Classification of slope area types and hydrocarbon accumulation rules in Wuerxun-Beier Depression

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Abstract. After more than 50 years of exploration and development, Wuerxun-Beier depression has entered a high exploration stage. It is more and more difficult to find large-scale structural reservoirs. Therefore, structural-lithologic reservoirs in slope areas have gradually become the focus of exploration. Based on the overall study and dissection of the depression, the geological differentiation characteristics of the large-scale slope area are discussed. According to the occurrence of the slope, the intensity of tectonic activity, the intensity of source supply and the pattern of synsedimentary fault combination, the slope zone in the study area can be divided into six types, namely, the steep slope with strong source along the fault step type, the compound fault step type of medium slope with strong source, the reverse fault step type of the gentle slope with strong source, and the weak supply type. Different types of slope have different sand control mechanisms and reservoir forming characteristics, such as the source gentle slope forward fault terrace type, the weak source gentle slope reverse fault terrace type and the weak source middle slope forward fault terrace type. Source supply intensity and slope dip control the development type of sedimentary system, the combination of synsedimentary faults and valleys controls the distribution characteristics of sedimentary system. Through exploration practice, significant discoveries have been made on the southwestern, southeastern and northern slopes of Beixi, Wuerxun-Beier depression, which confirms that the slope area is the main breakthrough direction for oil and gas exploration and large-scale reservoir increase in continental fault-depression lake basins.

1. Introduction
Wuerxun-Beier depression is the primary oil-gas rich depression in Hailaer Basin (Fig.1). With the reacquisition and processing of 3D seismic data during the 11th Five Year Plan period, the basin framework structure of Wuerxun-Beier depression becomes more and more clear. It can be seen that the slope area accounts for more than 75% of the total area of Wuerxun-Beier depression[1-4], which provides a necessary field for the large-scale occurrence of lithologic oil-gas reservoirs Institute. In recent years, a lot of scientific research work and exploration deployment have been carried out in the aiming slope area of Wubei depression, and significant exploration progress has been made in several slope areas. At present, three 50 million ton scale reservoir increasing areas have been formed, i.e. southwest slope, southeast slope and north slope of Wubei. However, the characteristics and enrichment degree of oil and gas in different slope areas are obviously different[5-8]. Based on the occurrence of slope, the intensity of tectonic activity, the intensity of source supply and the combination pattern of synsedimentary faults, this paper divides the types of slope belt, and then
analyzes the characteristics and differences of oil and gas accumulation of different types of slope, in order to find out the main controlling factors and the law of oil and gas accumulation of all kinds of slope, and further enrich the theory of oil and gas accumulation in the slope area of continental faulted lake basin.

Figure 1. Regional location of Wuerxun-Beier depression

2. Classification of slope area types
In this study, based on the data of drilling, logging and earthquake, it is believed that fan delta and braided river delta depositional system are mainly developed in the slope area of Wuerxun-Beier depression, in which fan delta depositional system is mainly distributed in the slope area of Beixi, while braided river delta depositional system is mainly distributed in the slope area of southeast. The alluvial fan can directly enter the lake from the mountain area and form the fan delta sedimentary system. And with the slope angle decreasing from north to south, the grain size of sediment also tends to be finer. The plane combination pattern of the synsedimentary faults in the northwest slope zone of Beixibi is mainly the fault terrace type. In this slope area, the direction of provenance is the same as that of slope, and the water body moves from mountain area to depression area along the valley. The horizontal distribution range of fan body will increase when encountering the structural slope break belt formed by along fault. Under the joint control of valley and slope break, a fan delta sedimentary system has been formed, which extends far forward and distributes widely. Because of the large slope angle, the sand body of fan delta front near the depression area is prone to collapse and form a lake bottom fan sedimentary system when encountering the fault slope break zone. In the middle slope zone of Beixi, there are abundant provenance, the same provenance direction as the slope tendency and the basin margin valley is developed. The plane combination pattern of the slope area and the sedimentary fault is composed of the forward fault step and the reverse fault step. Under the influence of this pattern, the slope angle of the middle slope of Beixi presents the change trend of "gentle steep gentle"(Fig.2).
Figure 2. Sedimentary system distribution map of Nantun Formation in Wuerxun-Beier depression

3. Oil and gas enrichment law and exploration practice in different types of slope areas

3.1. Strong supply, high slope, along fault step slope
The slope angle of the Beixibei is greater than 17 degrees. The fault activity is strong. The formation is warped while depositing. The formation attitude is steep and the thickness changes greatly. It has two geological characteristics: (1) the Beixibei slope is narrow and steep, close to the source area, and the source strength is large. It mainly develops fan delta sedimentary system and grain size. It is relatively coarse; (2) there are many main synsedimentary faults in the structure, forming a series of trending fault steps and a series of trending fault nose traps (Fig. 3). The Beixibei slope is narrow and steep, and the low part has entered into the hydrocarbon generating center area, with sufficient oil and gas.
sources and short migration distance. Oil and gas migrate laterally along the sand body at high angle, and conduct vertically along the fault, forming the oil-bearing characteristics of the first and second member of the south. As the sand body in the Beixibei slope is very developed, sand joint is still found on both sides of the upper and lower walls of the along fault, and the sand content of the fault rock is also high, so the lateral and vertical sealing capacity of the fault is poor. Only near the segmented growth point of the along fault, fault nose type structural oil and gas reservoir can be easily formed.

Figure 3. Characteristic map of downward fault-step slope profile of steep slope with strong supply source

3.2. Strong supply, medium slope, composite fault step slope
The slope angle of Beixizhong is between 10-13 degrees, and the fault activity is strong. It has two geological characteristics: (1) the middle slope is steep, close to the source area, and the supply intensity is large, mainly developed fan delta sedimentary system, and the particle size is coarse; (2) there are many step like synsedimentary faults in the structure The Beixizhong slope is steep, and the lower part has entered the hydrocarbon generation center area, and it is the main direction of oil and gas migration. The oil and gas transportation distance is small, near source reservoir formation, and oil source is sufficient. Oil and gas migrate laterally along the sand body at a high angle, and conduct vertically along the clockwise fault, forming the multi-layer oil-bearing characteristics of the first and second members of the south. The clockwise fault mainly develops fault nose type structural oil-gas reservoir at the growth point of the development section, while the reverse fault develops fault nose type structural oil-gas reservoir at the maximum fault distance, and the adjacent faults can form fault block type structural oil-gas reservoir. Generally speaking, the oil and gas accumulation degree of slope composite fault step slope is general, and the trap formed by reverse fault block is the most abundant (Fig.4).
3.3. Strong supply, medium slope, reverse fault step slope

The slope angle of Beixinan is between 7-9 degrees and the fault activity is general. It has two geological characteristics: the Beixinan slope is wide and gentle, but the source strength is large, mainly developed fan delta sedimentary system, and the grain size is medium; A series of reverse faults are developed in the wide and gentle slope zone, which are ladder like distribution and formed Anti trending fault block type trap group (Fig.5). The Beixinan slope is relatively gentle, and the end of the slope is deep into the southwest hydrocarbon generation trough. The slope direction is the main direction of oil and gas migration, and the oil and gas transportation distance is long. Oil and gas migrate along the sand body to the direction of the slope belt. In case of reverse fault shelter, the reservoir is formed in the high part of the structure of the descending disk. The oil and gas accumulation degree is high and most of them have the characteristics of single layer oil-bearing. Fault nose type or fault block type structural oil and gas reservoirs are mainly developed. In general, the slope of reverse fault step type in the strong source is relatively rich in oil and gas, and the main conditions for oil and gas accumulation are sand body development and reverse fault shelter Block.

3.4. Weak supply, low slope, downfaulted step slope

The slope with weak source and low slope is represented by the Wudongbei slope belt. The Wudongbei slope belt has a dip angle of 4-8 degrees. The fault activity is general and has two
geological characteristics: (1) the Wudongbei slope is wide and gentle, and the source strength is low, and the braided river delta sedimentary system is mainly developed, and the grain size of sediments is relatively fine; (2) there are many ladder like sedimentary faults and reverses in the structure Compensation faults form fault noses (Fig.6). The Wudongbei slope is gentle, and the oil and gas move vertically along the along direction oil source fault. After encountering the front sand body, they move laterally along the sand body and continue to be vertically dredged by the fault, forming the characteristics of oil-bearing in the first and second sections of the south. The slope direction is the direction of oil-gas migration. The oil and gas are mainly formed at the structural height of the hanging wall of the reverse fault and the sectional growth point of the along direction main fault In order to develop fault lithologic composite reservoirs, reverse fault sheltered reservoirs have the highest oil and gas enrichment. Generally speaking, the oil and gas accumulation degree of the slope with weak supply and low slope is better, and the oil and gas accumulation is mainly controlled by the development degree of sand body, the location of the growth point of the section along the fault and the shelter of the reverse fault.

![Figure 6. Characteristic map of downward fault-step slope profile on a gentle slope with weak supply source](image)

### 3.5. Weak supply, low slope, reverse fault step slope

The slope angle of the low gradient reverse fault terrace type of weak supply source is between 4-8 degrees, and the fault activity is general, with two geological characteristics: (1) the slope is wide and gentle, the supply intensity is low, and the braided river delta sedimentary system is mainly developed, and the sediment particle size is relatively fine; (2) there are many reverse dip synsedimentary faults distributed in the structure, forming the reverse dip fault block type trap group (Fig.7). The Wudongnan slope is relatively slow, and the migration distance of oil and gas is relatively long. Oil and gas migrate along the direction of sand body inclining upward to the slope belt. In case of reverse fault shelter, the reservoir is formed in the structural high part of the descending disk. The oil and gas enrichment degree is high, and most of them have the characteristics of single layer oil-bearing, mainly developed fault lithology type composite oil and gas reservoir. The main factors of oil and gas enrichment are the degree of sand body development and reverse fault block.
3.6. Weak supply, medium slope, downfaulted step slope
This kind of slope is represented by the Wubei slope belt, which has a dip angle of 10-13 degrees. The fault activity is strong, and the formation is warped while depositing. The formation attitude is steep and the thickness changes greatly. It has two geological characteristics: (1) the Wubei slope is narrow and steep, but the supply intensity is weak, and the braided river delta sedimentary system is mainly developed with medium grain size; (2) A series of fault noses and fault block trap groups are formed due to the development of synsedimentary and reverse compensation faults. Wubei slope is narrow and steep, and the low part has entered into the hydrocarbon generation center area, and it is the main direction of oil and gas migration. The oil and gas migration distance is short, the reservoir is close to the source, and the oil and gas source is sufficient. On the whole, this kind of slope supply source is mainly characterized by the downfaulted oil-gas accumulation and poor oil-gas enrichment. Whether the oil-gas accumulation is mainly controlled by the development of sand body and the location of the growth point of the downfaulted section (Fig.8).

4. Conclusion
According to the slope occurrence, structural activity intensity, source supply intensity and synsedimentary fault combination pattern, the slope belt of Wuexun-Beier depression can be divided
into six types, and different types of slopes have different sand control mechanisms and reservoir forming characteristics. In the slope area of Wuercun-Beier depression, there are mainly fan delta and braided river delta depositional systems. In the slope area of Beixi, there are mainly fan delta depositional systems, and in the slope belt of Wudongnan and Wubei, there are mainly discerned river delta depositional systems. The source supply intensity and slope angle control the development type of sedimentary system, and the combination of synsedimentary faults and gullies control the distribution characteristics of sedimentary system. Generally speaking, the reservoir formation of slope zone is mainly controlled by the development degree of sand body, the location of reverse fault block and the growing point of along fault segment. Among them, the reverse fault block type reservoir has the best reservoir forming conditions, which should be the main direction of exploration in slope area.

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