WETTABILITY EFFECTS ON OIL DISPLACEMENT BEHAVIOUR

by

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Abstract

This paper discuss the wettability of reservoir rocks and how it effects oil recovery by displacements processes.

1.0 Introduction

The factors that affect displacement behaviour can be categorised into four main groups. These are:

i) reservoir rocks properties

ii) reservoir rocks/reservoir fluids interaction

iii) fluid/fluid interaction

iv) applied injection pressure and gravity force

From the group (ii) factors, there are two important properties, that is wettability and adsorption. This paper will discuss the effect of wettability only.

2.0 What Is Wettability?

Wettability is defined by Craig (1971) as the tendency of one fluid to spread or adhere to a solid surface in the presence of other immiscible fluids. When the rock is water-wet, there is a tendency for water to occupy the small pores and to contact the majority of the rock surface. The situation is reversed in an oil-wet condition. Is it important to note that the term wettability is used for the wetting preference of the rock and does not necessarily refer to the fluid that is in contact with the rock at any given time.

3.0 Types of Wettability

Wettability can be divided into five types: water-wet, oil-wet, intermediate wettability, mixed wettability and fractional wettability. Detail description of each of these wettability types is given by Anderson (1986).

Cleaned sand, glass beads and berea cores are normally water-wet. The wettability of reservoir rocks varies widely as has been reported by Treiber et al (1971). Reservoir rocks can change from strongly water-wet by adsorption of polar compounds and/or the deposition of organic matter originally presence in the crude oil (Denekas at al 1959). Most previous experimental studies of displacement processes in laboratory scale equipments either used water-wet cores and bead packs or have simply ignored the wettability conditions.

4.0 Relationship Between Wettability and Oil Recovery

The relative preference of reservoir rock pore surfaces to be wet by water or oil plays and important role in determining the microscopic distribution of fluids in the pore space of reservoir rocks. As mentioned earlier in a water-wet rock, water will tend to occupy the smallest pores and crevices while the larger pores will be occupied by the oil. Similarly, in an oil-wet rock the oil will occupy the smaller pores, the fluid distribution being of fluids in the pore space of reservoir rocks influence the rates of flow of each fluid as well as recovery efficiency and is therefore very important in oil recovery processes.

The preferential wettability of the reservoir rock governs, to a large degree, the oil recovery in a waterflood. In water-wet resevoirs, most of the oil is typically displaced before water breakthrough with little or no oil flowing after breakthrough. The residual oil will be trapped by capillary forces as disconnected ganglia. In oil-wet reservoirs, early water breakthrough occurs and appreciable amounts of oil are recovered after breakthrough. Much of the residual oil will be trapped by capillary forces in the smaller pores. An accurate knowledge of the residual oil saturation and its distributions after a waterflood is imperative for the success of a tertiary recovery process.

The determination of relative permeability values are essential for any recovery process. This is because the relative permeability curves are strongly dependent on wettability. Furthermore, relative permeability data are required in many reservoir engineering calculations.

Many people have studied the effect of wettability on relative permeability. Among them were Donaldson et al (1969), Owen and Archer (1971) and McCaffery and Bennion (1974). Relative permeability curves is suitable for discriminating between strongly water-wet and strongly oil-wet cores. An example of relative permeability curves for a water-wet and oil-wet cores are shown in Figure 1. There is a significant shift of relative permeability curves due to wettability changes.

The effect of wettability in tertiary recovery process have also been conducted [Mat Hussin (1988)]. Generally the experimental studies have shown that the injected fluid breakthrough is earlier in water-wet cores than in oil-wet cores. In miscible displacement process residual oil recovery is more efficient in oil-wet rock than in water-wet rock. Residual oil recovery obtained from miscible displacement experiments using water-wet and oil-wet glas beads packs is given in Table 1.

Conclusion

The success of oil recovery by waterflooding and by miscible displacement is strongly influenced by the wettability of the reservoir rocks. Thus the determination of reservoir rocks wettability in any secondary or tertiary recovery project is necessary.

References:

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Table 1 - Effect of Wettability on Waterflood Residual Oil Recovery (after M.H. Yunan, 1988)

Experimental Conditions	Residual Oil Recovery, %	
	Water-Wet	Oil-Wet
1. Tandem pack vertical flood at 1.0 ft/day	77	99
2. Tandem pack vertical flood at 8.0 ft/day	74	96
3. Tandem pack horizontal flood at 1.0 ft/day	67	97
4. Tandem pack horizontal flood at 8.0 ft/day	72	98

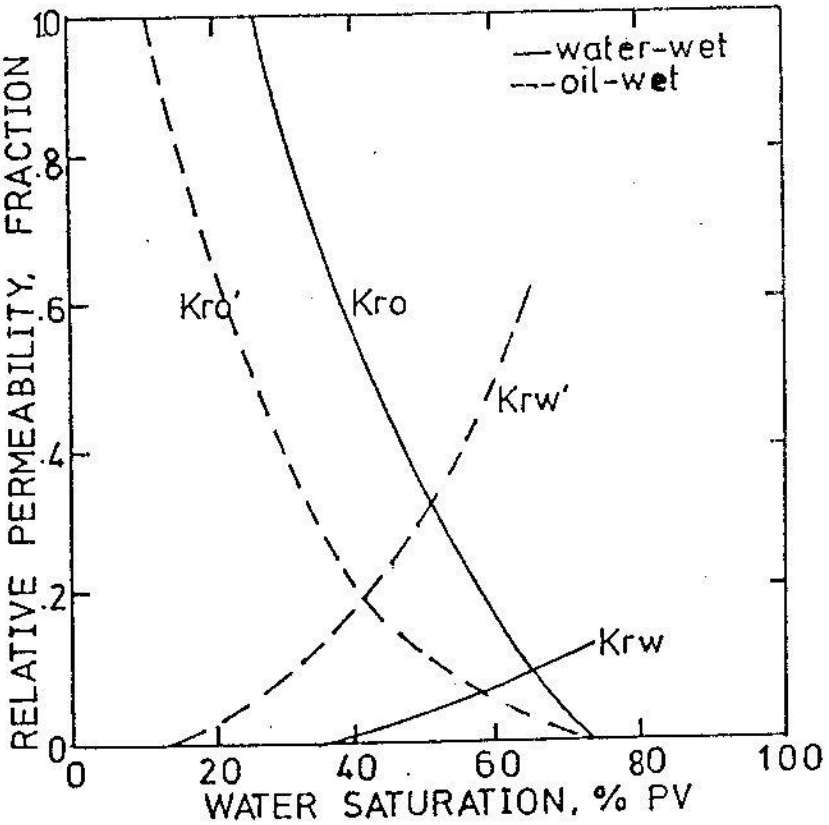

Fig. 1 - Typical Water-Oil Relative Permeability Characteristics For Strongly Water-Wet and Strongly Oil-Wet Rocks (after Craig, 1971)