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Types of Structural Slope-break Zone and Controls for Sand Bodies and Hydrocarbon of Huhehu Depression in Hailar Basin

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Abstract. Huhehu depression is a half graben rift which down faulting in the east and overlapping in the west. The structural slope-break zone which widely developed in depression period plays a significant controlling in sand bodies and accumulation of hydrocarbon. According to the characteristics of fractures and combination patterns of plane and section, many syndepositional fracture combination styles are identified in the depression, which includes parallel faulted step, brush, fork, faults-contacting and other forms. According to the distribution of fracture slope break zone, this paper expounds the controls to sedimentary filling and system in three types, which are fault-controlling steep slope, faulted-step gentle slope and trough margin. Combined with the exploration practice, this paper discusses the relation between accumulation of hydrocarbon and the sand bodies in fracture slope-break zone. The conclusion is that the fracture slope-break zone of trough margin is the most favourable exploration area.

1. Introduction

Structural slope-break zone has an abrupt change of sedimentary slopes which is caused by synsedimentary activity. The features of structural slope-break zone, including development, spatial distribution, evolution and combination patterns, determine the accommodation and provenance of the basin, which restrict the dispersion process of sediments and the distribution pattern of sand bodies. The research on relationship between structural slope-break zone and sedimentary facies distribution will be helpful to sedimentary system distribution and sand bodies' prediction [1]. And researches of structural slope-break zone become a hot topic because of its applicability in exploration in recent years [2-3].

In eastern petroliferous basins of China, which have active synsedimentary fault activity and drastic facies change, the controlling factors of the development and distribution of depositional sequence and system have received recent attention. How to predict the distribution of sedimentary facies and sand bodies effectively in these basins is the key to exploration breakthroughs, especially in some small fault basins.

At present, Huhehu depression is still at the stage of low exploration. However, with the increase of new drilling, the enhancement of well control and the acquisition of new seismic data, the recognition will be deepened. The previous studies mainly focus on source rock, structure, sequence stratigraphy, sand bodies type and sedimentary system evolution [4], excluding the theory of structural slope-break zone. Guided by the theory of the structural slope-break zone in rift lake basin, this paper reveals the controls of synsedimentary fault to sedimentary system distribution and sand bodies dispersion styles.

2. Geology

Huhehu depression, which is a secondary structural unit located southeast in Hailar basin, is one of the 16 potential exploration depressions in the basin. Huhehu depression with northeast orientation is a half graben rift which down faulting in the east and overlapping in the west. Its neighbors are Xilinbeier uplift in the east, Bayanshan uplift in the west, Yimin sag in the north and connected with Mongolia in the south (figure 1). The depression covers 2500 square kilometers, and its maximal buried depth is about 4600 meters. The Cretaceous system is the main deposit, including Tongbomiao(K_1t), Nantun(K_1n), Damoguaihe(K_1d), Yimin (K_1y) and Qingyuangang(K_2q) formation from bottom to top[4-6].

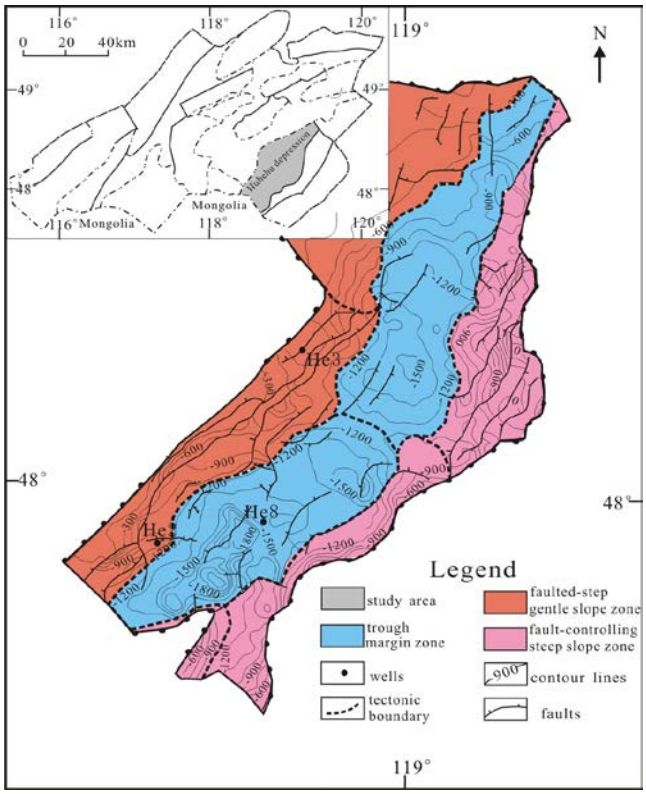

Figure 1. The location of the study area and the division of structural units

3. Structural slope-break zone and sedimentary system distribution

According to the structural position and sedimentary paleotopography, Huhehu depression can be divided into fault-controlling steep slope, faulted-step gentle slope and trough margin respectively (figure 2). Each zone has different controls to sedimentary filling and sequence stratigraphic development in different structural stages, and the different sedimentary systems have unique features. The Cretaceous system of Huhehu depression contains alluvial fan, fan-delta, braided river delta, sublacustrine fan and lake sediments.

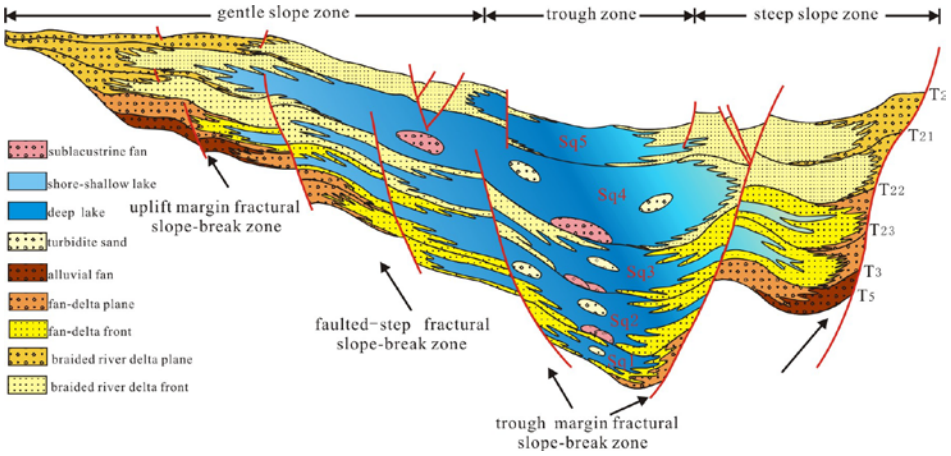

Figure 2. Distribution of structural slope-break zones and sedimentary system of Huhehu depression

3.1. Fault-controlling steep slope-break zone and sedimentary system

In a half graben rift, the side of basin-controlling faults is the steep slope zone. And the faults and source supply influence the Stratigraphic sequence and sedimentary facies of the downthrow side. The major sedimentary systems of the steep slope zone in Huhehu depression are alluvial fan, fan-delta and braided river delta. The fan-delta is the sedimentary system in lake basin that deposited by alluvial fan pushing, which is often formed in the short-axis and steep-slope areas. The fan-delta mainly contains grayish white conglomerate, conglomeratic coarse sandstone, coarse sandstone and fine sandstone. And it is no bedding inside, low maturity poor-sorted and poor-rounded.

3.2 Faulted-step gentle slope-break zone and sedimentary system

The gentle slope zone could be defined as a monoclinic zone of overlapping and denudation, which is adjacent to uplift and usually composed of multilevel synthetic faults. The zone can be the multilevel transport path of sediments. Controlled by the synsedimentary faulted-step, the sediments have a long motion distance and fine grain size. The major sedimentary systems of the gentle slope zone in Huhehu depression are braided river delta, fan-delta and shore-shallow lake. Some small synsedimentary faults or faulted-steps are developed on the transition zone between gentle slope and sag. Sag margin slope-break zone could form larger deposition space and tectonic palaeogomorphology due to differential sedimentation and impulsive fracture activity. This leads to obvious increase of sedimentary thickness, cycles and layers of sand bodies.

3.3 Trough margin slope-break zone and sedimentary system

The trough zone, which located in the sedimentation center of depression between the gentle slope and steep slope zone, is a permanent subsidence zone of a faulted lake basin. The zone has simple tectonic activities and few sedimentary systems such as deep and hemi-deep lake. At the front edge of fan delta and the braided river delta, sublacustrine fan and deep-water turbidite sand are well developed. According to core observation, many types of sedimentary structure have been found, including graded bedding, load cast, convolute bedding, slump structures, liquefaction structure and pillow structure.

4. Combinations of structural slope-break zone and distribution of sand bodies

Structural slope-break zone have many types of combination patterns which is closely related to synsedimentary faults. These combination patterns are controlled by tectonic stress field, fault reactivity and changes of gravity. Different combination patterns have their own palaeogomorphic features which control the distribution of sand bodies. According to the fracture characters and combination patterns of plane and section, many syndepositional fractural combinations are identified in the depression, which includes parallel faulted step, brush, and fork, faults-contacting and other

forms. These combinations built up the complicate structural palaeogeomorphy and fracture slope-break system, which strictly controlled the deposition and accumulation patterns of sand bodies.

4.1 Sand bodies distribution of parallel faulted step fracture system

This kind of fracture system developed at gentle slope zone in Huhehu depression. Generally, it is composed of multiple parallel faults with same direction, which is a three-dimensional combination consisted by faulted-step growth faults and its faulted-step plane. Represented by the faults combination near Well He3 (figure 3A), river system goes through the faults into trough by the controlling of slope and uplift margin faulted-step slope-break zone. The faults combination controls the distribution of braided river delta plain facies, while the trough margin fractural slope-break zone controls the distribution of braided river delta front facies.

4.2 Sand bodies distribution of brush fracture system

The brush system usually consists of a main fault and its secondary faults which is brush shape on plane. This kind of fractural slope-break zone can be developed on both sides of steep slope and gentle slope, and its development is closely related to the superposition of strike slipping. When the flow direction and the fault dip are opposite or large-angle skewed, the main fault controls the position of sedimentation center while the secondary faults control the sedimentary direction of clastic system. Represented by the faults combination near Well He 2 (figure 3B), the brush system consists of a main fault with southwest strike and its accompanying faults. The provenance is propelling from rising plate of main fault to the lake basin, and depositing at low position of the structure.

4.3 Sand bodies distribution of fork fracture system

Fork fracture systems formed by two intersecting synsedimentary faults whose interior angle pointing to low position of the structure. Represented by the faults combination which is formed by the faults in northwestern gentle slope and northeastern steep slope, clastic system from Xilinbeier and Bayanshan uplift accumulated along the fault declining plate and formed sandy sedimentary belt. The system controlled the direction of provenance and the distribution of sand bodies (figure.3C).

4.4 Sand bodies distribution of faults-contacting fracture system

At the end of the fault, the fault distance becomes smaller while the topography becomes gentler and lower. Especially at the connecting place of two faults, lower structure can be formed where are the injection position of maximal water system. Sand bodies deposited at the junction of two faults and distributed as leaf of cloud. Represented by Well He 8 area, fan-delta sedimentary system is developed at the faults junction between Dongbayangun and Hushumiao fault zone (figure.3D).

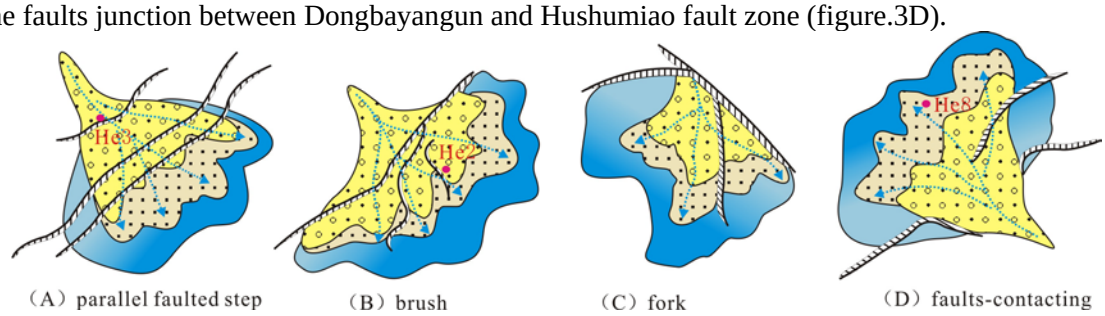

Figure 3. Types of Syndepositional structural slope-break zones and the sand bodies' distribution of Huhehu depression

5. Sand bodies controlled by fractural slope-break zone and accumulation of reservoirs

Fractural slope-break zone not only controls the thickness and distribution direction but also the development of organic-rich source rocks, and then controls the position of lithologic reservoirs enrichment zone. The long-term active synsedimentary faults or fractural slope-break zones are favorable hydrocarbon zones. In particular, trough margin fractural slope-break zone, which has ideal conditions of source-reservoir-cap, is the most favorable reservoir. There are mainly five reasons for

this. First, trough margin slope-break zone controls the distribution of deep and hemi-deep lake sags, which decide the development range of organic-rich source rocks. Secondly, thick sand bodies of fan-delta or braided river delta front have better reservoir physical properties. Third one is, sand bodies are often contacted with source rocks directly, and then the synsedimentary faults could be the important migration channels. Forth, the synsedimentary faults have a high growth index and muddy lateral sealing; these are favorable to fault sealing. Lastly, the thick mudstone overlay Nantun formation creates the most favorable conditions for the traps and forms fine combination of source-reservoir-cap. Therefore, fault-lithologic reservoirs are easily formed in the trough margin fractural slope-break zone.

6. Conclusions

Huhehu depression can be divided into fault-controlling steep slope, faulted-step gentle slope and trough margin respectively. According to the fractural characters and combination patterns of plane and section, many syndepositional fracture combinations are identified in the depression, which includes parallel faulted step, brush, fork, faults-contacting and other forms. The exploration in the region has shown that, long-term active synsedimentary faults or fractural slope-break zones are favorable hydrocarbon zones. In particular, trough margin fractural slope-break zone, which has ideal conditions of source-reservoir-cap, is the most favorable place for sandstone reservoir.

7. References

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