Insights into Oil Reservoir Characteristics: Analyzing Viscosity Parameters through Correlations

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Abstract **- Knowing the properties of the formation fluid is of particular practical importance for solving a number of problems related to the filtration process as well as choosing the best processing methods to ensure high oil recovery coefficient at low cost. [2] An important property that affects the flow of oil through porous media is viscosity. The main objective of this paper is to determine the temperature-dependent viscosity through correlations and descriptive statistics for the data obtained from the samples extracted for each oil-bearing formation from the wells of the Patos-Marinez reservoir in Albania. The data for the development of this study were obtained from the history of processing and exploitation of the Patos-Marinez area. The results so far for viscosity in this field are quite satisfactory because they directly affect the selection of methods of action in the layer for increasing the oil recovery factor.**

Keywords—Correlation, oil viscosity, oil recovery factor, Patos-Marinez oilfield.

I. INTRODUCTION

The Patos source area was discovered in 1928 by APOC (Anglo Persian Oil Co.) and in 1957 the Marinza field was discovered. The field of Patos-Marinëz is located in the central-southern part of Albania, east of the city of Fier. [1] Oil production began in 1939 and to date about 2550 vertical wells and 435 horizontal wells have been drilled. Production in this field until February 2014 was estimated at 3198 m^3/*day* from 450 active wells. [1] In 2004 Bankers Petroleum Albania Ltd receives the Hydrocarbon Agreement to operate in the Patos-Marinze field.

Figure 1. *The oilfield of Patos-Marinëz in Albania*

The field dips as a monocline with an angle of 12°-13° in the North-West direction and is interrupted in the southern area of the concession. The reservoir areas are abundant Upper Miocene sandstones that were deposited as deltaic sandstones and grass-type sandstones. [1] In this area, four main oil-bearing formations are distinguished: Gorani, Driza, Marinza and Bubullima. The Goran formation is located at a depth of 1000-1200 m, it consists of sandy layers separated by clay. The best oil bearing zones within this formation are G_5 and G_6. The viscosity of the oil in this formation fluctuates between values of 8000-30000 *cp*. [1] The Driza Formation at a depth of 1200-1450 *m* is the largest hydrocarbon reservoir in the Patos-Marinez field Figure 2. This formation is composed of 3 complex sandy formations, namely: $D_1, D_2^0, D_2, D_3, D_4, D_5$, which are separated by clay of different thicknesses. [1] The Marinza Formation, located at a depth of 1450-1800 m, consists of pure fine- to medium-grained sandstones alternating with calcareous clay. The viscosity of the oil in the Driza formation varies between 100-1000 cp. The Bubullima Formation is the deepest well formation located at a depth of over 1800 m. It consists of oil with a viscosity of less than 100 cp. [1]

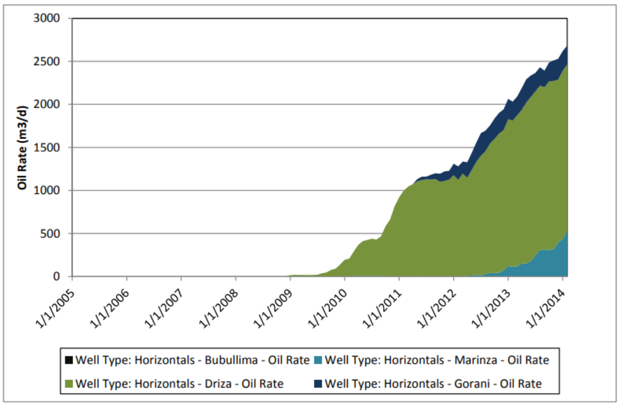

Figure.2 *Production for each Formacion- Horizontal Wells of the Patos-Marinez field in Albania [1]*

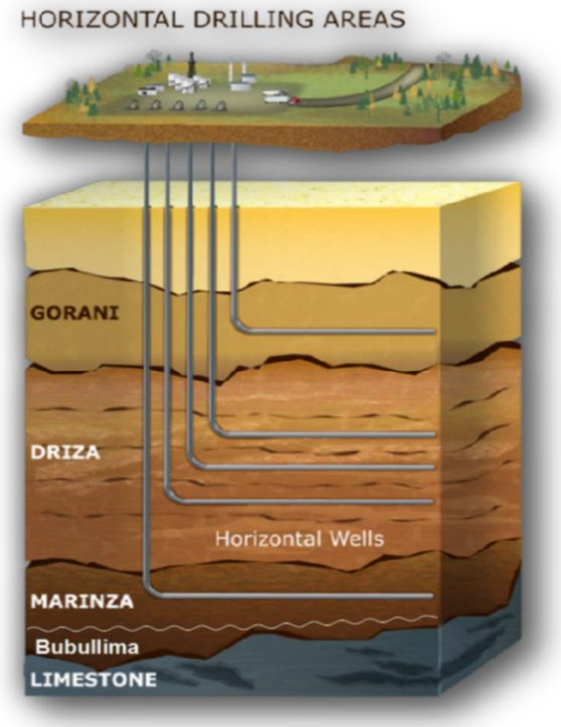

Figure.3 *Profile of horizontal wells in the Patos-Marinez reservoir in Albania*

The thickness for each formation is shown in Figure 3 through the profile of horizontal wells ranging from 200 m to 3200 m depth. However, not all sandstone levels are saturated with the same quality and quantity of oil. This is influenced by a number of factors, the most important of which are the properties of the reservoir fluid. In this paper, the study of the viscosity of the oil layer as a function of temperature at the Patos-Marinez location. [2] Density expressed in API and viscosity varies by area, shallow formations being usually and oil-bearing formations heavier. Next, a program to drill a vertical stratigraphic well focusing on the formation of heavy oil sands, which is more common in the southern area of the reservoir, is envisaged to better understand the characteristics of the reservoir.

I.I Literature review

Many mathematical relationships are proposed in Table 1 for estimating the viscosity of degassed oil in reservoir engineering. In 1946 Beal developed a correlation for determining the viscosity of degassed oil as a function of temperature. [5] This correlation was developed for 753 measured viscosity values for Mexican crude oil. Another correlation was developed by Beggs and Robinson in 1975 for determining oil viscosity. [8] The correlation was derived from the analysis of 460 oil viscosity measurements, which resulted in a mean error of -0.64% and a standard deviation of 13.53% when the test data was used in this correlation. Later it was Glaso who proposed a mathematical relationship to calculate the viscosity of degassed oil as a function of temperature. The relationship was developed for [7] experimental measurements on 26 oil samples taken in the field and can be used within the range of 50-300°F for the temperature parameter. From the tests performed, it was concluded that Glaso's correlation showed very good accuracy in relation to the above correlations. [7], [8], [9], [11],

	Correlation	Coefficient
Beal	$\mu_{nd} = \left(0.32 + \frac{1.8(10^7)}{API^{4.53}}\right)\left(\frac{360}{T-260}\right)^a$	$a = 10^{(0.43+8.33/API)}$
Beggs and Robinson	$\mu_{nd} = 10^x - 1$	$x = Y(T-460)^{-1.163}$ $Y = 10^Z$ $Z = 3.0324 - 0.02023\ {}^0API$
Glaso	$\mu_{nd} = [3.141(10^{10})](T-460)^{-3.444}[\log(API)]^a$	$a = 10.313\ [\log(T-460)] - 36.447$

TABLE 1. CORRELATIONS FOR THE ESTIMATION OF OIL VISCOSITY AS A FUNCTION OF TEMPERATURE

II. METHODOLOGY

The data for the performance of the work were obtained from the oil company Bankers Petroleum Albania Ltd. In this study, the correlations used to calculate oil viscosity, which is expressed by equation 1. To evaluate this parameter, descriptive statistics is used, as a statistical method that is widely applied in geosciences. For the data we received in the study, a histogram was built for each of the four main oil-bearing formations of the source, as well as statistical indicators such as: Average, Average and Standard Deviation were calculated.

To determine the viscosity of oil at the surface, Bankers has taken measurements in many of the horizontal wells drilled to date. [1] The viscosity of oil at the surface has been measured at different temperatures and ambient pressure in more than 50 samples per month. Measurements of oil viscosity at the surface, according to the corresponding API gravity, and estimates of reservoir temperature and pressure were used to calculate oil viscosity at reservoir conditions using the following correlation: [5], [10]

The correlation used when the viscosity of degassed oil takes values in the range 700*cp*-10000*cp* is:

$$\mu_0 = e^{[-a(lnp)^2+b(lnp)+c]} \qquad (1)$$

where: *a*, *b* and *c* are coefficient defined by the following expressions:

$$a = 6.393*10^{-12}(\mu_{od})^2 - 4.823*10^{-7}*\mu_{od} + 0.1786$$

$$b = 7.793*10^{-11}(\mu_{od})^2 - 6.241*10^{-6}*\mu_{od} + 1.5254$$

$$c = -2.487*10^{-10}(\mu_{od})^2 + 3.3359*10^{-5}*\mu_{od} + 3.991$$

μ_0 -oil viscosity below saturation pressure, cp

μ_{0d} - viscosity of degassed oil, cp

p- the pressure, psi

III. RESULTS AND DISCUSSIONS

The statistics and results for oil viscosity in the reservoir conditions are reflected in Table 2, respectively for the Gorani, Upper Driza (D_1, D_2^0, D_2), Lower Driza (D_3, D_4, D_5) and Marinza formations.

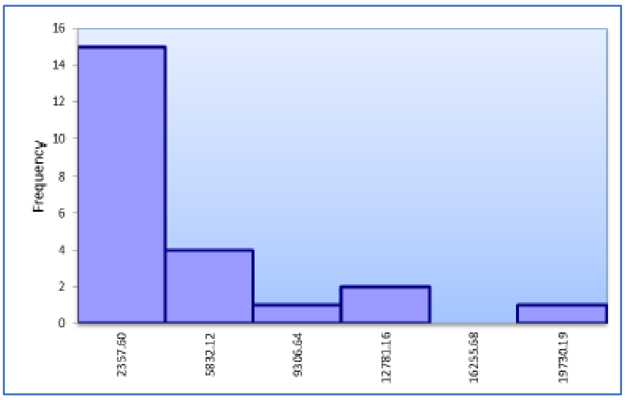

Figure 4. *Histogram for oil viscosity data in the Gorani formation (by the author)*

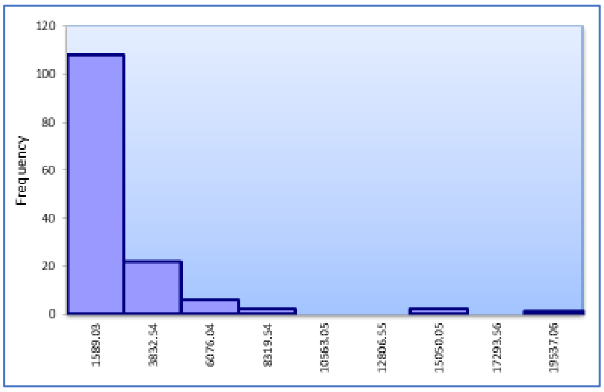

Figure 5. *Histogram for oil viscosity data in the Upper Driza formation (by the author)*

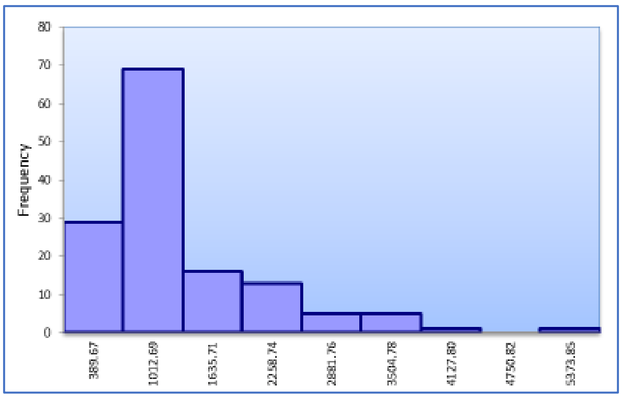

Figure 6. *Histogram for oil viscosity data in the Lower Driza formation (by the author)*

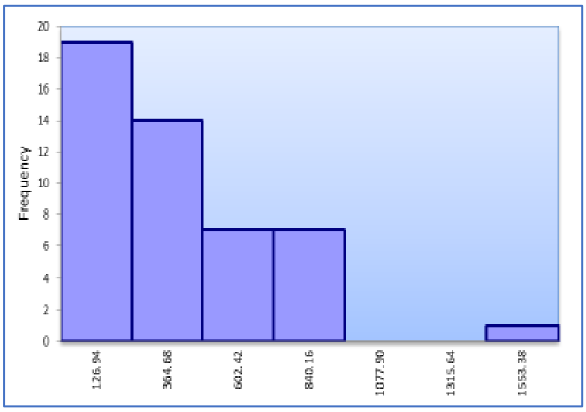

Figure 7. *Histogram for oil viscosity data in the Marinza formation (by the author)*

In the above histograms for the viscosity data measured in the wells for each formation it is noted that there is a left asymmetry of the data and from this representation we obtain the following statistical indicators:

Formation	***Mean***	***Median***	***Standard Deviation***
Gorani	5057	1949	5600
Upper Driza (D_1, D_2^0, D_2)	2544	2050	2492
Lower Driza (D_3, D_4, D_5)	1281	926	885
Marinza	390	335	325

Table 2. Statistical indicators of viscosity for the main formations in the Patos-Marinza field

The median, as the middle point of the observed values, shows that half of the viscosity values measured respectively in the Driza, Goran and Marinza formations are below the average and half of the values are above the average. Also, from the results of Table 2, it can be seen that the oil of the Marinza formation is lighter than the other formations. For this reason, oil viscosity at reservoir conditions is more sensitive to temperature and pressure and the determination for this oil is less certain than for heavy oils. Thus, the heavy oil in the Goran formation has a wider viscosity distribution at reservoir conditions.

As stated above, the properties of the oil from this reservoir indicate that it is a non-Newtonian fluid. [3] Non-Newtonian fluids differ from Newtonian ones because the flow curve expressing the dependence of the strain rate on the tangential tension is not a straight line passing through the origin, but a curved line. [3] Non-Newtonian fluids, depending on the tangential tension acting on them, present different states of structures. From the results of the oil analysis obtained in different wells of the Driza suite, carried out in the rotary viscometer, it is clearly stated that the dependence between the tangential tension and the degree of deformation speaks of the existence of an initial displacement pressure on which oil movement becomes sensitive and increases proportionally with the tangential tension acting in the direction of movement.[3]

Another very important factor affecting oil viscosity is the thermal effect. This is quite clear in the dependence of viscosity on temperature μ =f(t), Figure 8 and Figure 9 where for relatively small increases in temperature we have an immediate decrease in viscosity.

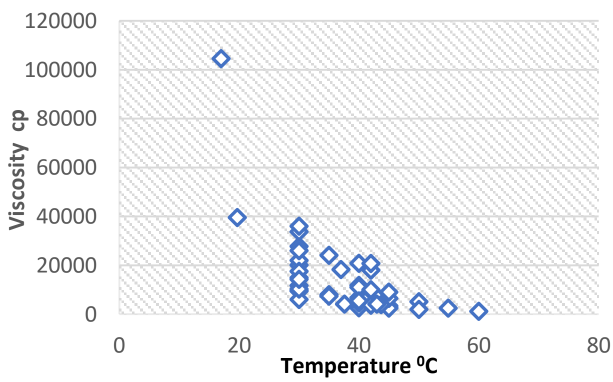

Figure 8. Viscosity of oil with not destroyed structure as a function of temperature μ =f(t), (by the author)

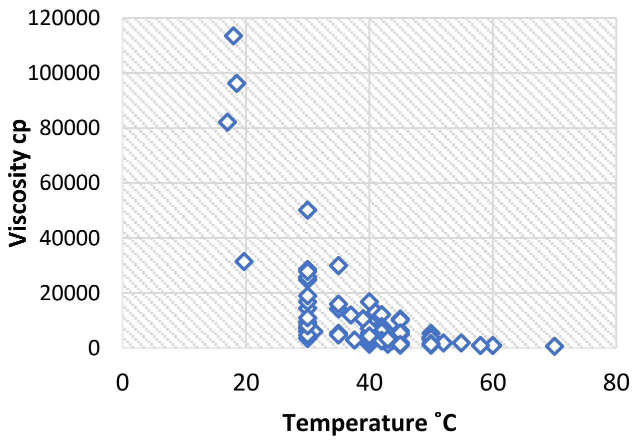

Figure 9. Viscosity of oil with a destroyed structure as a function of temperature μ =f(t), (by the author)

As shown by the destroyed structure oil viscosity graph Figure 8 measured experimentally in well **735**, the oil viscosity drops from 27850 cp to 5500 cp for increasing temperature from 30˚C to 45˚C. This effect is even more sensitive to the viscosity of oil with intact structure Figure 7. Thus, in this well, increasing the temperature from 42 ˚C to 45 ˚C means that the viscosity of intact oil decreases from 20718 cp up to 9000 cp. In the sand model, several experiments were carried out with the oil obtained from wells **520** and **735** to study the filtration of this oil under the conditions of the formation in the presence of dissolved gas in different amounts.

IV. CONCLUSIONS

Correlations for reservoir oil viscosity estimation are important and well known in the petroleum field because they are directly related to oil filtration in porous media. The accuracy of these empirical methods is limited by the accuracy with which the properties of the liquid placed in the layer are determined.

The study of the oil viscosity parameter serves to predict the progress of a well throughout its entire period of exploitation.

Oil viscosity is a parameter that is influenced by a large number of factors, but from the data observed in the Patos-Marinza well, we notice that with the increase in temperature, the viscosity value decreases significantly for each of the formations of the well.

Also, this parameter affects the selection of the best methods of action in the layer to increase the coefficient of oil extraction with the lowest possible cost for the company Bankers Petroleum Albania Ltd.

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