

Classification Scheme of Lithofacies of Fine-Grained Sedimentary Rocks in Continental Depression Lacustrine Basin: Insights from the Fine-Grained Sedimentary Rocks of Chang 7 Oil-bearing Formation in Ordos Basin



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Abstract: Fine-grained sedimentary rocks are the important foundation for the study of hydrocarbon source rocks, shale oil and gas and tight oil and gas (Curtis, 2002; Bowker, 2007). In view of the varieties of mineral composition and rock types and the complexity of the rock assemblage types in the continental depression lacustrine basin fine-grained sedimentary rocks of China, the lithofacies of the fine-grained sedimentary rocks need to be classified to improve the classification system of fine-grained sedimentary rocks in the continental depression basin of China. Due to the particle size of fine-grained sedimentary rocks is small, the observation is difficult and the conditions of ultra-microscopic experiment are limited, and the lack of attention, it has been one of the weak areas of sedimentology and even geology. At the same time, different scholars have different schemes in the method of lithofacies classification of fine-grained sedimentary rocks. In this study, the lithofacies of the fine-grained sedimentary rocks of China and abroad was investigated. Then, based on the observation results of the 19 field sections of Chang 7 oil-bearing formation, the cores of 51 wells, combined with the results of thin section observation and total rock quantitative analysis, the basic characteristics of the lithofacies of fine-grained sedimentary rocks were studied in detail. Finally, the classification scheme of the lithofacies of the fine-grained sedimentary rocks of the continental depression lacustrine basin in central and western China was discussed. The construction of the classification system of fine-grained sedimentary rocks is of important significance for the geological study and exploration and development of the unconventional oil and gas in Ordos Basin.

Ordos Basin belongs to the west of North China Platform. It is a large Mesozoic-Cenozoic intracraton depression freshwater lacustrine basin that is superimposed on Paleozoic basin. The Upper Triassic Yanchang Formation is composed of fluvial-delta - lacustrine terrestrial clastic deposits, which is one of the main oil and gas-bearing formations of the basin. The depositional period of Chang 7 was the peak development stage of lacustrine basin, with a large amount of widely distributed dark mudstone interbedded by thin - middle siltstone and fine sandstone, 100-

120m thick, and distributed stability (Lu et al., 2006; Liao et al., 2013).

Through the study of 141 pieces of thin section identification and scanning analysis in Chang 7 oil-bearing formation, it is found that the mineral composition of fine-grained sedimentary rocks in the study area is quartz, feldspar, calcite, dolomite, zeolite, clinoptilolite, pyrite and clay minerals. Another data show that through XRD analysis, the content of each mineral were respectively: quartz 31.7%, feldspar 38.1%, 24.2% clay minerals, 4% calcite+dolomite, 0.8% zeolite+clinoptilolite, and 1.2% pyrite. There are some differences in mineral composition between different areas and different sedimentary environments, but the transitional lithology is the main factor, quartz+feldspar minerals accounted for certain advantages. Therefore, according to the content of debris, clay, volcanic debris and carbonate, the fine-grained sedimentary rocks were classified into siltstone, clay rock, volcanic clastic rock and carbonate rock, the four-component classification scheme of fine-grained sedimentary rocks was proposed, among which, siltstone, dark mudstone and black shale are the most developed. On the basis of the above four-component classification, comprehensive nomenclature was performed based on mineral color, individual layer thickness, texture and structure and mineral components (Table 1), namely "color+individual layer thickness+structure+(organic matter content) mineral components", in this way, the parent rock property, transportation mechanism, depositional environment, hydrocarbon generation potential could be completely and comprehensively reflected.

Based on the study of the basic characteristics of fine-grained sedimentary rocks in the depression lacustrine basin of Chang 7 oil-bearing formation in Ordos Basin, the sedimentary mechanism is analyzed and discussed. The analysis shows that: the genesis mechanisms of the fine-grained sedimentary rocks of Chang 7 oil-bearing formation in the study area is complex, including tractive current transportation sedimentation, gravity current transportation sedimentation, gravity slumping sedimentation, volcanic eruption water flow, air transportation sedimentation and chemical precipitation sedimentation. Siltstone is mainly developed in delta front and semi-deep lake-deep lake. Light-colored mudstone is mainly developed in the

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Table 1 Types and characteristics of fine-grained sedimentary rocks of Chang 7 oil-bearing formation in Ordos Basin

| Main rock types | Color | | Rock types | Developmental condition |
|---|---|---|--|-------------------------|
| siltstone argillite rock | light green, gray | siltstone light mudstone dark mudstone | middle-thin ripple (horizontal) bedding lithic feldspar (feldspathic debris) siltstone | relatively developed |
| | grey black, gray | | massive deformation bedding lithic feldspar (feldspathic debris) siltstone | developed |
| | dark gray, grey black | | thin-thick graded bedding feldspar (lithic feldspar, feldspathic quartz) siltstone | well developed |
| pyroclastic rock siltstone argillite rock | gray, grey green | black shale | massive organic-poor illite (chlorite) mudstone | developed |
| | dark gray, grey black | tuff | horizontal bedding organic-contained illite chlorite mudstone | well developed |
| | grey black, black | | graded bedding organic-contained illite chlorite mudstone | developed |
| | grey black, black | | microwave organic-rich illite chlorite shale | developed |
| | black | light mudstone | straight laminated organic-rich illite chlorite shale | well developed |
| black | dark mudstone | intermittent laminated organic-rich illite chlorite shale | developed | |
| pyroclastic rock | yellowish-white yellowish gray, grey black | black shale | ribbon crystal (vitric) tuff | developed |
| | yellowish-white, dust color, grey black | tuff | thin-massive crystal (vitric) tuff | developed |
| | | | | |
| carbonate rock | dust color, gray | limestone | limestone | relatively developed |

interdistributary bay of delta front. Dark mudstone is mainly distributed in the semi-deep lake-deep lake environment. Dark shale is mainly distributed in deep lake environment.

Key words: four-component, classification and nomenclature, fine-grained sedimentary rocks, Chang 7 oil-bearing formation, Ordos Basin

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