Early and middle Jurassic sequence stratigraphic division of M coalfield in Xinjiang

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Abstract. The coal accumulation in the M coalfield occurred in the Early-Middle Jurassic. There are three main coal-bearing strata in the M coalfield, the Early Jurassic Talicike Formation, the Yangxia Formation and the Middle Jurassic Kizilenur Formation. Based on the sequence stratigraphic division and sedimentary environment analysis of 85 Jurassic wells in the Kubai Basin, and the compilation of sequence stratigraphic correlation profiles for 20 well-connected wells, this paper comprehensively studies the drilling, logging, outcrop, core and paleontological data. This paper establishes the isochronous sequence stratigraphic correlation framework of the Jurassic in the Kubai Basin with third-order sequences as units. Finally, this paper studies the sequence stratigraphic characteristics and lithofacies paleogeography of each Jurassic sequence in the M coalfield.

Key words. The M coalfield; Sequence stratigraphy; Lithofacies paleogeography; Coal-law

1. Introduction

The M coalfield is located at the southern foot of the Tianshan Mountains in Xinjiang, and the M coalfield is located on the northern edge of the Tarim Basin. The M coalfield starts from the Muzate River in the west of Baicheng in the west and extends to the east of the Kuqa River in Kuqa County in the east. M Coalfield is 230 kilometers long from east to west, 2-6.5 kilometers wide on average from north to south, and covers an area of 1250 square kilometers. The M coalfield is distributed in a nearly east-west narrow strip. The administrative division of M coalfield is under the jurisdiction of Baicheng County and Kuqa County in Aksu Region.

The Mesozoic depression coal-bearing basin in Kuqa on the northern margin of Tarim, where the M coalfield is located, belongs to the Mesozoic Northwest-North China coal-accumulating basin. This basin is superimposed on the Late Paleozoic sea-land transitional facies sedimentary basin. This basin has been around since the Late Permian, the formation of the inland sedimentary basin, this basin has deposited a complete sedimentary sequence from the Triassic to the Neogene.

The coal accumulation in the M coalfield occurred in the Early-Middle Jurassic, and there are three main coal-bearing strata in the Early Jurassic Talicike Formation, the Yangxia Formation and the Middle Jurassic Kizilenur Formation. The sedimentary facies types of M coalfield mainly include alluvial fan, fan delta, river, lakeside delta, shoreline shallow lake, etc. The sedimentary facies are alluvial fan, fan delta, lakeside, shallow lake and semi-deep lake from the edge of the basin to the center of the basin. The process of the braided river alluvial plain before the fan turning into a swamp and the process of the lakeside turning into a swamp and the deposition of the swamp.

2. Identification principles of key interfaces

The characteristics of the sequence interface are determined by the action process of the relative sea level decline on the sedimentary interface. Different processes and depositional facies are characteristic of different depositional environments, therefore, the manifestations of sequence interface formation are different at different locations. According to the "Vail" school of thought, combined with the sedimentary characteristics of the Kubai coalfield, the author identifies each key interface mainly by the following signs:

2.1 Sequence interface identification.

The sequence interface is usually a regional unconformity surface or a channel undercut scour surface at the edge of the lake basin. The sequence interface is usually a continuous sedimentary conformity surface in the interior of the lake basin. The specific characteristics of the sequence interface are as follows:

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2.1.1 The development of the lower incised valley glutenite body.

The development of this conglomerate body is accompanied by the relative decline of the lake level, and the undercut valley formed by the backwashing of the river is a typical sign of the sequence boundary. The undercut valley filling deposits are generally characterized by superimposed thick layers and lenticular glutenites. We can associate the undercut valley deposits at the sequence boundary with the next-level layers according to the scale of the undercut valley sand bodies and their vertical superposition relationship. sequenced fluvial sandstone.

2.1.2 The depositional phase transition surface.

The transition surface of sedimentary facies is generally the transition surface in the process of lake basin water body becoming shallow and then deep, which is an important symbol for identifying sequence boundaries when there is a lack of undercut valley filling sand bodies in the lake basin or between alluvial plain channels.

2.1.3 Paleosol layer on unconformity surface.

Paleosol layers are generally formed by base exposure through pedogenesis. Paleosol is an excellent indicator for identifying sequence boundaries in the inter-channel area of alluvial plains. The paleosol layer can be identified according to the following characteristics, namely, the vertical color changes regularly; the paleosol layer gradually disappears from the bottom to the top of the sedimentary structure, and the hardness of its stratum gradually weakens; the paleosol layer has plant root fossils. Exist; there are loam-forming calcium nodules in red and purple mudstone; mud cracks and argillaceous network structure are signs of stratum exposure; paleosol layers include pseudo-anticline structures, prismatic structures, honeycomb structures in clayey mudstones specific soil structure, such as the shape structure.

2.1.4 The color and lithology abrupt change of the strata above and below the sequence interface.

If the sequence interface shown in the drill hole is gray-white gravel-bearing coarse sandstone deposited in meandering channels, mainly quartz, and below the sequence interface is gray-black siltstone and coal seams below, the coal seams are interposed with gray-black mudstone And gray-white siltstone, we can see from the sedimentary environment that they belong to the inter-distributary bay sedimentary type. This reflects a sudden change in the water level, with the lake level suddenly changing from high to low.

2.1.5 Outcrop signs.

The most direct and objective means of dividing and identifying the sequence interface is to analyze and study the macroscopic signs in the field outcrops. We use the interface types with special genetic significance, such as structural unconformity surface, large scour and erosion surface, lithological abrupt surface and maximum flooding surface, etc. We divide the sequence according to the changing law of profile structure and facies sequence. It is most important to identify unconformities of different levels and types of origin. Multiple channel scours can be seen in field outcrops, and the presence of carbonaceous mudstone and coal seams reflects the lowest sea level.

2.1.6 Identification marks of logging curves.

On the electrical measurement curve, the sequence shows a certain rhythmic superposition and regular change of the curve shape. The sequence boundary shows the sudden change of the morphological law of the curve, and the GR curve reflects the most obvious, and the value above the boundary decreases obviously, which reflects the foreproduct process. Below the interface is generally a bell-shaped combination, while above the interface is characterized by a funnel combination.

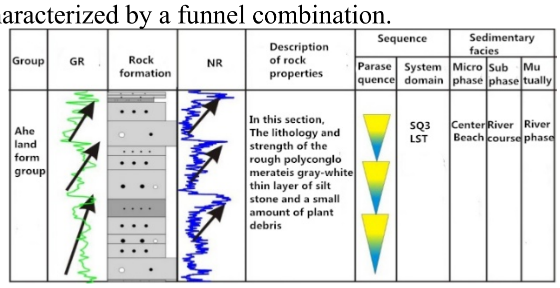

Fig. 1 Characteristics of logging mine curves in the SQ3 low-stand system tract of the Ahe landform formation

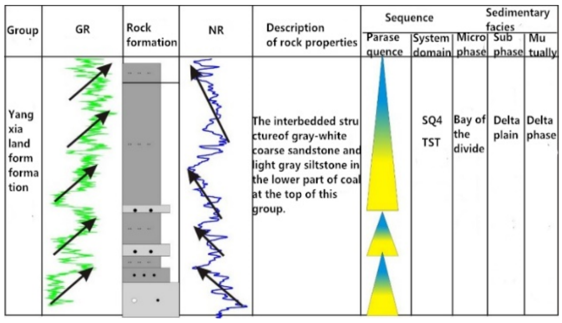

Fig. 2 Logging curve characteristics of the SQ4 lake transgressive system tract of the Yangxia landform formation

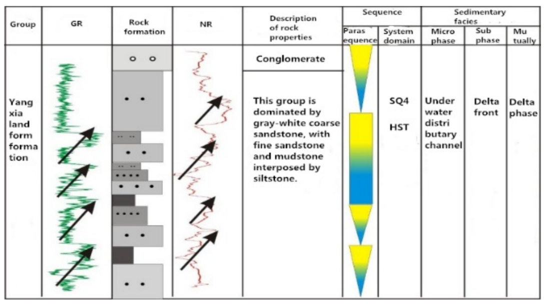

Fig. 3 Characteristics of logging mine curves in the SQ4 high-stand system tract of the Yangxia landform formation

Through the analysis of the logging curves of the coal measure strata in this area, the author draws the conclusion that the common combination types can be divided into three categories: the first is the regression combination with sudden change at the bottom and gradual upward change; the second is the gradual change at the bottom and the top The cumulative combination of sudden changes; the third is the cumulative combination of uniform changes from bottom to top. In logging profiles, most of the major sequence boundary positions demarcated by researchers are located at the bottom of abrupt bell-shaped, box-shaped or lateral accumulation curves.

2.2 Identification of the initial flooding surface

Theoretically, the initial flood surface is the flood surface formed by the first full overslope break zone or low-level undercut valley. Its identifying characteristics are as follows:

Researchers generally set the mudstone, siltstone, fine sandstone, etc. covered on the thick channel glutenite, and the bottom surface of the fine-grained rock as the initial flooding surface.

In the zone without river channel development, the initial sea flooding surface coincides with the sequence boundary, and paleosols may be relatively developed at this time.

2.3 Identification of the largest flood surface

The maximum flood surface represents the interface formed during the period of maximum continental transgression. Its identifying features are as follows:

In a set of sedimentary sequences that become thinner and deeper upward, the deepest lithofacies are littoral-shallow lacustrine mudstone and silt mudstone. When such lithologies generally appear in relatively large thicknesses, researchers Its bottom surface can be used as the location of the largest lake flooding.

If the deepest lithologic and lithofacies appear repeatedly on the section, then the bottom surface of the layer that changes upward to the thickest in thickness is the location of the largest lake flooding.

3. Sequence stratigraphic framework of the Middle and Lower Jurassic in M coalfield

3.1 Sequence stratigraphic correlation and establishment of sequence stratigraphic framework

The sequence stratigraphic correlation work of M coalfield is based on seismic data, and through detailed single profile (drilling) sequence stratigraphic analysis, the sequence stratigraphic correlation is carried out by drilling holes at different positions in the lateral direction. This kind of comparison includes: tracing and comparing the boundaries of third-order sequences; comparing the third-order sequence groups; tracing and comparing marked layers, coal seams, and sedimentary systems, etc.

The researchers established the sequence stratigraphic framework of the Middle and Lower Jurassic in the M coalfield through systematic sequence stratigraphic comparison analysis. The application of sequence stratigraphy enriches and promotes the study of coal accumulation theory, it effectively tracks the changes in the position of coal seams in sequence stratigraphy, it predicts changes in coal quality and coal facies, and it greatly improves the overall The reliability of the coal seam comparison in the coal field, which provides the basis for the prediction of coal field resources.

3.2 Sequence stratigraphic comparison method

3.2.1 Division and comparison of sequences.

Researchers establish sequence stratigraphic frameworks at the sequence level. The key to the research is the identification and comparison of the sequence interface. The identification of the sequence interface is mainly based on the unconformity surface and lithology revealed by the drilled section, the change of lithofacies, and the comparison of the stratigraphic interface depends on the surface reflector and the regional unconformity surface. The sequence interface is isochronous.

3.2.2 Division and comparison of system domains.

The researchers identified the first flooding surface and the largest flooding surface based on the phase sequence changes revealed by the borehole and outcrop profiles, and the researchers divided the system tracts that constituted the sequence. Within the same sequence, researchers make comparisons based on the genesis, characteristics, and spatial configuration of system tracts. Since the first flooding surface and the maximum flooding surface are isochronous, the same system domain bounded by them should be isochronous.

3.2.3 Division and comparison of parasequence groups.

Researchers establish the sequence stratigraphic framework of parasequence groups. The boundary of parasequence groups is formed by the sudden change of the base level. The parasequence groups correspond to the boundary of the formation stacking method of boreholes and outcrops or the stacking sequences. Deposition of ablated surfaces. The parasequence group actually delineated by the researchers is general due to the difference of identification accuracy and interface representation. The interfaces of parasequence groups are theoretically isochronous.

3.2.4 Comparison of coal and rock formations.

On the basis of the sequence interface, the first flooding plane, the maximum flooding plane, the system tract, and the parasequence group correlation, the researchers established the coal-rock correlation between parasequence groups, and the coal-rock correlation within the parasequence group was mainly based on sedimentary For the rhythm and the position of the coal seam in the sedimentary rhythm, researchers should consider the distribution law of the depositional system and depositional facies.

On the basis of the Jurassic second-order sequence in the M coalfield, the researchers further divided the coal-bearing strata into five third-order sequences.

Through the sequence stratigraphic division and sedimentary environment analysis of 85 Jurassic wells in the Kubai Basin, and the compilation of sequence stratigraphic correlation profiles for 20 well-connected wells, the researchers comprehensively studied drilling, logging, outcrops, cores and paleontology. On the basis of the data, the researchers established an isochronous sequence stratigraphic correlation framework of the Jurassic in the Kubai Basin with third-order sequences as units, as shown in Fig. 4.

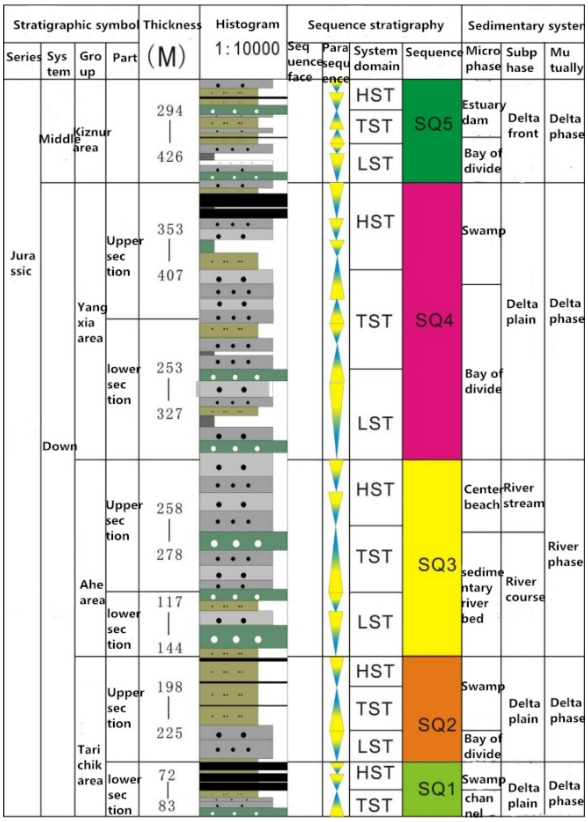

Fig. 4 Sequence division scheme of middle and lower Jurassic in M coalfield

Through the identification of two important unconformities, four local unconformities and scour surfaces, the researchers divided the Middle and Lower Jurassic of the Kubai Basin into five third-order sequences. The changes of lithology and lithofacies are subdivided into lowstand, lake transgression and highstand system tracts. The researchers divided them into 15 system tracts in total, of which SQ1 corresponds to the lower member of the Talichike Formation, and SQ2 corresponds to the upper member of the Talicik Formation, SQ3 is equivalent to Ahe group, SQ4 is equivalent to Yangxia group, SQ5 is equivalent to Kizinur group.

The top and bottom boundaries of each tertiary sequence have obvious drilling identification marks. The boundary between the lowstand system tract and the transgressive system tract is the first lake flooding, while the interface between the lake transgressive system tract and the highstand system tract is the largest lake flooding. noodle. The lowstand system tract is generally composed of delta plain, sandstone of front facies, mudstone and swamp of shallow lakes, and the transgressive system tract is generally composed of sandstone of delta front and mudstone of semi-deep lacustrine facies. It is composed of an upward thinning regression sequence, and its lake shoreline migrates landward. The highstand system tract is mainly composed of delta, shallow lake-semi-deep lake mudstone and swamp deposits, which have typical aggravation characteristics.

The internal architecture of the third-order sequence shows obvious sedimentary rhythm characteristics. The internal structure of the third-order sequence is a state in which the sedimentary grain size of sediments changes from coarse to fine and then coarse from bottom to top, and the corresponding sedimentary water depth is a process from shallow to deep and then shallow.

4. M coalfield lithofacies paleogeographical pattern

The Kuqa Basin has a unique sequence stratigraphic framework model and internal stratigraphic composition style. The lake basin during this period was flat, and the low-stand period of this period was characterized by regressive delta sediments or alluvial plains. The undercut valley is characterized by channel filling dominated by the upper braided river: due to the humid climate and sufficient water sources, when the lake level rise rate exceeds the sediment supply rate, the accommodating space increases and the lake area expands, forming a water inflow system A large area of swampy alluvial plains developed in the area, which is characterized by dark mudstone and coal seams with a small amount of channel sand deposits; at the high stage, the continuous filling of sediments led to a decrease in the accommodating space, and the bay line migrated to the lake. The starting point of the balanced river on the gulf line gradually moved towards the basin, which led to the rise of the river balance profile, forming a new accommodating space on land, and widespread alluvial plain deposits on land, such as river deposits and piedmont alluvial fans Sedimentation, and the edge of the lake basin forms a coastal sand bar.

In the early Jurassic, the area of the lake basin was further expanded, and the deposition center was located in the line from Baicheng to Kuqa. The front uplift of the lake basin area moved southward to the area north of Tarim River and south of Shaya, and its northern edge was about 20km south of Kuqa. The late Triassic tectonic activity tended to weaken. This period was dominated by river and lake sedimentation. This period was mainly meandering rivers, and most of the ancient currents were north-south. In the eastern part of the basin, there are a few east-west rivers flowing into the basin originating from the eastern uplift area. On the north and south sides of the depression, a large set of meandering river deposits developed along the piedmont of the thrust belt and the northern slope of the front uplift, which are mainly fine-grained deltas composed of sand and mudstone. The denudation highland connecting the Tianshan Mountains and the front uplift moved westward to Luntai, and small-scale braided river delta deposits developed in the adjacent highland. Braided deltas are also distributed in the Kuqa River, Kelasu River and Kapushaliang River in the northern depression, and the scale of the braided deltas is not large. There are also a small amount of fan delta deposits in the above-mentioned areas. In the early Jurassic, the sedimentary range of semi-deep lacustrine facies was further expanded, and its eastern margin reached the northwest area of Luntai.

5. Conclusion (The law and characteristics of coal accumulation in M coalfield)

5.1 Sequence architecture and distribution of thick coal seams

The accumulation of peat and carbon is mainly affected by the comprehensive effects of tectonic subsidence, water surface changes, climate, terrigenous detrital supply and redox conditions. The accumulation of peat depends largely on the preservation conditions, among which anoxic conditions are predominant, which effectively reduce the supply of oxygen at relatively high and steadily uplifted water surfaces. This situation may develop only when the climate is humid, lacks terrigenous detritus supply, the water surface rises, and there is an accommodating space that can accommodate rapid accumulation of peat deposits, especially when the growth rate of the accommodating space is roughly consistent with the rate of organic matter accumulation Widely distributed and thick coal seam. See Figure 5.

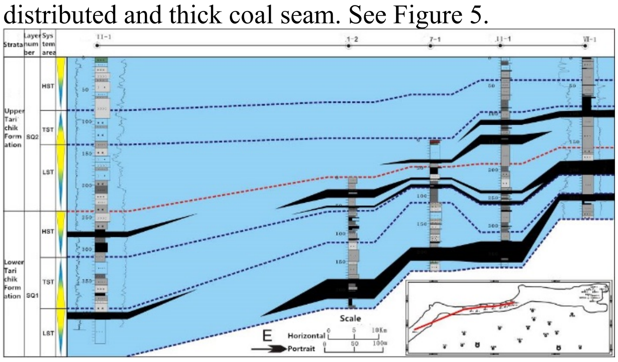

Fig. 5 Distribution structure of coal seams under the sequence framework

5.2 Distribution of main coal seams

The rate of change of lake level determines the equilibrium relationship between the rate of formation of accommodating space and the rate of peat accumulation. The area where this relationship is formed determines the geographical distribution position and plane distribution range of peat accumulation in the basin, and the distribution position of peat accumulation. And the plane distribution range determines the geographic distribution and plane distribution range of the coal seam, and at the same time, the length of time to maintain this equilibrium relationship determines the thickness of the coal seam. During the low-stand deposition period and the high-level deposition period, the falling and rising rates of the lake level were relatively low, and an equilibrium relationship between the rate of accommodating space change and the rate of peat accumulation could be formed in a large basin, and the duration of this equilibrium relationship was relatively long. However, during the depositional period of the transgressive sequence group, the lake level rose rapidly, and this equilibrium relationship was only formed in a few areas, and the duration of this equilibrium relationship was limited. This is the fundamental reason why the low- and high-stand coal seams in the study area are far better than the lacustrine transgressive sequence group coal seams in thickness and plane distribution.

References

1. Gu Jiayu. Concept and model of sequence stratigraphic framework in continental basins Petroleum Exploration and Development.Vol. 11(2019) No.23, p.21-26..
2. Feng Youliang, Zhou Haimin, Li Sitian, etc. Sequence types and tectonic characteristics of continental fault-depression basins. Geological Review, Vol.21(2018) No.53, p.78-79.
3. Zhu Xiaomin, Kang An, Wang Guiwen. Discussion on sequence stratigraphic style of continental depression and fault depression lake basins. Acta Sedimentologica Sinica, Vol. 15(2018) No.61, p.202-206.
4. hao Longyi, Zhang Pengfei. On episodic coal accumulation and research on sequence stratigraphy of coal-bearing rock series. See: Gu Jiayu et al. edited. Sequence stratigraphy and its application in oil and gas exploration and development. Beijing: Petroleum Industry Press, Vol. 33(2019) No.19, p.43-45.
5. Wu Yinye, Luo Ping, Tang Xianghua, et al. Sedimentary sequence evolution and reservoir characteristics in the Northwest Jurassic Basin. Geological Review, Vol. 67(2019) No.15, p62-63.
6. Guo Zhaojie, Zhang Zhicheng. Structural types and evolution of the Altun Basin Group. Geological Review, Vol. 7(2020) No.21 p.167-168.
7. Shao Longyi, Zhang Pengfei. On episodic coal accumulation and sequence stratigraphy research of coal-bearing rock series, academic conference paper on the application of sequence stratigraphy research in oil and gas exploration and development. Petroleum Geology Professional Committee of China Petroleum Society, Vol. 18(2020) No.29, p.22-24.
8. "Analysis of Coal Aggregation System in China". General Administration of Coal Geology of China. China University of Mining and Technology Press, Vol. 11(2019) No.57, p.101-103.