Research on Well-seismic Characterization of Multi-layer Sandstone Reservoir

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Abstract. Multi-layer sandstone reservoirs are one of the important types of A dilute oil reservoirs. They have reached the middle and later stages of development, with the following characteristics: controlled by multiple multi-level faults, many faults, small fault blocks, small fault block reservoir area; affected by sedimentation, the distribution of sand bodies is discontinuous and the connectivity is poor, resulting in serious reservoir heterogeneity; after long-term water injection scouring, the reservoir properties and oil-water properties have changed, and the remaining oil distribution is complicated. These characteristics determine that the research focus of this type of reservoir is to carry out fine characterization of reservoir well-seismic joints, establish the isochronous stratigraphic framework of the reservoir unit, analyze the characteristics of small faults and microstructures in the reservoir, and describe various sand bodies between wells. The internal heterogeneity and the three-dimensional spatial distribution regularity of the oilfield are used to establish a fine three-dimensional reservoir geological model, which provides strong technical support for revealing the spatial distribution characteristics and laws of the remaining oil.

1. Introduction

Before the second three-dimensional earthquake in A Basin (before 2000), seismic acquisition of 162,000 square kilometers was completed in the main structural area, which was highlighted in multiple deployments, different annual constructions, different acquisition methods, different construction teams, and different geological requirements. Coupled with the complex seismic geological conditions, a three-dimensional seismic exploration failed to meet the needs of exploration and development. With the deepening of exploration and development, the application of high-precision 3D seismic acquisition technology has improved the quality of original data. After 2001, the second earthquake collected 36 blocks of 7679km². On the basis of summarizing the previous parameter settings, the acquisition system is improved by combining the reservoir characteristics and geological objectives, the detector combination is optimized, the coverage is increased, and the CMP bin is reduced. Through a number of fine processing new technologies for development reservoirs, noise, comprehensive static correction, consistency processing, etc., the resolution of the pre-stack time migration profile is significantly improved, the main frequency is increased from 25 Hz to 35 Hz, and the frequency bandwidth is expanded from 55 to 80 Hz To 5 ~ 100Hz. The new seismic profile has fewer composite waves, continuous seismic reflections, and the same-phase axis is clearly misaligned, which provides reliable data for subsequent fine structural analysis and reservoir heterogeneity studies.
2. Well-seismic joint stratum isochronic comparison, effectively tamping the reservoir research foundation

Based on logging / logging, core data, high-precision 3D seismic, and production test data, a multi-level sedimentary cycle (or reference surface cycle) is used as a reference surface to establish a high-precision time stratigraphic correlation framework. The simple stratigraphic comparison of "sand, mud to mud" shifts to sequence stratigraphic analysis on the basis of isochronous framework, which effectively guarantees the accuracy and depth of understanding of underground geological bodies [1].

2.1 Based on the characteristics of the reservoir sedimentary system, establish an isochronous sequence stratigraphic framework

In order to solve the problem of unequal timing and low accuracy of stratigraphic correlation, the sequence stratigraphic development model under the control of Dujiai oil layer deposition in the Shushu District was established under the guidance of continental sequence stratigraphy principles.

Formation of "filling and filling" formation at the bottom of the III oil group. The Dujiai oil layer is divided into three oil groups, Du I - III, which are unconformably contacted with the underlying high-rise oil layer due to sedimentation. Uneven unevenness results in differential formation of the stratum. The thickness of the deposit is large in the low-lying terrain. The thickness of the deposit is thin in the area of the topography. The sedimentation of the stratum is generally "filling and filling" mode [2]. On the seismic profile, "filling and filling" mainly shows that the number of seismic in-phase axes increases and the frequency decreases. The number of the same-phase axis in the southwest part of the study area is obviously more than that in the middle, indicating that the strata are relatively complete in the southwest area and gradually disappearing towards the northeast.

2.1.1 The rapid lake retreat at the bottom of the oil group II controls the sand body overrun

Before the Dujiai II oil formation was deposited, there still existed differences in paleotopography. In the late deposition period of the Du III oil formation, stable penguin mudstones were formed in the lake. After the penguin mudstones were deposited, a rapid lake retreat was developed, followed by a four-level sequence of slow lake advance and source supply in the southwest and northeast directions. As a result, the bottom of the Du II Oil Formation in the northern part of the work area appears to be overlying in two directions to the middle, and the number of small layers is decreasing in the upward direction, forming a "stratified superstratification" sedimentary stratigraphic framework. Provenances in the south-west direction have a greater influence, while those in the north-east direction have a smaller influence. The “super” on the seismic profile is mainly represented by the reduction of the number of seismic in-phase axes. Outside the work area, the same-phase axis at the bottom of the oil group II in the direction of provenance is significantly overlaid.

2.1.2 There is a difference in the range of subsidence in the formation of oil group I

This stratum development model is that in areas with large settlements, the sedimentary strata are relatively thick; on the contrary, in areas with small settlements, the sedimentary strata are relatively thin. Before the deposition of the Du I oil group, the topography was relatively gentle, but the effect of the same sedimentary uplift caused the formation of the Du I oil group in the uplift to thin proportionally. Based on "model guidance, hierarchical constraints, multiple control, and detailed research", further research is carried out through technical means such as cycles and their combinations, stratigraphic process-response analysis, advanced sub-sequence control, and comprehensive comparison of seismic, logging, and core data. Fine comparison of cycle units of different grades in more than 600 wells in the district. Within the tertiary sequence, combined with different scales of advancing-depressing conversion surface (i.e., lake flooding surface), the Dujiai oil layer is divided into 5 mid-term, 11 short-term, and 29 ultra-short-term base level cycle sequences.
2.2 Comprehensive application of dynamic and static information to ensure the reliability of fine stratum comparison

The division and comparison of Dujiatai oil layer in the third Shu area can be summarized as three characteristics: "one break, two stripping and three unification". "One break" refers to the fact that when the stratigraphic correlation is not carried out through well-seismic combination, the trend of stratum thinning toward the edge of the basin is attributed to the role of faults, thereby delineating a series of faults in local well areas [3]. "Second stripping" means that with the contradiction in waterflooding development, the stratigraphic correlation work is gradually deepened. It is believed that the "filling and filling" stratigraphic model is developed at the bottom of the III oil group, which leads to the differential deposition of strata. And missing programs. "Three unifications" refers to the use of dynamic data to control the establishment of reservoir subdivision and comparison models to achieve the unification of seismic profile interpretation, drilling stratum comparison, and production performance data analysis [4]. Based on the backbone profile as the benchmark, the joint profile well-seismic joint comparison is carried out, the layering and breakpoint positions are continuously modified, and finally all vertical and horizontal profiles are closed. The sedimentary characteristics of the "group superstratification" in the local well area and the differential settlement of the oil group I are considered the main reason for the formation thinning has ensured the unity of the Dujiatai oil layer contrast. By reconstructing the sequence stratigraphic framework of the Dujiatai oil layer, a large number of breakpoints have been reduced, and the understanding of structural fragmentation in the work area has been changed. The structural model has been modified to be relatively complete.

Dujiatai oil layer division

![Figure 1. Reservoir division and comparison](image)

3. Layer-by-layer fine structure analysis to clarify the top surface structure of the main oil layer

3.1 The fine calibration of the interface of the target interval to ensure the unity of the seismic horizon and drilling stratification

The fine layer calibration refers to the calibration of the internal sand group (or the top surface of the oil layer) on the basis of the large structural layer calibration, which is the basis of the fine layer-by-layer structural interpretation. On the basis of determining and closing the large geological horizon boundaries of the 3D seismic profile, select and make synthetic records according to the area and the position of both sides of the fault, and stratify the small layers of the well, that is, the top boundary (or bottom boundary of each oil layer) ) The location is determined on the seismic profile, and the one-to-one correspondence between them and the seismic reflection wave is found to ensure the unity of the seismic interpretation horizon and drilling stratification to improve the recognition of the oil layer [5].
3.2 Combined well-seismic interpretation of faults to improve the accuracy of structural research

Use the main survey line, tie line multi-section and multi-window interactive interpretation, and use any line to select a closed section like "mouth" in any fault block to check the interpretation plan. The main identification signs of faults on conventional seismic profiles are: the in-phase axis on both sides of the fault is misaligned, but the reflected wave characteristics are clear, and the relationship between wave groups or wave systems is stable; the number of reflected wave in-phase axes suddenly increases or decreases, and the wave group interval Sudden changes are manifested by the increasing data of the in-phase axis of the descending disk and the formation thickening. The number of the in-phase axis of the ascending disk suddenly decreases and the formation is thinned. The shape of the in-phase axis of the reflected wave is abrupt, the reflection is disordered and blank reflection occurs.

4. Comprehensive description of the target sand body, significantly improving the reservoir characterization accuracy

For clastic rock sand and mudstone reservoirs, the thin layer tuning phenomenon and the lateral change of the reservoir result in changes in seismic wave amplitude, frequency and phase. This change is related to the single layer thickness, layer velocity, density, and the combination relationship between layers in the interlayer group, which makes the seismic wave field characteristics change more complicated. Using seismic frequency extension, reservoir inversion, seismic sedimentology and other methods, by giving vivid seismic significance to the seismic attributes based on the basis, the sedimentary configuration can effectively correspond to the seismic attributes and depict the distribution of different sedimentary sand bodies the forecast coincidence rate has increased significantly.

4.1 Extension of seismic data of narrow and thin sand bodies to further improve the prediction agreement rate of single sand bodies

Narrow and thin reservoirs mainly refer to "sand-covered sand" type thin interbeds and narrow small channel sand bodies. The thickness of sand bodies is generally less than 2m and the width of sand bodies is less than 200m. In the past, the prediction rate of such narrow and thin reservoirs is generally consistent Lower. The seismic frequency of narrow and thin reservoirs is low, and the thickness is not on the order of magnitude compared with the longitudinal resolution of existing seismic data. Therefore, it is a difficult task to study thin reservoirs by combining conventional well-seismic data. Through long-term development practice, it proposes a "responsive and identifiable" research idea, breaks through the constraints of seismic resolution, and effectively identifies the spatial distribution characteristics of thin reservoirs.

5. Conclusion

A dilute oil multi-layer sandstone reservoir is affected by sedimentation, the distribution of sand body is discontinuous, the reservoir heterogeneity is serious, and the remaining oil distribution is complex. Reservoir-well-seismic joint fine characterization significantly improves reservoir characterization accuracy, effectively characterizes the heterogeneous characteristics of various sand bodies and three-dimensional spatial distribution between wells, guides the establishment of a fine three-dimensional reservoir geological model, and describes the remaining oil space Lay the foundation for distribution and regularity analysis.

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