# Physical Simulation and Manuplation of Starbying Water Flooding in Low Viscosity Harword Reservoir in Eastern Country

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*Abstract*

To have a look at the go with the flow mechanism under special displacement modes of low permeability carbonate reservoir within the center East and to enhance the usage of numerous varieties of reservoirs, the physical simulation experiments of water flooding with the aid of extraordinary displacement methods had been performed. deciding on styles of rock samples with unique permeability ranges, two-layer coinjection and separated manufacturing experiments by samples I and III and conventional water flooding experiments via samples II and IV were completed. in addition, by using the usage of low magnetic subject nuclear magnetic resonance, the improvement effect of microscopic pore shape beneath the unique injection-production fashions became analyzed. results display that, in comparison with the coinjection, the recovery fee of pattern i used to be higher than II, 19.30%; sample III turned into decrease than IV, 23.22%; and the complete restoration degree reduced by using 3.ninety two%. NMR statistics additionally show that the crude oil is particularly distributed within the big pore throat; after water flooding, the displacement is also inside the big pore throat, whereas the small pore throat is specially acquired by the impact of infiltration absorption. The above studies provide a laboratory basis and foundation for the further development of low permeability carbonate reservoir in different Middle East strata.

## 1. Introduction

In recent years, the rational development of carbonate reservoirs has become a hot spot in the domestic and international oil industry. Most of the reservoirs that China was involved in their acquisition and development in the Middle East belong to the low permeability carbonate reservoirs. But the vertical heterogeneity of these reservoirs is strong, the contradiction between layers is prominent, the water content of some layers rises rapidly, and the degree of recovery is lower, which greatly influenced Chinese government for the oilfield development. Therefore, in order to recover the cost as soon as possible during the contract period and to improve the recovery degree and maximize the enterprise benefits, there are urgent needs for studying diverse development methods to improve the usage of various types of reservoirs.

Numerous scholars conducted a series of laboratory experiments on the heterogeneity characteristics of oilfields in different regions and suggested that ameliorating the water injection structure could improve the water absorption status and recovery degree through reasonable subdivision [1–4]. These research results are crucial for the efficient development of oil and gas fields, but mainly for Chinese domestic oil fields; less research on low permeability carbonate reservoirs in the Middle East rarely has a reference value. Therefore, based on the previous studies [5–8], we carried out colayer water flooding indoor simulation experiments and studied the microdistribution situation of residual oil and recovery degree of different pore range by means of low nuclear magnetic resonance (NMR) technique [9, 10]. We performed two different injection-production modes water flooding oil experiment under three states, which guide us to have a more comprehensive understanding on the effect of different interval microscopic pore structure. The results provide some efficient technical policies for the development of Middle East reservoir. In

addition, it has certain reference value for the development of colayer water flooding in other low permeability carbonate reservoir.

NMR technique as a new rock analysis technology developed rapidly in recent years in the petroleum industry. It can reflect the pore size distribution and the fluid volume in different pores, which can quantitatively calculate the displacement efficiency and residual oil in different pore size during water flooding oil. Therefore, NMR technique is a potent supplement of routine laboratory water flooding technology [11]. NMR could detect the signal of hydrogen nucleus , while, having fluid (oil or water) in the cores, NMR has different reflection in spectra. The property and amount of internal fluid could influence the shape of the spectra, which reflect the size of pore and throat. NMR relaxation time reflects core's pore size. According to the study [12], the corresponding pores are as follows: clay micropores

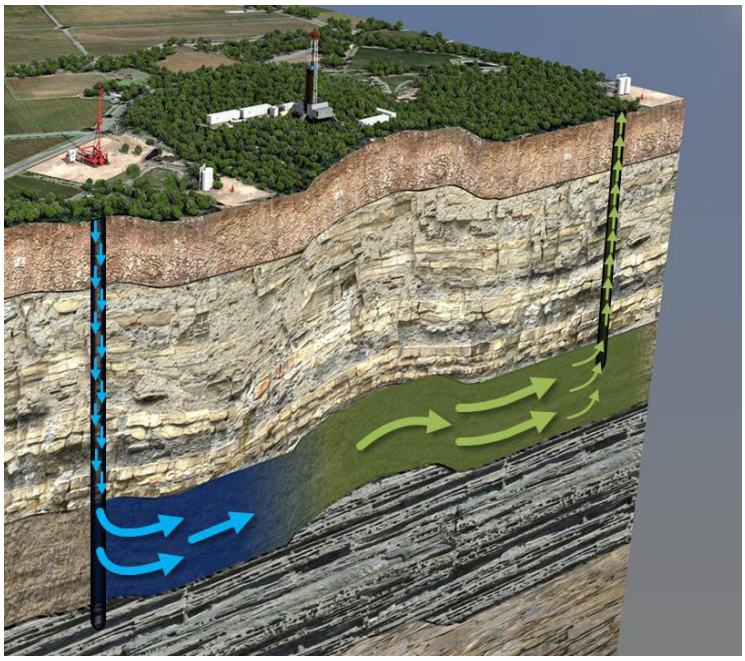
**when the relaxation time is less than 10 ms, large pores when** relaxation time **is greater than 100 ms, and medium pore when** relaxation time **is 10 ms–100 ms. According to the property of** recognizing hydrogen nucleus

of NMR technique, chlorofluorocarbon synthetic oil (no hydrogen nucleus ) was adopted to conduct physical simulation experiment, so that the signal measured by the NMR relaxation time spectrum was the distribution of the water phase in the rock sample.

## *2. Experimental Design*

According to the logging interpretation and core statistics, the average permeability of the Middle East M group is 18~65 × $10^{-3}$ μm$^2$ and the porosity is 14~22%. In vertical, the stratum is divided into three segments and 15 small layers, which indicate strong heterogeneous. Therefore, we used two sets of rock samples with different permeability difference to carry out the water flooding experiment of coinjection and separate production and used the single layer injection and production as the contrast experiment. Combining the nuclear magnetic resonance technique, we also studied the distribution of microscopic residual oil and recovery degree. The experiment

adopts 2 layer samples connecting in parallel, simultaneously injecting, and, respectively, measuring way to simulate the mine



field reservoir 2-layer water flooding process. The basic parameters of rock samples are shown in Table 1.

The experiment was carried out at room temperature. The experiment oil was chlorofluorocarbon synthetic oil. The density **of synthetic oil is 1.8 g/cm**$^3$ at 20°C, and the viscosity is **3.2 mPa·s. The experimental water is the simulated formation**
water based on the results of water quality test configuration, the

**mineralization degree is 200000 mg/L at 20°C, and the viscosity is 1.15 mPa·s. The experiment adopts constant p**ressure flooding **way, the average single layer injection pressure is 0.2 MPa, and**
the outlet pressure is normal pressure.

Figure 1 is the schematic diagram of the experiment process of the 2-layer coinjection and separate production. The QUAZIX type displacement pump simulates the formation water into the rock sample, and the confining pressure is applied to the core by the ring pressure pump. The experimental pressure is measured by the sensor, oil-water mixture flowing out from the exit end of the rock sample is, respectively, measured after being separated

**by the separator; that is, measurement accuracy is 0.01 cm**3.

Specific experimental procedures are as follows: (1) simulate saturated water condition; saturate rock sample with simulated

**formation water to 10 PV after the rock sample vacuums, and**

proceed with saturated water condition spectrum test; (2)

simulate saturated oil condition. Displacing rock sample with

chlorofl**uorocarbon synthetic oil to 10 PV after the rock sample** is loaded to the core holder in parallel, and proceed with saturated oil condition spectrum test; (3) simulate oil condition. Injecting the rock sample with simulated formation water at constant pressure, record displacement speed, displacement confining pressure, and the amount of displacement oil and water at different times until there is no oil, and proceed with residual oil condition spectrum test.

## *3. Results Analysis*

Figure 2 and Table 2 show the results of water flooding in different injection-production patterns with different permeability levels. It can be seen that, under the same injection-production patterns, the anhydrous recovery degree, residual oil

saturation, and final accretion amount of altered permeability levels are decidedly different. When the low permeability band I and top permeability band III are accompanying injected by connected pressure, a lot of of injected baptize abounding into top permeability layer, causing the baptize in top permeability band to breach through. The baptize breakthrough

time is 460 s, beneath than the low permeability 2875 s, and the

anhydrous accretion amount is 7.11%, beneath than the low permeability 23.10%. Due to the actuality that the top permeability band acceptable forms baptize appearance ascendant breeze approach and the injected baptize has lower amount of appulse to added breach afterwards baptize breakthrough, while continuously injecting baptize with the aforementioned pressure, this will aftereffect in the final accretion amount getting lower, alone 34.78%. But the low permeability band still maintains the action of oil and baptize aggression beneath the lower displacement speed, which could consistently displace the oil appearance of pores forward, consistent in the final accretion amount getting high, extensive 55.68%. When displacing the low permeability band II and the top permeability band IV with the connected pressure, the baptize advance time is 7800 s and 950 s respectively, and the anhydrous accretion amount is 20.00%

and 12.39%, respectively. It can be apparent that the lower permeability has college anhydrous accretion degree. But the final accretion amount of top permeability is 58.00%, college than the low permeability, 36.38%.

Table 2: Experiment after-effects of altered injection-production patterns of samples.

Figure 2: Experiment after-effects of baptize agreeable and accretion amount curve.

For the aforementioned permeability akin of bedrock samples, altered injection-production patterns on its accretion amount apply amazing influence. Bedrock sample I that accept coinjection and abstracted assembly arrangement enhances anhydrous accretion amount 3.10% compared to bedrock sample II that adopts individual band bang and assembly pattern, enhances the final accretion amount 19.30%, and reduces the balance oil assimilation 18.51%. Bedrock sample IV that adopts individual band bang and assembly arrangement enhances anhydrous accretion amount 5.28% compared to

rock sample III that adopts coinjection and separates assembly pattern, enhances the final accretion amount 23.22%, reduces the balance oil assimilation 15.28%, and reduces the absolute accretion amount by 3.92%.

Figure 3 shows the action of baptize calamity NMR spectrum of two accumulation altered permeability akin bedrock samples. It can be apparent that the altered permeability samples with the aforementioned injection-production patterns accept assorted responses; the aforementioned permeability samples with altered injection-production patterns aswell accept assorted responses. The spectra of 4 bedrock samples are bedeviled by bimodal form, which announce

that there are two or added types of pore structures in the bedrock samples. For the aforementioned injection-production patterns (I and II, III, and IV), as the permeability increases, the NMR spectrum moves to the appropriate gradually, advertence that the adaptable aqueous is aggrandized gradually.

Figure 3: NMR spectra allegory of altered injection-production modes.

From the saturated oil curve, the irreducible baptize is mainly broadcast in the baby pores, few in the ample pores, which is because, during the accumulation action of apprenticed water, the oil appearance preferentially flows forth the macropore, displacing the baptize in the ample pores and abrogation the baptize in the baby pores to anatomy irreducible water. From the baptize calamity ambit and the saturated oil curve, the capital displacement oil is broadcast primarily in the ample pores, few in the baby pores, which is because, in the action of displacement, baptize appearance acceptable flows forth the ample pores with baby breeze resistance, appropriately active out the a lot of of oil phase. From the saturated baptize ambit and the baptize calamity curve, the balance oil is primarily broadcast in the ample pores, rarely in the baby pores, which is because oil appearance in the baby pores is hardly and accompanying with the aftereffect of aggression absorption, consistent in balance oil assimilation in baby pores getting scarce, admitting balance oil acceptable forms in the bedrock apparent and aberrant accumulation of ample pores.

**4. Conclusions**

(1)In the same injection-production modes, the higher 4.

permeability bedrock samples breach through the baptize earlier, and

the aeon of anhydrous accretion amount is almost short.

5.

While breaking through the water, baptize agreeable acceleration rapidly.

The lower permeability bedrock samples breach through the water

relatively late, and the anhydrous accretion amount is beyond than 6. the college permeability bedrock samples. In the aforementioned permeability

level, the approach of coinjection abstracted assembly break through baptize beforehand than the approach of individual band bang and 7.

production.(2)The college permeability bedrock samples accept lower

recovery degree while adopting coinjection and separate

production modes than adopting individual band bang and 8. assembly modes. In contrast, the lower permeability rock

samples accept college accretion amount while adopting coinjection and abstracted assembly modes than adopting individual band 9.

injection and assembly modes. Therefore, for the different

permeability levels, bedrock samples should yield altered injection-

10.

production modes, and the specific aggregate boundaries need

further study.(3)The irreducible baptize is mainly broadcast in

the baby pores. During the displacement process, the oil appearance 11. was apprenticed primary on the ample pores. Moreover, the balance oil

primary concentrated in the ample pores due to the baby pores

being hardly saturated oil phase. The ample pores still have

enormous development potential.

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