The study of Yanshanian unconformity tectonic events in Northern Junggar Basin

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Abstract. Based on the background of Yanshanian tectonic activity in the northern Junggar basin, the temporal and spatial distribution characteristics of Yanshanian unconformity events in the northern Junggar basin are systematically studied through interpretation and comparison of outcrop profiles and seismic profiles. The study shows that Yanshanian stratigraphic unconformity in the northern part of Junggar Basin mainly manifests in the angle unconformity between Xishanyao formation and Toutunhe formation, Toutunhe formation and Tugulu group, which indicates that the study area mainly experienced three important periods of unconformity: the end of Xishanyao formation in middle Jurassic, the end of Toutunhe formation and the end of Tugulu group in early Cretaceous. From the analysis of the unconformity structure and its regional distribution characteristics, it can be concluded that the most prominent Yanshanian tectonic unconformity events occurred mainly in the late Jurassic and showed the unconformity distribution characteristics of the weak compression fold deformation under the background of strike-slip uplift.

1. Introduction
Since Wenhao Weng first named the major tectonic event in the Yanshan area of north China in the middle and late Jurassic as Yanshanian movement, people’s understanding of the Mesozoic tectonics in eastern China has been deepening[1,2]. Jishun Ren believes that the Yanshan orogeny is the most profound and overwhelming tectonic movement in eastern China since the Phanerozoic. Shuwen Dong et al. considered that Yanshanian movement recorded the tectonic events of convergence and compression from the north, east and southwest to East Asia in the Jurassic, and shed new light to the nature, time limit and dynamic connotation of Yanshanian movement[3]. They defined it as the “East Asian multi-directional convergence” tectonic system originating from 165.5 Ma and its extensive inland orogeny and structural changes. Yanshanian movement was an important tectonic event not only in eastern China but also in central and western China, even in eastern Asia during the Jurassic-Cretaceous period[4].

Because of the different tectonic backgrounds of east and west China, the intensity and manifestation of Yanshan movement are obviously different. Yanshanian movement in eastern China is more intense and often accompanied by strong tectonic-magmatic activity. However, in northwestern China, Yanshanian tectonic-magmatic activity seems to be relatively weak. In the past, it is generally believed that Yanshanian tectonic-magmatic activity is a regional tectonic uplift event with relatively weak tectonic deformation. Yanshanian movement in northwest China can be divided into three stages: the middle Jurassic (early), the late Jurassic and the early Cretaceous (middle) and
the late early Cretaceous (late). The tectonic movements from late Jurassic to Cretaceous are the main period of Yanshanian movement with the strongest tectonic activities, which caused the Jurassic and pre-Jurassic strata deformation, large-scale regional uplift, denudation and strata loss, and formed many large-scale paleo-uplifts and piedmont thrust systems. More and more studies show that the middle and late Yanshanian tectonic movement is of great significance to basin evolution and mineral accumulation in northwestern China[5,6].

In this paper, the temporal and spatial distribution characteristics of Yanshanian unconformity events in the northern Junggar Basin are analyzed from the aspects of outcrop profile and seismic profile and by the methods of sedimentary stratigraphy and tectonic geology.

2. Geological background of the study area
Junggar Basin, located in the north of Xinjiang, is a superimposed basin formed from the Permian period, covering an area of about 130,000 square kilometers[7,8]. The study area is located in the northern Junggar basin, mainly includes several tectonic units, such as Wulungu depression, Luliang uplift and Kexia fault terrace belt (Figure 1). During the Mesozoic Indosinian-Yanshanian movement, the sedimentary basement of the basin was relatively flat and the tectonic activity was not very strong [1-2]. The main features of the basin are the overall uplift, the narrowing of Jurassic sedimentary range and the discontinuity of sedimentation, and the occurrence of coarse clastic deposits in the front of the orogenetic belt, so this tectonic movement was often neglected by the researchers.

![Figure 1. Tectonic units of northern Junggar basin.](image)

3. Unconformity types and identification markers

3.1. Unconformity types and significance
Unconformity refers to a dissonant stratigraphic contact relationship between the two strata in the stratigraphic sequence where there is a sedimentary discontinuity or stratum loss[9]. In tectonic geology, the unconformity is an essential basis for dividing tectonic cycles. In stratigraphy, it is very important for dividing lithostratigraphic units. It can be seen that unconformity, as one of the important styles of sedimentary strata structure, has very important geological significance. The unconformity contact relationship of strata of different grades and types reflects the tectonic events under different tectonic intensity and background.

It is generally believed that unconformity is resulted by complex causes and is controlled by sedimentation and tectonism. Sedimentation influences the shape of overlying strata and tectonism influences the underlying characteristics of the strata. According to the main controlling factors and the mechanism of unconformity, it can be divided into four categories: tectonic, sedimentary, volcanic earthquake and karst origin[10].
3.2. **Distinguishing signs of unconformity**

We can find evidence to recognize and identify unconformity from three aspects based on the origin and geological significance of unconformity: (1) evidence from the time of stratum loss, mainly including discontinuity of paleontological records and stratigraphic sedimentation discontinuity; (2) evidence from stratum erosion, including irregular topography and inconsistent structure; (3) evidence from paleocontinental surface, mainly includes paleosoils, weathering surfaces, and other petrochemical processes. Unconformity in the study area can be identified from two perspectives: outcrop and seismic profile.

Through the identification of the field geological outcrop, the shape of unconformity and the sedimentary characteristics on the contact surface could be obtained, and then we could make a comprehensive analysis of the unconformity types and tectonic significance. Strata loss or discontinuity of sedimentation in upper and lower interfaces of unconformity is the direct result of tectonic movement. On seismic profiles, we can obtain the distribution characteristics, types and attributes of unconformity structures by systematically analyzing the characteristics of seismic reflection waves and their truncation or overlap relations in the upper and lower interfaces of unconformity.

4. **Yanshanian unconformity tectonic event**

4.1. **Yanshanian unconformity revealed by outcrop profile**

According to outcrop profile and drilling data, Shuixigou group includes Badaowan and Sangonghe formation of lower Jurassic, Xishanyao formation of middle Jurassic. It mainly deposits a set of coal-bearing debris and belongs to river-flood plain and shore-shallow lake-marsh facies sedimentary formations in humid climate. The middle Jurassic Toutunhe formation and upper Jurassic Karaza formation of Shishugou group (mostly absent in the study area) are mainly composed of a set of brown-red or variegated coarse-grained sandstones. The sediments are obviously bigger and the maturity is lower than those of the early and middle Jurassic(Figure 2, 3). They belong to active sedimentary formations in relatively arid environments, indicating that the lake basin at this time is smaller than in the early and middle Jurassic. The Tugulu group of lower Cretaceous is widely distributed in the study area. Its sedimentary thickness gradually increases from the edge to the center of the basin. It is mainly composed of a set of normal-grain-sequence fine-grained clastic rocks, which indicates that the climate at this time is wetter and the lake basin become wider than before. It belongs to river-shore shallow lake facies deposits formed under relatively stable environment.

![Figure 2. Angle unconformity between lower Cretaceous and upper Jurassic in the study area.](image-url)
4.2. *Yanshanian unconformity revealed by seismic profile*

According to the seismic profile data of the study area (Figure 4), Yanshanian unconformity mainly shows that the bottom of the Toutunhe formation of the middle-upper Jurassic mostly covers the Shuixigou group of the middle-lower Jurassic in the form of low-angle truncation or overlap unconformity, and the bottom of the lower Cretaceous covers the different strata of the Shishugou group of the Jurassic in the form of low-angle truncation or overlap unconformity. They all reflect the tectonic activities in the weak extension setting and the extrusion strike-slip thrust background.

From the seismic profile of the Piedmont zone, the characteristics of Yanshanian sedimentary strata show that stable sediments cover the Piedmont fault-fold zone and the paleo-uplift in the basin, and there are different fault-fold tectonic activities around the piedmont zone (Figure 5).
4.3. Temporal and spatial distribution characteristics of Yanshanian unconformity

The temporal and spatial distribution of Yanshanian unconformity tectonic events in the northern Junggar basin mainly shows the following characteristics: the angle unconformities between the Toutunhe formation of the middle Jurassic and the underlying Xishanyao formation, the bottom of the Cretaceous stratum and its underlying Jurassic stratum. These unconformities indicate that the tectonic events may mainly occur at the end of Xishanyao formation and the end of Toutunhe formation in middle Yanshanian, and most of the tectonic belong to the weak compression deformation under the background of strike-slip uplift. According to the geolithological characteristics of the study area, the Shishugou group mainly deposits a set of brown-red gravel sandstones. The Toutunhe formation and Karaza formation of the Jurassic is largely absent due to erosion. The above characteristics reflect that the tectonic activity in the late Jurassic was strongest with the characteristics of regional uplift denudation-uplift deformation.

5. Results and discussion

The Yanshanian movement formed three regional unconformities in the northern Junggar Basin, representing three tectonic activities, the most significant of which occurred in the late Jurassic. Studies from thermochronology also show that the northern Junggar Basin experienced significant tectonic thermal events in the Middle and Late Jurassic, with a high paleogeothermal background. For example, Zhenhua Li suggested that the geothermal gradient in the mid-Yanshanian in the north of Junggar Basin is 4℃/hm[11], Wanming Yuan pointed out the tectonic uplift event of 120Ma~60Ma in the Altai area[12], and Fuwen Chen studied the Yanshanian magmatic activity and mineral accumulation in the Altai area[13]. At the same time, many other evidences indicate that there are relatively strong tectonic activities in the middle Yanshanian, such as the uplift and denudation in the strata, angle unconformity and a large number of silicified wood, which are consistent with the conclusions drawn in this paper.

6. Conclusions

The Yanshanian movement is relatively gentle in the Junggar basin, which mainly manifested as the overall uplift of the basin and the narrowing of the sedimentary range. According to field outcrop and seismic profile data, three major tectonic activities occurred in the study area during the middle-late Yanshanian tectonic movement, and three regional unconformities were formed: the unconformity between the Toutunhe formation of middle Jurassic and its underlying Xishanyao formation, the unconformity between the bottom of Cretaceous stratum and the underlying Jurassic stratum, and the unconformity between the bottom of Tertiary stratum and the Cretaceous stratum. The most obvious tectonic unconformity occurred in the middle Yanshanian of late Jurassic and shows the characteristics of regional uplift denudation-uplift deformation. More and more studies show that the middle-late
Yanshanian tectonic movement is of great significance to the structural evolution and mineral accumulation of Junggar basin.

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