Application of Mesofacies Analysis Technology in Lithologic Reservoir Prediction

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Abstract: As an effective technique for exploration and development of lithologic reservoirs, curves and logging facies of several exploration wells and development wells in the facies analysis area were analyzed and sedimentary interpretation was carried out. Based on the analysis of well logs in the study area, this paper concluded that the main sedimentary facies in the study area are delta plain and fore-delta. It is concluded that the study area has experienced the sedimentary evolution process and sedimentary law of delta front, delta plain and delta front. It is pointed out that sedimentary micro-facies are the main oil and gas reservoir. Finally, the distribution and regularity of oil and gas enrichment areas are studied.

1. Introduction
At present, with the improvement of exploration degree, the proportion of proven reserves in lithologic and stratigraphic reservoirs is becoming larger and larger, and it has become the key area of current onshore oil and gas exploration. Logging facies and sedimentary facies analysis are important research methods in effective matching techniques for lithologic reservoir exploration. Seismic facies analysis and logging facies analysis, comprehensive study and interpretation of sedimentary facies are one of the most effective and important technical means for optimizing favourable zones and reservoir prediction of lithologic reservoirs. Using logging facies analysis and seismic facies analysis to comprehensively interpret sedimentary facies can greatly improve the prediction accuracy of lithologic traps, which is helpful to comprehensively understand and grasp the development and distribution law of reservoirs in the study area, and has become the most basic work in reservoir prediction. In addition, different sedimentary environments also have different logging curves, which can qualitatively reflect the stratigraphic characteristics, such as lithology, grain size, shale content changes and vertical combination, which is also the main basis for sedimentary facies analysis and reservoir analysis. Logging curve shape represents different geological significance, mainly including amplitude, shape and so on.

2. Logging curve form and sedimentary interpretation
It is a very important basic method to comprehensively interpret sedimentary facies and sedimentary environment by logging facies and seismic facies. Lithologic calibration logging, logging calibration and seismic are used to combine geological interpretation at logging site with geological interpretation on seismic surface to study the distribution of sedimentary facies and depict the distribution law of reservoirs. The hydrodynamic conditions of sedimentary environments are different, and the characteristics of sedimentary rocks or sequences formed in different sedimentary environments are different in grain size, sorting and shale content. The main basis of sedimentary facies analysis and
reservoir analysis, such as formation lithology, grain size, shale content change and vertical combination, can be reflected by logging curve shape.

2.1. Logging amplitude curve form
As an important feature of logging curve shape, the magnitude can reflect sediment changes such as grain size, sorting and shale content. As a product of high-energy environment, coarse-grained sediments have high resistivity, negative potential anomaly and low natural gamma characteristics. Besides, as a product of low energy environment, fine sediments have low resistivity and low spontaneous potential.

2.2. Logging shape curve form
Typical shapes of logging curves include box, bell, funnel, rhombus, etc., as well as their combination. Table 1 below shows a typical morphological example.

| Typical shape       | Typical examples                      |
|---------------------|---------------------------------------|
| Box shape           | Deltaic distributary channel          |
| Funnel shape        | Estuary bar deposit                   |
| Bell shape          | Point bar deposit                     |

The above shapes can be divided into smooth, dentate and micro-dentate. The smoothness of the curves is related to energy. Smoothness represents abundant provenance supply and strong hydrodynamic effect. Denaturation represents the accumulation of intermittent deposits.

3. Logging facies analysis of oil and gas reservoirs

3.1. Basic survey of the research area
The study area is a typical lithologic reservoir with a single tectonic background, small structural traps and undeveloped faults. Sedimentary environment stratigraphic sequence is complete, and there are many sets of hydrocarbon-generating strata vertically. Reservoirs in the study area have the characteristics of multi-layer system, complex reservoir physical properties and thin reservoir beds.

3.2. Logging facies analysis
Using natural gamma ray, spontaneous potential and resistivity curves, and referring to other curves, log analysis of important target intervals of wells in this study area is carried out. Based on the characteristics of the logging curves selected, it can be seen that the main shape of the study area is box, finger, bell and straight. From the regional geological data, it can be seen that the sedimentary environment is relatively stable, mainly in the deep lake, delta plain and delta front sub-facies zone.

Logging curves are mostly micro-toothed box-shaped, box-bell-shaped combinations and a small number of finger-shaped combinations. As shown in Fig. 1 below, they are box-shaped, box-bell-shaped combinations, reflecting the characteristics of normal grain order vertically, which are characterized by abundant provenance supply and stable hydrodynamic conditions, gradual weakening of hydrodynamic forces and decreasing provenance supply during the sedimentation period, which shows that this section is a river sedimentary system. Combining with seismic and lithological characteristics, box-shaped deposits are interpreted as channel or core beach, and bell-shaped and finger-shaped deposits are abandoned channel deposits left by channel diversion after flood.
4. Sedimentary facies characteristics and oil and gas accumulation law

Different from traditional logistics, intelligent logistics system starts with data, and the application of data runs through the whole process, and rises cyclically. Through reliable data source and processing technology, with the help of big data and its technology, we can design intelligent logistics system. The design and construction process of the system can be achieved through the following three steps.

4.1. Building intelligent sensor based on big data technology

Based on the analysis of logging facies and combined with geological and seismic information, it is found that the study area is a delta environment controlled by freshwater-saltwater lakes. The formation develops shallow-water deltas, which are characterized by the framework of distributary channel sand bodies, the development of delta plain and semi-deep lake facies, underwater distributary channel and distal bar sedimentary micro-facies. The natural gamma-ray curve is of medium and high amplitude, and generally decreases upwards, showing a micro-deninate shape. Spontaneous potential curves are mostly bell-shaped, and some rock sections are box-shaped. The underwater distributary channel deposits mainly consist of medium and fine sandstones with silty sand layers. The SP curves and natural gamma curves show higher negative values. The SP curves are bell-shaped, the natural gamma curves are low value box-shaped, dentate box-shaped, and the SP curves and natural gamma curves of thin sandstone sections are finger-shaped or spike-shaped.

The pre-delta sub-facies lithology is mainly composed of thick massive grey-black shale, mudstone with thin silty mudstone and argillaceous siltstone. Horizontal bedding, wavy bedding and massive bedding are developed. Logging curves are mostly low-amplitude toothed and micro-toothed. The lithology of lacustrine deposits is mainly gray thin sandstone and siltstone, with thin dark mudstone in the middle. The natural gamma curve is of medium and high value, showing dentate shape, the natural potential curve is nearly straight, the induction curve is of medium and low value, the time difference of high sound velocity and low resistance. In a word, shallow water delta is developed in formation, which is characterized by the framework of distributary channel sand body and the undeveloped estuary bar.

4.2. Distribution of sedimentary facies zone and oil and gas accumulation law

According to the analysis of logging facies and statistical analysis of logging data, combined with the sedimentary characteristics of delta facies and the law of hydrocarbon accumulation, the oil and gas in the study area are mainly concentrated in the reservoir rocks which can form lithologic traps or structural traps, such as distributary channels and underwater distributary channels, estuary bars and
distal sand bars. Oil and gas enrichment zones are mainly concentrated in the sedimentary distributary channel of delta plain and the underwater distributary channel of delta front, the contiguous zone composed of wells and a vertical southward belt in the east.

5. Conclusions
In this paper, the sedimentary characteristics of the district are analyzed by logging curve morphology analysis and single well facies analysis, and favourable reservoir zones are predicted. Reservoir prediction by logging facies in the study area is a very effective method. The favourable reservoirs in the study area are mainly developed in the distributary channel and underwater distributary channel, as well as in the estuary bar and distal sand bar. Facies analysis technology of sedimentary facies is comprehensively studied and interpreted by well logging data. Favourable facies zones of reservoirs are predicted, and those predicted by wave impedance inversion and other technical means. As an effective technical means in oil and gas exploration and development, facies analysis technology has broad prospects for development and great potential for popularization and use in the future.

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