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Research Status and Prospect of Reservoir Architecture

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Abstract: The study of reservoir configuration plays an important role in the prediction of remaining oil distribution. China's early oil field due to the long-term water injection development, in the late oil field development, the oil field synthesis contains water already reached 90% more than, but, underground still remains a large number of remaining oil. In this paper, the advantages and disadvantages of several methods for studying reservoir architecture, such as field outcrop and modern deposition, well pattern prediction, ground penetrating radar and high-resolution seismic, are introduced, and their application prospects are forecasted.

Keywords: Single sand body, Reservoir configuration, Remaining oil, Comprehensive water cut.

1. Introduction

Reservoir architecture, also known as reservoir architectural structure, refers to the shape, scale, direction and superposition relationship of reservoir constituent units (generally single sand body) at different levels. At present, much attention has been paid to the study of single sand reservoir architecture, and many oilfields have entered the high water cut stage. Since the 1980s, many petroleum geologists have realized that the distribution of oil and gas resources has an essential relationship with the formation mode of rivers, and the fine anatomy of fluvial depositional system forms the single sand body configuration. A.D.Miall, a foreign scholar, put forward the theory of reservoir architecture when studying fluvial facies. This concept reflects the relationship between reservoir architecture units of different genesis and different levels, which is of great significance to the development of remaining oil potential and fine water injection. This is a major progress in the field of fine reservoir description, which mainly describes the division of sedimentary interfaces, the division of lithofacies types and configuration units, and the integration of the formation process of single sand bodies. Through literature analysis, this paper compares the advantages and disadvantages of several research methods on configuration, and provides a reference for the research on reservoir configuration by combining the characteristics of reservoir development in China.

2. Progress and Status Quo

2.1. Ancient outcrop anatomy and modern deposition

The research method of ancient outcrops and modern sediments is the most direct and precise research method in structural research. Outcrops and sediments have the advantages of intuitionistic, accurate, relatively complete and strong measurability, and accurate configurations can be obtained. Ancient outcrop and sedimentology analysis is the most direct method for reservoir structure analysis, which is convenient for observation and direct measurement and comparable with underground reservoirs. It is the main object of early reservoir architecture research, but it can only be used for profile observation and plane distribution research [1]. The study of modern sedimentary made up for the inadequacy of the ancient outcrop section in the plane, with the continuous development of geographic information technology and satellite technology, the surface characteristics of the sediment is more and more clearly in front of scholars, however, are often human activities in the modern sediment constantly the transformation of modern sediment, it is difficult to reflect the natural result of geological stress. Therefore, an important method to study reservoir architecture is to combine ancient outcrop anatomy with modern sediments, and many landmark results have been obtained [2].

Study, in the early stages of the tectonics, fluvial facies, delta facies in aeolian deposits outcrop as the foundation[3], established the configuration element and interface of the classification system, Allen, aeolian deposits is put forward in the 1970 s and delta sediments are divided into a sequence, which can explain each level outcrop palaeocurrent data in different areas of the (group), The order from minimum to maximum includes large ripple mark, small ripple mark, dune, river course and "integrated system" [4]. Modern depositional methods and ancient outcrop dissection methods are also used to study the genesis and formation process of structural units in watercourses. Based on field outcrop interpretation and modern sedimentary observations, Miall proposed quaternary configurational elements of eight fluvial deposits, their genetic analysis and geometric characterization. In recent years, the development of technologies such as unmanned aerial vehicles and space satellites has greatly facilitated field observations and measurements for researchers [5]. For example, Andreas et al. used aerial photographs to build a large-scale realistic 3D geological model to study the fluviform sedimentary structure of the Black Hawk Formation in Utah. In addition, different structural characteristics of fluvial sand bodies in the stratum profile were analyzed [6], such as the morphology of single-phase river and the side of multiphase channel. The thickness distribution and width-thickness ratio of fluvial sand bodies at different locations were calculated by using contact model and vertical superposition model. The width and thickness of fluvial sand bodies at different locations were greatly different. The size of the integrated channel sand body is much larger than that of a single channel sand body. Yang Shaochun et al. [7] observed the central beach in a modern river by satellite photos and divided it into four parts: beach

head, beach tail, beach wing and beach middle on the plane, and divided the longitudinal plush vertically. There are five different types of sedimentary sequences: accumulation layer, sedimentary silt layer, lateral aggregate, vertical weighting zone and lateral weighting zone, internal structures on both sides of the body [8].

2.2. Well pattern data prediction

Single well identification and inter-well sand body morphology prediction using drilling and logging data is one of the important methods for reservoir morphology characterization of underground geological bodies in oil fields [9], and finally reservoir structure characterization under well pattern control [10].

Yue vigorously using core, logging and dynamic data such as meandering river reservoir in guangdong islands region was studied [11], satellite photography technology is used to calculate the length and width of modern meandering river deposition in the Banks of the river, the relationship between them and their application in the riparian zone identification in the study area, can guide horizontal well in the study area and dense well pattern control under the beach in the form of internal anatomy; Li Shunming et al. [12] studied the reservoir structure of sand-braided river in Gaoshangbao Oilfield by natural gamma curve and microelectrode curve, and determined the channel filling, downstream silting, sand bottom morphology, sand sheet and fine-grained four-stage building unit by using the fine genetic stratigraphic correlation method, combined with the data of geological outcropping and sedimentation simulation experiments. Chang-min zhang [13], such as natural potential and microelectrode curve was used to study the the raschig xing oil fields of daqing 3 ~ 6 tectonic units of braided river reservoir, according to the internal characteristics of river channel sedimentation and topographical features, divided into five quaternary tectonic units: boundary, beach dam core, core beach dam crest, riverbed, abandoned channel and deep pool; The percolation buffer zone formed by the sedimentary unit and the separation between the layers finally establish the internal structure framework of the reservoir and guide the dynamic analysis of oilfield development. Niu Bo et al. [14] conducted a detailed analysis of the internal structure of the central bank bar of braided river in Sazhong Development Zone of Daqing Oilfield through inter-well comparison, and found that there were two transverse deposition modes, transverse deposition and longitudinal deposition. The interface along the flow direction was characterized by downstream deposition, which was slightly steeper than the beach head, flat in the middle, and slightly inclined at the end of the dam. Distribution location and area The silt layer at the top of the beach changed during different periods of beach deposition. Under the guidance of existing geological models, Zeng Xiangping [15] used core observation and mathematical geological methods to study the edge beach and middle beach of Gudao Oilfield. The transverse density was 0.03-0.05 / m, and the new beach sand body mud interlayer was relatively developed, 0.2-0.8 m thick, 100-450 m wide, and the distribution area was 0.02-0.2 km2. Plane is narrow strip or isolated potato-shaped distribution, vertical continuity is poor, staggered distribution, according to various borehole data, the internal structure of the meandering river sand body were studied in the region of daqing, determines the single channel, side beach deposits and the three levels of scale, and occurrence of side, found the meandering river sedimentary system in the single channel sand body width 210-500 - m, The length of side beach is 130-190 meters, the density of side sedimentary interlayer is 2.8-6.5/ m, the inclination Angle of side sedimentary layer is 5.2 °-7.6°, the horizontal extension distance is 20-50 meters, and the horizontal spacing is 14-31 meters. Liu Yuming in research of daqing lamadian oilfield such as braided structure, the middle of the river beach sedimentary thickness is established and the quantitative relationship between micro gradient curve regression degree, and its application to the central bank deposits of multiple well explain, [16] through the analysis of the core and logging data, studies the noble fort oilfield guantao braided river central beach reservoir internal structure. It is found that the silt layer is not developed in the middle beachhead of the study area, and the dip Angle of the wing interlayer in the middle beachhead is large, while the dip Angle of the silt layer in the tail system is small, which is 0.9°.

2.3. Ground penetrating radar

Ground penetrating radar (GPR) is a wide spectrum electromagnetic (1 MHz ~ 1 GHz) technique for measuring the distribution of subsurface shallow media. GPR uses one antenna to transmit high frequency and wide band electromagnetic waves, and another antenna to receive the electromagnetic waves reflected from the underground medium interface. When electromagnetic wave propagates in a medium, its propagation path, electromagnetic field intensity and waveform will change with the electrical properties and geometric shape of the medium. Therefore, the structure of the medium can be inferred based on the propagation time (also known as bidirectional propagation time), amplitude and waveform data of the received wave. GPR technology makes the anatomy of three-dimensional structures inside geological outcrops more accurate and reliable, and can directly image the subsurface or shallow geological structures with high precision, with a resolution of up to centimeter, and a maximum detection depth of more than 55 meters. Since 1980, GPR measurement methods have been applied to field outcrop geological research in foreign countries. For example, Alexander et al. [16] used GPR data, core and sonar detection data to study modern sedimentary meander rings in Montana, United States, and analyzed the main causes of river migration. It is influenced by tectonic incline, fault, base level change, evolution of capacity space and climate change. Corbeanu et al. [17] used field outcrops, cores and GPR technology to conduct a detailed study on the internal structure of the Cretaceous iron sand body in the Coyote Basin, Utah, USA, and established a 3D model. GPR technology has high resolution and can be well applied to field outcrop research, but its cost is high and its application scope has not been popularized yet.

2.4. High-resolution seismic methods

Seismic attribute is a quantitative method to characterize the seismic characteristics of the target layer. With the development of reservoir interpretation technology of seismic data, seismic attribute analysis has been widely used in reservoir prediction, reservoir description and reservoir monitoring. Rijks et al. [18] combined automatic volume tracking with sub-sequence attribute extraction through data hierarchical analysis technology, pointed out the fine structure of attributes and the key to sequence detection, and used seismic attributes to analyze river channel and fracture fan deposits. Taking Green point Dam as an example, Vitor et al.

[19] simulated sections of composite point dam in different time evolution processes by combining outcrop research results and seismic data, and Richard et al. [20] determined the channel structure through high-resolution 3D seismic data, which showed moderate to highly curved channels in the upper eroded channel filling strata.

However, various geophysical techniques can spatially characterize the reservoir boundary, size and oil and gas content. The main problems affecting the geological effect are low signal-to-noise ratio, low resolution and fine seismic data. Is not enough. At present, attribute analysis techniques are still in the process of development and improvement to provide accurate spatial seismic images to accurately describe the morphology of underground reservoirs. At present, seismic data are far from meeting the needs of geologists; Multi-well methods have achieved many results in predicting reservoir structure, but interwell reservoirs are uncertain, and 3D seismic data [22] usually have better horizontal resolution. By taking full advantage of these two types of data and combining them organically, individual subsurface sand bodies can be identified and their spatial distribution can be predicted.

Seismic sedimentology is in high resolution seismic data in recent years, the modern sedimentary environment and outcrop depositional environment model, on the basis of comprehensive feedback, identify sedimentary unit 3 d geometry and internal structure of an emerging subject, the seismic sedimentology [23] was first put forward in 1998, the stratigraphic section can be used for basin analysis and reservoir description, And discuss the technology of frequency division and 90 ° phase wavelet in the thin layer interpretation of seismic data in the advantage [24], the seismic sedimentology is introduced into China, transformed 90 ° phase, the stratigraphic section, the key technology such as frequency division interpretation carried on the thorough discussion, gradually formed the seismic sedimentology system of research, using different inversion and attribute analysis, method of frequency division and reorganization, Combined with seismic imaging technology, the external morphology, internal structure, characteristics and attributes of oil and gas reservoirs can be characterized in detail. In recent years, seismic sedimentology [25], as a new method to carry out large-scale seismic geological research, has achieved good results in the characterization of fluvial facies reservoirs at home and abroad.

2.5. Numerical simulation

The purpose of reservoir numerical simulation is to predict the development performance of the reservoir and study the distribution pattern of remaining oil. The combination of reservoir numerical simulation and oilfield development data can enable us to master the development performance of the oilfield in advance [26] and provide guidance for the rational development of the oilfield.

3. Existing Problems and Development Trend

Combined with the current research status at home and abroad, the research on reservoir architecture mainly focuses on the following aspects: ① The current research on reservoir architecture mainly uses field outcrops and modern deposits, while the research results on underground reservoir architecture are few. ② The 3D modeling method is not mature enough.

Reservoir by conventional configuration method of outcrop and modern deposition[27] developed on the basis of well pattern data (single well coring, digital core, logging interpretation and dynamic data) to the 3 d seismic analysis of reservoir configuration, ground penetrating radar (GPR), flume experiment and numerical simulation method and other new technology transformation, reservoir architecture research methods in the direction of the refinement and comprehensive development, refinement, Comprehensive understanding of the internal structure of the reservoir and accurate understanding of the remaining oil distribution.

4. Conclusion and Prospect

The analysis of reservoir configuration is of great significance to the analysis of reservoir remaining oil. According to the research status of reservoir architecture development, the author believes that its development trend is mainly reflected in: ①to create different levels of configuration model library for comparison; ② Develop special logging techniques such as 3D seismic and imaging logging; (3) Give full play to the advantage of the dense well pattern data in the old oilfield, improve the well pattern and well spacing reasonably, and comprehensively analyze the configuration by using rich dynamic and static data.

Through the detailed study of the reservoir configuration of single sand body, the distribution of remaining oil can be predicted more accurately, and it has a good guiding role for oil and gas field development and recovery improvement.

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