ISSN 2616-5872 Vol.6, Issue 1: 109-113, DOI: 10.25236/AJEE.2024.060115

Study on development characteristics and contribution of high-quality source rocks to reservoir formation in the X basin of China

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Abstract: *The main component of hydrocarbon reservoir formation is source rock, and the quality and distribution of source rock will affect oil and gas exploration and later development. If high-quality source rocks can be developed in the basin, it will have a positive effect on its development and accumulation. Taking the X basin in China as an example, this paper focuses on analyzing the development characteristics of high-quality source rocks in the basin and their contribution to reservoir formation. Various analysis methods are used to analyze the controlling factors of source rock development in different regions (salt-bearing and salt-free regions), and the oil and gas charging situation is understood by combining fluid inclusions and other methods. Finally, the following conclusions are drawn: The development conditions of high-quality source rocks are humid climate and saline water environment, and the oil inclusions in different regions of the basin can make effective contributions to the reservoir.*

Keywords: *High quality source rock; Developmental characteristics; Accumulation contribution*

1. Introduction

The development of high-quality source rocks generally needs to meet three conditions: first, rich organic matter, the higher the content of organic matter, the higher the blackness of the rock; The second is suitable preservation environment, based on suitable climate and environment, good source rock types can be developed; The third is moderate maturity. Under the influence of pyrolysis, hydrocarbon materials will be released from source rocks. At this time, the maturity can be judged according to the content of organic matter and the color of rocks.

2. A Case overview

The X basin in China belongs to continental sedimentary environment, which is mainly composed of four regions: salt, brackish water, brackish water and fresh water. Salt lake facies: the main development state in the northern part of the basin; Freshwater lacustrine facies: the main developmental state in the southern part of the basin. By surveying the geology, the explorers found that the distribution of oil resources was uneven, with more resources in the north than in the south.

3. Development characteristics of high-quality source rocks in the X basin of China

3.1. Overview of source rocks

As the mother source of oil and natural gas, source rock plays an important role in oil and gas geological research and exploration.[1] The development of continental oil and gas exploration not only changes the content of source rock research, but also changes the research from macro to micro and qualitative description to quantitative characterization. According to the existing literature analysis, the research results mainly present the features of different plates: first, the tectonic background of the ancient lake basin in China; Second, the actual types of ancient lakes; Third, the features of paleontological groups. Facial features can show the law of hydrocarbon formation of organic matter, and can also be the basis of scientific and reasonable evaluation, so as to reflect the development of

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source rocks.[2]

3.2. The development principle of high-quality source rocks

In the process of source rock development, productivity and preservation environment will have a certain impact on it, and high-quality source rock can be developed only when both are in good condition.[3] Anoxic environment is the best environment for the preservation of organic matter. There are two ways to create such an environment in lake water: First, under the influence of salinity and temperature, the density of lake water changes, and then a thermocline (halocline and thermocline) will be formed in this area; Second, as the deposition rate increases, organic matter will consume a large amount of oxygen during degradation, thus forming such an environment.

3.3. Study on genetic accumulation of high-quality source rocks

Research on hydrocarbon generation in different areas (saline and non-saline) of the basin is carried out to analyze the main controlling factors of differential development of source rocks. Hydrocarbon formation can be divided into three stages: first, hydrocarbon generation; Second, migration; Third, storage. To study the genetic accumulation of high-quality source rocks, we can start from these three stages to analyze the specific influence of source rock quality on oil and gas accumulation.

The differences and development mechanisms of hydrocarbon generation potential of source rocks in different regions are summarized as follows:

(1) According to the basic attribute index of the source rock, the hydrocarbon potential is further explored. Basic attribute index: first, organic matter type; Second, abundance of organic matter; Third, maturity of organic matter. Combined with logging data and geochemical values, a comprehensive geochemical profile of the source rock in a single well is constructed to comprehensively study the vertical and horizontal distribution characteristics of the source rock.

(2) Using GC/MS technology, the molecular geochemical characteristics of source rocks in different regions are studied in detail.

(3) To construct the development model of high-quality source rocks, the main construction basis is as follows: first, mineral composition; Second, main trace elements; Third, molecular geochemistry restores the source rock development environment in different regions.

Genetic accumulation of high-quality source rocks:

(1) According to the above research methods, two sets of values are obtained: the measured values of source rock geochemistry; Well log data prediction value. Combined with the data analysis, we can see that there are 3 medium-good hydrocarbon source layers in this region, which belong to the main layer sources in the region.

(2) high-quality source rock formation environment: First, the climate is humid; Second, the type of water body is saline. This type of environment can reproduce a large number of algae, but also can occur in a relatively short time of algae death phenomenon, so it can provide rich organic matter and be well preserved. Preservation environment: oxygen-poor environment or anoxic environment, which can form high-quality source rocks. By comparing the development difference of source rocks in North and south regions, it can be found that the development patterns of the two regions have different characteristics. Among them, the undulation deep-water-environment control model is the northern region development model. The source rocks in this area are easily affected by water environment. The control type of student origin was the southern developmental model. The study shows that the source rocks in this area are susceptible to the influence of biogenic input.

(3) The composition of crude oil molecular markers was analyzed, and the main test method was gas chromatography-mass spectrometry. Test results: The composition of special molecular markers of crude oil in different regions (salt and no salt zones) is different: First, the content of long chain tricyclic terpenes in crude oil in salt zone is rich, while the content of this substance in no salt zone is decreasing. This means that algae are growing well in the saline environment; Second, both regions contain the same substances, such as the methylsterane series and the C30 dinosterane series. It can be seen that the mutual contains dinoflagellates and other substances; Third, the crude oil in the salt area is rich in short-chain aromatic isoprene, which shows that the environment of the basin is anoxic, which controls the development of source rocks. However, there is no such material in the salt-free area, and the basic reason for the low productivity may be the depositional environment of the hypoxic-free transparent layer.

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(4) According to the genetic types of crude oil, the oil migration tracer parameters are optimized. Parameters: ①Nitrogen content; ② Containing sulfur; ③ Oxygen-containing compounds. After studying and analyzing the parameters of the three types of substances, it is concluded that the main parameter of the migration fractionation effect is the third type of substances.

3.4. Exploration experiment

3.4.1. Sample collection

Source rock and crude oil were the main samples collected. Sample information can be seen in Table 1.

Table 1: Information of experimental samples

The sample type	The pound number	Sample number
Source rock	Ma 11-16, Ma 11-7, Ma 15, Pu 115, Pu 63, Pu 6-33, Pu Shen 18-1, Pu Shen 7, Pu Shen 8, Qianshen 2, Tang 8, Wei 146, Wei 20, Wei 69, Wei 79-13, Wei 79-8, Wen 149, Wen 164, Wen 177, Wen 201, Wen 248, Wen 33-105, Wen 96, Xu 10 Xu 14-14	43
Crude oil	Hu 10-10, Hu 12-158, Hu 12-173, Hu 39-12, Hu 39-20, Hu 5-125, Hu 5-247, Hu 68-2, Qing 12, Qing 25-10, Qing 28-3, Qing 5, Qing 6-11, Qing 67, Qing 6 side, Qing 85-21, Qing 92-1, Qing 98-5, Wen 101-48, Wen 1 01-5, 138-42, 142, 164, 179-33, 181-3, 192, 197, 203-58, 220-12, 38-84, 79-60, Xinqing 29	52

According to the industry standard, the source rock chloroform asphalt powder sample was extracted for 3d. The asphaltene was filtered by precipitation after obtaining chloroform asphalt. The main substance used is n-hexane. Using the "silica gel + alumina" chromatographic column to separate the residual material composition, to obtain the hydrocarbon, aromatic and non-hydrocarbon composition. Obtained substances: ①n-hexane; ②"n-hexane + dichloromethane" mixed solvent, in which the n-hexane content is 7, dichloromethane content is 3; ③"dichloromethane + methanol" mixed solvent, in which the dichloromethane content is 95, the methanol content is 5.

The analysis method is as follows:

(1) Rock pyrolysis and TOC analysis method. The rock sample is cleaned with a methanol solution and ground into a powder in a dry environment. The instrument was used to carry out TOC analysis, and the air inside the instrument was removed before pyrolysis and heated to 600℃ for combustion. Timely recording of rock information: ①free hydrocarbon content; ②amount of pyrolyzed hydrocarbon; ③ Maximum temperature.

(2) Whole oil chromatography method. Sample extraction with the aid of the instrument: First take out 80 ~ 100g oil sand sample, and crush it in the dry state. After the diameter reaches 0.5 ~ 1.5cm, it can be soaked in medicine. Drugs: methylene chloride; Soaking time: 2d. In this way, free oil and gas components can be obtained. The remaining sample particles can be soaked with tetrahydrofuran-dichloromethane-methanol drug for 2d. Adsorbed hydrocarbon can be obtained after soaking.

3.5. Hydrocarbon generation potential evaluation of source rocks

After the experiment, the hydrocarbon generation potential of source rocks in the basin was evaluated. After evaluation, it is concluded that the abundance of organic matter in the salt-free area is low, but the abundance of organic matter in the source rocks in some strata is high, and the hydrocarbon generation potential is good. In addition to evaluating the abundance of organic matter in source rocks, it is also necessary to master the maturity of organic matter. The degree of thermal evolution of organic matter can be studied and analyzed by means of vitrinite reflectance index. The organic matter maturity of a large number of samples in the experiment is at the stage of Ro greater than 0.7%, which indicates that the restriction factor of hydrocarbon generation in source rocks is not organic matter maturity.

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4. Contribution of high-quality source rocks to reservoir formation in the X basin of China

4.1. Reservoir extraction formation

High-quality source rocks have two characteristics: first, good porosity; Second, high permeability. Based on these two characteristics, migration and storage are more convenient. Therefore, when judging the properties of high-quality source rock reservoirs, we can analyze them according to their characteristics. The reservoir oil and gas in this basin can be divided into two forms: one is mobile oil and gas; The other form is immobile oil and gas. Generally, the extracted crude oil represents the flow pattern, and there are differences in the extract and material composition under this pattern. The main reason for the change of hydrocarbon injection composition is the difference of composition factors, which include crude oil, reservoir extracts and hydrocarbon inclusions.

Division of reservoir hydrocarbon composition: First, mobile hydrocarbons. It mainly refers to the hydrocarbons between open pores and intergranular pores, which can realize free migration and change after mixing with external oil and gas. Second, bound hydrocarbons. This type of hydrocarbon mainly consists of mineral phase and postal phase. Third, hydrocarbon inclusions. The composition of such hydrocarbons can be unchanged, and the hydrocarbons captured in the diagenetic process can be isolated from the outside world, so it is not easy to change.

4.2. West Slope oil and gas accumulation

Combined with the structural relationship between different materials, the history of hydrocarbon migration and charging is reconstructed. Substances are mainly divided into two types: First, fluid encapsulation characteristics; Second, diagenetic minerals. By the method of fiber fluorescence observation, it can be seen that the inclusions in different areas of the basin have different shapes, such as oval shape and long rod shape. The presentation of inclusions: one is the state of "liquid hydrocarbon + brine", the color is white and blue; The second is the "salt water" state, the color is yellow.

Hydrocarbon inclusions can be found in the first step zone at different Wells. After exploration, it is found that the cracks of perforated quartz particles exist in this material, which shows the gas-liquid two-phase state. Fluorescent color can be divided into two kinds: one is yellow; The other is blue-white. According to the fluorescence color, the number of hydrocarbon filling history and hydrocarbon maturity of inclusion were determined, and the study showed that the former number was 2 times. The latter is at a high stage.

In the second step zone, it can be found that the hydrocarbon inclusion state of the reservoir in the well belongs to the gas-liquid phase, and the hydrocarbon charging history in this area can be judged and identified according to the fluorescence color. Results: There may be more than 2 hydrocarbon charging histories. In addition, it is found that the hydrocarbon inclusions have different particle fissures in the reservoir: first, quartz particle fissures; Second, through the cracks of quartz particles. Fluorescent colors can be divided into three kinds, yellow, red and blue and white, in which yellow is the main. The color indicates that the hydrocarbon maturity is medium. Hydrocarbon charging: 1 time. There is also a lot of asphalt in this area, and the material does not emit light under fluorescence irradiation. According to this phenomenon, the asphalt is presumed to be the product after the destruction of hydrocarbons. It can be found that more than two hydrocarbon charging phenomena have occurred in the step belt in the basin.

The contents of hydrocarbon accumulation and fluid evolution are as follows:

(1)The hydrocarbon charging history of Es3 reservoir in a step area in this basin is two periods. Charging temperature: ①120 ~ 130℃; ②140 ~ 150℃. The reservoir-forming time was calculated by using the method of burial history-thermal history projection point: ①19 ~ 10Ma; ②6 ~ 3Ma. The average pressure coefficient of oil inclusions in this area is obtained based on the results of paleo-pressure reconstruction, and its value is 1.51. The measured reservoir pressure coefficient is 1.54. It can be seen that oil inclusions can make effective contributions to the reservoir.

(2)The hydrocarbon charging history of Es3 reservoir in another step area also has two periods. Charging temperature: ①90 ~ 110℃; ②110 ~ 120℃. Using the above calculation method, the accumulation time is calculated as follows: ①30 ~ 25Ma; ②3Ma. The temperature of CO2 and CH4 is usually 117 ~ 90℃. 28 ~ 24Ma is the fluid charging time. Combined with the pressure reconstruction results, the number of crude oil filling in the region is analyzed, and the average pressure coefficient is 1.26, which belongs to overpressure. During the 24Ma fluid charging time, CO2 and CH4 changed, and

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the formation uplifted, destroyed the internal crude oil in the step area, and then formed the reservoir asphalt and other materials. After the pressure coefficient was affected, its original value showed a decreasing trend. The coefficient value is basically maintained between 1.06 and 1.17, and the pressure value belongs to the weak overpressure state. After the deposition and burial of the inner layer, the source rocks matured gradually. After the completion of the second hydrocarbon charge, if the pressure coefficient value needs to be tested, it should be completed after the formation of the reservoir, and the value measured in this state is more accurate. After testing, it is found that the pressure value is 1.06, and the pressure coefficient value belongs to the normal pressure state.

(3) Fluid filling pores are found in the second step reservoir, with a large number of pores. The fracture asphalt maturity value of these pores ranges from 0.67% to 1.04%, and the basic average value is 0.91%. The main reason of bitumen pores is that the reservoir is easily oxidized when exposed to air, and oxidation occurs in superficial layer.

5. Conclusions

Based on the research and analysis of the development and accumulation contribution of high-quality source rocks in the X basin in China, we can see that the main conditions for the formation of high-quality source rocks in this region are climate and environment, in which the climate is humid and the environment is saline water environment. As for its contribution to reservoir formation, the oil inclusions in the region can make effective contributions to the reservoir. The hydrocarbon generation potential and development mechanism of source rocks in different regions are different, so it is necessary to build a good preservation environment according to the development mechanism of source rocks in the region to ensure the continuous generation of high-quality source rocks in the region.

References

[1] Yang Zhi, Zou Caineng, Wu Songtao, Pan Songqi, Li Jiarui, Jiang Wenqi, Wang Xiaoni.(2022). Cracking to produce hydrocarbons or modifying to produce hydrocarbons? -- On reservoir properties and source rock properties of oil-gas source rock series. Acta Geologica Sinica (01), 183-194.
[2] Liu W. (2020). Research on Formation mechanism and development model of high-quality lacustrine source rocks in Bozhong Depression, Doctoral dissertation, Yangtze University.
[3] Li Yao, Xie Rujie, Huang An, Cao Yongqiang. (2022). Identification and distribution characteristics of high-quality source rocks in Western Sichuan Depression. Journal of Chongqing University of Science and Technology (Natural Science Edition), (03), 9-13.