THE RELATION OF INITIAL PRODUCTION TO TRUE RESISTANCE IN THE SOUTHEAST NEWCASTLE FIELD, CLEVELAND AND McCLAIN COUNTIES, OKLAHOMA

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Resistance may be defined as the property of a conductor which determines the current produced by a certain difference of potential. It is a function of the shape, the dimensions, the texture and composition, and the temperature of the conductor.

Electric logs present curves known as resistance curves, which are obtained by the application of a current flowing from a source electrode, through a formation or bed, to other pick-up electrodes placed within the bore hole. Since it is extremely difficult in electric log interpretation to determine the dimensions of the bed or medium under investigation, the specific resistance, or true resistance, is generally considered. Specific resistance, hereafter called true resistances, is the resistance of a portion of the medium having a unit length and unit cross section, measured at zero degrees centigrade. True resistance is therefore independent of the shape and dimensions of the medium, and is specifically dependent upon the composition and content of the medium.

True resistance then may be defined as the intrinsic or real resistance of the medium, and is independent of the manner in which the electrical measurements are made. The apparent resistance, which is the curve shown on an electric log, is not only a function of the true resistance, but is also affected by the specific electrode arrangement used in the bore hole, and by the resistance of adjacent beds, among many other factors. The usefulness of the true resistivity value lies in the fact that is free from, or independent of the manner of electrode spacing and arrangement.

Much work has been done on the application of resistance data to electric log interpretation. Most petroleum geologists are familiar with the excellent papers written by Guyod, Jones, Pirson, Doll, Legrande and Stratton, and other writers too numerous to mention. Several methods have been devised to enable the petroleum geologist to obtain a close approximation of the true resistance value for use in the interpretation of electric logs. Each method has its practical applications, and also its limitations. For the purposes of this study, the method outlined by Guyod (1945) was chosen. It is particularly applicable because the beds under survey in this field were at least twice as thick as the electrode spacing, and little or no data of the type used in other methods of true resistance determination were available.

The true resistivity of the bed under investigation was determined as shown in Figure 2.

The use of true resistivity has been mainly one of correlation with other factors such as porosity, the mud resistivity, the amount of cementation, and the saturation factor. It is the purpose of this paper to determine whether the true resistivity value alone could be used in determining the initial production from the Bois d'Arc limestone in the Southeast Newcastle Field.

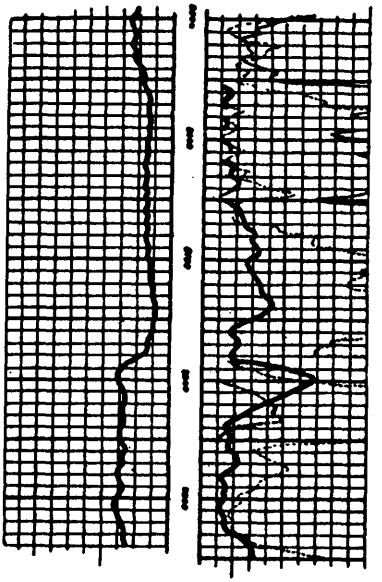
In this field, there are 13 oil wells and 5 dry holes. Of the 13 oil wells, production data on only 6 wells could be used. The other wells could not be used for various reasons. In one instance the log was unable to penetrate to the bottom of the hole, and in the others, testing had not been completed.

In the oil wells, the true resistivity value varies from 950 ohm meters to 2400 ohm meters, with one exception. One well is producing with a true resistivity value of only 240 ohm meters. In those wells that are dry holes, the true resistivity value varies from 362 ohm meters to 937 ohm meters.

Figure 1 illustrates the resistivity curves of a producing well and a dry hole.

PRODUCING

Berry Estate No. 1 NW SW NW Sec. 32-9N-3W McClain Co., Okla.

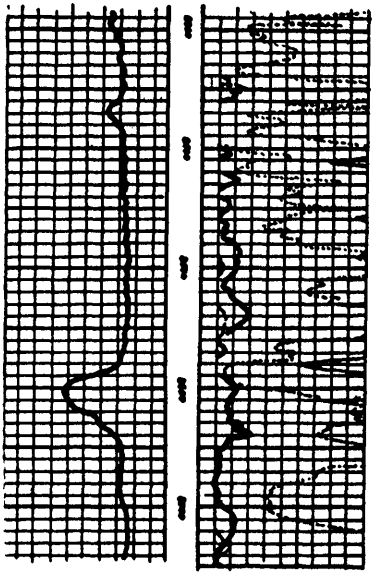


True Resistance 1950 ohm meters

Apparent Resistance 2475 ohm meters

NON-PRODUCING

Ben Arnold No. 1 C SW SE Sec. 13-9N-4W, McClain Co., Okla.



True Resistance 425 ohm meters

Apparent Resistance 545 ohm meters

FIGURE 1. Comparison of Producing and Non-Producing Wells

Production in those oil wells having a true resistivity value of from 240 ohm meters to 2400 ohm meters varied from a low of 91 barrels to a high of 814 barrels, and in general those wells having a higher true resistivity value had a higher initial production. This general relationship of higher initial production with greater true resistance values would seem to indicate that there might be a definite relationship between the true resistivity value and initial production.

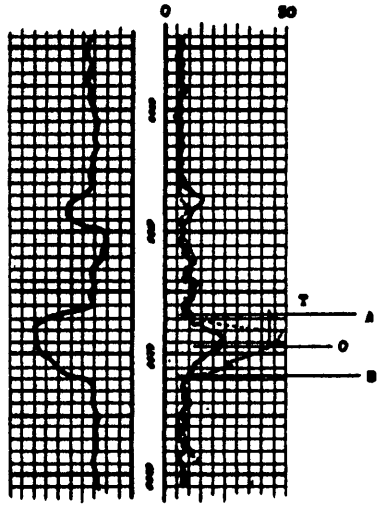
Guyod gives the equation:

$$\rho = \frac{Rw}{P^m (1-S)^n}$$

where

ρ is the resistivity of the bed, in true resistance
Rw is the resistivity of interstitial water
P is the porosity fraction
S is the oil or gas saturation (Fraction of the pore space)
m is the cementation factor

EXAMPLE LOG



METHOD

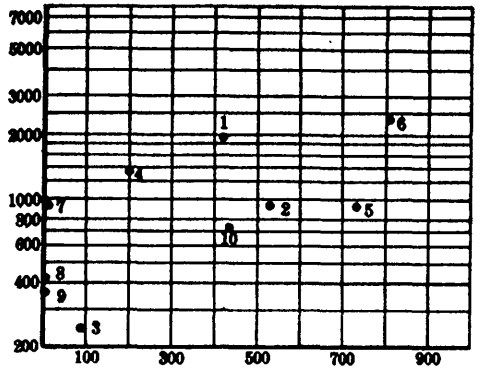
1. Determine the top of the bed under survey. Draw line A horizontally through the top.
2. Determine the bottom of the bed under survey. Draw line B horizontally through the bottom.
3. Draw line O exactly half-way between line A and line B.
4. The intersection of line O with the apparent resistivity curve gives a close approximation of the true resistivity, point T.

NOTE: This method may be used where the bed is at least twice as thick as the spacing length. To obtain correct results where the bed is invaded near the drill hole, other curves than the normal curve should be used.

(From True Resistivity, Herbert Guyod, *The Oil Weekly*, December 17, 1945.)

FIGURE 2. Graphical Determination of True Resistivity

This equation shows that the resistivity of the permeable bed is a function of the oil or gas saturation, and three other factors. Then the assumption might be made that a direct relationship between the resistivity and the production may exist, *IF* the cementation factor and the resistivity of interstitial water factor were the same in each well investigated. In the Southeast Newcastle field, the resistivity of interstitial water has not been determined, but should average approximately the same in each well. The porosity factor is the factor that does not remain the same in each well, and since it does vary, the true resistivity value will vary. Here is an indication that we cannot directly correlate true resistivity with production, but that other factors must be taken into consideration. Those other factors are the porosity, the degree of cementation, the resistivity of interstitial water, the oil or gas content, the permeability, and the bottom hole pressure. Affecting the production is another unknown factor: the manner in which the well was completed.



	TRUE RESISTIVITY	PRODUCTION
1.	1950 ohm m	422 bbls.
2.	950 ohm m	531 bbls.
3.	240 ohm m	91 bbls.
4.	1350 ohm m	200 bbls.
5.	950 ohm m	736 bbls.
6.	2400 ohm m	814 bbls.
7.	937 ohm m	dry
8.	425 ohm m	dry
9.	362 ohm m	dry
10.	750 ohm m	438 bbls.

Note wells 7, 2, and 5. Each has approximately 950 ohm meters true resistance, while production varies from 18 bbls. to 736 bbls. Of wells 7, 8, 9, and 3, the first three are dry, while well No. 3 produced 91 bbls.

FIGURE 3. Resistivity vs. Production

Figure 3 compares the true resistivity and the initial production of 8 wells in the Southeast Newcastle field. Notice that even with a relatively high true resistivity value, well 4 produced only 200 barrels in initial production tests, while well 10 had an initial production of 438 barrels with a true resistivity value of only 750 ohm meters. The further plotting of other wells on this chart brings attention to the fact that 3 wells, numbers 2, 5 and 7, have almost the same true resistivity value, while their initial productions vary from 18 barrels to 736 barrels.

The scattering of these points indicates once more that there is no direct relationship between true resistivity and initial production. The resistivity of a bed is controlled completely by the characteristics and fluid content of that bed, and the possibilities of that bed's producing oil or gas must be controlled by the same factors, but it does not seem probable that there is a unique relationship between the ability of a well to produce and the resistivity of the bed. Other characteristics of the bed must be interpreted.

In conclusion, this is one small area, where erratic completion practices make the correlation of production data difficult. No one company has drilled a sufficient number of wells in this field to establish a standard method for the completion and testing of each well. Production therefore varied in some degree due to different completion methods.

In this study, no direct relationship is apparent between the true resistivity and production. Further study over a larger area may bring more understanding of the relationship.

As has been brought out, at the present level of understanding of electric log resistivities, it is necessary to use other intermediate data and other testing methods, properly to evaluate the potential of a limestone reservoir.

BIBLIOGRAPHY

GUYOD, HERMAN. 1945. True resistivity. Oil Weekly. December 17.