The Heterogeneity of Lacustrine Shale Gas Reservoir in Yanchang Formation, Xiasiwan Area, Ordos Basin

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In recent years, China shale gas exploration and practice confirmed that shale gas resources distributed in the marine facies, the marine-continental transitional facies and lacustrine facies. Three types of shale gas resources have the same resource potential and different geological conditions (Zhang Dawei, et al., 2012). Lacustrine shale influenced by local climate and provenance, since they have the geological features of rapid litho facies change, complicated lithology (Wang Xiangzeng, 2014, 2014). Leading to the parameters of the shale reservoir in space distribution inhomogeneity, How to describe the shale reservoir effective thickness and the effective area is more difficult. How to characterize the heterogeneity of lacustrine shale is one of hard problems to identify desert and evaluation reservoir. Due to the measured sample quantity is less, it is difficult to accurately describe the shale framework and the hydrocarbon fluid in it. For accurately describe the heterogeneity of lacustrine shale gas reservoir, This article take the in Yanchang formation of Xiasiwan area in ordos basin as the research object, describe the heterogeneous characteristics from the macroscopic reservoir framework, geochemical parameters, microscopic pore structure and mechanical parameters of the four aspects by the core experimental data analysis, conventional logging and special logging interpretation. The definition, classification and characterization methods of heterogeneity during the study of lacustrine shale gas reservoir were discussed in this article.

The results show that: (1) In the study area, sand-shale thin interbed series were more common developed Under the background of deep-shallow lacustrine in Mesozoic strata. This article take the principle of "fine division of strata subdivision, hierarchical description", Chang 7 shale is divided into four series unit according to the characteristics of sedimentary cycle, Thin sandy lamina and interlayer were frequent distributed in single layer of shale, when statistics the content of sand and number of sandy interlayer, frequency can be used to characterize the content and occurrence characteristics of sandy interlayer in single shale at a certain depth, Such as the statistics in 5054.43 cm long core of Chang 7 shale in YCYV1112 well, Contain 1880 sandy lamina and interlayers that accumulative total thickness of 601.13 cm, sandstone content is 11.89%, Frequency of sandy lamina is 37.2/m, thickness of single sandy lamina distribution between 0.2-2 mm, the most up to tens of centimeters thick, Sandstone development has a strong heterogeneity, Sandy lamina were common distributed at depth of 1357.78 ~ 1380.00 m in ching 7_2 shale and the depth of 1401.14 ~ 1416.71m in ching 7_4 shale, sandstone content is 11.89%, 22.4% respectively, frequency of sandy lamina is 67.8n/m, 36n/m respectively, Sandy lamina were very few distributed at depth of 1380. 00 ~ 1393.94 m and 1395.70 ~ 1401.14m in ching 7_1 shale, sandstone content is 3.19%, 2.64% respectively, frequency of sandy lamina is 18.8 n/m, 14.1 n/m respectively, Combined with gas logging data, interval that have the high density and frequency of sandy lamina also have gas logging abnormal value, The distribution of sandy lamina and interlayer improve the property of shale, provide effective space for free gas enrichment and migration and channel. Sand-shale thin interbed series in microscopic scales for three types of rhythm: Mean rhythm, compound reverse rhythm and composed rhythm(figure 1), Combined with pulse penetration test data, the permeability of the three types of rhythm with different degree of anisotropy, Horizontal permeability is higher than vertical permeability, But Close in Mean rhythm that have higher permeability and weak anisotropy, The lithological change fast in composed rhythm, shale become vertical fluid seepage barrier, the vertical permeability close to 0, The distribution of sandy lamina and interlayer improve Improve permeability, also decided the anisotropy of fluid flow, has important influence on the output mechanism of shale gas.

(2) At present, the dark shale thickness used as The main

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evaluation of shale gas reservoir parameters. The geochemical parameters of effective source rocks were adopted from arithmetic mean of the Experimental parameters, This simple practice ignored the strong heterogeneity of shale and hydrocarbon expulsion effects, Greatly affect the description precision of the shale formation, In the study area, vertical heterogeneity characteristics of the shale were caused by sedimentary evolution sequence from Chang9 to Chang7 in Mesozoic strata. Due to the less of measured data, In this paper, explore the coarsening the geochemical data to geological model in three-dimensional space by use of logging data. The key is the geochemical logging evaluation method. Practice confirmed that the $\triangle \log R$ method can identify high TOC shale section in the study area, The TOC heterogeneity of geological model could be set up by Reservoir modeling technology combination with the sedimentary background in the study area (figure 2). According to the relationship between AC and RD at different interval of YCYV1112 well (figure 3), the experimental data and single shale thickness analysis, Chang 7, shale, Chang 8 shale and the upper Chang 9 shale were source rocks that have best hydrocarbon expulsion ability in study area. Chang 7, shale, and the under Chang 9 shale have middle degree hydrocarbon expulsion, has certain hydrocarbon bearing amount, Sandy laminas was less developed in Chang 7, shale, thickness of Chang 7, shale is biggest in study area, Physical properties of Chang 7, shale is the worst, hydrocarbon bearing amount of Chang 7, shale is higher, Hydrocarbon migration in Chang 7, shale has not occurred, the hydrocarbon expulsion ability of Chang 7, shale is the weakest (figure 3), Therefore, Shale section of the heterogeneity of hydrocarbon expulsion ability in shale affects the shale gas content, Weak heterogeneity of shale, its the adsorption gas content is higher, Stronger heterogeneity of shale, its higher physical interval were more developed, and more enrichment of free gas.

(3) According the microscopic observation, the nitrogen adsorption test results and nuclear magnetic resonance (NMR) logging data, Nanoscale pores in the shale and macro pore (diameter > 50 nm) in sandy laminate are broth developed in study area, Macro pore and micro pore connectivity into complex pore network system caused by the rhythm of clastic particles, Therefore, the heterogeneity of microscopic pore structure is strong, Shale pore connectivity and clastic particles surface features were more complex, All that affect the enrichment and seepage mechanism of different phase shale gas at the condition of complex medium.

(4) Young's modulus, compressive strength, poisson's ratio and other parameters can be calculated by Shear wave logging or reconstructed Shear wave logging, all the Mechanical parameters can be used to evaluate shale reservoir anisotropy (figure 4).

The heterogeneity of shale reservoir is more complicated than conventional sandstone reservoir, Using conventional sandstone heterogeneity research methods, Consideration of geochemical and mechanical parameters, The redefined and study of the heterogeneity of lacustrine shale gas reservoir Is useful to find shale gas dessert, shale gas reservoir evaluation, perforation interval optimization and fracturing simulation.

References
Fig. 2 Calculate TOC of Chang7 to Chang 9 shale by use of $\Delta \log R$ and TOC of 3d geological model.

Fig. 3 The hydrocarbon expulsion and logging response characteristics affected by heterogeneity of Chang7 to Chang 9 shale.

Fig. 4 The heterogeneity characteristics of mechanical parameters from well logging interpretation, Chang7 shale, YCYV1133 well.