Reservoir Engineering II

Reserve Estimation III

By

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Introduction

Reserve estimation methods may be classified as:

- **Analogical Methods.**
- **Volumetric Methods.**
- **Performance Methods.**
  - Material Balance.
  - Computer Simulation.
  - Performance/Decline Trend Analysis.

Performance Methods

- Performance methods are the most accurate methods in calculating the oil in place because these methods take into consideration more reservoir variables in comparison with the previous methods.

- Before starting with the Performance Methods oil recovery methods should be studied

Oil Recovery Methods

1-Primary recovery

2-Secondary recovery

3-Tertiary recovery

Primary Recovery (oil recovery less than 30%)			Natural flow	- Rock and liquid expansion drive. - Depletion drive. - Gas-cap drive. - Water drive. - Gravity drainage drive. - Combination drive.
			Artificial lift	- Pump - Gas lift - Other
Improved Oil Recovery - IOR	**Secondary Oil Recovery** (oil recovery: 30-50%)		Water flood	
			Pressure Maintenance	Water/Gas Reinjection
	Enhanced Oil Recovery - EOR	**Tertiary Oil Recovery** (oil recovery more than 50% and up to 80%)	Thermal	- Combustion - Steam soak/cyclic - Huff-and-puff - Steam drive/flood - Hot water drive - Electromagnetic
			Gas miscible/ immiscible	- CO_2 - Nitrogen - Flue gas - Hydrocarbon
			Chemical & other	- Alkaline - Micellar-Polymer - Microbial/foam

Reservoir Primary Recovery Mechanisms

- Primary recovery refers to the production of hydrocarbons from a reservoir by natural drive mechanisms; Without the use of any process (such as fluid injection) to supplement the natural energy of the reservoir.

- For a proper understanding of reservoir behavior and predicting future performance, it is necessary to have knowledge of the driving mechanisms that control the behavior of fluids within reservoirs.

Reservoir Primary Recovery Mechanisms

- There are basically six driving mechanisms that provide the natural energy necessary for oil recovery:

- **Rock and liquid expansion drive.**
- **Depletion drive.**
- **Gas-cap drive.**
- **Water drive.**
- **Gravity drainage drive.**
- **Combination drive.**

Reservoir Primary Recovery Mechanisms

1-Rock and Liquid Expansion:

Oil reservoirs initially exists at a high pressure, As the reservoir pressure declines, the rock and fluids expand due to their individual compressibilities.

The reservoir rock compressibility is the result of two factors:

- Expansion of the individual rock grains.
- Formation compaction.

As the expansion of the fluids and reduction in the pore volume occur with decreasing reservoir pressure, the crude oil and water will be forced out of the pore space to the wellbore.

Reservoir Primary Recovery Mechanisms

1-Rock and Liquid Expansion:

Because liquids and rocks are only slightly compressible, the reservoir will experience a rapid pressure decline.

This driving mechanism is considered the least efficient driving force and usually results in the recovery of only a small percentage of the total oil-in-place.

Reservoir Primary Recovery Mechanisms

2-The Depletion-Drive Mechanism:

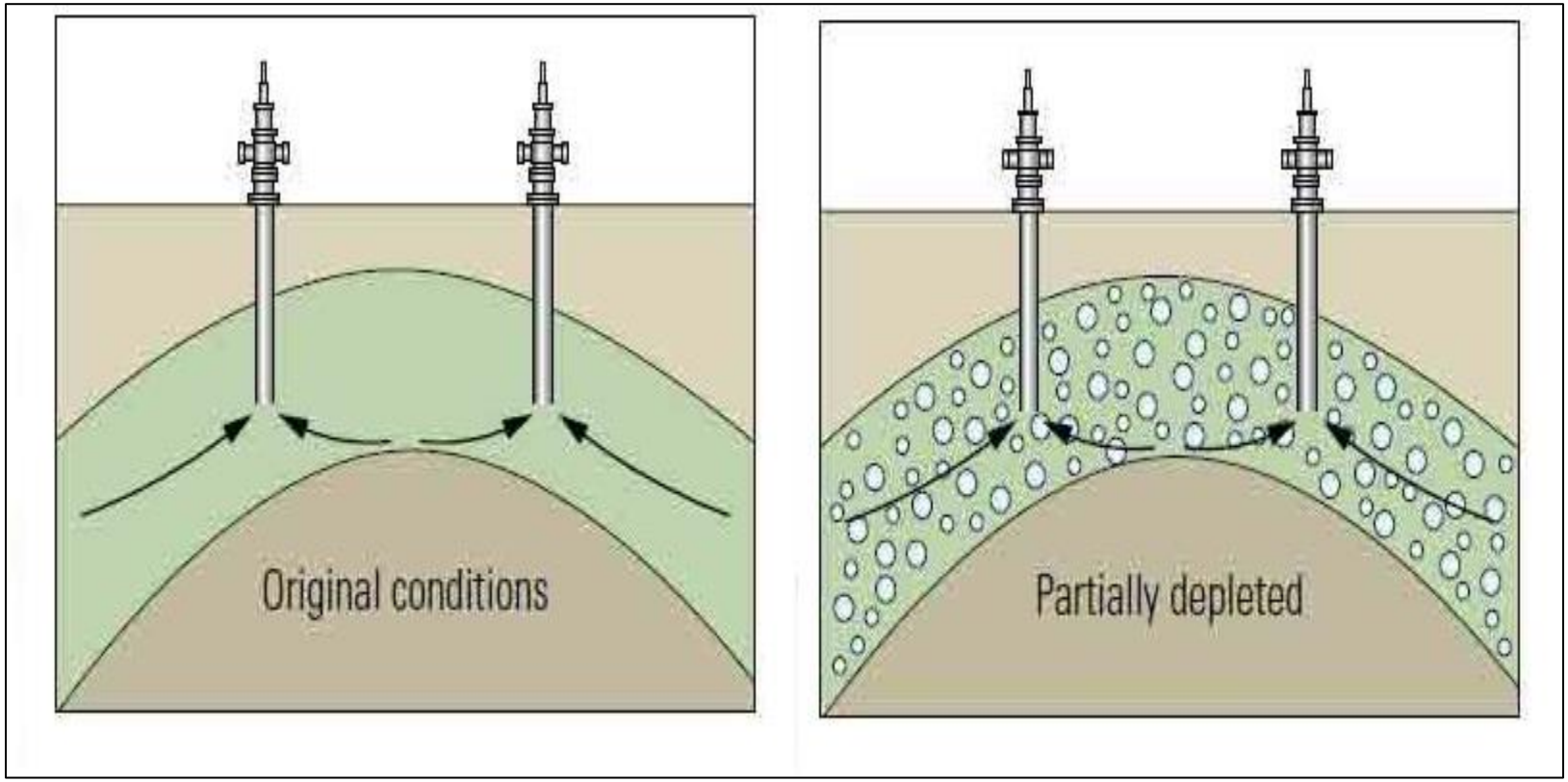
This driving form may also be referred to by various terms such as solution gas drive, dissolved gas drive, internal gas drive.

The principal source of energy is a result of gas liberation from the crude oil and the subsequent expansion of the solution gas as the reservoir pressure is reduced.

As pressure falls below the bubble-point pressure, gas bubbles are liberated within the microscopic pore spaces. These bubbles expand and force the crude oil out of the pore space.

Reservoir Primary Recovery Mechanisms

2-The Depletion-Drive Mechanism:



Reservoir Primary Recovery Mechanisms

3-Gas-Cap Drive:

Gas-cap-drive reservoirs can be identified by the presence of a gas cap with little or no water drive.

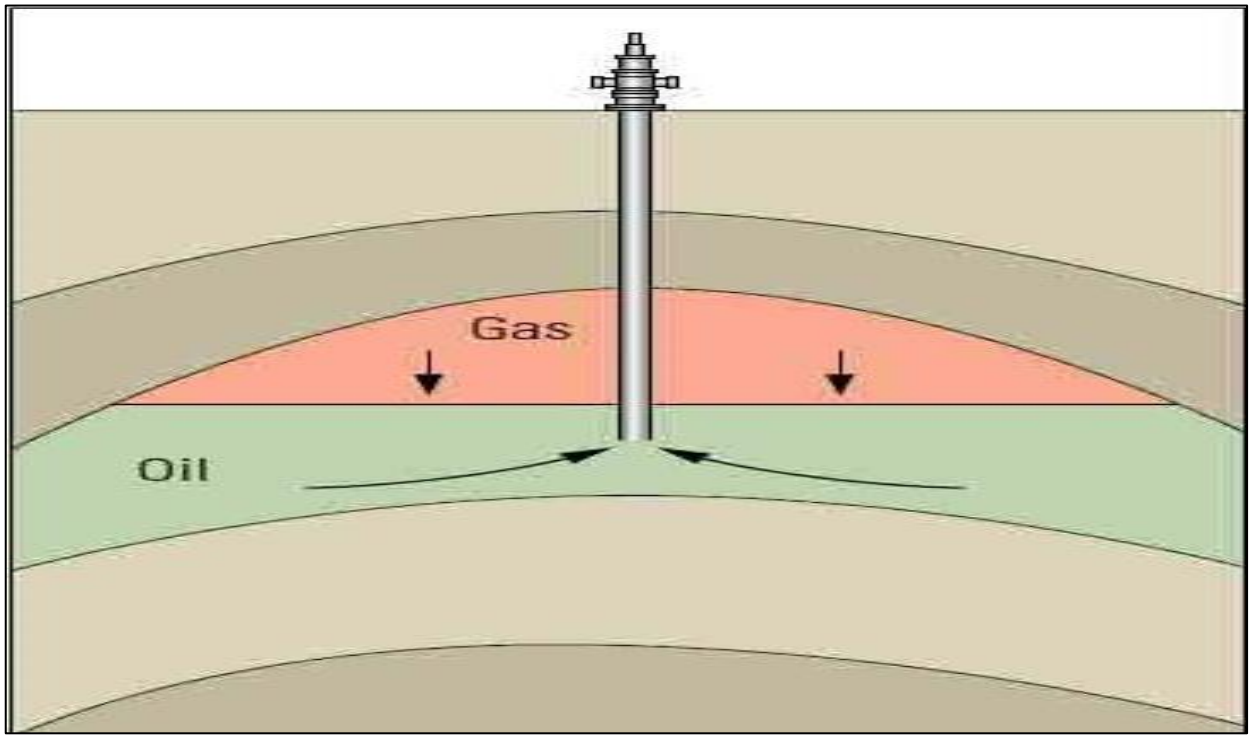
Due to the ability of the gas cap to expand, these reservoirs are characterized by a slow decline in the reservoir pressure.

The natural energy available to produce the crude oil comes from the following two sources:

- Expansion of the gas-cap gas.
- Expansion of the solution gas as it is liberated

Reservoir Primary Recovery Mechanisms

3-Gas-Cap Drive:



Reservoir Primary Recovery Mechanisms

4-The Water-Drive Mechanism:

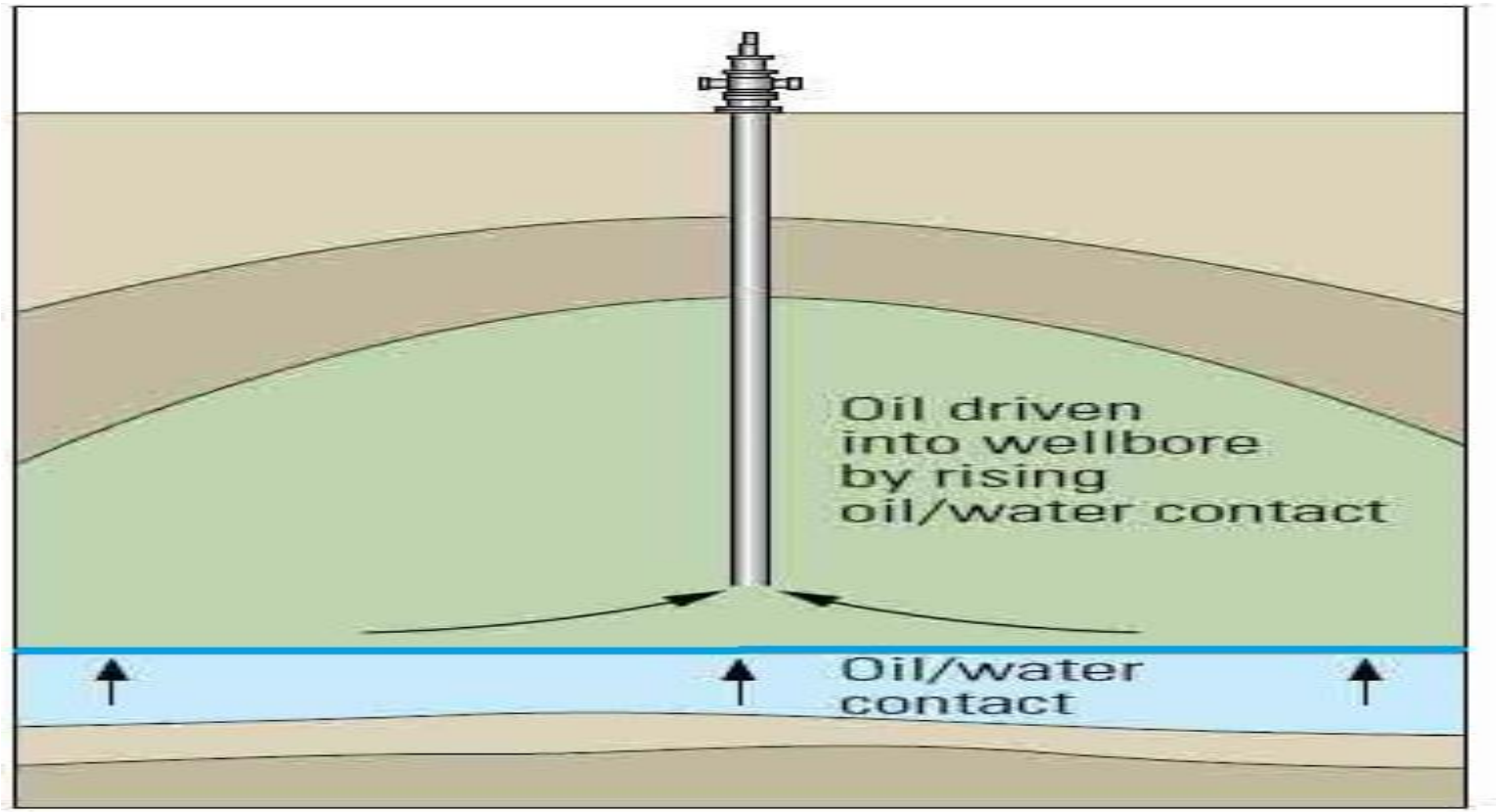
Many reservoirs are bounded on a portion or all of their peripheries by water bearing rocks called aquifers.

As oil is produced, pressure declines at the point where oil is withdrawn from the reservoir. Water then moves in to replace the oil as it is produced because of expansion of the minutely compressed water.

Many of the most important reservoir in the world are producing by energy supplied by water drives.

Reservoir Primary Recovery Mechanisms

4-The Water-Drive Mechanism:



Reservoir Primary Recovery Mechanisms

5-The Gravity-Drainage-Drive Mechanism:

The mechanism of gravity drainage occurs in petroleum reservoirs as a result of differences in densities of the reservoir fluids.

The effects of gravitational forces can be simply illustrated by placing a quantity of crude oil and a quantity of water in a jar and agitating the contents.

After agitation, the jar is placed at rest, and the denser fluid (normally water) will settle to the bottom of the jar, while the less dense fluid (normally oil) will rest on top of the denser fluid. The fluids have separated as a result of the gravitational forces acting on them.

Reservoir Primary Recovery Mechanisms

5-The Gravity-Drainage-Drive Mechanism:

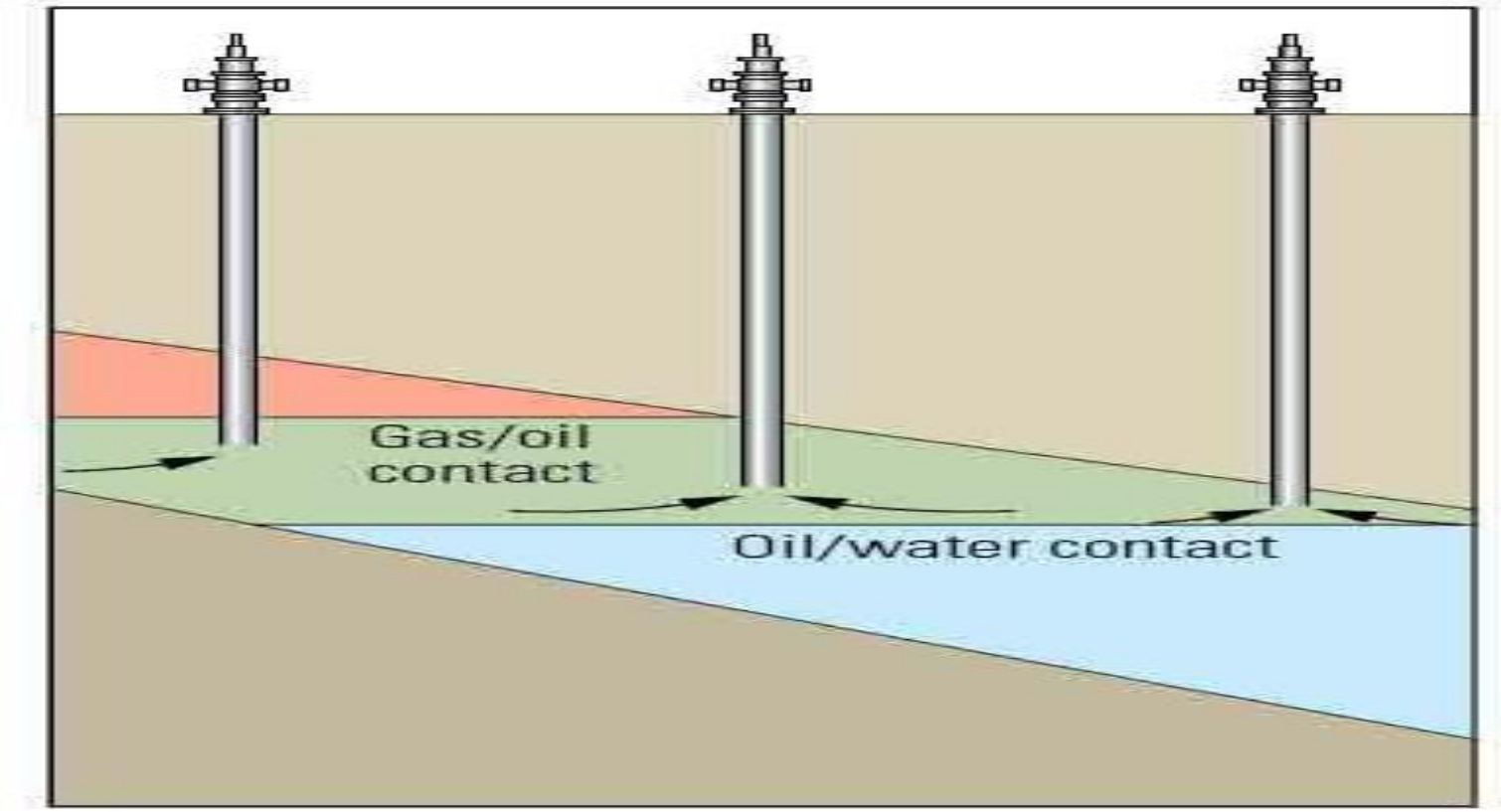
The fluids in petroleum reservoirs have all been subjected to the forces of gravity, as evidenced by the relative positions of the fluids, i.e., gas on top, oil underlying the gas, and water underlying oil.

Due to the long periods of time involved in the petroleum accumulation-and-migration process, it is generally assumed that the reservoir fluids are in equilibrium.

Gravity segregation of fluids is probably present to some degree in all petroleum reservoirs, but it may contribute substantially to oil production in some reservoirs.

Reservoir Primary Recovery Mechanisms

5-The Gravity-Drainage-Drive Mechanism:



Reservoir Primary Recovery Mechanisms

6-The Combination-Drive Mechanism:

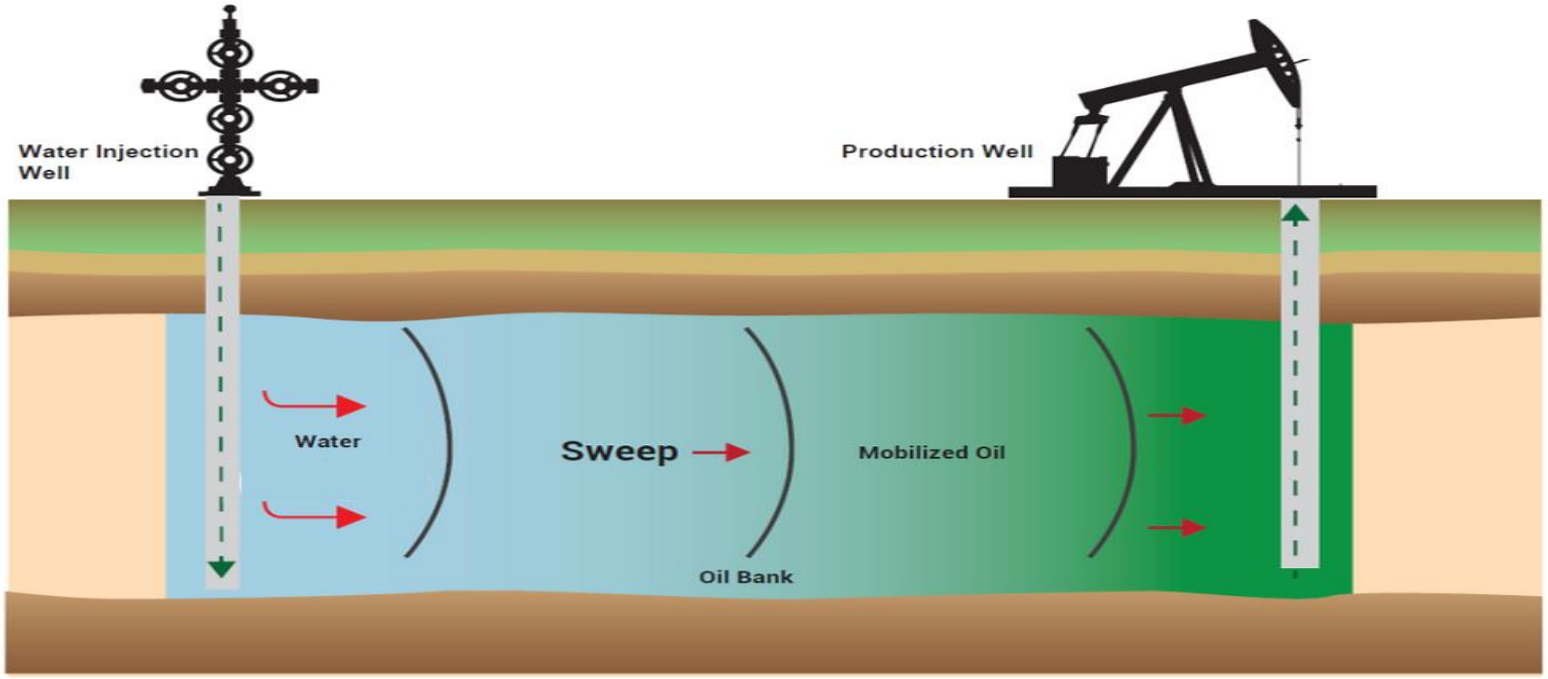
Reservoirs are seldom found to fit exactly one type of drive classification.

The most common type of drive encountered, is a combination drive.

Production problems are exceedingly complicated because of the infinite number of combinations characterizing the various reservoirs occurring naturally.

Reservoir Secondary Recovery Mechanisms

When natural drive energy is depleted or too small for economic oil recovery, energy must be added to the reservoir to permit additional oil recovery. That additional energy is usually in the form of injected water or gas Reinjection.



Reservoir Tertiary Recovery Mechanisms

when secondary recovery is no longer economic, supplemental energy of a different kind permits additional oil recovery.

Enhanced fluid flow conditions within the reservoir are usually induced by addition of heat, chemical interaction between the injected fluid and the reservoir oil, mass transfer, and/or changing of oil properties in such a way that the process facilitates oil movement through the reservoir.

Tertiary recovery processes generally include thermal, chemical, gas miscible and microbial.

They are also often referred to as enhanced oil recovery (EOR) processes.