— University of Mosul —
College of Petroleum & Mining Engineering

Enhanced Oil Recovery Processes

Fourth Year

Lecture 2

Prof. Dr. Majid Majdi Al-Mutwali

Petroleum and Refining Engineering Department

majidmutwaly@uomosul.edu.iq

Principal influences on the efficiency of enhanced recovery

The lack of sufficient natural drive in most reservoirs has led operators to introduce some form of artificial drive, the most basic method being the injection of natural gas or water.
The efficiency of an enhanced recovery method is a measure of its ability to provide greater hydrocarbon recovery than by natural depletion, at an economically attractive production rate.
The efficiency of an enhanced recovery method depends on:
a- The reservoir characteristics.
b- The nature of the displacing and displaced fluids.

1- The influence of reservoir characteristics
The most important characteristics of a reservoir are:
a- Average depth.
b- Structure in particular the dip of the bed.
c- Degree of homogeneity.
d- Petrophysical properties (permeability, capillary pressure, wettability).

A- Depth

Reservoir depth has an important influence on both the technical and economic aspects of an enhanced recovery project.

On the technical level, a shallow reservoir puts a restraint on the injection pressure that can be used, since this must be less than fracture pressure.

Economically, the cost of an enhanced recovery project is directly related to depth, as reflected, for example, in the cost of drilling the extra wells required, or in the compressor power required in the case of gas injection.

B- Dip

The hydrocarbon recovery from a porous medium is greater when gravity plays a part than when it does not. In practice, gravitational forces are only truly effective in reservoirs containing highly permeable sands or in which the dip is unusually large.

For horizontal beds the critical velocity is zero, injected water forming a tongue at the base of the bed and injected gas forming an umbrella at the top of the bed (Fig. 1). These phenomena cause rapid breakthrough of the injected fluid at the production wells.

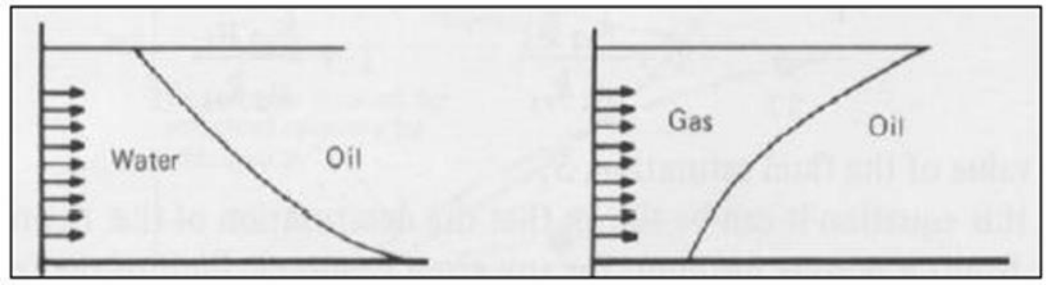

Figure 1

C- Homogeneity

In order to achieve a high recovery of hydrocarbons, there should be no impediment to fluid flow within the reservoir. Possible impediments may be of tectonic (e.g. isolating faults) or stratigraphic nature (e.g. lateral facies variation, lenses, unconformities).
In faulted and fissured reservoirs, and those with high permeability streaks, channelling allows the displacing fluid to bypass some of the oil in place and leads to a low recovery factor.
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D- Petrophysical properties

Porosity, permeability, relative permeability, capillary pressure and wettability are all properties which should be taken into account in the study
of an enhanced recovery project.

The higher the porosity and the higher the residual oil saturation at the end of the natural recovery phase, the more attractive an enhanced recovery project becomes.

For enhanced recovery as for natural recovery a high permeability is encouraging (high initial oil saturation, larger pore throats, etc.). However, the higher the permeability the greater the chance that the natural recovery will be so high that any enhanced recovery project would be uneconomic.

The effect of capillary forces on recovery efficiency depends on the rate of production. The capillary forces often have a detrimental effect, being responsible for the trapping of oil within the pores. This trapping is a function of the ratio of viscous forces to capillary forces. The residual oil saturation decreases as the ratio of viscous forces to capillary forces increases

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Relative permeability is the ratio of effective permeability of a particular fluid at a particular saturation to absolute permeability of that fluid at total saturation. If a single fluid is present in a rock, its relative permeability is 1.0. Calculation of relative permeability allows comparison of the different abilities of fluids to flow in the presence of each other, since the presence of more than one fluid generally inhibits flow

2- The influence of fluid characteristics

The principal fluid property to be taken into account when designing an enhanced recovery project is the viscosity.

If the fluids are highly viscous the displacement velocities will be low. Oil production will be at such a low rate that it will not be economically attractive.

For a given volume of injected fluid, all other things being equal, the residual oil saturation will be higher the higher the oil viscosity.

Viscosity has a further important effect on sweep efficiency in that it is one of the parameters which determine the mobility ratio (mobility ratio is defined as the mobility of the displacing fluid (i.e. water) divided by the mobility of the displaced fluid (i.e. oil).