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Synthesis Porosity logs based on fuzzy logic in Buzrgun Member at Fauqi Oil Field Southeastern Iraq

Huda F. Al-Saad*, Muwafaq F. Al-Shahwan**

*Basra Oil Company

**Department of Geology, Collage of science, University of Basra

Corresponding Author Email: huda_alsaad58@yahoo.com

Abstract:

In this paper, the artificial intelligent technique represents fuzzy logic, had been employed to generate missing well logs for three common logs sonic, neutron and density. A total Input data of 432 readings represent both depth and porosity, which belong to Buzurgun member were used to build fuzzy model. Input data were divided into two groups including training data 308 data points, which represent FQ-6, FQ-7, FQ-20 and FQ-21wells; and testing data 124 data points which represent FQ-15. Performance of model were evaluated by using two statistic aspects such as root mean square error and correlation coefficient. The results show that this technique offer more accurate and reliable missing logs. Fuzzy logic is used as a powerful tool in oil industry in Iraq because it is more flexible and realistic for evaluation, by employing the sufficient data for training and testing.

Key words: Porosity logs, fuzzy logic, Buzurgun Member, Fauqi, Southeastern Iraq.

تخمين المجسات المفقودة بالاعتماد على المنطق المضبب لعضو بزركان في حقل فكه جنوب شرق العراق

الخلاصة:

تطرقت الدراسة الحالية إلى استخدام تقنية الذكاء الاصطناعي المتمثل بالمنطق المضبب في مجال تخمين الفقدان الحاصل في قيم منحنيات مجسات الآبار لثلاثة مجسات شائعة، هي المجس الصوتي والنيوتروني ومجس الكثافة. لغرض بناء النموذج المضبب أُستخدمت 432 قراءة تعود الى عضو بزركان في حقل فكة، تتمثل هذه القراءات بقيم العمق والمسامية. قسمت بيانات الإدخال إلى مجموعتين تتمثل الأولى ببيانات التدريب Training data وتضم 308

نقطة إدخال لأربعة آبـــار (FQ-6, FQ-7, FQ-20, FQ-21) إما الثانية فهي تمثل بيانات الاختبار Testing Data وتضم 124 نقطة إدخال والتي تتمثل بالبئر FQ-15. قيمت أدائية الموديل باستخدام معيارين إحصائيين هما مربع معدل الخطأ ومعامل الارتباط. بينت النتائج أن تخمين منحنيات المجسات المفقودة كان على درجة عالية من الدقة والثقة. خلصت الدراسة إلى إمكانية استخدام تقنية المنطق المضبب كأداة جيدة في مجال جيولوجيا النفط في العراق بسبب مرونتها العالية وكونها أكثر واقعية في مجال التخمين فكل ما تحتاج إليه توافر بيانات كافية لتدريبها واختبارها.

Introduction:

Generally, the reservoir evaluation needs to know the capacity of rock on the existence liquid which is called Porosity. It is represents one of the importance petrophysics properties in reservoir rock. Through it can be able to assessment reserve oil and gas in reservoir. The best outcome of porosity obtained from core and well logging density, neutron and sonic. Well log represent one of the importance tool to calculate the petrophsics properties and production possibility from reservoir. The data analysis from log easy economically expensive as compared to the extract core [8]. Log analyses become more reliable by obtain is the complete set. In some cases wasn't possible to get it for many reasons: not completion well logging in old wells or destroy loges from bad store or error in measurement consequences from logging tool or well conditions. For this reason, log became not complete and not reliable [7]. It is very difficult when log is required to description facies of well or geological and rock composition or any purpose like seismic interpretation. The solution of this problem in easy represents to make copy the part of missing from identical well neighbor, this will complete the missing in this logs [9].

Fuzzy logic:

Fuzzy logic is a concept derives from mathematical branch of fuzzy set. In narrow sense, it refers to a logical system made generalize traditional logic. In broad sense, it is theoretical and techniques used fuzzy sets without the crisp boundary. It represents easy method to describe the human experience. It introduced practical solutions for actually troubles with effective and reasonableness cost compared with solutions offered by other techniques [4]**.** Fuzzy logic is a logical application was developed to get approximate

solutions for problems subjected ambiguous description. It can assist researches to treatment uncertainty and ambiguous information [11].

Fuzzy set theory, introduced by Zadeh [1965], an extension to the standard mathematical theory of set. In classical set or crisp set, an element either belongs to a set or does not belong to a set. In fuzzy logic, the boundary of a fuzzy set is not accurate. That is, the change from non-membership to membership in a fuzzy set may be gradual rather than surprising. This gradual change reflects the function of membership function, which is defined the relative degree as an element [1].

Fuzzy logic response real input data from universe and conversion to Linguistic variables, the main point in fuzzy logic is to convert the input space to the output space that's through by the (IF-THEN) bases', this is called rule base. It is prepared by designer to achieve the possible results [6].

The concept fuzzy logic offers a degree of membership to a set in place of usual idea member or not member to set [2].

Recently, the fuzzy logic (FL) is applied in many reservoir and geologic studies because geology science is descriptive science use at most unclear information and uncertainty fuzzy set has able to manage with same the information and merged it with Quantity observation. Therefore, this science used in many purpose such as seismic application, stratigraphic models and formations evaluation [6]. In pedology and geomorphology, it is applied to represents old and new sedimentation models, design models to simulate products, erosion, transfer and deposition of sediments. Also (FL) used to design repletion sedimentary basin from sediments. In addition to that the interpretation sedimentation process.

In the hydrocarbons exploration, Soft computing techniques (fuzzy logic, Neural network and genetic algorithms) have been considered a good tool for design and estimations in the oil industry [7].

Application:

Fauqi field or jabal Fauqi is located in Missan province about 50 km north-east of Amara city, southeast Iraq (Figure1). It's shared with Iran especially north part of field. Where extend part of it inter Iranian land. Fauqi field products from Asmari Reservoir belongs to (Oligocene- Lower Miocene), it represents the second reservoir products after Mishrif Reservoir in field. Lithologically, Asmari reservoir characterizes very complex lithology, it consistence from some formations. One of it represent Buzrgun member is basically consist of sand with high porosity and good reservoir characterization in field, which method applied on it.

Data collection

The data used in this research are obtained from archive of SOC of Iraq for Asmari reservoir. The total number of wells drilled at the time of this study to 24 wells. All of the wells do not have sufficient number of log needed for petrophysics evaluation except 5 wells these are FQ6, FQ7, FQ15, FQ2 and FQ21. The petrophysics data of almost these wells were available; Therefore, they have been chosen. Wireline logs obtained from these wells are resistivity, density, neutron porosity, sonic porosity, gamma ray log and pontaneous potential. Methodology used these parameters to study the petrophysics properties for this wells and estimation the missing well logs.

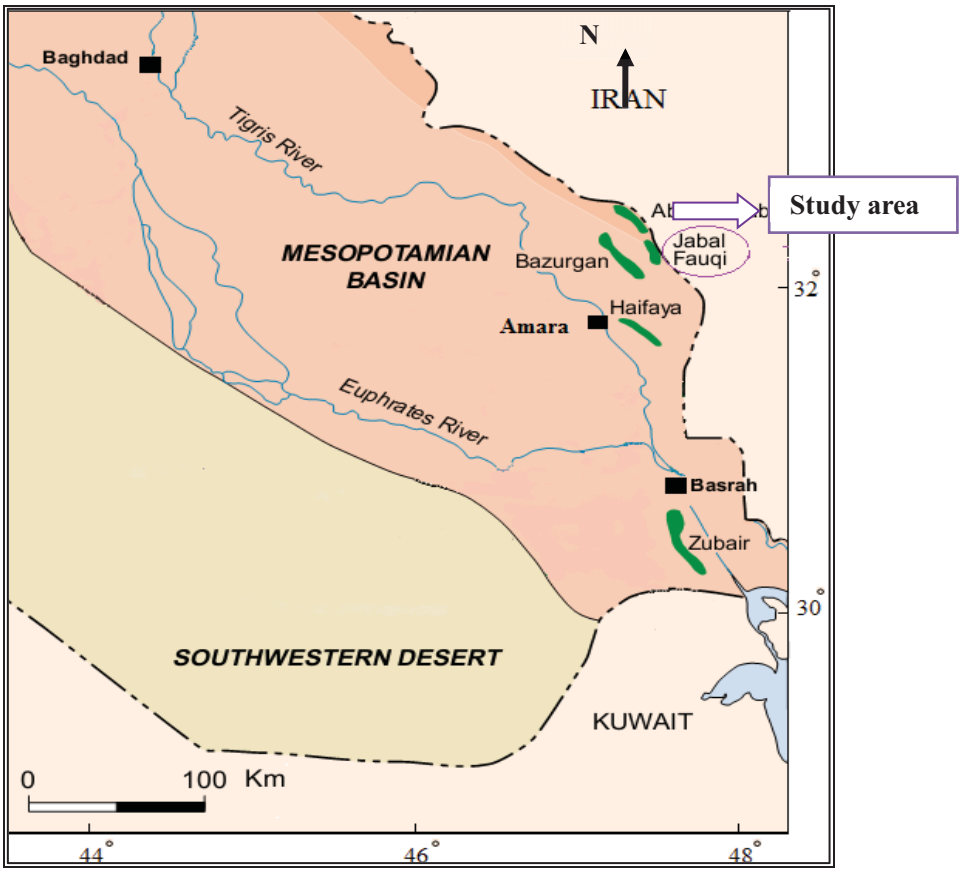

Fig. (1) Location map of study area

Methodology:

The study data well logs obtaind from five wells of Buzurgan member of Fauqi field FQ-6, 7, 15, 20 and FQ-21. Although, these wells have a complete suite of log. The study assumed that the FQ-15 has not logs and considered as well testing. Fuzzy logic used to determine the missing well data to this well and after that use it to evaluate truth of this model in estimation processing. The wells have resistivity log, gamma ray, in addition to porosity log sonic, neutron and bulk density for all depth of Asmari formation. In present study, three logs are chosen such as DT, RHOB, and NPHI for synthesis the missing well log. Table (1) shows the suitable input data for estimation processes and Figures (2, 3 and 4) show the input data to synthesizing the output.

Table (1) Input to synthesis missing well log

Inputs	*Predicted Well log*
DEPTH, NPHI, DT	RHOB
DEPTH, DT, RHOB	NPHI
DEPTH, RHOB, NPHI	DT

Takagi Sugeno uses inference system to for forming missing log in Matlab program: 7a, Four input data are used represent Depth, NPHI, RHOB, DT for purpose to estimate the Intelligent Model depending on fuzzy logic, Table (1) they were divided into two groups including training data plus 308 point from four well, and testing data with 124 point from testing well. Table (2) shows the value and the range for input data. All membership function and role base designee depend on clustering radius [7]. In this work, the triangle membership function is chosen.

Table (2) The value and ranges of the input data neutron, density and sonic log.

Well No.	*Depth(m)*	*Density(gm/cm^3)*	*Neutron(%)*	*Sonic(µs/ft)*
FQ-6	3129-3153	2.21-2.46	17-26.5	76-89
FQ-7	3120-3142	2.15-2.47	14-33	66-93
FQ- 15	3112-3142	2.22-2.45	19-29	70-94
FQ-20	3108-3123	2.19-2.46	18.5-26.5	70-94
FQ- 21	3123-3135	2.2-2.44	18-24	66-90

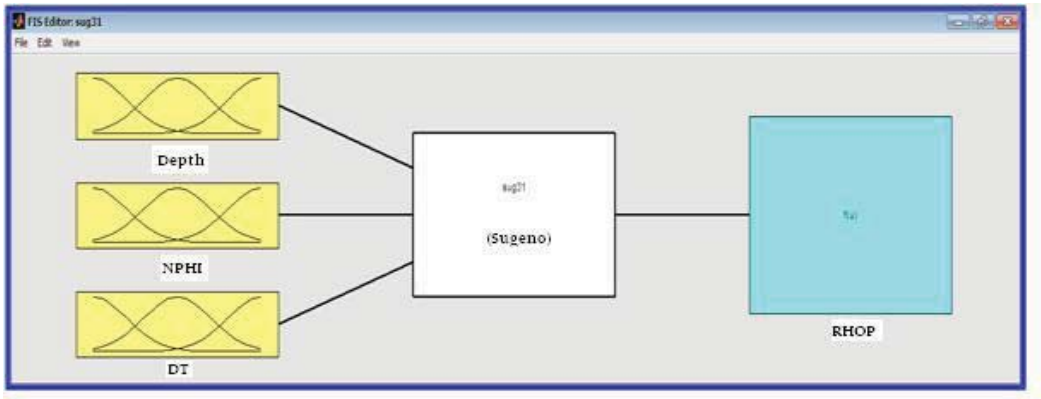

Fig. (2) Show the DEPTH, NPHI, DT as input synthesizing RHO

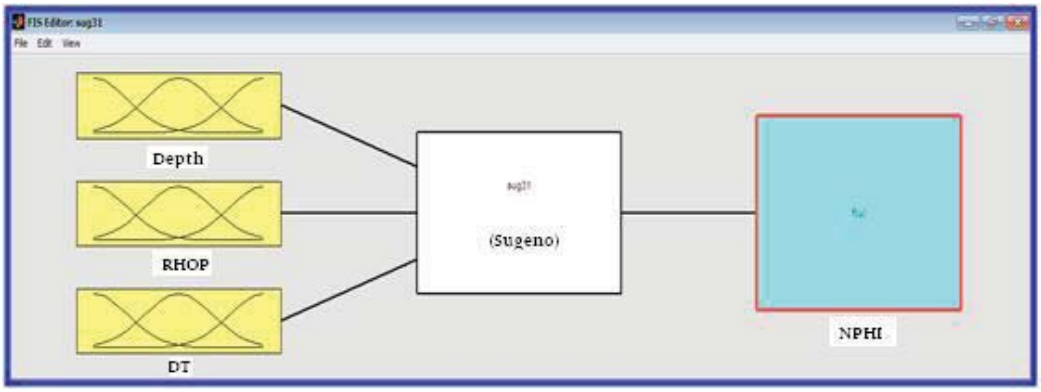

Fig. (3) Shows the input DEPTH, RHOP, DT as input for synthesizing NPHI

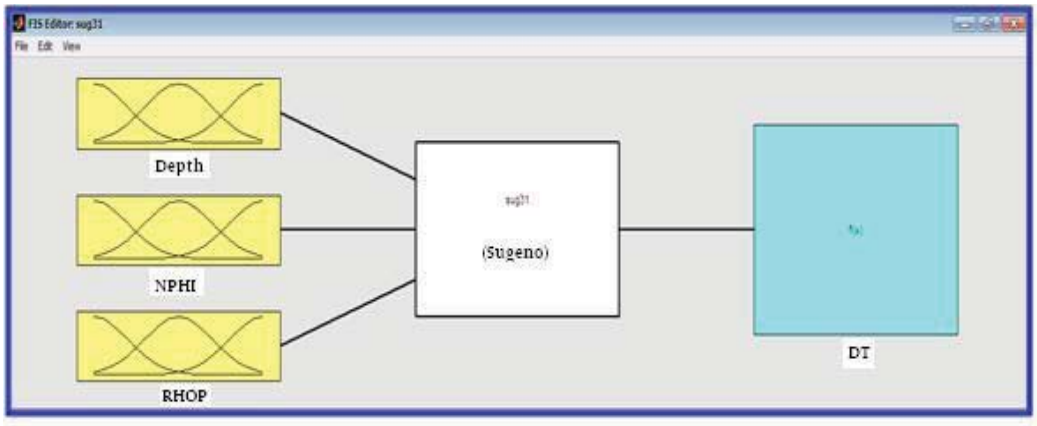

Fig. (4) Shows the DEPTH, RHOP, NPHI as input for synthesizing DT

Evaluation of the Model Performance:

Performance of process is evaluated based on (Correlation of Determination). It is measured the linear correlation between measured and prediction value. Correlation of determined can be measure from equation:-

$$R^2 = 1 - \frac{SSE}{SSy}$$

$$SSE = \sum_{i=1}^{n}(xi - x\hat{}\,)^2 \qquad SSy = \sum_{i=1}^{n}(xi - \bar{x})^2$$

Where:-

R^2 : Correlation of determination $\bar{x}$: mean of measured value

xi : Measured value $x\hat{}$: prediction value

Also depended on other correlation which is called root Mean Square Error, to calculate from this equation:-

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(xi - x\hat{}\,)^2} \qquad n : \text{number of input}$$

The value of R range between (1,-1) when R equal to (1) between input and output data [10]. In this study, it is obtained on acceptance value for all true and prediction input. The perfect value can be obtained at the RMSE near from (0) [3].

Table (3) The result of correlation of determination and root mean square Error for well testing for all density, neutron and sonic well log

Predicted Log	*Error Statistics*	
	R^2	*RMSE*
RHOP (gm/cm3)	0.709	0.0483
NPHI (%)	0.775	0.432
DT (µs/ft)	0.819	0.804

Results:

To obtain best model, every value from estimate is compared with measured which inter it to model Figure (6). Solid line refers to measured value while dashed line for the value log.

Figure (5) shows the correlation between measured and estimate value to testing well, we obtain acceptance value to correlation Table (3). Figure (6) shows coincide between measured and estimation value, relatively density log appear excellent coincide between measured and estimate value, neutron and sonic log appear some disagreement between this value these belong to several process such as reservoir complex, mineral change, change in liquid content and mistake in data Modeling or Testing Data [3].

Conclusion:

It was concluded that the use of fuzzy logic technique offered a better results for prediction porosity. If core log is unavailable and cannot be able to extract porosity we can use this method for this purpose. The performance of model appeared good value of (correlation of determination & Root mean square error). Cross plot gives good matching between measured and estimation value. It was found that this method was more useful and flexible for the predicted porosity.

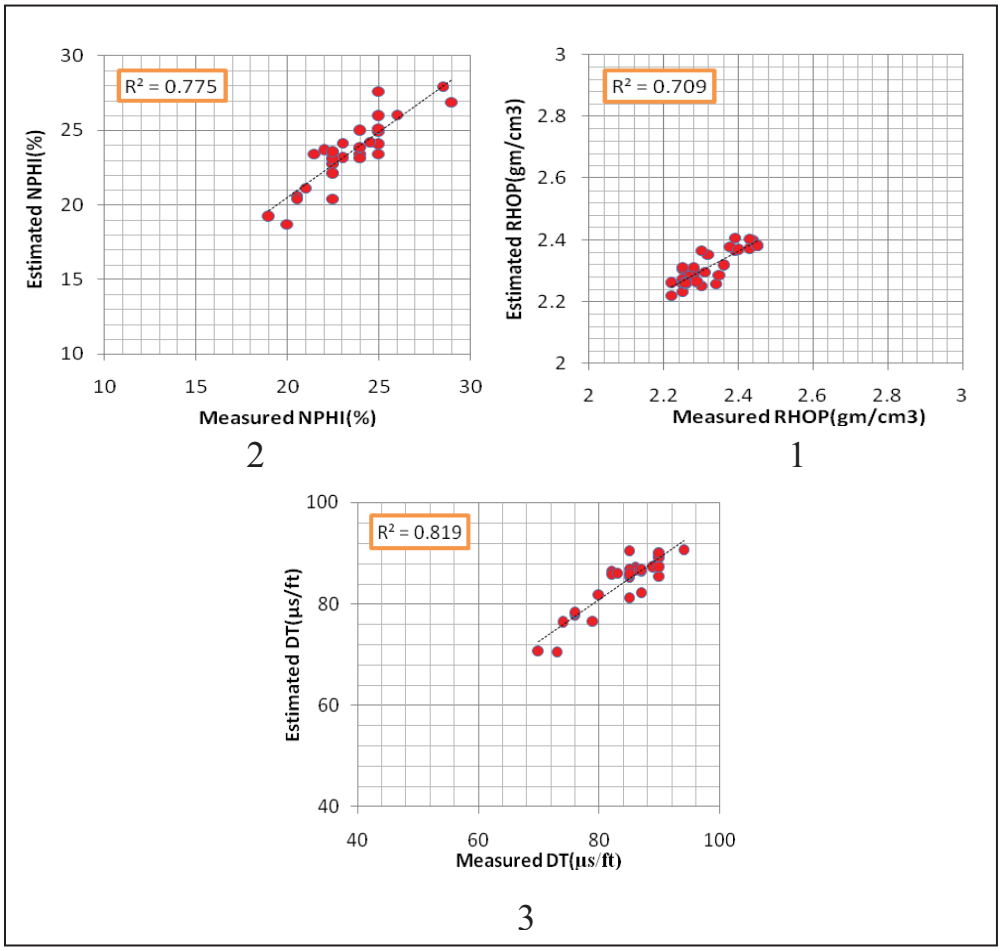

Fig. (5) Cross plot showing the correlation coefficient for synthesizing (1) ROHB, (2) NPHI, (3) DT for the test well.

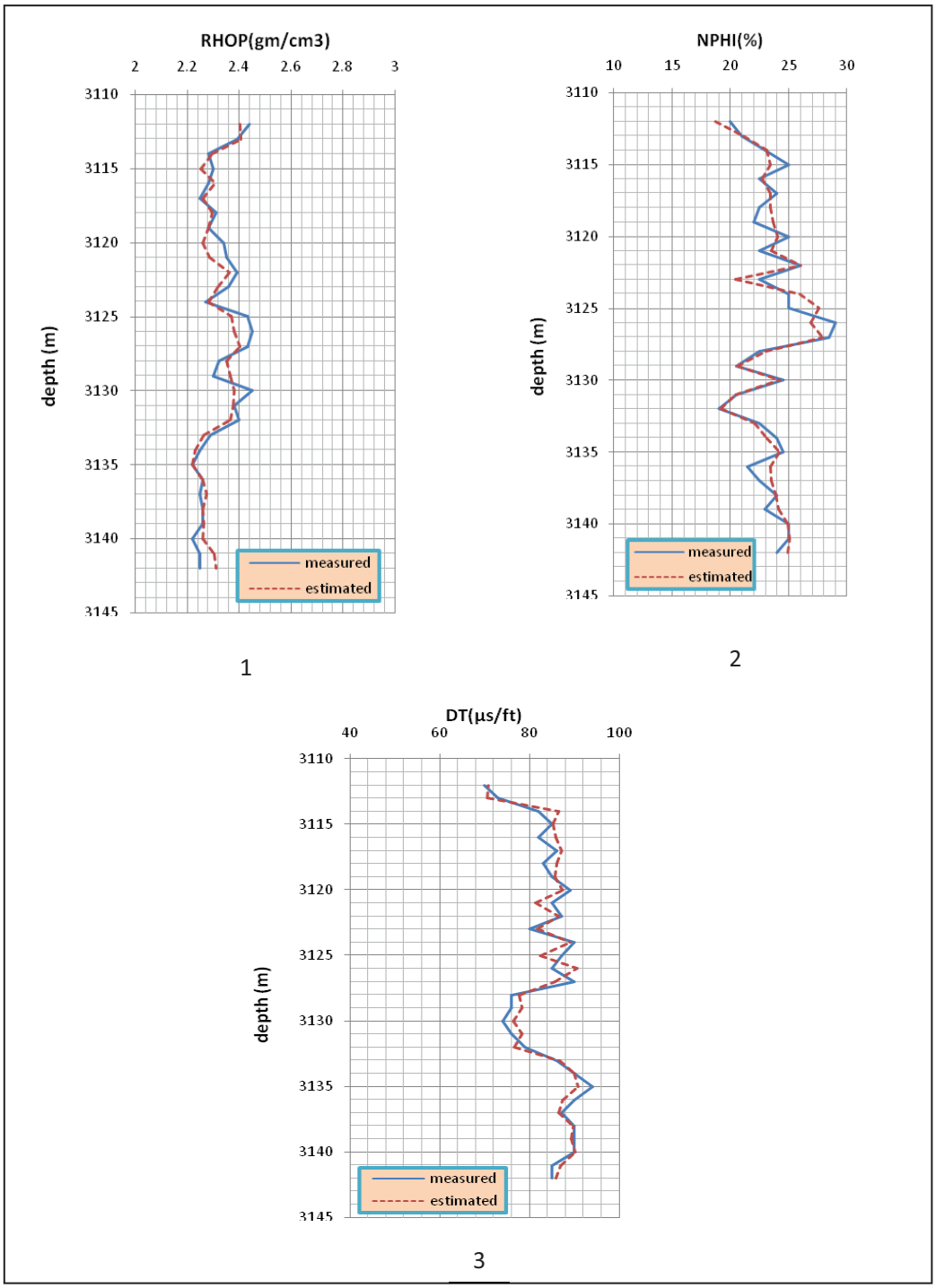

Fig. (6) synthesized (1) RHOB, (2) NPHI, (3) DT logs for the test well.

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