

Study on standard of Fu Yang reservoir effective thickness interpretation

Guanchun Yan

The fifth production plant of Daqing oilfield co., LTD of China Petroleum Corporation. Daqing 163513, China

Keywords: Fu Yang reservoir, low porosity and low permeability, the effective thickness, sandwich, hierarchical values.

Abstract. Fu Yang oil belongs to low porosity and low permeability reservoir, the thickness of development is thin and the content of oil is less. Oil-bearing occurrence mainly in oil immersion and oil stain, the jump range of spa is low, and it is not sensitive to the lithology reflection. Through the analysis of the lithological and physical property, the physical property plays a controlling role to the oil content. The porosity of the sample in Fu Yang reservoirs with oil stain or above level mainly distributed between 10-16%, and the air permeability mainly distributed between 0.1-1.5mD. According to the method of hierarchical values to reach the effective thickness and interlayer standards of Fu Yang reservoir. According to Layered accessory methods and Software development to implement the connection between the effective thicknesses lower limit value standard and mezzanine standard of Fu Yang reservoir and the software platform. It has vital significance for research the potential of Fu Yang reservoir, submit backup reserves, and the guidance of the development on test work.

1. Introduction

The effective thickness of Reservoir means the thickness of the part with capacity, or the thickness of reservoir who play a role in oil production when it reach the standard of industrial oil flow. The effective thickness of Reservoir is an important parameter in oilfield development, and it is the basis of correct understanding of reservoir distribution and accurate calculation of oil geological reserves. Accurate divide the effective thickness of reservoir is an important work to research the oil geological reserves. Using oil-bearing occurrence law to research the effective thickness interpretation standard of FuYang reservoir and connect the computer software platform has vital significance for expand the scale of evaluation of FuYang reservoir and improve the interpretation accuracy of the effective thickness.

2. General situation of Geological

FuYang reservoir belongs to under system of the Mesozoic cretaceous, the main sedimentary system is delta plain faces, the developing scale of channel is small, the planar sand body phase change fast, and the connectivity is poor. The main oil-bearing series is cretaceous strata, the main purpose layer is the quantou formation, quantou formation continue to fill basin after the denglouku formation, quan three and four are the overall uplift in the late spring two basin developed on the background of a set of water into the sedimentary system, Sedimentation development is accompanied with basin subsidence rate increased, range of sedimentary increased, and the process of subsidence center moved. The sedimentary condition is very complex, the all basin in a state of bridge in the spring four sedimentary, the max thickness is between 1500~2200m.

Fu-Yang reservoir divide into two part named FuYang reservoir and Yangdachengzi reservoir. Subdivided into Fu I, II, III group and Yang I, II, III group. The thickness of Fu I reservoir is between 85-110m. For the single layer of Fu I No.1, No.7, development channel sand in the Midwest, for the single layer of Fu I No.2, development channel sand in the Middle East. For the single layer of Fu I No.3, No.4, No.5, No.6, the channel sands present a local distribution status. The average thickness of sandstone in Fu I is 12.2m and the average effective thickness is 2.8m. The thickness of Fu II is

between 40-55m. For the single layer of Fu II No.3, No.4, the development of channel sand is better in all the district, for the single layer of Fu II No.1, No.2 and No.5, the channel sands present a local distribution status. The average sandstone thickness and the average effective thickness of Fu II group are 7.3m and 1.9m respectively. For Fu III group, the reservoir formation thickness is about 45-60m and the channel sands present a local distribution status, too. The average sandstone thickness and the average effective thickness of Fu III group are 7.4m and 0.5m respectively.

3. The lithology, physical property and oil bearing

During logging appraisal for reservoir stratum, it is of great importance to study the relationship between the lithology, the dingheit and the oiliness of the reservoir. Only on the basis of fully understanding the reservoir characteristics, establishing the well-logging interpretation model, and reasonable logging interpolation parameters are selected, the logging interpolation results can meet the geological rule of the reservoir.

3.1 Relationship between lithology and oiliness

The statistics of porosity, permeability and shaliness coupled with the relation between permeability and porosity for different lithologic cores indicate that the shaliness has a significance influence on the porosity and the permeability of reservoir. Specifically, both of the porosity and the permeability decreases with the increasing of the shaliness. The lithology of reservoir mainly consists packsand and siltstone, which possess a low shaliness and a high porosity and permeability.

3.2 Relationship between lithology and oiliness

Relation between different oil-bearing occurrence, permeability and porosity of different lithologic cores shows that the packsand and the siltstone in the Fu-Yang oil layer have a large oil content, however, the argillaceous siltstone and the calcareous siltstone possess a relative low oil content.

3.3 Relationship between dinghies and oiliness

The oil-bearing occurrence can be divided into six status, they are oil saturated, oil containing, oil invaded, oil spot, oil stains and no oil, respectively. The relation between core permeability and porosity in these six circumstance indicates an evident connection between the dingheit and the oiliness, namely, the oiliness increases with respect to the better of the oil-layer dingheit. Additionally, the reservoir dingheit is relatively well when the oiliness is large than oil spot.

4. Establishing of Fu-Yang oil-layer parametric model

4.1 Shaliness model

In general, the shakiness of reservoir can be well reflected by the natural gamma curve. Based on natural gamma curve, the equation for calculating the shakiness can be expressed as

$$\Delta GR = \frac{GR - GR_{\min}}{GR_{\max} - GR_{\min}}$$

$$V_{sh} = \frac{2^{C \cdot \Delta GR} - 1}{2^C - 1}$$

Where, GR – Natural-gamma-ray log value, API; C - Constant

GR_{min}- Nature gamma ray value of pure sandstone, API;

GR_{max}- Nature gamma ray value of pure shale, API;

ΔGR- Relative value of nature gamma ray, API;

Vsh- Value of shakiness.

Using 69 core analysis layer of shale content and natural gamma curve to establish Shale content interpretation model, get the type after multivariate regression: $V_{sh} = 0.9527V_{sh} + 1.0456$, the average relative error of the model is 20.9%.

4.2 Effective porosity

The most commonly used method to explain effective porosity in well measurement is based on the logging response of reservoir feature selection acoustic time, lithology density, compensatory neutron logging curve in the combination of one or a few [3] and calculate with the experience

model developed by the analysis of the core porosity to establish a formula of FuYang reservoir porosity.

Calculate the porosity by acoustic time and density curve.

$\Phi = 17.98239 + 0.1203696AC - 14.78954DEN$ (correlation coefficient: 0.92 average relative error: 7.4%)

Calculate the porosity by Sound waves, density and neutron curve.

$\Phi = 4.521890 + 9.6665487E-02AC - 8.458818DEN + 0.2139275NPHI$

(Correlation coefficient: 0.92 average relative error: 7.5%)

4.3 Permeability model

In reservoir logging evaluation, Permeability calculation is usually applied the experience model established according to the core permeability and porosity to establish Permeability model.

$LNK = -1.949342 + 0.7220785\Phi - 2.986867\Phi$ (correlation coefficient: 0.85 average relative error: 50.2%)

4.4 Water saturation model

Based on the Archie formula, through litho-electric experiment to determine the initial oil saturation calculation model for reservoir. Archie formula can be written as:

$$S_w^n = \frac{abR_w}{R_t \times \Phi^m} \quad (1-1)$$

Where: R_w -Formation water resistivity, $\Omega \cdot m$;

R_t -Formation resistivity, $\Omega \cdot m$;

Φ -Effective porosity, v/v;

S_w -Water saturation, v/v;

m -Porosity index;

n - Saturation exponent;

a, b - Empirical coefficient related to lithology, and pore structure.

We calculate original water saturation according to Archie equation, first step is to make sure the value of m, n, a , and b , $a=1.307$, $b=0.9046$, $m=1.3782$, $n=1.3137$ [4].

The formation water resistivity mainly are determined by water analysis. According to actual water analysis of Fuyang oil layer, formation water resistivity under the equivalent reservoir condition is $0.5\Omega \cdot m$.

Build the suitable saturation model according to the data of real porosity, resistivity, and oil saturation

Take the log of both ends of the formula (1-1), we can obtain the following formula by arranging it:

$$\log(S_w) = \frac{1}{n} \times \log(abR_w) - m \times \log(\Phi) - \frac{1}{n} \times \log(R_t)$$

The values of R_w, a, b, m , and n changed very little in an area, they can be regarded as constant value, thus the above formulas will be changed into:

$$\log(S_w) = A - B \times \log(\Phi) - C \times \log(R_t)$$

3 A, B , and C , and D , so as to establish the equation that calculate reservoir initial oil saturation.

$$\lg(S_w) = -0.37027 - 1.0491 \times \lg(\Phi) - 0.76126 \times \lg(R_t)$$

Where is, Φ is effective porosity, %; R is deep lateral logging resistivity value $\Omega \cdot m$.

4.5 validation of the results

Preferred 2 wells that were not participate in Interpretation model for validation [5]. The average single well is validated 49 layer, porosity of the average absolute error is 1.7%, and permeability average relative error was 19.7%.

5. The effective thickness standard research of FuYang reservoir

5.1 standard of the property

The different levels relations between oil-bearing occurrence and effective porosity, air permeability showed that oilbearing grade increase with the increase of permeability and porosity. When effective porosity is 10.6%, air permeability is greater than 0.105mD, oil-bearing occurrence that over oil patch silty sand class mutation appear more frequently, show lower limit of oiliness and lithological characters should be oil patch siltstone.

5.2 electrical property standard

Establish the electrical standard chart of Fu Yang reservoir effective thickness, according to acoustic and deep lateral logging resistivity of data point of 45 layers, effective layer number is 42, and 3 layers were strayed, plate accuracy is 93.3%. The standard is: When acoustic is greater than 250 μ s/m, deep lateral logging is greater than 11 $\Omega \cdot m$; acoustic is greater than 230 μ s/m and Less than 250 μ s/m [6], deep lateral logging is equal or greater than $-0.63AC+169.2 \Omega \cdot m$.

5.3 Mezzanine standard

Sandwich deduction standard. The fuyang reservoirs is the reservoir heterogeneity, Oil layer With calcium layer and mudstone, Effective thickness interpretation need to deduct the part of sandwich, The thickness of sandwich deduction is 0.2m.

Low resistivity interbred deduction standard. Micro resistivity curve of low resistivity layer obviously return, Acoustic time curve showed lower value, the natural gamma curve showed a higher value [1]. Microspheres resistivity value and microspheres mean return correlation of fuyang reservoir effective thickness the low resistivity layer showed that, When the return of microspheres resistivity greater than 31%, In the laminated part of the deduction.

High resistivity interbred deduction standard. Microspheres resistivity value and microspheres mean return correlation of fuyang reservoir effective thickness the low resistivity layer showed that, When the acoustic travel time less than 230 μ s/m, according to the dissection of partial deduction.

6. Curve layering method

The formation is a layer by layer deposition, Reflect the formation properties and layers, Well logging data of the reflect the formation properties is also a layer by layer, Therefore the log interpretation can be layer by layer according to the log interpretation, Layer by layer to eliminate the effect of thin layer interpretation, Can improve the logging parameters determine the speed.

6.1 The principle of stratification curve

With the high resolution deep three side as layered reference curve, The other curves layer interface to benchmark curve stratified interface shall prevail, A hierarchical method all curves by hand layered and layered combination theory [7], To determine the interfacial delamination by hand, The theory of stratification to determine curve inflection point and steps, The roots of 1/3 interface, main interface and interface layer effective thickness uniform.

Microsphere, high resolution three lateral, three micro resistivity curve as a potential natural potential condition recognition of mudstone.

For different natural potential logging series distinguish mudstone conditions, at the same time, natural potential to meet certain requirements thickness, on the basis of mudstone points divided into spontaneous potential baseline.

6.2 Curve value principle

The value of reference curve shape, The spontaneous potential curve with the thickness weighted geometric average value; The average value of acoustic curve area; Microspheres, shallow lateral and microelectrode curve is adopted to form; The density and the natural gamma curve using the maximum thickness of the weighted geometric mean value, Sp read layer relative to the baseline, as the final value.

7. Curve of layering software and hanging

Using object oriented programming in VC++, Every one of the layered method, value method, hierarchical principle, value principle to make the standard function, At the same time, the establishment of the standard function call, Function call different through different operation, And the hierarchical module is made of standard interface, Packaged as dynamic link library (DLL), Attached to the software platform, And the software platform SQL Server database to realize data sharing, To complete the various operations layer value. The embedded value standard and limit of the effective thickness of interlayer in the PC version of the software platform (Figure 1), Implementation of software platform for the effective thickness of different blocks of standard operation.

Application of the PC version of the reservoir parameter interpretation software, 147 wells in Fu Yang reservoirs (because some wells without drilling Yangdachengzi oil layer) Explain the thickness, The average single well development of sandstone thickness 22.3m, The average single well development effective number 3, The development of the effective thickness is 4.7m; The effective thickness of 5.0m single well of 66 wells, The average single well development of effective number of 5, the development of effective thickness is 8.3m.

8. Conclusion

1. Through the study of the relationship between the oil and the content of lithology, the reservoir of oil bearing plays a controlling role.

2. The occurrence of oil method, Determination of Fuyang reservoir effective thickness of interlayer standard and standard.

3. Through the method of hierarchical software and research value, Realization of Fuyang reservoir effective thickness of interlayer and lower limit standard and standard PC explain hanging software platform.

4. Application of computer automatic interpretation software version 4, the reservoir parameters, In 147 wells of Fu-yang reservoir effective thickness interpretation.

Reference

- [1] Guan Chunyan. Xingshugang oilfield of FuYang reservoirs and water layer identification method [J]. Petroleum Geology and engineering, 2011, 25 (5): 75-78.
- [2] Han Xue. [J]. layer identification method of complex oil and water in oil layers of low porosity and low permeability. Chinese and foreign energy, 2009, 14 (5): 61-64.
- [3] Zhang Li, Xia Zheng Han, Zhao Shuying. Evaluation of reservoir fluid properties of [J]. quantitative application of logging data. Petroleum Geology and development, Daqing 2006, 25 (3): 27-28.
- [4] Wang Xue. Songliao Basin Qijia sag and oil source in Daqing Changyuan Fu Yang reservoirs [J]. The exploration and development of oil, 2006, 33 (3): 294-298.
- [5] Yang Sitong, Sun Jianmeng, Ma Jianhai. Low porosity and low permeability reservoir well logging data of oil and gas identification method of [J]. Oil and gas geology, 2007, 17 (3): 51-54.
- [6] Yi Dinghong. Xingshugang Taipingtung area - Fuyang reservoir of sequence stratigraphy [J]. Petroleum geology of Xinjiang, 2004, 25 (6): 607-609.
- [7] Lin Jingye. analysis of Daqing Changyuan Fuyu Yangdachengzi reservoir exploration potential [J]. Petroleum Geology and development, Daqing 2003, 22 (3): 16-18.