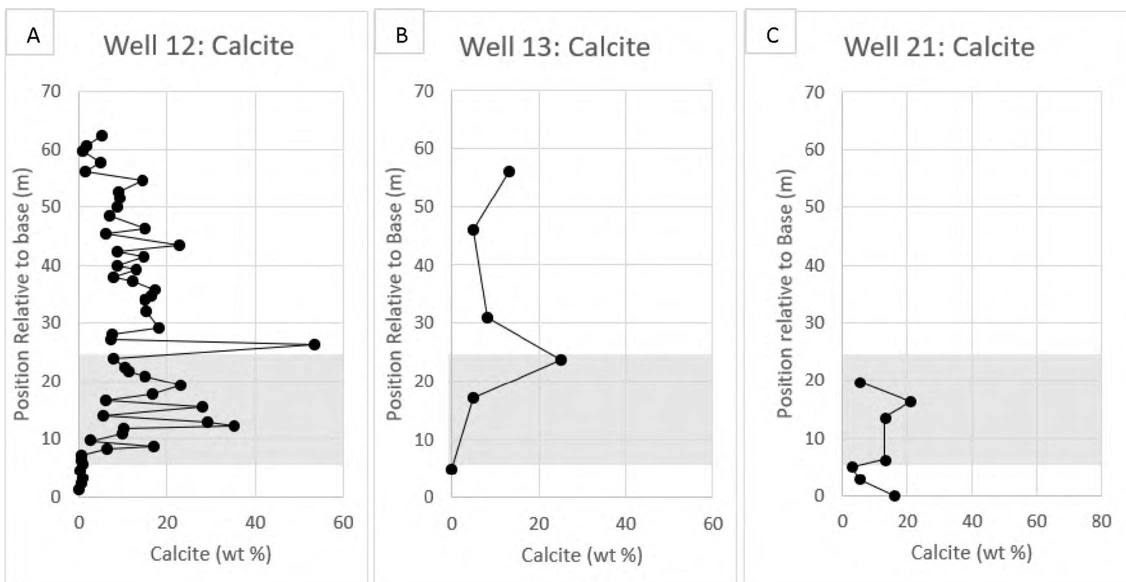


Figure 4.3 Calcite concentrations (wt%) vs depth: a) well 12, b) well 13, c) well 21.

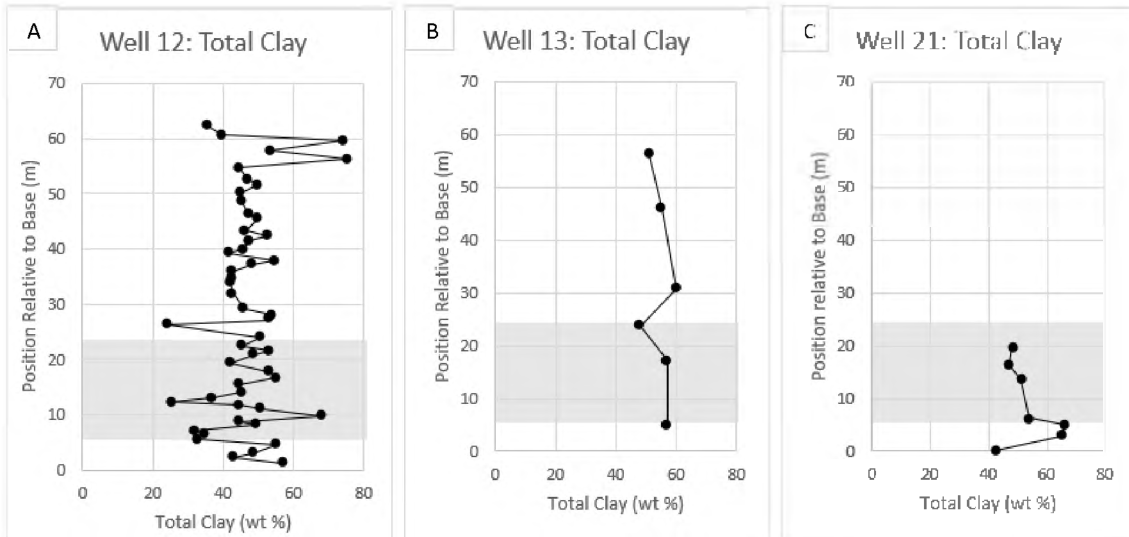


Figure 4.4 Total clay concentrations (wt%) vs depth: a) well 12, b) well 13, c) well 21.

Figure 4.5 is the contour map of average quartz content in the basal section of the TMS. Areas where average quartz concentrations are >30 wt% in the basal section occur in the eastern region of the study, more specifically, in eastern Wilkinson and Amite counties in Mississippi, as well as northern East Feliciana and St. Helena parishes in Louisiana. Most of the wells in Amite County contain average quartz concentrations within the top 50% of the data (>27 wt% quartz). One well located in the western portion of the study area contained high average quartz concentrations (~30 wt%) as well.

Figure 4.6 shows the interquartile range in quartz content in the basal section of 16 wells. Wells where the middle 50% of the data varied by more than 10 wt% are located along the Mississippi and Louisiana border and in the eastern edge of the study area (more specifically in northern East Feliciana, St. Helena, and Tangipahoa parishes of LA). While higher averages of quartz content generally indicate a higher siliciclastic input, a high variability of quartz content may indicate recurrent periods of coarser clastic influx where quartz-rich zones are interbedded with fine-grained shale and/or calcite.

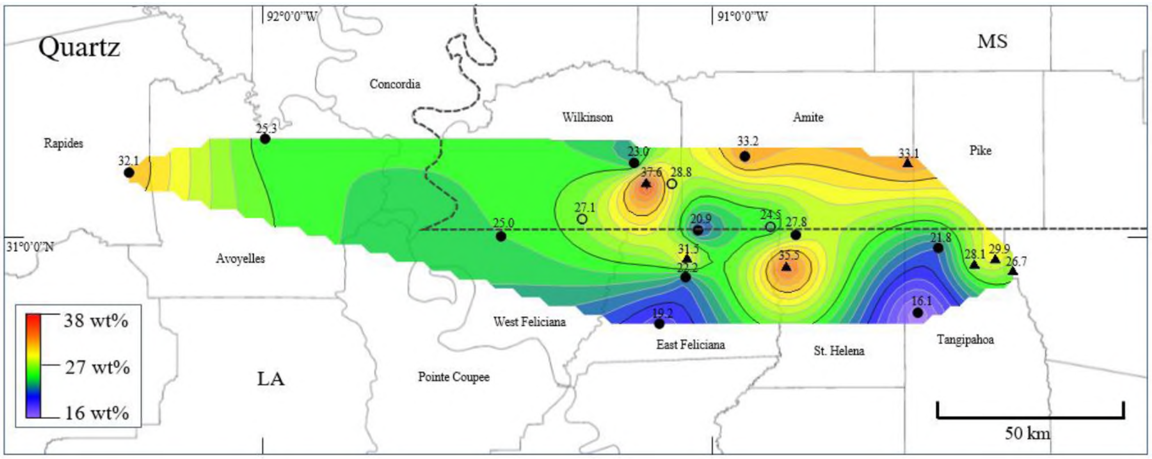


Figure 4.5 Contour map of average quartz concentrations in the basal section of the TMS.

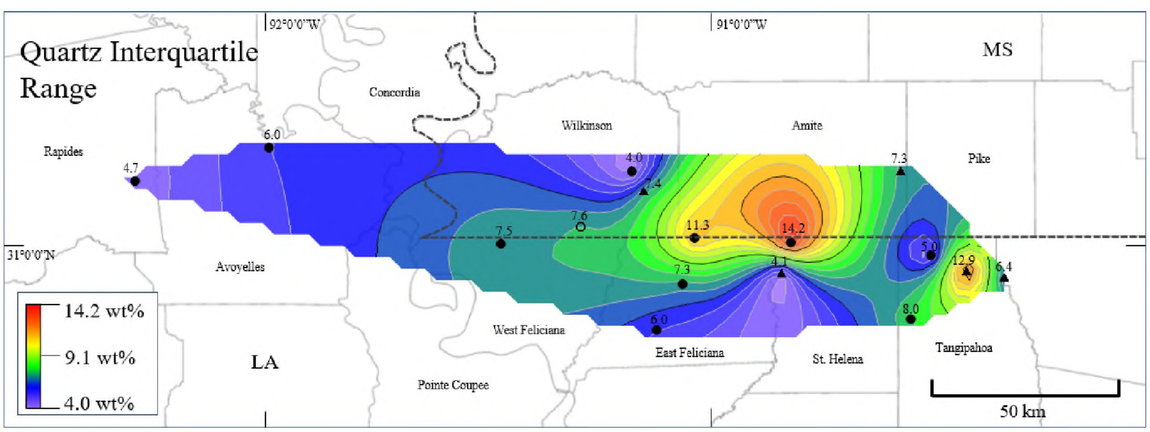


Figure 4.6 Contour map of interquartile range of quartz data in the basal section of the TMS.

The contour map of average calcite content (Figure 4.7) shows high concentrations of calcite (>20 wt%) in the basal section of the TMS occurring in one well in the central region of the study area (in West Feliciana) and in many wells in the eastern part of the study area (particularly in Amite county in MS and St. Helena and Tangipahoa parishes in LA). The bottom 50% contours, with average concentrations of calcite less than 17 wt%, occur spatially between these areas in the central region (Wilkinson, western Amite counties in MS and East Feliciana in LA) and in the far western region of the study area. The lowest calcite concentrations (<11 wt%) occur in Amite and Wilkinson counties in MS, at the very northern part of this region. Figure 4.8 shows that the areas where the middle 50% of calcite data have high variability (>20 wt%) occur in two wells in the central region of the study area (West Feliciana county) and in three wells in the eastern edge of the study area (Tangipahoa parish). In the eastern area, the highest interquartile range of calcite corresponds with the area of highest average calcite. The same is true for the lowest interquartile range (<12 wt% variability) corresponding with lowest average concentrations of calcite in the northern part of the study area.

Previous petrographic investigations confirm the presence of carbonate foraminifera and shell fragments within the TMS (Lu et al., 2015; Lohr et al., 2020). These carbonate fragments likely indicate depositional conditions of high energy and possibly oxygenation. High variability in the middle 50% of the data, as seen in the east, suggests the presence of isolated layers with high calcite content interbedded with fine-grained siliciclastics. This is indicative of fluctuations in depositional conditions similar to the observations of siliciclastic influx with the variability of quartz. High concentrations of calcite here suggest a greater frequency of these calcite prone layers which indicates different depositional conditions in the eastern area. The low average concentrations of calcite and low variability in these concentrations in eastern Wilkinson county for example, demonstrate the absence of carbonate organisms and shell fragments which is indicative of depositional conditions that are lower energy.

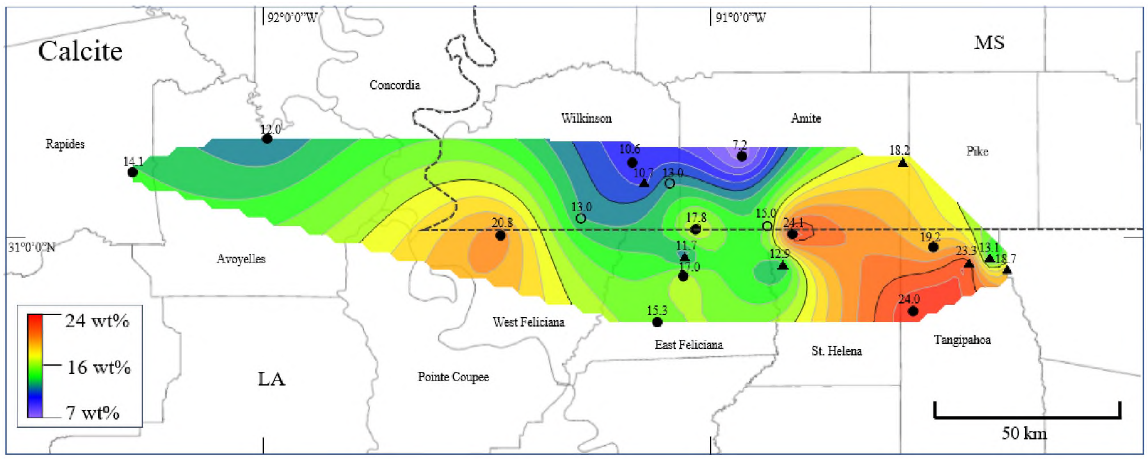


Figure 4.7 Contour map of average calcite concentrations in the basal section of the TMS.

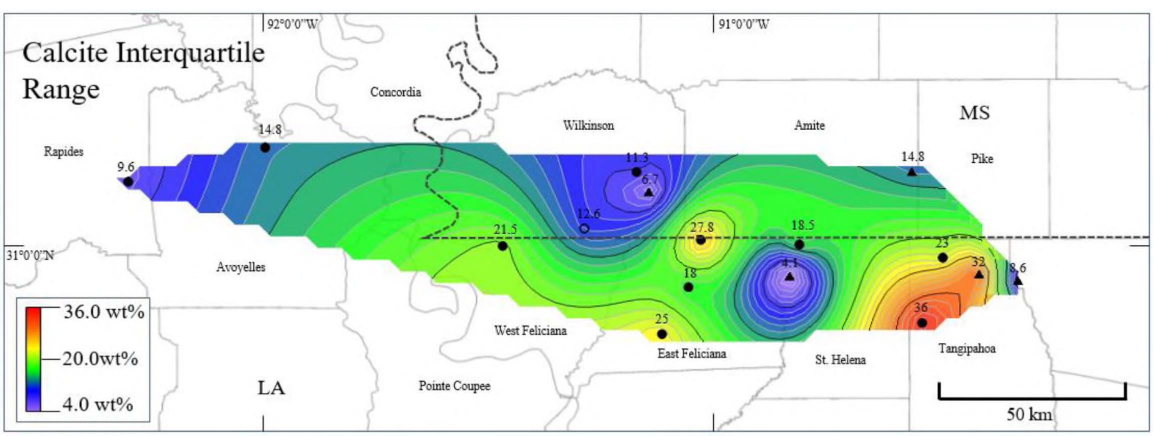


Figure 4.8 Contour map of interquartile range of calcite data in the basal section of the TMS.

The average clay content in the basal region of each well is contoured in Figure 4.9. The lowest average concentrations of total clay (<41 wt%) occur in two wells in Amite county, MS and one well in St. Helena parish, LA. Highest average concentrations of total clay (>50 wt%) are spatially located directly adjacent to the lower concentrations, in the western corner of Amite and Wilkinson counties, MS and across the border into East Feliciana parish, LA. Moderate average concentrations of total clay extend to the far western region of the study area. In Figure 4.10, high variability of total clay occurs along the eastern edge of the study area, particularly in three wells in Tangipahoa parish, LA. One well in East Feliciana parish, LA has a very high variability of total clay.

There is a sharp transition from higher to lower concentrations of total clay from west to east within Amite county, MS. The higher average concentrations of total clay in the western side of the county indicates a low energy environment where fine-grained particles were deposited. To the east, less fine-grained particles were deposited, which suggests a depositional setting with higher clastic influx of coarser grains. Large inter-quartile ranges of total clay are probably a reflection of fluctuations in sea level and perhaps depositional centers during sedimentation. Previously determined by Borrok, et al. (2019), Well 7, located in Tangipahoa parish, LA, showed increasing calcite with elevation at the expense of clay in the ternary diagram and the depth graphs, indicating a transition between environments of low clastic influx and high carbonate deposition here.

The isopach map of the TMS (Figure 2.2b) shows that the TMS thickens from northwest to the southeast. Increasing thickness indicates both a higher rate of deposition/sediment supply and greater accommodation space. Wells in the southeastern edge of the study area (Tangipahoa parish, LA), where the thickness of the TMS in the study area is the largest (~150m), show very high average calcite concentrations and high variability in those concentrations. This area is also marked by a higher variability of quartz and total clay concentrations. Thickness and mineralogical evidence suggest that this area might be a different paleoenvironment from the rest of the study area. As seen in Figure 2.1, the deltaic system influential in the transport of the sands of the Lower Tuscaloosa was present in this area and could have possibly mixed coarser grains with fine-grained particles creating the thicker unit (Pair, 2017). In Amite county, MS and St. Helena parish, LA, the TMS has a moderate thickness (~130 m) and a high proportion of quartz and calcite to total clay. This indicates high rates of clastic input and close proximity to the clastic depocenter (Figure 2.1). The variability of minerals here as well (quartz in particular), perhaps indicates fluctuations in sea level. Average concentrations of total clay increase towards the west where the TMS is relatively thinner.

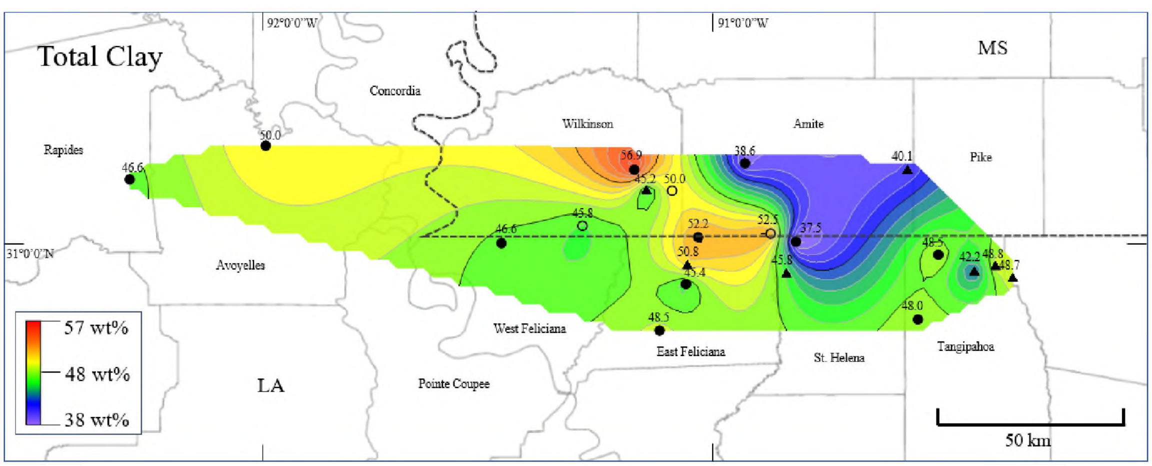


Figure 4.9 Contour map of average total clay concentrations in the basal section of the TMS.

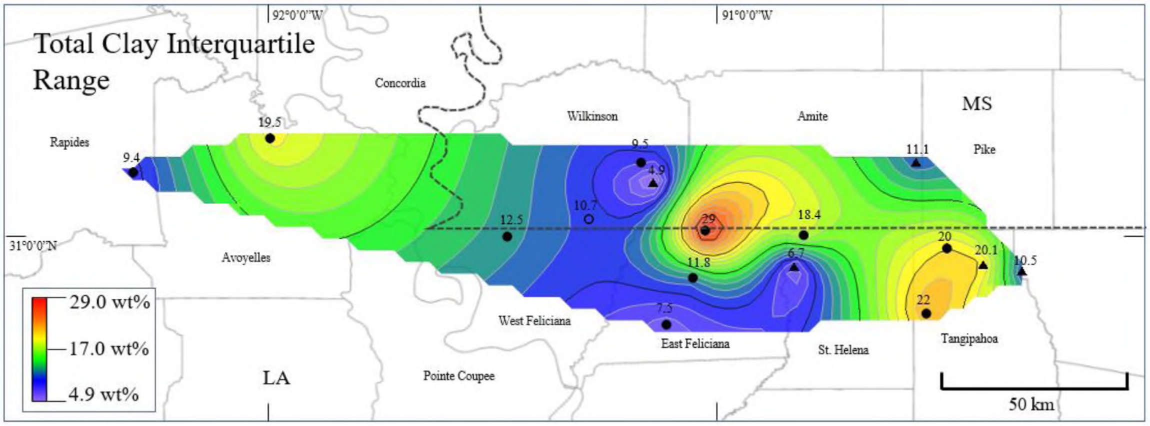


Figure 4.10 Contour map of interquartile range of total clay data in the basal section of the TMS.

4.2. ORGANIC GEOCHEMISTRY

Table 4.3 reports the averages for measured geochemical parameters near the base of the TMS. Only part of the information for the cuttings samples is included, as the solvent extraction process used to remove drilling oil contamination also removed any naturally occurring free hydrocarbons. This effectively removes the S1 peak from the pyrolysis data. The TOC data reported for the cuttings is therefore a minimum value, only recording the TOC associated with the kerogen. The average TOC near the base of the TMS for all wells, and excluding the minimum TOC for cuttings samples, was 1.58 wt%.

All the samples (including the new cuttings data) from wells 1-21 are plotted on a pseudo-Van Krevelen diagram in Figure 4.11. The diagram shows that the kerogen in the majority of the wells is mixed type II and type III kerogen (e.g., wells 14, 16, 17, 18, and 20). Wells 12, 13, 19, and 21 appear to follow a pattern suggesting a predominance of type II kerogen or oil prone kerogen, while wells 15 and 16 are associated with more type III or gas prone kerogen. Samples from well 11 and some from well 13 plot near the

Table 4.3 Statistical compilation of organic geochemical data in the basal section of the TMS. New cuttings results are highlighted in red.

Well #	n samples	Avg. S1	1 Std Dev	Avg. S2	1 Std Dev	Avg. Tmax	1 Std Dev	Avg. TOC	1 Std Dev	Avg. HI	1 Std Dev	Avg. OI	1 Std Dev	Avg. PI	1 Std Dev
		(mg/g)		(mg/g)		°C		wt%							
1	13	0.15	0.05	2.49	1.7	445	1.4	1.83	0.6	129	71.1	11	4.5	0.08	0.05
2	8	0.12	0.03	4.36	1.3	451	1.5	2.48	0.3	178	54.6	8	10.6	0.03	0.01
3	4	1.00	0.2	4.63	0.8	443	1.1	1.94	0.24	238	16.4	15	4.6	0.18	0.02
4	2	0.58	-	2.86	-	434	-	1.51	-	132	-	19	-	0.27	-
5	18	1.53	0.7	1.93	0.8	460	1.2	1.41	0.4	133	20.8	14	5.1	0.44	0.03
6	33	1.40	0.8	2.90	1.7	456	1.8	1.50	0.6	179	36.1	17	6.5	0.33	0.1
7	15	1.27	0.7	5.61	2.9	444	2.1	1.88	0.6	305	58.8	42	75.8	0.19	0.06
8	21	1.86	0.9	2.88	1.0	449	2.4	1.32	0.4	221	27.0	41	11.7	0.38	0.1
9	9	0.92	0.4	2.42	1.1	451	1.1	1.33	0.5	177	22.0	35	17.7	0.28	0.03
10	8	0.94	0.5	6.23	3.2	444	1.0	1.83	0.4	322	94.3	19	6.7	0.13	0.02
11	9	0.81	0.4	1.29	0.6	465	5.2	2.06	0.5	62	22.0	10	3.0	0.39	0.95
12	19	0.83	0.5	2.66	1.7	447	3.8	1.25	0.6	192	55.6	11	6.7	0.25	0.06
13	7	0.29	0.3	2.77	3.7	452	2.4	1.55	0.9	126	104.8	12	4.7	0.11	0.02
14	6	N/A	-	2.25	0.4	439	0.9	1.13	0.1	198	13.6	36	5.7	-	-
15	10	N/A	-	1.83	1.0	435	1.0	1.72	0.3	106	64.5	66	14.8	-	-
16	6	N/A	-	3.01	1.9	433	2.9	2.33	0.7	122	73.1	54	19.2	-	-
17	9	N/A	-	3.14	0.9	437	2.3	1.56	0.5	202	16.0	37	8.1	-	-
18	8	N/A	-	4.24	1.5	434	1.0	1.70	0.4	244	43.8	48	10.6	-	-
19	10	N/A	-	7.25	1.7	436	1.2	2.22	0.4	324	18.5	19	3.2	-	-
20	7	N/A	-	1.90	0.6	441	1.1	1.09	0.1	171	30.3	36	5.2	-	-
21	17	0.65	0.4	3.44	1.7	445	1.1	1.45	0.5	218	55.0	17	4.4	0.16	0.05
Total (without cuttings)	183	1.00	0.8	-	-	-	-	1.58	0.6	-	-	-	-	0.25	0.13
Total (with cuttings)	239	-	-	3.26	2.2	447	8.8	-	-	191	82.3	25	26.3	-	-

Sorigin of the diagram, suggesting that these are thermally mature samples that had been depleted of hydrocarbons.

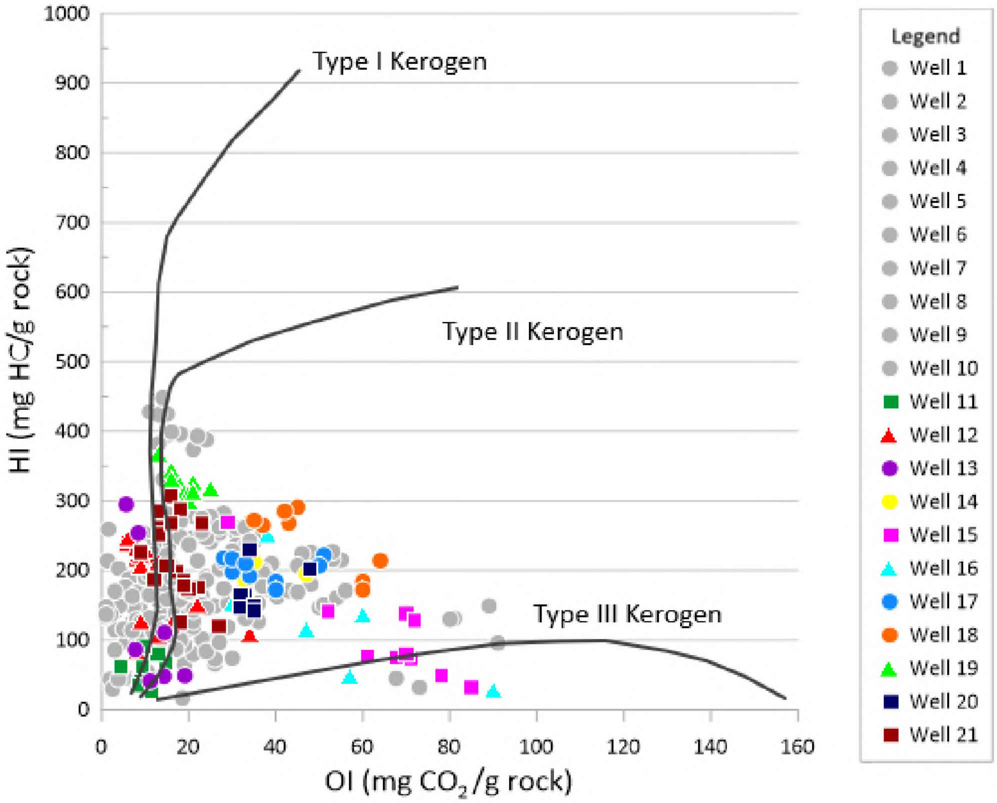


Figure 4.11 Pseudo-Van Krevelen diagram of samples in the basal section of the TMS.

TOC measurements for the new core sample data were plotted as a function of depth in Figures 4.12 a, b, and c. In well 12, the transition from the Lower Tuscaloosa to the TMS is reflected by an increase in TOC, which reaches maximum values in the designated 18 m basal section of the TMS (highlighted in gray). After reaching peak values, the concentrations of TOC in well 12 decrease with increasing elevation above the basal section (Figure 4.12a). The same trend where TOC is the highest in the basal section was described by Borrok et al. (2019) for many of the other TMS wells. In well 13, concentrations of TOC were about 1% at the base of the TMS and did not change much with increasing elevation until a transition to a maximum of 3.2 wt% TOC at the top of the basal TMS section (Figure 4.12b). Concentrations of TOC in well 21 are quite heterogeneous with no clear pattern as a function of depth (Figure 4.12c).

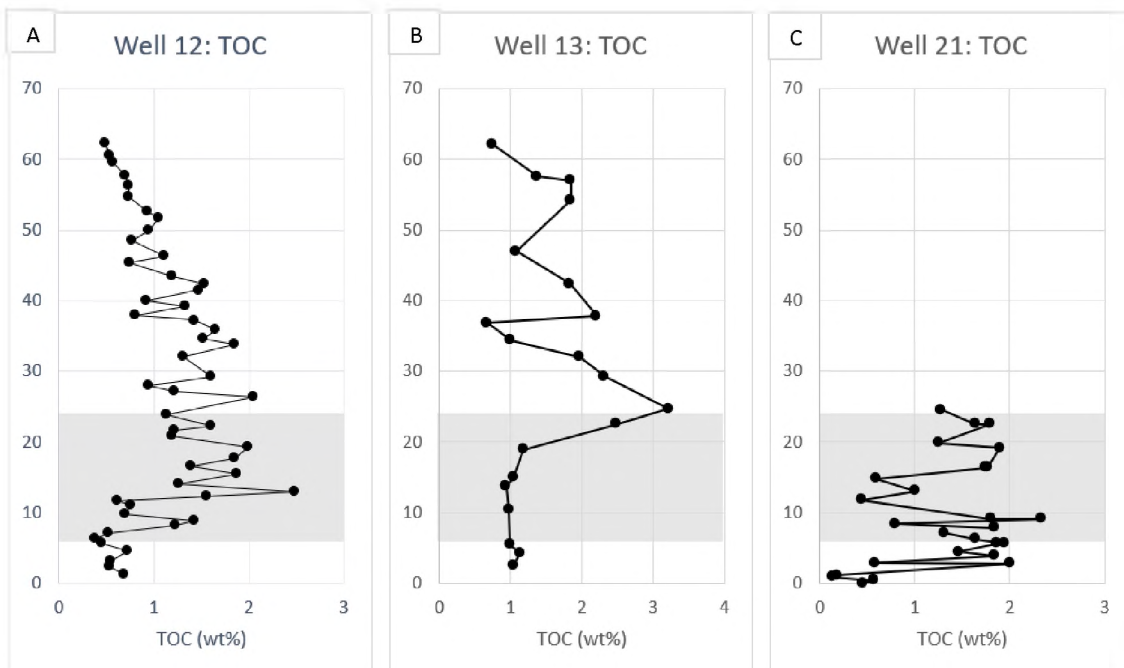


Figure 4.12 TOC (wt%) vs depth: a) well 12, b) well 13, c) well 21.

The concentration of total organic material is used as a geochemical parameter for describing source rocks. Poor source rocks contain 0-0.5 wt% TOC, fair source rocks contain 0.5-1 wt% TOC, good source rocks contain 1-2 wt% TOC, and very good source rocks have over 2 wt% TOC (Peters, 1986). The average concentrations of TOC in the basal 18 m section for wells 1-13 and 21 are contoured in Figure 4.13. All the wells plotted in Figure 4.13 have average values of TOC that exceed the minimal value of a "good" source rock (i.e., >1 wt% TOC). The lowest concentrations of TOC (<1.5 wt%) are found in the central and west regions of the study area in Wilkinson County in MS and in East Feliciana, West Feliciana, and Avoyelles Parishes in LA. Higher concentrations of TOC (>1.9 wt%) occur in the east (Amite County in MS and St. Helena, Tangipahoa Parishes in LA) and far west sides (Rapides Parish, LA) of the study area. The interquartile range of TOC increases towards the east (Figure 4.14), with high variability (>0.8 wt% difference in the middle 50% of data) along the MS and LA border and the highest variability of 1.2 wt% in Tangipahoa Parish in LA. Wells 7 and 10, located in Tangipahoa Parish, both contain more TOC in the base and decreases with higher elevation.

Areas of high TOC concentrations indicate more organic matter accumulation, which likely occurred around the OAE 2 event in this region. The variability of TOC may be due to abundance changes of benthic foraminifera during the maximum flooding interval (Lowery et al., 2017). The eastward trend of TOC variability correlates with the thickening direction (towards the southeast) indicating that the higher rate of sedimentation corresponds with variability of organic matter accumulation. This area also has a dominant presence of quartz and calcite and variable mineralogy in this area (especially calcite) indicating an environment of high clastic influx and the presence of carbonate organisms. Wells 15 and 16, located in Tangipahoa Parish are type III kerogen indicative of a shallower environment with more terrestrial humic input as opposed to a more marine influx of organic matter. There is high variability of TOC (and minerals) in this area which indicates that the intervals of clastic and terrestrial input are interrupted by intervals of more marine input. The high average concentrations of TOC may be preserved by periodic rapid burial of organic matter by the fluctuations (Allen, 2014). There is high variability in TOC moving westward across the study area as well, however, the increasing presence of total clay indicates a lower energy depositional environment which is generally a more suitable environment for organic matter accumulation. The majority of the kerogen moving westward is mixed type II and III with type II kerogen most present in wells 12 and 21 (both of which are located in southeastern Wilkinson County, MS).

Figure 4.15 is a cross-plot of the quantity of free and crackable hydrocarbons (S1+S2 peaks from pyrolysis or the generative potential) versus the concentrations of TOC in the rock. In pyrolysis, the S1 peak represents the amount of free hydrocarbons and bitumen while the S2 peak represents the amount of kerogen available that can produce additional hydrocarbons. The new results for Well 11 are plotted in Figure 4.15 along with the data from the three new wells with samples from core. Note the cuttings are excluded because the S1 peak was eliminated through the solvent extraction pre-treatment used to remove contamination. Most of the new results follow a linear trend where the generative potential and TOC increase proportionally. Samples from Well 11 and some from Well 13 display higher TOC values and a relatively low generative potential. Samples from Well 11 also plotted near the origin of the Pseudo-Van Krevelen diagram (Figure 4.11), suggesting that these samples were depleted of hydrocarbons or are overly thermally mature. It is unclear why several of the samples from Well 13 plot in this area.

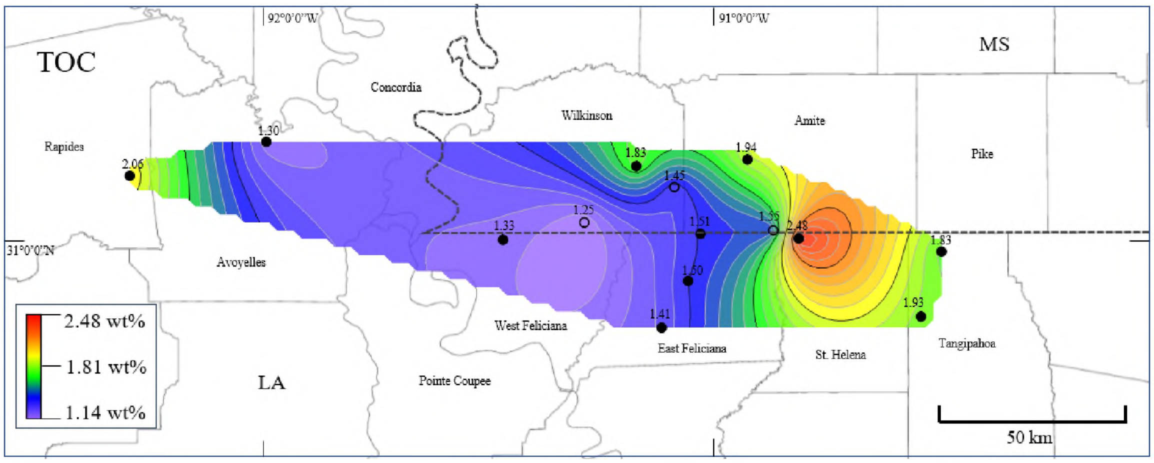


Figure 4.13 Contour map of average TOC concentrations in the basal section of the TMS.

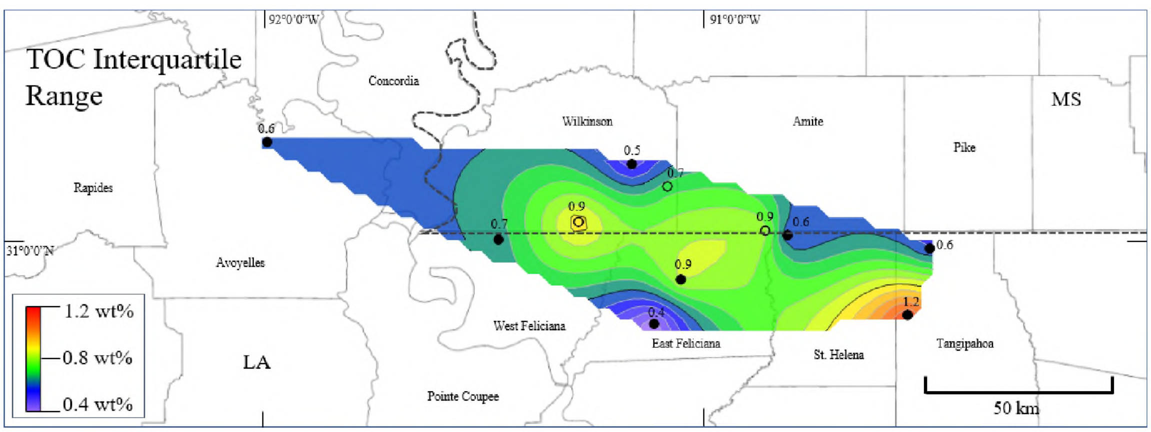


Figure 4.14 Contour map of interquartile range of TOC data in the basal section of the TMS.

Tmax values from pyrolysis were used to determine thermal maturity, however, many factors such as the mineral matrix, type of organic matter, or contamination during pyrolysis could affect the Tmax values and cause them to not be as reliable as other thermal maturity indicators such as vitrinite reflectance (VRo; Peters, 1986). Because VRo data for these samples were not available, Tmax values were plotted in the map and cross-plot to display thermal maturity trends (Figure 4.16). Note that the Tmax values for the cutting samples are included in this case because Tmax is determined by the S2 peak and therefore not impacted by the removal of free oil from drilling fluids.

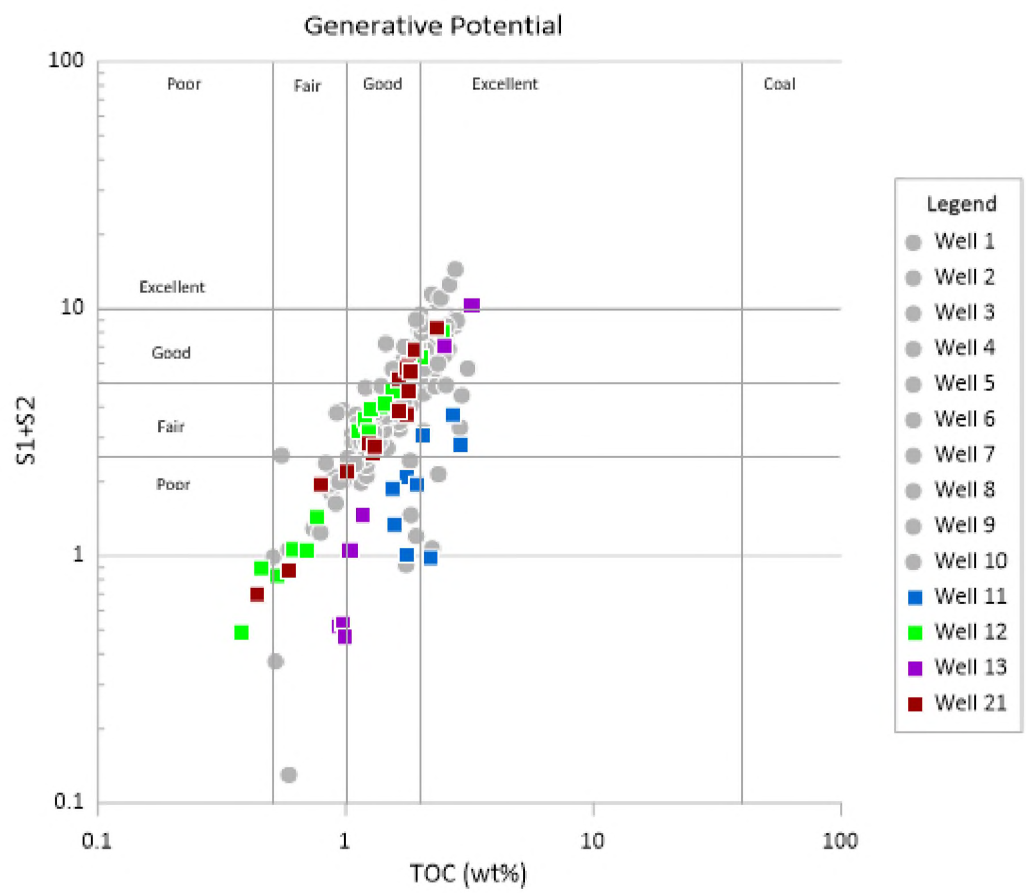


Figure 4.15 Generative potential graph (S1 +S2 vs. TOC wt%). Only core data is plotted.

Generally, the early stage of oil and gas maturation is defined by Tmax values ranging from 430-445 °C, while peak maturation ranges from 445-450 °C, and late-stage maturation ranges from 450-470 °C (Peters and Cassa, 1994). However, each basin is different as depth the types of organic matter and clays present can affect thermal maturity. Because of these factors, this standard by Peters and Cassa, (1994) cannot necessarily be strictly applied. A direct relationship between vitrinite reflectance (VRo) and Tmax was determined by Borrok et al. (2019) by correlating VRo and Tmax values from a limited number of samples. The best fit equation, as determined by Borrok et al. (2019), is Tmax = 20.3(VRo) + 431 °C. Based on the thermal maturity parameters for VRo (Early stage: 0.6-0.65, Peak stage: 0.65-0.9, Late stage: 0.9-1.35) by Peters and Cassa (1994), early stage oil generation for the TMS was calculated to be around 443-444 °C, peak stage is around 444-445 °C, and late stage is around 445-458 °C.

As seen in Figure 2.2a, the depth of TMS unit increases towards the southwest. Therefore, assuming that present burial depth is indicative of paleo conditions, it is logical that the most thermally mature rock occurs in the southwest part of the study area as the geothermal gradient causes the kerogen to be more thermally mature. The highest value of 465 °C occurs in one well in the far west (Rapides Parish, LA) and then 460 °C occurs in the well in the far south of the study (East Feliciana Parish, LA). Two wells along the border of Amite County, MS and St. Helena Parish, LA also have average Tmax values within the late maturation stage. One well in this area (Well 13) has an average Tmax of 452 °C and plotted with some samples at the base of the Psuedo-Van Krevelen diagram indicating the depletion of hydrocarbons in those samples (Figure 4.11) and confirming that the base of the TMS is in the late maturation stage in this area. It is unclear why this area has higher average Tmax values. Perhaps a localized structural feature not seen in the regional TMS depth map (Figure 2.2a) influences thermal maturation in this area. An area directly west of this localization (eastern Wilkinson and western Amite counties, MS) is now considered to be immature (<443 °C) according to the recalculated parameters. Directly surrounding these areas are projections of average Tmax values in the early and peak maturation stage for oil generation. Immaturity also occurs in the rock in the eastern edge of the study area (eastern Amite and Pike counties, MS and Tangipahoa parish, LA).

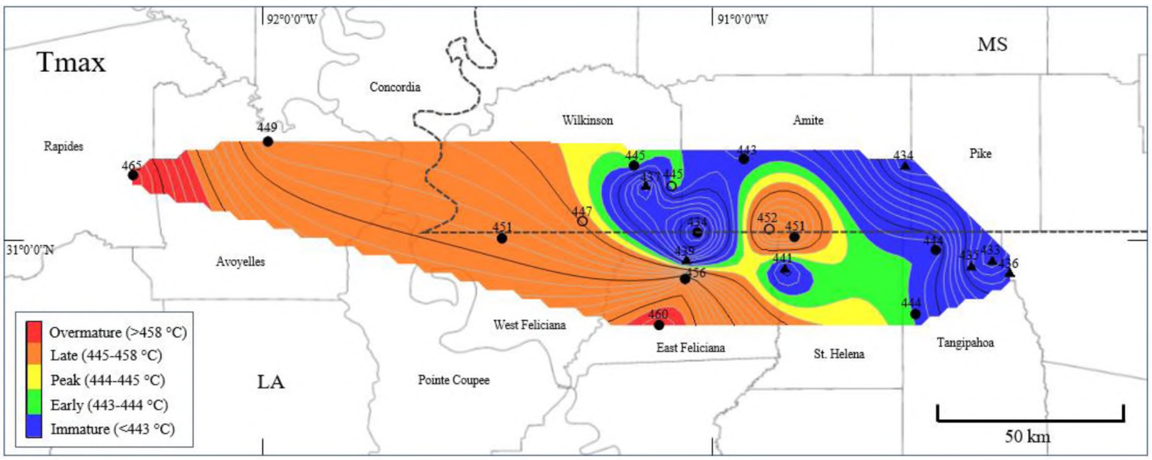


Figure 4.16 Contour map of average Tmax values in the basal section of the TMS.

The Tmax values of the TMS wells are displayed against PI (Production Index) in Figure 4.17. The PI is calculated as S1/S1+S2. Therefore, the cuttings are excluded from this plot, although their Tmax values are indicated by the gray box. The Tmax values of the cuttings generally fall below the recalculated oil generation window. Although, the majority of new core samples plot within the main stage of generation area. Well 11, however, plots in the inert carbon and postmature areas of the graph with high values of Tmax and relatively high PI values. This in conjunction with the HI and OI information is a good indication that the base of the TMS in this well is overly thermally mature.

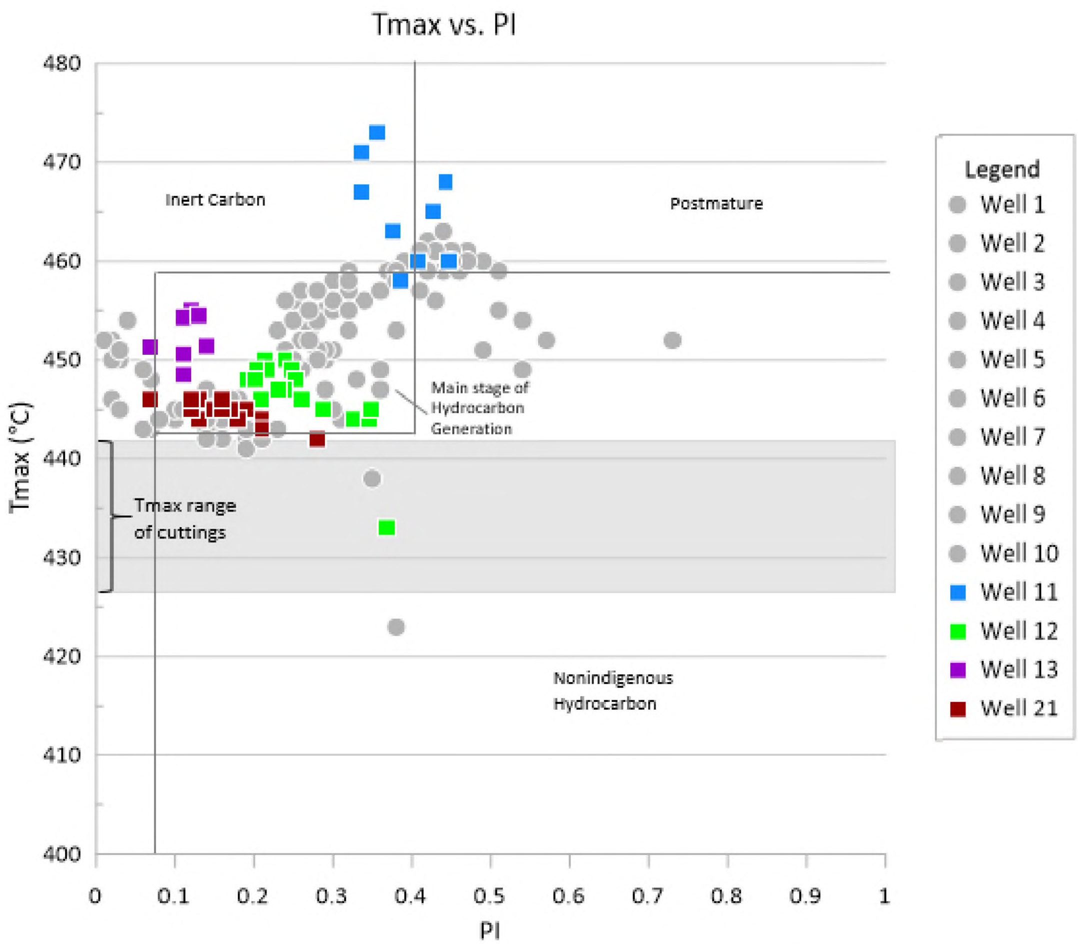


Figure 4.17 Tmax (°C) vs. Production Index.

4.3. DRILLING DATA

The cumulative volume of oil production in the TMS in the first 12 months of well operation generally increased with younger completion dates (Figure 2.3). This could be due to a multitude of factors, including changes in drilling and completion practices and improved knowledge of the best landing zones for wells. To further investigate these factors, available data such as the amount of proppant, additives, and fluid used in hydrofracking were plotted versus cumulative 12-month oil production in Figure 4.18. We found that none of these measurable factors correlated with the extent of oil production.

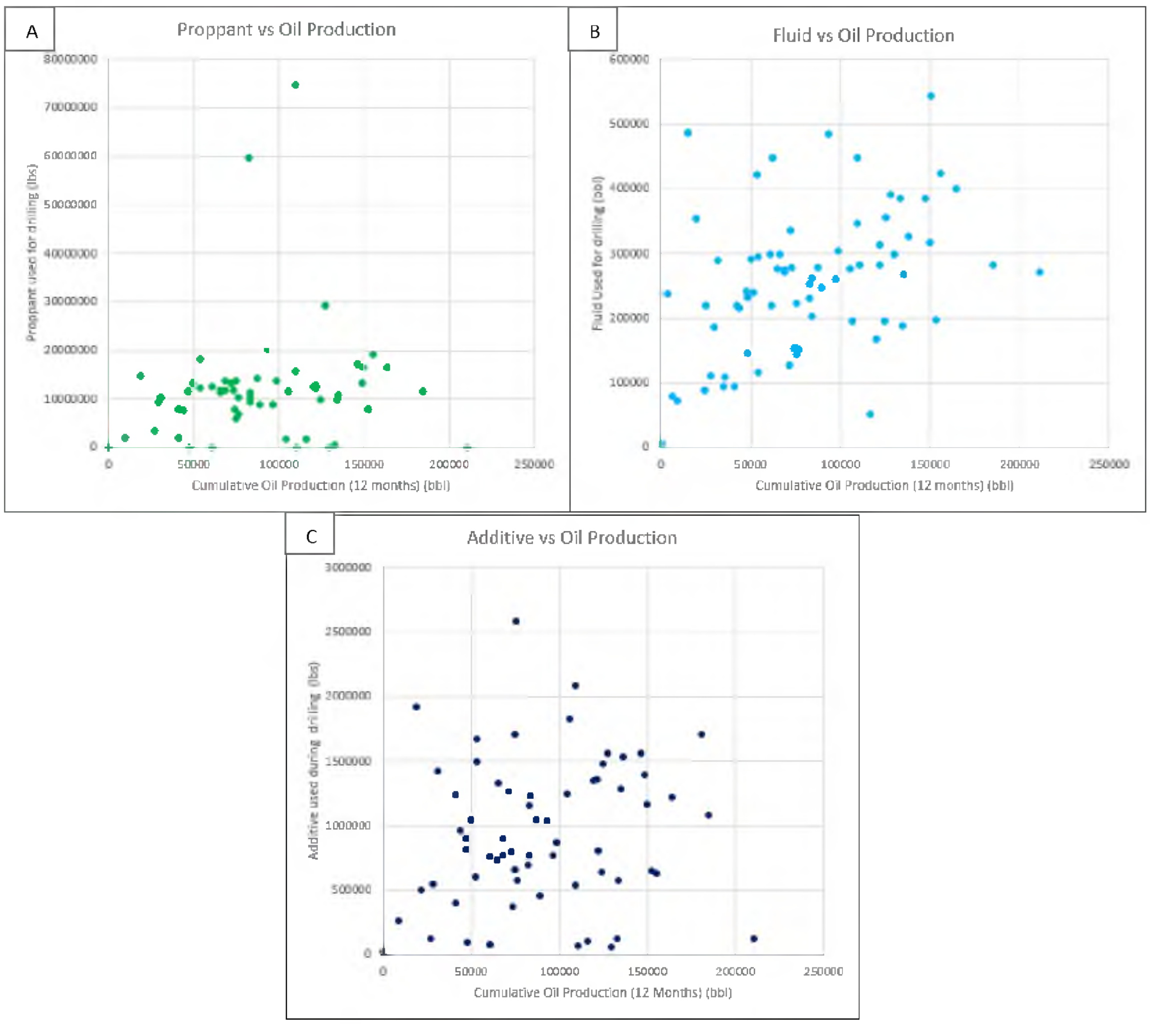


Figure 4.18 Drilling factors vs. cumulative oil production over the first 12 months: a) proppant, b) drilling/fracking fluid, c) additive.

Another factor that was considered was the lateral lengths of the wells, as lateral lengths have generally increased over time. Figure 4.19 shows a weak correlation (R^2 =0.39) between lateral length up to 1500 m and cumulative oil production (bbl). It is possible that over time, the lateral length contributes to oil production success in addition to other factors, however, the very low R^2 value (R =0.06) over 1500 m ultimately suggests that longer lateral length for TMS wells alone does not have appreciable impact on success in terms of the amount of oil produced.

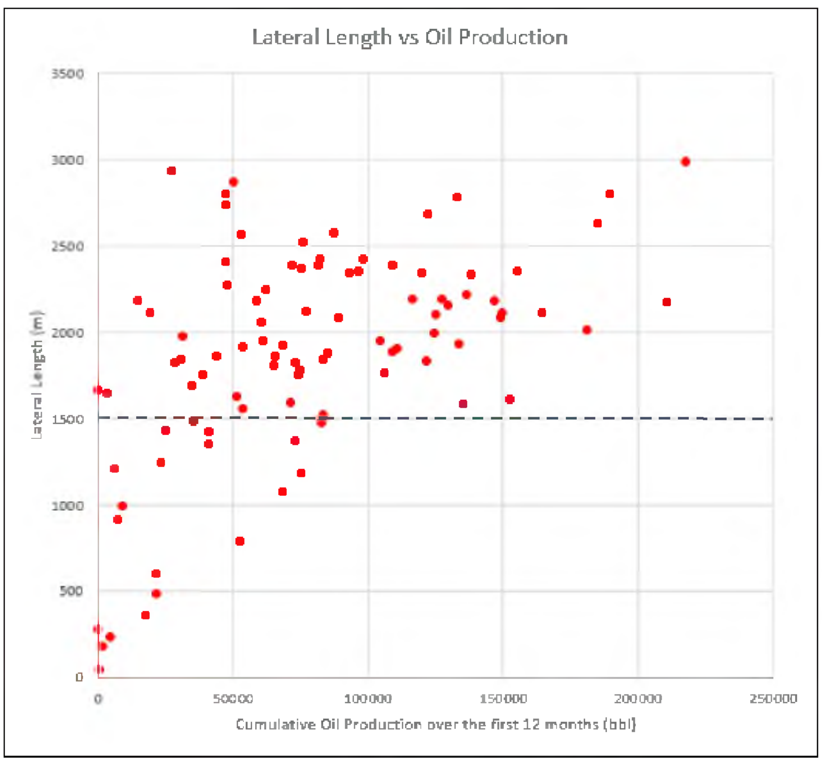


Figure 4.19 Lateral length vs. cumulative oil production over the first 12 months.

4.4. PRODUCTION CONTOURS

Cumulative 12-month oil, gas, and water production contour maps for all TMS wells were created using the kriging gridding technique (Figure 4.20, 4.21, and 4.22, respectively). Extrapolations were not made outside of the range of available data points. The contours that represent the top 30% of oil and gas production are outlined in red. The area in the TMS with the highest initial 12-month oil production is the northeastern region of the study area, primarily in southern Mississippi (Wilkinson and Amite counties) and into northern Louisiana (St. Helena Parish).

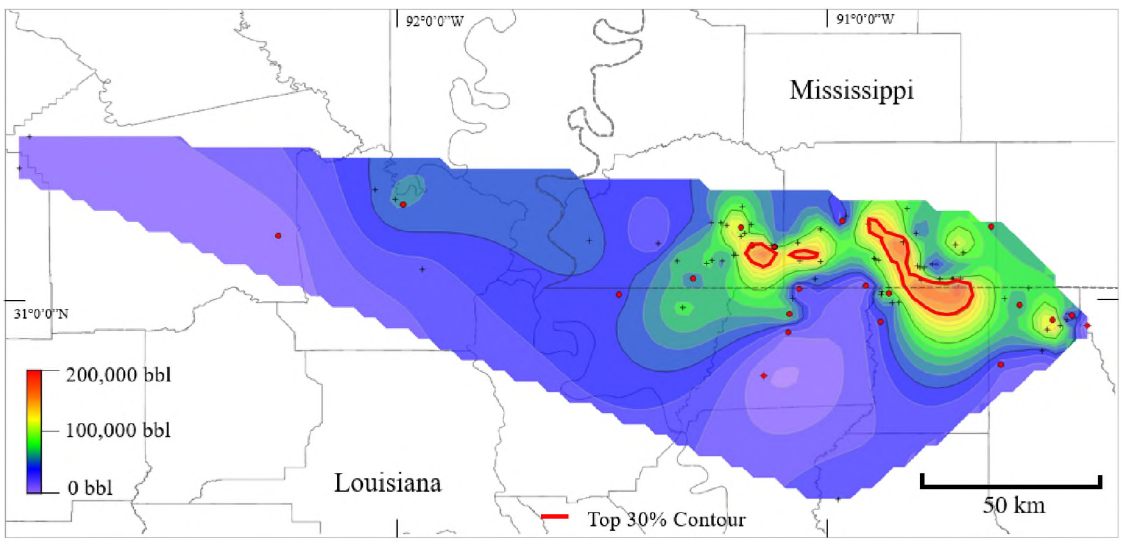


Figure 4.20 Contour map of cumulative oil production for the first 12 months of TMS wells. Red dots indicate the 21 wells with mineralogical and geochemical data available.

The gas production contours are greatly skewed by two wells (indicated by yellow stars): one in the far southern part of the study region, with a cumulative 12-month gas production value of 375,514 Mcf and one in the north-central part of the study region with a cumulative 12-month gas production value of 246,754 Mcf. Data for all remaining wells were less than 142,200 Mcf. Therefore, the color gradient and contours were adjusted by making 142,200 the highest value. Areas that are colored orange represent all the contours between 142,200 and 375,500 Mcf. The top 30% of gas production was also recalculated based on the 142,200 value. Of the remaining wells, the most gas production occurred in Wilkinson and Amite counties, MS in areas that were coincidental with the higher oil production (Figure 4.21). The highest amounts of gas production occur slightly west of the highest amounts of oil production. Water production is more sporadic within the study region with the top 30% water production often occurring in the same locations as the highest amounts of gas. However, other areas of the top 30% produced water are also found more in the northeast, mainly in northern Amite County, MS (Figure 4.23).

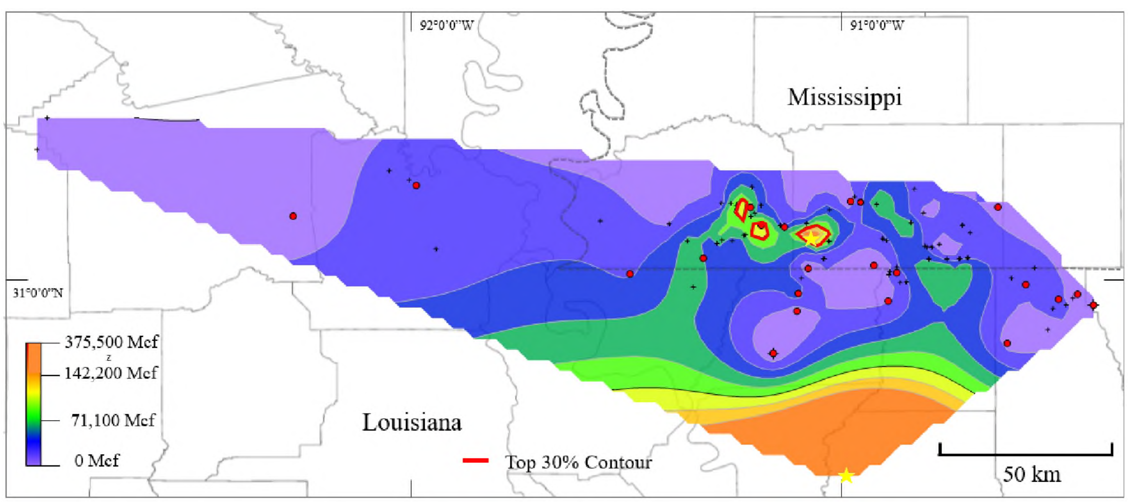


Figure 4.21 Contour map of cumulative gas production for the first 12 months of TMS wells. Red dots indicate the 21 wells with mineralogical and geochemical data available. Yellow stars indicate the wells with the high amounts of gas production.

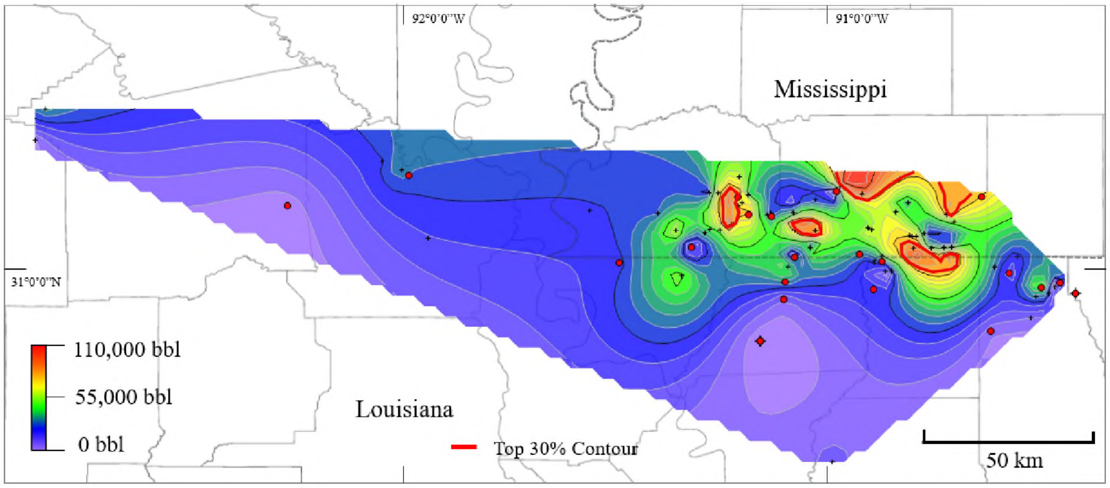


Figure 4.22 Contour map of cumulative water production for the first 12 months of TMS wells. Red dots indicate the 21 wells with mineralogical and geochemical data available.

4.5. COMPARISONS OF MINERALOGY AND GEOCHEMISTRY WITH PRODUCTION DATA

The contours for the top 30% of data for oil (red) and gas (purple), are outlined and overlayed on top of the mineralogical and geochemical contour maps to visually compare the spatial relationships for production with average concentrations of quartz, calcite, total clay, TOC, and Tmax (Figure 4.23, 4.24 ,4.25, 4.26, and 4.27 respectively).

There may be a weak spatial correlation between the concentrations of quartz in the basal section and cumulative oil and gas production (Figure 4.23a). Most of the top 30% cumulative oil production contour overlays areas where the quartz content is predicted to be in a moderate to high range (>27 wt%). However, a cross plot of quartz content versus oil production does not appear to be statistically meaningful (Figure 4.23b). The top 30% of cumulative gas production contours overlay areas of quartz concentrations in the moderate range (>23 wt%) but there is also no meaningful correlation of quartz content versus gas production.

In the northern area of the study area (in Wilkinson and into Amite counties), the top 30% of cumulative oil and gas production corresponds with low average calcite concentrations (<16 wt%; Figure 4.24a). This situation is also reflected in the cross-plot between average calcite content vs gas production (Figure 4.24b). However, towards the east (in southern Amite County, MS, and into St. Helena Parish, LA), there are also areas of higher calcite content (up to 22 wt%) that correspond to high oil production. Overall, no definitive correlation can be made between average calcite concentrations at the base of the TMS and oil production both spatially and in cross-plots.

A notable correlation can be made between low average clay content (<44 wt%) and the largest areas of the top 30% oil production (central Amite County, MS and St. Helena Parish, LA) however, this is not reflected in the cross-plot (Figure 4.25b). In the western region of the study area, areas of high oil production overlay areas of moderate clay concentrations (46-50 wt%) and areas of high gas production overlay areas of projected moderate to high clay content (up to 57 wt%). Because areas where the top 30% of cumulative oil production overlay both areas of low and high total clay concentrations, no clear trend can be recognized. Potential relationships involving individual clay minerals and oil and gas production were investigated as well, however, no significant results were found. The individual clay minerals investigated were illite, kaolinite, smectite (including montmorillonite and bentonite), and chlorite.

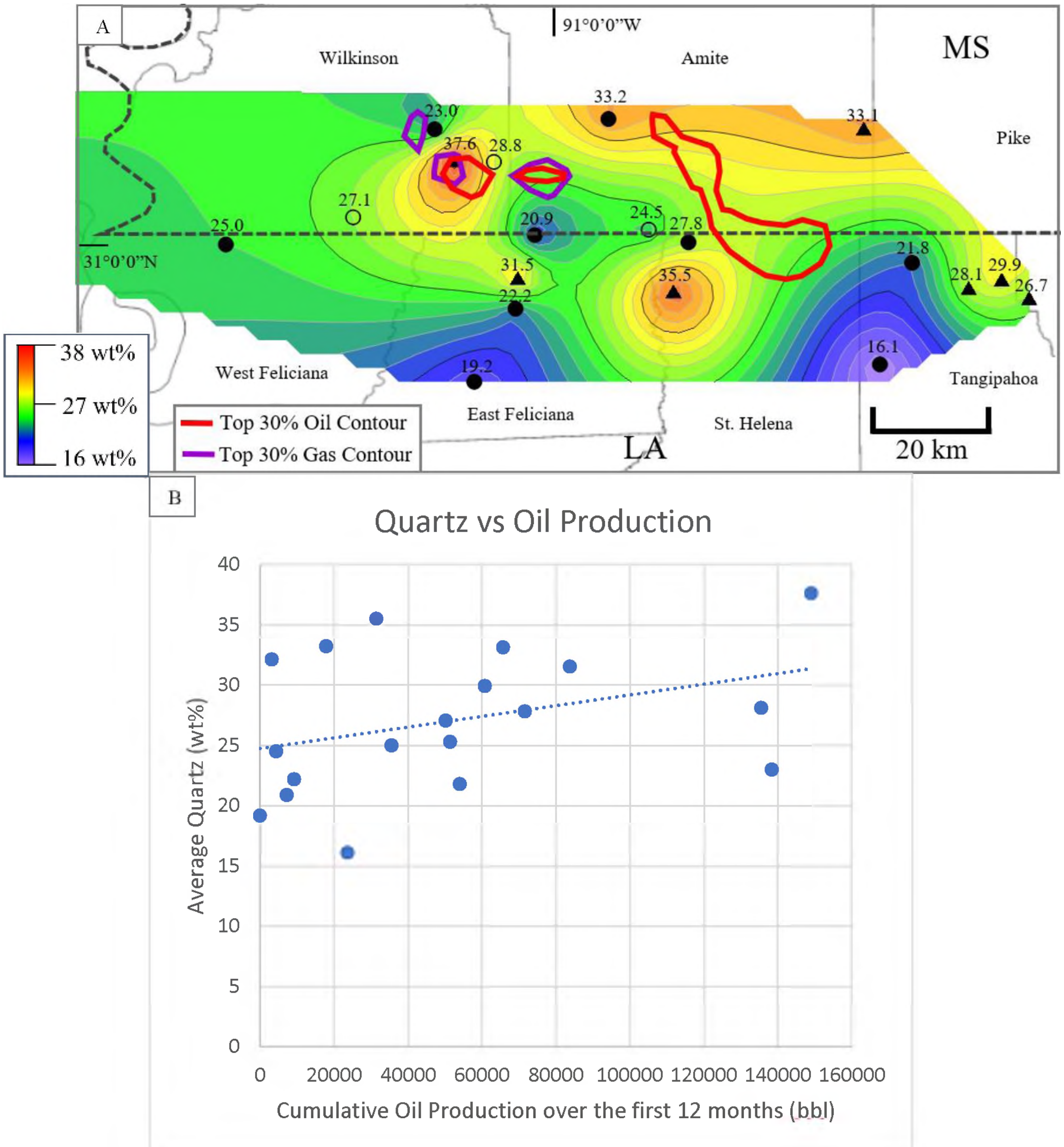


Figure 4.23 Comparison of quartz vs production a) Contour map of average quartz concentrations in the basal section of the TMS with top 30% oil (red) and gas (purple) contours b) Cross-plot of quartz content vs cumulative oil production over the first 12 months.

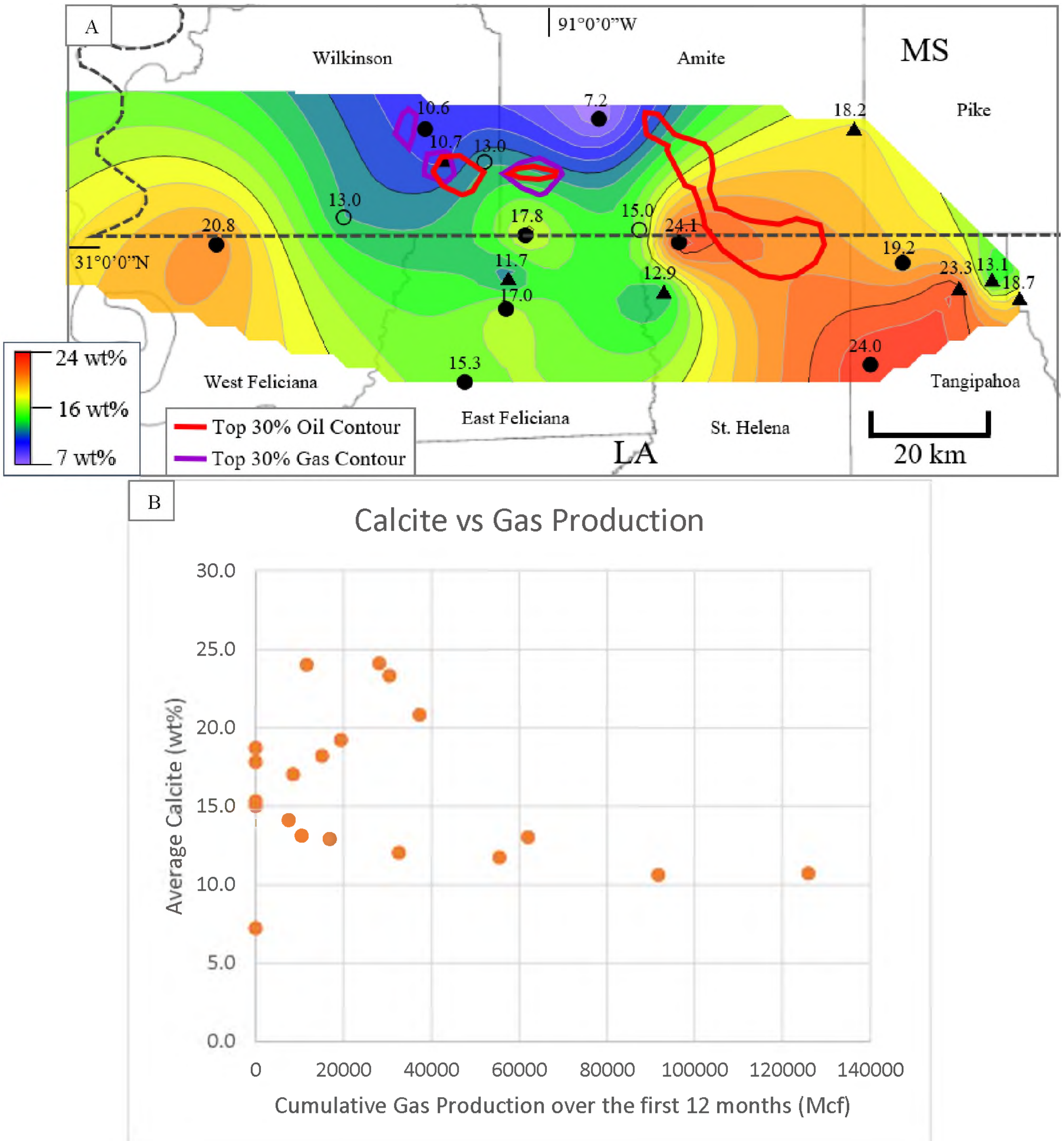
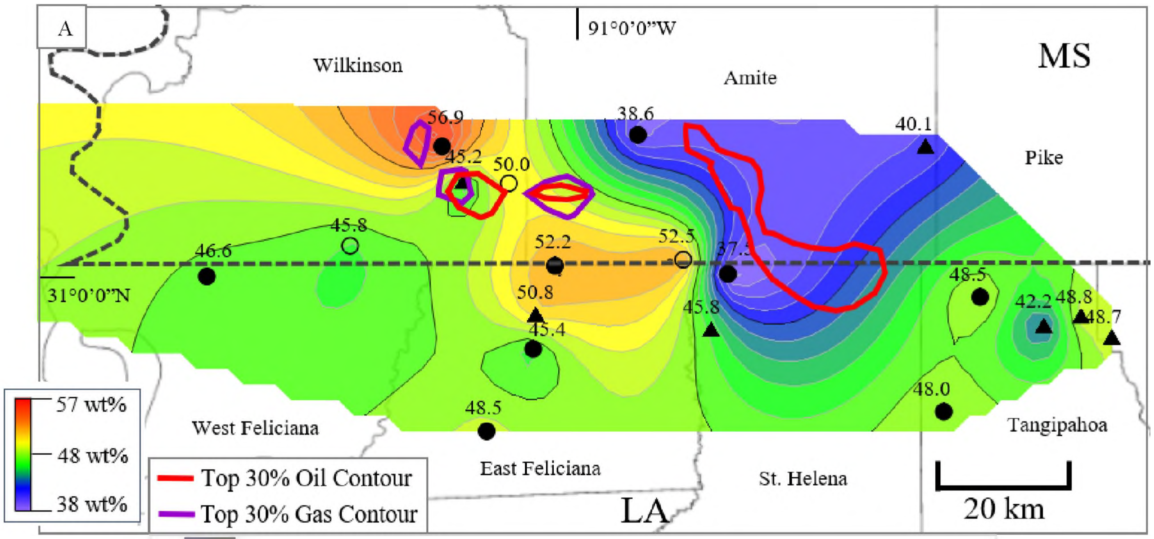


Figure 4.24 Comparison of calcite vs production a) Contour map of average calcite concentrations in the basal section of the TMS with top 30% oil (red) and gas (purple) contours b) Cross-plot of calcite content vs. total gas production over the first 12 months.



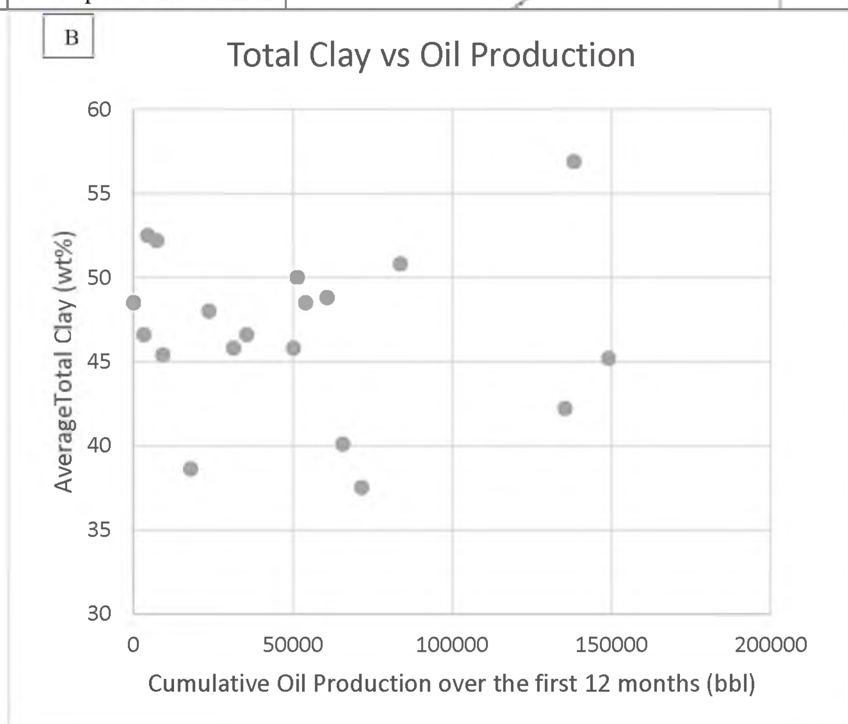


Figure 4.25 Comparison of total clay vs production a) Contour map of average total clay concentrations in the basal section of the TMS with top 30% oil (red) and gas (purple) contours b) Cross-plot of total clay content vs total oil production over the first 12 months.

The largest area of highest cumulative oil production (Amite County, MS and St. Helena Parish, LA) overlays the area of highest predicted TOC (>2.0 wt%). However, the areas in eastern Wilkinson and western Amite Counties, MS with >30% oil production are concurrent with lower TOC (ranging between 1.5-1.8 wt%). The cross-plot shows that the three most successful wells, in terms of cumulative 12-month oil production, have an average TOC above 1.75 wt% (Figure 4.26b).

Overall, the Tmax values are quite lower than expected. Most of the areas where there is high oil production and all areas where there is high gas production fall within various stages of maturation according to the calculated VRo values and adjusted Tmax ranges (Figure 4.27a). A majority of these areas are within the oil generating window (443-458 °C). Some areas, however, are considered to be immature according to the recalculated parameters. Wells with Tmax values below 443 °C are located on the eastern edge and central part of the study area. The cross-plot shows that the greatest cumulative oil production (in the top 4 wells) occurred when Tmax was within the range of 435-445°C. The observation that areas of high oil and gas overlay areas that contain projections of immature or weak thermal maturity may indicate that some oil has migrated updip from more thermally mature rocks. The natural fracture system of the TMS could contribute to this possibility (Echols et. al, 1994).

In summary, there are two areas where the top 30% of cumulative oil production occurs. One area is located in central Amite County and crosses the MS-LA border into St. Helena Parish, LA. This area strongly correlates with low average total clay (~40 wt%), high average quartz content (28-30 wt%), variable calcite, and high TOC values (>2.0 wt%). Shale reservoirs that have higher amounts of quartz tend to be easier to fracture (Jarvie, 2012). Quartz is the most brittle of the major minerals, more so than calcite (Mews et al. 2019). Shell fragments are less likely than quartz to aid in fracturing and calcite cement that has filled fractures actually inhibits stimulation (Bowker, 2007). It is possible that the variability of interbedded siltstones or pockets of larger grained quartz interspersed with the clay make the formation more brittle and aid in drilling and stimulation in this area. TOC is also predicted to be high in this area (>2.0 wt%). TOC greater than 2.0 wt% are very good for a source rock (Peters, 1986). Two wells just west of this area (Wells 2 and 13) have type II kerogen indicating that this area contains both the quantity and quality of organic matter to contribute to oil production (Figure 4.11). Favorable drilling conditions and adequate geochemical parameters contribute to successful oil production in this area.

The second area which contains the highest gas production in addition to high oil production, is located in eastern Wilkinson and western Amite Counties in Mississippi. This area contains moderate to high average quartz as well (23-38 wt%), with higher total clay concentrations (>45 wt%). While average TOC is in moderate amounts here (1.45-1.8 wt%), TOC has very high variability in this area. Conditions for organic matter accumulation appear to be favorable, however, mineralogy and TOC concentrations are variable. Therefore, it is unclear why oil and gas production are very high in this area relative to most others.

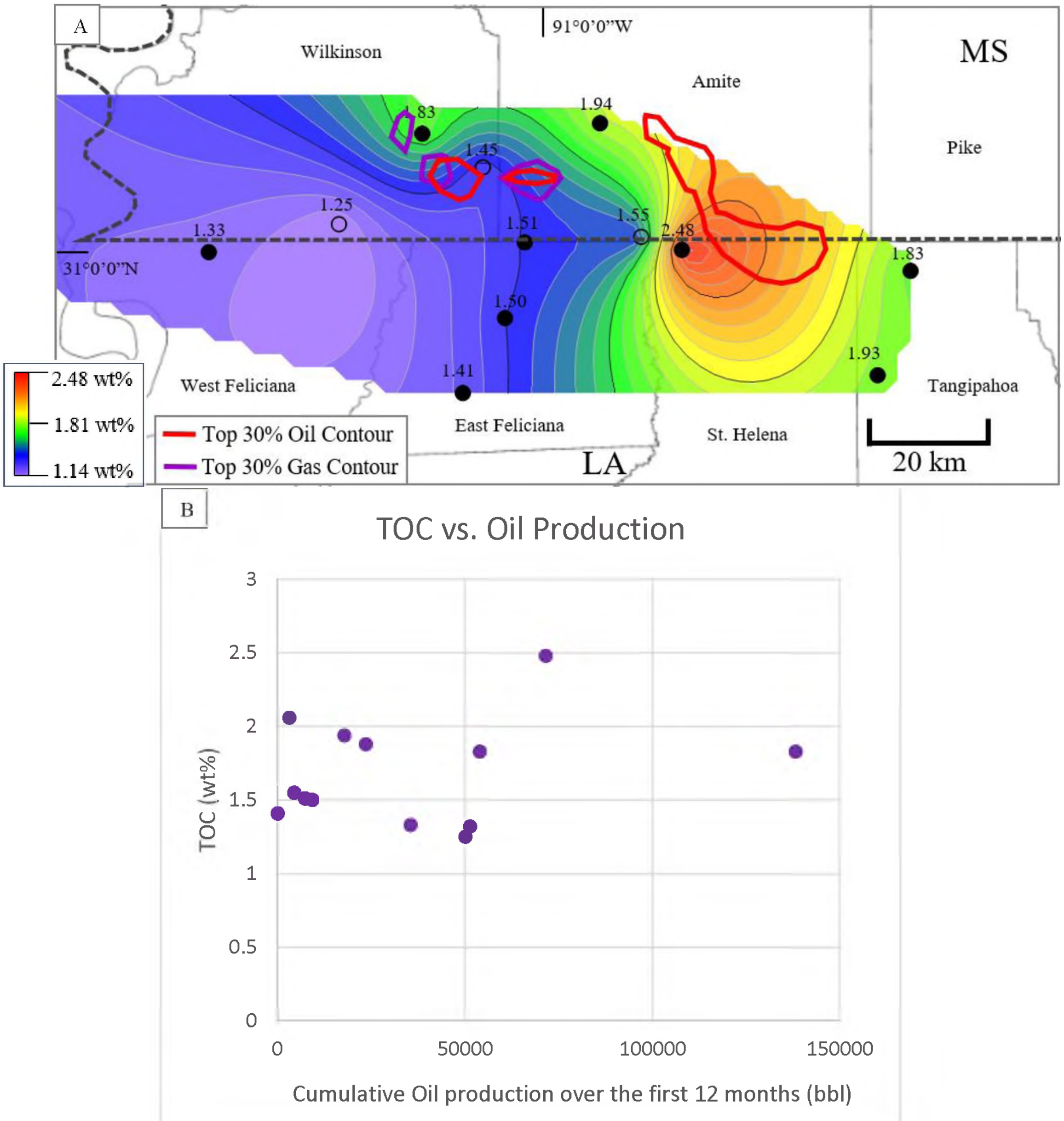


Figure 4.26 Comparison of TOC vs production a) Contour map of average TOC concentrations in the basal section of the TMS with top 30% oil (red) and gas (purple) contours b) Cross-plot of TOC vs total oil production over the first 12 months.

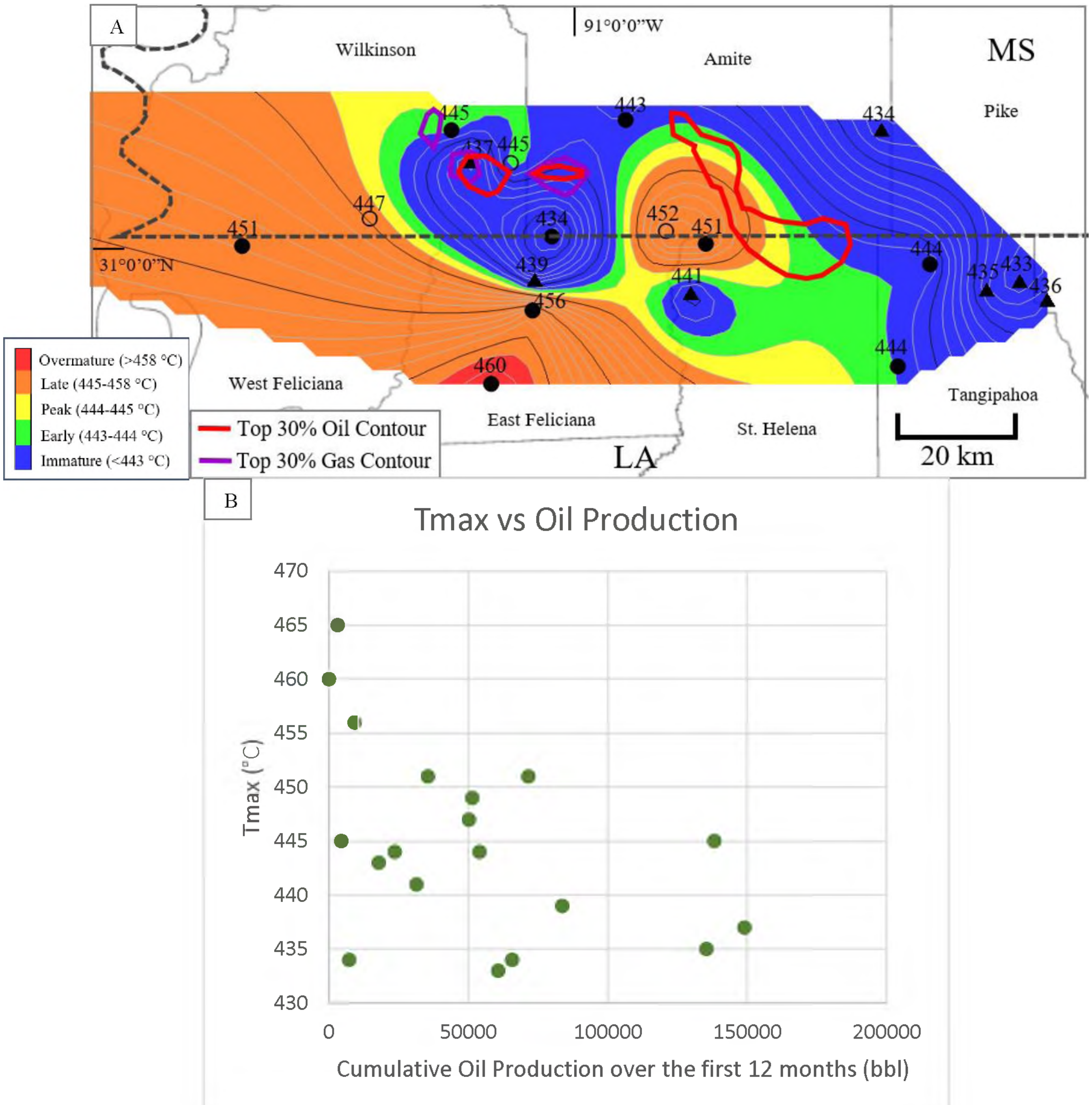


Figure 4.27 Comparison of Tmax vs production a) Contour map of average Tmax concentrations in the basal section of the TMS with top 30% oil (red) and gas (purple) contours b) Cross-plot of Tmax vs cumulative oil production over the first 12 months.

5. CONCLUSION

This study compiles existing mineralogical, organic geochemical, and production data for the TMS and attempts to establish relationships among them. In addition to the eleven previously analyzed wells, we contributed nine more wells, two with samples from core and seven with samples from cuttings in addition to new geochemical data for one original core and data from Enomoto et al. (2018). The average minerals in the basal section of the wells are as follows: 25.2 wt% quartz, 16.8 wt% calcite, 47.0 wt% total clay, 3.2 wt% plagioclase, and 3.7 wt% pyrite. The XRD results confirm the TMS is clay-dominated with various amounts of quartz and calcite. The cuttings samples were determined to be contaminated and were subjected to an extraction method process to remove hydrocarbons. The S1 peak was eliminated and TOC and PI were affected in the new results. The averages for pyrolysis measurements in the basal section are as follows: S1 (excluding cuttings): 1.0 mg/g, S2: 3.26 mg/g, Tmax: 447 °C, TOC (excludes cuttings): 1.58 wt%, HI: 191, OI: 25, PI (excluding cuttings): 0.25. The Pseudo-Van Krevelen diagram suggests a mixed type II and III kerogen, with the new core samples plotting towards the type II and two new cuttings wells plotting more towards type III kerogen. Variability of quartz, calcite and total clay in the base of the TMS in the eastern section of the study indicate a paleo environment with clastic input, a close proximity to the depocenter, and fluctuations in sea level. Westward (in the direction of TMS thinning), the depositional environment changes to a lower energy setting where fine-grained clay is dominantly deposited. The relationships established that tie to oil production in some areas are low total clay, high amounts of quartz, an average TOC greater than 1.5 wt%, and thermal maturity within the range of 435-445°C Tmax. After recalibration of Tmax based on VRo, some Tmax values were considered immature and weakly mature, indicating that the oil may have migrated from more thermally mature rocks. The large interquartile ranges of minerals and TOC highlight the heterogeneity of the TMS. There are no obvious correlations with factors such as amount of proppant used, amount of additives used, or amount of drilling fluid used. However, there is a weak correlation of oil production with increasing lateral length up to 1500 m.

Adding more mineralogical and geochemical data will help better define these preliminary trends and aid in the understanding of the heterogeneity of the TMS. Future work could possibly include a more statistical approach to address the heterogeneity in the TMS. Future work could also include investigating porosity and permeability of the TMS in areas of high production and exploring relationships of natural fracture systems of the TMS. Formation evaluation of the TMS is an important component in the production success of the TMS and better understanding of the formation would improve the yield for recoverable hydrocarbons.

APPENDIX A.

X-RAY DIFFRACTION DATA

Table A.1. XRD data from samples for wells 1-13 & 21. The samples are from conventional and rotary sidewall cores. The 18-meter basal section for each well is highlighted in yellow. Wells 1-11 were previously published by Borrok, et al. (2019) and well 21 was previously published by Enomoto, et al. (2018). The following mineral content values are included in the table: quartz, calcite, illite, kaolinite, smectite, chlorite, plagioclase, k-feldspar, pyrite, marcasite, dolomite, siderite, and total clay.

Table A.2. XRD data for wells 14-20. The samples are from cuttings. The depth ranges in which the cuttings were collected are listed in the table. The following mineral content values are included in the table: quartz, calcite, illite, montmorillonite, kaolinite, chlorite, plagioclase, pyrite, fluorapatite, barite, dolomite, siderite, muscovite, biotite, and total clay.

Table A.1 XRD data from samples for wells 1-13 & 21.

Well #	Depth relative to base of TMS	Quartz	Calcite	Illite	Kaol.	Smect.	Chlor.	Plag.	K-Spar	Pyrite	Marc.	Dol.	Sid.	Total Clay
	(m)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	33.7	17.6	11.9	19.6	23.1	13.0	8.0	3.3	0.8	2.7	0.0	0.0	0.0	63.7
1	32.2	16.2	34.6	11.3	15.2	10.6	7.9	2.6	0.0	1.6	0.0	0.0	0.0	45.0
1	30.6	25.2	6.9	14.0	17.8	14.0	11.8	3.6	0.6	6.1	0.0	0.0	0.0	57.6
1	29.0	27.9	8.0	14.4	16.8	11.0	9.8	5.1	0.9	3.7	0.0	0.0	2.3	52.1
1	27.6	19.8	21.9	15.1	15.1	11.3	8.6	4.1	0.0	4.1	0.0	0.0	0.0	50.1
1	26.1	18.7	35.1	12.2	12.5	9.7	7.2	2.9	0.0	1.1	0.6	0.0	0.0	41.6
1	24.4	27.1	7.5	14.9	17.2	13.0	9.1	3.7	0.0	7.5	0.0	0.0	0.0	54.2
1	23.0	21.9	16.0	16.6	15.1	12.0	9.2	3.5	0.0	5.7	0.0	0.0	0.0	52.9
1	21.5	24.4	23.3	11.7	14.9	11.4	8.1	3.3	0.0	1.4	1.6	0.0	0.0	46.1
1	20.0	22.5	8.0	18.8	17.3	12.8	9.6	3.9	0.8	6.4	0.0	0.0	0.0	58.5
1	18.4	26.3	20.3	13.0	13.4	11.5	7.0	5.0	0.7	1.8	0.9	0.0	0.0	44.9
1	16.9	17.4	10.4	20.8	18.7	14.6	9.9	3.5	0.7	2.0	2.1	0.0	0.0	64.0
1	15.4	22.4	9.7	19.8	14.9	15.4	10.6	3.6	0.0	2.5	1.0	0.0	0.0	60.8
1	13.9	21.9	6.1	22.6	14.6	16.7	10.7	4.5	0.0	0.9	1.9	0.0	0.0	64.7
1	12.3	19.3	0.6	22.0	15.8	19.5	11.1	3.6	1.1	6.3	0.6	0.0	0.0	68.5
1	10.8	23.8	12.3	18.5	13.9	13.9	9.1	6.2	0.0	1.7	0.8	0.0	0.0	55.3
1	9.3	20.8	17.3	18.8	11.6	15.0	7.6	6.2	0.0	2.8	0.0	0.0	0.0	53.0
1	7.8	23.6	1.9	18.3	15.5	17.7	9.4	5.8	0.0	6.0	1.7	0.0	0.0	60.9
1	6.2	27.1	4.6	21.0	12.6	11.9	10.7	7.6	0.8	3.7	0.0	0.0	0.0	56.2
1	4.7	42.8	8.1	12.8	6.2	8.1	8.9	8.9	1.1	3.1	0.0	0.0	0.0	36.0
1	3.2	54.6	1.5	8.6	8.4	8.0	6.2	9.5	0.5	2.7	0.0	0.0	0.0	31.2
1	1.7	44.6	0.0	13.0	13.0	12.0	7.0	7.7	0.0	2.6	0.0	0.0	0.0	45.1
1	0.2	48.6	0.0	11.3	11.6	10.9	7.3	7.4	0.7	2.2	0.0	0.0	0.0	41.1
2	24.8	34.9	27.3	5.8	9.1	8.2	3.0	4.6	0.0	5.3	0.0	0.0	1.8	26.1
2	23.3	22.8	14.4	10.4	18.4	16.1	8.3	3.5	0.0	6.1	0.0	0.0	0.0	53.3
2	20.0	40.3	22.2	5.8	7.6	5.4	3.2	5.6	1.3	4.6	0.0	0.0	3.9	22.1
2	19.7	19.5	39.3	8.7	9.3	10.5	4.6	3.0	0.0	5.1	0.0	0.0	0.0	33.1
2	18.3	25.6	11.5	10.9	21.0	12.0	8.0	4.5	1.7	3.7	0.0	0.0	1.1	51.8
2	17.7	39.9	12.4	6.9	13.0	8.3	5.6	4.6	1.8	5.9	0.0	0.0	1.6	33.8
2	15.8	23.7	31.2	9.4	14.6	9.8	5.6	3.6	0.0	2.0	0.0	0.0	0.0	39.5
2	14.5	10.1	64.8	4.2	5.5	5.6	3.3	1.8	0.0	3.6	0.0	0.9	0.0	18.7
2	12.0	25.4	19.8	11.1	14.9	14.2	5.5	3.1	1.8	2.8	1.4	0.0	0.0	45.7
2	9.4	26.7	11.4	13.7	12.1	14.4	6.3	6.9	3.2	2.0	1.6	0.0	1.7	46.4
2	8.1	38.0	7.7	14.0	13.2	11.6	5.2	5.1	1.6	2.0	1.4	0.0	0.0	44.1
2	6.6	26.7	26.8	9.0	9.1	12.3	4.7	5.1	0.0	6.1	0.0	0.0	0.0	35.1
2	4.7	36.7	5.8	11.2	10.2	13.2	6.0	10.3	0.0	6.6	0.0	0.0	0.0	40.6
2	2.8	33.8	32.7	5.3	4.1	6.4	4.0	7.9	0.9	2.3	0.0	1.1	1.6	19.7
2	0.8	42.4	38.8	2.3	1.2	3.0	1.3	8.1	0.0	1.7	0.0	1.3	0.0	7.7
2	0.3	67.1	7.7	2.8	2.9	3.2	3.4	11.0	0.0	1.9	0.0	0.0	0.0	12.3
2	0.2	60.2	6.2	4.9	5.1	5.7	4.7	11.1	0.0	2.0	0.0	0.0	0.0	20.5
2	-2.1	63.6	1.0	5.5	3.1	6.4	13.4	3.4	1.1	2.5	0.0	0.0	0.0	28.4
2	-2.6	37.6	0.0	14.2	11.1	20.1	8.7	3.7	0.0	1.5	0.0	0.0	3.1	54.1
3	15.5	23	5	14	18	11	14	5	2	7		0	1	57
3	14.8	38	8	7	9	5	7	19	2	4		0	1	28
3	12.6	28	4	13	16	10	12	10	3	3		0	1	51
3	8.2	41	14	5	5	3	4	18	2	7		0	1	17
3	5.9	36	5	10	12	8	10	9	2	6		0	2	40

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

3	2.8	59	11	4	4	3	3	12	2	1		0	1	14
3	1.5	69	3	3	5	3	3	9	2	3		0	0.5	14
3	0.5	59	1	6	7	4	5	12	2	3		0	1	22
3	0.1	55	1	7	10	6	7	9	1	3		0	1	30
3	-0.8	26	0.5	16	21	13	16	4	1	1		0	2	66
3	-1.6	28	1	15	20	11	15	5	2	2		0	1	61
3	-2.1	50	1	9	11	7	8	8	2	3		0	1	35
4	11.6	22	10	25	22	4	9	3	1	4		0.5	0	60
4	11.2	18	1	29	26	5	10	3	1	7		0.5	0	70
4	10.8	20	12	26	23	4	8	3	1	3		0.5	0	61
4	9.3	28	3	24	22	4	8	4	1	6		0.5	0	58
4	8.9	30	16	18	16	3	6	7	1	3		0.5	0	43
4	8.4	24	3	27	24	5	9	4	1	3		0.5	0	65
4	6.9	14	49	13	11	2	4	2	1	4		0.5	0	30
4	6.6	16	42	8	7	6	13	5	1	2		0.5	0	34
4	6.3	16	24	12	9	9	19	4	1	6		0.5	0	49
4	5.9	27	27	5	4	4	9	9	1	13		1	0	22
4	5.2	33	34	4	3	3	5	13	1	4		0.5	0	15
4	4.1	19	9	16	12	11	25	4	1	3		0.5	0	64
4	1.1	18	49	5	3	4	8	10	1	2		0.5	0	20
4	0.3	54	2	8	6	6	13	7	1	3		0.5	0	33
4	0.2	54	11	6	4	4	8	8	1	4		0.5	0	22
4	-0.5	63	1	6	4	4	7	11	1	3		0.5	0.5	21
4	-0.6	61	1	7	5	5	10	6	1	4		0.5	0.5	27
4	-3.5	44	0	18	7	8	12	6	1	3		1	0.5	45
4	-3.7	51	2	9	6	7	12	7	1	5		0.5	0.5	34
4	-4.3	50	0.5	11	6	7	13	8	1	4		0.5	0.5	37
4	-4.5	61	2	6	4	5	10	9	1	2		0.5	0.5	25
5	58.7	22	1	15	7	13	9	7	3	3		0	7	56
5	57.9	36	3	19	10	5	8	6	2	2		1	2	47
5	56.0	20	9	18	11	12	7	6	2	2		0	2	58
5	55.5	22	7	21	11	9	9	7	1	3		1	2	57
5	54.0	20	9	15	11	14	5	6	4	3		0	0	57
5	51.8	27	4	14	10	8	7	5	7	4		2	1	49
5	50.6	21	4	16	9	9	10	11	4	2		1	2	54
5	49.8	23	5	18	10	11	6	6	3	2		3	1	56
5	48.4	23	5	16	10	12	9	10	0	3		0	1	57
5	48.0	43	6	10	8	6	8	5	2	4		1	1	37
5	46.4	28	3	23	10	6	7	5	4	3		2	1	54
5	44.7	20	2	24	10	5	11	10	6	3		1	3	55
5	43.1	26	10	19	10	10	6	6	0	2		0	1	53
5	40.3	48	5	11	7	4	7	5	4	3		0	1	32
5	40.2	36	14	16	8	5	4	5	2	4		1	1	38
5	39.1	23	5	18	12	11	7	7	2	2		1	2	58
5	37.7	32	3	17	8	9	7	6	2	3		1	3	49
5	36.7	20	8	26	12	7	7	6	4	3		0	1	58
5	36.1	19	6	22	12	9	8	7	2	3		0	2	60
5	34.1	25	3	18	10	11	8	9	1	4		1	1	55
5	33.5	32	2	19	11	7	7	5	4	4		3	1	49
5	32.7	19	15	24	12	4	7	4	6	3		0	1	50
5	31.8	19	12	19	15	8	6	4	3	4		0	2	56
5	31.2	25	11	27	14	5	3	5	0	4		1	2	52
5	29.9	31	2	18	13	8	6	3	2	4		3	2	52
5	26.4	20	18	14	13	10	5	3	1	4		1	2	52
5	25.8	20	20	17	12	4	4	5	7	4		1	2	41

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

5	25.3	25	7	24	13	7	6	6	1	3		2	1	57
5	23.4	23	8	17	11	7	9	9	1	3		3	2	52
5	21.8	16	8	28	29	2	2	3	2	8		1	0	62
5	21.7	28	4	23	13	6	9	7	0	3		0	2	56
5	21.1	20	4	25	13	8	7	9	1	4		1	2	61
5	19.2	20	7	14	14	10	7	8	2	4		2	2	55
5	18.6	16	18	32	14	0	7	9	0	3		0	1	53
5	17.4	16	40	19	11	0	5	2	3	3		1	1	34
5	17.0	18	17	15	15	9	4	4	4	4		1	1	51
5	16.2	19	8	18	13	8	7	7	4	4		1	2	55
5	15.0	22	19	15	15	8	4	1	2	4		1	0	50
5	13.8	18	5	13	13	9	8	7	7	5		2	2	54
5	12.3	9	57	9	6	3	4	1	5	3		1	0	25
5	11.9	18	3	19	13	10	8	10	1	5		1	2	61
5	10.4	25	7	22	9	7	9	4	2	5		3	1	52
5	9.5	20	4	24	13	8	6	10	1	4		2	1	58
5	7.8	13	55	3	6	2	3	2	6	4		3	0	16
5	7.5	25	20	4	9	7	7	5	6	7		3	1	32
5	6.4	22	6	27	9	9	8	4	2	2		2	1	61
5	6.3	20	5	21	8	11	7	3	4	3		1	6	57
5	4.6	33	25	9	4	5	4	6	4	2		3	1	27
5	4.0	31	20	11	5	7	4	6	3	1		3	2	33
5	3.1	18	6	35	10	6	5	6	1	3		1	2	62
6	29.1	26	10	18	13	17.7	4	3	4	2		0	1	53
6	27.2	41	17	10	4	5.3	4	4	6	7		1	1	23
6	25.7	23	6	21	13	21.6	7	5	0	3		0	0	63
6	25.5	23	7	23	12	10.6	8	6	5	3		1	1	54
6	25.4	25	2	17	14	22.2	4	8	0	4		3	1	57
6	24.6	26	6	17	14	17.3	6	3	3	2		1	3	55
6	23.4	21	9	21	11	15.1	8	6	2	4		1	1	56
6	21.4	21	1	17	11	21.8	10	7	2	6		2	1	59
6	21.4	30	25	11	5	8.5	6	5	3	5		1	2	30
6	21.1	15	24	22	12	12.7	5	5	1	3		0	0	52
6	20.9	17	13	25	15	8.9	5	5	6	3		0	1	54
6	19.6	21	31	11	8	13.4	6	2	2	2		1	1	39
6	17.6	21	17	16	12	13.5	6	3	10	2		0	0	47
6	16.6	22	13	14	10	12.0	11	4	10	3		0	1	47
6	15.0	33	5	13	10	13.4	9	6	3	4		1	2	46
6	13.8	35	10	10	11	12.8	7	4	5	4		1	2	40
6	13.5	28	5	22	11	9.4	7	3	6	7		1	1	49
6	13.4	25	8	17	8	12.7	9	5	6	7		2	1	46
6	12.3	15	37	14	9	11.3	5	2	3	2		1	0	40
6	11.5	32	5	14	11	17.6	6	3	3	5		3	2	48
6	10.9	23	4	15	10	18.5	7	8	9	5		0	1	50
6	10.0	21	17	11	12	12.4	7	6	7	5		1	1	42
6	9.9	19	9	18	12	9.9	9	7	7	5		2	1	49
6	9.3	22	13	18	14	9.9	7	5	2	4		1	2	49
6	9.1	23	23	10	7	15.3	6	1	10	3		0	1	38
6	8.9	26	24	19	9	0.0	7	1	8	4		1	1	35
6	8.8	24	27	8	8	11.8	6	2	6	4		1	1	34
6	8.6	19	25	23	13	0.0	6	2	6	4		1	1	42
6	8.5	17	17	17	12	18.6	6	7	0	2		2	1	53
6	7.4	18	6	17	13	19.0	9	7	6	3		0	2	57
6	6.6	14	35	14	12	9.4	4	2	5	3		1	0	39
6	6.5	18	25	18	13	8.9	7	2	1	3		1	2	47

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

6	6.2	16	44	17	9	0.3	5	2	2	4		2	0	31
6	5.7	22	27	15	10	5.8	5	6	0	6		2	0	36
6	5.4	20	32	11	9	11.3	5	2	4	3		1	0	37
6	5.4	19	34	8	9	13.1	6	2	4	3		1	1	36
6	4.7	10	64	4	4	6.9	2	0	5	3		1	0	17
6	4.5	11	79	3	1	0.0	0	0	3	1		3	0	3
6	3.5	20	16	16	12	17.9	6	4	4	2		1	1	52
6	3.2	21	11	21	12	17.4	6	4	3	2		1	1	57
6	2.6	21	23	24	8	8.4	5	4	2	3		2	1	45
6	1.9	22	5	20	9	14.7	9	9	4	4		3	2	52
6	1.3	20	29	17	5	7.8	6	3	7	4		1	0	36
6	0.2	21	46	5	3	7.9	5	3	2	3		3	0	21
6	0.1	18	50	6	3	2.1	4	3	7	3		4	0	14
6	0.1	31	28	5	5	2.8	6	8	7	6		2	0	19
6	-0.2	26	4	6	12	16.3	9	4	10	8		4	0	44
6	-0.4	26	29	8	4	8.6	6	6	4	5		3	1	26
6	-0.5	9	71	4	2	0.5	4	3	2	4		2	0	10
6	-0.6	19	10	15	12	14.5	8	4	8	7		1	0	49
6	-0.7	15	52	8	5	6.7	5	3	0	2		2	1	24
6	-0.7	30	20	8	6	11.4	5	9	5	4		1	1	30
6	-0.8	27	11	13	7	18.2	8	7	4	4		2	1	45
6	-1.4	27	5	22	9	13.1	7	6	6	3		1	0	52
6	-1.7	29	4	19	6	16.8	10	8	0	2		3	1	52
6	-2.8	24	12	15	6	18.9	8	3	7	3		1	2	48
6	-3.5	25	5	20	9	13.6	10	5	5	4		2	1	53
6	-3.8	34	25	8	3	5.0	6	6	7	2		3	2	22
6	-5.0	26	8	21	9	14.1	6	4	6	3		2	2	49
6	-5.8	68	13	5	1	0.0	2	7	2	0		3	0	7
6	-6.2	71	2	7	3	0.0	6	6	1	1		2	1	15
7	37.8	26.0	5.0	16.0	27.0	11.0	3.0	3.0	1.0	4.0		0.0	2.0	57
7	37.7	32.0	14.0	4.0	18.0	13.0	3.0	7.0	1.0	6.0		0.5	0.5	36.5
7	36.2	52.0	14.0	2.0	7.0	3.0	2.0	10.0	2.0	4.0		0.5	0.5	13
7	35.3	18.0	16.0	7.0	27.0	19.0	3.0	2.0	1.0	3.0		0.5	0.5	55
7	35.1	15.0	15.0	7.0	23.0	27.0	3.0	3.0	1.0	2.0		0.0	1.0	60
7	33.1	16.0	36.0	6.0	22.0	11.0	3.0	1.0	0.5	2.0		0.0	0.5	41
7	32.0	14.0	35.0	5.0	19.0	17.0	3.0	1.0	0.5	4.0		0.0	1.0	43.5
7	31.1	22.0	5.0	6.0	27.0	21.0	4.0	4.0	2.0	6.0		0.5	0.5	56.5
7	29.4	21.0	11.0	5.0	23.0	22.0	6.0	3.0	1.0	4.0		0.5	0.5	55
7	27.4	17.0	20.0	7.0	22.0	15.0	4.0	3.0	1.0	6.0		0.5	0.5	46.5
7	27.1	17.0	22.0	6.0	24.0	20.0	3.0	2.0	0.5	3.0		0.0	1.0	52.5
7	23.8	14.0	38.0	6.0	18.0	14.0	4.0	2.0	0.5	1.0		0.0	0.5	41
7	21.2	16.0	26.0	6.0	19.0	16.0	3.0	1.0	1.0	9.0		2.0	0.5	43.5
7	21.0	22.0	7.0	6.0	23.0	26.0	3.0	3.0	1.0	5.0		0.0	1.0	58
7	18.3	15.0	30.0	5.0	22.0	16.0	4.0	1.0	1.0	3.0		0.5	0.5	46
7	16.1	17.0	9.0	7.0	26.0	22.0	3.0	2.0	2.0	8.0		0.5	0.5	57
7	15.5	13.0	14.0	6.0	24.0	28.0	3.0	3.0	1.0	4.0		0.5	1.0	60.5
7	15.1	17.0	18.0	7.0	31.0	15.0	2.0	2.0	1.0	4.0		0.5	0.5	54
7	14.6	12.0	53.0	6.0	17.0	4.0	3.0	2.0	0.5	2.0		0.5	0.5	28
7	13.7	20.0	14.0	5.0	25.0	21.0	3.0	2.0	0.5	6.0		0.0	1.0	53.5
7	13.5	20.0	5.0	10.0	23.0	22.0	7.0	2.0	2.0	6.0		0.5	0.5	61
7	12.5	21.0	4.0	7.0	26.0	25.0	4.0	3.0	2.0	5.0		0.0	0.5	61.5
7	12.2	17.0	2.0	3.0	40.0	26.0	2.0	1.0	1.0	5.0		0.0	0.5	70.5
7	12.1	16.0	25.0	8.0	23.0	18.0	2.0	2.0	0.5	4.0		0.5	0.5	49
7	11.5	22.0	2.0	10.0	38.0	12.0	4.0	2.0	0.5	8.0		0.0	0.5	63
7	11.2	7.0	74.0	2.0	5.0	1.0	1.0	2.0	0.5	5.0		1.0	0.5	8

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

7	9.4	18.0	2.0	7.0	27.0	30.0	2.0	3.0	1.0	7.0		0.0	0.5	65.5
7	9.1	21.0	4.0	11.0	26.0	15.0	3.0	4.0	2.0	11.0		0.5	0.5	54
7	9.0	14.0	28.0	7.0	28.0	12.0	4.0	2.0	1.0	2.0		0.0	0.5	50.5
7	7.9	23.0	9.0	7.0	30.0	15.0	2.0	4.0	1.0	5.0		0.5	0.5	53
7	7.6	12.0	41.0	8.0	17.0	11.0	4.0	2.0	1.0	3.0		0.5	0.5	38.5
7	6.6	11.0	51.0	5.0	16.0	5.0	4.0	2.0	0.5	3.0		0.5	0.5	28.5
7	6.0	7.0	72.0	3.0	7.0	2.0	2.0	2.0	0.5	2.0		1.0	0.5	12.5
7	5.8	10.0	60.0	3.0	10.0	10.0	2.0	1.0	0.0	1.0		0.0	0.5	24.5
7	4.7	13.0	22.0	7.0	27.0	14.0	3.0	3.0	2.0	5.0		0.5	0.5	50
7	4.0	28.0	27.0	6.0	15.0	11.0	2.0	2.0	1.0	6.0		0.5	0.5	33
7	2.7	21.0	10.0	14.0	19.0	20.0	2.0	4.0	2.0	5.0		0.0	0.5	54.5
7	1.8	15.0	30.0	7.0	16.0	20.0	4.0	2.0	0.5	3.0		0.0	0.5	46
7	1.7	6.0	18.0	0.1	42.0	17.0	3.0	1.0	1.0	11.0		0.5	0.5	60.5
7	0.0	17.0	31.0	6.0	14.0	19.0	3.0	3.0	0.5	4.0		0.0	2.0	41
7	-0.7	45.0	0.5	13.0	10.0	10.0	5.0	9.0	4.0	3.0		0.0	0.5	36.5
8	48.8	63.0	9.0	3.0	7.0	3.0	3.0	5.0	2.0	3.0	1.0	0.5	0.5	16
8	47.4	65.0	17.0	1.0	3.0	1.0	1.0	6.0	3.0	2.0	0.0	0.5	0.5	6
8	47.0	39.0	2.0	14.0	15.0	8.0	5.0	6.0	3.0	5.0	0.0	0.5	0.5	42
8	45.2	32.0	7.0	15.0	15.0	17.0	2.0	5.0	2.0	3.0	1.0	0.5	0.5	49
8	43.5	29.0	11.0	10.0	20.0	18.0	2.0	4.0	2.0	3.0	0.0	0.5	0.5	50
8	42.1	49.0	4.0	9.0	10.0	10.0	4.0	6.0	2.0	3.0	1.0	0.5	0.5	33
8	40.3	34.0	4.0	8.0	22.0	14.0	3.0	4.0	2.0	7.0	0.0	0.5	0.5	47
8	38.5	30.0	9.0	14.0	14.0	15.0	6.0	4.0	2.0	3.0	1.0	0.5	0.5	49
8	36.7	27.0	10.0	9.0	25.0	15.0	3.0	3.0	1.0	3.0	1.0	0.5	0.5	52
8	35.4	29.0	12.0	9.0	19.0	15.0	3.0	4.0	2.0	5.0	0.0	0.5	0.5	46
8	34.8	21.0	19.0	8.0	23.0	17.0	3.0	3.0	1.0	2.0	0.5	0.5	0.5	51
8	33.3	24.0	17.0	14.0	24.0	11.0	3.0	1.0	1.0	3.0	1.0	0.5	0.5	52
8	31.5	25.0	16.0	7.0	25.0	15.0	3.0	3.0	1.0	2.0	1.0	0.5	0.5	50
8	29.6	29.0	10.0	6.0	29.0	12.0	3.0	5.0	1.0	2.0	0.5	0.5	0.5	50
8	27.8	23.0	9.0	8.0	22.0	20.0	4.0	6.0	2.0	3.0	1.0	0.5	0.5	54
8	27.7	25.0	9.0	8.0	22.0	20.0	2.0	6.0	2.0	3.0	1.0	0.5	0.5	52
8	26.0	22.0	21.0	9.0	23.0	14.0	4.0	3.0	1.0	1.0	1.0	0.5	0.5	50
8	24.5	28.0	25.0	5.0	16.0	10.0	3.0	2.0	1.0	9.0	0.0	0.5	0.5	34
8	22.6	26.0	19.0	7.0	23.0	8.0	6.0	4.0	2.0	3.0	0.5	0.5	0.5	44
8	20.8	25.0	30.0	5.0	24.0	6.0	1.0	3.0	1.0	2.0	1.0	0.5	0.5	36
8	19.0	25.0	26.0	4.0	22.0	7.0	3.0	4.0	1.0	5.0	0.0	0.5	0.5	36
8	17.1	28.0	7.0	8.0	28.0	13.0	5.0	3.0	2.0	5.0	0.5	0.5	0.5	54
8	15.6	26.0	6.0	8.0	20.0	20.0	3.0	5.0	3.0	7.0	0.0	0.5	0.5	51
8	14.1	21.0	2.0	21.0	22.0	10.0	7.0	4.0	3.0	8.0	0.0	0.5	0.5	60
8	13.1	23.0	4.0	20.0	28.0	11.0	3.0	2.0	1.0	6.0	0.0	0.5	0.5	62
8	13.1	21.0	5.0	17.0	24.0	16.0	3.0	4.0	2.0	7.0	0.0	0.5	0.5	60
8	12.9	32.0	18.0	7.0	15.0	8.0	4.0	4.0	1.0	8.0	0.0	0.5	0.5	34
8	12.3	21.0	5.0	16.0	24.0	15.0	4.0	3.0	2.0	8.0	0.0	0.5	0.5	59
8	10.4	31.0	2.0	15.0	25.0	8.0	3.0	2.0	3.0	10.0	0.0	0.5	0.5	51
8	8.6	24.0	3.0	21.0	20.0	9.0	7.0	3.0	3.0	8.0	0.0	0.5	0.5	57
8	6.9	22.0	33.0	8.0	13.0	14.0	3.0	2.0	1.0	2.0	1.0	0.5	0.5	38
8	6.8	22.0	10.0	14.0	17.0	20.0	5.0	4.0	3.0	2.0	1.0	0.5	0.5	56
8	6.4	22.0	7.0	16.0	16.0	26.0	3.0	4.0	3.0	2.0	0.5	0.5	0.5	61
8	6.2	28.0	6.0	16.0	17.0	20.0	3.0	4.0	2.0	2.0	1.0	0.5	0.5	56
8	6.1	30.0	8.0	13.0	12.0	23.0	3.0	5.0	2.0	1.0	1.0	0.5	0.5	51
8	5.8	25.0	2.0	28.0	14.0	12.0	5.0	4.0	3.0	6.0	0.0	0.5	0.5	59
8	5.7	34.0	4.0	11.0	14.0	18.0	6.0	4.0	2.0	5.0	0.5	0.5	0.5	49
8	5.0	31.0	1.0	18.0	16.0	10.0	4.0	6.0	3.0	10.0	0.0	0.5	0.5	48
8	4.7	23.0	7.0	20.0	15.0	21.0	3.0	4.0	2.0	4.0	0.0	0.5	0.5	59
8	4.5	71.0	3.0	1.0	5.0	0.0	1.0	8.0	4.0	2.0	0.0	4.0	0.5	7

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

8	4.3	58.0	0.5	6.0	13.0	3.0	2.0	3.0	4.0	10.0	0.0	0.5	0.5	24
9	67.1	56.0	2.0	7.0	9.0	2.0	5.0	13.0	3.0	2.0	0.0	0.5	0.5	23
9	65.2	28.0	0.5	27.0	18.0	11.0	7.0	3.0	2.0	3.0	0.0	0.0	0.5	63
9	63.1	47.0	2.0	11.0	11.0	1.0	8.0	11.0	2.0	2.0	0.0	0.0	0.5	31
9	60.4	47.0	0.5	13.0	14.0	2.0	10.0	3.0	2.0	4.0	0.0	0.0	0.5	39
9	55.5	48.0	1.0	13.0	13.0	2.0	9.0	7.0	2.0	3.0	0.0	0.0	0.5	37
9	53.3	34.0	1.0	20.0	17.0	9.0	7.0	5.0	2.0	4.0	0.0	0.0	0.5	53
9	50.9	33.0	8.0	18.0	8.0	15.0	4.0	5.0	2.0	2.0	0.0	0.0	0.5	45
9	48.5	39.0	4.0	19.0	13.0	4.0	7.0	6.0	3.0	3.0	0.0	0.0	0.5	43
9	46.6	34.0	5.0	19.0	15.0	1.0	9.0	4.0	2.0	3.0	0.0	0.5	0.5	44
9	45.1	40.0	17.0	11.0	6.0	10.0	3.0	8.0	2.0	2.0	0.0	0.5	0.5	30
9	43.6	39.0	7.0	18.0	13.0	2.0	5.0	9.0	2.0	4.0	0.0	0.5	0.5	38
9	42.1	35.0	8.0	24.0	12.0	10.0	3.0	3.0	1.0	3.0	0.0	0.5	0.5	49
9	40.5	66.0	11.0	3.0	3.0	2.0	1.0	8.0	2.0	4.0	0.0	0.5	0.5	9
9	39.0	50.0	3.0	11.0	9.0	5.0	7.0	7.0	1.0	5.0	0.0	0.0	0.5	32
9	37.5	52.0	1.0	12.0	9.0	5.0	7.0	5.0	2.0	5.0	0.0	0.0	0.5	33
9	36.0	35.0	2.0	16.0	13.0	7.0	10.0	4.0	1.0	10.0	0.0	0.0	0.5	46
9	33.8	59.0	12.0	5.0	6.0	2.0	1.0	8.0	2.0	4.0	0.0	0.5	0.5	14
9	31.7	29.0	12.0	19.0	19.0	6.0	3.0	4.0	2.0	3.0	0.0	0.5	0.5	47
9	30.2	29.0	5.0	19.0	24.0	5.0	4.0	5.0	2.0	3.0	0.0	0.0	0.5	52
9	29.3	43.0	4.0	14.0	18.0	4.0	4.0	5.0	2.0	4.0	0.0	0.0	0.5	40
9	27.7	32.0	4.0	19.0	24.0	5.0	4.0	2.0	1.0	6.0	0.0	0.0	0.5	52
9	26.5	37.0	4.0	17.0	21.0	5.0	4.0	4.0	2.0	4.0	0.0	0.0	0.5	47
9	24.4	22.0	23.0	13.0	20.0	13.0	2.0	2.0	0.5	3.0	0.0	0.0	0.5	48
9	21.9	33.0	12.0	17.0	18.0	9.0	2.0	3.0	2.0	3.0	0.0	0.0	0.5	46
9	20.1	26.0	12.0	13.0	26.0	14.0	2.0	2.0	1.0	3.0	0.0	0.0	0.5	55
9	18.3	25.0	10.0	14.0	21.0	16.0	3.0	2.0	2.0	5.0	0.0	0.5	0.5	54
9	15.8	30.0	8.0	14.0	20.0	16.0	3.0	2.0	1.0	5.0	0.0	0.5	0.5	53
9	14.0	28.0	20.0	11.0	17.0	14.0	3.0	2.0	0.5	3.0	0.0	0.0	0.5	45
9	12.8	22.0	37.0	9.0	14.0	11.0	2.0	2.0	0.5	2.0	0.0	0.0	0.5	36
9	11.3	21.0	31.0	14.0	14.0	10.0	2.0	3.0	1.0	2.0	0.0	0.0	0.5	40
9	7.3	18.0	34.0	10.0	17.0	11.0	4.0	2.0	0.5	2.0	0.0	0.5	0.5	42
9	3.7	14.0	42.0	9.0	15.0	10.0	4.0	1.0	0.5	4.0	0.0	0.5	0.5	38
9	0.3	21.0	12.0	15.0	24.0	15.0	6.0	1.0	1.0	4.0	0.0	0.0	0.5	60
9	-1.8	27.0	10.0	20.0	19.0	11.0	5.0	2.0	1.0	3.0	1.0	0.0	0.5	55
9	-3.4	25.0	3.0	24.0	22.0	9.0	5.0	2.0	1.0	7.0	0.0	0.0	0.5	60
9	-4.9	22.0	17.0	14.0	25.0	13.0	3.0	1.0	1.0	2.0	0.0	0.5	0.5	55
9	-6.1	18.0	23.0	13.0	13.0	12.0	4.0	2.0	1.0	11.0	0.0	0.5	0.5	42
9	-7.0	21.0	11.0	24.0	20.0	14.0	2.0	3.0	1.0	3.0	0.5	0.5	0.5	60
9	-8.5	24.0	12.0	21.0	18.0	13.0	2.0	5.0	1.0	3.0	0.5	0.0	0.5	54
9	-9.4	26.0	12.0	27.0	6.0	14.0	3.0	6.0	1.0	4.0	0.0	0.5	0.5	50
9	-10.4	41.0	4.0	14.0	13.0	6.0	4.0	10.0	2.0	5.0	0.0	0.0	0.5	37
9	-11.3	30.0	13.0	12.0	12.0	15.0	3.0	8.0	2.0	3.0	0.0	0.0	0.5	42
9	-12.8	36.0	12.0	11.0	8.0	10.0	5.0	9.0	2.0	3.0	0.0	0.0	0.5	34
9	-14.0	37.0	1.0	22.0	12.0	8.0	4.0		2.0	5.0	0.0	0.0	0.5	46
9	-14.9	32.0	0.5	25.0	14.0	10.0	5.0	6.0	2.0	5.0	0.0	0.5	0.5	54
9	-16.2	35.0	0.5	27.0	13.0	9.0	4.0	6.0	2.0	3.0	0.0	0.5	0.5	53
9	-18.0	40.0	1.0	21.0	14.0	9.0	4.0	6.0	2.0	2.0	0.0	0.0	0.5	48
9	-20.1	62.0	6.0	6.0	7.0	1.0	3.0	9.0	3.0	2.0	0.0	0.5	0.5	17
9	-21.6	33.0	0.5	28.0	12.0	8.0	8.0	5.0	3.0	2.0	0.0	0.5	0.5	56
10	54.3	24.0	21.0	14.0	19.0	9.0	1.0	6.0	2.0	2.0		0.0	1.0	43
10	51.8	26.0	11.0	18.0	24.0	11.0	2.0	3.0	1.0	3.0		0.0	0.5	55
10	46.6	20.0	32.0	10.0	16.0	7.0	4.0	3.0	0.5	5.0		0.0	2.0	37
10	43.9	17.0	20.0	14.0	24.0	10.0	6.0	4.0	0.5	2.0		0.5	2.0	54
10	42.1	24.0	5.0	19.0	26.0	9.0	6.0	4.0	2.0	3.0		0.5	1.0	60

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

10	39.6	22.0	57.0	2.0	4.0	3.0	1.0	3.0	0.5	6.0		0.5	1.0	10
10	37.5	34.0	15.0	13.0	15.0	9.0	2.0	4.0	1.0	5.0		0.0	1.0	39
10	33.5	32.0	4.0	15.0	28.0	5.0	4.0	4.0	1.0	6.0		0.5	0.5	52
10	31.1	18.0	18.0	10.0	27.0	18.0	1.0	2.0	1.0	3.0		0.5	1.0	56
10	28.7	25.0	5.0	17.0	30.0	7.0	3.0	3.0	1.0	5.0		0.0	3.0	57
10	26.8	24.0	9.0	16.0	28.0	6.0	3.0	3.0	1.0	8.0		0.0	1.0	53
10	25.3	18.0	4.0	19.0	33.0	8.0	4.0	3.0	2.0	7.0		0.5	1.0	64
10	24.1	33.0	4.0	8.0	30.0	10.0	2.0	3.0	1.0	6.0		0.0	1.0	50
10	22.6	22.0	4.0	10.0	37.0	13.0	3.0	2.0	0.5	7.0		0.0	1.0	63
10	20.7	20.0	33.0	13.0	19.0	8.0	1.0	3.0	1.0	1.0		0.5	0.5	41
10	19.2	24.0	17.0	12.0	21.0	18.0	2.0	2.0	1.0	1.0		0.5	1.0	53
10	18.3	18.0	48.0	7.0	11.0	4.0	1.0	3.0	0.5	6.0		0.5	1.0	23
10	17.1	30.0	22.0	10.0	14.0	8.0	2.0	4.0	0.5	8.0		0.5	1.0	34
10	16.2	20.0	11.0	17.0	22.0	13.0	3.0	4.0	1.0	7.0		0.5	1.0	55
10	15.2	19.0	20.0	17.0	22.0	13.0	3.0	2.0	1.0	3.0		0.0	0.5	55
10	13.4	22.0	22.0	13.0	17.0	10.0	2.0	4.0	2.0	6.0		0.5	1.0	42
10	12.2	22.0	25.0	11.0	15.0	9.0	2.0	3.0	1.0	10.0		0.5	1.0	37
10	11.0	16.0	33.0	15.0	14.0	11.0	2.0	3.0	1.0	3.0		0.5	1.0	42
10	9.8	21.0	11.0	21.0	22.0	16.0	1.0	2.0	2.0	3.0		0.5	0.5	60
10	8.8	19.0	6.0	17.0	30.0	13.0	4.0	3.0	1.0	5.0		0.5	1.0	64
10	7.9	22.0	4.0	16.0	29.0	13.0	3.0	3.0	1.0	7.0		0.5	1.0	61
10	7.3	25.0	6.0	22.0	21.0	6.0	6.0	3.0	0.5	9.0		0.5	1.0	55
10	6.7	24.0	7.0	24.0	22.0	6.0	6.0	3.0	2.0	4.0		0.0	1.0	58
10	6.1	13.0	53.0	5.0	13.0	9.0	4.0	1.0	0.5	1.0		0.5	0.5	31
10	4.6	11.0	57.0	5.0	9.0	7.0	5.0	2.0	1.0	2.0		0.5	0.5	26
10	3.7	18.0	39.0	7.0	11.0	8.0	6.0	4.0	1.0	4.0		0.0	1.0	32
10	2.7	21.0	15.0	19.0	10.0	19.0	4.0	4.0	1.0	6.0		0.5	0.5	52
10	1.5	25.0	16.0	16.0	15.0	16.0	3.0	5.0	0.5	3.0		0.5	1.0	50
10	0.3	63.0	4.0	4.0	7.0	3.0	4.0	11.0	2.0	2.0		0.5	0.5	18
10	-0.6	44.0	0.5	10.0	14.0	8.0	4.0	9.0	2.0	7.0		1.0	0.5	36
10	-1.8	28.0	0.5	19.0	18.0	18.0	3.0	6.0	3.0	3.0		2.0	0.5	58
10	-2.4	71.0	0.0	4.0	6.0	0.0	2.0	12.0	3.0	1.0		1.0	0.5	12
10	-2.7	64.0	0.5	2.0	3.0	0.0	1.0	10.0	4.0	1.0		15.0	0.5	6
10	-3.4	36.0	0.5	19.0	13.0	11.0	3.0	10.0	3.0	4.0		0.5	0.5	46
10	-4.6	46.0	0.5	13.0	16.0	7.0	3.0	9.0	2.0	3.0		1.0	0.5	39
10	-5.5	31.0	0.5	25.0	16.0	10.0	5.0	6.0	1.0	5.0		0.5	0.5	56
10	-6.4	53.0	0.5	10.0	11.0	3.0	4.0	10.0	2.0	5.0		1.0	0.5	28
10	-7.9	39.0	1.0	17.0	11.0	12.0	4.0	8.0	2.0	4.0		1.0	0.5	44
10	-9.8	44.0	0.5	16.0	10.0	12.0	4.0	6.0	2.0	4.0		1.0	0.5	42
10	-11.6	31.0	0.5	24.0	16.0	13.0	7.0	4.0	2.0	2.0		1.0	0.5	60
10	-13.4	58.0	0.5	8.0	9.0	4.0	4.0	11.0	2.0	3.0		1.0	0.5	25
10	-15.2	31.0	1.0	17.0	15.0	14.0	9.0	7.0	2.0	4.0		0.5	0.5	55
10	-17.1	27.0	0.5	22.0	19.0	18.0	6.0	2.0	3.0	2.0		0.5	0.5	65
11	72.7	38.2	7.4	21.8	9.9	3.4	7.3	4.8	2.3	4.8	0.0	0.0	0.0	42.50
11	69.5	39.2	25.0	13.6	7.6	2.0	4.8	4.0	1.3	2.5	0.0	0.0	0.0	28.00
11	67.4	50.3	6.1	15.0	9.6	2.7	9.5	3.9	0.0	2.9	0.0	0.0	0.0	36.80
11	64.0	37.5	1.2	25.7	10.4	4.4	8.6	3.1	3.1	6.0	0.0	0.0	0.0	49.10
11	62.6	49.4	2.0	17.1	9.6	3.9	6.9	3.1	2.1	5.8	0.0	0.0	0.0	37.60
11	60.4	31.2	5.1	32.1	10.0	5.4	9.1	1.8	0.0	5.2	0.0	0.0	0.0	56.70
11	58.5	62.9	1.9	11.4	5.2	2.8	8.5	2.8	0.0	4.4	0.0	0.0	0.0	28.00
11	55.3	41.4	2.3	22.3	10.5	4.8	10.1	3.2	0.0	5.5	0.0	0.0	0.0	47.60
11	53.5	37.7	5.2	21.1	12.2	4.1	7.5	2.4	1.3	4.9	0.0	0.0	3.5	45.00
11	51.5	44.8	5.3	18.7	9.9	3.5	8.2	2.9	1.8	3.3	0.0	0.0	1.7	40.20
11	49.8	41.8	2.3	21.5	9.4	4.6	9.1	2.6	2.2	6.5	0.0	0.0	0.0	44.60
11	48.6	33.1	0.8	27.9	10.3	5.4	9.1	2.5	1.6	5.2	0.0	0.0	4.0	52.80

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

11	45.6	43.2	2.9	19.5	10.6	3.5	8.9	1.6	1.5	7.1	0.0	0.0	1.1	42.60
11	43.7	43.2	6.3	19.5	11.0	3.5	8.3	4.6	0.0	3.6	0.0	0.0	0.0	42.30
11	41.9	36.8	12.7	19.7	10.2	4.3	8.3	2.9	1.7	2.0	1.4	0.0	0.0	42.50
11	40.1	37.2	4.6	24.8	11.9	3.8	8.9	3.5	0.0	5.3	0.0	0.0	0.0	49.40
11	37.9	51.7	2.3	14.5	10.6	3.2	8.1	2.7	1.4	5.5	0.0	0.0	0.0	36.40
11	36.1	38.2	4.4	25.0	9.8	3.8	7.8	2.8	2.2	6.0	0.0	0.0	0.0	46.40
11	34.3	33.9	11.5	22.6	10.7	4.4	8.3	2.7	1.2	2.2	1.3	0.0	1.2	46.00
11	32.5	41.7	5.9	15.8	14.7	3.7	9.9	3.5	0.0	4.8	0.0	0.0	0.0	44.10
11	30.2	33.9	24.1	15.1	10.2	2.8	6.9	3.0	0.0	4.0	0.0	0.0	0.0	35.00
11	28.8	28.4	15.7	22.4	12.0	3.8	10.7	2.3	0.0	2.7	2.1	0.0	0.0	48.80
11	27.0	27.8	26.4	13.4	14.5	3.3	8.6	2.0	1.5	0.0	2.5	0.0	0.0	39.80
11	25.1	30.9	15.9	17.8	14.9	3.8	8.3	3.0	2.6	2.8	0.0	0.0	0.0	44.80
11	23.3	35.5	12.0	16.3	16.4	3.2	8.6	2.2	1.2	2.6	2.0	0.0	0.0	44.50
11	21.5	28.0	27.1	17.3	10.6	3.4	8.3	2.7	0.0	1.4	1.3	0.0	0.0	39.50
11	17.7	29.6	17.1	21.6	12.9	4.6	9.8	1.6	0.0	2.8	0.0	0.0	0.0	48.90
11	16.0	33.8	19.7	14.2	13.8	4.1	7.6	2.3	0.0	2.4	2.1	0.0	0.0	39.70
11	14.2	32.4	12.5	19.7	14.0	3.7	10.1	2.0	0.0	5.6	0.0	0.0	0.0	47.50
11	12.3	31.3	8.8	23.9	12.2	3.9	10.5	1.9	0.0	6.5	0.0	0.0	0.9	50.60
11	10.5	30.4	6.9	22.7	14.8	5.0	10.3	2.3	0.0	7.6	0.0	0.0	0.0	52.80
11	8.7	36.8	13.9	18.4	13.1	3.4	9.0	1.6	0.0	2.4	1.4	0.0	0.0	43.90
11	5.2	31.4	8.8	27.7	10.9	4.3	8.9	2.2	0.0	3.0	2.9	0.0	0.0	51.70
11	3.4	33.4	6.4	19.5	15.9	4.4	9.8	3.5	0.0	7.2	0.0	0.0	0.0	49.50
11	1.5	32.5	2.4	26.1	14.9	4.6	11.1	3.1	0.0	5.3	0.0	0.0	0.0	56.70
11	-0.3	53.6	0.0	15.5	10.8	3.2	8.3	3.6	0.0	5.0	0.0	0.0	0.0	37.80
11	-1.7	47.2	1.2	21.9	9.3	3.8	7.5	5.1	0.0	3.9	0.0	0.0	0.0	42.60
11	-4.0	51.1	1.2	21.1	7.6	3.9	5.5	4.0	2.2	3.4	0.0	0.0	0.0	38.10
11	-5.8	52.7	13.3	11.9	7.2	3.0	6.3	2.1	0.9	2.6	0.0	0.0	0.0	28.40
11	-7.2	40.9	0.0	22.8	12.6	4.9	9.3	2.8	2.6	4.1	0.0	0.0	0.0	49.60
11	-9.8	62.0	0.0	9.3	20.1	2.0	0.0	0.7	1.5	4.4	0.0	0.0	0.0	31.40
11	-11.7	86.5	0.0	0.1	3.3	0.0	0.3	0.0	0.0	0.0	0.0	9.9	0.0	3.60
11	-13.1	63.1	0.0	11.9	9.7	3.0	5.7	1.1	1.9	1.6	0.0	0.0	2.1	30.20
11	-15.0	78.9	0.0	6.8	7.1	1.3	0.0	1.0	1.5	2.5	0.0	0.0	0.8	15.30
11	-16.4	82.6	0.0	0.2	7.1	0.0	3.9	0.0	0.0	0.0	0.0	2.0	4.2	11.20
11	-18.0	71.7	0.0	1.6	10.2	0.3	4.9	0.0	0.0	0.7	0.0	9.0	1.6	17.00
11	-19.4	57.7	0.0	16.4	14.7	3.6	0.0	1.6	2.8	3.3	0.0	0.0	0.0	34.60
12	62.3	48.6	5.2	13.6	4	7.3	10.7	2.9	1.7	3		0.1	1.2	35.6
12	60.6	42.5	1.8	14.7	6.5	8.1	10.5	4.3	3.6	4.5		0	2	39.8
12	59.7	13.6	0.9	13.7	8.2	52.6	0	6	0	2		0	0	74.5
12	57.8	28.7	5	26.4	5.2	10.2	11.8	3.7	0.9	3		0	3.4	53.6
12	56.3	11	1.4	3.4	2	63.7	6.4	8	0	1		0	0	75.5
12	54.7	28.4	14.5	17.4	9.4	5.5	12.3	4.9	1	3		0	1.5	44.6
12	52.7	29	8.8	21.9	13.3	11.9	0	3.8	5.7	3		0	1.6	47.1
12	51.7	30.4	9.1	12.8	8.9	15.6	12.6	3.1	1.5	2.3		0	1.4	49.9
12	50.0	33.4	8.7	15.9	15.1	14.0	0	3.6	4.2	2.3		0.2	0.9	45
12	48.6	33.8	7	14.1	9.1	8.9	13.4	3.4	3.8	2.2		0	1.9	45.5
12	46.3	24.8	15.1	19.8	8.1	6.8	12.7	0.9	5.1	3.4		0	3.1	47.4
12	45.4	30.5	5.9	18.8	7.8	10.3	12.7	5.7	1	3.8		0	2.3	49.6
12	43.5	20.5	22.9	23.3	15	8.1	0	0.6	2.3	3.1		0.3	2.5	46.4
12	42.5	23.6	8.7	18.5	11.2	10.4	12.7	3.3	4.2	2.7		0	3.1	52.8
12	41.5	25.8	14.8	13.8	8.4	11.6	13.7	3.9	2.7	1.4		0.3	1.5	47.5
12	40.0	33.9	8.7	15.9	19.1	10.8	0	0	4	2.9		1	1.5	45.8
12	39.3	29.8	12.9	14.6	9.7	5.5	11.6	3.4	8.2	2.8		0	1	41.4
12	37.9	23.5	7.7	17	12.8	12.6	12.1	2.2	2.1	5.6		0	1.2	54.5
12	37.2	19.9	12.1	19.3	7.6	9.2	12.2	8.2	6.3	3.2		0	1	48.3
12	35.9	30	17.2	10.3	8.9	14.8	8.4	2.4	4.5	2.9		0	0.1	42.4

Table A.1 XRD data from samples for wells 1-13 & 21 (cont.).

12	34.6	29.1	16.5	13.2	9.1	9.1	11.1	1.7	3.2	4.7		0.4	0.5	42.5
12	33.9	27.9	15	13.8	8.4	10.1	9.8	3.3	3.7	6.4		0	1.1	42.1
12	32.1	32.6	15.2	16.2	8.9	7.7	9.9	3.8	2.1	2.4		0.5	0.1	42.7
12	29.2	24.2	18.2	15.9	12.4	6.5	11.2	1.5	2.8	4.2		0	1.6	46
12	28.0	23.9	7.5	14.1	12.4	14.8	12.8	4.8	1.3	4.4		0	0.3	54.1
12	27.2	21.7	7.2	9.6	11	19.5	13.2	0.4	11	4.4		0	0.5	53.3
12	26.4	16	53.5	12.3	7.8	4.2	0	0	2.3	2.6		0.3	0.7	24.3
12	23.9	25.1	7.7	16.2	8.4	13.5	12.5	1.3	10.4	2.8		0.1	0	50.6
12	22.4	28.9	10.4	19.7	10.5	4.5	10.7	8.2	1.9	2.7		0.8	0.5	45.4
12	21.6	22.7	11.2	15.4	13.2	14.9	9.9	0.9	7.2	2.4		0	0.8	53.4
12	20.9	22.8	15.1	24.4	17.6	7.0	0	0.7	7.6	3.6		0	0.1	49
12	19.3	20.4	23	14.6	8.5	7.1	11.7	0.6	9.9	2.1		0.1	0.9	41.9
12	17.7	19.3	16.6	22.8	14.3	16.1	0	2.7	2	5.7		0.1	0.1	53.2
12	16.6	23.2	5.9	21.9	9.8	13.3	9.9	4.7	5.1	4.3		0	0.9	54.9
12	15.5	20.5	28	21.3	12.5	10.6	0	0.8	2.6	2		0	1.1	44.4
12	14.1	27.8	5.5	17.2	7.6	5.0	15.6	3.4	11.5	2.7		0	1.3	45.4
12	13.0	19.5	29.1	17.3	9.2	10.5	0	3.9	4.5	4.9		0.9	0	37
12	12.4	26.9	35.3	10	2.4	5.1	8.1	4.5	4	3.4		0	0	25.6
12	11.7	27.8	10	7.7	9.6	7.8	19.2	4.5	3.5	6.4		0	0	44.3
12	11.0	24.3	9.9	18.5	7.1	12.3	12.9	5.9	3.5	3.7		0	1.4	50.8
12	9.7	13.4	2.5	5	2.3	46.1	14.7	7.5	0	1		0	0	68.1
12	8.8	25.4	16.9	24.3	10.8	9.6	0	0.4	4.3	4.6		0.7	2.6	44.7
12	8.2	31	6.2	23.9	4.7	8.5	12.2	5.3	1.1	4.1		0	2	49.3
12	7.1	53.5	0.6	9.3	3.8	7.2	11.7	8.4	1.9	2.6		0	0.6	32
12	6.4	54.4	0.6	8.1	5.4	9.0	12.2	4.5	2.3	2		0	0	34.7
12	5.6	54.9	0.8	8.6	5	8.0	11.1	5.2	2.7	1.7		0	0	32.7
12	4.5	30.3	0.2	22.2	7.8	14.5	10.4	5.8	4.8	2.2		0.1	0.3	54.9
12	3.2	34.6	0.9	20	6.6	9.3	12.7	3.5	5.8	2.4		2.2	0	48.6
12	2.4	43.1	0.4	14	5	9.9	14	6.9	2.9	1.9		0	0.2	42.9
12	1.3	18	0	16.5	4.9	26.3	9.3	8.6	14.4	0.1		0	0	57
13	56.1	27	13	17	18	9	7	4	1	3			1	51
13	46.0	31	5	19	19	10	7	3	1	5			1	55
13	30.8	22	8	22	20	12	6	3	1	4			1	60
13	23.8	20	25	14	16	14	4	3	1	3			0	48
13	17.1	29	5	21	13	18	5	4	2	4			0	57
13	4.9	37	Tr	22	12	14	9	3	2	1			1	57
21	19.8	38	5	26	16		5	2		6				48
21	16.4	24	21	20	16		6	1		5				47
21	13.6	28	13	24	18		7	1		6				51
21	6.3	25	13	29	16		9	1		6				54
21	5.1	24	3	40	16		9	1		6				66
21	2.9	23	5	35	19		11	1		3				65

Table A.2 XRD data for wells 14-20.

Well #	Depth Range	Qtz	Cal	Ill	Mont	Kaol	Chl	Plag	Pyr	Fluor	Bar	Dol	Sid	Musc	Bio	Total Clay
	m	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
14	4462- 4471	26.7	8.9	9.0	0.4	20.3	2.6	0.0	1.9	0.2	0.5	1.1	4.7	0.4	0.9	56.0
14	4471- 4480	29.2	11.9	2.5	1.2	22.2	1.1	0.0	1.5	2.2	2.0	0.0	0.9	6.8	0.5	52.3
14	4480- 4489	31.0	12.2	3.8	1.0	21.4	3.8	5.4	1.1	0.5	0.0	0.4	0.0	9.3	2.1	49.3
14	4489- 4499	28.2	11.3	14.2	4.2	23.4	0.8	0.0	1.2	0.0	1.6	0.0	0.2	9.7	0.0	57.5
14	4499-4508	38.4	14.1	0.0	4.0	17.7	2.4	1.3	0.0	0.6	1.0	0.6	2.5	10.1	3.5	41.4
14	4508- 4517	35.3	11.7	15.2	1.4	7.2	4.2	0.0	1.6	1.9	0.1	0.0	0.8	0.0	5.6	48.6
15	4548- 4557	31.6	15.7	3.0	1.2	22.1	1.5	2.1	1.0	0.0	3.2	0.0	0.3	4.6	2.4	46.2
15	4457- 4566	32.9	9.5	17.7	5.8	20.9	1.6	0.0	1.1	0.0	1.3	1.2	3.0	0.0	1.0	50.9
15	4566- 4575	36.1	13.0	9.3	7.0	24.3	0.7	0.8	1.9	0.3	0.4	1.0	0.0	1.3	0.1	46.4
15	4575- 4584	31.6	10.8	0.0	3.5	21.8	1.9	0.0	0.9	0.0	3.4	0.0	0.0	10.5	5.5	53.3
15	4584- 4593	17.8	47.1	0.0	0.4	16.3	2.6	0.0	1.8	2.3	2.2	0.3	0.1	3.8	0.7	28.3
15	4593- 4602	16.7	45.7	8.2	1.2	11.2	2.6	0.0	0.0	5.1	0.0	0.7	1.3	0.0	2.7	30.4
15	4602- 4612	21.1	44.1	0.0	4.2	22.0	1.1	2.9	1.1	1.1	0.6	0.0	0.9	0.0	0.7	28.1
15	4612-4621	30.5	17.3	0.0	1.7	13.3	2.2	0.9	0.5	0.1	0.5	0.1	0.3	10.7	4.5	49.7
15	4621- 4630	33.7	15.5	10.9	5.4	20.3	1.1	0.9	1.7	0.0	1.8	2.3	0.4	1.5	2.4	43.8
15	4630- 4639	29.3	14.5	2.6	3.3	13.7	2.1	3.7	0.6	2.4	1.2	3.6	0.0	8.3	6.0	44.7
16	4112- 4139	28.7	11.3	4.4	2.3	23.9	1.8	0.0	2.0	0.0	1.9	3.3	6.4	0.8	0.2	46.3
16	4139- 4167	29.6	11.1	5.8	3.1	26.5	2.0	0.0	1.3	0.0	2.8	0.5	0.0	9.6	5.0	54.6
16	4167- 4194	37.3	13.1	3.3	5.4	18.9	1.2	0.0	2.1	0.0	2.4	0.4	0.2	0.6	7.4	44.6
16	4194- 4221	24.8	18.9	8.0	4.0	17.4	2.5	0.0	1.7	0.9	1.0	0.0	0.4	0.7	6.3	52.3
16	4880- 4907	32.3	10.5	6.1	6.5	31.0	0.1	0.0	1.7	0.9	6.3	0.0	3.3	0.0	0.2	44.9
16	4907- 4935	26.6	13.8	3.2	0.1	21.7	1.7	3.2	1.8	3.0	1.4	0.0	0.2	0.0	0.5	50.0
17	4051- 4060	34.9	7.9	7.3	6.2	22.7	3.7	2.4	3.1	2.1	0.2	0.5	0.0	4.1	0.3	48.9
17	4060- 4069	31.4	9.8	11.8	5.2	18.5	2.6	0.0	2.6	3.2	0.4	0.5	0.2	0.8	9.5	52.0
17	4069- 4078	39.6	16.2	0.2	4.7	14.7	3.0	6.4	2.1	0.0	1.8	0.1	0.2	2.1	1.5	33.7
17	4078- 4087	37.2	12.6	13.8	7.7	16.9	1.1	0.0	2.2	0.0	1.1	0.0	0.4	0.1	3.8	46.5
17	4087- 4096	38.0	11.2	11.3	6.2	14.9	1.4	0.0	1.7	1.7	2.7	1.3	0.3	0.0	7.7	43.0
17	4096- 4106	33.4	15.3	0.0	0.4	21.7	5.2	0.0	3.3	0.0	2.1	0.0	0.5	7.9	2.2	45.4
17	4389- 4398	41.6	8.0	0.0	3.2	18.0	4.0	0.0	1.3	0.4	1.3	0.0	0.3	10.4	2.7	47.0
17	4398- 4417	44.5	4.2	6.9	6.2	9.2	1.4	3.1	1.5	1.0	0.7	0.0	0.0	6.3	5.6	44.9
18	3798- 3807	29.6	19.2	11.8	5.9	20.9	1.9	2.1	2.1	1.7	0.6	0.2	0.1	0.0	0.3	44.5
18	3807- 3816	29.9	19.8	10.2	7.0	18.9	4.0	0.0	1.9	1.5	1.2	2.4	0.1	0.0	2.2	43.2
18	3816- 3825	30.6	23.5	7.5	3.0	11.5	4.1	2.8	1.1	0.8	0.6	0.2	8.2	2.1	3.6	32.1
18	3825- 3834	30.5	19.6	9.6	2.2	15.3	2.0	0.0	4.5	2.2	1.4	4.2	1.6	4.7	2.0	36.1
18	3834- 3843	28.4	30.0	12.5	3.5	14.3	2.1	0.0	3.2	1.7	1.3	1.9	0.2	0.0	0.1	33.3
18	4465- 4474	34.4	23.3	0.0	3.6	17.8	3.0	1.1	0.0	0.1	0.0	1.3	1.5	8.1	5.8	38.3
18	4474- 4484	37.9	4.6	7.5	2.9	16.5	4.2	1.6	0.5	2.0	1.0	3.3	1.1	8.8	4.9	47.9
18	4484- 4493	43.5	5.2	2.0	1.9	22.9	4.1	2.2	2.0	0.0	1.7	0.0	0.0	12.1	2.0	45.4
19	3917- 3935	21.7	28.5	0.0	0.8	20.5	1.5	0.0	0.7	1.8	1.9	2.7	0.3	0.0	1.4	42.5
19	3935- 3944	22.2	28.9	9.1	4.6	24.6	0.1	0.0	1.1	0.1	1.5	0.3	0.8	0.2	0.0	45.1
19	3944- 3953	32.2	16.7	0.0	3.3	28.0	1.4	0.0	1.2	0.0	2.0	0.0	0.4	1.3	3.3	47.5
19	3953- 3962	28.5	19.6	0.0	2.9	21.6	1.5	0.0	1.4	4.1	0.8	0.8	0.2	0.0	2.9	44.6
19	3962- 3981	23.1	17.6	13.8	2.2	21.7	1.1	0.0	1.7	0.2	0.2	1.0	0.2	2.4	3.0	56.0
19	4346- 4365	26.7	19.3	3.7	4.7	25.1	2.7	0.0	1.4	2.8	0.7	0.4	3.8	0.2	0.9	44.8
19	4365- 4374	27.0	18.0	4.7	8.5	29.2	1.6	0.0	1.5	1.9	1.2	0.0	0.8	0.0	1.1	49.5
19	4374- 4383	27.7	12.7	2.2	2.4	27.0	3.7	0.0	2.3	0.0	2.2	0.0	0.0	7.8	4.6	55.1
19	4383- 4392	31.6	13.4	0.0	0.2	31.5	2.4	0.0	1.6	1.5	3.9	1.7	0.7	1.0	2.2	45.6
19	4392-4401	26.7	12.5	15.4	1.8	23.8	2.5	0.0	1.8	0.0	2.4	0.1	0.0	0.0	2.2	56.5
20	4417- 4426	36.9	15.7	11.1	3.2	16.1	1.9	3.1	0.9	0.0	2.0	0.5	0.3	0.0	4.0	40.6
20	4426- 4444	36.5	11.2	3.4	6.7	25.6	1.9	0.1	1.7	0.0	2.2	0.1	0.0	9.1	1.3	48.1

Table A.2 XRD data for wells 14-20 (cont.).

20	4444-4453	32.5	15.6	0.0	2.5	14.7	4.7	0.0	0.6	1.1	0.1	1.6	0.8	9.8	2.8	47.7
20	4453- 4471	32.1	14.2	8.5	5.8	21.6	0.9	0.0	1.4	0.2	0.4	0.0	0.9	5.6	1.7	50.7
20	4471- 4481	37.1	14.5	0.0	5.9	22.5	0.6	5.8	0.4	0.5	1.4	0.0	0.6	5.5	0.0	39.7
20	4481- 4499	36.2	11.2	0.0	4.1	25.1	2.7	0.0	0.8	0.1	1.6	0.0	2.0	10.6	4.0	48.1
20	4499- 4508	38.3	12.7	0.0	0.9	18.7	3.7	0.2	0.4	1.8	1.1	1.4	0.1	0.0	11.7	43.9
20	4508- 4526	34.2	8.1	9.6	2.2	14.6	3.5	3.8	0.1	0.1	4.6	1.4	0.2	11.6	1.3	47.4

APPENDIX B.

PYROLYSIS DATA

Table B.1. Pyrolysis data from samples for wells 1-13 & 21. The samples are from conventional and rotary sidewall cores. The 18-meter basal section for each well is highlighted in yellow. Wells 1-11 were previously published by Borrok, et al. (2019) and well 21 was previously published by Enomoto, et al. (2018). The following geochemical values are included in the table: TOC (wt.%), S1 (mg/g), S2 (mg/g), S3 (mg/g), Tmax (°C), Production Index (PI), Potential Yield (S1+S2), Hydrogen Index, and Oxygen Index.

Table B.2. Pyrolysis data for wells 14-20. The samples are from cuttings and are the reanalysis after the extraction of free hydrocarbons. The depth ranges in which the cuttings were collected are listed in the table. The following geochemical values are included in the table: TOC (wt%), S1 (mg/g), S2 (mg/g), S3 (mg/g), Tmax (°C), TpkS2 (°C), Production Index (PI), Potential Yield (S1+S2), Hydrogen Index, and Oxygen Index.

Table B.1 Pyrolysis data from samples for wells 1-13 & 21.

Well #	Depth relative to base of TMS (m)	TOC (wt.%)	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	Tmax (°C)	PI	Potential Yield (S1+S2)	Hydrogen Index	Oxygen Index
1	33.5	1.24	0.13	1.54	0.16	444	0.08	1.67	123.89	12.87
1	32.0	1.19	0.15	1.91	0.23	445	0.07	2.06	160.64	19.34
1	30.5	2.21	0.26	3.26	0.16	444	0.07	3.52	147.64	7.25
1	28.8	1.59	0.14	1.55	0.09	445	0.08	1.69	97.73	5.67
1	27.4	2.43	0.19	4.66	0.21	445	0.04	4.85	191.69	8.64
1	25.9	0.91	0.16	1.62	0.21	447	0.09	1.78	177.53	23.01
1	24.2	1.83	0.14	1.32	0.17	445	0.10	1.46	72.17	9.29
1	22.9	3.10	0.15	5.58	0.21	445	0.03	5.73	179.94	6.77
1	21.3	1.15	0.19	1.78	0.20	444	0.10	1.97	155.46	17.47
1	19.8	1.92	0.15	1.05	0.20	446	0.13	1.20	54.74	10.43
1	18.3	1.64	0.21	3.27	0.27	443	0.06	3.48	199.27	16.45
1	16.8	1.64	0.22	3.03	0.22	448	0.07	3.25	184.53	13.40
1	15.2	2.06	0.21	2.98	0.18	446	0.07	3.19	145.01	8.76
1	13.7	1.82	0.18	2.24	0.12	446	0.07	2.42	123.01	6.59
1	12.2	1.75	0.12	0.80	0.09	445	0.13	0.92	45.82	5.15
1	10.7	2.23	0.13	5.26	0.14	446	0.02	5.39	235.66	6.27
1	9.1	1.83	0.14	3.95	0.22	445	0.03	4.09	215.49	12.00
1	7.6	2.23	0.07	1.00	0.14	443	0.07	1.07	44.92	6.29
1	6.1	0.59	0.03	0.10	0.11	443	0.23	0.13	16.85	18.53
1	4.6	1.53	0.11	1.61	0.14	445	0.06	1.72	105.30	9.16
2	23.3	2.94	0.13	4.32	0.04	451	0.03	4.45	147.19	1.36
2	19.7	2.89	0.08	3.22	0.34	450	0.02	3.30	111.61	11.79
2	18.3	2.60	0.09	6.75	0.04	452	0.01	6.84	259.32	1.54
2	17.7	2.36	0.12	2.02	0.07	449	0.06	2.14	85.77	2.97
2	14.5	2.54	0.13	4.77	0.16	450	0.03	4.90	188.02	6.31
2	12.0	2.29	0.20	4.65	0.09	454	0.04	4.85	202.79	3.92
2	9.4	2.06	0.12	4.42	0.71	451	0.03	4.54	214.77	34.50
2	8.1	2.21	0.12	4.73	0.03	452	0.02	4.85	213.93	1.36
2	4.7	1.60	0.04	0.48	0.04	449	0.08	0.52	29.93	2.49
2	0.2	1.06	0.04	0.46	0.02	452	0.08	0.50	43.60	1.90
3	16.2	1.79	0.86	3.81	0.24	444	0.18	4.67	212.49	13.39
3	13.6	1.64	0.91	3.84	0.25	441	0.19	4.75	233.86	15.23
3	11.4	2.04	0.89	5.15	0.20	443	0.15	6.04	252.57	9.81
3	8.9	2.27	1.34	5.71	0.51	442	0.19	7.05	251.76	22.49
3	5.2	1.11	0.47	1.96	0.06	441	0.19	2.43	176.58	5.41
3	0.1	0.40	0.05	0.18	0.27	441	0.22	0.23	45.11	67.67
4	11.0	0.52	0.14	0.23	0.02	423	0.38	0.37	44.23	3.85
4	9.0	2.497	1.01	5.49	0.86	444	0.16	6.50	219.86	34.44
4	3.7	1.033	0.39	1.04	0.14	442	0.27	1.43	100.68	13.55
4	2.0	1.664	0.92	2.7	0.67	444	0.25	3.62	162.26	40.26
5	38.8	0.76	1.76	0.93	0.12	456	0.65	2.69	122	16
5	38.6	0.57	1.31	0.65	0.04	447	0.67	1.96	114	7
5	37.5	0.82	0.84	1.12	0.01	455	0.43	1.96	137	1
5	36.2	0.71	0.72	1.05	0.01	453	0.41	1.77	148	1
5	35.2	1.28	1.34	2.18	0.04	459	0.38	3.52	170	3
5	34.6	1.00	1.01	1.63	0.07	460	0.38	2.64	163	7
5	32.6	0.59	0.42	0.81	0.01	454	0.34	1.23	137	2
5	31.9	0.82	0.71	1.09	0.01	459	0.39	1.80	133	1
5	31.2	1.15	1.14	1.71	0.05	458	0.40	2.85	149	4
5	30.3	1.11	1.18	1.57	0.03	457	0.43	2.75	141	3
5	29.7	1.67	1.70	2.81	0.14	457	0.38	4.51	168	8

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

5	28.4	0.79	0.65	0.92	0.04	452	0.41	1.57	116	5
5	24.8	1.09	0.98	1.35	0.15	458	0.42	2.33	124	14
5	24.3	1.42	1.34	1.87	0.15	459	0.42	3.21	132	11
5	23.8	1.99	2.01	3.25	0.21	459	0.38	5.26	163	11
5	21.9	1.39	1.57	1.95	0.19	460	0.45	3.52	140	14
5	20.3	0.86	0.76	1.17	0.11	460	0.39	1.93	136	13
5	20.2	0.91	0.68	0.95	0.07	459	0.42	1.63	104	8
5	19.6	1.30	1.15	1.64	0.12	461	0.41	2.79	126	9
5	17.7	1.43	1.61	1.84	0.12	460	0.47	3.45	129	8
5	17.1	1.36	1.23	1.64	0.18	461	0.43	2.87	121	13
5	15.9	1.90	2.86	3.02	0.35	460	0.49	5.88	159	18
5	15.5	1.79	2.36	2.83	0.33	461	0.45	5.19	158	18
5	14.7	1.36	1.48	1.74	0.28	459	0.46	3.22	128	21
5	13.5	1.55	1.79	2.04	0.30	461	0.47	3.83	132	19
5	12.3	0.87	0.80	1.00	0.03	459	0.44	1.80	115	3
5	10.8	2.10	3.02	3.77	0.23	459	0.44	6.79	180	11
5	10.4	1.21	1.01	1.30	0.18	463	0.44	2.31	107	15
5	8.9	1.32	1.96	1.86	0.19	459	0.51	3.82	141	14
5	7.9	1.21	0.88	1.23	0.28	462	0.42	2.11	102	23
5	6.2	1.47	1.02	1.71	0.29	459	0.37	2.73	116	20
5	5.9	0.82	0.57	0.61	0.25	458	0.48	1.18	74	30
5	4.9	0.76	0.30	0.50	0.20	462	0.38	0.80	66	26
5	4.7	0.69	0.26	0.45	0.18	461	0.37	0.71	65	26
5	3.1	0.74	0.64	0.74	0.18	458	0.46	1.38	100	24
5	2.5	0.75	0.47	0.66	0.18	460	0.42	1.13	88	24
5	1.6	0.88	0.46	0.84	0.17	460	0.35	1.30	95	19
6	34.9	1.01	0.8	1.55	0.29	456	0.34	2.35	153	29
6	32.9	1.32	0.77	2.25	0.27	456	0.25	3.02	170	20
6	31.5	0.97	0.44	1.39	0.2	459	0.24	1.83	143	21
6	31.3	0.81	0.35	1.03	0.17	458	0.25	1.38	127	21
6	31.1	0.86	0.24	0.92	0.13	459	0.21	1.16	107	15
6	30.4	0.95	0.44	1.3	0.19	460	0.25	1.74	137	20
6	29.0	0.97	0.44	1.15	0.2	455	0.28	1.59	119	21
6	27.1	0.63	0.22	0.55	0.11	457	0.29	0.77	87	17
6	26.9	1.55	1.03	2.8	0.22	457	0.27	3.83	181	14
6	26.7	1.02	0.51	1.49	0.24	456	0.26	2	146	24
6	25.4	1.51	0.99	2.91	0.25	454	0.25	3.9	193	17
6	24.2	1.56	1.06	2.69	0.29	457	0.28	3.75	172	19
6	23.4	2.53	1.99	5.61	0.38	452	0.26	7.6	222	15
6	22.4	2.07	1.4	4.35	0.31	456	0.24	5.75	210	15
6	20.8	1.09	0.75	1.62	0.28	455	0.32	2.37	149	26
6	19.6	1.19	0.68	1.8	0.27	455	0.27	2.48	151	23
6	19.3	0.79	0.47	0.77	0.21	458	0.38	1.24	97	27
6	19.1	1.23	0.78	1.96	0.18	457	0.28	2.74	159	15
6	18.1	2.8	2.71	6.23	0.33	456	0.3	8.94	223	12
6	17.3	1.28	0.75	2.09	0.29	457	0.26	2.84	163	23
6	16.7	1.21	0.85	2.03	0.25	456	0.3	2.88	168	21
6	15.8	0.51	0.32	0.67	0.17	453	0.32	0.99	131	33
6	15.7	1.15	0.87	2.02	0.16	455	0.3	2.89	176	14
6	15.1	0.9	0.66	1.42	0.16	455	0.32	2.08	158	18
6	14.8	1.51	1.58	2.85	0.23	457	0.36	4.43	189	15
6	14.7	1.21	0.85	2.14	0.2	454	0.28	2.99	177	17
6	14.6	1.3	0.99	2.15	0.14	458	0.32	3.14	165	11
6	14.4	1.47	1.15	2.87	0.16	455	0.29	4.02	195	11
6	14.3	2.74	2.1	6.39	0.2	454	0.25	8.49	233	7

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

6	13.2	1.95	1.28	4.39	0.19	453	0.23	5.67	225	10
6	12.4	2.4	2.62	5.6	0.27	457	0.32	8.22	233	11
6	12.3	1.37	0.97	2.63	0.21	453	0.27	3.6	192	15
6	12.0	1.66	1.32	3.04	0.21	456	0.3	4.36	183	13
6	11.5	1.07	1.19	1.68	0.14	457	0.41	2.87	157	13
6	11.2	0.74	0.44	0.85	0.1	456	0.34	1.29	115	14
6	11.1	1.69	2.64	3.47	0.2	456	0.43	6.11	205	12
6	10.5	1.2	2.61	2.18	0.19	454	0.54	4.79	182	16
6	10.3	0.55	1.85	0.7	0.2	452	0.73	2.55	127	36
6	9.3	2.79	2.91	6.29	0.26	459	0.32	9.2	225	9
6	9.0	2.01	1.6	4.72	0.25	456	0.25	6.32	235	12
6	8.4	1.7	1.52	3.5	0.27	458	0.3	5.02	206	16
6	7.7	0.98	0.65	1.37	0.17	458	0.32	2.02	139	17
6	7.1	1.94	3.02	4.01	0.24	456	0.43	7.03	207	12
6	6.0	1.06	1.58	1.53	0.18	455	0.51	3.11	144	17
6	5.9	1.77	1.73	2.91	0.24	455	0.37	4.64	164	14
6	5.9	0.94	0.61	0.94	0.17	455	0.39	1.55	100	18
6	5.6	0.79	0.41	0.78	0.11	453	0.34	1.19	99	14
6	5.4	1.85	1.26	3.52	0.19	456	0.26	4.78	190	10
6	5.3	0.55	0.56	0.65	0.16	457	0.46	1.21	119	29
6	5.2	0.62	0.3	0.57	0.12	452	0.34	0.87	93	19
6	5.1	1.17	1.13	1.83	0.21	456	0.38	2.96	156	18
6	5.1	0.62	0.29	0.52	0.15	453	0.36	0.81	84	24
6	5.0	0.62	0.32	0.5	0.13	456	0.39	0.82	80	21
6	4.4	0.57	0.3	0.42	0.15	453	0.42	0.72	73	26
6	4.1	0.64	0.24	0.42	0.12	457	0.36	0.66	65	19
6	3.0	1.07	0.72	1.61	0.19	457	0.31	2.33	150	18
6	2.3	0.78	0.45	0.69	0.15	459	0.4	1.14	88	19
6	2.0	1.24	1.17	1.98	0.23	458	0.37	3.15	160	19
6	0.8	2.17	1.51	4.72	0.25	454	0.24	6.23	218	12
6	0.0	0.11	0.06	0.03	0.08	0	0.63	0.09	32	73
7	37.7	1.31	0.62	3.43	0.43	444	0.15	4.05	262	33
7	36.2	0.94	0.56	2.11	0.45	443	0.21	2.67	226	48
7	35.3	1.55	0.70	4.19	0.28	445	0.14	4.89	271	18
7	33.1	1.26	0.69	3.45	0.36	443	0.17	4.14	273	29
7	31.1	1.19	0.51	2.78	0.40	442	0.16	3.29	233	34
7	29.4	1.63	1.65	3.58	0.45	443	0.32	5.23	268	34
7	27.4	2.02	0.93	4.33	0.39	444	0.18	5.26	265	24
7	23.8	2.02	1.33	6.69	0.28	444	0.17	8.02	331	14
7	21.2		0.26	0.48	0.51	438	0.35	0.74	306	325
7	18.3	1.25	0.64	3.26	0.39	444	0.16	3.9	261	31
7	16.1	0.83	0.41	1.96	0.26	444	0.17	2.37	237	31
7	15.1	2.41	1.14	6.79	0.35	444	0.14	7.93	281	15
7	14.6	2.62	2.52	9.99	0.35	445	0.20	12.51	382	13
7	13.5	1.19	0.7	2.94	0.25	443	0.19	3.64	247	21
7	12.5	2.41	1.54	9.51	0.36	447	0.14	11.05	394	15
7	12.1	1.58	0.72	3.97	0.49	446	0.15	4.69	252	31
7	11.5	1.76	1.13	4.66	0.45	444	0.20	5.79	264	26
7	11.2	1.97	2.51	5.63	0.36	444	0.31	8.14	285	18
7	9.1	1.13	0.78	2.93	0.39	442	0.21	3.71	260	35
7	9.0	2.55	1.42	7.09	0.53	446	0.17	8.51	278	21
7	7.9	2.22	2.02	9.42	0.34	446	0.18	11.44	425	15
7	6.6	2.34	1.91	8.76	0.5	444	0.18	10.67	374	21
7	6.0	2.73	1.14	8.32	0.53	444	0.12	9.46	305	19
7	4.7	2.60	2.07	10.34	0.43	447	0.17	12.41	398	17

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

7	4.0	2.19	1.49	6.16	0.3	445	0.19	7.65	281	14
7	1.7	3.20	3.2	13.7	0.34	445	0.19	16.9	428	11
8	37.6	1.44								
8	36.7	1.10	2.12	2.46	0.51	449	0.46	4.58	224	46
8	35.7	0.83								
8	34.8	1.18	3.91	2.55	0.63	448	0.61	6.46	216	53
8	33.8	1.83								
8	33.3	1.64	5.30	3.45	0.64	448	0.61	8.75	210	39
8	32.4	1.04								
8	31.5	1.77	2.48	5.00	0.49	448	0.33	7.48	282	28
8	30.6	1.61								
8	29.6	1.05	1.14	1.89	0.50	449	0.38	3.03	180	48
8	28.7	1.16								
8	27.8	1.10	1.05	2.14	0.38	452	0.33	3.19	195	35
8	26.9	1.29								
8	26.0	1.63	2.42	3.94	0.56	452	0.38	6.36	242	34
8	25.1	1.01								
8	24.5	1.49	2.47	3.59	0.51	449	0.41	6.06	241	34
8	23.5	1.61								
8	22.6	1.55	1.72	3.98	0.58	451	0.30	5.7	257	37
8	21.7	0.80								
8	20.8	1.10	1.36	2.37	0.61	447	0.36	3.73	215	55
8	19.9	1.52								
8	19.0	0.92	2.14	1.64	0.55	452	0.57	3.78	179	60
8	18.0	1.36								
8	17.1	0.97	1.89	1.98	0.44	451	0.49	3.87	205	46
8	16.2	0.95								
8	15.6	1.45	3.91	3.31	0.44	449	0.54	7.22	228	30
8	15.0	1.89								
8	14.1	1.15	1.08	2.51	0.61	445	0.30	3.59	218	53
8	13.2	0.96								
8	12.3	0.80	0.56	1.39	0.30	447	0.29	1.95	174	38
8	11.3	1.54								
8	10.4	1.72	2.66	4.37	0.47	453	0.38	7.03	254	27
8	9.5	1.01								
8	8.6	1.39	1.61	3.26	0.46	448	0.33	4.87	235	33
8	7.7	1.37								
8	6.8	1.66	1.62	4.00	0.42	450	0.29	5.62	241	25
8	5.9	2.04								
8	5.7	1.96	4.09	4.74	0.68	448	0.46	8.83	242	35
8	4.6	1.89								
8	4.3	0.56	1.14	0.54	0.51	449	0.68	1.68	96	91
9	44.8	0.55	0.50	1.10	0.26	449	0.31	1.60	201	48
9	43.6	0.49	0.33	0.83	0.27	448	0.28	1.16	171	56
9	42.1	0.94	0.63	1.67	0.38	451	0.27	2.30	177	40
9	40.5	0.61	0.28	0.98	0.33	448	0.22	1.26	161	54
9	39.0	0.46	0.19	0.60	0.37	449	0.24	0.79	130	80
9	37.5	0.35	0.17	0.52	0.31	448	0.25	0.69	149	89
9	36.0	0.47	0.19	0.66	0.33	449	0.22	0.85	140	70
9	33.8	1.22	0.67	2.12	0.34	448	0.24	2.79	174	28
9	31.7	0.89	0.47	1.57	0.33	449	0.23	2.04	177	37
9	30.2	0.75	0.36	1.13	0.38	449	0.24	1.49	151	51
9	29.3	0.71	0.45	1.20	0.32	449	0.27	1.65	169	45
9	27.7	0.88	0.43	1.51	0.38	449	0.22	1.94	171	43
9	26.5	0.66	0.37	0.97	0.33	449	0.28	1.34	147	50

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

9	24.4	0.59	0.29	0.77	0.48	452	0.27	1.06	131	81
9	21.9	1.09	0.58	1.77	0.36	450	0.25	2.35	163	33
9	20.1	1.02	0.65	1.84	0.34	449	0.26	2.49	181	33
9	18.3	1.12	1.23	2.20	0.42	449	0.36	3.43	196	37
9	15.8	0.94	0.55	1.44	0.34	450	0.28	1.99	153	36
9	14.0	1.54	1.09	2.86	0.37	451	0.28	3.95	186	24
9	12.8	1.59	1.31	3.21	0.43	451	0.29	4.52	202	27
9	11.3	1.71	1.04	3.26	0.41	451	0.24	4.30	191	24
9	7.3	2.35	1.55	4.45	0.38	452	0.26	6.00	189	16
9	3.7	2.00	1.57	3.72	0.35	451	0.30	5.29	186	18
9	0.3	1.25	1.44	2.51	0.46	449	0.36	3.95	200	37
10	54.3	1.72	0.86	4.72	0.39	442	0.15	5.58	275	23
10	51.8	1.49	0.67	3.82	0.35	443	0.15	4.49	256	23
10	46.6	1.43	0.80	3.75	0.38	442	0.18	4.55	262	27
10	43.9	1.74	0.68	4.82	0.44	444	0.12	5.50	277	25
10	42.1	0.81	0.34	1.67	0.36	443	0.17	2.01	207	45
10	39.6	0.95	0.91	2.15	0.50	440	0.30	3.06	227	53
10	37.5	0.64	0.40	1.52	0.13	442	0.21	1.92	237	20
10	31.1	1.47	0.53	3.14	0.32	443	0.14	3.67	214	22
10	28.7	1.03	0.37	2.18	0.29	442	0.15	2.55	213	28
10	26.8	1.86	0.86	7.43	0.30	443	0.10	8.29	399	16
10	25.3	1.55	0.86	6.08	0.34	444	0.12	6.94	393	22
10	24.1	1.32	0.55	3.25	0.32	442	0.14	3.80	247	24
10	22.6	1.72	0.59	3.63	0.15	444	0.14	4.22	211	9
10	20.7	2.76	2.04	12.36	0.39	444	0.14	14.40	448	14
10	19.2	1.92	1.43	7.59	0.35	444	0.16	9.02	396	18
10	18.3	2.03	0.72	7.89	0.49	444	0.08	8.61	388	24
10	17.1	1.45	0.58	3.10	0.44	442	0.16	3.68	215	30
10	16.2	1.43	0.56	3.56	0.26	443	0.14	4.12	248	18
10	15.2	1.99	1.05	8.43	0.25	445	0.11	9.48	424	13
11	72.69	1.379	0.17	0.31	0.15	458	0.35	0.48	22	11
11	69.49	0.7417	0.13	0.19	0.28	457	0.41	0.32	26	38
11	67.36	0.9648	0.17	0.26	0.22	458	0.40	0.43	27	23
11	64.01	1.766	0.16	0.35	0.13	460	0.31	0.51	20	7
11	62.64	1.366	0.17	0.33	0.09	459	0.34	0.50	24	7
11	60.35	1.418	0.17	0.34	0.18	457	0.33	0.51	24	13
11	58.52	1.55	0.22	0.37	0.08	458	0.37	0.59	24	5
11	55.32	1.87	0.21	0.39	0.1	461	0.35	0.60	21	5
11	53.49	1.479	0.35	0.64	0.15	460	0.35	0.99	43	10
11	51.51	1.178	0.27	0.47	0.21	460	0.36	0.74	40	18
11	49.83	1.923	0.26	0.49	0.13	461	0.35	0.75	25	7
11	48.62	1.341	0.2	0.38	0.17	460	0.34	0.58	28	13
11	45.57	0.6878	0.1	0.14	0.12	466	0.42	0.24	20	17
11	43.74	1.084	0.27	0.4	0.16	461	0.40	0.67	37	15
11	41.91	1.585	0.52	0.85	0.2	463	0.38	1.37	54	13
11	40.08	1.189	0.19	0.26	0.17	456	0.42	0.45	22	14
11	37.95	1.543	0.33	0.46	0.14	453	0.42	0.79	30	9
11	36.12	1.767	0.53	0.74	0.27	461	0.42	1.27	42	15
11	34.29	1.29	0.38	0.59	0.2	459	0.39	0.97	46	16
11	32.46	1.376	0.29	0.38	0.18	459	0.43	0.67	28	13
11	30.63	1.058	0.25	0.33	0.18	460	0.43	0.58	31	17
11	28.80	1.835	0.67	0.88	0.17	460	0.43	1.55	48	9
11	26.97	1.649	0.9	1.3	0.18	465	0.41	2.20	79	11
11	25.15	1.76	0.89	1.19	0.26	465	0.43	2.08	68	15
11	23.32	1.576	0.6	0.74	0.14	460	0.45	1.34	47	9

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

11	21.49	2.056	1.36	1.71	0.17	468	0.44	3.07	83	8
11	17.68	1.55	0.63	1.24	0.20	467	0.34	1.87	80	13
11	16.00	2.71	1.25	2.47	0.26	471	0.34	3.72	91	10
11	14.17	1.77	0.39	0.62	0.15	458	0.39	1.01	35	8
11	12.34	2.93	1.00	1.81	0.13	473	0.36	2.81	62	4
11	10.52	2.21	0.40	0.58	0.25	460	0.41	0.98	26	11
11	8.69	1.94	0.73	1.21	0.18	463	0.38	1.94	62	9
11	5.18	2.19	0.72	1.32	0.17	468	0.35	2.04	60	8
11	3.35	2.32	0.79	1.50	0.17	473	0.34	2.29	65	7
11	1.52	1.35	0.15	0.29	0.10	462	0.34	0.44	22	7
11	-0.30	0.98								
11	-1.68	0.76								
11	-3.96	0.80								
11	-5.79	0.70								
11	-7.16	0.86								
11	-9.75	1.97								
11	-11.66	0.04								
11	-13.11	0.52								
11	-15.04	0.46								
11	-16.37	0.04								
11	-17.95	0.04								
11	-19.37	0.94								
12	62.27	0.49	0.14	0.70	0.14	444	0.17	0.84	143	29
12	60.61	0.54	0.13	0.72	0.13	442	0.15	0.85	133	24
12	59.62	0.58	0.13	0.75	0.10	445	0.15	0.88	130	17
12	57.73	0.70	0.23	1.13	0.17	445	0.17	1.36	162	24
12	56.27	0.73	0.29	1.25	0.15	447	0.19	1.54	171	21
12	54.62	0.74	0.25	1.22	0.20	445	0.17	1.47	166	27
12	52.64	0.94	0.34	1.64	0.17	449	0.17	1.98	174	18
12	51.64	1.05	0.47	1.89	0.26	444	0.20	2.36	180	25
12	49.99	0.95	0.54	1.95	0.19	446	0.22	2.49	205	20
12	48.54	0.77	0.40	1.58	0.06	447	0.20	1.98	205	8
12	46.24	1.11	0.55	2.28	0.14	447	0.19	2.83	205	13
12	45.32	0.75	0.33	1.09	0.07	447	0.23	1.42	146	9
12	43.43	1.19	0.82	2.59	0.19	448	0.24	3.41	218	16
12	42.43	1.53	1.04	3.83	0.16	448	0.21	4.87	250	10
12	41.48	1.47	0.84	3.63	0.09	449	0.19	4.47	247	6
12	39.96	0.92	0.45	1.63	0.09	448	0.22	2.08	177	10
12	39.26	1.33	0.80	3.04	0.10	446	0.21	3.84	229	8
12	37.89	0.81	0.37	1.35	0.09	450	0.22	1.72	167	11
12	37.22	1.43	0.80	3.38	0.11	449	0.19	4.18	236	8
12	35.84	1.65	1.40	3.92	0.11	447	0.26	5.32	238	7
12	34.55	1.52	1.05	3.75	0.08	448	0.22	4.80	247	5
12	33.89	1.85	1.19	4.50	0.07	448	0.21	5.69	243	4
12	32.06	1.31	0.80	3.05	0.09	447	0.21	3.85	233	7
12	29.20	1.60	1.54	3.72	0.14	446	0.29	5.26	233	9
12	27.98	0.95	0.44	1.94	0.08	449	0.18	2.38	204	8
12	27.19	1.22	0.98	2.83	0.17	453	0.26	3.81	232	14
12	26.37	2.05	1.55	5.02	0.20	446	0.24	6.57	245	10
12	23.90	1.14	0.68	2.52	0.12	449	0.21	3.20	221	11
12	22.34	1.61	0.98	3.84	0.10	449	0.20	4.82	239	6
12	21.61	1.22	0.71	2.69	0.14	446	0.21	3.40	220	11
12	20.91	1.19	0.86	2.73	0.12	450	0.24	3.59	229	10
12	19.29	1.99	1.36	4.99	0.12	450	0.21	6.35	251	6
12	17.71	1.85	1.42	4.05	0.15	446	0.26	5.47	219	8

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

12	16.61	1.39	0.99	3.01	0.11	449	0.25	4.00	217	8
12	15.51	1.87	1.27	4.58	0.14	449	0.22	5.85	245	7
12	14.09	1.26	0.99	2.92	0.10	448	0.25	3.91	232	8
12	12.99	2.48	1.92	6.11	0.16	447	0.24	8.03	246	6
12	12.35	1.56	1.33	3.30	0.20	445	0.29	4.63	212	13
12	11.73	0.62	0.39	0.67	0.21	433	0.37	1.06	108	34
12	10.98	0.76	0.29	1.14	0.17	449	0.20	1.43	150	22
12	9.72	0.69	0.20	0.85	0.11	448	0.19	1.05	122	16
12	8.80	1.43	0.95	3.18	0.13	447	0.23	4.13	222	9
12	8.20	1.23	0.64	2.53	0.11	448	0.20	3.17	206	9
12	7.13	0.53	0.27	0.56	0.07	444	0.33	0.83	106	13
12	6.36	0.38	0.17	0.32	0.03	444	0.35	0.49	84	8
12	5.61	0.46	0.31	0.58	0.04	445	0.35	0.89	127	9
12	4.50	0.72	0.15	0.50	0.03	450	0.23	0.65	69	4
12	3.15	0.55	0.13	0.46	0.03	447	0.22	0.59	83	5
12	2.37	0.53	0.08	0.37	0.03	446	0.18	0.45	70	6
12	1.31	0.69	0.10	0.59	0.08	452	0.14	0.69	86	12
13	62.2	0.74	0.06	0.43	0.08	449.2	0.12	0.49	58.1	10.8
13	57.6	1.38	0.26	1.74	0.17	447.8	0.13	2	126.1	12.3
13	57.0	1.85	0.17	1.42	0.2	448.5	0.11	1.59	76.8	10.8
13	54.3	1.85	0.13	1.23	0.17	452.3	0.09	1.36	66.5	9.2
13	46.9	1.08	0.19	1.21	0.11	447.8	0.13	1.4	112.0	10.2
13	42.4	1.83	0.49	3.28	0.16	447.3	0.13	3.77	179.2	8.7
13	37.8	2.21	0.39	4.38	0.16	448.7	0.08	4.77	198.2	7.2
13	36.9	0.67	0.14	0.6	0.11	447.7	0.19	0.74	89.6	16.4
13	34.4	1	0.17	0.98	0.11	448.3	0.15	1.15	98.0	11.0
13	32.0	1.97	0.51	4.31	0.15	450.5	0.11	4.82	218.8	7.6
13	29.3	2.32	0.47	5.38	0.15	450	0.08	5.85	231.9	6.5
13	24.7	3.22	0.77	9.5	0.18	451.3	0.07	10.27	295.0	5.6
13	22.6	2.49	0.75	6.32	0.21	448.5	0.11	7.07	253.8	8.4
13	18.9	1.18	0.15	1.31	0.17	450.6	0.11	1.46	111.0	14.4
13	14.9	1.04	0.15	0.9	0.08	451.4	0.14	1.05	86.5	7.7
13	13.7	0.94	0.06	0.46	0.18	455	0.12	0.52	48.9	19.1
13	10.4	0.98	0.06	0.47	0.14	454.3	0.11	0.53	48.0	14.3
13	5.5	0.99	0.06	0.41	0.11	454.5	0.13	0.47	41.4	11.1
13	4.3	1.13	0.01	0.09	0.12	468.3	0.13	0.1	8.0	10.6
13	2.4	1.04	0.05	0.53	0.29	454.6	0.09	0.58	51.0	27.9
21	18.3	1.28	0.34	2.26	0.28	446	0.13	2.6	176	22
21	16.3	1.64	0.9	4.29	0.22	445	0.17	5.19	262	13
21	16.3	1.79	0.41	5.5	0.29	446	0.07	5.91	307	16
21	13.7	1.25	0.37	2.47	0.21	444	0.13	2.84	198	17
21	12.9	1.9	1.33	5.48	0.34	445	0.19	6.81	288	18
21	10.2	1.77	0.43	3.3	0.21	446	0.12	3.73	187	12
21	10.2	1.75	1.04	4.69	0.4	444	0.18	5.73	268	23
21	8.5	0.59	0.16	0.71	0.16	444	0.18	0.87	120	27
21	6.8	1.01	0.32	1.87	0.19	445	0.15	2.19	185	19
21	5.5	0.44	0.15	0.55	0.08	444	0.21	0.7	126	18
21	2.9	1.8	0.55	4.07	0.17	445	0.12	4.62	226	9
21	2.9	2.33	1.71	6.63	0.31	443	0.21	8.34	285	13
21	2.1	0.8	0.55	1.39	0.16	442	0.28	1.94	173	20
21	1.6	1.84	0.92	4.64	0.24	445	0.17	5.56	252	13
21	1.6		0.96	4.93	0.29	445	0.16	5.89	268	16
21	0.9	1.31	0.43	2.33	0.25	446	0.16	2.76	178	19
21	0.0	1.64	0.46	3.39	0.24	446	0.12	3.85	207	15
21	-0.6	1.95	0.47	4.43	0.16	446	0.1	4.9	228	8

Table B.1 Pyrolysis data from samples for wells 1-13 & 21 (cont.).

21	-0.6	1.86	0.95	5.04	0.35	443	0.16	5.99	271	19
21	-1.8	1.46	0.42	2.88	0.22	446	0.13	3.3	198	15
21	-2.3	1.84	0.27	3.57	0.25	445	0.07	3.84	194	14
21	-3.4	0.58	0.33	1.4	0.07	443	0.19	1.73	242	12
21	-3.5	2.01	1.18	5.45	0.3	443	0.18	6.63	271	15
21	-5.1	0.18	0.26	0.29	0.26	440	0.47	0.55	158	142
21	-5.4	0.14	0.09	0.12	0.23	440	0.43	0.21	84	161
21	-5.8	0.57	0.78	0.52	0.23	442	0.6	1.3	92	40
21	-6.2	0.45	0.35	0.43	0.25	441	0.45	0.78	96	56

Table B.2 Pyrolysis data for wells 14-20.

Well #	Depth range (m)	TOC	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	Tmax (°C)	TpkS2 (°C)	PI	Potential Yield (S1+S2)	HI	OI
14	4462- 4471	0.94	0.06	1.66	0.38	439	478	0.03	1.72	17	40
14	4471- 4480	1.18	0.09	2.4	0.36	439	478	0.04	2.49	20	31
14	4480- 4489	1.22	0.1	2.62	0.38	439	478	0.04	2.72	21	31
14	4489- 4499	1.33	0.09	2.82	0.47	437	476	0.03	2.91	21	35
14	4499-4508	1.14	0.07	2.12	0.38	440	479	0.03	2.19	18	33
14	4508- 4517	0.96	0.08	1.87	0.45	439	478	0.04	1.95	19	47
15	4548- 4557	1.83	0.04	1.38	1.24	435	474	0.03	1.42	75	68
15	4457- 4566	2.17	0.04	1.59	1.54	434	473	0.03	1.63	73	71
15	4566- 4575	1.76	0.07	1.36	1.08	435	474	0.05	1.43	77	61
15	4575- 4584	2.01	0.09	2.83	1.04	435	474	0.03	2.92	14	52
15	4584- 4593	1.68	0.09	2.31	1.17	437	476	0.04	2.4	13	70
15	4593- 4602	1.67	0.04	0.82	1.31	435	474	0.05	0.86	49	78
15	4602- 4612	2.02	0.08	2.59	1.46	436	475	0.03	2.67	12	72
15	4612-4621	1.24	0.03	0.4	1.06	435	474	0.07	0.43	32	85
15	4621- 4630	1.36	0.05	1.09	0.95	433	472	0.04	1.14	80	70
15	4630- 4639	1.47	0.09	3.96	0.42	436	475	0.02	4.05	26	29
16	4112- 4139	2.63	0.05	3.02	1.23	435	474	0.02	3.07	11	47
16	4139- 4167	1.99	0.05	2.7	1.2	435	474	0.02	2.75	13	60
16	4167- 4194	1.44	0.03	0.4	1.3	427	466	0.07	0.43	28	90
16	4194- 4221	2.18	0.1	5.48	0.83	435	474	0.02	5.58	25	38
16	4880- 4907	2.18	0.05	1.05	1.25	433	472	0.05	1.1	48	57
16	4907- 4935	3.54	0.11	5.38	1.07	434	473	0.02	5.49	15	30
17	4051- 4060	1.64	0.05	3.25	0.5	437	476	0.01	3.3	19	30
17	4060- 4069	1.72	0.07	3.75	0.49	437	476	0.02	3.82	21	28
17	4069- 4078	2.35	0.07	4.52	0.79	438	477	0.02	4.59	19	34
17	4078- 4087	1.81	0.07	3.92	0.55	438	477	0.02	3.99	21	30
17	4087- 4096	2.09	0.08	3.84	0.83	438	477	0.02	3.92	18	40
17	4096- 4106	1.44	0.07	3.03	0.48	438	477	0.02	3.1	21	33
17	4389- 4398	0.98	0.07	2.18	0.5	434	473	0.03	2.25	22	51
17	4398- 4417	0.9	0.07	1.86	0.45	432	471	0.03	1.93	20	50
18	3798- 3807	1.13	0.05	1.94	0.45	440	479	0.03	1.99	17	40
18	3807- 3816	2.4	0.11	6.35	0.89	435	474	0.02	6.46	26	37
18	3816- 3825	1.49	0.1	4.33	0.67	434	473	0.02	4.43	29	45
18	3825- 3834	1.6	0.08	3.42	1.03	434	473	0.02	3.5	21	64
18	3834- 3843	2.36	0.11	6.43	0.83	434	473	0.02	6.54	27	35
18	4465- 4474	1.57	0.07	4.2	0.68	435	474	0.02	4.27	26	43
18	4474- 4484	1.67	0.09	4.76	0.7	435	474	0.02	4.85	28	42
18	4484- 4493	1.33	0.06	2.45	0.8	433	472	0.02	2.51	18	60
19	3917- 3935	1.14	0.06	1.96	0.68	432	471	0.03	2.02	17	60
19	3935- 3944	2.86	0.06	9.84	0.45	437	476	0.01	9.9	34	16
19	3944- 3953	2.89	0.08	10.62	0.39	437	476	0.01	10.7	36	13
19	3953- 3962	1.98	0.07	6.39	0.36	437	476	0.01	6.46	32	18
19	3962- 3981	2.45	0.08	7.99	0.51	436	475	0.01	8.07	32	21
19	4346- 4365	1.86	0.06	5.8	0.36	435	474	0.01	5.86	31	19
19	4365- 4374	1.87	0.07	5.81	0.37	434	473	0.01	5.88	31	20
19	4374- 4383	1.93	0.07	5.78	0.39	436	475	0.01	5.85	29	20
19	4383- 4392	2.03	0.09	6.35	0.42	435	474	0.01	6.44	31	21
19	4392-4401	2.25	0.07	7.44	0.37	437	476	0.01	7.51	33	16
20	4417- 4426	2.04	0.1	6.46	0.5	434	473	0.01	6.56	31	25
20	4426- 4444	1.32	0.07	2.66	0.64	439	478	0.03	2.73	20	48
20	4444-4453	1.09	0.05	1.79	0.36	440	479	0.03	1.84	16	33
20	4453- 4471	1.22	0.08	2.81	0.41	442	481	0.03	2.89	23	34

Table B.2 Pyrolysis data for wells 14-20 (cont.).

20	4471- 4481	1.09	0.06	1.8	0.35	440	479	0.03	1.86	16	32
20	4481- 4499	0.98	0.04	1.44	0.31	441	480	0.03	1.48	14	32
20	4499- 4508	0.96	0.04	1.43	0.34	440	479	0.03	1.47	14	35
20	4508- 4526	0.95	0.04	1.35	0.33	442	481	0.03	1.39	14	35

APPENDIX C.

PRODUCTION DATA

Table C.1. Well information of TMS wells. Data in this table as well as Tables 2 and 3 were collected from drillinginfo.com (Enverus) and the Louisiana Department of Natural Resources (sonris.com) and the Mississippi State Oil & Gas Board (www.ogb.state.ms.us/TMSDevelopment.php). This table includes well name, state, latitude, longitude, API Number, current operator, total vertical depth, lateral length, elevation, completion date, and 1st production date.

Table C.2. Drilling information of wells in the TMS. This table includes upper perforation in ft, lower perforation in ft, total fluid (bbl), total additive (lbs), and total proppant (lbs).

Table C.3. Production information of wells in the TMS. This table includes cumulative production data from 12, 24, and 36 months for oil, gas and water.

Table C.1 Well information of TMS wells.

Well name	State	Latitude	Longitude	API Number	Current Operator	Total Vertical Depth	Lateral Length	Elev- ation	Completion Date	1st Prod. Date
						ft	ft	ft		
Anderson 17H #1	MS	31.04923	-90.7318	2300520739	AUSTRALIS TMS INC.	11876	7939	351	4/12/2012	5/1/2012
Anderson 17H #2	MS	31.04874	-90.72141	2300520760	AUSTRALIS TMS INC.	11853	8446	323	7/5/2013	7/1/2013
Anderson 17H #3	MS	31.04886	-90.7214	2300520761	AUSTRALIS TMS INC.	11788	8414	348	7/5/2013	7/1/2013
Anderson 18H #1	MS	31.05189	-90.73796	2300520741	AUSTRALIS TMS INC.	11783	8786	267	5/2/2012	10/1/2012
Ash 13H #1	MS	31.06411	-91.02184	2300520802	AUSTRALIS TMS INC.	12470	7139	378	12/3/2014	1/1/2015
Ash 13H #2	MS	31.06396	-91.02189	2300520803	AUSTRALIS TMS INC.	12747	7191	373	11/19/2014	1/1/2015
Ash 31H #1	MS	31.02121	-90.98405	2300520745	AUSTRALIS TMS INC.	12679	7161	353	3/14/2013	4/1/2013
Ash 31H #2	MS	31.02106	-90.98407	2300520746	AUSTRALIS TMS INC.	12828	7350	341	3/12/2013	4/1/2013
Bates 25-24H #1	MS	31.19067	-90.76343	2300520791	Goodrich Petroleum		4830	393	8/26/2014	9/1/2014
BEECH GROVE 94 H 001	LA	30.9362903	-91.0462155	1703720157	EOG Resources	13421	6036	264	6/20/2014	7/1/2014
BEECH GROVE LAND CO 68 H 001	LA	30.8932357	-91.0495489	1703720151	Goodrich Petroleum	13650	3253	197	10/30/2011	10/1/2011
BENTLEY LUMBER 32-001	LA	31.2868515	-92.9026075	1711520211	PERDIDO ENERGY LOUISIANA, LLC	12500	142	245	5/7/2011	5/1/2011
BENTLEY LUMBER 34 H001	LA	31.3638167	-92.8777403	1707920538	PERDIDO ENERGY LOUISIANA, LLC	11063	3949	260	11/28/2011	11/1/2011
Black Stone 4H #2	MS	31.07823	-91.17951	2315722060	SIGNAL, LLC	12970	3505	322	7/14/2014	7/1/2014
Bloomer #2H	MS	31.11294	-91.52939	2315722240	SANCHEZ ENERGY	12898	9168	138	6/13/2015	6/1/2015
B-NEZ 43 H002	LA	30.9343474	-90.3656482	1710520055	GOODRICH PETROLEUM	11623	5927	301	6/27/2015	6/1/2015
BOE 1H	MS	31.05605	-90.70245	2300520727	AUSTRALIS TMS INC.	11987	5536	345	6/12/2011	6/1/2011
C.H. Lewis 30-19 #1H	MS	31.10269	-90.64645	2300520789	Goodrich Petroleum	11510	6886	332	5/12/2014	5/1/2014
CMR 8-5H #1	MS	31.06544	-90.83139	2300520774	Goodrich Petroleum	12126	6822	375	2/23/2014	3/1/2014
CMR Foster Creek 28-40 #1H	MS	31.1957	-91.15986	2315722099	GRIFFIN & GRIFFIN EXPL, LLC	11985	7947	295	12/15/2014	12/1/2014
CMR Foster Creek 8H #1	MS	31.15141	-91.13724	2315722097	Goodrich Petroleum	12151	4468	348		3/1/2015
CMR Foster Creek 8H #2	MS	31.15108	-91.13731	2315722098	Goodrich Petroleum	12344	6140	342		3/1/2015
CMR/FOSTER CREEK 31-22H 1	MS	31.10238	-91.13676	2315722095	Goodrich Petroleum	13400	6821	326	9/11/2014	9/1/2014
CMR-Foster Creek 20-7H #1	MS	31.13169	-91.15281	2315722047	Goodrich Petroleum		7153	361	9/9/2013	10/1/2013
CMR-Foster Creek 24-13H #1	MS	31.12409	-91.16233	2315722089	Goodrich Petroleum	12248	5996	274	9/25/2014	9/1/2014
Creek Cottage West #1H	MS	31.06433	-91.20737	2315722133	SIGNAL, LLC		7889	345		9/1/2016
CROSBY 12-1H 1	MS	31.14601	-91.16338	2315722037	Goodrich Petroleum		7654	200	1/25/2013	1/1/2013
Denkmann 33-28H #2	MS	31.00068	-90.8065	2300520799	Goodrich Petroleum	13000	6376	281	8/16/2014	8/1/2014
Dry Fork East Unit #2H	MS	31.1565	-91.23402	2315722083	SANCHEZ ENERGY	12100	8962	211	9/15/2014	9/1/2014
DUPUY LAND CO 30 H001	LA	31.2127562	-91.9951575	1700920649	FORTUNE RESOURCES LLC	11740	6265	46	8/16/2013	8/1/2013
Fassmann 9H #1	MS	31.15609	-91.21125	2315722067	SIGNAL, LLC		7816	189		9/1/2014
FRANKLIN PST PROP H	LA	30.9986094	-90.4706595	1710520051	SIGNAL, LLC OF MISSISSIPPI	11637	5817	239	8/21/2016	8/1/2016

Table C.1 Well information of TMS wells (cont.).

GAUTHIER 14 H	LA	31.0443174	-91.9302171	1700920644	FORTUNE RESOURCES LLC	13640	4684	46	1/31/2013	2/1/2013
George Martens, et al #2H	MS	31.06403	-91.31697	2315722140	SIGNAL, LLC	13097	7820	361	11/9/2014	11/1/2014
Horeseshoe Hill 10H	MS	31.057951	-91.244745	2315722027	AUSTRALIS TMS INC.	13138	7753	322	3/6/2012	3/1/2012
Horseshoe Hill 11-22H #1	MS	31.06621	-91.2327	2315722045	SIGNAL, LLC	13248	8249	320	5/25/2014	5/1/2014
Huff 18-7H #1	MS	31.13188	-90.7414	2300520773	Goodrich Petroleum	11521	6105	381	12/9/2013	12/1/2013
JOE JACKSON 4-13H	MS	31.1603826	-90.91892	2300520714	AUSTRALIS TMS INC.	12168	1157	318		12/1/2007
Joe Jackson 4H-2	MS	31.17204	-90.90959	2300520748	AUSTRALIS TMS INC.	11049	9613	343	10/8/2012	10/1/2012
KENT 41 H	LA	30.8479606	-90.4378705	1710520048	GOODRICH PETROLEUM	11900	5973	184	12/16/2014	1/1/2015
KINCHEN 58 H	LA	30.9737904	-90.5273184	1710520054	GOODRICH PETROLEUM	11736	5973	285	7/13/2015	8/1/2015
LAMBERT H-1	MS	31.00463	-90.86228	2300520664	EXCHANGE EXPL & PRODN CO	13614	766	220		11/1/2000
LANE 64 001	LA	30.7904601	-91.1076061	1703720149	Goodrich Petroleum	15500	886	170	3/20/2012	4/1/2012
Lawson 25-13H #1	MS	31.02132	-90.65289	2300520804	AUSTRALIS TMS INC.		9798	274		3/1/2015
Lawson 25H #1	MS	31.02123	-90.65337	2300520762	AUSTRALIS TMS INC.	11921	3849	274	3/15/2014	3/1/2014
Lewis 7-18H #1	MS	31.0685	-90.8397	2300520801	AUSTRALIS TMS INC.	12284	9127	320	6/29/2014	7/1/2014
Longleaf 29H #1	MS	31.109	-90.7719	2300520794	AUSTRALIS TMS INC.	11704	7056	357	2/7/2015	3/1/2015
Longleaf 29H #2	MS	31.10882	-90.77198	2300520795	AUSTRALIS TMS INC.	12028	7105	361	2/3/2015	3/1/2015
Lyons 35H #1	MS	31.10727	-91.02635	2300520786	AUSTRALIS TMS INC.	12210	6383	358	4/9/2014	5/1/2014
Lyons 35H #2	MS	31.10722	-91.02635	2300520787	AUSTRALIS TMS INC.	12343	5280	359	7/31/2014	8/1/2014
Mathis 29-17H #1	MS	31.01983	-90.72807	2300520857	AUSTRALIS TMS INC.	12089	9178	357		2/1/2015
Mathis 29-32H #1	MS	31.02017	-90.72799	2300520798	AUSTRALIS TMS INC.	12284	6247	360		6/1/2014
McIntosh 15H #1	MS	31.06335	-90.97198	2300520843	AUSTRALIS TMS INC.	12244	7698	302	4/1/2015	4/1/2015
Morris 2H	MS	31.10592	-91.36143	2315722176	SANCHEZ ENERGY	13446	6911	398	1/15/2015	2/1/2015
NUNNERY 12-1H 1	MS	31.14667	-90.55965	2300520790	Goodrich Petroleum	11200	6092	389	5/24/2014	5/1/2014
PAUL 15 H	LA	31.2352731	-92.0437153	1700920648	FORTUNE RESOURCES LLC	11145	4666	52	7/1/2013	7/1/2013
Pintard 28H #1	MS	31.10187	-91.09012	2315722054	AUSTRALIS TMS INC.	12281	7437	340	5/9/2014	5/1/2014
Pintard 28H #2	MS	31.10176	-91.09023	2315722055	AUSTRALIS TMS INC.	12594	8604	339	8/10/2014	9/1/2014
Reese 16H #1	MS	31.06318	-90.9715	2300520845	AUSTRALIS TMS INC.	12652	6167	300	4/1/2015	4/1/2015
RICHLAND FARMS INC 74 H	LA	30.9737895	-91.038993	1703720154	EOG RESOURCES	7950	4428	292	4/29/2012	4/1/2012
RICHLAND PLANTATION A 001	LA	30.9969679	-91.0224183	1703720145	AUSTRALIS TMS INC.	12842	2989	314	5/5/2008	5/1/2008
Rogers 1H	MS	31.07913	-91.17518	2315722156	SIGNAL, LLC	12803	7835	318	7/21/2015	7/1/2015
S. D. SMITH 1H	MS	31.02203	-91.278	2315722102	HALCON RESOURCES	12331	9419	324	8/30/2014	09/1/2014
Sabine 12H #1	MS	31.15365	-90.85555	2300520796	AUSTRALIS TMS INC.	12000	6901	338	11/1/2014	11/1/2014
Sabine 12H #2	MS	31.15352	-90.85553	2300520797	AUSTRALIS TMS INC.	12000	6925	338	10/24/2014	11/1/2014
Shuckrow 10H #1	MS	31.15016	-91.19785	2315722104	SIGNAL, LLC	12343	7167	186	10/3/2014	10/1/2014
SLC INC 81 H	LA	30.9521228	-91.3026107	1712520132	EOG RESOURCES	14393	6951	206	7/26/2014	7/1/2014
Smith 5-29H #1	MS	31.08435	-90.6277	2300520756	Goodrich Petroleum	11800	7694	366	7/9/2013	7/1/2013

Table C.1 Well information of TMS wells (cont.).

Spears 31-6H #1	MS	31.10298	-90.64639	2300520809	Goodrich Petroleum	11649	7688	336	10/9/2014	10/1/2014
St. Davis Unit #1H	MS	31.13989	-90.97066	2300520819	SANCHEZ ENERGY	11887	5778	365	10/31/2014	11/1/2014
T. Lewis 7-38H #1	MS	31.07059	-90.84143	2300520866	Goodrich Petroleum	12291	6310	312	8/4/2015	8/1/2015
TMS RA SUA;BLADES 33 H 001	LA	30.9224031	-90.4120377	1710520046	Goodrich Petroleum	11660	5188	324	3/13/2014	4/1/2014
TMS RA SUA;BROADWAY H 001	LA	31.124574	-92.27827	1707920539	SIGNAL, LLC OF MISSISSIPPI	13829	5381	56	3/18/2013	8/1/2013
TMS RA SUA;DUPUY LAND CO 20 H 001	LA	31.1994782	-91.9778983	1700920645	FORTUNE RESOURCES LLC	11336	5322	45	11/29/2012	11/1/2012
TMS RA SUA;MURPHY 63 H 001	LA	30.9836921	-91.4570314	1712520131	Goodrich Petroleum	14200	4850	246	8/20/2012	8/1/2012
TMS RA SUA;SOTERRA 6 H 001	LA	30.8149055	-90.5370388	1710520039	Goodrich Petroleum	12615	4073	219	2/7/2012	2/1/2012
TMS RA SUA;THOMAS 38 H 001	LA	30.9579576	-90.4917621	1710520042	Goodrich Petroleum	11808	5083	205	9/28/2012	9/1/2012
TMS RA SUA;WEYERHAEUSER 51 H 001	LA	30.91768	-90.827323	1709120152	Goodrich Petroleum	12762	6459	235	3/12/2014	2/1/2014
TMS RA SUC;WEYERHAEUSER 73 H	LA	30.9867897	-90.8063647	1709120145	AUSTRALIS TMS INC.	12709	5205	314	11/22/2011	11/1/2011
TMS RA SUD;B-NEZ 43 H 001	LA	30.9343474	-90.3656482	1710520053	Goodrich Petroleum	11460	6744	301	6/29/2015	6/1/2015
TMS RA SUJ;PAINTER ETAL 5 H 001	LA	30.9080894	-90.3270545	1711720247	Goodrich Petroleum	11601	5436	287		
VERBERNE 5 H	LA	30.8993482	-90.425371	1710520049	GOODRICH PETROLEUM	11729	6546	278	11/29/2014	11/1/2014
WEYERHAEUSER 14 H001	LA	30.9646235	-90.7828782	1709120148	GOODRICH PETROLEUM	12590	5733	293	6/25/2012	6/1/2012
WEYERHAEUSER 60 H	LA	30.9827314	-90.8255093	1709120147	AUSTRALIS TMS INC.	12713	7675	306	2/27/2013	2/1/2013
WEYERHAEUSER 60 H002	LA	30.9826842	-90.8254066	1709120150	AUSTRALIS TMS INC.	12607	4969	306	2/27/2013	3/1/2013
WEYERHAEUSER 72 H	LA	30.9629569	-90.7978784	1709120151	GOODRICH PETROLEUM	12491	5739	295	2/18/2013	2/1/2013
WEYERHAEUSER001	LA	30.9895257	-90.8233985	1709120137	AUSTRALIS TMS INC.	15079	1953	305	11/8/2008	11/1/2008
WILLIAMS 46 H	LA	30.9082369	-90.393426	1710520050	GOODRICH PETROLEUM	11614	6329	291	11/25/2014	12/1/2014
16700 TUSC RA SUH;DEN SPR C CL 001	LA	30.4920175	-90.9289257	1706320320	ORX RESOURCES, INC.	19000	6028	47	10/20/2014	10/1/2014
BERGOLD 29H 2 NO. 2	MS	31.02287	-90.63332	2300521123	AUSTRALIS TMS, INC.	11851	1572	314	12/18/2018	1/1/2019
STEWART 30H 1 NO. 1	MS	31.02273	-90.63332	2300521124	AUSTRALIS TMS, INC.	11801	6584	316	12/18/2018	12/1/2018
TAYLOR 27H-1 NO. 1	MS	31.02002	-90.68413	2300521121	AUSTRALIS TMS, INC.	11999	7251	331	3/24/2019	4/1/2019
WILLIAMS 26H 2 NO. 2	MS	31.02013	-90.68412	2300521122	AUSTRALIS TMS, INC.	12104	2566	331	3/26/2019	4/1/2019
WINFRED BLADES 001	LA	30.924581	-90.3775926	1710520007	EXCHANGE EXPL &PRODN CO	11590	572	317	5/26/1978	5/1/1978
Graves 37-1	MS	31.0981855	-91.080095	2315721993	AXIS ONSHORE, LP			403		

Table C.2 Drilling information of TMS wells.

Well name	Upper perf.	Lower perf.	Total fluid	Total additive	Total proppant
	ft	ft	bbl	lbs	lbs
Anderson 17H #1			305702	869174	14055269
Anderson 17H #2			281018	1041040	14199355
Anderson 17H #3			422517	1668130	18411048
Anderson 18H #1			283729	806700	13045016
Ash 13H #1			386277	1557841	17437292
Ash 13H #2			391814	1557467	29528223
Ash 31H #1			486576		
Ash 31H #2			447613		
Bates 25-24H #1			252494	1151387	10398414
BEECH GROVE 94 H 001	13952	19653	263462	1228760	11359417
BEECH GROVE LAND CO 68 H 001	14275	17013	73523	260670	2231623
BENTLEY LUMBER 32-001	11562	11704			
BENTLEY LUMBER 34 H001	11005	14954	80668		
Black Stone 4H #2			271483	898594	13930371
Bloomer #2H			243369	899288	11849655
B-NEZ 43 H002	12264	18191	277469	726005	11520795
BOE 1H			94048		
C.H. Lewis 30-19 #1H			356778	1472926	
CMR 8-5H #1			246925	448651	9045589
CMR Foster Creek 28-40 #1H			230538	688922	59847792
CMR Foster Creek 8H #1					
CMR Foster Creek 8H #2					
CMR/FOSTER CREEK 31-22H 1			316848	1396570	13192623
CMR-Foster Creek 20-7H #1					
CMR-Foster Creek 24-13H #1			314850	1353687	12517562
Creek Cottage West #1H					
CROSBY 12-1H 1			326937		
Denkmann 33-28H #2			277234	1244128	1841806
Dry Fork East Unit #2H			146717	814706	
DUPUY LAND CO 30 H001	11850	18115	295871	1497465	12455604
Fassmann 9H #1					
FRANKLIN PST PROP H	11885	17702	223769	1703039	13840598
GAUTHIER 14 H	14407	19091	222022		
George Martens, et al #2H			337374	1263602	13449627

Table C.2 Drilling information of TMS wells (cont.).

Horeseshoe Hill 10H			153110	2584937	7050420
Horsehoe Hill 11-22H #1			152862	576592	10285460
Huff 18-7H #1			216143	957907	7655925
JOE JACKSON 4-13H	12019	13426			
Joe Jackson 4H-2			111513	121825	3416606
KENT 41 H	12548	18521	186889	540443	9462591
KINCHEN 58 H	12266	18239	279908	793953	12081848
LAMBERT H-1	13614	14630			
LANE 64 001	14244	15130	6031	16231	283552
Lawson 25-13H #1					
Lawson 25H #1			143581	655853	6088492
Lewis 7-18H #1			386882	121608	417085
Longleaf 29H #1			299441	58185	187196
Longleaf 29H #2			272963	121490	294173
Lyons 35H #1			220035	72546	260552
Lyons 35H #2			197475	642901	8168202
Mathis 29-17H #1					
Mathis 29-32H #1			281865	63985	295612
McIntosh 15H #1			425493	631162	19358689
Morris 2H			355207	1915062	14986123
NUNNERY 12-1H 1			299295	1327064	12038419
PAUL 15 H	11682	16348	221891	1238234	8182996
Pintard 28H #1			233252	92274	343822
Pintard 28H #2			283074	1077230	11813207
Reese 16H #1	12743	18910	347551	536040	15862276
RICHLAND FARMS INC 74 H	13718	18146	94806	393523	2006177
RICHLAND PLANTATION A 001	13850	15900			
Rogers 1H			447210	2079843	74723895
S. D. SMITH 1H			291252	1046953	13226547
Sabine 12H #1			544321	1166040	16768181
Sabine 12H #2			401892	1217447	16480957
Shuckrow 10H #1			52132	101312	1698156
SLC INC 81 H	14358	21309			
Smith 5-29H #1			259166	765583	8977960
Spears 31-6H #1			169894	1344166	12596681
St. Davis Unit #1H			195893	1823464	11784486
T. Lewis 7-38H #1			274076	768478	11981046

Table C.2 Drilling information of TMS wells (cont.).

TMS RA SUA;BLADES 33 H 001	12064	17009	268625	1277401	10934971
TMS RA SUA;BROADWAY H 001	14059	19381	237076		
TMS RA SUA;DUPUY LAND CO 20 H 001	11980	16835	239687		
TMS RA SUA;MURPHY 63 H 001	14428	19170	109657		
TMS RA SUA;SOTERRA 6 H 001	13108	16829	91044		
TMS RA SUA;THOMAS 38 H 001	12383	17114	117585		
TMS RA SUA;WEYERHAEUSER 51 H 001	13361	19502	289588	1422062	10309524
TMS RA SUC;WEYERHAEUSER 73 H	12862	18019	127237		
TMS RA SUD;B-NEZ 43 H 001	11960	18452	300160	758923	12719117
TMS RA SUJ;PAINTER ETAL 5 H 001					
VERBERNE 5 H	12255	18801	197293	635248	9989933
WEYERHAEUSER 14 H001	12920	18653	153173	372477	8201998
WEYERHAEUSER 60 H	12550	20408	485503	1036030	19892690
WEYERHAEUSER 60 H002	12615	17584	204368	765977	9529340
WEYERHAEUSER 72 H	13102	16784			
WEYERHAEUSER001	14750	16703			
WILLIAMS 46 H	12172	18501	187624	571762	10009866
16700 TUSC RA SUH;DEN SPR C CL 001	17762	17946			
BERGOLD 29H 2 NO. 2			91679	495262	4207214
STEWART 30H 1 NO. 1			326230	1706796	14876911
TAYLOR 27H-1 NO. 1			321089	1533827	17023612
WILLIAMS 26H 2 NO. 2			125269	602081	6814067
WINFRED BLADES 001	11072	11644			
Graves 37-1					

Table C.3 Production information of TMS wells.

Well name	12 mo. Σ Oil	12 mo. Σ Gas	12 mo. Σ Water	24 mo. Σ Oil	24 mo. Σ Gas	24 mo. Σ Water	36 mo. Σ Oil	36 mo. Σ Gas	36 mo. Σ Water
	bbl	Mcf	bbl	bbl	Mcf	bbl	bbl	Mcf	bbl
Anderson 17H #1	98601	32472	66225	142372	46951	115646	161884	49274	153939
Anderson 17H #2	87268	37161	117071	111841	48066	148590	127106	53421	188797
Anderson 17H #3	53327	23268	86164	67909	27942	99771	79838	32412	132944
Anderson 18H #1	122217	37177	74509	167573	51571	121905	192275	53387	151794
Ash 13H #1	146759	246754	121033	205988	428028	215316	253213	641757	339143
Ash 13H #2	127757	69641	76468	179938	96732	111129	212372	114936	131150
Ash 31H #1	14691	7379	10608	20745	8751	11569	28488	10499	16045
Ash 31H #2	62212	38874	66926	83595	57292	90700	100688	63572	99047
Bates 25-24H #1	83126	34182	77841	109430	46541	121728	123451	53056	148733
BEECH GROVE 94 H	83730	55580	33863	115984	77954	43022	134249	96270	46975
BEECH GROVE LAND CO 68 H	9240	8558	8381	13576	15559	10750	15711	21357	12294
BENTLEY LUMBER 32-001	535	1728	4643	758	1728	5022	867	1728	5140
BENTLEY LUMBER 34 H001	6175	2221	37502	9556	4931	38986	12101	8193	39702
Black Stone 4H #2	68432	65093	109478	90114	88219	156600	103915	104248	207227
Bloomer #2H	47239	34891	24580	77408	67049	43745	96003	92518	54584
B-NEZ 43 H002	65315	17377	26431	81703	25129	29003	98833	35228	32475
BOE 1H	34753	12397	25639	44772	14650	32621	53156	15371	36359
C.H. Lewis 30-19 #1H	125320	53861	72840	179405	68320	120689	210966	87571	149197
CMR 8-5H #1	89077	35349	59105	116531	43630	78534	132446	51465	88126
CMR Foster Creek 28-40 #1H	82513	57769	65026	105292	75977	90481	117887	88202	99973
CMR Foster Creek 8H #1	73434	43828	38742	95651	62703	52310	105428	72353	58333
CMR Foster Creek 8H #2	85282	53715	96038	111223	71682	166823	132013	90997	183701
CMR-Foster Creek 31-22H #1	149068	126000	82456	215001	217589	174628	257751	293145	254355
CMR-Foster Creek 20-7H #1	58964	34371	47900	84050	46321	63279	96185	58503	80717
CMR-Foster Creek 24-13H #1	121639	83164	82573	167857	135460	136218	191887	162644	171210
Creek Cottage West #1H	47549	32969	49367	73737	56860	74566		0	
Crosby 12-1H #1	138264	91792	91767	187130	143064	157399	210865	183164	195456
Denkmann 33-28H #2	104638	41895	61836	135313	56142	84478	152081	63229	96303
Dry Fork East Unit #2H	47628	22264	22099	62167	32818	25235	71295	46050	27666
DUPUY LAND CO 30 H001	53832	38701	36612	73036	53233	46645	85885	59343	53102
Fassmann 9H #1	81803	76271	72566	105093	103702	152787	117606	122516	217337
FRANKLIN PST PROP H	75158	25050	20575	114495	50732	51357	136283	68237	70924
GAUTHIER 14 H	25174	24781	19667	31072	31231	22533	34945	35496	25485

Table C.3 Production information of TMS wells (cont.).

George Martens, et al #2H	72110	70147	67038	92934	97259	109116	102168	110220	132450
Horeseshoe Hill 10H	75679	43109	37156	102797	58194	57682	120743	66634	70062
Horseshoe Hill 11-22H #1	76303	107377	51766	104779	174338	70965	134185	231929	91471
Huff 18-7H #1	43935	15588	39883	58141	20031	55878	66916	25110	61386
Joe Jackson 4-13H	17922	0	3994	24662	0	5507	29155	0	6480
Joe Jackson 4H-2	27502	18428	100127	43197	41540	194527	55464	41749	217151
KENT 41 H	28902	7379	9239	33128	8173	9341	36615	8941	9531
KINCHEN 58 H	73308	24704	32970	97171	39136	43556	111064	49482	49160
Lambert H1	4452	0		6454	0			0	
Lane 64	59	0	59		0			0	
Lawson 25-13H #1	217814	59084	62863	318257	99440	164189	378392	118289	229091
Lawson 25H #1	75522	24673	44778	100890	34125	122064	115210	40778	129824
Lewis 7-18H #1	133365	42688	81678	184591	59548	115474	218915	71931	148894
Longleaf 29H #1	129838	42843	44237	189035	64562	82999	224073	77481	103897
Longleaf 29H #2	211163	86707	69248	316192	126223	99877	421099	172466	129331
Lyons 35H #1	61214	28066	21253	89238	49928	31130	105936	57248	45130
Lyons 35H #2	152755	89162	55137	211044	129169	100153	237667	142824	115379
Mathis 29-17H #1	189937	75784	116376	257162	105376	161657	298088	128497	190523
Mathis 29-32H #1	110717	47276	72303	151472	65551	91640	178049	78982	106266
McIntosh 15H #1	155338	98455	106754	219583	148509	186327	259246	202373	247094
Morris 2H	19273	16670	29107	27255	24292	35627	31776	26000	38633
Nunnery 12-1H #1	65711	15097	75404	92979	22601	107887	109094	29141	127526
PAUL 15 H	41499	27438	24589	61006	41554	30820	74577	50113	38571
Pintard 28H #1	47924	28027	21843	113014	58621	39737	157606	78444	59085
Pintard 28H #2	184949	63368	30594	247164	110235	62433	284068	152446	79739
Reese 16H #1	109495	69529	98257	153632	93047	141396	176542	111996	166129
RICHLAND FARMS INC 74 H	41183	32857	55108	64904	54005	60158	81257	64089	63898
RICHLAND PLANTATION A001	7293	0	2638	9569	0	2857	11171	0	2951
Rogers 1H	109407	92745	61505	147942	127674	95632	169908	146686	116040
S.D. Smith #1H	50205	62075	1968	70947	99448	3936	84366	137187	5904
Sabine 12H #1	150047	86094	106272	221048	120049	238099	261105	138919	343099
Sabine 12H #2	164512	74649	77477	237788	110528	132134	280983	135663	169070
Shuckrow 10H #1	116387	142130	96170	152522	208338	128725	170341	245912	148233
SLC INC 81 H	77198	67834	56668	101362	93430	74907	115567	107304	90577
Smith 5-29H #1	96764	30158	53907	130931	39710	80391	146052	46290	89722
Spears 31-6H #1	120090	36451	90065	159067	50116	134608	181214	59332	165736
St. Davis Unit #1H	106423	53316	25424	145886	76705	40196	169003	89624	47883

Table C.3 Production information of TMS wells (cont.).

T. Lewis 7-38H #1	68763	30725	53283	88450	45461	67313	99258	55185	73651
TMS RA SUA;BLADES 33 H 001	135431	30519	61627	195063	44888	82540	236266	55291	94011
TMS RA SUA;BROADWAY H 001	3233	7551	2154	4098	15988	3362	4514	21180	3613
TMS RA SUA;DUPUY LAND CO 20 H 001	51407	32689	27691	66798	39567	34353	76977	44033	36182
TMS RA SUA;MURPHY 63 H 001	35548	37379	22258	54047	88574	34775	65620	130535	43714
TMS RA SUA;SOTERRA 6 H 001	23660	11605	6223	33554	17079	11636	39447	20912	14120
TMS RA SUA;THOMAS 38 H 001	54032	19400	13476	85020	30903	33627	102659	35755	59499
TMS RA SUA;WEYERHAEUSER 51 H 001	31452	16855	24930	52455	27713	36702	65233	34051	38367
TMS RA SUC;WEYERHAEUSER 73 H	71586	28159	27592	94079	37013	42324	104519	40882	85837
TMS RA SUD;B-NEZ 43 H 001	60775	10502	18763	92513	24132	23683	117038	36324	25708
TMS RA SUJ;PAINTER ETAL 5 H 001	0	0			0			0	
VERBERNE 5 H	124493	29119	31834	182769	43521	42047	225007	55426	49172
WEYERHAEUSER 14 H001	74103	38563	16518	110486	56715	25912	128702	63749	38711
WEYERHAEUSER 60 H	93183	30370	19432	130151	44929	71938	153768	52578	71938
WEYERHAEUSER 60 H002	83456	27357	27948	127293	43623	35291	150036	51086	40162
WEYERHAEUSER 72 H	38736	19289	3902	52296	25005	12601	58465	28445	20950
WEYERHAEUSER001	21884	0	7467	27105	0	8503	30483	0	8503
WILLIAMS 46 H	133996	29938	25071	197427	51027	32557	236138	65147	38486
16700 TUSC RA SUH;DEN SPR C CL 001	31191	375514	11667	40464	514677	54539			
BERGOLD 29H 2 NO. 2	21737	15694	14714						
STEWART 30H 1 NO. 1	181367	66229	96459						
TAYLOR 27H-1 NO. 1	136507	61927	75072						
WILLIAMS 26H 2 NO. 2	52864	15541	27826						
WINFRED BLADES 001	1732	12	62	3048	24	309			

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