The Morphological Characteristics of Oil- Water Relative Permeability Curve

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Abstract

This paper describes the relationship between the oil-water relative permeability curve and the rock's pore structure and wettability. Taking the low permeability sandstone reservoir of S Oilfield as an example, based on the relative permeability curve data of 36 cores in oil field, the morphology of the osmotic curve was divided into two types: the concave type and the convex type in the water phase. The morphological characteristics of the two types of relative permeability curve were analyzed, and the relative permeability curve of the concave type was more favorable to the development of water injection.

Keywords

Relative permeability curve, wettability, porosity, permeability.

1. Introduction

The relative permeability curve of low permeability reservoir is characterized by large irreducible water saturation, small permeability range and low relative permeability of water phase. For low permeability rock, porosity, hydrophilic characteristics of rock is [1]. Non Darcy flow increases the relative permeability of oil phase in low permeability sandstone reservoir, and decreases the relative permeability of water phase. The heterogeneity of reservoir physical property, pore structure and wettability of rock have great influence on the shape of relative permeability curve.

2. Analysis of geological characteristics of S Oilfield

The difference of grain size of sandstone in different sedimentary facies in S Oilfield is obvious. Therefore, it is the difference between sandstone groups. The sandstone group median grain size is 0.126 mm, sandstone group was 0.134 mm. The rock structure characteristics are the main factors affecting the reservoir properties. The pore structure coefficient of northern area is 3.85, the southern region is 4.12, indicating a smaller structure coefficient and a bigger fluid flow resistance of S Oilfield. The measurement results of the wettability of the grape flower oil layer in S Oilfield show that the irreducible water saturation of S Oilfield is 34.3% - 36%, and the biggest relative permeability of water phase is less than 30%, generally 7.3% - 7.9%. According to the wetting property, the V0 is close to zero, and the water absorption of Vw is less than 5%, both are weak hydrophilic, which is beneficial to the development of water injection.

3. Morphological classification of oil water relative permeability curve in S Oilfield

Usually the oil-water relative permeability curves are divided into five categories, water-phase top concave type, water-phase straight line type, water-phase below concave type, water-phase top convex type and water-phase chair type[3].Refer to the S Oilfield of 36 cores of relative permeability curve data, oil phase relative permeability curve trend is consistent, and water phase relative permeability curve shows obvious differences. Thus the relative permeability curve is classified according to the trend of relative permeability of water phase. The morphology of 36 cores is divided into two types: the concave type and the convex type in the water phase. The concave water phase relative permeability curve is 19, the convex aqueous phase relative permeability curve is 17, the former accounted for the majority.

From Figure 1 and Figure 2 we know the change characteristics of the concave water phase: with the increase of water saturation, relative permeability of water phase increase faster and faster; convex type on the water relative permeability curve variation: with the increase of water saturation, relative permeability of water phase increase slower.

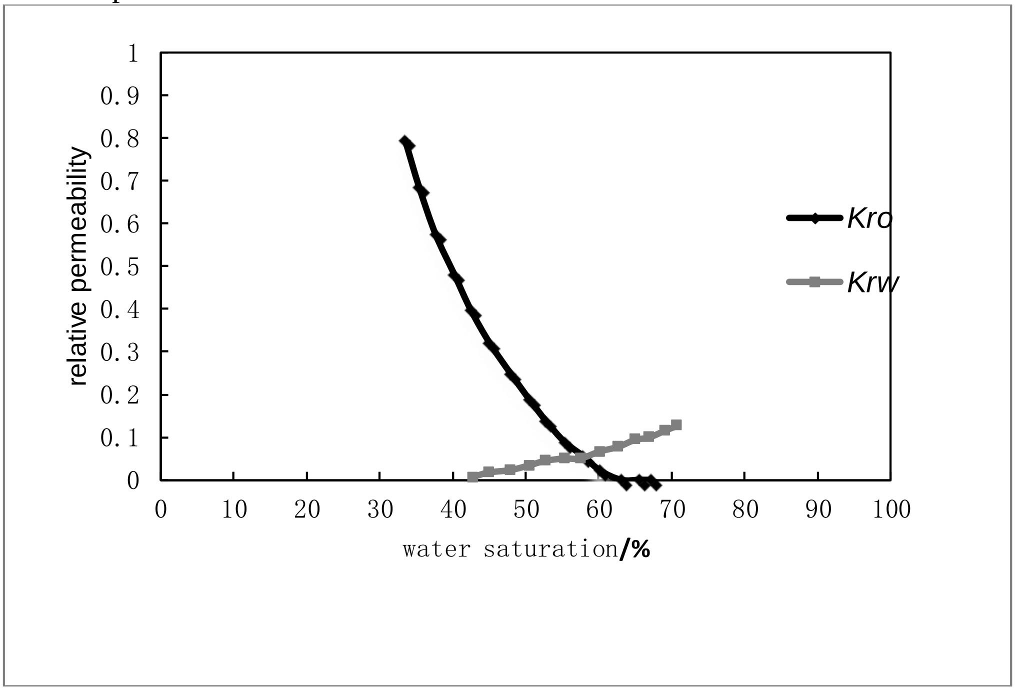

Figure 1 water-phase below concave type

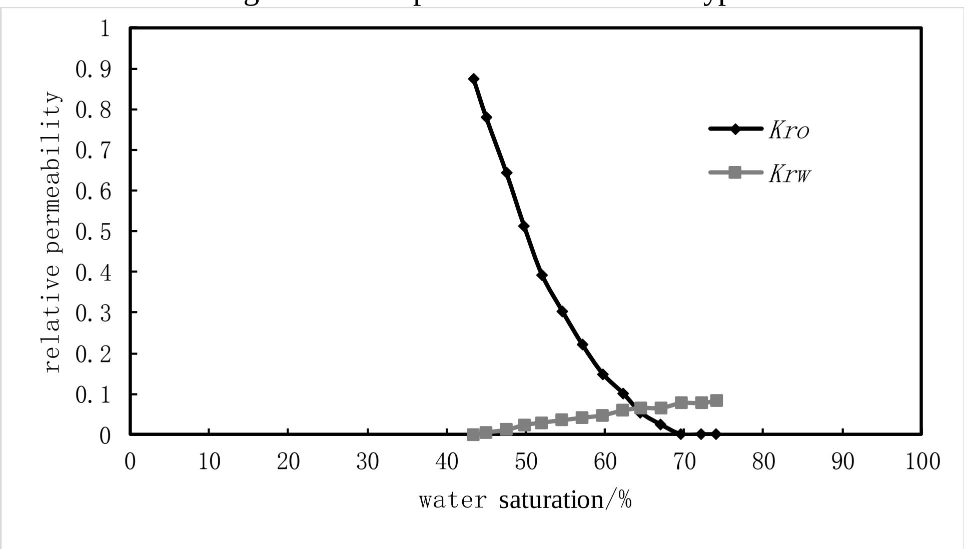

Figure 2 water-phase top convex type

4. Evaluation of morphological characteristics of oil water relative permeability curve

The relative permeability curve data of S Oilfield analyzed the curve shape feature from two aspects-water content change rule and oil displacement effect.

the variation of moisture content by the data in Table 1 and figure 3 and Figure 4 can see the range of water content in 0 ~ 40% range changes each block water rising rate is larger in this range includes water increased rapidly, the range of water content in the 40% ~ 80% range of block water rising rate values decreased and water rate reached more than 80% when the water content rate of rise is further reduced, water cut rising speed slows down.

Table1 Water content and water cut rising rate curve

Moisture content/%	water-phase below concave type	water-phase top convex type
0～40	4.51	7.66
40～80	3.27	4.39
＞80	1.31	1.61

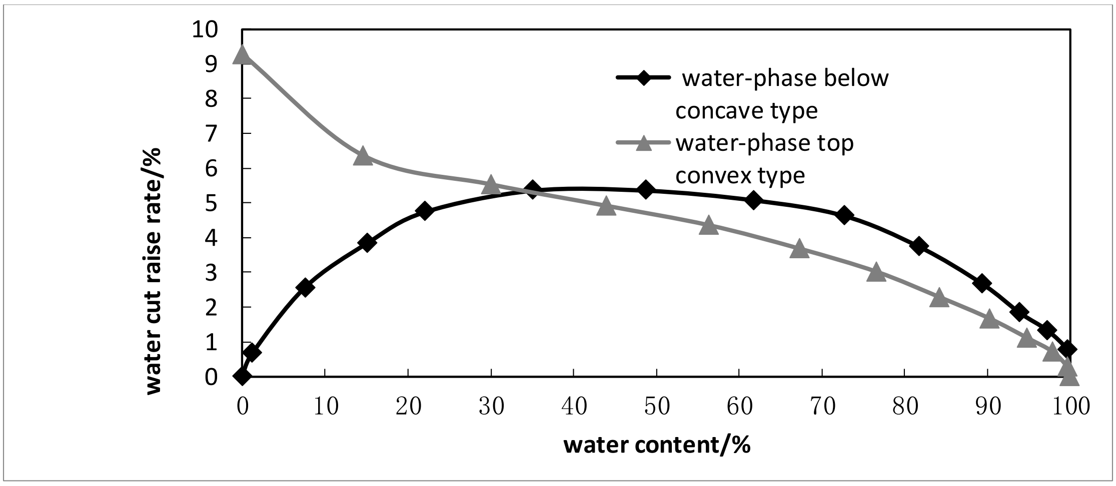

Figure 3 Relationship between water content and water cut rise rate curve

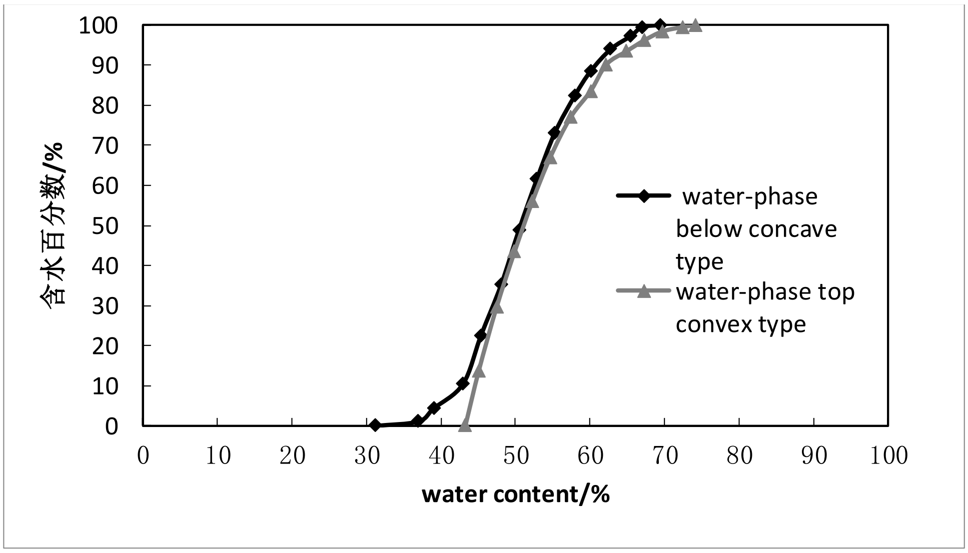

Figure4 Relationship between water content and water saturation curve

From the data of figure1, figure 3 and Figure 4 , combined with the storage layer parameters data shows that, because of S Oilfield's reservoir heterogeneity is strong, structure coefficient is small, the different sedimentary phase sandstone grain size median differences obviously, thus causing differences between sandstone groups [2]. water-phrase below concave curve as the high permeability type has a slower water injection, instead, the rising speed of water content in oil well is slower, but as the low permeability type, it's water content rise faster.

Oil displacement effect

The statistics of stone core between water-phrase below concave type and water-phase top convex type showed in Table 2.

Table 2 Comparison of parameters of different types of infiltration curve

Phase infiltration type	water-phase below concave type	water-phase top convex type
The number of	19	17
Oil displacement efficiency	0.55	0.45
Water-free recovery/%	26.82	21.20
Initial oil saturation /%	60.09	55.29
porosity /%	21.85	21.22
permeability /μm^2	213.28	90.95
Oil phase permeability /μm^2	107.43	45.95
Irreducible water saturation /%	39.91	44.71
Residual oil saturation /%	27.11	30.49
Co permeation range	32.97	24.80

It can be seen from table 2 that, Two types of oil-water relative permeability curve reservoir rocks have water moisture. In the water-phase below concave type, the average water-oil permeability range, oil displacement efficiency, water-free recovery and other parameters are higher than water-phase top convex type. These phenomena are decided by the reservoir physical properties, reservoir physical property is appropriate with oil- water relative permeability curve. It's the important reason why the performances of different relative permeability curves are different. Because in the hydrophilic reservoir, the formation water will occupy the small pore and the dead pore firstly. The formation of the water-phase below concave type is because the big pore structure, so the irreducible water saturation is small, and with the water injection, the water film attached on the stone surface become thicker, then the water phase relative permeability rate increase slow, the range of oil water co infiltration is larger; while, the water-phase top convex type relative permeability curve is different, because the smaller stone pore structure, the formation water can easily occupy the stone pore, so the irreducible water saturation is larger, and this is conducive to the development of water injection, together with the of swelling of clay minerals' big influence, causing the oil-phase relative permeability rate rapid decline, water-oil co infiltration point is reduced, co infiltration range is small.

5. Countermeasures and measures

5.1 take water control measures,slow down the rising speed of water content

In order to solve the plane and interlayer development contradiction caused by the heterogeneity, we took several water control measures on the oil well, which contain water and the moisture content increase fast, and expand the volume of water injection, and, at the same time, we plugged the oil wells, and controlled the water from the source of water injection, all the measures above has effectively slowed down the water cut rising speed of S Oilfield.

5.2 Improve the physical properties of the rock reservoir parameters and improve the recovery rate

According to different types of curve shapes, in the process of oilfield development, we should refer to the component of clay mineral, and the test results of reservoir layer sensitive, and take appropriate measures to protect the reservoir layer, besides, we also need to think about the clay mineral's occurrence to recognize the develop measures, think about the reservoir layer's salt-sensitive, speed-sensitive. During developing the oil well, must add anti-swelling agent to the injection fluid, and control the injection rate, so we can develop the oil mineral properly[4]. Due to oil mineral stone selective wetting, water rock is better than oil rock. In order to achieve the most ideal oil displacement effect, during the reservoir water injection development, usually add surfactant into the water to change the wettability of rocks, so we can achieve the purpose of enhancing oil recovery.

6. Conclusions

According to the relative permeability curve of the water phase, the relative permeability curve of sandstone reservoir in S oilfield is divided into the water-phase below concave type and the water-phase top convex type.

On the basis of analysis of the morphological characteristics of the phase permeability curve, the relative permeability curve of the water-phase below concave type is more favorable to the development, and puts forward the improvement measures for different reasons.

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