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Mesozoic structural attribute and its control of on sedimentary system in the southern Ordos Basin

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Abstract

Ordos Basin is a large Mesozoic continental basin superimposed on the Paleozoic cratonic terrace of North China. Mesozoic Era is an important transformation phase for Ordos Basin. The studies of Ordos Basin made by predecessors are centered on the west of the basin, and little studies involving the south of the basin, phenomena of structure in the southern Ordos Basin is complicated with different chatacteristics. To different scholars, their views about the structure attribute and the evolution in Mesozoic of this region are not the same, especially there are large differences with regard to the provenance, sedimentary system and tectonic property of the south of the basin. In this paper, on the basis of wildly collecting the information about this region and mainly discusses the provenance, sedimentary system and tectonic property, then analysised the structure features of the southern Ordos Basin and its effection on controling the evolution of deposition from the background of regional geodynamics and the ideas of coupling basin.

Keywords: southern Ordos Basin, sedimentary provenance, sedimentary system,structural

attribute, geotectonic evolution

1. Introduction

Ordos Basin extends across five provinces and regions, including Shaanxi, Gansu, Ningxia, Inner Mongolia and Shanxi, and it is also known as Shan-Gan-Ning Basin. The surrounding area is imbedded by Wei River (Guanzhong), Yinchuan, Hetao and other graben basins, and the periphery is surrounded by Qinling Mountains, Liupan Mountains, Helan Mountains, Daqing Mountains and Lvliang Mountains. According to today's tectonic form, combined with the evolution history of the basin, Ordos Basin can be divided into six first-class tectonic units, including Yimeng Uplift, Weibei Uplift, Western Shanxi Flexure, Yishaan Slope, Tian-huan syncline and Thrusting Fault Tectonic Zone in Western Edge. Ordos Basin in a broader sense includes Weihe River, Yinchuan, Hetao, Liupan Mountains and other small Mesozoic-Cenozoic basins, with a total area of 36 $\times 10^4 km^2$ (Figure 1). This basin is a multi-cycle cratonic superimposed basin with stable sedimentation, migratory depression and obvious shearing (Mu et al, 2001). The study area lies to the west of Lvliang Mountains, the east of Helan Mountains-Liupan Mountains, and the south of Ring Road-Yan'an to the northern region of Qinling Mountains, with an area of about 10 $\times 10^4 km^2$. On the basis of synthesizing previous studies, this paper briefly discusses Mesozoic tectonic property of the south of the Ordos Basin and its controls on sedimentation, and puts forward comments and suggestions on the next work.

2. Provenance analysis

Provenance analysis is an important part of basin analysis, and the research content mainly includes the orientation of provenance area, the geographical position of denuded zone and parent rock zone, determination of ancient erosion area, remodeling of ancient geomorphological features, lithology of parent rock, transport distance and route of the sediments (Wu, 1999; Wang et al, 2000; Xu et al, 2007). The judgment of provenance direction may provide an important basis for determining the distribution law of sand body, analyzing the sedimentary system of sedimentary province, reappearing the sedimentary evolution history of the basin and reflecting the relationship between provenance area and sedimentary province, in order to finally reconstruct the paleogeography of this area. Provenance analysis has many methods, and the more common methods are palaeocurrent

analysis, clastic rock analysis, heavy mineral analysis, geochemical analysis and so on (Zhao et al., 2003).

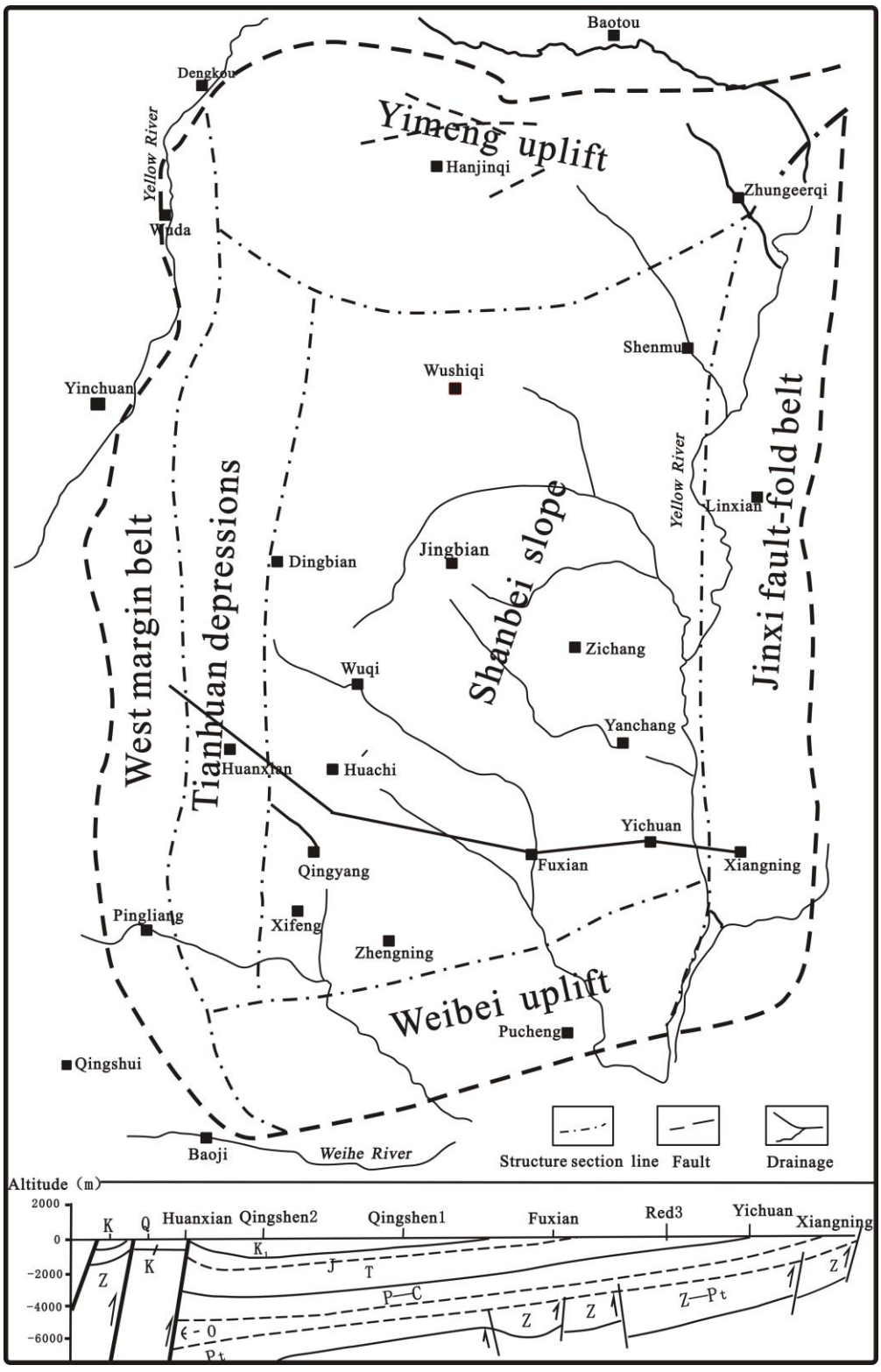

Figure.1 Distribution of Ordos Basin

The predecessors have made a lot of researches on the provenance of Ordos Basin. These researches are mainly concentrated in the Paleozoic Era (Guo et al., 1998; Wang et al., 2001;

Xi et al., 2002; Liu et al., 2003; Chen et al., 2006; Chen et al., 2006; Chen et al., 2007; Wu et al, 2007; Xiao et al., 2008; Qu, 2011; Li et al., 2011); they consider Erdos Paleozoic erathem is affected by the control of multiple provenance, but mainly based on the northern provenance. Little researches involve the study on the Mesozoic provenance of the south of the Ordos Basin. According to heavy mineral assemblage, paleocurrent direction, clastic particle size and other information, Wei (2003) believes that the main provenance of Ordos Basin is from the north and the southwest in the early-middle sedimentation stage of Yanchang Formation, and the provenance in the southwest is in a dominant position during the late sedimentation stage. Chen (2009) uses paleocurrent analysis, research of heavy mineral characteristics, particle size analysis, thin skeleton mineral composition analysis and other methods, systematically studies the provenance of Yanchang Formation of the upper Triassic in the south of the Ordos Basin and the lithology of parent rock in the provenance area, and thinks that Yanchang Formation has the provenance from the northeast, southwest, southeast and west the four directions. Through the comprehensive analysis of tectonic properties, sedimentary patterns and paleocurrent of the provenance area in the south of the Ordos Basin, combined with sandstone components, light and heavy minerals, trace elements and other data, Zhu (2010) has made a deep analysis on the provenance of the Late Triassic of the southern basin, and points out that the sedimentary provenance of the Late Triassic of the south of the basin is mainly hypometamorphic crystalline schist and gneiss of Archean Group as well as neritic facies clastic rock and carbonate rock of Paleozoic erathem.

3. Sedimentary system snd the distribution characteristics of sedimentary facies

Sedimentary system refers to the aggregate of sedimentary facies associated with the sedimentation. It can also be interpreted as three-dimensional stratigraphic unit spatially constituted by genetically associated sedimentary facies, and its meaning includes the three-dimensional combination of supply provenance, action process and geographical environment.

About Mesozoic sedimentary system of Ordos Basin, the predecessors have made a lot of research, which are mostly restricted to the Triassic (Wu Fuli, 2004; Yang et al, 2005b; Lin et al, 2008; Yang et al, 2008; Deng et al, 2008; Luo et al, 2008; Chen et al., 2009; Han et al, 2009; Yang et al, 2010; Zhao et al, 2011), while few researches involve the study on Jurassic

and Cretaceous in the Mesozoic Era. In the Late Triassic, the basal topography of Ordos Basin has produced differentiation due to the unbalanced lower limit, especially the southwest basin is subsided strongly, the boundary slope is steeper than the northern basin, and the sedimentation center obviously inclines to the south of the basin (Liu et al., 1997; Zhao et al., 2006; Zhao et al., 2008). Influenced by palaeotectonics, the sedimentary facies belt of Yanchang Formation to the south of Ring Road - Yan'an of the south of the basin is changing rapidly and forms the sedimentary facies type dominated by fan delta and braided river delta(Fig.2). Song (2002) divides the delta sedimentation of Yanchang Formation of the upper Triassic in the middle Ordos Basin into two delta sedimentary systems, namely Ansai delta sedimentary system, Zhijing delta sedimentary system and Anbian delta sedimentary system in NE-trend and Yanding delta sedimentary system in NW-trend. Yang (2005a) points out that Chang 6-8 members of Yanchang Formation are from delta systems in the southwest provenance of the basin, and they are not fan-delta system but the braided river delta system, which form gravity flow sedimentation of Chang-7 oil groups in Weibei area through the second-time transport of the sediments in fan delta and braided river delta of the slope zone on the southern margin of the basin. Lin (2008) considers the sedimentary system types of Yanchang Formation in Ordos Basin are mainly the following six types: alluvial fan, fan delta, river, river delta, lake and lake turbidite fan Luo (2008) thinks that Chang 8 oil reservoirs of Yanchang Formation of the upper Triassic in the southwestern of the Ordos Basin are proximal and rapid accumulation of alluvial fan and fan delta sedimentary system characterized by linear or point-like provenance, which are formed during the period of changing the basin from the fast depression to the thrusting load settlement. Chen (2009) points out that Yanchang Formation takes braided river delta and meandering river delta - lacustrine sedimentary system as the main body, accompanied by deepwater gravity flow sedimentation, the main body is leading edge of braided river delta-prodelta facies and leading edge of meandering river delta- prodelta facies, and the lacustrine facies are mainly shallow lake facies- semi-deep lake sedimentary system.

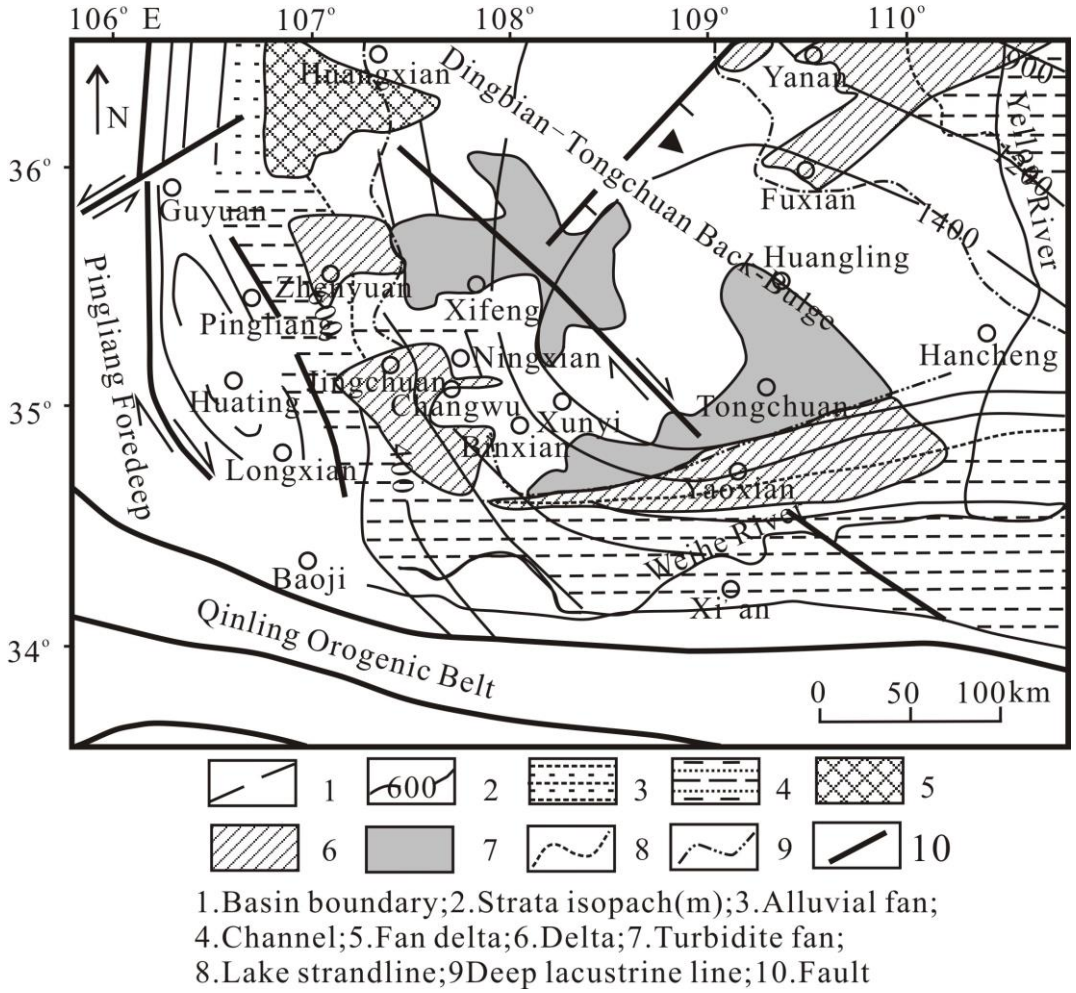

Figure.2 Tectonic framework and depositional system of southern Ordos basin（modified after Zhu et al.,2010）

4. Structural attribute of Basin

In geological history, the geodynamic environment suitable for the development of foreland basin is rather limited in time and space (Liu et al., 2002). Foreland basin is formed between the orogenic belt of contraction and adjacent craton, parallel to asymmetrical thrusted and flexural basin with a narrow strip distribution in the orogenic belt (Liu et al., 2002). This concept or definition shows, foreland basin: ① is formed in the period and the tectonic environment of strong extrusion by splicing and collision of two plates; ② is accompanied by the orogenic belt of contraction formed between the two convergent plates, distributes in parallel, develops simultaneously and couples with each other; ③ has asymmetrical flexural structure and thrust deformation features; ④ has distinctively sedimentary responses in the aspects of provenance, lithology, thickness and facies.

Ordos Basin has a wide range of lake basin distribution in the Middle Triassic - Middle Jurassic, which is evolved by the westward movement of basin sedimentary range in the craton basin of great North China in Paleozoic era and the gradual contraction, and the overall belongs to the superimposed basin in continental facies remnant craton basin (Zhao et al., 1992). The south of the basin has the property of peripheral foreland basin due to the influence of collisional orogeny of Qinling Mountains (Liu et al, 2005).

Terrigenous clastic constituents of sedimentary basin are controlled by many factors and their interactions, especially the tectonic environment and action determine the types of the basin and provenance area, the characteristics of terrigenous clastic constituents and the configuration relationship in time and space. Thus, the analysis of terrigenous clastic constituents and their relationship with tectonic origin and environment largely provides possible methods and ways for determining the tectonic property of the basin. Chen et al (1999) uses a comprehensive research method of combining the regional sedimentation - tectonic setting analysis and the determination of tectonic environment with terrigenous clastic constituents, and points out that Ordos Basin is a para-foreland basin controlled by the thrust-nappe role of western edge, and has a sedimentary tectonic framework of foredeep sedimentation in the west and stable slope in the east; Subsidence zone in the west of the basin, characterized by coarse clastic sedimentation of alluvial fan delta, begins to appear since from the Late Triassic and continuously moves forward the sedimentary central area of the basin, indicating the thrust-nappe of western edge has occurred in the Late Triassic at the latest, continuously developed and moved eastward in Jurassic and Cretaceous, and the tectonic activity is enhanced successively; Terrigenous clastic constituents reveal the thrust-nappe of western edge may begin in the Triassic, especially the composition of clastic particles and the characteristics of chemical composition further indicate the tectonic property of this basin is para-foreland basin.

5. Geotectonic evolution

The growth time limit for Ordos Basin was the Middle-Late Triassic-the early Cetaceous, Late Cretaceous were the later transformation period of the basin. The main body of the Mesozoic Era had the feature of the craton basin. The current Jin basin is the residual basin through multiple phase transformation. The basin is superimposed on early and late Paleozoic large basin, and belongs to multiple superimposed basins. The basin of Mesozoic Era had

experienced four period obvious changes in the structure. Liu et al (2006) divided the evolution and sedimentation process of the basin into four stages: The development time of each stage respectively is as below: Middle-Late Triassic, Early-Middle Jurassic Fu county-Yan'an period, middle Jurassic straight- stable period and early Cretaceous.

The occurrence of Ordos Basin began in China and the indosinian period of global tectonic dynamics environment with big changes, and its occurrence, evolution and extinction experienced and recorded the whole process of North China Craton destruction. The evolution and sedimentation (deposition), distribution and migration of accumulation center of the basin, recorded the change of North China Craton from north-south difference to east-west differentiation and the ebb and flow change with time development and their interaction of the surrounding tectonic domain.

The occurrence of Ordos Basin in Triassic, was performance and results of the North China Craton with east-west obvious differentiation (east uprising and west declining) Mesozoic sedimentary-settlement center of every period was in the south of the basin, with the overall characteristics of south thick and north thin, south deep and north shallow and early-middle Jurassic depositional - sedimentary center extended northward(Fig.3), which was closely related in the foreland flexural sedimentation before the strong convergence orogenic activity of Qinling orogenic belt at the same time (Liu et al., 2005b; Zhao et al., 2006; He et al., 2003).

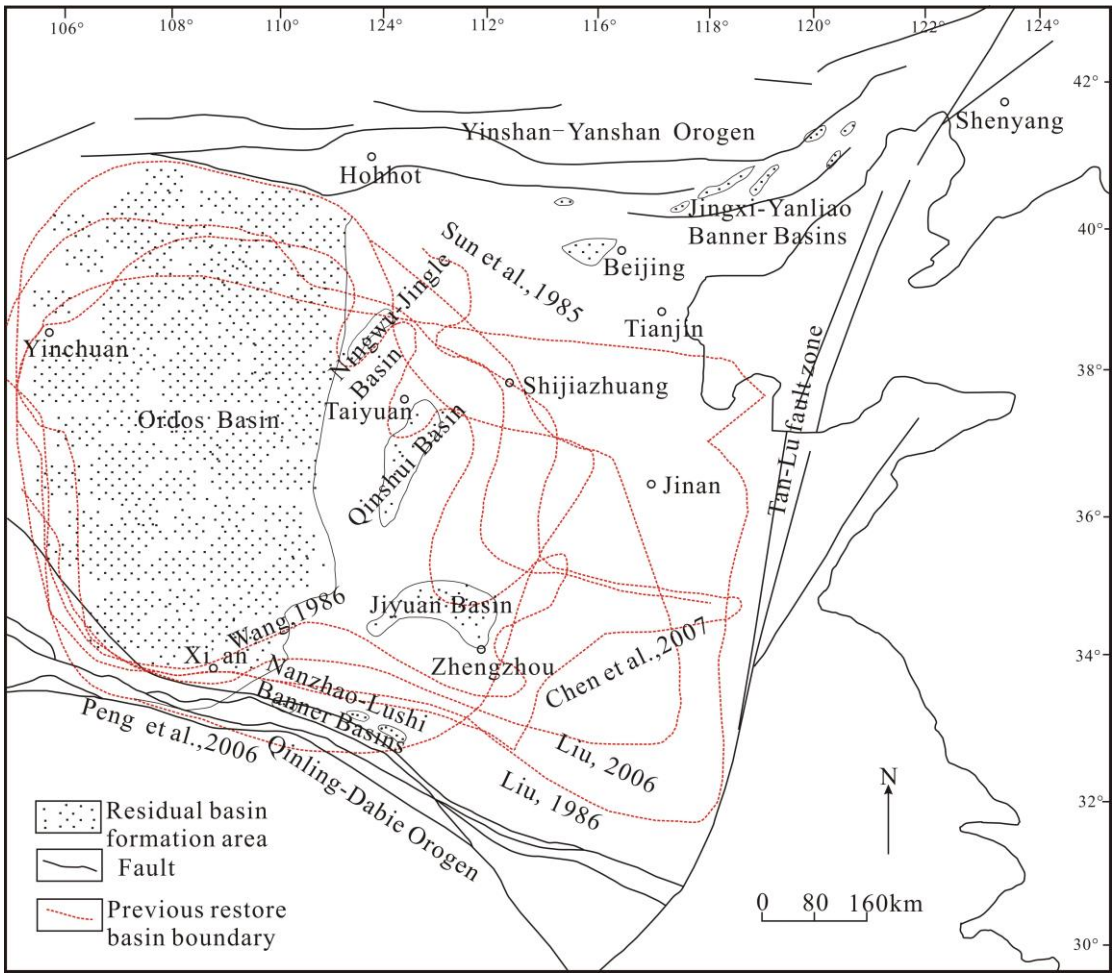

Figure.3 Distribution of sedimentary boundary, depocenters and accumulation centers of Mesozoic Ordos Basin

Enter into the Jurassic, the activities of the Pacific tectonic domain and its influence on the North China Craton being enhanced obviously, caused the sedimentation and transformation of Ordos Basin from north-south differentiation to east-west differentiation. The stratum thickness and accumulation center migration of the main sedimentary stage dynamically reflected the transformation process of regional tectonic background. Until Middle Jurassic straight - stable period, sedimentary facies belt distribution and stratigraphic thickness within the scope of Jin Ordos Basin (originally, the west of the basin) showed the obvious east-west differentiation characteristics, sedimentation and accumulation center separated east and west. Until the end of the middle Jurassic, overall of Jin basin was still tectonic framework with west high and east low paleogeography Each period the direction of flow was from northwest, west and southwest of Jin basin flowing to sedimentary-settlement center of Yan'an - Fu county area of southeast basin.

In the Late Jurassic, the eastern structure of North China Craton-when thermal activity

reached climax, the lithosphere was obviously damaged; To the west of the Ordos Basin, Alashan area suffered closed extrusion of North Mongolia - Okhotsk and diving convergent effect of tethys sea in the south, as dual squeeze it moved eastward; Resulted in the uprising of the eastern basin, the western suffered extrusion, and thus formed Thrust Nappe Structure. The conglomerate of the fragrant river group is limited and accumulated in the front of extruded and folded zone of the west of the basin. So, within the scope of Jin basin it initially showed slope of east high and west low and the rudiment of natural and annular depression.

In the early Cretaceous, the basin was in the weak stretch tectonic environment, east of the basin continued to rise, sedimentation, accumulation and the settlement center as trinity roughly compositely distributed in the southern section of the west of the basin.

6. Conclusions

Ordos Basin is a large Mesozoic continental basin superimposed on the Paleozoic cratonic terrace of North China. Mesozoic Era is an important transformation phase for Ordos Basin. From the above discussion, we can see our predecessors do a lot of research on Ordos basin, but differences of the south of the Ordos Basin still exist in aspects of Mesozoic provenance, sedimentary system, tectonic property and so on. So we need to combine structural geology, sedimentary geology, geochemistry etc. multidisciplinary approach to research Ordos basin, to prove the Mesozoic tectonic property of the south of the Ordos Basin and its control of sedimentation in the south of the Ordos Basin.

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