High Precision Sequence Division and Geological Significance of Nantun Formation in Wunan Subsag

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Abstract. Based on the data of core and logging, high precision sequence stratigraphic framework of Nantun Formation of Wunan subsag, Wuerxun Depression in Hailar Basin and sedimentary systems distribution characteristics which is under its control are studied. It shows that there are five types of sequence boundaries in Nantun Formation, and it can further be broken into 3 three-level and 9 four-level sequence. According to the variation of remaining layer thickness of each sequence, the change rule of deposition centers in Nantun Formation appears transferring to west gradually, and from down to up the formation distribution characteristics changes from ‘medium thickness to east and west thin’ to ‘west thick- east thin’. During the sedimentary period, four sedimentary systems mainly develops: braided river delta, fan delta, sublacustrine fan and lake. The plane distribution of sedimentary system has the characteristics of ‘east-west zoning’. The fan delta sedimentary system mainly develops in the western Wuxi slope zone, and the braided river delta mainly develops in the eastern Wudong gentle slope zone. The plane distribution characteristics of each sedimentary system in different periods have obvious inheritance.

1. Introduction

High-precision sequence stratigraphy and its related technical methods [1-4] have been widely used in the analysis of complex and changeable continental petroleum basins in China in recent years [5-7]. The theory holds that sedimentary cyclicity is under the control of the global sea level rising and falling, which can supply good applicability for analyzing climatic variations rapidly, tectonic moving frequently, accommodation space and sediment supply rate of continental fault basin. At present, the main exploration fields of Wunan sub-sag in Wuerxun sag of Hailar Basin have been transferred from structural reservoir to lithologic reservoir. It is more important to find lithologic traps and analyze the favorable formation conditions of lithologic traps. The predecessors have made study about tectonic evolution in Nantun sedimentary period, sedimentary system controlling by structure, and the main reservoir-forming models. However, the classification accuracy of Nantun Formation sequence is low, and there are few studies on the plane distribution characteristics and vertical evolution of sedimentary system under the high-precision sequence framework. Therefore, on the basis of the characteristics of sequence boundary that reflected by drilling, coring, seismic and logging data, applying the related techniques of high precision sequence, and with fine division and correlation of sequence at all levels, a high-precision sequence stratigraphic framework of Nantun Formation has been established. And then to study the distribution of sedimentary system and evolution rule in the framework, in order to get important guiding significance of further tapping in Wunan Subsag lithological reservoirs.
2. Geological Survey of Research Area

Wuerxun Depression is located in the south of the fault in the middle of Hailar Basin fault zone, which is the second largest oil-rich depression in the basin. The south is adjacent to the Beier Depression, the north is connected to Hongqi and Xinbaolige Depression, overlapping the Qagan uplift in the west, and connect the Bayan Mountain uplift in the east, which is a typical compound dustpan-like depression of 2166km². The depression is mainly controlled by the basement fault in the north-south direction, and there are two successive subsags in the south and north. The Wunan subsag is located in the south of Wuerxun depression.

3. Recognition of Sequence Interfaces at Different Levels

Recognition of sequence boundary is an important basis for sequence division and establishment of regional high-precision isochronal stratigraphic framework. In continental faulted basins, a complete sequence usually consists of low system tract, water invasion area and highstand system tract. Its boundary is conversion surface that base level rises up to the highest point then falls down, and conversion surface that drops to the lowest point then rises up. The former is an important lake flooding surface with isochronal significance, and the best comparability is the largest lake flooding surface of medium and long term base-level cycles. The latter is a sequence interface which is often characterized by erosion surfaces of different sizes and origin, or structural unconformity. Considering the classification standard of sequence boundaries, category II and III sequence boundary that mainly controlled by tectonic factors and category IV, V, VI sequence boundary that mainly controlled by astronomical period and climate fluctuation in Nantun Formation can be recognized. Apart from category II and III sequence boundaries characterized by regional tectonic unconformities at the top and bottom of Nantun Formation, it mainly develops category IV and VI sequence boundaries which has decreasing gradually scales in Nantun Formation. The occurrence is erosion washing surfaces. The core, logging and seismic profile characteristics of these interfaces are shown in Fig.1.

![Figure 1. The characteristics of sequence boundary seismic reflection of Nantunformation in Wunan Subsag](image)

4. Fine Contrast Method and Establishment of Isochronic Framework

High-precision sequence stratigraphic division and correlation is an important basis for fine study of planar sedimentary microfacies, which is directly related to the accuracy of reservoir prediction. This article applies stratigraphic correlation methods such as ‘multi-level mark layer system controlling, regional closure skeleton profile closure, sedimentary model guidance of syngenetic fault and gradually approximation priority comparison’, and guided by high precision sequence stratigraphy theory, to establish a unified and fine isochronal stratigraphic framework. The following are the principles in this comparison:

Firstly, a single layer or lithologic combination with regional stability, particularity and easy identification is selected as a marker layer. In this study, the identified marker layer is divided into
four levels according to its stability and controllable range. The first-level marker layer can be tracked and compared in the whole region, and the stability degree is more than 80%. The second-level marker layer can be traced and compared in many third-order structural belts in the depression, and the stability degree is more than 60%. The third-level and fourth-level markers can be traced and compared within a single third-order tectonic belt or smaller scales, and the stability degree is more than 40% (Fig.2).

Figure 2. High precision sequence stratigraphic correlation in Nantun Formation of Wunan Subsag

Then using the first-level marker layer such as plane of unconformity at the top and bottom of Nantun Formation recognized. The top of Nantun Formation in the study area extensively develops marker layers with medium-high gamma, low resistivity thick mustone mutation to low gamma, medium-high resistivity thick sandstone. The bottom of Nantun Formation extensively develops marker layers with high gamma, low resistivity thick mudstone mutation to medium-low gamma and medium-high resistivity sand mudstone interbedding. Based on the secondary marker layer such as the local unconformity surface and secondary Lake flooding surface comparing to fourth-order sequence, the fourth-order sequence often has stable stratigraphic superimposition characteristics. Secondary Lake flooding often occurs at the transition point between the fourth-order sequence with the regressive superposition pattern and the fourth-order sequence with the progressive superposition pattern, which is the most recognizable and reliable marker for four-level sequence tracing and correlation. To use of the third and fourth grade marker beds, such as local lake flooding surface and the top of large-scale river channel, and combining with the syngenetic fault model, and to test results with closed skeleton section closure. Finally, the characteristics of sedimentological response caused by variation of base level cycles at different levels are summarized. Nantun Formation in Wunan subsag can be divided into three third-order sequences and nine fourth-order sequences (Fig.3), and a high-precision isochronal stratigraphic framework covering the whole area is established.
Figure 3. High Precision Sequence Stratigraphic Division Map of Nantun Formation, Wunan Subag
5. Conclusion
Based on the data of core, logging, combining seismic data with regional tectonic evolution characteristics, it is considered that there are five types of sequence boundaries in Nantun Formation of Wunan sub-depression, which can be divided into three third-order sequences and nine fourth-order sequences. After the establishment of high-precision sequence stratigraphic framework, throughout the variation of residual stratum thickness of each sequence, it is found that the sedimentation center of Nantun Formation moved westward gradually during the sedimentary period, the distribution characteristics of strata gradually changes from "medium thickness to East and West thin" to "west thick to East thin" from bottom to top. During the sedimentary period of Nantun Formation in Wunan Subsag, four sedimentary systems were developed, including braided river delta, fan delta, sublacustrine fan and lake. The fan delta sedimentary system mainly develops in the western Wuxi steep slope zone, while the braided river delta sedimentary system mainly develops in the eastern Wudong gentle slope zone. The distribution characteristics of each sedimentary system in different periods have obvious inheritance.

6. References
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