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Research on Sequence Stratigraphy of Nantun Formation in Bayanhushu Depression of Hailar Basin and Favorable Target Prediction

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Research on Sequence Stratigraphy of Nantun Formation in Bayanhushu Depression of Hailar Basin and Favorable Target Prediction

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Abstract. Exploration in Bayanhushu depression has been published from time to time, showing great exploration potential, but the degree is low at present. We divided Nantun formation into two third sequences through comprehensive analysis and studied on the types and distribution of sedimentary facies. The conclusion shows that Nantun formation is mainly comprised of fan delta, braid delta and lacustrine facies. The fan delta sedimentary facies mainly distribute in the western steep slope zone, while the braided river delta develops in the eastern gentle slope zone, and the lacustrine facies mainly develops in the middle trough zone and the edge of the fan delta. The sedimentary pattern has the characteristics of "east-west zoning". From the steep slope to the gentle slope, the types of sedimentary facies gradually change from fan delta to shore-shallow lake, semi-deep lake to deep lake and then to braided river delta. The study of source-reservoir-cap assemblages and accumulation conditions shows that fan delta front and braided delta front have good physical properties and are close to high grade source. So it is easy to form inversion structural reservoirs in the steep slope break zone, while fault-lithologic reservoirs in gentle slope zone, a lithologic reservoirs near trough areas.

1. Introduction

Bayanhushu depression, which is a secondary structural unit located southeast in Hailar basin, has a low degree of exploration, multi-stage tectonic activities and complicated geological conditions. Previous studies mainly focused on source rock evaluation and oil-source correlation [1-2], but less on sequence stratigraphy and accumulation conditions. Strong structural reformation results in unclear understanding of sedimentary system types and distribution, which restricts the exploration in Bayanhushu depression.

Sequence stratigraphy is one of the effective theories and methods for predicting favorable reservoirs in continental rifted basins [3-4]. Therefore, based on the comprehensive analysis of the data and the genetic characteristics of sequence boundaries, we construct the stratigraphic framework of Nantun formation, study the types of sedimentary facies and distribution characteristics, and point out the favorable exploration targets.

2. Geology

Bayanhushu depression is located in the southwest of Hailar Basin. It is a half graben rift which down faulting in the east and overlapping in the west. The area is about 1500 square kilometer. The Western steep slope belt, the central trough belt and the eastern gentle slope belt are successively developed from West to east. And the central trough zone can be divided into three sub-depressions which are



Banan, Bazhong and Babei. The Bazhong sub-depression is well developed with large sedimentary thickness, and the two left in the north and south are relatively shallow (Fig.1).

The depression has experienced three stages of tectonic evolution which are early fault depression stage, middle fault-depression transition stage and late depression stage [5]. The Cretaceous system is the main deposit, including Tamulangou, Tongbomiao, Nantun, Damoguaihe, Yimin and Qingyuangang formation from bottom to top. Among them, Nantun formation is the target strata.

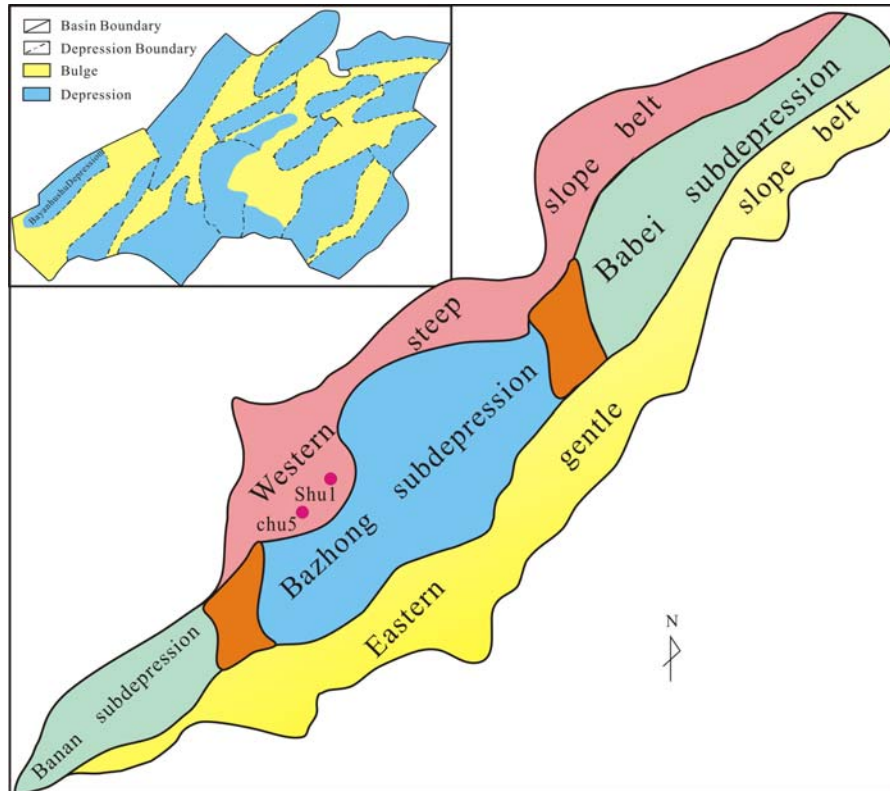


Figure 1. Location of Bayanhushu Depression and division of structural units

3. Sequence Stratigraphic Characteristics

Identification of sequence boundaries is the key to sequence stratigraphic division and correlation. And it is also the main symbol of regional isochronous stratigraphic correlation. Based on the comprehensive analysis of data and the genetic characteristics of sequence boundaries, Nantun formation can be divided into two third sequences, which are Sq1 and Sq2 from bottom to top. The corresponding sequence boundaries are SB1, SB2 and SB3.

SB1 is the interface between Tongbomiao Formation and Nantun Formation. It is a regional angular unconformity interface corresponding to T3 reflector. Obvious onlap can be seen on the reflection interface inside the depression, and obvious truncated reflection can be seen under the reflection interface at the edge of the depression. The upper and lower lithologies between the interfaces are quite different, usually the tuffaceous sandstone of Nantun Formation contacts directly to the sandy conglomerate of Tongbomiao Formation. And in some areas the sandy conglomerate of Nantun Formation directly covers the basement volcanic breccia.

SB2 is the interface between second section and first section of Nantun Formation. It is a partial unconformity interface corresponding to T23 reflector. Obvious onlap can be seen on the reflection interface inside the depression. The grain sizes between the interfaces are quite different. The upper lithology of the interface is relatively coarse, mainly argillaceous siltstone with a thin layer of dark gray mudstone, and lower lithology is mostly grey-black mudstone and a small amount of silty mudstone.

SB3 is the interface between Nantun Formation and Damoguaihe Formation. It is a regional unconformity interface corresponding to T22 reflector. Obvious onlap can be seen on the reflection interface inside the depression, and obvious truncated reflection can be seen under the reflection interface at the edge of the depression. Obvious onlap and truncated reflection can be seen above and below the interface.

4. Sedimentary System Analysis in Sequence Framework

Based on the sequence stratigraphic framework, three sedimentary facies types, which are fan delta, braided river delta and lake, were identified in Nantun Formation in Bayanhushu depression by using drilled cores, logging and seismic data.

4.1 Types of Sedimentary facies

Fan delta facies is a kind of coarse-grained clastic sediments formed by alluvial fans directly entering the lake. It usually develops in the steep slope zone of the lake basin, which generally contains gravity current and traction current. Fan delta can only develop by following conditions: terrain elevation difference is bigger and gradient is relatively steep, the provenance supply is adequate and close to sediments. The rocks types of fan delta, which mainly are conglomerate, gravel-bearing sandstone and coarse sandstone, followed by a small amount of siltstone and argillaceous siltstone, are poorly rounded and sorted, mostly distributed in disorder, reflecting the characteristics of near provenance, short transport distance and rapid deposition. The sedimentary facies of fan delta mainly distributes in the steep slope zone of the western part of the study area which mainly develop two subfacies including plain and front.

Fan delta plain mainly deposits on land. Their rocks are mainly variegated sandy conglomerate, gravel sandstone and medium-coarse sandstone. There are two microfacies developed in plain which are braided channel and braided interchannel. The braided channel is mainly composed of thick layers of variegated conglomerate, sandy conglomerate and coarse sandstone. It is characterized by normal cycle in vertical direction and large single layer thickness. The braided interchannels are brown, purple and massive mudstone, light gray fine sandstone and siltstone. The thickness of single layer is thin.

Braided delta plain mainly develops two microfacies: braided channel and flood plain. The lithology of braided channel is relatively coarse and poor sorting. It is mainly composed of variegated and purplish red massive sandstone and fine sandstone, and locally developed siltstone and mudstone. The braided channel have the positive rhythm which develop scour structure at the bottom with large plate and trough cross bedding. The lithology of flood plain is mainly variegated siltstone, argillaceous siltstone and purple-red, light gray mudstone. And carboniferous plant fragments are developed.

4.2 Sedimentary System Distribution

Sedimentary period of first section was in strong rifting stage. Controlled by three NE-trending and NEE-trending faults, the depression has a large subsidence. This led to large-scale water entry, deepened waters and rapid expansion of lake. During this period, fan delta and braided river delta were developed which deposited lacustrine fine-grained sediments mainly consisted of dark mudstone and oil shale, calcareous mudstone and marl. This fine sediment is the main source rock of the basin. The fan delta facies mainly distributes in the steep slope zone in the western part of the study area, while the braided river delta mainly develops in the gentle slope zone in the eastern part, and the deep and semi-deep lake facies deposits in the central depression. The reservoirs of fan delta front and braided river delta front have better physical properties. They are key field of structural-lithologic reservoir exploration because of its direct contact with high-quality source rocks and favorable reservoir-forming conditions (Fig 2).

Sedimentary period of second section was the peak period of fault depression. At this time, the fault activities are more frequent, the water body continued to deepen, and the lake expanded. Braided river delta and fan delta and were developed in this period. Their front sandbodies extend into deep lake mudstones and enclosed by mudstones which called "mud-encased sand". Sand beds are thin and have poor connectivity. They are easy to form fault-lithologic and lithologic reservoirs. The sandstone of braided river delta and fan delta front have good physical properties and close to high-quality

source rocks. At the same time, the overlying thick mudstone is a regional cap rock, forming a good reservoir, reservoir and cap assemblage (Fig 2).

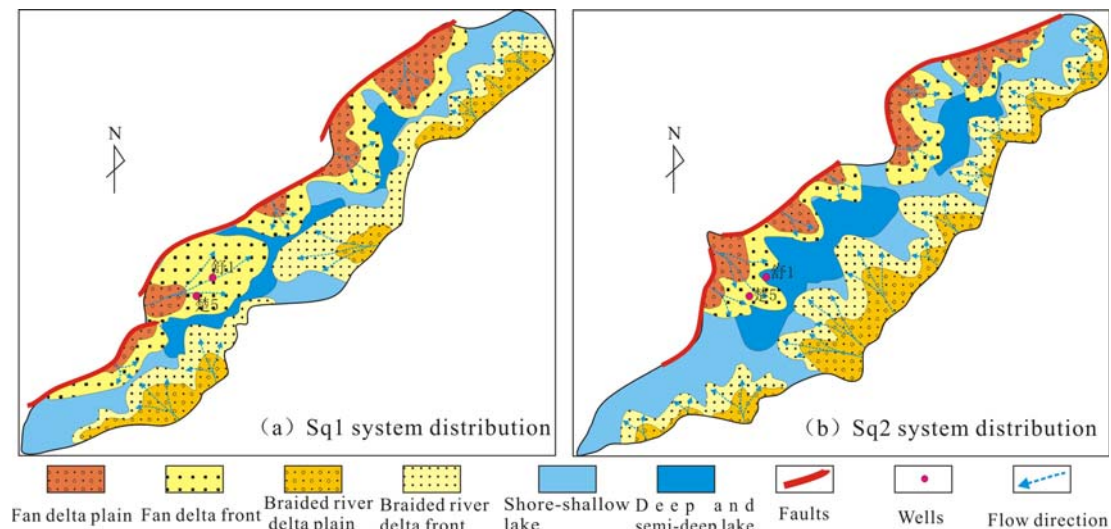


Figure 2. The plane distribution of sedimentary system in Nantun formation of Bayanhushu depression

5. Favourable Zone Prediction

The fault accommodation zone on the western steep slope of the depression experienced two stages of structural inversion at the end of Nantun and Yimin formation which formed a large-scale nose-like structural belt. The inversion at the end of Yimin formation did little damage to the structure and the original nose-like structure was preserved completely. The fan delta front sand bodies accumulate at the intersection of the two faults, forming "leaf" or "multiform" fan deposits along the nose-shaped structural belt. Affected by multi-stage tectonic activities, many undercompacted zones are formed, forming abnormally high porosity zones with good reservoir properties and porosity generally greater than 10%. The mudstones with rich organic matter, which contact to fan delta front sandbody, have strong hydrocarbon generation ability and wide distribution range and reach the grade of high-quality source rock (Fig. 3). High yield industrial oil flow is obtained in well Shu1 and well Chu5 in steep slope area, which confirms that steep slope zone is a favorable zone.

The eastern gentle slope zone is bounded by parallel trough-controlling faults. The area is adjacent to the main oil generating center with good supply conditions. Faults are well developed in this area, which are contrary to the strike of the slope zone, forming multiple fault break zones. The structure of this area is relatively gentle, and it is hard to form local structural traps (Fig. 3). At present, drilling has been revealed that the gentle slope zone is a favorable prospecting zone.

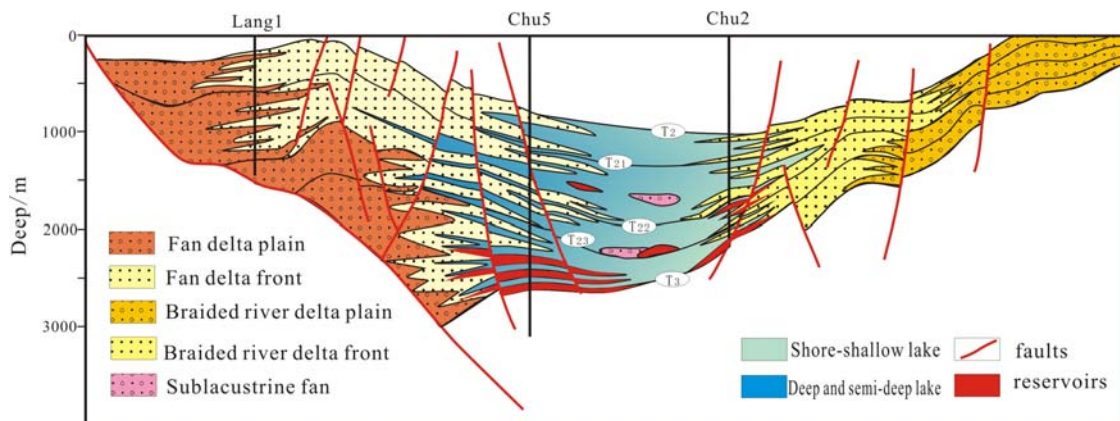


Figure 3. Oil and gas accumulation model in Nantun formation of Bayanhushu depression

6. Conclusion

Based on the comprehensive analysis of data and the genetic characteristics of sequence boundaries, Nantun formation can be divided into two third sequences, which are Sq1 and Sq2 from bottom to top. Based on the sequence stratigraphic framework, three sedimentary facies types, which are fan delta, braided river delta and lake, were identified in Nantun Formation. The fan delta facies mainly distributes in the steep slope zone in the western part of the study area, while the braided river delta mainly develops in the gentle slope zone in the eastern part, and the deep and semi-deep lake facies deposits in the central depression. The reservoirs of fan delta front and braided river delta front have better physical properties which close to high-quality source rock. It is easy to form steep slope inversion structure reservoir in the fault developed area of steep slope zone, fault-lithologic reservoir in gentle slope zone, and lithologic reservoir near trough.

7. References

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