

Study on reservoir description technology of complex fault block oilfield—Taking the South 1st member of D sag as an example

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Abstract. The D sag has developed faults, serious erosion and fault loss, developed glutamate, strong heterogeneity, and large formation dip, which makes stratigraphic comparison difficult and unclear understanding of oil reservoir and oil-water relationship during the development process. For this reason, this study was carried out. On the basis of the existing seismic interpretation results, carry out the fine structural interpretation of the main sub-layers in the study area; carry out the study of sedimentary characteristics, divide the sedimentary facies, and clarify the sedimentary characteristics of the main sand bodies; use the core analysis data to establish the interpretation of physical parameters in the study area model, and establish a fine three-dimensional geological model, through the study of oil-water distribution law, carry out potential research, and select favorable well-distributed blocks.

1. Introduction

At present, there are many methods for reservoir description at home and abroad, mainly guided by related theories such as sedimentary petrology, reservoir geology, petroleum geology, geophysical logging, etc. For geological outcrops, drilling, logging and other data, a combination of macro and micro research methods is adopted.

In recent years, in Dagang, Changqing, Huabei and other oilfields, based on the cycle of lithology and lithofacies changes and their combination characteristics reflected in the shape of the electrical survey curve, the well-seismic combination has put forward the isochronous comparison technology of hierarchical constraints and multiple control. Including deposition control framework, well vibration control structure, microfacies control change, dynamic control connection and other methods, stratigraphic division and comparison are carried out, which can improve the sublayer comparison of complex fault block reservoirs.

The study of reservoir sedimentary microfacies is to clarify the sedimentary environment, sedimentary facies and microfacies types and their temporal and spatial evolution of the reservoir, and to reveal the heterogeneity of sand body genetic type, geometric shape, size, distribution and vertical and horizontal connectivity. The fine description technology of reservoir sand bodies mainly includes subdivision sedimentary microfacies research, well-seismic combination sand body characterization, logging interpretation and evaluation, etc.

The analysis of development potential is mainly through fine reservoir description, continuously deepening the fine research of reservoir and structure, based on 3D

seismic data, applying sand body tracking technology and theories such as compound oil and gas reservoirs, lithologic oil and gas reservoirs as the guidance, broadening the exploration of oil and gas. Oil ideas. From the known to the unknown, striving to discover new small traps in the periphery of the old area to realize rolling reserves increase; according to the oil layers drilled in the edge wells of the oilfield and the production situation, combined with the prediction results of sedimentary facies and reservoir sand bodies, Deploy rolling wells in favorable areas of structures and reservoirs to increase geological reserves and recoverable reserves; look for new blocks to increase reserves in blocks such as the periphery of oilfields and structural fracture zones.

2. Reservoir description method for complex fault-block reservoirs

Facing the complex geological conditions of Sag D, on the basis of summarizing and absorbing previous research results, by systematically sorting out and studying well data, constantly summarizing past experience and lessons, and constantly innovating and practicing, through four aspects of research, complex fault-block oil reservoirs have been formed. Layer description method.

2.1 Well-seismic combination to improve structural interpretation accuracy

The research idea of "well-seismic combination, hierarchical control, cycle comparison, and multi-information comprehensive verification" is adopted. Based on previous research and understanding, various models are used to form objective constraints and various information are used as verification conditions. The

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establishment of the system is an important content, closely combined with seismic data, to clarify the corresponding relationship between multi-level and different base level cycles and horizon boundaries, and to carry out stratigraphic division and comparison with the appropriate stratigraphic correlation unit as the carrier, aiming to finally identify the main force. The distribution characteristics of oil layers and formations, and the fine division and comparison of stratigraphic series and sublayers in D sag has been completed. The Nantun Formation is divided into six oil layer groups by identifying four sequence boundaries by means of transformation surface, lake flood surface and unconformity surface.

Through the subdivision and comparison of sub-layers, 100 wells with 3645 layers of connectivity were re-judged, and the degree of water flooding control decreased from 89.6% to 85.0%, a decrease of 4.6 percentage points, of which the proportion of one-way connectivity decreased by 4.3% and the proportion of two-way connectivity decreased by 2.8%, the proportion of multi-directional connectivity increased by 1.3%.

Table 1 Changes in the control degree of water flooding in the comparison of old and new layers

Classification		Connectivity efficiency (m)				Total
		One-direction	Two-direction	Three-direction	Four-direction	
original layer	Total thickness(m)	826.3	803.7	458.2	155.2	2243.4
	Water drive control degree(%)	33.0	32.1	18.3	6.2	89.6
new layer	Total thickness(m)	738.6	754.1	411.8	285.7	2187.6
	Water drive control degree(%)	28.7	29.3	16.0	11.1	85.0

Aiming at the complex geological structure of D depression, in order to accurately calibrate the horizon and establish accurate well seismic relationship, synstool in SMI was used to make synthetic records of all wells and calibrate the horizon. In this work, six seismic reflection layers are calibrated, and the seismic wave resistance characteristics of the interface of each reflection layer are determined. The three-dimensional velocity body is established by verifying the real drilling data of dense well pattern and dynamic data, and then the fine structural interpretation is carried out, and the structural error is controlled within 0.3%.

2.2 Multi data fusion, recognition of sedimentary microfacies

According to core observation and sedimentary facies identification, combined with the analysis of regional sedimentary background and hydrodynamic conditions, the sedimentary facies model is established. Under the guidance of facies model, refine the types of sedimentary microfacies, analyze the logging response characteristics of each microfacies type, establish the corresponding relationship between facies and electricity, guide the division of microfacies types of non coring wells, and then

characterize sedimentary microfacies through single well facies judgment and plane facies combination.

According to the core observation of 26 coring wells, in the sedimentary period of the first member of Nantun Formation, the lake area is large and the lake is shallow. Block D is a tongue shaped lake bank. The color of mudstone is mostly green and grayish green, which represents the sedimentary environment of shallow water. Sandy conglomerate siltstone and other sandstones are developed in the work area. Some debris rocks contain tuffaceous components and the particle sorting is general; There are many gravel bearing sections, the gravel composition is complex, and the sorting and grinding are medium; The rock structure maturity and composition maturity are medium, which represents a low-energy, far source and nearshore sedimentary environment. From the C-M diagram and particle size probability diagram of sedimentary period, which are similar to the particle size probability diagram of beach bar sand body in Dongying depression, the core contains plant stem fossils and carbon debris, and the lithology is relatively fine, indicating that the river action energy was weak and the lake action ability was strong at that time, which was conducive to the development of shore shallow lake beach bar sedimentary system.

In the sedimentary period of Naner member, D is the middle uplift area with large angle, which is easy to form gravity flow. The color of mudstone is mostly black, which represents the sedimentary environment of underwater reduction. Various sandstones such as sandy conglomerate siltstone are developed in the work area, and some clastic rocks contain tuffaceous components, with general particle sorting; There are many gravel sections, the gravel composition is complex, and the sorting and grinding are poor; The maturity of rock structure and composition is low, which represents a low-energy and shallow water sedimentary environment. From the C-M diagram and particle size probability diagram of sedimentary period, which are similar to the particle size probability diagram of gravity flow sedimentation, the core can clearly see the typical characteristics of gravity flow sedimentation, such as River Scouring surface, cross bedding, imbricate structure, carbonaceous debris in mudstone.

2.3 Reservoir parameter interpretation

The core analysis data is ≥ 3 points / interval, the interval of oil layer group is improved, and the multiple regression analysis model of reservoir porosity is established. The relative error of porosity is within 8%, which meets the development needs.

According to the core analysis and test data of 339 sample points of 14 coring wells in the development zone of depression D, count the porosity and permeability of each core, calculate the reservoir quality factor RQI and flow interval index FZI, and draw the cumulative frequency curve of FZI value (Fig. 1). The flow unit can be divided into three categories: I, II and III. see Table 2 for the specific classification.

The FZI of class I flow unit is greater than 1.4, the porosity distribution range is 1.8-29.7%, the average

value is 18.8%, the permeability distribution range is $0.13\text{-}2030.0 \times 10^{-3} \mu\text{m}^2$, the average value is $382.8 \times 10^{-3} \mu\text{m}^2$, and the median probability is $156.0 \times 10^{-3} \mu\text{m}^2$. The lithology is mainly sandy conglomerate and sandy conglomerate. The FZI of class II flow unit is greater than 0.3 but less than 1.4, the porosity distribution range is 1.8-29.7%, the average value is 13.1%, the permeability distribution range is $0.01\text{-}90.6 \times 10^{-3} \mu\text{m}^2$, the average value is $4.69 \times 10^{-3} \mu\text{m}^2$, and the median probability is $0.79 \times 10^{-3} \mu\text{m}^2$. The lithology is mainly pebbly sandstone and fine sandstone. The FZI value of class III flow unit is less than or equal to 0.3, the porosity distribution range is 5.4-23.0%, the average value is 15.6%, the permeability distribution range is $0.01\text{-}1.31 \times 10^{-3} \mu\text{m}^2$, the average value is $0.21 \times 10^{-3} \mu\text{m}^2$, and the median probability is $0.05 \times 10^{-3} \mu\text{m}^2$. The lithology is mainly siltstone and argillaceous siltstone.

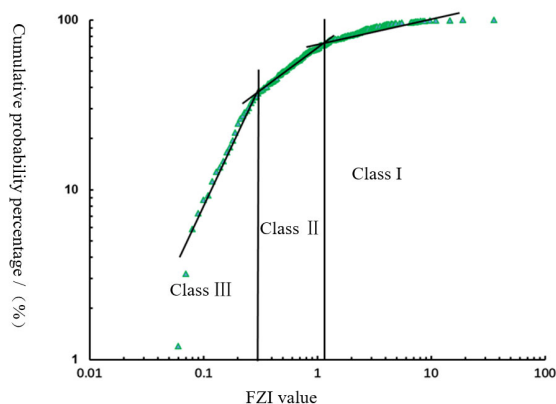


Figure 1. Cumulative probability distribution of core FZI value

Table 2 The permeability interpretation model is established by flow unit

Classification	Number of wells	Sample number	Permeability calculation formula	correlation coefficient
Class I	11	50	$K = 0.2677e^{0.2898 * \text{POR}}$	0.89
Class II	14	146	$K = 0.0206e^{0.2696 * \text{POR}}$	0.92
Class III	14	143	$K = 0.0008e^{0.2967 * \text{POR}}$	0.70

According to the division of flow units, the permeability interpretation model is established by using the core analysis porosity and permeability data. The standardized logging sample data is input into SPSS as samples. 58 intervals of 12 wells are selected for discriminant analysis, and the discriminant functions of various flow units are obtained.

Table 3 Flow unit discriminant equation

Discriminant	Class I	Class II	Class III
AC μs/ft	4.496	4.282	3.884
LLD Ω.m	1.633	1.291	1.166
ΔSP mV	1.639	1.152	1.024
(constant)	-240.177	-205.674	-169.284

Since there is no closed coring well in Huo 3-3 block, there is a certain relationship between core capillary pressure curve and oil saturation. Oil saturation can be calculated by using oil column height and j function. The following formula is obtained by fitting the j function of core analysis with oil saturation, and the correlation coefficient is 0.90.

$$S_o = 12.62 \ln(J(S_w)) + 48.627 \quad (1)$$

2.4 Three dimensional geological model for reserve recalculation

According to the reservoir type, structure and reservoir development, the oil-bearing area of each oil layer group is delineated, and the calculated reserves by oil layer group are reduced by $497.0 \times 10^4 \text{t}$. The main reason is that the porosity is lower than before, the effective thickness is reduced, and the oil-bearing area is slightly reduced.

The model frame is established by using well point layering and reservoir group top structural line, and the grid accuracy is $25 \times 25 \times 0.5 \text{m}$, with a total number of grids of 14.98 million. The lithofacies model is generated by using the sand ground ratio as the 2D trend line, and then the lithofacies model is used to control the generation of attribute model.

According to the research results, in 2018, measures were taken to increase production and injection for the oil wells with low permeability in the south section I. A total of 10 fractured oil wells and 6 water wells increased injection. In the initial stage, the daily oil increase of a single well was 4.7T. At present, the daily oil increase of a single well is 3.4t. In 2018, the cumulative oil increase was 5993t, and the liquid production of the target layer increased by 97%, achieving good application results.

3. Conclusion

- (1) The key basis of reservoir description of complex fault block reservoir is reservoir correlation, structural interpretation, parameter interpretation and three-dimensional model establishment.
- (2) The combination of well and earthquake, through seismic type control, cycle subdivision and correlation, and improving the accuracy of reservoir correlation and structural interpretation are the key to the reservoir description of complex fault block reservoir.
- (3). using the organic integration of sedimentary characteristics, logging curve characteristics, sand ground ratio, formation dip angle, core analysis and other data, carry out the research on sedimentary characteristics and finely describe the reservoir distribution.
- (4). the permeability model of the study area established by sub flow unit can improve the accuracy of permeability interpretation. For non closed coring wells, core analysis data and J-function method can be used to calculate oil saturation.

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