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Geological Characteristics and Tectonic Evolution Setting of the Middle Uplift Zone in the South Yellow Sea

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Abstract

Based on the research of latest seismic data, combining geological background and drilling data in adjacent region, four discernible seismic reflectors, i.e. T11, T12, T13 and Tg can be tracked out below the T2 reflection which represents the subsurface of Neogene strata in the middle uplift zone of the South Yellow Sea. The seismic reflection characteristics and analysis of stratigraphic framework indicate that the South Yellow Sea Basin where the middle uplift zone locates is the Yangtze block's extension to sea. Through the interpretation of gravity data, magnetic data, and seismic data, this study put forth the viewpoint that the faults of the middle uplift zone are mainly NE-strike, NNE-strike, and EW-strike, and compress-shear faults are dominated, some faults inversed latter. This research also analyzed the geological structure characteristics of the middle uplift zone. Referring to the tectonic evolution process of Yangtze block, together with seismic reflection characteristics, contact relationship between stratums and structural styles analysis, the tectonic evolution process of the middle uplift zone can be subdivided into four stages including basement formation phase, marine craton evolution phase, collision uplift and denudation phase and extensional subsidence phase.

Keywords: The South Yellow Sea; Seismic Stratigraphic Sequence; Faults Characteristics; Tectonic Evolution

1 INTRODUCTION

The middle uplift zone lying on eastern sea area of Jiangsu province west of 124° E and stretching from 35°15′N to 33° 40′ N is the biggest stable tectonic units of the South Yellow Sea basin in lower-Yangtze block[1] (Fig.1). The lack of drilling data and constraint of no enough high quality seismic data restrict the geological research of this area, some basic geological problems such as stratigraphic framework, faults characteristics and tectonic evolution process have not been clear and no unanimous conclusion can be drawn. As the focal point of oil-gas exploration transferred from the Mesozoic and Cenozoic to deeper Mesozoic-Paleozoic stratum, the middle uplift zone again became the hot spot of geological research, and latest geophysical data had been collected, especially the clear traceable seismic reflection below the T2 (subsurface of Neogene strata in the South Yellow Sea basin) obtained in 2006~2007 seismic data initially confirmed the existence of very thick Mesozoic-Paleozoic marine deposit. Based on the latest interpretation results of geophysical data, this paper studied seismic stratigraphy, faults development and tectonic evolution process of the middle uplift zone contributing to providing some basis for some basic geological problems and petroleum exploration.

2 GEOLOGICAL CHARACTERISTICS

2.1 Seismic-sequence Stratigraphy

Twenty-six drilling wells totally distributed in the northern depression (i.e. Yantai depression) and the southern depression (i.e. Qingdao depression) in South Yellow Sea basin and the middle uplift zone have not been drilled. On the basis of seismic wave groups' reflection features and regional geological correlation, this research indicates that the Mesozoic-Paleozoic marine facies deposition of the middle uplift zone is the same as those of lower Yangtze land zone and T11, T12, T13 and Tg can be tracked out below the T2 reflectors, next six effective seismic sequences are depicted below (Fig.2).

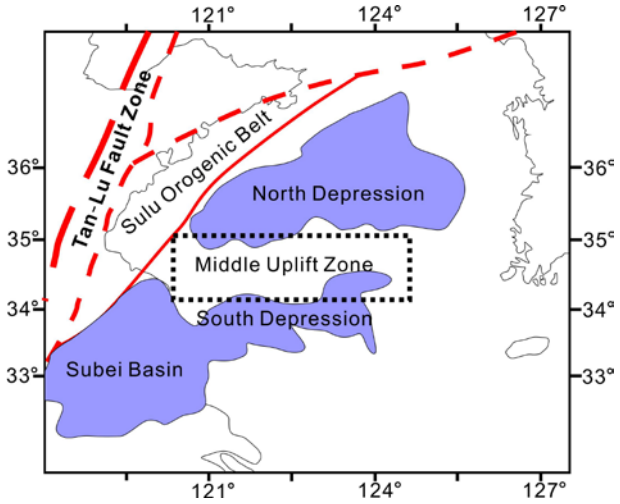

FIG.1 LOCATION MAP OF THE MIDDLE UPLIFT ZONE AND TECTONIC BACKGROUND

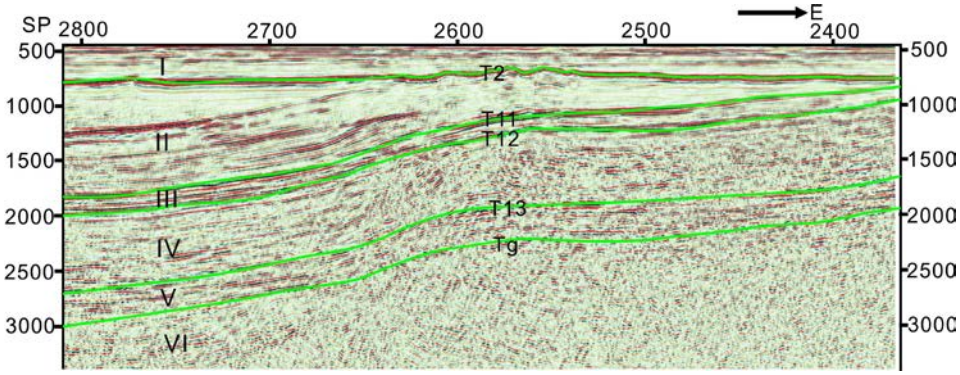

FIG.2 LATEST SEISMIC PROFILE ON THE MIDDLE UPLIFT ZONE

I'st seismic sequence: several wells have drilled through and distributes steadily in the whole South Yellow Sea basin. Seismic reflection is characterized by high frequency, high continuity and strong amplitude, and internal wave group feature is parallel or sub-parallel structure. The bottom of I'st seismic sequence is T2 reflection which is a large unconformity surface with the underlying formation. This seismic sequence is Neogene-Quaternary continental clastic deposit.

II'st seismic sequence: locates between T2 and T11, mainly are blank reflection band and includes several intermittent-clutter reflection. Seismic reflection are characterized by low to medium frequency, weak amplitude and interval velocity is 5800~6500m/s. According to the strong amplitude, high continuity reflection of Longtan coal-bearing formation in lower Permian series and iconic blank reflection band of Qinglong limestone formation in lower Triassic series drilled by WX5st-1 and CZ35-2-1, however, those two classic reflections are not identified in the middle uplift zone, then this research speculate T2-T11 seismic sequence represents the Carboniferous-Permian deposit and T2 represents Indosinian movement tectonic surface.

III'st seismic sequence: locates between T11 and T12. Seismic reflection are characterized by low to medium

frequency, high continuity and medium to strong amplitude, and interval velocity is 4200~5500m/s. This seismic sequence reflection distributes steadily and has good regional correlation but no drilling well drills into this interval in the middle uplift zone. Referring to regional seismic geological comparison, T12 reflection is concluded as the Caledonian movement tectonic surface and this seismic sequence represents Devonian-Silurian clastic deposit.

IV'st seismic sequence: locates between T12 and T13. Seismic reflections are characterized by low frequency, intermittent reflection and weak amplitude, and interval velocity is 6000~6500m/s which is the same as II'st seismic sequence. According to well and seismic response characteristics of the northern Jiangsu area in the lower Yangtze block, this seismic sequence may represents Ordovician-Cambrian carbonate deposit.

V'st seismic sequence: locates between T13 and Tg. Seismic reflection are characterized by low frequency, high continuity and low to medium amplitude, and interval velocity is 5800~6400m/s. This seismic sequence reflection distributes stablely in the South Yellow Sea area and may represents Sinian system deposit.

VI'st seismic sequence: locates below Tg reflection surface and has low seismic quality with low continuity and weak amplitude and is concluded as Presinian system deposit.

Therefore, the marine-dominated facies deposits below T2 reflection in the middle uplift zone and its sedimentary stratigraphic evolution is roughly consistent with the lower Yangtze land area, indicating the South Yellow Sea area as the seaward extension of the Yangtze block.

2.2 Faults Development Characteristics

The lack of drilling wells and low quality of seismic data constraint the research about faults development features and structural deformation in the middle uplift zone. Generally, regional tectonic background determines the structural pattern of manifestation. The South Yellow Sea area undergone multiple tectonic movements, especially the block collision orogeny occurred between Yangtze block and Huabei block in Indosinian which controlled the formation of thrust fault system under the regional N-S strike compression background. Thus the thrust fault system of the northern Jiangsu area extends to eastern marine area. In addition, the South Yellow Sea area superimposed stretching extension affection after entering Mesozoic and caused several former faults structural inversion, but the degree of inversion was limited and mainly distributed in eastern area. NEE strike and EW strike faults are dominated in the South Yellow Sea basin which constitutes the main fault system of marine facies nappe of Mesozoic-Paleozoic.

The faults system of the middle uplift zone was studied according to the latest 2D seismic data interpretation results. Controlled by the lower Yangtze regional tectonic background, the faults of the middle uplift zone are mainly NE strike, NNE strike, EW strike and few EW strike [2, 3]. These faults can be classified into thrust faults, facing thrust faults, reversed faults and normal faults, but mainly are compressive shear faults. Several faults occurred structural inversion [4]. Compressional fault system is the prominent fault characteristic in the middle uplift zone especially around the southern and northern margin area which dominates the formation of the NS facing thrust fault system. The thrust strength becomes weaker to the east as away from the orogenic belt. Extensional fault system contains some reversed faults and new normal faults which seldom develop inside the uplift zone but mostly distribute in the southeast and north rim area and the reason may be that the subsequent extensional process was offset by south and north deep faults.

2.3 Geological Structure

The middle uplift zone is a typical Meso-Cenozoic positive structure unit in the South Yellow Sea basin of the lower Yangtze area. The gravity and magnetic data show similar anomalous characteristics in research area, both showing conspicuous gradient zones between the middle uplift zone and southern and northern depression. Gravity anomaly represents the tectonic relief of basement, the relatively higher gravity anomaly the middle uplift zone than southern and northern depression approximately distributes between 33°N and 35°N. Bouguer gravity anomaly indicates the middle uplift zone tilts from east to west and a relatively lower gravity anomaly distributing in 34°N~35°N area have been depicted inside the middle uplift zone which also can be detected from magnetic anomaly map. Moreover, the

southern 34°N and 123°E~125°E area shows widespread distribution of volcanic rocks in negative anomaly. The gravity and magnetic anomalies characteristics also display alternating depressions and uplifts structural framework above the basement of the middle uplift zone[5].The faults in the northern edge of the middle uplift zone are more obvious than the south where mainly is slope according to gravity and magnetic data and seismic interpretation results.

3 TECTONIC EVOLUTION PROCESS

Through analysing the contact relationships between seismic reflections, fault system and structural styles, this paper divides the tectonic evolution process of the middle uplift zone into four stages including basement formation phase (Presinian period), marine craton evolution phase (Sinian period to middle Triassic epoch), collision uplift and denudation phase (late Triassic epoch to Oligocene) and extensional subsidence phase (after the end of Oligocene).

The Yangtze block where the middle uplift zone locates completed cratonization in Neoproterozoic [6], and had early Precambrian crystalline basement and late Precambrian metamorphic basement which were composed of migmatite, gneiss, and gneissic granite with strong migmatization [7-10]. Marine craton evolution process included two sub-stages, the first is carbonate deposition in platform edge from Sinian to early Paleozoic and the second is carbonate deposition in stable platform from late Paleozoic to middle Triassic epoch. The boundary of those two sub-stages is Caledonian movement structural surface which presents conspicuous unconformable contact. Referring to drilling well results of adjacent region, the conclusion that the middle uplift zone is lack of upper Silurian and middle-lower Devonian can be speculated. After the Caledonian movement, influenced by the expansion of the ancient Tethys Ocean, the middle uplift zone transferred from interactive marine and terrestrial deposition in Carboniferous to platform carbonate deposition in Permian to early Triassic. Until the stage of middle Triassic, the regional uplift occurred because of the Indosinian collision orogeny movement and formed the rudiment of the current middle uplift zone. At the end of Triassic stage, with the collision between the Yangtze block and The Huabei block, the continuous regional compression caused incessant compressive folding and uplifting in research area which ultimately resulted in the formation of the middle uplift zone. The regional stress converted to NW direction from late Jurassic to early Cretaceous in the South Yellow Sea area [3, 8], and the middle uplift zone did not receive deposit in this period. At the end of Oligocene the South Yellow Sea basin got into the regional subsidence stage until Quaternary period and transgression occurred from the southeast, then the current tectonic pattern of the South Yellow Sea formed.

4 CONCLUSIONS

The Mesozoic-Paleozoic marine facies deposition of the middle uplift zone is the same as those of lower Yangtze land zone and T11, T12, T13 and Tg can be easily tracked out below the T2 reflectors. Through regional geological comparison, the existence of very thick Mesozoic-Paleozoic marine deposit in the middle uplift zone can be confirmed.

The faults of research area are mainly NE strike, NNE strike, EW strike and few EW strike which can be classified into thrust faults, facing thrust faults, reversed faults and normal faults, but mainly are compressive shear faults. Several faults later occurred structural inversion.

The tectonic evolution process of the middle uplift zone can be subdivided into four stages including basement formation phase, marine craton evolution phase, collision uplift and denudation phase and extensional subsidence phase. The South Yellow Sea Basin where research area locates is the Yangtze block's extension to sea.

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REFERENCES

[1] Zhang Haiqi, Chen Jianwen, Li Gang, et al. Discovery from Seismic Survey in LaoShan Uplift of the South Yellow Sea and the Significance. Marine Geology & Quaternary Geology, 2009(03): 107-113

[2] Li Huijun, Lin Niantian, Jin Xing, et al. The Fracturing Characteristics of Mesozoic and Paleozoic Eras in Laoshan Uplift of South Yellow Sea Basin. Journal of Shandong University of Science and Technology(Natural Science), 2012, 31(6): 69-75

[3] Sun Jing, Wang Jianqiang, Xiao Guolin, et al. Distribution Pattern of Marine Upper Structural Layer and Fault System on the Central Uplift of the South Yellow Sea Basin. Marine Geology Frontiers, 2014(10): 18-25

[4] Wang Feng, Li Huijun, Zhang Yinguo. Stratigraphic Geologic Attribute and Hydrocarbon Geology in LaoShan Uplift of South Yellow Sea. Marine Geology & Quaternary Geology, 2010(02): 95-102

[5] Ou Yangkai, Zhang Xunhua, Li Gang. Characteristics of Stratigraphic Distribution in the Middle Uplift of South Yellow Sea. Marine Geology & Quaternary Geology, 2009(01): 59-66

[6] Lu Songnian, Li Huaikun, Chen Zhihong, et al. Relationship between Neoproterozoic Cratons of China and the Rodinia. Earth Science Frontiers, 2004(02): 515-523

[7] Li Huijun. The Tectonic Division of the Mesozoic-Paleozoic in the South Yellow Sea Basin. Marine Geology Frontiers, 2014(10): 8-13

[8] Yang Changqing, Dong Heping, Li Gang. Formation and Tectonic Evolution of the Central Uplift of the South Yellow Sea Basin. Marine Geology Frontiers, 2014(07): 17-21

[9] Zhang G W, Guo A L, Wang Y J, et al. Tectonics of South China Continent and its Implications. Science China: Earth Sciences, 2013, 56: 1804-1828

[10] Zhou Xiaojin, Yang Fan. Tectonic Evolution and Prototypes Analysis from Neoproterozoic to Early Paleozoic in South China. Petroleum Geology & Experiment, 2007(05):446-451

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