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Research on Source Rock of Hari Sag, Yin'e Basin, China

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Abstract

The formation of unconventional mudstone gas reservoirs largely depends on sufficient gas source conditions. The organic-rich mudstone in the Hari Sag is well developed, with a vertical cumulative thickness of up to 2474m. Combining the previous evaluation criteria for effective source rocks, this study selects the lower limit standards for the evaluation of effective source rocks suitable for gas sources in the Hari Sag are as follows: (1) The single layer and cumulative thickness are large, and the single layer and cumulative thickness are both ≥30 meters as the lower limit; (2) The rock color is dark, generally reaching gray , Dark gray or dark gray, black; (3) The abundance of organic matter is above medium, TOC≥0.6% and S1+S2≥2mg/g; (4)The source rock that reaches the high maturity stage, Ro≥1.3, meets the above standards Mudstone can be used as a source rock for effective gas supply. The distribution of effective source rocks in the Bayingebi Formation shows that the effective source rocks of the gas source are mainly distributed in the deep depression area in the southeast of the depression. The hydrocarbon center is located in the H1 well-YHC1 well area, and the northern hydrocarbon generation center is located in the YH6 well area. The maximum thickness of the effective source rock in the depression is about 80 meters, and the effective source rock supply area that can be used as a gas source: 111.2km^2.

Keywords

Source rock; Organic matter abundance; Source rock maturity.

1. Introduction

The accumulation of natural gas in various mudstone reservoirs of the Lower Cretaceous in the Hari Sag of the Yin'e Basin has its special geological conditions and controlling factors [1]. The rapid rifting and subsidence of the Hari Sag during the Early Cretaceous of the Cretaceous occurred during the deposition period of the Bayingebi Formation and the Yingen Formation. For the rapid and continuous development of the faulted lake basin, the lake level as a whole rise, and the lake basin area is also expanding. Most of the sedimentary period is a warm and humid freshwater environment [2]. Under the background of insufficient supply of peripheral sources and a sedimentation rate greater than the sedimentation rate, the sag is deposited with multiple sets of huge thick ash-bearing mudstone, cloud-bearing mudstone, dolomitic mudstone and tuff-bearing tuffaceous mudstone [3-5]. Sandstone is underdeveloped. This set of mudstone contains organic matter of different abundance, which is the source of mudstone oil and gas reservoirs [6]. Hydrocarbon foundation. During the later tectonic activities, diagenetic evolution and hydrocarbon generation process, various types of micropores and microfractures developed in mudstone source rocks have laid a good foundation for self-generating and self-storing natural gas reservoirs. Due to the lack of provenance supply in the deposition process, the effective sandstone drainage layer in the sag is not developed, and the sag area has little fracture communication [7]. The natural gas generated by the mudstone cannot be effectively migrated. A large amount of natural gas is only accumulated in the

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mudstone itself and a small amount of adjacent thin layers [8]. Sandstone or magmatic rock intrusions. In addition, the multi-stage magmatic rock developed in the basin can also accelerate the cracking and conversion of source rocks, making gas source conditions more sufficient, and accelerating the accumulation of natural gas in the micropores and microfractures of mudstone.

2. Distribution of Source Rock

The Lower Cretaceous source rocks of the Hari Sag are developed in the Bayingebi, Suhongtu, and Yingen formations [9]. As the depression subsides, the area generally expands. The thickness of the source rocks is controlled by the deposition center and slopes gently along the lake basin center. The lithology of the source rocks of the Yingen Formation is mainly dark gray, gray gas-bearing dolomitic mudstone or argillaceous dolomite, with a small amount of argillaceous siltstone or silty mudstone and dark mudstone. The thickness is 200m-600m, which occupies 70%-100% of the stratum thickness. The distribution area of source rocks is about 589km^2; the second member of Suhongtu Formation is one of the main hydrocarbon-generating horizons in this area. Dark mudstone is also relatively developed, with main lithology It is dark gray, gray lime mudstone, marl, dolomitic mudstone, and silty dolomite. Drilling reveals that the thickness of mudstone is between 85m-578m, accounting for 54% to 99% of the thickness of the formation. The distribution area of source rocks Approximately 573km^2; a certain source rock is also developed in the first member of the Suhongtu Formation, and its lithology is mainly dark gray, gray lime mudstone, tuffaceous mudstone, and accompanied by a large set of volcanic rocks. This section is a secondary source rock in the depression Developed strata with a thickness of 8m-170m. The second member of the Bayingebi Formation is another main source rock development section in the sag. The lithology is mainly dark gray, gray gas-bearing limestone mudstone, tuffaceous marl and silty dolomite. Drilling revealed that the thickness of dark mudstone is in Between 92m and 670m, the percentage of the formation thickness is 11.4%~73.7%. The average thickness of the dark mudstone in the deep depression area is basically greater than 300m, and the percentage of the formation is greater than 50%. The distribution area of the source rock is about 461km^2; Bayingebi Formation The first volcanic rock is also relatively developed; the thickness of the source rock is smaller than that of the second member of the Bayingebi Formation. The lithology is mainly dark gray, gray lime mudstone, tuffaceous mudstone and sandy mudstone. Drilling reveals that the thickness of the dark mudstone is between 15m and 259m. On the plane, the distribution of the Hari sag is controlled by the center of deposition and subsidence. The thickness contours of the source rock are distributed in a northeast-north-north direction as a whole, and are basically consistent with the distribution of sedimentary facies. The thickness of the sag center of each strata system is the largest. It is mainly distributed from the YHC1 well to the fault in the southeast boundary.

3. Organic Matter Abundance and Source Rock

The abundance of organic matter is an important basis for evaluating the quality of source rocks [10]. The content of organic matter depends on the sedimentary environment of the basin, source input and preservation and transformation conditions, and its hydrocarbon generation potential depends on the quantity and quality of the organic matter contained. From the perspective of geochemical indicators such as organic carbon content (TOC), chloroform bitumen "A", oil generation potential (S1+S2) in the Hari Sag, the abundance of organic matter in each source rock section of the Cretaceous is generally low, and most of them are poor-Medium organic matter abundance source rocks, but there are also medium-good source rocks developed. The Yingen Formation is the layer with the highest abundance of organic carbon

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from source rocks in the Hari Sag. Its organic carbon content is between 1.14% and 8.56%, with an average of 4.49%; chloroform pitch "A" is between 0.027% and 0.82%, with an average of 4.49% It is 0.29%; the oil generation potential is between 0.87mg/g~62.71 mg/g, and the average is 25.58% mg/g; it is good-excellent source rock; the overall organic matter abundance of Suhongtu Formation is relatively high. The carbon content is between 0.19% and 3.06%, with an average of 0.86%; the chloroform pitch "A" is between 0.002%-0.12%, with an average of 0.039%; the oil generation potential is between 0.05mg/g and 25.32mg/g The average is 4.2% mg/g, which is a poor-medium source rock; the organic carbon content of the Bayingebi Formation source rock is between 0.08% and 5.15%, with an average of 1.08%; the chloroform bitumen "A" is 0.01% -0.22%, the average is 0.15%; the oil generation potential is between 0.01mg/g~18.67 mg/g, and the average is 3.24% mg/g, which is a poor-medium source rock.

4. Type of Source Rock

The type of organic matter determines the hydrocarbon-generating ability and properties of the source rock [11]. Different types of organic matter have different hydrocarbon-generating potentials and form different products. This difference is related to the chemical composition and structure of the organic matter. Therefore, the source rock type is also determined Important factors for hydrocarbon accumulation. According to the relationship chart of the hydrogen index (IH) and the highest pyrolysis peak temperature (Tmax), the classification chart of the hydrogen index and the oxygen index of the rock pyrolysis parameters, the Lower Cretaceous source rocks in the Hari Sag are distributed from Type Ⅰ to Type Ⅲ. Deep to shallow organic matter types gradually become better. The source rocks of the Yingen Formation are dominated by type I-II1 kerogen, with good organic matter types; the source rocks of the Suhongtu Formation have a wide range of kerogen types, and types I-III are all distributed, indicating that the hydrocarbon-generating parent material is both low There are also higher plants in other aquatic organisms, which are mixed-source organic matter, and are mainly higher plants. The hydrocarbon generation is mainly partial gas; the source rocks of the Bayingebi Formation are mostly type Ⅱ2-type Ⅲ, and the parent material for hydrocarbon generation is mainly higher plants. Poor organic matter type.

5. Source Rock Maturity

Source rock maturity indicates the degree of thermal evolution from sedimentary organic matter to oil and gas conversion [12]. The degree of maturity determines the amount of oil and gas produced by the original hydrocarbon-generating material. It is an important factor in the conversion to natural gas at the maturity stage of source rock. The source rocks of the Yingen Formation in the Hari Sag are low in maturity and belong to biogenic natural gas. Causes natural gas. Draw lessons from the study of the relationship between the distribution and maturity of shale gas such as Barnett shale gas in the Fort Worth Basin and Antrim in the Michigan Basin: The main shale gas production areas are concentrated in the high-mature source rock areas with Ro ≥ 1.1%, Ro ≤ 0.6 % Of the low-mature source rock area accounts for only a small part. Similarly, the Cretaceous mudstone gas reservoirs in the Hari Sag have similar characteristics. The Yingen Formation, which is located in shallow layers (generally less than 1100 meters deep), only sees gas in drilling and logging. It is shown that the gas test results are often poor. The best gas-bearing section is only ignited and combustible, and the duration is less than 10 minutes; the mud logging of the Bayingebi Formation located in the deep layer (generally more than 2000 meters deep) generally shows good oil and gas displays. The effect is better. Under the same fracturing conditions and technological conditions, the best gas-bearing interval can reach a daily production of about 100,000 cubic meters after fracturing. Therefore, the maturity

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of the source rock controls the formation and accumulation of natural gas in mudstone. An important factor in the degree of enrichment.

From the experimental analysis of vitrinite reflectance Ro and pyrolysis peak temperature (Figure 6-2), the source rock in the upper part of the Yingen Formation in Hari Sag is basically immature, and the Tmax as a whole is less than 440℃, and the bottom of the Yingen Formation basically reaches low maturity. During the oil generation stage, the Ro at the bottom is 0.55-0.7; the source rock Ro of the Suhongtu Formation is between 0.55-1.2, and the Tmax is between 435℃ and 450℃. The exploration wells at different locations are slightly different, and they are generally low-mature. Mature hydrocarbon generation stage; Bayingebi Formation source rock Ro is distributed between 0.8-1.8, Tmax is also larger than the upper strata, most of which are distributed at 445℃-460℃, reflecting the high degree of thermal evolution and mature oil generation -Thermal cracking stage of wet gas generation; Paleozoic mudstone Tmax is basically greater than 455℃, indicating that the Paleozoic source rock is in a higher evolution stage. According to gas chromatography analysis of saturated hydrocarbons, the above analysis results can be basically confirmed by the application of alkane odd-even advantage, OEP value, CPI value, pristane/phytane, Pr/Ph and other parameters. For example, the CPI of the upper source rock of the Yingen Formation in Well YHC1 is 3.825, OEP is 2.372, and the surface source rock is immature, the bottom organic matter CPI is 2.45, OEP is 1.455, and the source rock has reached a low maturity stage; the CPI index of the Suhongtu Formation is 1.640, OEP is 1.373, and the source rock is in mature generation. Oil stage; the CPI index of the Bayingebi Formation is 0.950-1.700, OEP is 1.520-2.560, and the source rock is in the mature-high-mature stage.

In addition to the increase in maturity of the Bayingebi Formation as the main source rock section, the large number of igneous rocks developed at its bottom and at the bottom of the Suhongtu Formation is another important factor that promotes the maturity and high maturity of source rocks. The overlying strata of the main source rock of the Bayingebi Formation in the Hari Sag are generally developed with 350-meter-thick andesite, dacite, basalt and other volcanic rock strata at the bottom of Suhongtu. At the bottom of the first member of the Bayingebi Formation, there are also 193-270 meters of andesite and basalt. Andesite strata, judging from the mudstone of the Bayingebi Formation containing a large amount of tuff minerals, volcanic activity was very active in the Cretaceous Period in the Hari Sag. Evolution has an important impact. The high maturity of the Bayingebi Formation source rocks is affected by the baking, hydrogenation and catalysis of the upper and lower volcanic rocks. On the other hand, during the process of hydrocarbon expulsion, the volcanic rocks produce High temperature, high pressure driving and concentration difference also promoted the expulsion of source rocks, laying a solid material foundation for the formation of a large number of enriched mudstones to form natural gas reservoirs.

6. Conclusion

The formation of unconventional mudstone gas reservoirs largely depends on sufficient gas source conditions. The organic-rich mudstone in the Hari Sag is well developed, with a vertical cumulative thickness of up to 2474m. Combining the previous evaluation criteria for effective source rocks, this study selects the lower limit standards for the evaluation of effective source rocks suitable for gas sources in the Hari Sag are as follows: (1) The single layer and cumulative thickness are large, and the single layer and cumulative thickness are both ≥30 meters as the lower limit; (2) The rock color is dark, generally reaching gray , Dark gray or dark gray, black; (3) The abundance of organic matter is above medium, TOC≥0.6% and S1+S2≥2mg/g; (4)The source rock that reaches the high maturity stage, Ro≥1.3, meets the above standards Mudstone can be used as a source rock for effective gas supply. The distribution of effective source rocks in the Bayingebi Formation shows that the effective source rocks of the gas source are mainly

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