Analysis of sedimentary facies of the Chang 7 reservoir in Binchang area, Ordos Basin

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Abstract. The sedimentary facies characteristics has been investigated based on the core examination, logging facies analysis and seismic interpretation, Eight types of microfacies grouped into three subfacies associations are recognized in the Chang 7 reservoir. Braided delta front subfacies is rich-sand deposits comprising fine sandstones with thickness of about 10 meters. The sandstones are mainly developed in subaqueous braided distributary channel and mouth bar. Lacustrine sediments composed of mudstones, carbonaceous mudstones and shales are the powerful oil generation zone.

1. Introduction

Sedimentary facies is a mix of a particular set of lithological characteristics deposited by a separate set of energy conditions which determine the reservoir quality to a large extent [1]. This study takes the Chang 7 reservoir of Binchang area located in southwestern Ordos Basin as research area. The sandstones of the Chang 7 reservoir are characterized by massive form, good oil saturation and great lateral variation difficult to explain the distribution of sandstones.

2. Regional stratigraphic setting

During the early and middle Triassic period, the deposits of Ordos Basin were fluvial dominated, where the lacustrine deposits were limited. Continental deposition occured to Ordos Basin with complete and typical continental clastic sedimentary system affected by Indochina movement in the late Triassic period. Especially in the Yanchang depositional period, the basinal depression developed sustainably and sank stably and reached its peak stage. Then the lacustrine basin began to shrink with continuous injection and filling of fluvial deposits [2]. The Binchang area was supplied by its southern and southwestern regions in the developmental stage of the lacustrine basin.

From the onset of lacustrine transgression in the late Triassic, three main sedimentary layers were recognized. The topmost Chang 71 layer comprises dark gray mudstones interbedded with light gray silts, fine sandstones, carbonaceous mudstones and oil shales, and grades downward into Chang 72 layer, comprising mostly sandstones, with shale content decreasing with depth. The basal Chang 73 layer is made up of a large segment of dark carbonaceous mudstones, oil shales interbedded with sandstones and tuffs (Fig. 1). The oil shales of this layer are the main source bed and regional correlation marker bed with stable distribution in almost entire basin [3].

The Binchang area has slightly suffered the tectonization in the tectonic evolution, whose current structural form is relatively simple. The current tectonic feature of this area is characterized by uniclinal nose-like structure which slopes toward northwest. The nature of fault is reverse fault. The northern and central faults are relatively concentrated while the southern faults are dispersed.

3. Method of analysis

This study involves the examination and description of cores recovered from the Chang 7 reservoir section of about 10 wells, analysis of logging facies from about 30 wells and seismic interpretation of 22 two dimensional lines. The description of the cores was done based on lithology, grain size and

visible primary and secondary structures [1]. The analysis of logging facies was on the basis of the variation of the natural gamma curve, including shape, amplitude, morphology and contact relationship of top and bottom.

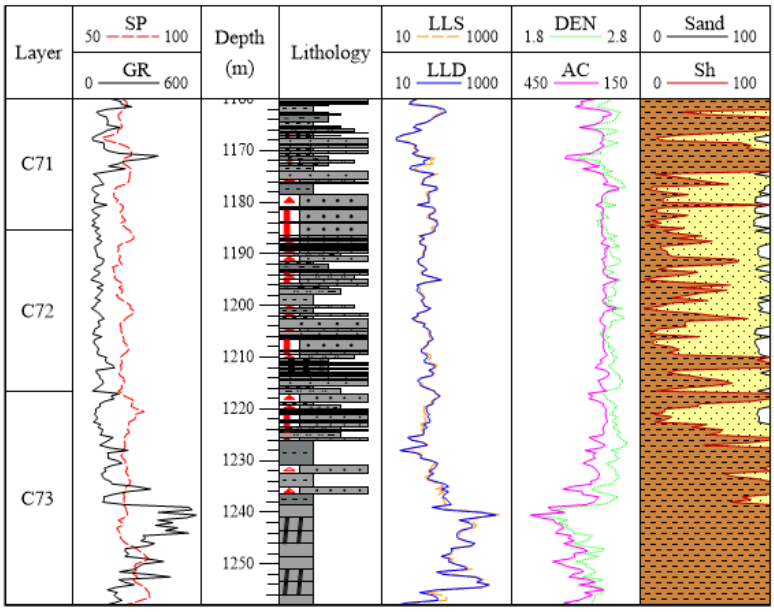

Fig. 1 Stratigraphic column of JH8 well showing the three formations of the Chang 7 reservoir in Binchang area

4. Results and discussions

Two facies associations were recognized in this area, including lacustrine facies and braided delta facies. The former is composed of both two of shore-shallow lacustrine and semi-deep to deep lacustrine subfacies, and the latter comprises braided delta front subfacies. These subfacies associations can be divided into eight types of microfacies.

4.1 Subaqueous distributary channel microfacies

Subaqueous distributary channel is the subaqueous continuation of braided channel after flowing into the lake [4]. These sediments mostly comprise fine sandstones (Fig. 2a and 2b). The common sedimentary structures include large-scale cross bedding and parallel bedding (Fig. 2c). The natural gamma logging curves range from medium value to high value with smoothly and thickly box, bell-shaped or their complex features, exhibiting abrupt or gradual contacts on the top and abrupt contacts on the bottom (Fig. 2a). Seismic sections reveal that subaqueous distributary channel is typified by continuous peak reflection with medium to high amplitude, and that neighboring upper peak is convex upwards and adjacent lower peak looks concave downwards (Fig. 2d). Frequent shifting of subaqueous braided distributary channels leads to lateral combining and vertical superimposing of positive rhythm sands. Single period channel is rare.

4.2 Subaqueous inter-distributary bay microfacies

Subaqueous inter-distributary bay deposits are retained after shifting of subaqueous distributary channels. The lithology is mainly mudstones, silty mudstones and argillaceous siltstones with a little lenticular siltstones. The sedimentary structures are mainly horizontal bedding and wavy bedding. Because subaqueous inter-distributary bay deposits are mostly thin and part of subaqueous deposits, the natural gamma curves mostly show low trough amplitude with tooth profile between two high peak amplitude.

4.3 Mouth bar microfacies

Mouth bars are in front of and at the side of subaqueous distributary channels [4]. The main lithology is fine sandstones interbedded with thin sands and shales. Fine sandstones show a distinct coarsening upward sequence with parallel bedding and middle-small cross bedding due to the winnowed effect of wave. The natural gamma curves show funnel or funnel-box complex in shape, and display medium and medium-high value in amplitude, and have slightly jagged or highly smooth

form, generally exhibiting either topmost gradual or abrupt contacts and exhibiting basal gradual contact.

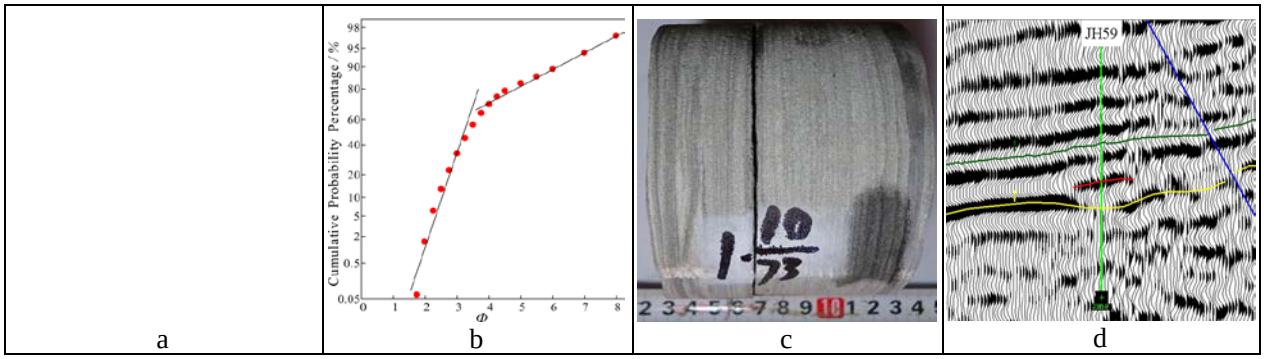

Fig. 2 Microfacies markers of subaqueous distributary channel in Binchang area
a. Lithological electric combination of Wu2 well; b. Grain size probability curve of Wu3 well in the depth of 1072.9m c. Core photos of JH41 well; d. Seismic section of line ew164.

4.4 Distal bar microfacies

Distal bars are continuous sediments, locating at the end of mouth bars. Distal bars are composed of flaggy siltstones and fine sandstones. These sandstones have the feature of laterally stable distribution and vertically thin thickness. Compared with mouth bars, distal bars have thinner sands and finer celadon lithology which is mainly silty mudstones with lenticular bedded. Sedimentary structures are characterized by horizontal bedding as well as wavy cross-bedding. The natural gamma curves are finger-like.

4.5 Frontal sheet sand microfacies

Under the condition of strong wave action, sands of pre-formed subaqueous distributary channels with mouth bars and distal bars are transformed, migrating laterally and growing confluent to form frontal sheet sands [4]. The lithology is typically flaggy siltstones and mudstones with high sorting and roundness, which have either reverse or none grain size order in vertical. The main lithology is gray mudstones interbedded with silty mudstones and calcareous tuffaceous mudstones as well as sandstones. The natural gamma curves of frontal sheet sands have jagged shape.

4.6 Shore-shallow lacustrine sand bar microfacies

Shore-shallow lacustrine sand bars, the most extensively developed deposits, are the separate sands in the lacustrine basin, which are form large sandbodies of near deltas. The strike of sand bars is parallel to the lacustrine shoreline. Sands are mostly lenticular and characterized by “sand wrapped by mud” in deposition profiles. The thickness of single sand layer is smaller generally about from 5 to 15 meters. Depositional beddings such as parallel bedding, cross-bedding, massive bedding, wave bedding and ripple lamination are well developed. The natural gamma curves looks like smooth finger.

4.7 Shore-shallow lacustrine mud microfacies

Shore-shallow lacustrine muds are the main microfacies of shore-shallow lacustrine deposition, including argillaceous and carbonaceous sediments. Argillaceous layers have horizontal bedding while silt layers have miniature wave bedding.

4.8 Semi-deep to deep lacustrine mud microfacies

Semi-deep to deep lacustrine mud microfacies is located in the deepest zone of the basin where the water is almost quiet [5]. The lithology is mainly mudstones, shales, marls and oil shales with high organic content. These sediments are fine, pure and dark gray. The deposits with laterally stable distribution and high sedimentary thickness are the powerful oil generation zone. Depositional structures such as horizontal beddings and horizontally laminated beds are well developed. The natural gamma curves show abnormity with high value. This microfacies is high peak reflection with high frequency, high amplitude and high continuity, which can be easily tracked in the whole area to become the regional comparative indicator horizon (Fig. 3).

5. Sedimentary facies association

During the depositional period of the Chang 7 reservoir, significant strengthened faulting of Binchang area and violent sinking of the entire basement resulted in the peak development stage of the basin and the huge thick mudstone deposits [2]. Regressive deposition was gradually appeared due to the rapid rise of lake level. Continuously push forward the basin lead to the fact that the delta progressively showed the deposition pattern which is from distal bars to mouth bars and subaqueous distributary channels. Each well is almost in the alternation zones between braided delta front deposits and shore-shallow lacustrine deposits, where the thickness of sandstones with poor connectivity is generally less than 10 meters.

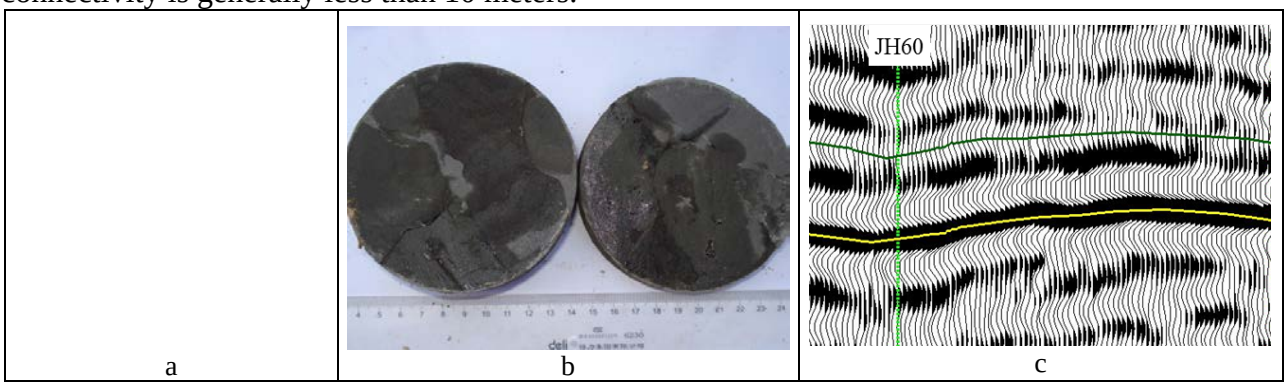

Fig. 3 Microfacies markers of semi-deep to deep lacustrine mud in Binchang area

a. Lithological electric combination of JH67 well; b. Core photo of JH60 well in the depth of 1221.8m; c. Seismic section of line sn655

6. Conclusions

Comprehensive results of core description, analysis of logging facies and seismic interpretation suggest the delineation of eight distinct types of microfacies derived from two depositional settings representing transitional delta and lacustrine deposit, respectively. The braided deposits are mainly fine sandstones with abundance of parallel and cross bedding. The lacustrine deposits mostly comprise dark gray mudstones, carbonaceous mudstones and shales which are the powerful oil generation zone. The topmost Chang 71 and Chang 72 formations is in the alternation of the braided delta front and shore-shallow lacustrine, and the thickness of sandstones is about 10 meters.

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