Oil & Gas Research

Bird, Oil Gas Res 2022, 8:9

Research Article Open Access

Analyzing API Gravity, Pour Point, and Paraffin Content of Tuscaloosa Marine Shale Wells in Amite and Wilkinson County, Mississippi

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Received: 13-Sep-2019, Manuscript No. M-2460; **Editor assigned:** 19-Sep-2019, PreQC No. P-2460; **Reviewed:** 04-Oct-2019, QC No. Q-2460; **Revised:** 24-Aug-2022, QI No. Q-2460; Manuscript No. R-2460; **Published:** 22-Sep-2022, DOI: 10.4172/2472-0518.1000260

Citation: Bird A (2022) Analyzing API Gravity, Pour Point, and Paraffin Content of Tuscaloosa Marine Shale Wells in Amite and Wilkinson County, Mississippi. Oil Gas Res 8: 9.

Abstract

Background: This research report provides the background, sampling techniques, and laboratory analyses results of an extensive research undertaking of oil wells producing crude oil in the Tuscaloosa Marine Shale. This research was completed for the benefit of the Tuscaloosa Marine Shale Laboratory on behalf of the University of Louisiana at Lafayette.

Results: Laboratory analyses in this research report include API gravity, pour point, and paraffin wax content. The results of this research give quantitative results that are graphed out for easy interpretation. These results will provide a baseline for monitoring the crude oil as the wells mature and as new wells are introduced in the Tuscaloosa Marine Shale.

Conclusion: This research report shows evidence that a well drilled and completed in the Tuscaloosa Marine Shale should be a very predictable oil. The laboratory analyses proved that even though the wells were sampled at different geological location, the crude oil showed very similar results in the laboratory analyses.

Keywords: Tuscaloosa marine shale; Paraffin wax content; Heavy weight oils

Introduction

The purpose of this report is to provide the results of laboratory analyses on the crude oil being produced in the Tuscaloosa Marine Shale for the benefit of the Tuscaloosa Marine Shale Laboratory. The data obtained from the analyses can be used to compare oil being produced in different zones and at different geological locations. The data can also be used to predict many problems in the future production of the Tuscaloosa Marine Shale crude oil. The Tuscaloosa Marine Shale is an oil and gas play that covers a big area, stretching from Southwest Mississippi to the middle of Louisiana. “The TMS is the middle of the three units, conformably overlying the basal Lower Tuscaloosa and situated beneath the upper tuscaloosa. The Tuscaloosa Marine Shale has been speculated to have a potential reserve of 7 billion barrels of oil. These reserves are hard to produce with conventional wells but with the use of horizontal drilling, production can be maximized. This study was undertaken because there was a lack in current oil property studies. The properties of a crude oil are a big factor in the production of the oil and should not be overlooked. This report focuses on the sampling and analyses of 11 producing wells that target the Tuscaloosa Marine Shale. Samples were taken from the west and east side of Liberty, Mississippi. These wells are owned and operated by the Goodrich Petroleum Company, with Liberty, Mississippi being the headquarters for their operations in the Tuscaloosa Marine Shale. The analyses conducted in this research are API gravity, pour point, and paraffin wax content (Figure 1).

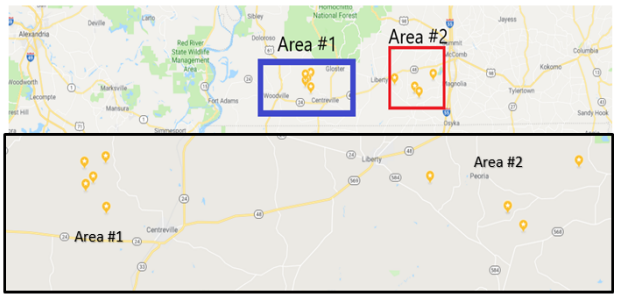

Figure 1: Map of the wells sampled labeled Area 1 and Area 2.

Background

Crude oil has many characteristics that can be analyzed for multiple reasons. Three key properties of a crude oil included API gravity, pour point, and paraffin wax content. Knowing these three properties of the oil will give a person a great understanding of how to produce the oil, how much it will cost to produce the oil, and how to increase production on the oil. When these analyses are performed on multiple wells within a geographical region, you can correlate the oils to a certain production zone. The Mississippi State Oil and Gas Board has a schematic drawing that shows depth, zone, and location of every well in Mississippi. An example of this schematic, for well CMR-Foster Creek 20-7H. In the picture you can see the depth of the vertical, depth

of the horizontal, and the zone that the well produces from. On the Mississippi State oil and gas board website, the drawing is interactive shows the multiple zones below and above the wellbore (Figure 2) [1].

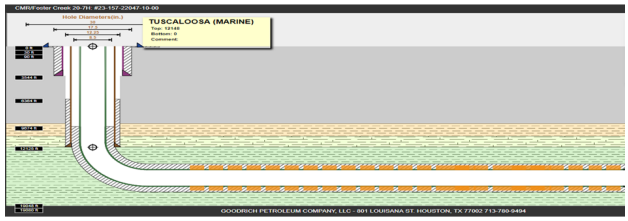

Figure 2: Schematic drawing of a wellbore in the Tuscaloosa Marine Shale. Note: :Surf; : Cond; : Inter; : Linear; : Prod; : Tube

Paraffin wax molecules are straight-chain alkanes that contain more than 15 carbon atoms and have very little branching". These paraffin molecules can cause trouble in a production system, but the paraffin problems have many other factors such as: Temperature, pressure, and flowrates. Pictures are provided below, in a pipeline filled with paraffin before chemical treatment and then after a costly chemical treatment. "Paraffin deposits form on the wall of downhole tubulars and in low-velocity zones near entrances and exits of chokes, collars, or similar restrictions in the flow path. Costly preventive chemical treatments or remedial preventive chemical treatments or remedial workover procedures are required to cut away the paraffin deposit with mechanical knives or scrapers, as an alternative, hot oil can be used to melt these deposits". Knowing the paraffin wax content of the crude oil will help with predicting production problems (Figure 3) [2].

Figure 3: Pipeline congested with paraffin (left) and then after remedial chemical treatment (right).

API gravity is measured as the inverse of the density of a petroleum liquid relative to water. The higher the API gravity, the lower the density of the petroleum liquid, so light oils have high API gravities". API gravity is used to categorize crude oil into light, medium, or heavy weight oils. Geary states that "API gravity is one of the key characteristics of crude oil that, along with other characteristics such as sulfur content, is used by refiners when evaluating different crude streams for processing into petroleum products". Knowing the API gravity of oil can help track the production of oil to ensure the oil's properties are not changing as the well matures. Pour point of a crude oil is the "temperature at which a fluid ceases to pour". A pour point analysis is important because the operating temperatures may be below the pour point in some cases. According to Schlumberger, "High pour points usually occur in crude oils that have significant paraffin content. Paraffins (or waxes) will start to precipitate as temperature decreases". If a crude oil pour point is above the operating temperature, there will need to be chemical or thermal treatment to make sure that the oil keeps its fluid-like consistency. This problem would lead to a more costly production operation [3,4].

Materials and Methods

The methods used in the analyses are: ASTM D4052-11 ("ASTM D4052-11", 2019) for API gravity, ASTM D5853-11 ("ASTM D5853-11", 2019) for pour point, and a proprietary low temperature extraction developed and used by Infinity Energy Solutions for paraffin wax percent. Experiments for API gravity and pour point can be repeated by following the ASTM standards. The units for API gravity will be referred to as degrees but is mathematically unit less. The pour point analysis is analyzed in degrees Celsius but is then converted to degrees Fahrenheit. The paraffin wax content is a weight/weight percentage. All samples taken in the field were pulled from the heater treater oil dump after being circulated to retrieve a fresh sample. A picture of a heater treater used by the goodrich petroleum company is provided in Figure 4 and a close-up of the sample point valve in Figure 5. The amount of crude oil sampled was around 600 milliliters but only 100 milliliters was needed for these laboratory experiments. The remaining amount of oil was given to the Tuscaloosa Marine Shale Laboratory to hold for future experiments if needed (Figure 6). The sampling of the oil was taken and labeled with the proper well name on it, with labels on both the glass bottle and metal cap. Mr. Dan Melander, an operator for the Goodrich Petroleum Company, was also interviewed for information on wells being produced by the goodrich petroleum company [5-7].

Figure 4: Example of a goodrich heater treater.

Figure 5: Valve for heater treater oil dump.

Figure 6: Oil samples as taken in the field.

Results

The results of the laboratory analyses are provided in the table below. The data is correlated to the appropriate well. The data is also organized in bar graphs for easy interpretation of each analysis. Below the table and graphs of the laboratory analysis are the current average production numbers per day for each of these wells, provided by Goodrich Petroleum Company. The unit mcf stands for one thousand cubic feet. Wells 1-6 are located in the western part of the crude oil sampling (Area #1), and wells 7-11 are located on the eastern side of the sampling (Area #2). The median analyses numbers for all 11 wells are: 41.1 API Gravity, 6.63 percent paraffin wax content, and 23.8°C fahrenheit pour point. For the mathematics, the median takes into account a number of -4°C Fahrenheit for pour point, where the real number is less than -4 degrees. The median numbers for wells 1-6 (Western) are: 41.93, 6.10, and 18.5 respectively. The median numbers for wells 7-11(Eastern) are: 40.12, 7.26, and 30.2 respectively. These numbers show a slight trend but are not strong enough for substantial evidence. To obtain complete knowledge of the crude oils being produced in the Tuscaloosa Marine Shale would be nearly impossible. This research and report present the analyses in a simple manner that is easily to analyze and correlate to other data. The research presented in this report was limited by a few factors including; physical sampling of the oil, cost and length of the laboratory analyses, limited equipment, and proprietary rights. The findings of the analyses could have also been affected by the production chemicals, provided by Baker Hughes, pumping at the time of sampling (Table 1). A list of the chemical name and numbers are listed along with the well system they are pumping into. This is an unavoidable event due to the nature of the production system and the proprietary information [8,9].

Well #	Well Name	Baker Hughes Chemicals
1	CMR-Foster Creek 8H#1	SCW-4058, CRW-9239
2	CMR-Foster Creek 8H#2	SCW-4056, CRW-9239
3	CMR- Foster Creek 20-7H	SCW-4058, CRO-9159, PAO 30
4	CMR-Foster Creek 24-13H #1	SCW-4058, CRW-9239
5	CMR- Foster Creek 31-22H #1	SCW-4058, CRW-9239, PAO 30
6	Crosby 12-1H #1	SCW-4056, CRO-9159
7	Huff 18-7H #1	SCW-4058, CRO-9159
8	Spears 31-6H #1	XC- 137, SCW-4058, CRW-9239
9	C.H. Lewis 30-19#1H	XC- 137, SCW-4058, CRW-9239, PAO 30
10	Smith 5-29H #1	SCW- 4058, CRO-9159
11	Nunnery 12-1H #1	SCW-4058, CRW-9239, PAO 30
Note: Wells located in western part		

Table 1: List of production chemicals on each well.

Discussion

The laboratory numbers do not show a strong trend for geographical locations of the wells, but will be discussed with information retrieved from an interview with Mr. Dan Melander. The findings from the laboratory analyses show that the crude oil being produced in the Tuscaloosa Marine Shale should be a typical oil to produce and requires nothing special due to API gravity, pour point, and paraffin content. The numbers are all in a general range for API gravity and paraffin content, but do show a vast range in pour point. According to the Mississippi State Oil and Gas Board, the well Spears 31-6H #1 is vertical, while all the rest are horizontal wells. The mississippi state oil and gas board also shows that the C.H. Lewis 30-19#1H is drilled into the Lower Tuscaloosa formation but nothing from the analyses shows different numbers compared to the Tuscaloosa Marine Shale. In an interview with Mr. Dan Melander of the Goodrich Petroleum Company, he mentioned that a well in Kentwood, Louisiana is a big paraffin wax producer. Kentwood is located southeast of the farthest east sample that was taken in this research. With Mr. Melander's information taken into account, that may shift the analyses from not showing much geographical correlation, to the eastern half of sample location having a higher paraffin percent and higher pour point. This may be a point for further research and discussion. The well Nunnery 12-1H #1 attracts attention to it because it has the highest pour point, highest paraffin content, and

lowest API gravity (Table 2). More investigation would need to take place to understand if the oddity of the low API gravity has a correlation to high paraffin content and pour point. Due to the proprietary factor of the chemicals being pumped into the production system, there would need to be more knowledge of the chemicals to understand if they affected the laboratory results. The numbers analyzed in the experiments lead to show that the crude oil is being sourced from the same shale play (Figures 7-9) [10].

#	Well Name	API	Paraffin content	Pour point °F
1	CMR-Foster Creek 8H #1	41.7	5.92	<-4
2	CMR-Foster Creek 8H #2	42.3	6.92	<-4
3	CMR-Foster Creek 20-7H	43.2	5.05	6.8
4	CMR-Foster Creek 24-13H #1	41.9	6.17	33.8
5	CMR-Foster Creek 31-22H #1	40.2	6.67	35.6
6	Crosby 12-1H #1	42.3	5.84	42.8
7	Huff 18-7H #1	40.6	5.76	28.4
8	Spears 31-6H #1	40.2	5.74	<-4
9	C.H. Lewis 30-19 #1H	40.7	8.25	44.6
10	Smith 5-29H #1	40.3	7.54	35.6
11	Nunnery 12-1H #1	38.8	9.02	46.4
Note: Wells located in western part.				

Table 2: This may be a point for further research and discussion. The well nunnery 12-1H #1 attracts attention to it because it has the highest pour point, highest paraffin content, and lowest API gravity.

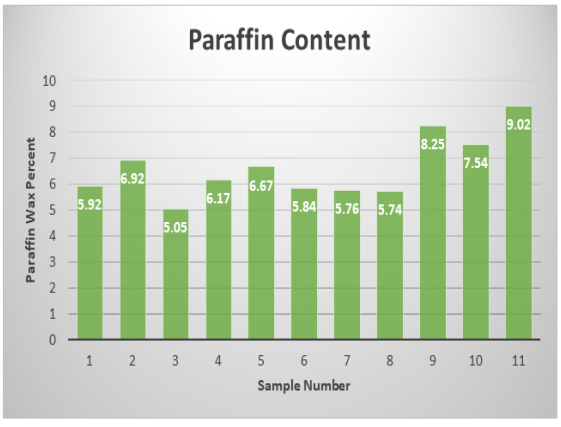

Figure 7: Paraffin content.

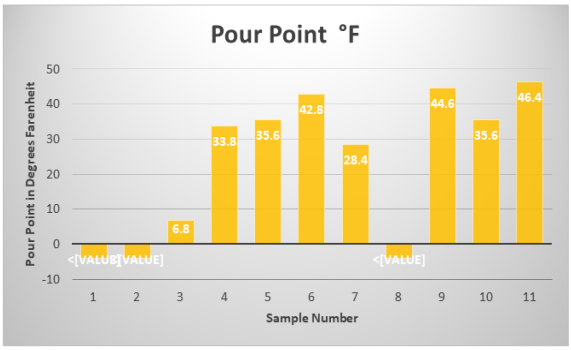

Figure 8: Pour point.

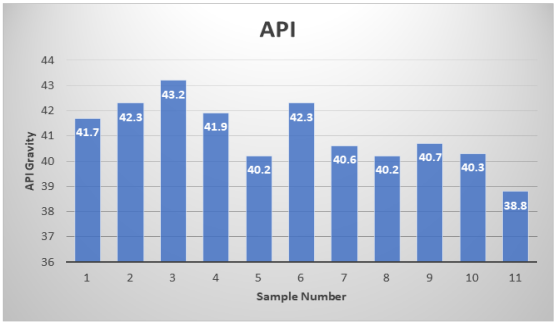

Figure 9: API gravity.

Conclusion

The findings from this report give current baseline numbers for the oil being produced in the Tuscaloosa Marine Shale. The crude oil is light oil that does not show any abnormal properties. The recoverable reserves that are predicted in the Tuscaloosa Marine Shale can be produced, stored, and transported like any other light oil with the right equipment. The results from the study show that the Tuscaloosa Marine Shale should produce a crude oil with an API gravity between 38-44 with a relatively low paraffin content and pour point. With just the 11 wells sampled in the study, the geographical location of the wells cannot predict the properties of the oil. States that the mineralogy and organic content within the TMS is heterogeneous from well to well, which is the case with this research also. If Mr. Dan Melander's information is taken into account and the crude oil from Kentwood has a high paraffin wax content and high pour point, it shifts the trend to a much higher paraffin content and higher pour point in the eastern wells.

Recommendations

Now that there is a study done on the oil being produced in the Tuscaloosa Marine Shale, researchers and students can use this information as an aid in their experiments. Future studies on the oil can use these numbers as a baseline as new wells are drilled and the current wells mature. Future studies on the crude oil should include the depth that the oil is being produced from, the mechanical actions that influence the oil production, and possibly obtaining chemical-free samples. Future studies could also possibly include why there is a vast difference in pour point between the oil and not a vast difference in the other numbers. Another possible study that can be done is the

sampling of the oil in Kentwood, Louisiana. With the Kentwood information included in this study, it would map out a much bigger region of the producing wells in the tuscaloosa marine shale.

Acknowledgements

I would like to thank the following companies and people for helping in my research. Goodrich Petroleum Company, Infinity Energy Solutions, Mr. Dan Melander, Mr. Kevin Gibbs, Dr. Mehdi Mokhtari, and Dr. Gholam Massiha.

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