— University of Mosul —
College of Petroleum & Mining Engineering

Enhanced Oil Recovery Processes

Fourth Year

Lecture 3

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Secondary oil recovery:

Secondary hydrocarbon (oil and / or gas) recovery involves the introduction of artificial energy into the reservoir via one wellbore and production of oil and / or gas from another wellbore. Usually, this is recovery driven by the injection of water or gas from the surface. Secondary recovery refers to the volume of hydrocarbons produced as a result of the addition of energy into the reservoir, such as fluid injection, to increase the original energy within the reservoir. The most common fluid injected is water because of its availability, low cost, and high specific gravity which facilitates injection.

When oil production declines because of hydrocarbon production from the formation, the secondary oil recovery process is employed to increase the pressure required to drive the oil to production wells. The mechanism of secondary oil recovery is similar to that of the primary oil recovery except that more than one wellbore is involved, and the pressure of the petroleum reservoir is maintained artificially to force oil to the production wells. Two techniques are commonly used:

1- Water flood process
2- Gas flood process

Injection well location

The relative location of injection and production wells depends on the geology of the reservoir, its type, and the volume of hydrocarbon – bearing rock required to be swept in a time limited by economics.

There are two types of injection well location:

a- Central and peripheral flooding, in which the injectors are grouped together.

b- Pattern flooding, in which the injectors are distributed amongst the production wells.

1- Central and peripheral flooding:

This type of injection occurs in the following cases:

a- reservoir with a gas-cap in which gas injection is taking place. If the reservoir is a fairly regular anticlinal structure, the injection wells are normally grouped in a cluster around the top of the anticline (Figure 14.11).

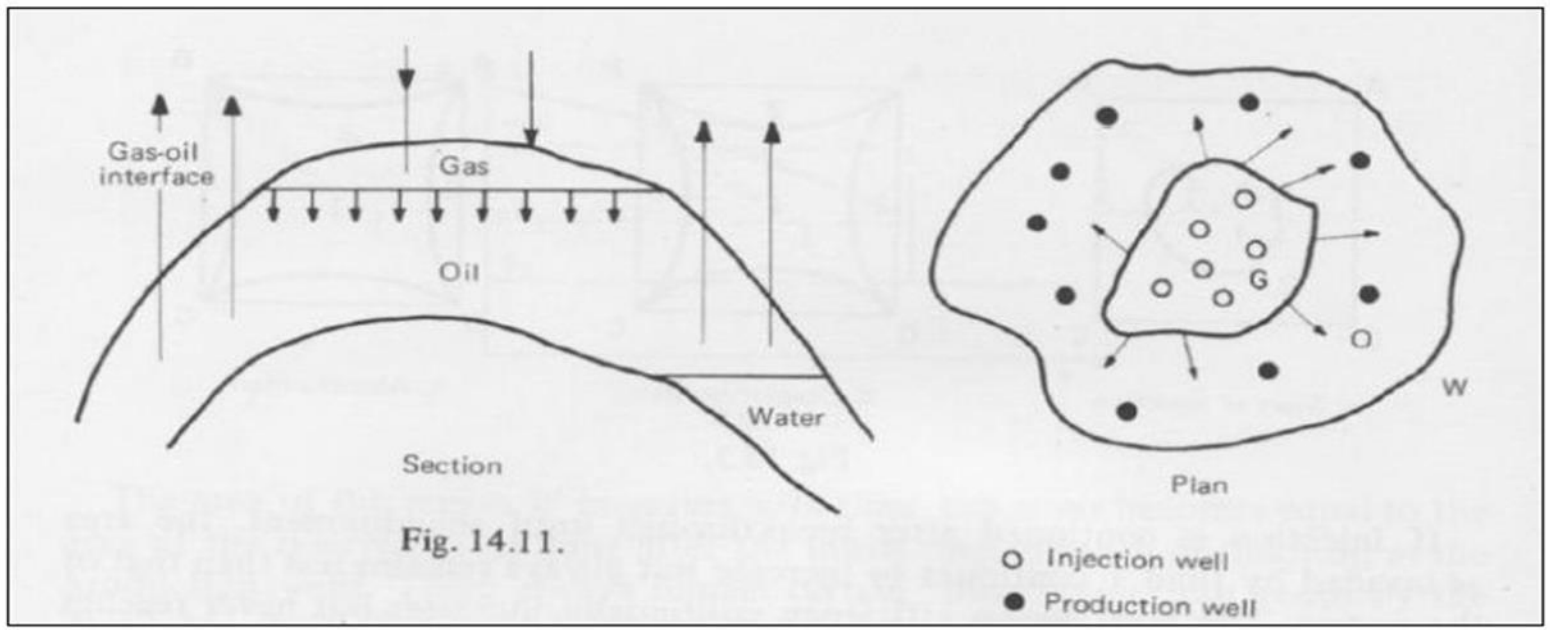

Fig. 14.11.

b- Anticlinal reservoir with an underlying aquifer in which water injection is taking place. In this case the injectors will form a ring around the reservoir (Figure 14.12).

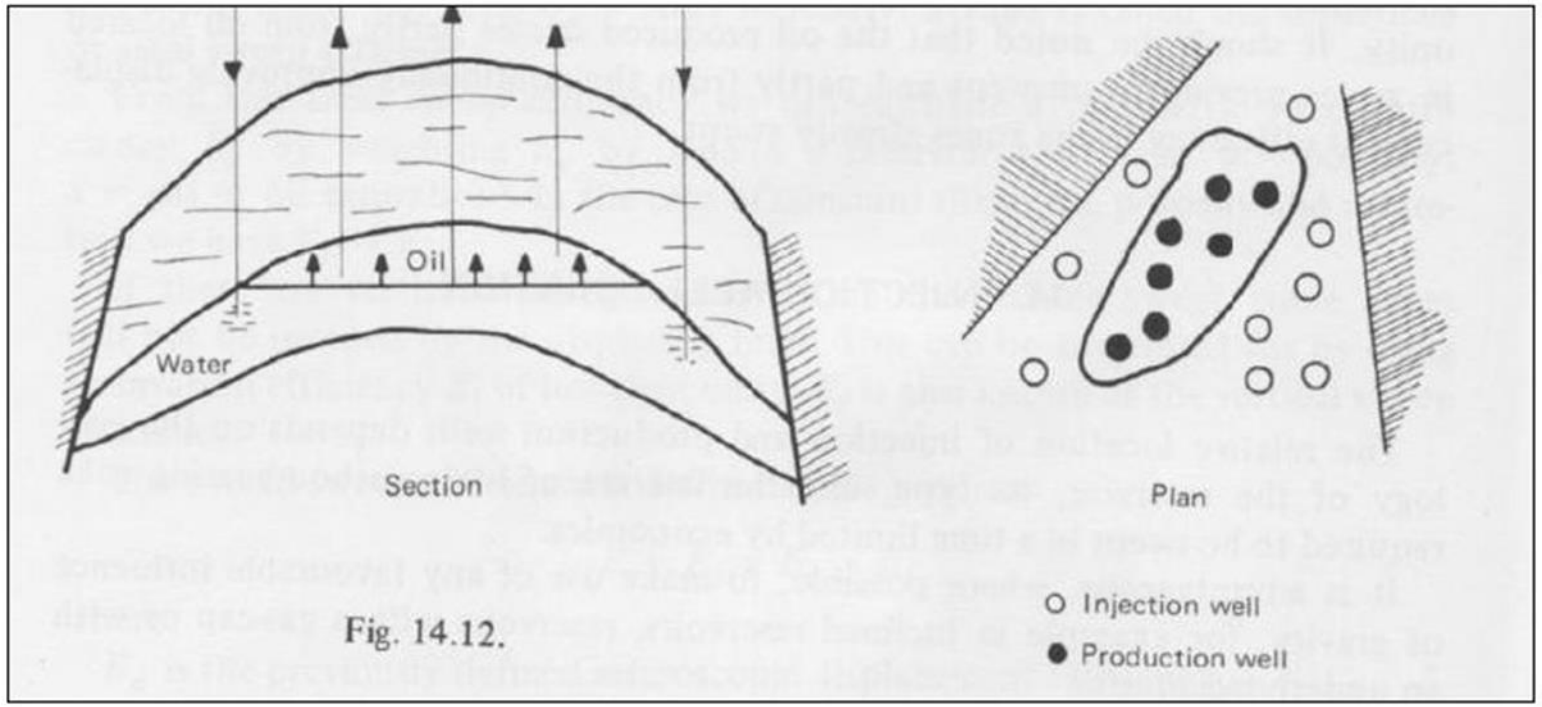

Fig. 14.12.

c- Monoclinal reservoir with gas-cap or aquifer undergoing gas or water injection. The injectors are grouped in one or more lines located towards the base of the reservoir in the case of water injection, towards the top in the case of gas injection (Figure 14.13).

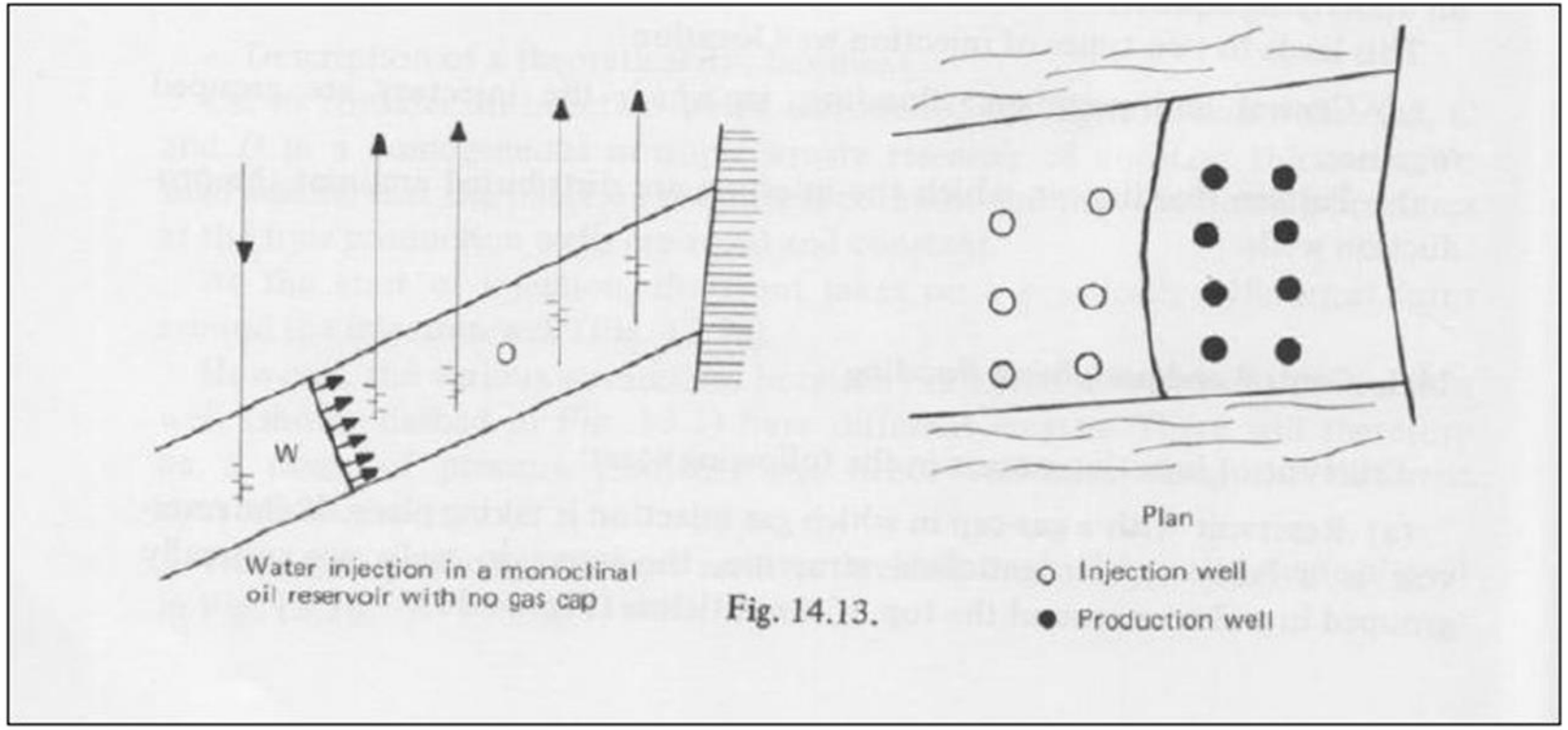

Fig. 14.13.

2- Pattern flooding

Pattern flooding is principally employed in reservoirs having a small dip and a large surface area. In order to ensure a uniform sweep the injection wells are distributed amongst the production wells. This is done either by converting existing production wells into injectors or by drilling infill injection wells. In both cases, the aim is to obtain as uniform a distribution of wells as was used for the natural recovery phase.

The most common patterns are the following:

a- Direct line drive:

The lines of injection and production wells are directly opposed (Figure 14.21). The system is characterised by the two parameters:

- Spacing between wells of the same type.
- Spacing between lines of injection and production wells.

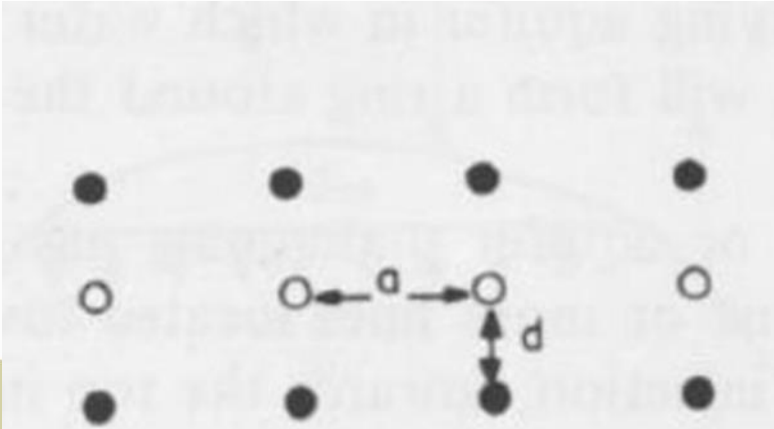

Fig. 14.21.

b- Staggered line drive

The wells are in lines as before, the injectors and producers being no longer directly opposed but laterally displaced, normally by a distance of a/2.

c- Five-spot

This is a particular case of staggered line drive in which d/a = ½, and is the most well known pattern (Figure 14.22). Each injection well is located at the centre of a sequare defined by four production wells. In patterns a, b and c, the injection and production wells are equal in number.

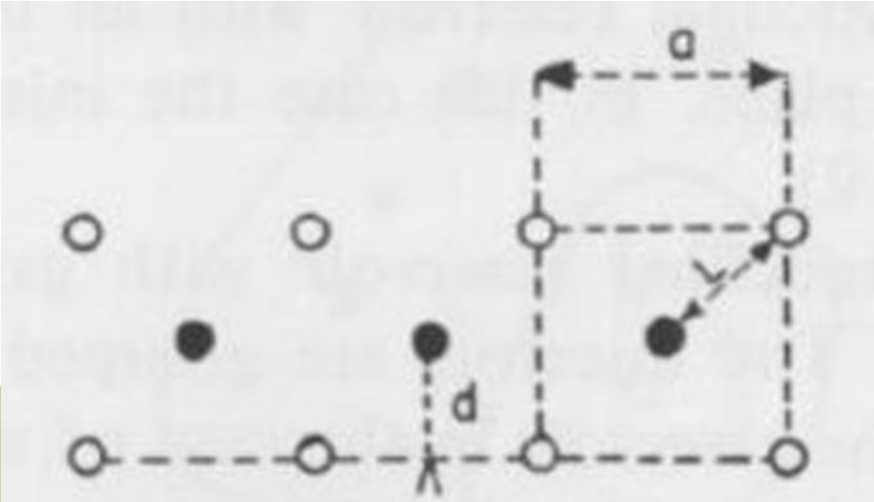

Fig. 14.22.

d- Seven-spot

The injection wells are located at the corners of a hexagon with a production well at its centre (Figure 14.23).

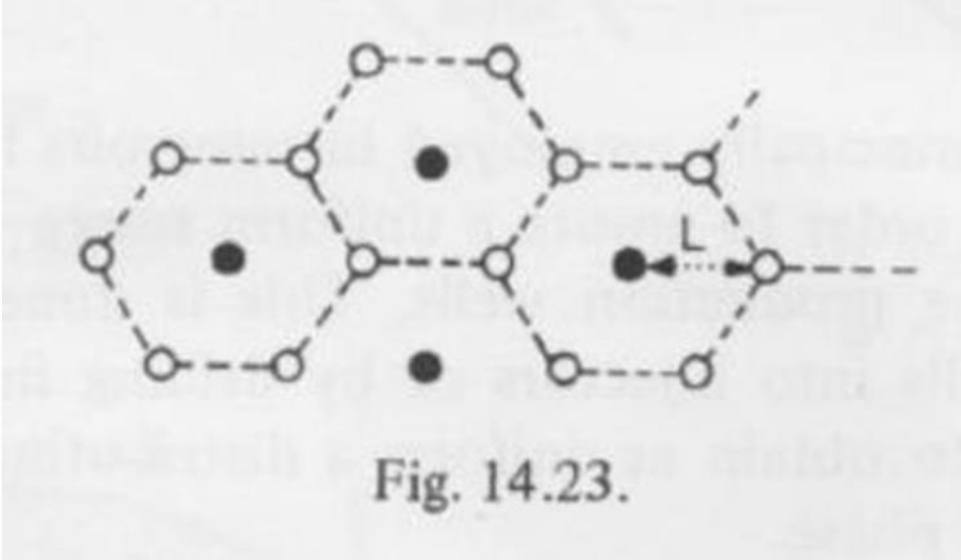

Fig. 14.23.

e. Nine-spot

The pattern is similar to that of a five-spot, but with extra injection well drilled at the middle of each side of the square