



Estimation of Reservoir Parameters in Old Russian Wells through Statistical methods for Reservoir Characterization to reduce Uncertainty

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Keywords

Porosity , Saturation Sw, Histogram, statistical modeling

Summary

Estimation of Petro physical Parameters like effective porosity (ϕ), water saturation (Sw) & volume of clay (Vcl) using Russian logs have always been a challenging task due to the limited number of log information. Therefore Russian log interpretation has become an important and integral part of well log interpretation for major oil companies. Most of the data in old fields are acquired from Russian tools. These data play a crucial role in reservoir characterization. Russian log interpretation poses different kinds of problems compared to conventional western log interpretation due to the absence of porosity logs. An innovative technique for estimation of reservoir parameters effective porosity (ϕ) & saturation (Sw) have been developed through resistivity (RT) vs (ϕ , Sw) transforms in absence of porosity log. This technique is based upon statistical method where a correlation has been established between Resistivity & estimated reservoir parameters (ϕ , Sw) in the new wells. This regression correlation has been applied in Russian wells having RT log. Application of this regression correlation involves a detailed data analysis for identification of same type of lithological environment through histogram method as in Fig. 2, 3, 4. Histograms, regression analysis, cross-correlation are among the statistical processing methods suitable to examine these petrophysical parameters of each wellbore and the validation of these have been done through production data & Archie's equation. The results showed that these processes are regarded as the fast and efficient ways for estimating petrophysical parameters in the vintage fields with large area having Russian logs only.

Introduction

The natural complexities of petroleum reservoir systems continue to provide a challenge to geoscientists. The absence of reliable data leads to an inadequate understanding of reservoir behavior and consequently to poor predictions.

Open hole logging data contain information about porosity of rocks, water and hydrocarbon saturation, specific volumes of shale & mineral constituents. In hydrocarbon exploration, these quantities are especially important because they underlie the calculation of reserves.

Petrophysical parameters cannot be measured directly but can be translated from well logging data through theoretical response equations.

Russian log data consists of only SP & Resistivity logs, are not able to compute petrophysical parameters via theoretical response equations. To overcome this problem, Statistical methods have given a lead for better prediction of reservoir properties.

Study Area

Kalol field (Fig:1) is located around 20 Km NNW of Ahmedabad city. The field is spread over 350 sq Km. and is situated in the Ahmedabad–Mehsana tectonic block and the most prolific HC producer of the basin. Kalol field is a doubly plunging anticline with longitudinal and transverse faults. The field had 11 pay zones from K-II to K-XII where K-IX & K-X are main producer with K-VII being next wide spread sand unit.

In the present study, till date about 715 wells have been drilled in Kalol field targeting different pays. Logs of 350 wells were processed using multi mineral optimization technique in ELANPLUS software. Out of 700 drilled wells, 237 wells had Russian logs recorded. The well numbers shown in the figures are replaced with imaginary names.

Method

Estimation of petro physical parameters using statistical modeling consists of two steps.

A. Histogram Analysis

A histogram is a bar graph of raw density data that creates a picture of the data distribution. The bars represent the frequency of occurrence showing how often each different value in a set of data occurs. The histogram's shape & statistical information help us to decide how to improve the system. If the system is stable, you can make predictions about the future performance of the system.

The sand wise histogram of density was constructed to better understand how frequently or infrequently density

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values occur for all Kalol pay sands K-I to K-XII (Fig.:2,3,4).

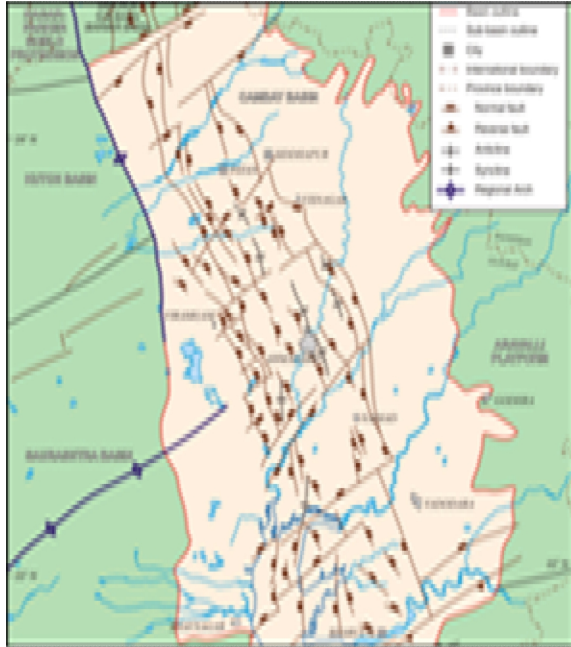


Figure 1: Location Map

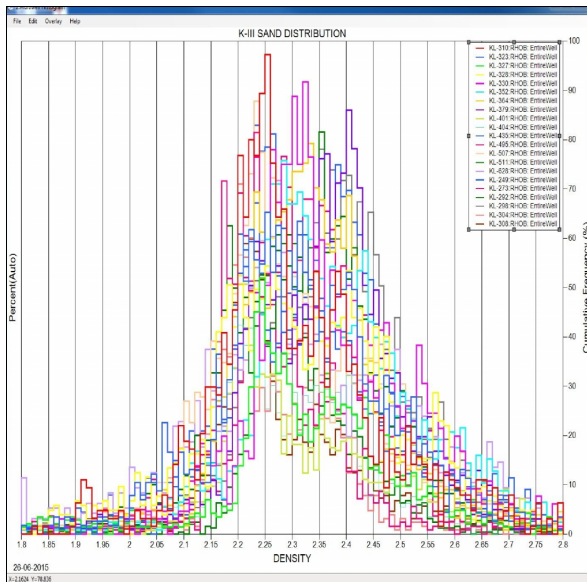


Figure 2: Histogram of K-III pay sand

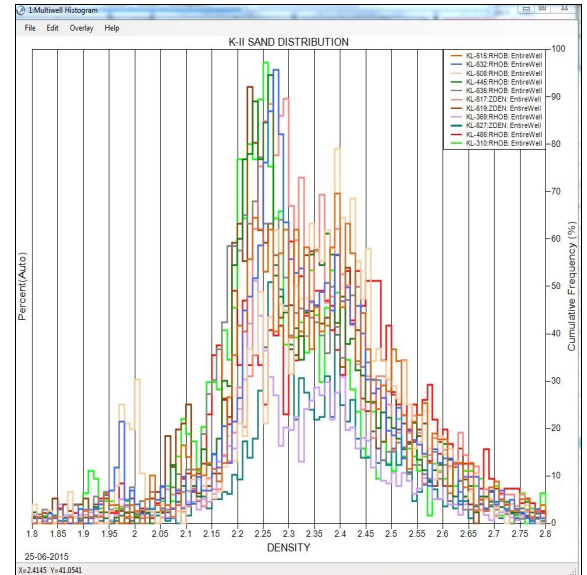


Figure 3: Histogram of K-II pay sand

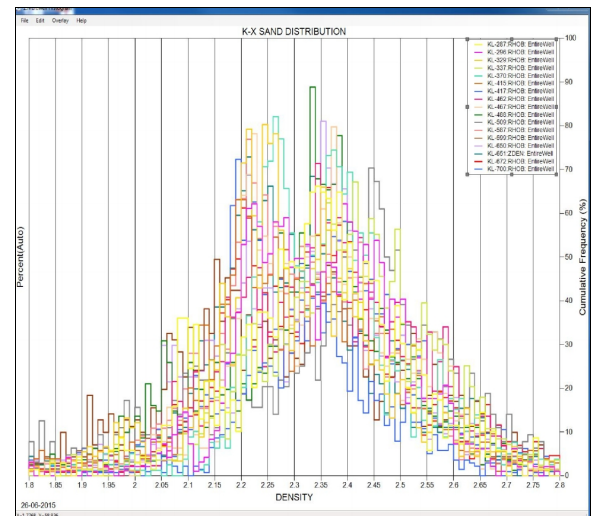


Figure 4: Histogram of K-X pay sand

All plots represent density data with a well-defined peak that is close in value to the median and the mean. While there are "outliers," they are of relatively low frequency. Thus it can be said that deviations in this data group from the mean are of low frequency. Thus we would say the density in the Kalol field is normally distributed. The spread of distribution are different for each sand unit.

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B. Regression Analysis

Regression Analysis is a mathematical method that is used to estimate relationships between dependent variable and independent variable that is thought to influence the dependent variable.

The processed output of effective porosity () has been taken as PIGN & water saturation (Sw) as SUWI during ELAN processing sequence.

Based on the processed output petrophysical parameters PIGN and SUWI of 350 wells from log processing and log responses, cross plots of resistivity (RT) vs. effective porosity (PIGN) and resistivity (RT) vs. saturation (SUWI) have been generated for all Kalol pay sands (Fig.:5-10).

The purpose of regression is to build a model $Y=f(x)$ that best fit a model to observed data in order to quantify the relationship between two variables. The fitted model describes the relationship of PIGN with RT and SUWI with RT and so could predict PIGN and SUWI parameters in wells having only Russian logs recorded. All the relationship are different for all pay sands. This also reveals from the histogram analysis shown in Fig. 1, 2, 3.

C. Estimation of Reservoir Properties , Sw

The estimated effective porosity and water saturation has been taken as PIGN_M and SW_M.

Based upon this statistical approach, PIGN_M & SW_M have been estimated in 215 wells where Russian log data was available. These parameters have also been estimated in the wells where the ELAN processing was done & a correlation of more than 90% was established through regression analysis.

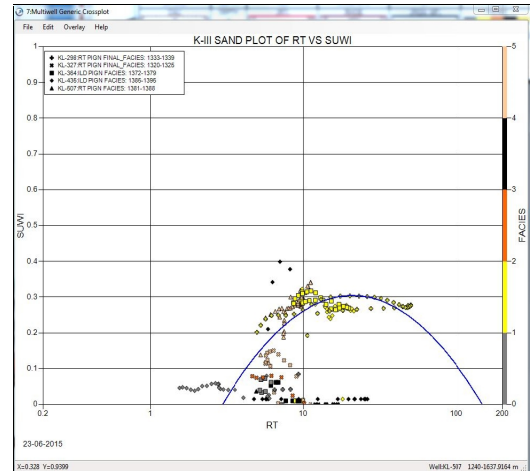


Figure 6: Cross plot of Porosity vs. Resistivity for K-III sand

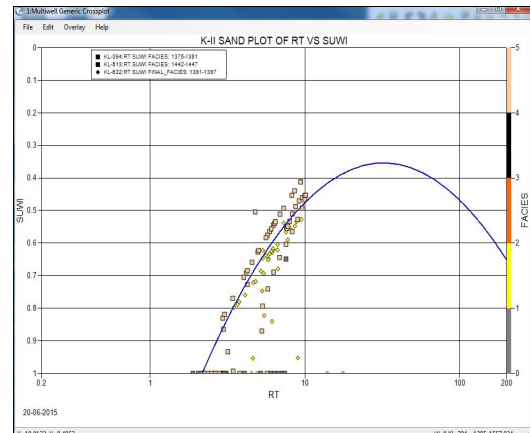


Figure 7: Cross plot of Saturation vs. Resistivity for K-II sand

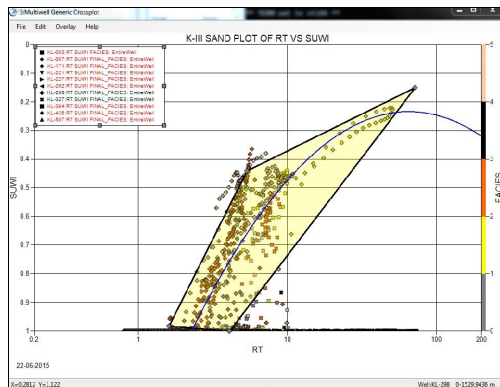


Figure 5: Crossplot of Saturation vs Resistivity for K-III sand

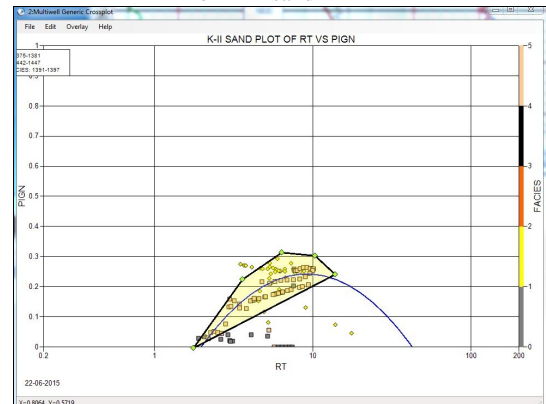


Figure 8: Cross plot of Porosity vs. Resistivity for K-II sand

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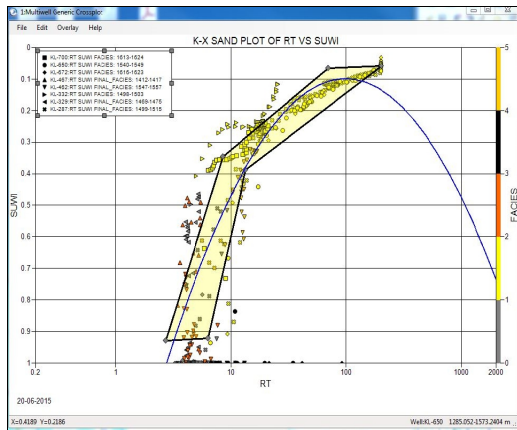


Figure 9: Cross plot of Saturation vs. Resistivity for K-X sand

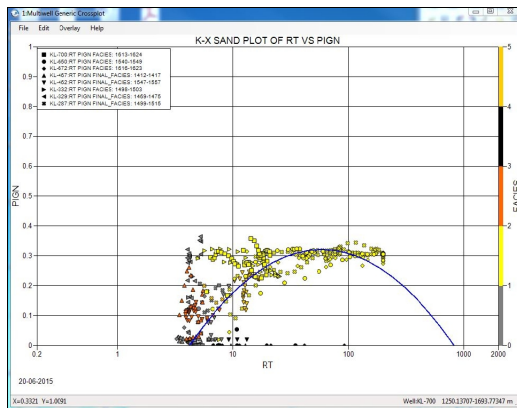


Figure 10: Cross plot of Porosity vs. Resistivity for K-X sand

Validation of Method

The Estimated reservoir properties PIGN_M & SW_M have been validated in the wells where processed values of PIGN & SW were available as in Fig. 11-13. Their cross-correlations have been checked and the results have been validated from production data in all the wells. All the prediction were found satisfactory and matches with well production behavior as illustrated in Fig. 14-16.

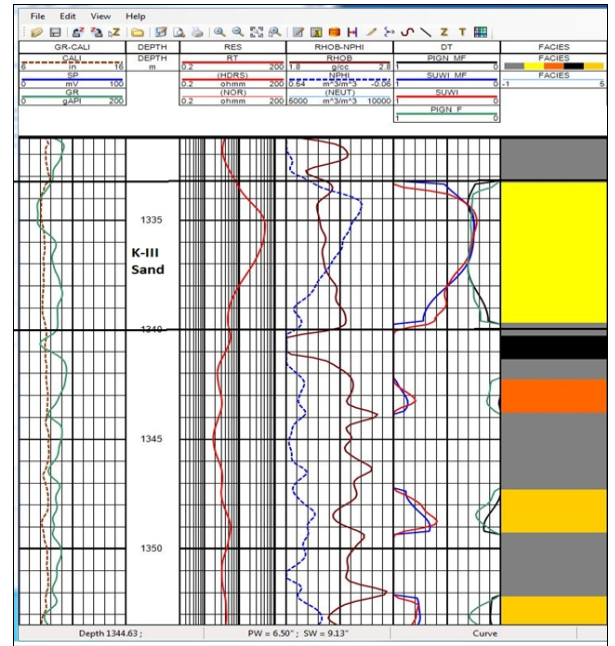


Figure 11: Model and Processed porosity and Saturation of K-III sand

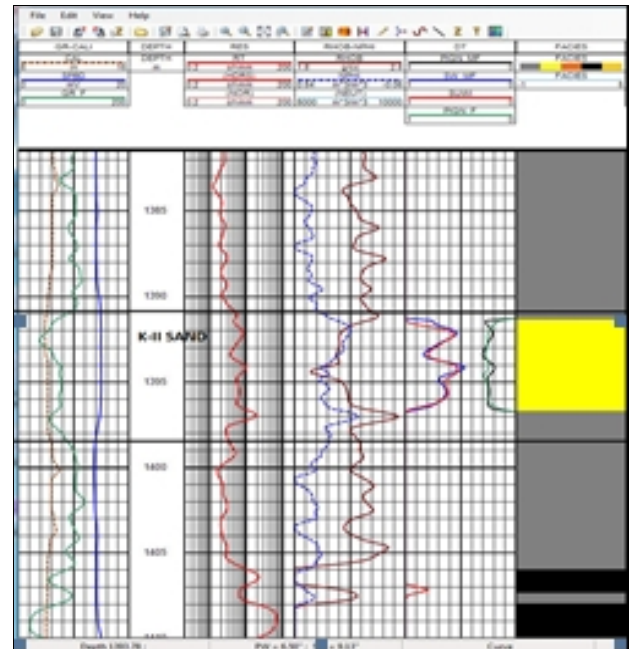


Figure 12: Model and Processed porosity and Saturation of K-II sand

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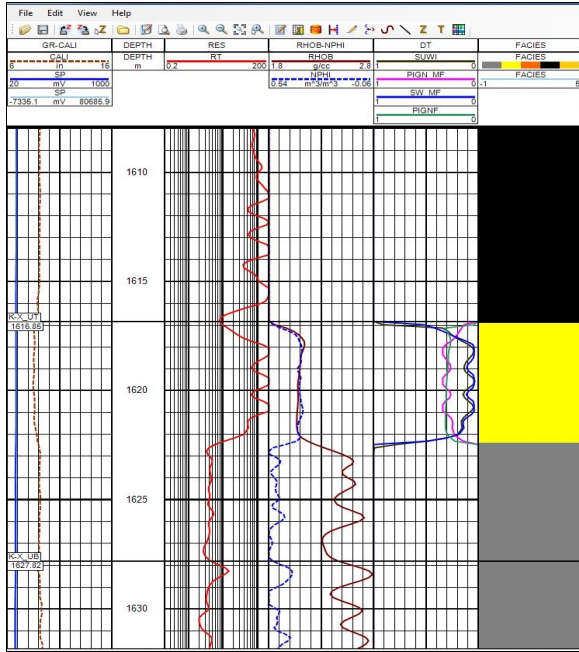


Figure 13: Model and Processed porosity and Saturation of K-X sand

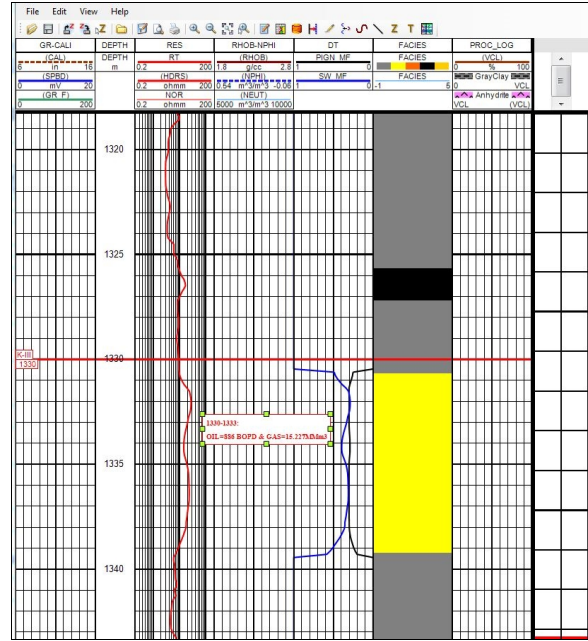


Figure 15: Model porosity and Saturation estimated in K-III SAND

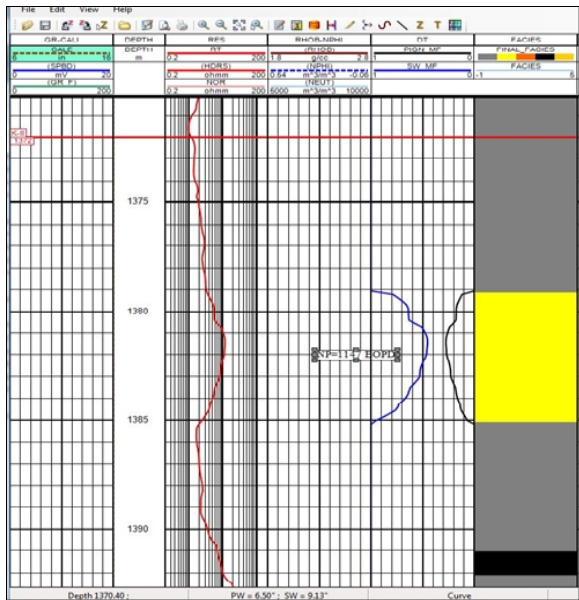


Figure 14: Model porosity and Saturation estimated in K-II SAND

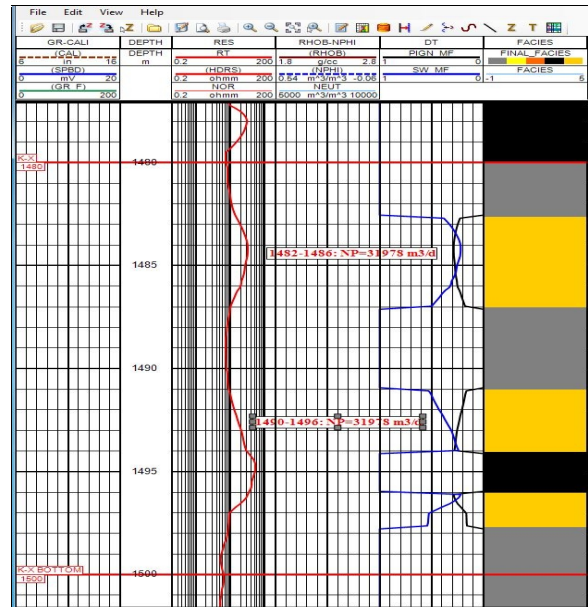


Figure 16: Model porosity and Saturation estimated in K-X SAND

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Value Addition

This approach has not only estimated the reservoir parameter & Sw but also fill the data gap due to Russian logs in Reservoir model. Using an additional data of 215 wells in the model has reduced uncertainty in property population in entire 3D volume. This will have a direct impact on Exploitation strategy in this Brown field.

Conclusion

- The present study has clearly brought out an approach for estimating petro physical parameters using statistical methods when there are no other logs to create response equations.
- These estimated reservoir parameters have been validated in other wells and matches with production data of the wells.
- These wells having Russian data have fill the data gap in the reservoir model.
- Using the data of these additional wells for property population in 3D reservoir model has reduced uncertainty and given a confidence for reservoir estimation & exploitation strategy.

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