High resolution sequence stratigraphic analysis of Qingyi section in Hei-258 area

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Abstract. In order to solve the problems of unclear division of the delta front pre delta facies belt of the first member of Qing Dynasty in Hei-258 area of Daqingzijing in the south of Songliao Basin and the lack of a unified fine isochronous stratigraphic framework in the whole region, the types and genesis of the cycle interface of the first member of Qing Dynasty are summarized by using the core data of a coring well and the logging data of more than 70 wells, combined with the theory of high-resolution sequence stratigraphy and sedimentology, Establish a high-resolution sequence stratigraphic framework and summarize the control of base level cycle on sedimentary evolution. The results show that the delta front subfacies are the main subfacies in the first member of Qinghe formation in Hei-258 area, and a small amount of pre delta deposits are developed in the northeast of the study area in some periods. The types of cycle interfaces are mainly Lake flooding surface of different levels, conversion interface from progradation to retrogradation or retrogradation to progradation, lithologic catastrophe interface, etc., and the short-term cycles are classified into three categories according to the structural style. The above understanding can provide a theoretical basis for the distribution range of sedimentary facies belt and the establishment of high-resolution sequence stratigraphic framework in Daqingzijing area.

1. Introduction

The division and correlation of isochronous strata is an important basic work for the exploration and development of oil and gas fields. Daqingzijing area in the south of Songliao basin is an important oil and gas exploration area, and Qingyi member is also an important oil exploration horizon in recent two years. However, because Hei-258 area has not established a unified small-scale isochronous stratigraphic framework in the whole area, the geological understanding of sand body development, distribution law and effective reservoir distribution characteristics is not clear, It is urgent to carry out high-precision sequence stratigraphic correlation and establish a fine isochronous stratigraphic framework. Chinese scholar Deng Hongdi has confirmed that the theory of high-resolution sequence stratigraphy can be applied to the sequence division and correlation of different sedimentary environments. Scholars Miao Xiaolong, Wang Hongliang and others divided short-term base level cycles by quantifying the ratio of accommodation space to sediment supply; Li Chen and others combined Fischer diagram with wavelet transform to analyze the long-term base level cycle. This paper will use high-resolution sequence stratigraphy to divide and compare the sequence of Qingyi member in Hei-258 block in Daqingzijing area of Songliao basin from the perspective of the origin of base level cycle, analyze its evolution law, deepen the geological understanding of Qingyi member, and provide a theoretical basis for the subsequent work of oil and gas field exploration and development.

2. Regional geological background of Daqingzijing Hei-258 area in Songliao Basin

Songliao basin is located in the central part of the basin in the three eastern provinces of China, mainly Songnen Plain. The south of Songhua River is also known as the south of Songliao basin. Daqingzijing production area is located in the middle of Changling sag, the central depression in the south of Songliao Basin, and is located in the two secondary depressions of Changling sag. Hei-258 area is located in the middle and north of Changling sag and in the outer front belt of delta.

Qingyi member is located in the lower Cretaceous of Mesozoic, which is also the key research section of this paper . According to the data investigation, the Songliao Basin began to prosper in the sedimentary period of Qingyi member, the lake basin expanded strongly and transgressed rapidly, and the sedimentary environment of Daqingzijing area changed into delta front subfacies. The stratum thickness is between 100m and 120m, which is thicker in the southwest and thinner in the northeast of the study area, and the sand body is relatively developed in the south of Hei-258 area. The formation lithology is mainly composed of mudstone, silty mudstone and siltstone (locally containing calcium). The color of

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mudstone is mostly gray black, the color of silty mudstone is mostly dark gray and gray, and the color of siltstone is mostly gray.

3. Sequence boundary identification in Daqingzijing Hei-258 area

Identifying cycle boundary, also known as sequence boundary, is the basic work of high-resolution sequence stratigraphic division. The ascending and descending movement of base level makes the vertical sequence representation different, so the vertical cycle law of sequence can also deduce the ascending and descending situation of base level.

During the development of the basin, there will be two large-scale movements, namely, the rise and fall of the basin and the retreat of the basin. Therefore, the isochronous stratigraphic framework can be established by accurately identifying the cycle interface and finely dividing the isochronous stratigraphic units of Qingyi member. Based on the analysis of the core data of a coring well and the logging data of 78 wells, the base level cycle interface in Hei-258 area is comprehensively studied, and the traceable isochronous stratigraphic interface is found.

3.1 Types and causes of base level cycle interface

3.1.1 Datum level falling to rising transition surface

Conversion interface from progradation to retrogradation: when the base level changes from decline to rise and the material source supply is stable, the accommodation space reaches the minimum value in the deposition time unit, and the A / s also reaches the minimum value. For example, the top of SSC2 and SSC6 descending half cycles of well Hei-258 (Fig. 1) is the conversion interface of progradation and retrogradation.

Color mutation in mudstone section: rapid transgression occurred at the end of the first member of Qinghe formation in hei258 area. The sedimentary environment is dominated by the former delta subfacies, and a large number of mudstone is developed. The change of GR curve is not obvious. Therefore, the boundary of base level cycle is identified with the help of mudstone color mutation. For example, the base level cycle boundary of SSC14-SSC13 (Fig. 2) has a depth range of 2376.86 ~ 2378.98m, and the lithology changes from gray massive argillaceous siltstone to black horizontal bedding mudstone. The cycle boundary is divided by gray silty mudstone and black mudstone, which is also the conversion surface of the base level falling first and then rising.

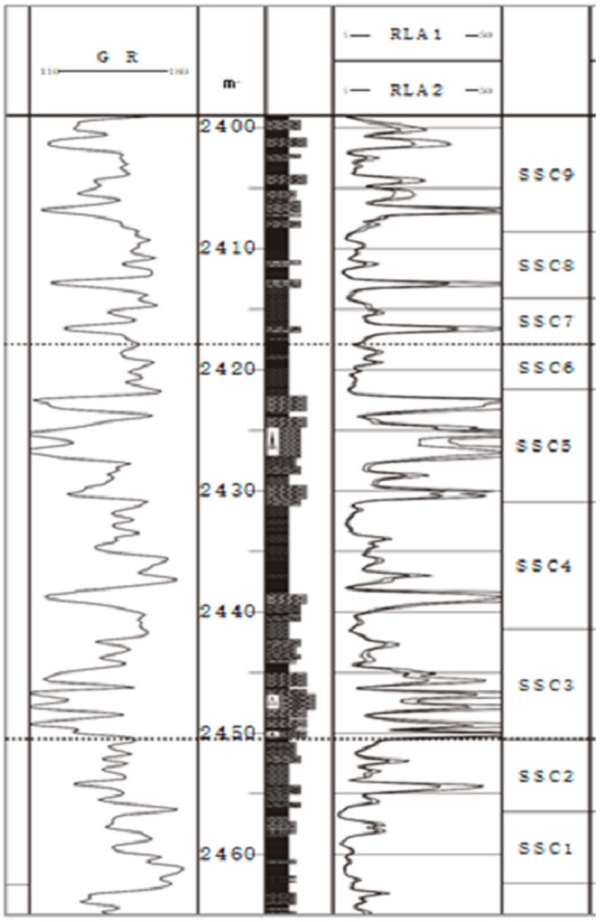

Fig. 1 Progradation retrogradation conversion surface

Fig. 2 Sudden change interface of mudstone color

3.1.2 Base level up to down conversion surface

Different levels of Lake flooding surface: it indicates that the base level reaches the highest value or local high value in this period. At this time, the accommodation space is the largest and the A / s value is the highest. Therefore, the lake flooding surface of different levels can be used as the identification mark of the cycle boundary of the base level. In the continental basin, the lake flooding surface is advancing towards the center of the basin. The stratum is thin but widely distributed. Vertically, it is mainly composed of mudstone and oil shale. The natural gamma value on logging is from low to high, and the resistivity curve is close to the baseline and straight. A total of three

lake flooding surfaces have been identified in the first member of Qinghe formation in hei258 area, which can be used as the conversion interface for dividing the base level from rising to falling. For example, the top of Qingyi section (Fig. 3) is the largest lake flooding surface in Qingyi section, which also controls the boundary of long-term cycle.

Conversion interface from retrogradation to progradation: the sequence is transformed from retrogradation superposition style to progradation superposition style. The short aggradation interface in the middle represents that the base level changes from rising to falling, with the largest A / s value and the largest accommodation space. In the sedimentary period when the lake flooding surface is less developed, the conversion interface from retrogradation to progradation can be used as the identification mark of the cycle boundary of the base level. For example, during the transition period of SSC4 ~ SSC5 of Hei-258 well (Fig. 4), the base level rotates from rising half cycle to falling half cycle, and the short aggradation interface in the middle is the local lake flooding surface in this period. At this time, the base level is the highest and the accommodation space is large, so this interface is used as the transition interface between SSC4 and SSC5.

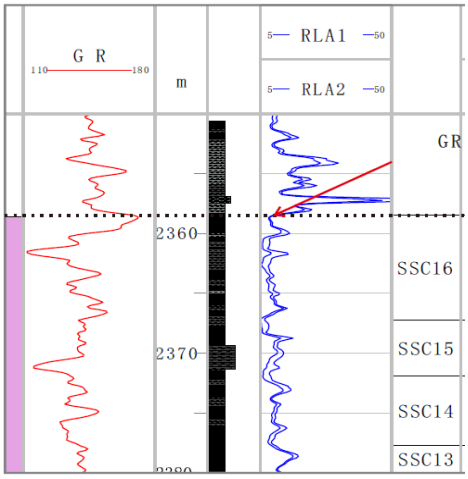

Fig. 3 Lake flooding surface identification

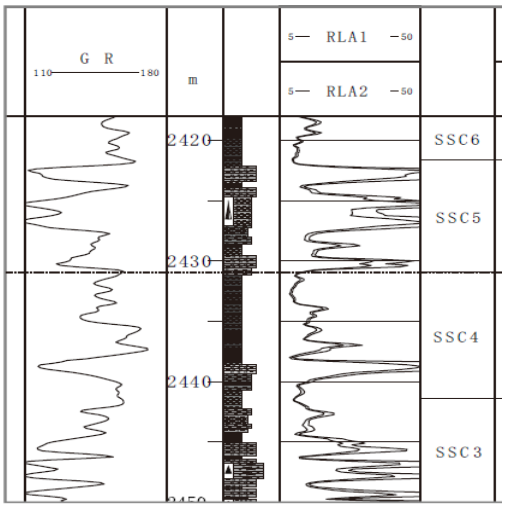

Fig. 4 Retrograde progradation conversion surface

Lithologic abrupt change surface covering the mudstone layer: it represents the sudden drop of the base level from a higher position to a lower position, which is manifested in the rapid transition of lithology from mudstone to sandstone. The obvious change of lithology in the vertical direction is a reliable basis for the short-term cycle interface. In the early stage of Qingyi formation in Hei-258 area, the water energy fluctuated, and this conversion interface is widely developed. Mudstone interlayer is developed in some underwater distributary channel sand bodies and estuarine bar sand bodies. Therefore, when the study area is divided into short-term cycles, the lithologic abrupt interface covering the mudstone section less than 3m can not be used as the identification basis of short-term cycle interface.The cycle interface of SSC8 ~ SSC9 half cycle (Fig. 5) and the thin sandstone layer at the bottom of ssc9 is stably developed in the whole area.

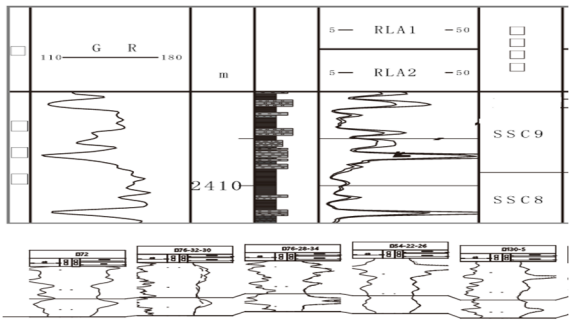

Fig. 5 Mutation interface and distribution range at the bottom of SSC9

3.1.3 Relationship between local reference isochronous interface and cycle interface

In the identification of short-term cycle interface, Lake flooding surface, conversion interface and stable mudstone layer are less developed, so it is difficult to identify, and the change of mudstone color depends too much on core data. Therefore, the detailed observation and analysis of logging curves is particularly important for identifying short-term cycle interfaces. There is a special thin rock layer caused by small-scale Lake flooding surface in Qingyi member. Its resistivity curve is mostly high value, and its characteristics are obviously different from adjacent rock layers. As a local isochronous interface, its bottom interface plays a good control role in the division of short-term cycle boundary, and its genesis is mainly the special thin rock layer developed in some front sheet sand deposits.

3.2 Short term cycle structure style

Four short-term cycle structural styles are identified in the first member of Qinghe formation in Hei-258 area, which are upward "deepening" asymmetric cycles; Upward "shallowing" asymmetric cycle; First "deeper" upward and then "shallower" upward, almost symmetrical cycle; First "shallower" upward and then "deeper" upward, which is a nearly symmetrical cycle. In the early stage of Qingyi formation, the water body oscillation is dominated by upward "shallowing" asymmetric cycle, and in the middle and late stage, it is dominated by upward

"deepening" asymmetric short-term cycle. It respectively represents the control effect of the change of A/ S ratio on the vertical formation at different positions of the base level.

3.2.1 Upward "deepening" asymmetric structure

As a typical short-term cycle type of Qingyi member, the upward "deepening" asymmetric structure represents the transformation of the base level from low value to high value, the stratigraphic sequence is eroded, the scouring interface is developed at the bottom, forming an upward half cycle, the material source supply is stable and sufficient, and the A / S ratio is less than one. It is mainly composed of the delta front estuary bar sand body in Qingyi member. The base level is in the transition stage from low value to high value. At this time, the accommodation space is small, and the sediments cannot be deposited here. Most of them are eroded, leaving only the sand body at the bottom of underwater distributary channel or estuarine bar.

3.2.2 Upward "shallowing" asymmetric structure

The short-term cycle is mainly developed in the sheet sand microfacies of delta front subfacies, which represents the transformation of base level from high value to low value, forming a descending half cycle. The sedimentation is controlled by the under compensated sedimentation with insufficient source supply and a / S ratio greater than one. The sequence top boundary is mostly sedimentary discontinuity. The main bodies of short-term cycles are mostly estuarine bars and sheet sand bodies. Due to the insufficient supply of material sources during the rise of base level or large-scale water inflow during this sedimentary period, the accommodation space gradually decreases due to the continuous decline of base level, forming a sedimentary sequence from aggradation to progradation. Vertically, the grain size of sand body becomes coarser, and the sedimentary microfacies transition from sheet sand to estuary bar.

3.2.3 Symmetrical structure

When the rising rate of base level is greater than the supply rate of material source, the increasing rate of accommodation space is greater than the sedimentation rate of sediment. Under the condition of under compensated sedimentation, the rising and falling movements of base level cycle exist at the same time (in different order). If the base level rises first and then falls, the vertical sediment particle size changes from coarse to fine and then coarse, showing a good symmetrical sedimentary sequence, and the highest position of base level is the development period of Lake flooding surface, Taking this as the boundary, the overall performance is the superposition of positive rhythm and anti rhythm, which reflects a complete water inflow and retreat base level cycle of ancient water body in the sedimentary period of Qingyi member.

4. Control of base level cycle on sedimentary evolution

The provenance direction of hei258 area is southwest, and the river pushes into the lake from southwest. The first member of Qinghe formation experienced the underwater sedimentary environment of the delta front in the early stage (SSC1 ~ SSC12), and then the transformation of the pre delta sedimentary environment in the late stage (SSC13 ~ SSC16) is controlled by the rising half cycle of the early slow uplift of the base level, and the A / S value gradually increases. When the base level reaches a high value, the base level rapidly drops below the surface, and the material supply capacity is enhanced. At this time, a large number of sediments are deposited on the basis of the original dense mudstone layer, At this time, the accommodation space and the base level cycle height reach the lowest value of the whole Qingyi section; Subsequently, the base level continued to rise and fall, and the accommodation space continued to increase to the top of Qingyi section, forming the largest lake flooding surface and developing pre delta subfacies.

At the end of the long-term base level rise and the beginning of the decline, the corresponding conversion interface is the largest lake flood surface. At this time, the accommodation space is the largest. The delta front subfacies are mainly developed in the lake, and a small amount of pre delta subfacies are developed in the northeast of the study area. The lithology is mostly underwater distributary microfacies dominated by dark mudstone. As a result of the long-term benchmark decline, the accommodation space becomes smaller, the water body becomes shallow, the hydrodynamic force becomes stronger, the ability to carry sediment becomes stronger, the sediment particle size becomes coarser, the lithofacies changes from dark mudstone to sandstone, and the sedimentary microfacies change from underwater distributary to delta front subfacies such as estuarine bar, sheet sand and underwater distributary channel. With the long-term base level rising again, the accommodation space increases again, the sediments are dominated by mudstone again, and the sedimentary environment is dominated by delta front subfacies and pre delta subfacies.

5. Conclusion

(1) Daqingzijing Hei-258 area in Songliao basin is dominated by clastic deposits. After studying the drilling and logging data of more than 70 wells in the study area, one sedimentary facies, two sedimentary subfacies and six sedimentary microfacies, namely delta facies, are identified, which are also divided into delta front subfacies and pre delta subfacies. Microfacies include: underwater distributary channel, estuarine bar, etc.

(2) According to the theory of sequence stratigraphy, three lake flooding surfaces and two cycle transition interfaces are identified in Hei-258 area. According to these cycle interfaces, Qingyi member is divided into one long-term cycle interface (lsc1), five medium-term half cycles (MSC1 ~ MSC5) and sixteen short-term half cycles (SSC1 ~ SSC16).

(3) It is concluded that the first member of Qing experienced the underwater sedimentary environment of the delta front in the early stage (SSC1 ~ SSC12), and then the pre delta sedimentary environment in the late stage (SSC13 ~ SSC16) was controlled by the early oscillation of the base level, but generally tended to decline. In SSC6 period, the base level fell to the lowest position of the first member of Qing, and the A / S value was the smallest, which was the subfacies of the delta front; During SSC13 period, the base level continued to rise, and the A / S value increased, so that it transited to the pre delta sedimentary environment.

References

1. Deng Hongwen Problems in the application of high resolution sequence stratigraphy [J] Journal of paleogeography, 2009,11 (05): 471-480
2. Sun Yu Study on high resolution sequence stratigraphy and lithologic reservoir forming law of river delta system [D] Northeast Petroleum University, 2010
3. Sun Yu, Ma Shizhong, Zhang Xiuli, et al High resolution sequence stratigraphic division and isochronous correlation of single sand body in fluvial delta system of Fuyu reservoir in North Honggang area [J] Journal of petroleum and natural gas, 2010,32 (01): 22-26 + 12
4. Miao Xiaolong, Wang Hongliang, Yu Bo, et al Research and Discussion on quantitative method of a / s value in high resolution sequence stratigraphy [J] Journal of sedimentation, 2013,31 (06): 1088-1093
5. Li Chen, fan Tailiang, Xie Weiwei Identification of long-term base level cycle by wavelet transform combined with Fischer Diagram -- Taking oil layer X of an oil field in eastern China as an example [J] Advances in geophysics, 2016,31 (05): 2116-2123
6. Liu Minghui High resolution sequence stratigraphy and subtle reservoir prediction of Qingshankou Formation in the western front [D] Beijing: China University of Geosciences, 2010
7. Liu Qingwei Study on sedimentary microfacies characteristics of Qing1 member in Daqingzijing area [J] Geophysical and geochemical calculation technology, 2013,35 (06): 690-695
8. Gao Hongbo Reservoir evaluation of hei124 block in Daqingzijing oilfield [J] Petroleum knowledge, 2019 (05): 58-59
9. Fan Chen, Li Hongliang, Wang Taiyuan High resolution sequence stratigraphic analysis of fan delta -- xingi oil formation in Block D of Liaohe Oilfield [J] Journal of Chongqing University of science and Technology (NATURAL SCIENCE EDITION), 2019,21 (04): 10-16