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Sequence Paleogeography of the Middle Jurassic Shimengou Formation in the Yuka Area

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ABSTRACT

To investigate in detail the evolution characteristics of lithofacies and sedimentary facies belts within a sequence stratigraphic framework, the sequence stratigraphic framework of the lower member of the Shimengou Formation in the Yuka area was established based on field drilling core descriptions. Single-factor isoline maps were drawn according to systems tracts, and the lithofacies paleogeography was reconstructed.

KEYWORDS

Yuka area; Dameigou Formation; Sequence; Systems tract; Paleogeography.

1. INTRODUCTION

The Yuka area is one of the important Jurassic coal-rich belts in the Qaidam Basin, with the main coal seams developed in the Middle Jurassic Dameigou Formation [5]. Sequence stratigraphy is now widely used for sedimentary analysis of coal-bearing basins, representing the latest advancement in coal-bearing sedimentology. This paper applies sequence stratigraphy methods to conduct a lithofacies paleogeographic analysis by systems tracts for the Dameigou Formation in the Yuka area, aiming to provide theoretical reference for the study of peat accumulation and coalfield exploration in this region.

2. GEOLOGICAL SETTING

The Yuka area is located in the western part of the Yuka-Hongshan fault depression on the northern margin of the Qaidam Basin. At the beginning of the Jurassic, eastward compression from the Tarim Plate caused the Qaidam Block and the North China Plate to migrate northward at different rates. Simultaneously, the Qaidam Block underwent clockwise rotation, leading to the development of a series of fault depression sediments on the northern margin of the Qaidam Basin [1] [3] [4]. The sedimentary basement of the Yuka-Hongshan depression consists of Proterozoic Daken Daban Group biotite schist, Late Ordovician chlorite schist, Carboniferous Zongwulong Mountain Group limestone, and Late Paleozoic granodiorite. The Dameigou Formation is divided into an upper coal-bearing member and a lower sandy conglomerate member. The coal-bearing member is primarily composed of siltstone, mudstone, and thick coal seams, while the sandy conglomerate member mainly consists of medium- to coarse-grained sandstone interbedded with pebbly coarse sandstone [3] [6].

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3. IDENTIFICATION OF KEY SEQUENCE AND SYSTEMS TRACT BOUNDARIES

3.1. Sequence Boundaries

The base of the Dameigou Formation is marked by a thick bed of pebbly coarse sandstone or conglomerate. In the Yuka area, this sandy conglomerate layer mainly comprises multiple stacked, upward-fining sandstone complexes, commonly featuring erosional bases, large-scale wedge-shaped cross-bedding, or parallel bedding, representing meandering or braided river channel deposits. In the Dameigou section, it consists mainly of grey conglomerate and pebbly coarse sandstone. The gravel composition is dominated by quartz sandstone and quartzite, with poor sorting, angular to subangular shapes, and matrix- or grain-support, representing debris flow deposits on alluvial fans. Regionally, this sandy conglomerate layer is relatively stable and can serve as a regional correlation marker, representing a third-order sequence boundary.

The top boundary of the Dameigou Formation is marked by a set of white to grey-white sandstone and pebbly coarse sandstone at the base of the Shimengou Formation. In the Yuka area, it appears as thick beds with relatively loose lithology that softens upon contact with water. The composition is primarily quartz with a high content of kaolinized feldspar. In the Dameigou area, it mainly consists of gravelly channel and overbank deposits adjacent to channels, with lithology being grey-white fine conglomerate several to tens of meters thick, exhibiting large-scale wedge-shaped cross-bedding. This represents a regionally correlatable third-order sequence boundary.

3.2. Systems Tract Boundaries

The maximum regressive surface (MRS) marks the transition from regression to transgression, separating the underlying progradational sequence set from the overlying retrogradational sequence set [2]. In the Dameigou Formation sequence of the Yuka area, the maximum flooding surface is located at the base of a set of fine-grained clastic rocks, with lithofacies dominated by lacustrine mudstone, silty mudstone, and siltstone interbedded with thin layers of fluvial sandstone. The maximum flooding surface represents the end of transgression, indicating a change in the shoreline trajectory from transgression to highstand normal regression [7]. In the Dameigou Formation sequence of the Yuka area, the maximum flooding surface occurs at the base of a set of shore-shallow lacustrine mudstone and silty mudstone, forming a fining-upward succession.

4. PALEOGEOGRAPHIC CHARACTERISTICS BY SYSTEMS TRACT WITHIN THE SEQUENCE FRAMEWORK

The Dameigou Formation in the Yuka area corresponds to a complete sequence, subdivided into the Lowstand Systems Tract (LST), Transgressive Systems Tract (TST), and Highstand Systems Tract (HST). To finely study the distribution and evolution of lithofacies and sedimentary facies belts withinet the sequence framework, single-factor isoline maps were drawn for each systems tract, and the lithofacies paleogeography was reconstructed.

4.1. Lowstand Systems Tract (LST)

The LST is primarily composed of medium sandstone, fine sandstone interbedded with siltstone, mainly developing alluvial fan and braided river depositional systems. Based on drilling and seismic data, the LST is mainly developed in the Beishan area, Yangshui River, eastern Yuka, Gaxiu, and the No.2 and No.1 Wellfield exploration areas. Based on sandstone and conglomerate thickness isolines, combined with sedimentary facies and depositional system analysis, the lithofacies paleogeography of the LST was reconstructed using the "dominant facies" method. The main paleogeographic units during this depositional period include: alluvial fans, with sand-conglomerate thickness >160 m; sandy and gravelly braided rivers, with sand-conglomerate thickness between 50-160 m; meandering river channels, with thickness between 20-50 m; upper delta plain distributary channels, with thickness between 10-50 m; and lower delta plain subaqueous distributary channels, with thickness <10 m. In the Yangshui River exploration area, sandstone and conglomerate thickness decreases gradually from northwest to southeast. In the Beishan area, sand-conglomerate thickness decreases from east to west, indicating that the Daken Daban Mountains to the northwest and east of the Yuka area provided two sediment source directions. Mudstone and shale are essentially undeveloped during this depositional period.

4.2. Transgressive Systems Tract (TST)

The TST is primarily composed of grey-black siltstone, mudstone, and fine sandstone, mainly developing braided river and meandering river depositional systems. Based on drilling and seismic data, the TST is mainly developed in western and eastern Yuka, with thickness ranging from 10-110 m. The depositional center is located in the Gaxiu and Beishan exploration areas, with an average stratigraphic thickness exceeding 80 m. With the onset of transgression, the deposition expanded from south to north during this period. The lithofacies paleogeographic units along the transgression direction in the Yuka area, from proximal to distal, sequentially include: subaqueous delta - shore-shallow lake (sand/mud ratio <0.3), lower delta subaqueous interdistributary bay (sand/mud ratio 0.3-0.5), upper delta plain interdistributary bay (sand/mud ratio 0.5-0.7), meandering river floodplain (sand/mud ratio 0.7-1.0), and braided river alluvial plain (sand/mud ratio >1.0). The sediment source during this period was still mainly from the Daken Daban paleo-uplift to the north and east of the basin.

4.3. Highstand Systems Tract (HST)

The HST resulted from the maximum lacustrine transgression within this sequence, also representing the most extensive and intense lacustrine transgression during the Middle Jurassic in the study area. The sediment composition is mainly thick, upward-fining deep-water shale and oil shale. Based on the oil shale thickness isoline map, the boundary between deep lake, semi-deep lake, and shore-shallow lake facies can be distinguished. Areas with oil shale distribution are defined as deep to semi-deep lake environments, while areas without oil shale, such as the No.2 Wellfield area, are classified as shallow lake environments.

In summary, the main paleogeographic units during the Dameigou Formation depositional period include braided river alluvial plains, delta plains, and shore-shallow lakes, etc. The coal-bearing sediments are mainly delta plain deposits. The developed deltas, such as the Lvliangshan Delta and Yangshui River Delta, received sediments primarily from the Daken Daban paleo-uplift to the east and north of the basin. Delta front depositional systems developed outward from the delta plain, widely surrounding the lower delta plain. The delta front transitions basinward into a shore-shallow lake environment with relatively deeper water.

5. CONCLUSIONS

Based on sandstone and conglomerate thickness isolines, combined with sedimentary facies and depositional system analysis, the lithofacies paleogeography for each systems tract was reconstructed using the "dominant facies" method. The main lithofacies paleogeographic units of the Lowstand Systems Tract include alluvial fan deposits, sandy and gravelly braided channels, meandering channels, upper delta plain distributary channels, and lower delta plain subaqueous distributary channels. The main paleogeographic units of the Transgressive Systems Tract include meandering river floodplains, braided river alluvial plains, subaqueous delta - shore-shallow lake, lower delta subaqueous interdistributary bays, and upper delta plain interdistributary bays. The main lithofacies paleogeographic units of the Highstand Systems Tract include deep lake, semi-deep lake, and shore-shallow lake facies.

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