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Characteristics and Sensitivity of Tight Sandstone Reservoir in Q Area of the Southeast Edge of Ordos Basin

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Abstract

Taking Chang 6 reservoir in Q area of the southeast edge of Ordos basin as an example, the basic characteristics of the reservoir are studied from three aspects of reservoir physical properties, petrological characteristics and pore throat structure characteristics by means of X-ray diffraction, section analysis and identification, and the sensitivity and main control factors of the tight sand reservoir in the study area are studied and analyzed by water drive experiment. The results show that the lithology of Chang 6 tight sandstone reservoir in Q area of the southeast edge of Ordos basin is mainly feldspathic sandstone, and the grain size is mainly fine sand. The physical property of the reservoir is poor. The pore types of the reservoir are mainly intergranular pores and feldspar dissolved pores. The main throat types are flaky, curved and necked, and the throat connectivity is poor. Based on the physical properties, pore type and capillary pressure curve characteristics, the Chang 6 reservoir in Q area is divided into three types, of which, Type I reservoir is the reservoir with the best reservoir capacity and seepage capacity in this area. The reservoir in the study area is characterized by medium to weak velocity sensitivity, medium water sensitivity, weak to medium to weak salt sensitivity, medium to strong acid sensitivity and weak alkali sensitivity.

Keywords

Tight sand reservoir, reservoir characteristics, sensitivity study

1. Introduction

The development of oil and gas fields will be affected by various factors, which will lead to changes in the porosity and permeability of the reservoir, and also have a negative effect on the productivity of the reservoir and the properties of the reservoir itself. For low permeability reservoirs or even ultra-low permeability reservoirs, the nature of their reservoirs is very different from that of conventional reservoirs, and the damage degree of the reservoirs is particularly serious [1]. Therefore, it is particularly important to study the sensitivity of low permeability reservoirs, and it is also of great economic and practical significance for the development and utilization of low permeability reservoir oilfields. Taking Chang 6 reservoir in Q area of Ordos Basin as an example, this paper studies the reservoir characteristics through section observation, X-ray diffraction, scanning electron microscope, high-pressure mercury injection and other methods, and combines sensitivity experiments to evaluate the sensitivity of tight reservoirs of the study area.

2. Basic characteristics of reservoir

2.1 Petrological characteristics

According to the statistics and observation of cast thin sections of Chang 6 reservoir in Q area, the lithology of the study area is mainly feldspathic sandstone, with fine sand as the main particle size, followed by medium sand. The clastic composition is mainly feldspar, followed by quartz, and rock debris is the least. Among them, the rock debris is mainly composed of magmatic rock debris and metamorphic rock debris, and sedimentary rock debris is less. Clay minerals and carbonate cements constitute the main types of interstitial materials, with an average volume fraction of 7.8%.

2.2 Physical characteristics

Based on the analysis of the measured physical property data of Chang6 reservoir in the study area, the porosity of Chang6 reservoir in the study area is 1.78%~12.9%, with an average of 8.3%; Permeability value is distributed between 0.01~2.66 × 10^{-3}μm^2, average 0.40 × 10^{-3}μm^2, it is considered that the physical properties of Chang 6 reservoir in the study area are quite different.

2.3 Pore throat structure characteristics

2.3.1 Pore type

According to the observation of casting thin section of Chang 6 reservoir in the study area, the pore types of tight sandstone reservoir in Chang 6 member in Q area are mainly intergranular pore and feldspar dissolution pore, and the pore combination types are mainly primary pore-dissolution pore and residual intergranular pore.

(1) The intergranular pore refers to the primary pore of the particles in the rock, which is the main pore type in the study area. The volume fraction is 1.0%~7.15%, and the average volume fraction is 4.5%, accounting for about 60% of the total pore. The intergranular pore plays a particularly prominent role in improving the permeability of the reservoir in this area.

(2) Feldspar dissolved pores are secondary pores formed by the dissolution of minerals or soluble parts between clastic particles. Feldspar dissolved pore is an important pore type in the study area, which also plays a positive role in improving the seepage capacity. The volume fraction is 0.9%~3.1%, and the average volume fraction is 1.6%, accounting for about 21% of the total porosity.

(3) Some areas in the study area develop microfractures, which are important storage space and migration channels for fluid in tight sandstone reservoirs. The average volume fraction of microfractures in the study area is 0.5%, accounting for about 7% of the total porosity.

2.3.2 Throat type

There are two types of throat in the study area: sheet or bent sheet throat and necking throat. Sheet or bent sheet throats are mainly composed of sandstone particles which are closely arranged by compaction and pressure dissolution during diagenesis. The pore space is greatly reduced, and the particles are in line contact and concave-convex contact, forming sheet or bent sheet throats. When the particles are closely arranged or the cement is annular cemented, the throat is relatively narrow, and the throat formed is necking throat. The coordination number of the two types of throat in the study area is low, mostly 1-2, and the connectivity of the throat is poor.

2.3.3 Reservoir classification and evaluation

Different petrological characteristics, physical properties and percolation mechanism can reflect different sedimentary environments of the reservoir. Therefore, we take physical properties, pore type, capillary pressure curve and other parameters as reference factors to divide the Chang 6 reservoir in Q area of to three types: I, II and III.

Type I reservoir is the most common in the study area. The porosity of Type I reservoir is between 5.7% and 9.6%, and the average porosity is 7.9%; Permeability between 0.025 × 10^{-3}~0.381 × 10^{-3}μm^2, the average value is 0.176 × 10^{-3}μm^2; The middle flat section of the capillary pressure curve is long and inclined to the lower left , the displacement pressure is the lowest (average 0.39MPa), there are many large pore throats (average skewness coefficient 0.727), the sorting property is good (average sorting coefficient 1.235), and the final mercury saturation is high (average 87.47%). Type I reservoir is the reservoir with the best reservoir capacity and percolation capacity in this area.

Type II reservoirs are common in the study area. The porosity of Type II reservoirs is between 2.2% and 10.4%, and the average porosity is 5.5%; Permeability between 0.005×10^{-3}~$0.097 \times 10^{-3}\mu m^2$, the average value is $0.040 \times 10^{-3}\mu m^2$; The flat section in the middle of the capillary pressure curve is short and inclined to the upper right , the displacement pressure is medium (3.48MPa on average), there are many large pore throats (1.040 on average), the sorting property is medium (1.031 on average), and the final mercury saturation is high (65.19% on average). Type II reservoir is a reservoir with large pores and small pores coexisting, and it is the reservoir with the second best reservoir capacity and seepage capacity in this area.

Type III reservoir is relatively rare in the study area. The porosity of Type III reservoir is between 3.9% and 0.7%, with an average porosity of 6.7%; Permeability between 0.009×10^{-3}~$0.66 \times 10^{-3}\mu m^2$, the average value is $0.183 \times 10^{-3}\mu m^2$; The flat section in the middle of the capillary pressure curve is short and inclined to the upper right , with the largest displacement pressure (10.41MPa on average), less large pore throats (-0.897 on average), poor sorting (0.998 on average), and low final mercury saturation (24.77% on average). Type III reservoir has small pore throat and poor reservoir capacity and seepage capacity.

3. Reservoir sensitivity evaluation

When the foreign fluid that does not match or match with its own reservoir fluid enters the reservoir, because its chemical and physical properties are inconsistent with the original fluid in the original reservoir, the mineral and pore structure in the reservoir will be changed, thus causing damage to the reservoir. Therefore, the sensitivity of the reservoir should be studied. 80 samples of Chang 6 reservoir in the study area were classified for reservoir sensitivity test, and the sensitivity of tight reservoir was studied [2-5].

3.1 Velocity sensitivity characteristics

Reservoir velocity sensitivity refers to that when the fluid velocity in the reservoir changes, the particles in the reservoir will be transported and moved, and bridge plug will be formed at the small pore throat, thus reducing the permeability of the reservoir [6-8]. In this study, salt water is used to simulate formation water, and 16 groups of samples of Chang 6 reservoir in the study area are evaluated for reservoir velocity sensitivity, with the purpose of determining the critical velocity of the reservoir and calculating the damage rate of the reservoir, so as to provide scientific and reasonable theoretical basis for determining the displacement velocity in the process of water flooding in this block in the future. The distribution range of velocity sensitive index of Chang 6 reservoir is 0.20~0.49, with an average of 0.34, so the reservoir has medium to weak velocity sensitivity [9].

3.2 Water sensitivity characteristics

The water sensitivity of the reservoir means that when the reservoir enters a fluid that does not match or match with its own reservoir fluid, its chemical and physical properties are inconsistent with the original fluid in the original reservoir, which will cause the hydration and expansion of the clay minerals in the reservoir, and form a bridge at the pore throat, thus reducing the permeability of the reservoir. We injected formation water and non-ionic water (distilled water) into the core at a speed below the critical flow rate to determine the water sensitive index of the reservoir [10-12]. The damage rate of ionic water in Chang 6 reservoir in the study area is 0.24~0.59, with an average of 0.44, which is generally medium to weak water sensitivity.

3.3 Salt sensitivity characteristics

The salt sensitivity of the reservoir refers to that when the salt water that does not match or match the reservoir fluid enters the reservoir, because its salinity is inconsistent with the original salinity in the original reservoir, the clay minerals in the reservoir will undergo hydration and expansion, and as the fluid migrates, a bridge will be formed at the small pore throat, thus reducing the permeability of the reservoir. The main reason for the salt sensitivity of the reservoir is that the clay minerals in the reservoir are easy to react with the ions in the foreign salt water, thus changing the layered structure of the clay minerals themselves and reducing the permeability [10].

The purpose of salt sensitivity test of the reservoir is to determine the salinity value that causes the permeability of the reservoir to decrease significantly. Generally speaking, when the salinity of the external brine is higher than that of the original fluid of the reservoir, it will lead to the separation and stripping of clay minerals, while when the salinity of the external brine is lower than that of the original fluid of the reservoir, it will lead to the expansion of clay minerals. The critical salinity of Chang 6 reservoir in the study area is between 12500 and 25000mg/L, and the reservoir has weak - medium to weak salt sensitivity.

3.4 Acid and Alkali sensitivity characteristics

The acid-sensitivity of the reservoir refers to that when the acid fluid that does not match or match the reservoir fluid enters the reservoir, it will react with the acid-sensitive minerals in the reservoir to generate precipitation or new particles, thus reducing the permeability of the reservoir [13].

Alkali sensitivity of the reservoir refers to that when the reservoir enters the alkaline fluid that does not match with itself, it will react with the alkali-sensitive minerals in the reservoir or its own fluid to generate precipitation, thus reducing the permeability of the reservoir.

The acid sensitive index of Chang 6 reservoir in the study area is between - 0.75 and 0.90%, with an average of 0.48%. The reservoir has medium to weak to strong acid sensitivity, and some core permeability has also improved after acid injection. The alkali sensitive index of Chang 6 reservoir in the study area is between - 0.13 and 0.27, with an average of 0.13%. The reservoir has weak alkali sensitivity, and some cores also show no alkali sensitivity. It is considered that Chang 6 reservoir is generally weak alkali sensitivity.

4. Conclusion

(1) The lithology of Chang 6 tight sandstone reservoir in Q area of the southeast edge of the Ordos Basin is mainly feldspathic sandstone, and the grain size is mainly fine sand, followed by medium sand. The physical property of the reservoir is poor, with porosity of 1.78%~12.9%, with an average of 8.3%; Permeability is 0.01×10^{-3}~$2.66\times 10^{-3}\mu m^2$, average $0.40 \times 10^{-3}\mu m^2$. The reservoir pore types are mainly intergranular pores and feldspathic dissolved pores, with few microfractures developed. The main throat types are sheet or bent sheet and necking, and the throat connectivity is poor.

(2) Based on physical properties, pore type and capillary pressure curve characteristics, the Chang 6 reservoir in Q area is divided into three types. Among them, Type I reservoir has good physical properties, mainly intergranular pores, and good connectivity of pore throat. It is the reservoir with the best reservoir capacity and percolation capacity in this area.

(3) The Chang 6 tight reservoir in Q area is characterized by medium to weak velocity sensitivity (average velocity sensitive index is 0.34), medium to weak water sensitivity (average water sensitive index is 0.44), weak to medium to weak salt sensitivity, medium to strong acid sensitivity (acid sensitive index is 0.48) and weak alkali sensitivity (alkali sensitive index is 0.13).

References

[1] Li Guannan, Sun Wei, Liu Dengke. Sensitivity of Chang 6 reservoir in Wuqi Xuecha Area of Ordos Basin and its Main Controlling Factor [J]. Geological Science and Technology Information, 2018, 37(06):138-147.

[2] Song Yuchun, Huang Hao, Zhou Chuangfei, Ke Xianqi, Tang Haodi, Zhu Yushuang. Evaluation on sensitivity difference between Chang 4+5 and Chang 6 Reservoirs in Mahuangshan Area of Jiyuan Oilfield [J]. Xinjiang Petroleum Geology, 2022, 43(05):546-553.

[3] Liu Shugen, Ma Yongsheng, Huang Wenming, Cai Xunyu, Zhang Changyun, Wang Guozhi, Xu Guosheng, Yong Ziquan, Pan Changlin. Densification process of Upper Sinian Dengying formation, Sichuan Basin [J]. Natural Gas Geoscience, 2007(04):485-496.

[4] Wu YS, He SL, Da SP, Li YG and Dai YD. Diagenetic patterns and pore systems of the Lower Ordovician Majiagou Formation reservoirs of the central Changqing gas fields [J]. Acta petrology sincia, 2006, 22(08):2171-2181.

[5] Li Yonggang. Estimate of sensitivity of reservoir in Qinjiatum Oil Field [J]. Journal of Jiling University (Earth Science Edition), 2004(S1):51-54.

[6] Li Chuanliang, Zhu Suyang, Wang Fenglan, Du Qinglong, You Chunmei, Zhu Lihong, Shan Gaojun. Some topics about reservoirs sensitivity evaluation [J]. Xinjiang Petroleum Geology, 2017, 38(04):488-491.

[7] QIU Yinan, XUE Shuhao. Evaluation technology of oil and gas reservoirs [M]. Beijing: Petroleum Industry Press, 1997: 284-342.

[8] Zhu Huayin, Jiang Desheng, An Laizhi, Zhang Liwen. An experimental analysis of sensitivity of the Jiulongshan conglomerate reservoirs in West Sichuan Basin [J]. Natural Gas Industry, 2012, 32(09):40-43+129-130.

[9] National Energy Administration. Formation damage evaluation by flow test: SY/T 5358—2010 [S]. Beijing: Petroleum Industry Press, 2010.

[10] Liu Dawei, Kang Yili, He Jian, Shu Zhuangzhi. Laboratory investigation of water sensitivity of carbonate reservoirs and discussion of its mechanism [J]. Natural Gas Industry, 2007(02):32-34+148-149.

[11] Wang Weiying, Tang Zhouhuai, Lu Yinghong, Du Yan, Zhao Lei. Influencing factors of water sensitivity in reservoir rock [J]. Journal of Jianghan Petroleum Institute, 2001(02):49-50+3-2.

[12] Dang Ben, Zhao Hong, Kang Xiaoyan, et al. Sensitivity microscopic mechanism study of superlow permeability reservoirs in depth of Yanchang formation in central of Shanbei slope Ordos basin NW China [J]. Journal of Central South University (Natural Science Edition), 2013, 44(3):1100-1107.

[13] Liu Dawei, Kang Yili, Li Qiangui, Lei Ming, Shu Zhuangzhi. Experimental research on fluid sensitivity of carbonate reservoirs with high content of acid gas [J]. Oilfield Chemistry, 2007(03):193-+196+201.