Types of Beixi slopes and the process of tectonic evolution

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Abstract: The phenomenon of oil and gas accumulation on the Beixi slope is obvious, which is one of the important directions of oil and gas pre-exploration and increasing reserves and production in the future. Taking the Beixi slope as the target area, according to the geological characteristics, the Beixi slope is divided into the differential subsidence type of the same fault depression, the reverse normal fault tilting and lifting slope and the compound slope. The evolution profile of Beixi slope is restored by using 2Dmove application software. based on the joint action of structure and deposition of Beixi slope, the fault evolution process of Beixi slope can be divided into four stages: rift stage 1 (Tongbamiao formation-N14 reflection layer), rift stage 2 (N14 reflection layer-T22 reflection layer), fault depression conversion stage (T22 reflection layer-T04 reflection layer) and depression inversion stage (above T04 reflection layer).

Key words: Beixi slope; slope type; evolution process.

1. Introduction

The phenomenon of oil and gas accumulation on the slope belt is obvious, which is the main breakthrough direction of oil and gas pre-exploration and large-scale reservoir increase in small faulted lacustrine basins[1] . It is mainly the transition zone from the deep zone to the uplift zone, that is, the monoclinic zone connected with the uplift zone in the form of slope [2-6]. At present, slope classification has always been one of the research hotspots of oil and gas distribution, such as Dong Wanbai et al. [7] according to the morphological characteristics, the slope is divided into reverse step type, simple bend type, multi-stage break type and multi-stage break type. Wang Xiabin et al. [8] divided the slope into outer slope break zone, middle slope break zone, inner slope break zone and depression zone according to the relationship between the position of slope break zone and trough area. Zhao Xianzheng et al. [9] according to the basement sedimentary relationship, the intensity of tectonic activity and the occurrence and shape of the slope, the slope can be divided into flexure slope break type, gentle platform slope type, wide and gentle fault step type, narrow and steep fault step type, tilting and tilting type. Meng Qi'an et al. [10] according to the slope occurrence, tectonic activity intensity, supply source intensity and synsedimentary fault combination style, the slope is divided into strong supply source high slope forward fault step type, strong supply medium slope compound fault step type, strong supply medium slope reverse fault step type, weak supply source low slope forward fault step type, weak supply low slope reverse fault step type and weak supply medium slope reverse fault step type. This paper will classify the slope types according to the structural change characteristics of the Beixi slope from north to south, and then analyze the tectonic evolution process of different types of slopes.

2. Tectonic background of the study area

Beier sag is located in the south of Beihu depression in Hailaer basin, connected with Wuerxun sag in the north, adjacent to Nanbeir sag in Mongolia in the south, Bayanshan uplift in the east and overlying on the Qianggang uplift in the west. It is a typical east-west super-dustpan-like faulted basin [11,12]. The main body of Beier sag is controlled by NE and NEE trending basement faults and presents the present basin structure through the superposition of multi-stage tectonic deformation (figure 1c). The whole structural pattern can be divided into "three depressions, two uplifts and one slope". It mainly includes Beixi slope belt, Beixi depression belt, Beibei sub-sag, Hodomore fault uplift belt, Suderte fault structural belt, Beizhong depression belt and Beidong fault uplift belt. It has the obvious characteristics of "east-west zoning and north-south division" [13-15] (figure 1A). From bottom to top, there are Lower Cretaceous Budate Group (J1b), Tongbamiao formation (K1T), Nantun formation (K1n), Damoguaihe formation (K1D), Yimin formation (K1y) and Upper Cretaceous Qingyuangang formation (K2Q) (figure 1b). The discovered oil and gas are distributed from bedrock to Damoguaihe formation, and the main reservoir is Nantun formation [16]. Multiple sets of source-reservoir-cap assemblages are developed due to the division of regional and local caprocks.

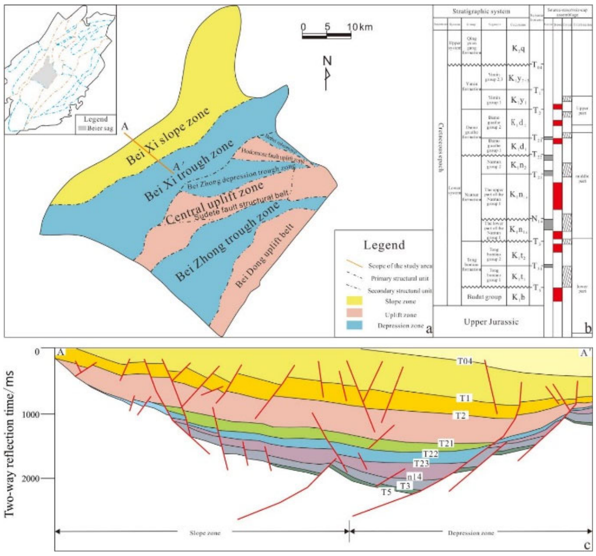

Fig. 1 Structural pattern map of Beier sag. (a) division of structural units in Beier sag. (b) stratigraphic development, source-reservoir-cap assemblage and structural layer division in Beier sag. (c) typical equilibrium profile in Beier sag.

The Beixi slope belt is located in the northwest of Beier sag, with narrow and long shape, north-south strike, fault development controls oil and gas distribution, and a large number of faults develop in the middle stage. Yimin formation is the main period of hydrocarbon generation and expulsion, so it is beneficial to oil and gas accumulation. Late faults control oil and gas migration, faults and structures control oil and water distribution, so faults are well sealed, which is conducive to oil and gas accumulation and preservation [17]. Therefore, the structural location of the study area is superior, which meets the conditions of oil and gas accumulation and oil and gas enrichment, which is the main exploration field of Beier sag.

3. Classification of slope types

This paper studies the structural background of the Beixi slope in the area, understands that there are obvious differences in the structural characteristics of the slope, considers the actual situation of the Beixi slope and draws lessons from the previous classification scheme to reclassify the slope belt. According to the geological characteristics, the Beixi slope is divided into differential subsidence slope in the same fault depression, reverse normal fault tilting and uplift slope and compound slope (figure 2), which lays a foundation for the next study of fault formation and evolution.

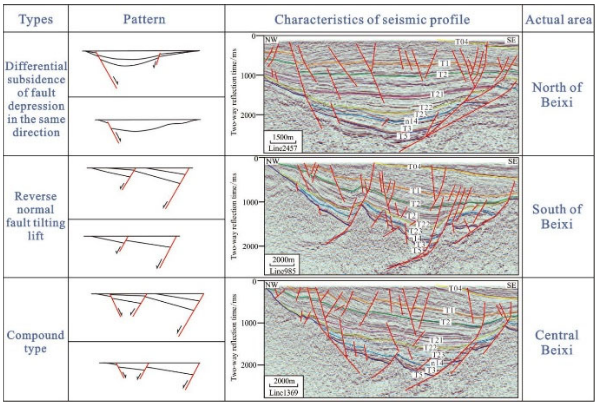

Fig. 2 Classification of typical slope zones in Beier sag

The differential subsidence type slope in the same direction fault depression is represented by the northern part of the Beixi slope belt, the dip angle of the slope belt is larger, the width of the slope belt is narrow, the activity of the main subsidence-controlling faults is relatively weak, and the upper strata are mainly characterized by differential subsidence. With the continuous evolution of the depression, an adjusting fault consistent with the slope stratigraphic tendency is formed at the slope.

The slope of this kind of slope is relatively slow, and the formation time of co-directional adjustment fault in the slope is relatively late, which is a typical post-sedimentary fault.

The reverse normal fault tilting and uplift slope is represented by the southern part of the Beixi slope belt, the dip angle is usually small, the tectonic activity of the strata is not frequent, the width of the slope belt is larger, the distribution of hydrocarbon source rocks near it is less, and the main sedimentary system is braided river delta. the deep strata in this area produce tensional deformation in the process of late tectonic activity, resulting in fault activity, which is opposite to the occurrence of the strata. The fault which is consistent with the occurrence of the main fault is active at the same time, which makes it have the structural characteristics of compound semi-graben, the slope continues to tilt, and the slope is relatively large.

The composite slope is represented by the middle part of the Beixi slope belt, which is mainly represented by the strong activity of the main fault and the fault strengthening and tilting similar to the occurrence of the main fault. at the same time, the adjustment of the codirectional fault consistent with the stratigraphic tendency of the slope is formed at the same time, which is a typical feature in the middle of the Beixi slope belt in the study area.

4. Formation and evolution of faults

Based on the mechanism of regional tectonic deformation, the fault formation and evolution process of Beixi slope can be divided into four stages: rift stage 1 (Tongbamiao formation-N14 reflector), rift stage 2 (N14 reflector-T22 reflector), fault depression conversion stage (T22 reflector-T04 reflector) and depression inversion stage (above T04 reflector). As the typical slope belt of Beier sag has experienced a complex evolution process of multi-stage tectonic superposition, in order to restore the structural evolution process of Beixi slope, on the basis of comprehensive analysis of its regional geological conditions, the 2Dmove application software is used to restore the structural evolution process of typical sections of three slopes in northwest, middle and southwest of Bei (figure 3). The evolution process of slope development is analyzed longitudinally and the evolution difference of slope is compared horizontally.

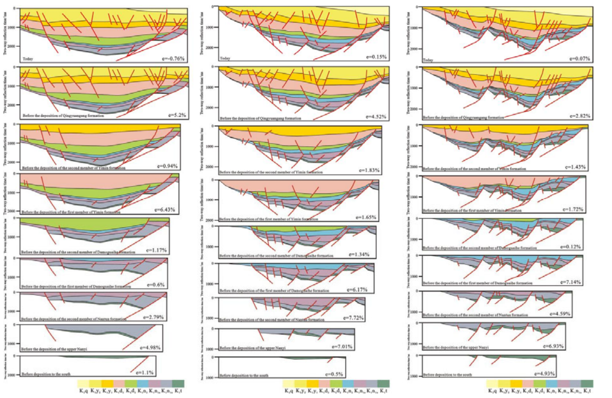

Fig. 3 Balanced profile of tectonic evolution in northwestern, central and southwestern Beibei

The scene of fault depression: the northwest of Bei is a double-fault asymmetric graben completely controlled by faults, the early faults in the middle of Beixi are arranged in a domino type, the intensity of subsidence control is small, and the southwest of Bei is a half-graben completely controlled by faults.
The second act of fault depression: because there is no obvious change in fault pattern compared with the first act of fault depression, it is mainly inherited development; the thickness of strata reflects the intensity of tectonic activity; the strata of the second member in the middle and south-south of Beshi are thicker than those in the south-west of Bei, so the fault activity in the middle and southwest of Bei is stronger.
Fault-depression conversion: the phenomenon that tectonic activity is controlled by faults becomes less, which is mainly a kind of filling-filling type of strata, forming a shape of thick middle and thin edge, and the development of faults is not obvious. at the end of Yimin formation, the tectonic activity is strong and some small stimulating faults are formed.
Depression inversion: the compression inversion deformation mainly occurred and some reverse faults were formed; the first stage compression deformation occurred in the northwest of Bei, and the strata continued to accept deposition due to the compression inversion deformation in the direction of SN in Beixi; and the strong tectonic uplift deformation occurred in the southwest of Bei and the compression inversion deformation occurred.
Generally speaking, from the pre-sedimentation of the south second member to the big second member, it can be clearly seen that the north of the Beixi slope is characterized by differential subsidence in the same fault depression, and gradually shows the characteristics of the reverse normal fault tilting slope from the compound slope to the south of the Beixi slope.

5. Conclusion

The main results are as follows: (1) different types of slopes have different controlling effects on oil and gas. According to the structural change characteristics of Beixi slope from north to south, the types of Beixi slopes are divided into the following three types: differential subsidence slopes in the same fault depression, reverse normal fault tilting slopes and compound slopes.
the northern part of the Beixi slope is characterized by differential subsidence in the same fault depression, and gradually shows the characteristics of the reverse normal fault tilting slope from the compound slope to the south of the Beixi slope, based on the regional tectonic deformation mechanism. The fault formation and evolution process of Beixi slope can be divided into four stages: rift stage 1 (Tongbamiao formation-N14 reflection layer), rift stage 2 (N14 reflection layer-T22 reflection layer), fault depression conversion stage (T22 reflection layer-T04 reflection layer) and depression inversion stage (above T04 reflection layer).

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