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Control Mode of Fault on the Buried-Hill Tectonic Zone of Kendong - Chengdao

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Abstract: Kendong - Chengdao region buried-hill tectonic zone formation mechanism and accumulation difference was unclear. The buried-hill tectonic zone faulting characteristics and mode for the control mountain had been systematically studied. Studies had shown that originated in NW of indosinian to the basement fault controlled the formation of buried-hill tectonic zone. Originated in NE of the Late Jurassic to the basement fault tectonic zone divided into Kendong, GuDong, changti and chengdao four relatively independent buried-hill;Different direction of the basement faults in paleogene tensile stress field in NS under action of the resurrection, controlling the structure of the pattern of buried-hill ftectonic zone. The number activity style and activity intensity of the boundary fault, controled the height difference of different-buried hill. Accordingly, the establishment of a single break- low convex type, double break - convex type and multi broken - high convex type in three kinds of fault mode control mountain, it had been clear about the different types of buried-hill reservoir in paleogene filling style, sedimentary system and reservoir assemblage characteristics.

Keywords: *Fault activity characteristics, Basement faults, Faults in paleogene Fault control mountain mode, Kendong-chengdao buried-hill tectonic zone*

1. Introduction

Kendong-chengdao buried-hill tectonic zone located in the east of the jiyang depression, which were positive tectonic zone separated the jiyang depression and bozhong depression, it had a superior accumulation conditions, oil and gas was very enrich , formed before the paleogene system, paleogene and neogene three sets of oil-bearing series. It had been found Chengdao, Zhuangxi, Wuhaozhuang, Long Beach, Gudong ,Xintan and Xinbei.etc. Many large and medium oil and gas fields, the cumulative petroleum geological reserves had reached more than one hundred million tons. The zone was a north to west overlap and drape of the tectonic belt, at different times, different direction of the fracture system interaction cutting, formed the overall zonal and relatively independent multiple buried-hill. Different height structure of the buried hill and the difference of tectonic style, the control law of Cenozoic strata filling style and development law of depositional system, which played an important controlled role on hydrocarbon accumulation. At present, the formation mechanism of the buried-hill tectonic zone, the reason of the different buried-hill and links between the two basic problems had been lacked of the system and in-depth research [1-11]. To this end, the author had done systemic research on Kendong-chengdao buried-hill tectonic zone characteristics activity, which defined clearly about the different periods and different strike fault control function of the tectonic zone. Set up three kinds of fault point mountain mode, it defined clearly about the different types of buried-hill reservoir in paleogene filling pattern, sedimentary system and trap Combination characteristics, in order for the regularity of hydrocarbon accumulation in the optimization of in-depth study and exploration direction provided a reference.

2. Characteristics of basement fault

Basin basement faults formed prior to the formation of the basin, Early tectonic rupture due to weak tectonic zone in the late tectonic stress activity again, large fault in the fault basin originated from the basement fault. Therefore, basement fault had played an important controlling role on late basin structure in the process of tectonic development and evolution, directly affected the tectonic framework of basin and fault systems [12].From the eastern Jiyang Depression Paleogene basement structure outline (Figure 1a) could be seen,The main development in NNW, NW and NE three groups different direction of the basement faults, the NW and NE trending basement fault had important control action on Kendong-chengdao buried-hill tectonic zone formation and tectonic evolution.

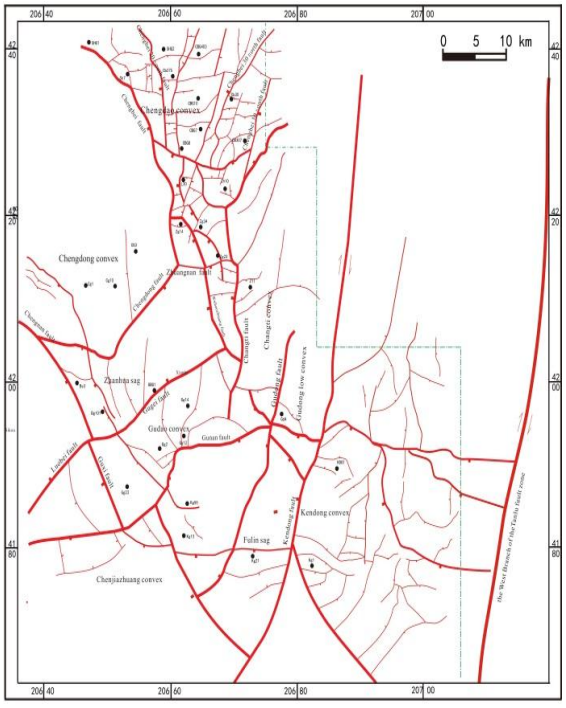
2.1. North-west basement fault

Eastern development in jiyang depression two major large north-west trending basement fault zone, the NW fault zone originated in Triassic in indosinian period, which was the north China and south China plate along the dabie-sulu orogenic belts collision orogenic forming the thrust fault, reversed in yanshan period, turned into a normal fault [13-14]. The basement fault in NE was lateral fault and tear fault of the basement fault in NW. The basement fault zone in

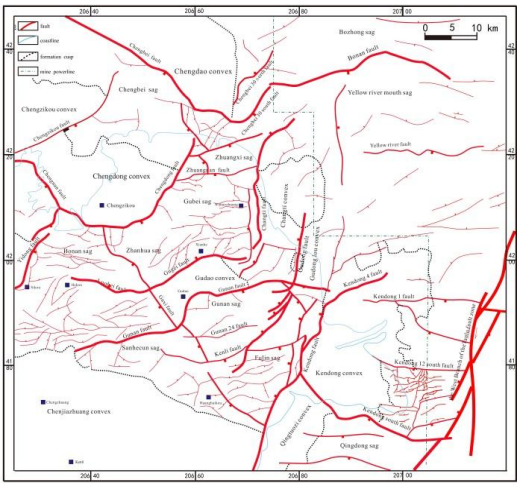
NW controlled the macro tectonic characteristics in NW. Among them, the basement fault zone in NW of the most eastern part had been extended from the southern Kendong to the northern Chengdao areas, controlled the formation of Kendong – Chengdao buried-hill tectonic zone.

2.2. North-east basement fault

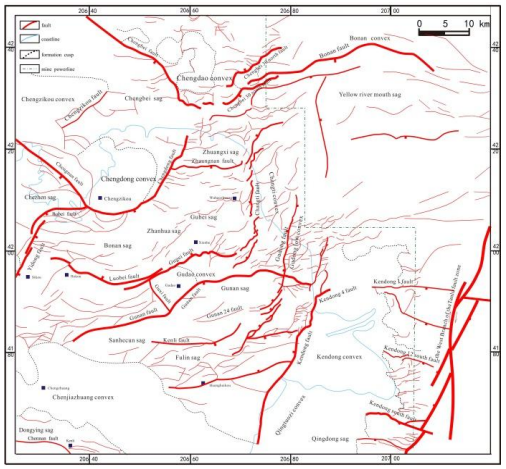
Tanlu fault zone in the eastern part of the area was a giant basement strike-slip fault zone in NE, the southern section of the fault zone originated in middle Triassic indosinian period, which was formed in the process of collision orogenic intracontinental transform fault. In the late Jurassic Yizenaqi plate towards to the NW high-speed oblique subduction, occurred left translation activities, extending into the bohai sea to the north and more north of northeast China. In the process of the left-lateral about the Tanlu fault zone, the side associated with a series of NNE to the NE secondary fracture left-lateral translation, formed the Tanlu strike-slip fault system [13-15].In this area developed multiple north-east trending basement fault, such as Kendong fault, Gudong fault, Long Beach fault, Chengbei 30 south fault and Chengbei 30 north fault, etc. The NE trending basement fault were bolong to Tanlu strike-slip fracture system, with closer to the eastern Tanlu fault zone, the development of the characteristics(figure 1). Since the phase fault later than thrust Indosinian NW thrust fault , the left-lateral activities making NW basement faults occurred left-shifted with the traction bent, thereby divided Kendong-Chengdon buried-hill tectonic zone in NE into Kendong, Gudong, Changti, Chengdao, four relatively independent of the buried-hill structure.



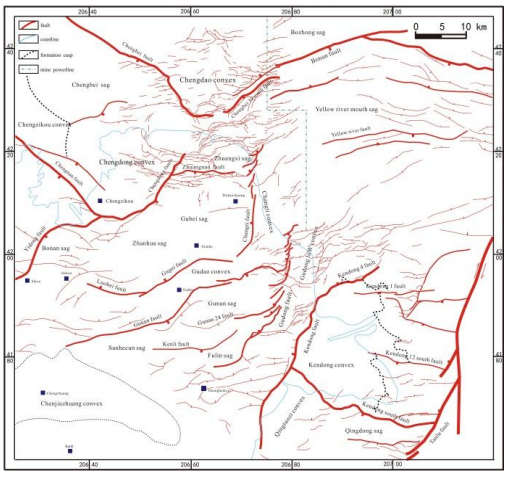
(a)Paleogene basement



(b)Internal Paleogene(T6)



(c)Internal Paleogene(T2)



(d)top Paleogene(T1)

Figure 1.*Jiyang Depression in the eastern Paleogene structural outline diagram*

3. Characteristics of fault in Paleogene

Kendong-Chengdon buried-hill tectonic zone fracture system was very complex, with multi-directional fault intertwined and network distribution characteristics, mainly development NNE, NE, NW and nearly EW

four sets of fault systems (figure 1).From the comparison of different standards reflector, having the characteristic from bottom to top development of more and more features fault. The NE and nearly EW fault number increaseed gradually, and the NW and NNW fault had gradually decreasing trend, especially the late fault development at least in the NW(figure 1).Overall, Kendong- chengdao buried-hill tectonic zone taking NNW fracture system as the leading factor, which was the main buried-hill boundary fault,the second for the NW, nearly EW and NE fracture system (figure 1). Different trends fault system activities, activity intensity and different evolution , controlled Kendong-Chengdao buried-hill tectonic zone of differences buried-hill structural.

3.1. Tectonic stress field

Regional dynamic state was the key factors decided basin fracture system formation, distribution and activity. Related research showed that the Bohai bay basin in the state of tensile stress in NS in paleogene [16-18]. Kendong - chengdao buried-hill tectonic zone fault activity was also controlled by tensile stress field of north and south trending, different directions total elongation rate comparison showed that NS direction stretch ratio were significantly greater than other direction (figure 2).In NS, under the action of tensile stress field, it produced two genetic types of normal fault and translation normal fault , one was before the resurrection of basement faults in paleogene, one kind was Paleogene in the formation of the newborn normal fault. The fault strike of the former way was controlled by the basement fault and fault activity, activity time was longer, the fault scale was larger, controlled pattern of the buried-hill tectonic zone;The latter was given priority to fault in EW, the activity time was shorter, fault scale was smaller, formed a complex tectonic style in the area.

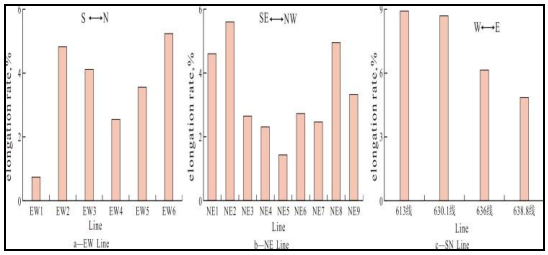


Figure 2.*Kendong – Chengdao buried-hill tectonic zone in different directions total elongation rate comparison*

3.2. Basement fault reactivation

Under the action of tensile stress field In NS, different direction of the basement fault showed a different ways of resurrection. If the basement fracture and tensile stress direction to vertical, normal fault is formed under the action of positive tension;If basal fracture and tensile stress direction obliqued, formed left or right translation component of the translation normal fault under the action of oblique tension [19]. Basement resurrection faults formed under the action of diagonal tension ,on the plane seemingly translational fracture. But due to its dynamic background, formed fully in the area stretching fault properties in extensional fault, rather than the strike-slip faults. In the same tectonic stress field, activity intensity of basement resurrection fault ,in a certain extent depends on the basement fault trending and Angle size of tensile stress direction. The larger the angle, the greater the effect on the tensile stress intensity of basement faults, the greater the intensity of fault activity, on the contrary, the smaller the intensity of fault activity.

Kendong – Chengdao buried-hill tectonic zone mainly developed two groups in NW and NNE trending basement faults, In oblique with the action of tensile stress in NS, respectively occurred left-normal fault activities and the right normal fault activity, showing different ways of resurrection (figure 3).The larger intensity of fault Activity in the position of the basement fault continuous disconnect (FIG. 3 a). And expanded, plane length increased, cross-section further upward and downward extension. Even different orientations basement faults connection into a normal faults become positive faults track (Fig. 3b);The fault activity intensity was relatively weak, in the plane formed the echelon arranged fault combination style (FIG. 3 c).

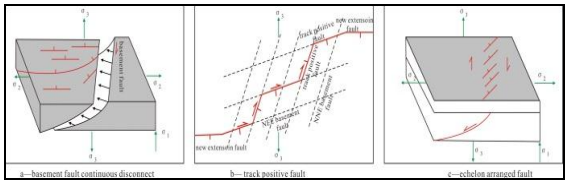


Figure 3.*Kendong-chengdao buried-hill tectonic belt basement fault resurrection way*

The main basement resurrection faults in paleogene had the characteristics of the migration activity intensity gradually weakened with time (figure 4). Some faults activity intensity was greater in the early days, expressed as a continuous large fault. With the weakening of late activity intensity , characterized by multiple echelon arrangement of branch fault fracture zone, such as Changti fault nearly NS-trending in Paleogene bottom and lower bottom a continuous big fault was shown in figure (1b),And in the upper performance for an echelon fault zone (Fig. 1b, c).

3.3. Newborn normal faults

Paleogene area mainly developed two types of newborn normal faults, one kind was the independent development of the small-scale normal faults, one kind was large fault zone associated or derived normal fault.

Newborn independent normal faults more perpendicular to the direction of regional tension. Therefore in a nearly NS-trending tensile stress state formed the fault strike mainly for nearly EW trending.

This nearly EW trending small normal faults appeared within each secondary sub-sag, often with activities of synthetic basement fault integration reduced [20～23].

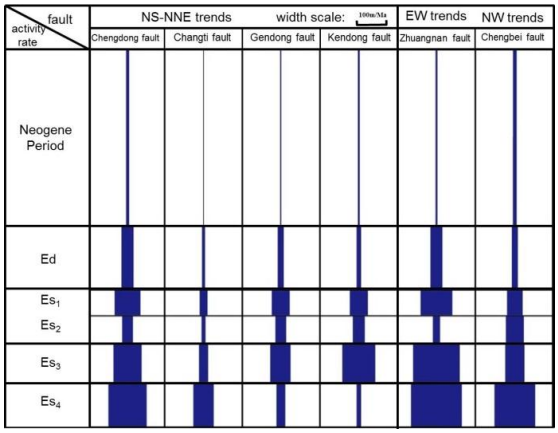


Figure 4.*Kendong – Chengdao buried-hill tectonic zone boundary fault activity rate comparison*

Large fault zone associated or derivative normal fault was derived in diagonal tension of basement fault during the process of shear resurrection. In the side fault generated regional tectonic stress field, thus derived with the small Angle oblique normal fault and normal fault of parallel. By the local stress field and regional stress field superimposition influence, often formed part side of an arc fault. Such faults were often associated with major faults, showing a feathery faults combination tectonic styles.The area Kendong fault in NNE trending, Gudong fault, the fault of Long Beach, Chengdong fault and NW of Chengbei fault etc.and other associated and derivative faults phenomenon was very common, these derived and associated fault scale was small, extension distance was short, far away from the main basement fault was disappear quickly (figure 1).

4. Control mode of fault

Kendong - chengdao buried-hill tectonic belt, the resurrection of basement faults two different direction groups in NW and NNE activities in paleogene , and a set of Newborn EW faults controlled the tectonic pattern and tectonic style. According to the buried-hill boundary fault number, fault activity style and the activity intensity, set up the three kinds of fault control mountain mode, namely single break - low convex type, double break - convex type and more – broke high convex type. Different types buried-hill of the Cover Paleogene overlap strata and overlap range and cladding layer was different. The differences of the stratigraphic overlap and drape structure was further control the type of depositional system and development pattern, and then controlled a favorable development of reservoir-seal combination and combination features of traps (Table 1).

Table 1: *Kendong-Chengdao buried-hill tectonic zone convex characteristics*

mode	boundary number	Fault activity intensity	Stratigraphic contact relationship	Sedimentary types	Reservoir development situation	Favourable assemblages	Trap combinations features	Buried-hill instance
single break - low convex type	one	Weaker	Es3 lower part overlap, Es3 upper - Ed overall drape	(Fan) delta, biogenic limestone beach bar	upper development, middle not development, lower part development	Es3 — Ed	tectonic, lithologic and stratigraphic traps	GuDong convex; changti convex
double break - middle convex type	two	Stronger	Es3—Ed lower part overlap, Ed upper drape	(Fan) delta, Channel sandstone, biogenic limestone beach bar	upper development, middle more development, lower part not development	Es3 — Ed lower part	Es3—Ed lower lithologic trap and stratigraphic overlap trap, Ed upper drape structural, lithologic - structural traps combination	Chengdao convex
multi broke - high convex type	More than 3	Strong	Es3—Ed overlap	(Fan) delta	Overall development	Es3	The multi stratigraphic overlap trap combination	Kendong convex

4.1. Single break - low convex type

The type represented by GuDong convex and long beach convex, both of which respectively controlled by GuDong fault and long beach fault (figure 5 a). In paleogene times, under the action of tensile stress in NS, in the basement fault of Xiqing changdi fault in NNE and GuDong fault reactivation, happened the right-lateral translation normal fault activity , controlled the settlement of Xipan depression and relative lift of Dongpan low convex , thus formed the Changti low convex and GuDong low convex. Since Long Beach fault and Gudong fault presented left echelon order form, appropriately controlled these two convex inclined type appeared, The falling plate of fault on the west side respectively were Gubei subsag and Gunan subsag , while low convex on the east side in the form of gentle slope tectonic belt gradually transition to the Yellow River Mouth Sag.

The formation and evolution of this type convex mainly controlled by a boundary fault. And boundary fault and tensile stress of direction Angle was small, the fault activity intensity was weak, rising plate lift range was limited, thus formed low convex. In the Paleogene exposed above the water time span and range limited. Three lower part and the following formation of Changti low convex and GuDong low convex was overlap type deposit, the sand in the three sections of the upper and the above series of strata were lie on the convex. The stratigraphic structure characteristics determined GuDong area and long beach area overlap formations near source fan delta deposits ,relatively reservoir development; Sand beach was mainly for some biological limestone yantan dam reservoir, other groups mainly for the far source delta sediments. Overall , single break - low convex type buried-hill reservoir caprock conditions of the ancient Tertiary was relatively good, all the strata could form favorable reservoir-cap combination, trap type was relatively abundant, but development of stratigraphic overlap, lithology, structure ,etc. and various types of traps.

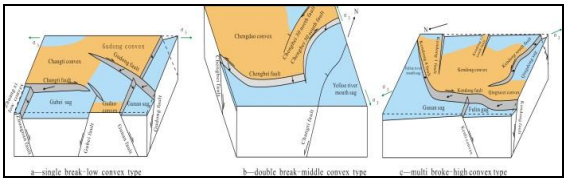


Figure 5.*Kendong - Chengdao buried-hill tectonic belt fault control mountain schematic diagram*

4.2. Double break - middle convex type

The type represented by chengdao convex , which is controlled by Chengbei fault and Chengnan 30 south fault formed a relatively high low-convex (FIG. 5 b). Chengbei fault and Chengnan 30 south fault were recover basement fault, under the action of tensile stress in NS, tChengbei in NW fault occurred left transtensional sexual activity. From the NNE to Cheng north 30 south fault in NEE was right lateral transtensional sexual activity, two two bounding faults together to make Chengdao low convex rising..Two basement faults strike and an angle of the tensile stress in NS slightly larger than Long Beach faults and Gudong faulst, the larger intensity resurrection fault.Two fault fall plate respectively controlled the Chengbei sag and the Yellow River Mouth sag tectonic subsidence, jointly controlled the Chengdao convex relative uplift.

Due to the double break - in the convex type buried-hills was controlled by the two fault, and the fault activity intensity was bigger. Its tectonic uplift magnitude was larger than Changti and Gudong low convex of single break - low convex type, exposure to the water before the time span in paleogene and scope was bigger. Chengdao convex under Dongying lower part formation in paleogene was mainly for overlap type deposit, Dongying group in upper formation and above was only the drape formula deposits type. The stratigraphic structure characteristics determined Chengdao convex peripheral sand bottom three - dongying group, mainly for the near-source fan delta deposits. Local development biogenic limestone beach bar, the upper and the far source delta in dongying group was mainly for fluvial facies sedimentary. Paleogene three sections, the sand in the lower part group and the lower section of Dongying reservoir cap had a good combination condition. Common development of lithologic trap and stratigraphic overlap trap, dongying upper group reservoir - caprock assemblages had worse condition , mainly development drape structure, lithologic - structural trap.

4.3. Multi broke - high convex type

This type was represented Kendong convex , it was subject to three or more border fault control formed high convex (Fig. 5c). The west boundary fault of Kendong convex was Kendong fault, the fault was a basement resurrection fault for NNE trending. Xiqing in Paleogene times, under the effect of NS tension, the resurrection of fault happened right transtensional sexual activity, the west side of the fault fall plate was Gunan –Fulin sag.Kendong fault in EN turn to NNE, connected Kendong 4 faults ,Kendong 4 faults was north-dipping normal faults in NEE . With tensile stress direction Angle was bigger, dip-slip predominates, combined with the north was also developed a series of north normal fault in EW, becoming the north falling broken order tectonic belt, gradually transition to Yellow River mouth sag. Taking Kendong southeast fault as boundary, apart Qingdong Sag, fault down control of tectonic subsidence of Qingdong Sag. Kendong convex eastern appeared nearly EW, kengong 1 fault and Kendong 12 south fault, etc, These nearly EW fault to the east and the west branch of the tanlu fault zone

fault intersection, taking the east fault zone as boundary and apart laizhou bay sag.

Around Kendong convex, all apart with fault and four concave (hollow) fall, the boundary fault number was large, activity intensity was strong, duration was long, caused Kendong convex up time and lift the amplitude were very big. So three system sand in paleogene, sand paragraph and dongying group strata were overlap type, which had the characteristics surrounding convex onto a layer in the northeast. Various strata were near the source of fan delta sediments, so the reservoir was very development, reservoir cap combination was relatively poor, stratigraphic was mainly for stratigraphic and development a small amount of fault nose of structural traps.

5. Conclusion

(1) Kendong-chengdao buried-hill tectonic belt in jiyang depression, had NW and NNE played a leading role in the two groups in the pre-cenozoic basement fault. The former formed thrust fault originated in the Middle Triassic Indosinian continental deformation , the latter associated left-slip fault in late Jurassic tanlu fault zone in translation.

(2) In Paleogene times, under the effect of the SN regional extensional stress field, the basement fault line transtensional left alived in NW,NNE trending basement fault right transtensional resurrection, the resurrection of NW trending fault controlled the whole tectonic belt of the macro pattern ,NNE trending resurrect faults NW \ is divided the buried-hill in WN into Chengdao, Long Beach, Gudong and Kendong and other buried-hill, and newborn normal fault in EW raised convex further complicate, controlled the formation local fault block structure.

(3) Established three kinds of fault control mountain mode, namely single break - low convex type, double break - in convex type and multi broke - high convex type. Different types of buried-hill level difference controlled Paleogene strata filling patterns, and the difference of stratigraphic overlap and drape structure further controlled the type of depositional system and development pattern. And then controlled the development of favorable reservoir-cap combination and trap combination features.

6. Acknowledgements

The author confirms that this article content has no conflict of interest.

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