Introduction

The oil-water transition zone reservoir, due to its abundant geological reserves and ideal carbon sequestration conditions for oil water rock, can become a potential resource for carbon flooding and storage, and a new field for the application of CCUS-EOR technology.Through geological reserves of oil-water transition zone(TZ) in oil reservoirs may account for 30%~50%, it has been considered as uneconomical resources because of high water cut and low abundance. With the oil saturation decrease of the main pay zone and the advance of EOR technology, the TZ resource offer a new source of oil production. Unlike water flooded layer, the oil in the TZ is unsaturated rather than residual oil after water flooding, which would lead to special oil-water seepage law and recovery mode.

The experiment-results show that the residual oil saturation depends on the initial oil saturation rather than constant under certain conditions of core and oil, which means the amount of recoverable oil in the TZ depends on the distribution of the initial oil saturation. When the initial oil saturation is less than 40%, the initial oil saturation affects the value of the residual oil saturation rather than the oil viscosity. Under the condition of high permeability and low oil viscosity, the influence of initial oil saturation on residual oil saturation is relatively weak. The initial water cut is mainly controlled by the initial oil saturation and oil viscosity rather than the core permeability. Under the condition that the oil viscosity is greater than 50cp, the cores unsaturated with crude oil are all corresponds to the initial water cut higher than 80%, which will increase the recovery difficulty of such reservoirs.

This study aims to quantify the influence of initial oil saturation on oil-water seepage in unsaturated oil reservoirs, which can be used to calculate the key development parameters, such as the recovery factor, initial water cut and final recovery factor in original low-saturated reservoirs

Method and/or Theory

A series of experiments to characterize the relationship between residual oil saturation and initial oil saturation. Permeability of 20mD, 50mD, 100mD and 500mD cores and viscosity of 1cp, 20cp, 50cp, 80cp and 100cp oil are used to simulate different reservoir conditions, and that water flooding experiments for each permeability and oil viscosity are performed with initial oil saturation of 100%, 66.7%, 50% and 33.3% of maximum oil saturation separately. A total of 36 sets of water flooding experiment data are used to draw the initial oil saturation & residual oil saturation chart.

Results

1. When the initial oil saturation is lower than 40%, the viscosity of crude oil has little influence on the residual oil saturation, and the residual oil saturation basically does not change with the initial oil saturation. When the initial oil saturation is greater than 40%, under the same crude oil viscosity conditions, the higher the initial oil saturation, the higher the residual oil saturation.(Fig.1)

2. when the viscosity of crude oil is between 1 and 100 cp and the initial oil saturation is lower than 40%, the viscosity has little influence on the residual oil saturation. Under the conditions of low permeability and high viscosity conditions, the control degree of initial oil saturation over residual oil saturation is relatively strong. Therefore, the influence of initial oil saturation on CO_2 flooding efficiency should be fully considered when calculating the recovery factor. (Fig.2)

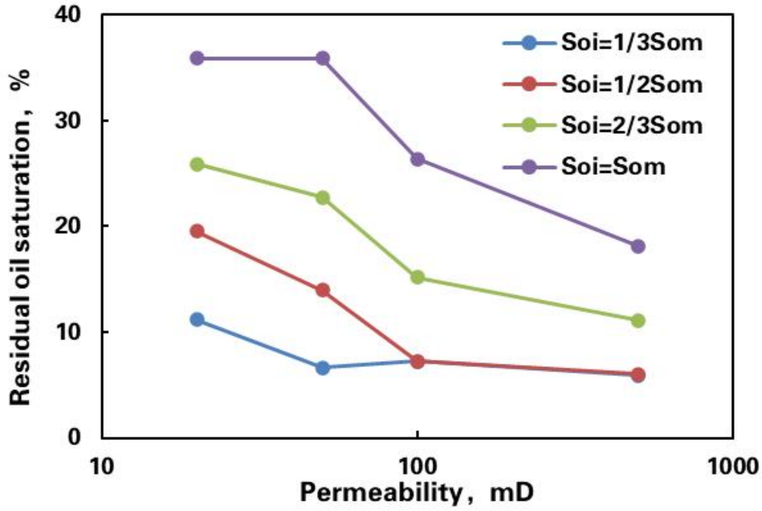

Fig. 1 The influence of permeability and initial oil saturation on residual oil saturation after CO_2 flooding

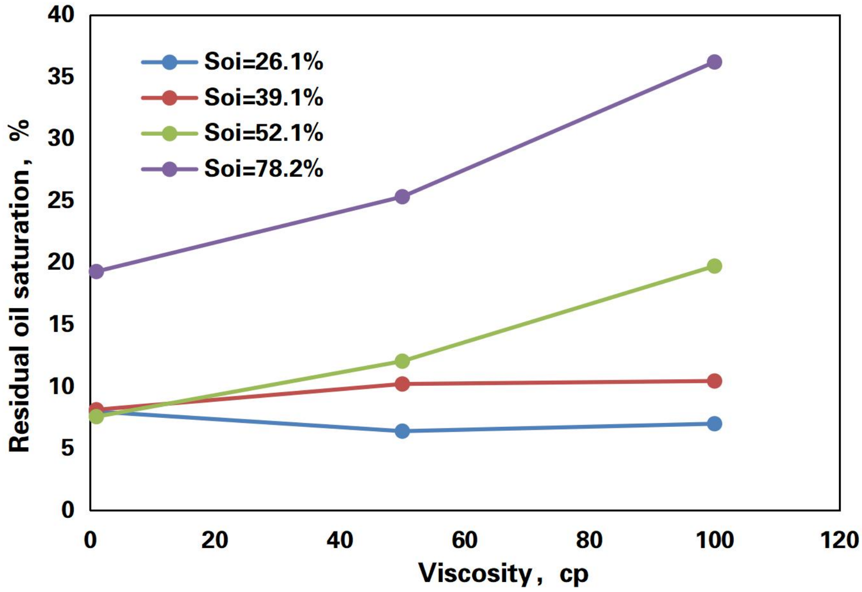

Fig. 2 The influence of viscosity and initial oil saturation on residual oil saturation after CO2 flooding

Conclusions

Based on the capillary force-phase permeability fractal model, a key variable, initial oil saturation, was added to establish the chart evaluation method of residual oil saturation, forming a three-dimensional control model based on the core permeability, oil viscosity, and the initial oil saturation. Based on 36 sets of CO2 flooding experiment results, the chart has been drawn, which can be used to calculate the residual oil saturation and evaluate the production potential of typical reservoirs.

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