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Studying on the interpretative method of physical properties of reservoir in Weixing Oilfield

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Abstract: This paper bring up two models of physical properties of reservoir,includeing a multi parameter fitting model and a BP neural network which are proposed to predict the nonlinear reservoir parameters. It is aimed to solve the complex structure of the formation and the low interpretative precision of porosity and permeability in Putaohua reservoirs of Weixing Oilfield Yaojia formation. The two models are tested with 8 coring wells in the study area.The results show that the evaluated method of reservoir physical parameters based on BP neural network is the best.The mean absolute error of porosity is 1.33%. The mean relative error of permeability is 37.61%.This model can effectively solve the problem of the low interpretative precision of porosity and permeability in the study area. It can provide a strong guarantee for the evaluation of oil field reserves, exploitation and exploitation.

Key words: - *BP neural network, multi parameter fitting; Putaohua reservoirs, physical parameters.*

I. INTRODUCTION

Weixing Oilfield is located in the northwest of Three Zhao Sag.The target layer is the formation of Putauhua.The reservoir depth is 1250-1490m[1].Controlled by the northern depositional system, the study area is mainly developed delta plain and delta front facies.The lithology is dominated by the green mud stone and the over-lithology of the fine sandstone[2].

II. FITTING MODEL OF RESERVOIR PHYSICAL PROPERTY PARAMETERS

Porosity and permeability are two very important physical properties of reservoir.Accurate evaluation has a profound influence on the evaluation of oil reservoir, oil and gas productive capacity, and oil and gas reserves evaluation.Statistical analysis of porosity and permeability of the core wells in the study area.The results are shown in Figure 1, Figure 2:porosity is mainly distributed in the range of 11.5%-26.5%,the average value of 21.1%. Permeability is mainly distributed in the range of 0.1-10mD, 10-75mD and 75-1000mD.The statistical results show that the difference is obvious in the distribution of the holes in the study area,and a reasonable and accurate evaluation method is more important for the reservoir evaluation.

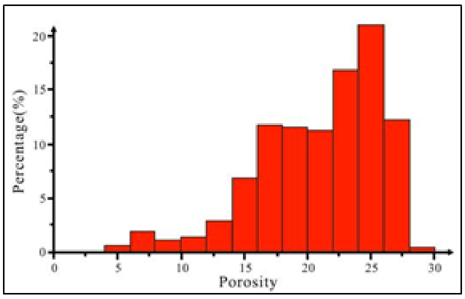


Fig.1 Histogram of porosity distribution range

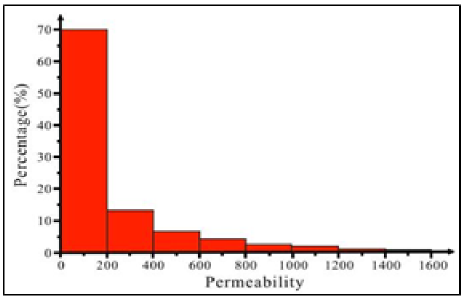


Fig.2 Histogram of permeability distribution range

2.1. FITTING MODEL OF MULTI PARAMETER

Set dependent variable y and independent variable $x_1, x_2, \cdots x_m$,there are n groups of actual observation data.Supposing dependent variable y and independent variable $x_1, x_2, \cdots x_m$ is a linear relationship.Its mathematical model is:

$$y_i = \alpha_0 + \alpha_1 x_{1j} + \alpha_2 x_{2j} + \cdots + \alpha_m x_{mj} + \varepsilon_j,\ j = 1, 2, \cdots, n \ ;$$

In the model, $x_1, x_2, \cdots x_m$ are observable general variables,y is observable random variables,changing with $x_1, x_2, \cdots x_m, \varepsilon_j$ is independent and obey the normal distribution of the random quantity [3].

Using the core analysis data of the study area, the physical parameters were explained by the multiple regression method. A multiple parameter fitting model is established by the selection of acoustic logging, neutron logging, density logging and core analysis porosity.The fitting coefficient results are shown in Table 1, and the significance is less than 0.05, indicating that the selected parameters DEN, HAC and CNL are very significant for the interpretation of porosity.Figure 3,the histogram of the normalized residuals and Figure 4 standard P-P diagrams for standard residuals, scattered points are distributed in the vicinity of the diagonal. The sample data is in line with normal distribution, and the model is reasonable.

Table 1 The result of fitting coefficient

Model	Coefficient	Standard error	Sig.
Constant	43.756	-0.014	0.007
DEN	-9.343	5.123	0.005
CNL（%）	0.025	0.214	0.017
HAC	-0.014	0.04	0.023

Get multiple regression equation:

$$\phi = 43.756 - 9.343DEN + 0.025CNL - 0.014HAC$$

In the equation:

ϕ – *porosity*; *DEN* – density log; *CNL* – Neutron log; *HAC* – acoustic logging value;

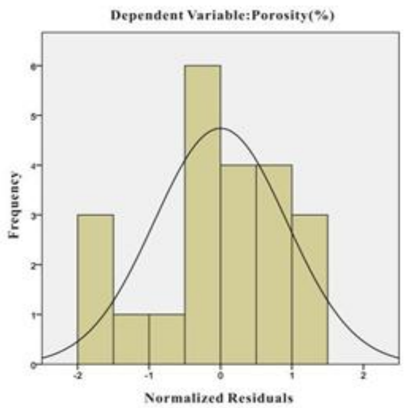


Fig.3 The histogram of the normalized residuals

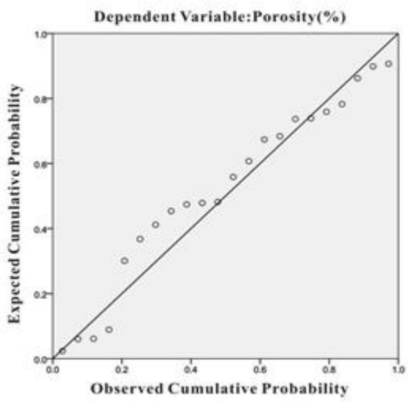


Fig.4 Standard P-P diagrams for standard residuals

2.2. BP NEURAL NETWORK MODEL

BP neural network is a multi layer feedforward neural network.An artificial neural network technique is proposed by R.h etal. in 1985[4].The basic process: inputting training samples and target, constantly adjust the weights and thresholds, the gradient decline method of learning algorithm, so that the output of the trained samples tends to be uniform.BP neural network is usually made from the input layer, multiple hidden layers and one or more output layers[5], BP neural network model, as shown in Figure 5.

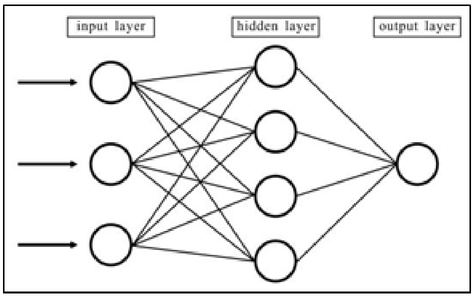


Fig.5 The model of BP neural network

In the building process of reservoir parameter interpretation model with nonlinear reflection ability of BP neural network,which can effectively solve the problem of different kinds of well logging methods under different conditions.

By many trials,in porosity parameter interpretation model,we chose the density, neutron porosity and acoustic time difference as the input layer, the input node is 3.According to the empirical formula,the hidden layer node is 8[5].The output layer node is 1. The data is divided into two groups: learning sample and testing sample.We obtain a learning sample of the predicted output porosity and the actual output porosity as shown in Figure 6. Figure 7 and 8 are the cross-plots of the predicting
porosity by BP and the core porosity of the learning sample and testing sample.

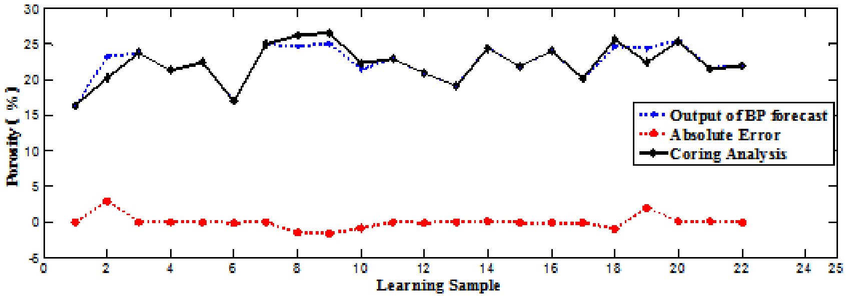
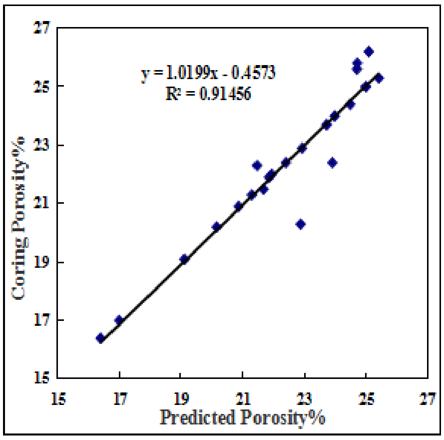


Fig.6 Porosity of learning sample BP forecast and coring analysis



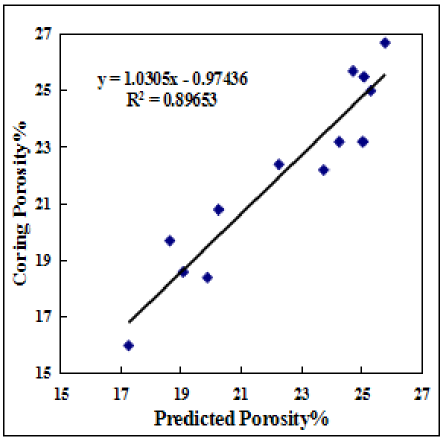


Fig.7 Cross-plot of porosity learning sample BP forecast and coring analysis

Fig.8 Cross-plot of porosity inspecting sample BP forecast and coring analysis

In permeability parameter interpretation model,we chose the density, neutron porosity,acoustic time difference,porosity and relative value of gamma as the input layer, its node is 5.According to the empirical formula,the hidden layer node is 9.The output layer node is 1. The data is divided into two groups: learning sample and testing sample.We obtain a learning sample of the predicted output permeability and the actual output permeability as shown in Figure 9. Figure 10 and 11 are the cross-plots of the predicting permeability by BP and the core permeability of the learning sample and testing sample.

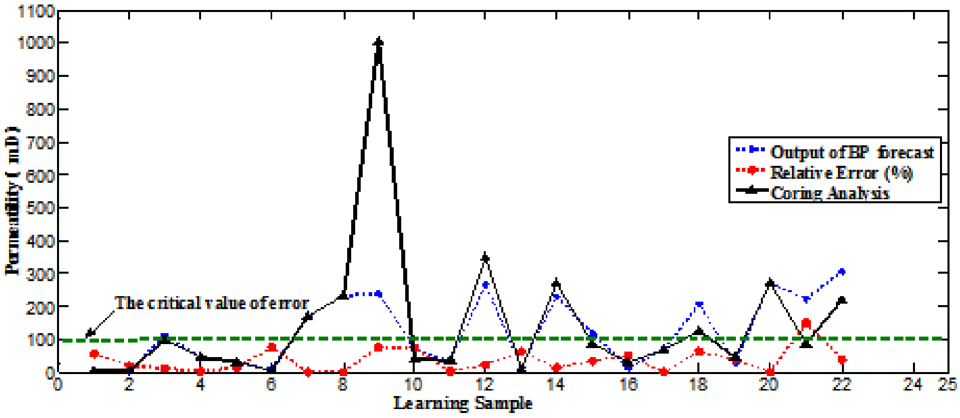


Fig.9 Permeability of learning sample BP forecast and coring analysis

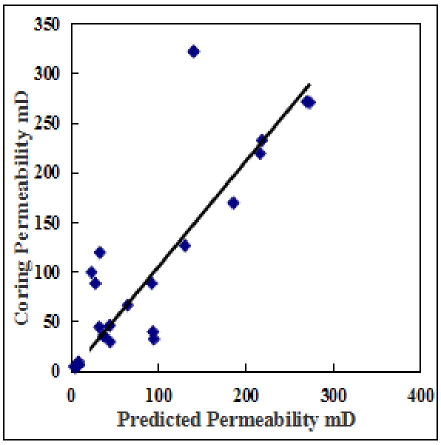


Fig.10 Cross-plot of permeability learning sample BP forecast and coring analysis

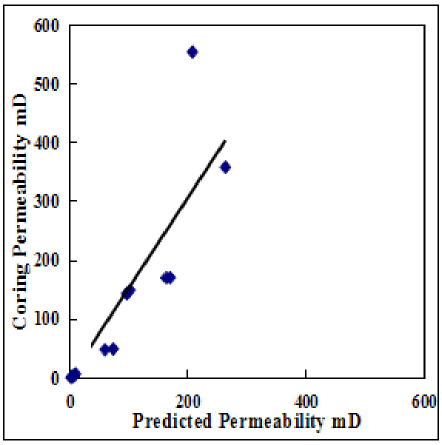


Fig.11 Cross-plot of permeability inspecting sample BP forecast and coring analysis

III. OPTIMIZE THE INTERPRETIVE MODEL OF RESERVOIR PARAMETER

A multi phase sedimentary system is superimposed on a section of the zone Yaojia in the Weixing Oilfield.The complex sedimentary environment has a very significant difference in the distribution of porosity and permeability in the plane and vertical distribution. It is very difficult to evaluate the reservoir parameters.A multi parameter fitting model and BP neural network nonlinear reservoir parameter prediction model are established.A more accurate reservoir parameter interpretation model is found by comparing the two methods.BP neural network forecasting model is the much accurate.Using different evaluation methods to study the 8 wells in the study area,the results are as shown in Figure 12. The error statistics are shown in Table 2.The evaluation results of BP neural network model and core analysis results are the smaller.The average absolute error of porosity is 1.33%, the average relative error of permeability is 37.61%;The average absolute error of porosity of the model is 3.78% by using fitting model of multi parameter.

Table2 The errors of two interpretative models

Model	average absolute error of porosity	average relative error of permeability
Fitting model of multi parameter	3.78%	Not applicable
BP neural network model	1.33%	37.61%

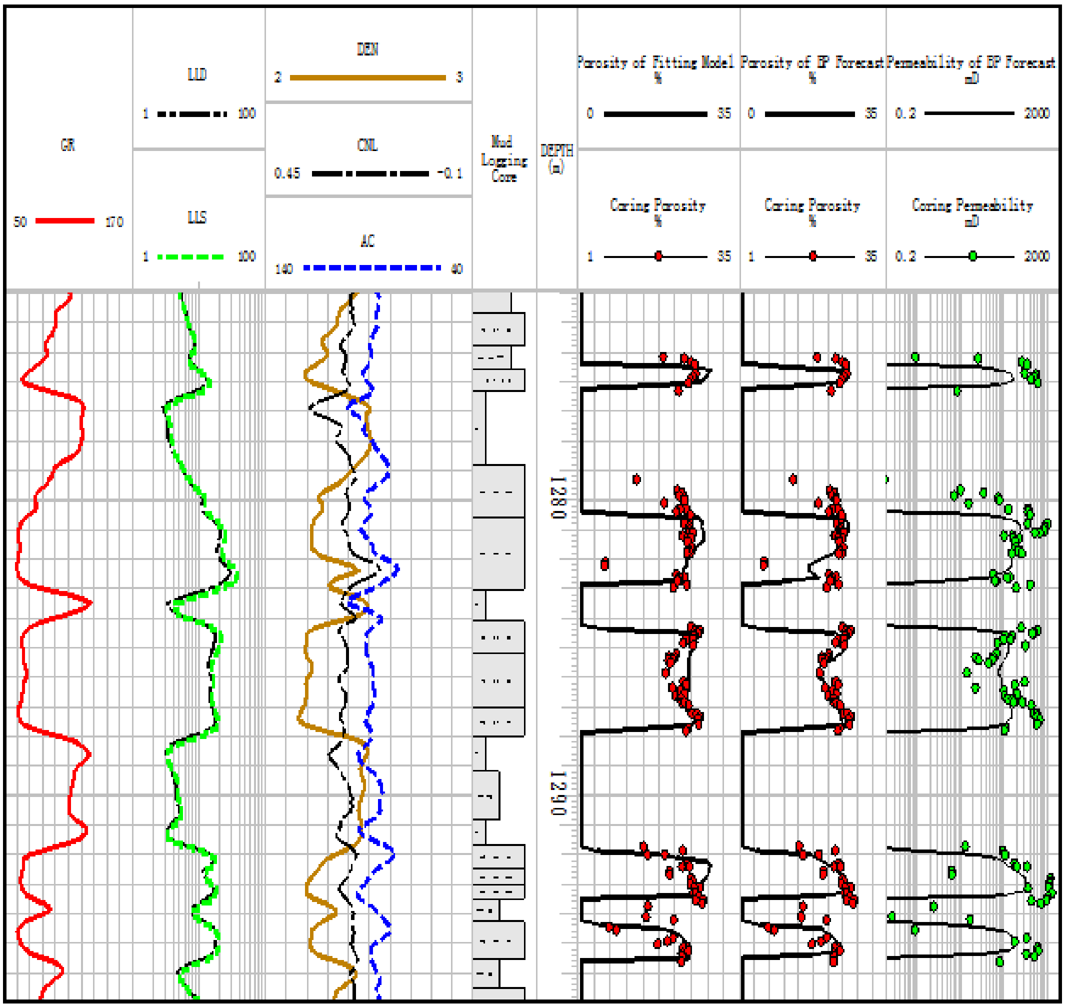


Fig.12 The results of tested parameters

IV. CONCLUTION

1 Discussing on the evaluation method of reservoir physical properties is beneficial to improve the response of the various logging parameters in the study area, and to find a more effective method for reservoir evaluation.

2 The evaluation model of reservoir physical parameters based on BP neural network method can well solve the problem of difficulty and low accuracy of the evaluation method of reservoir physical property.It is formed by the complex sedimentary environment.

3 The average absolute error of porosity is 1.33%, the average relative error of permeability is 37.61% by the BP neural network method for reservoir parameter interpretation model,which improves the accuracy of reservoir physical interpretation, and provides a strong guarantee for oil field reserves evaluation.

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