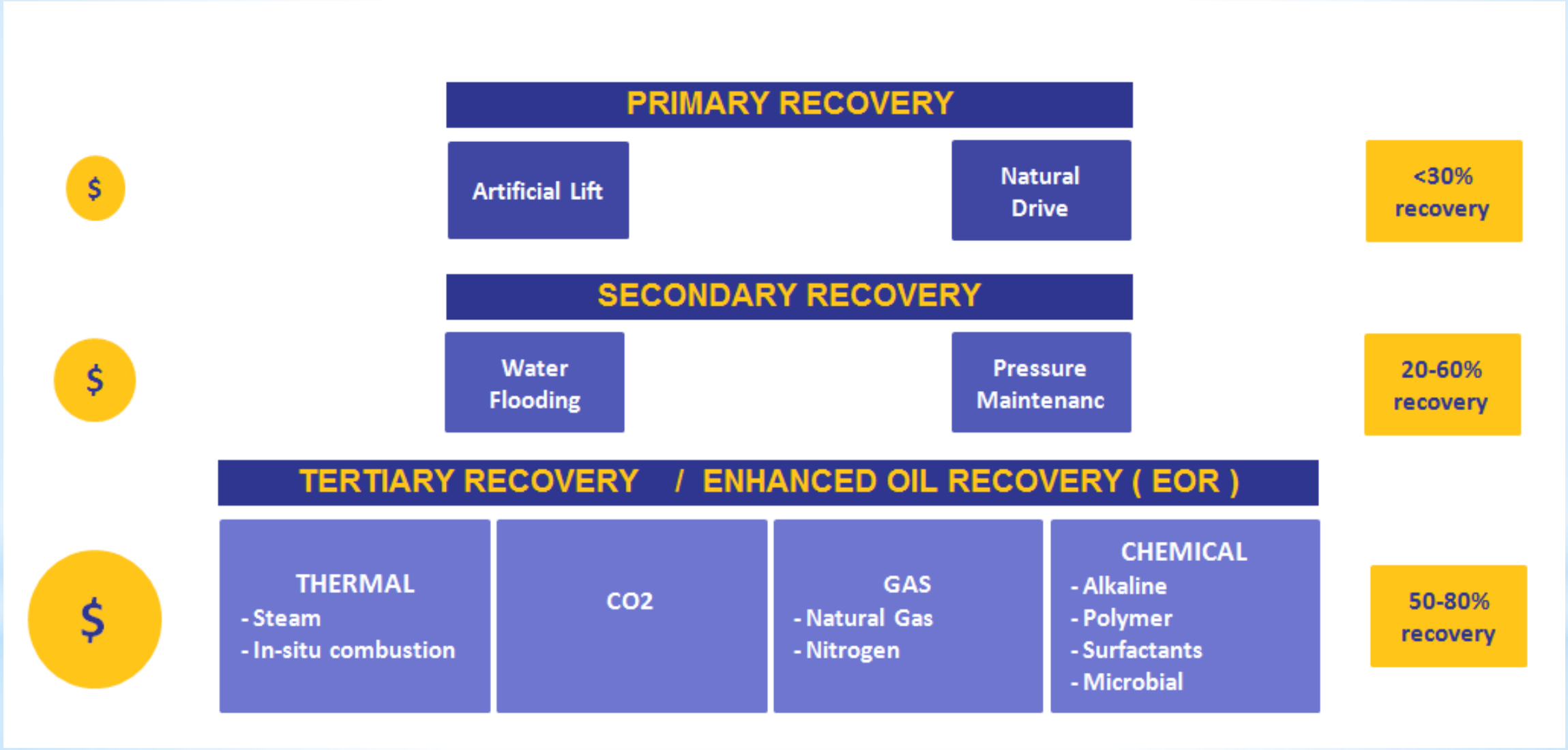
Lecture 10-11-12
CHARACTERIZE THE METHODS OF ENHANCED OIL RECOVERY

* OIL RECOVERY CONSISTS OF THE FOLLOWING

- Primary recovery, using only the natural energy of reservoirs, typically recovers up to 50% of OOIP (average 19%)

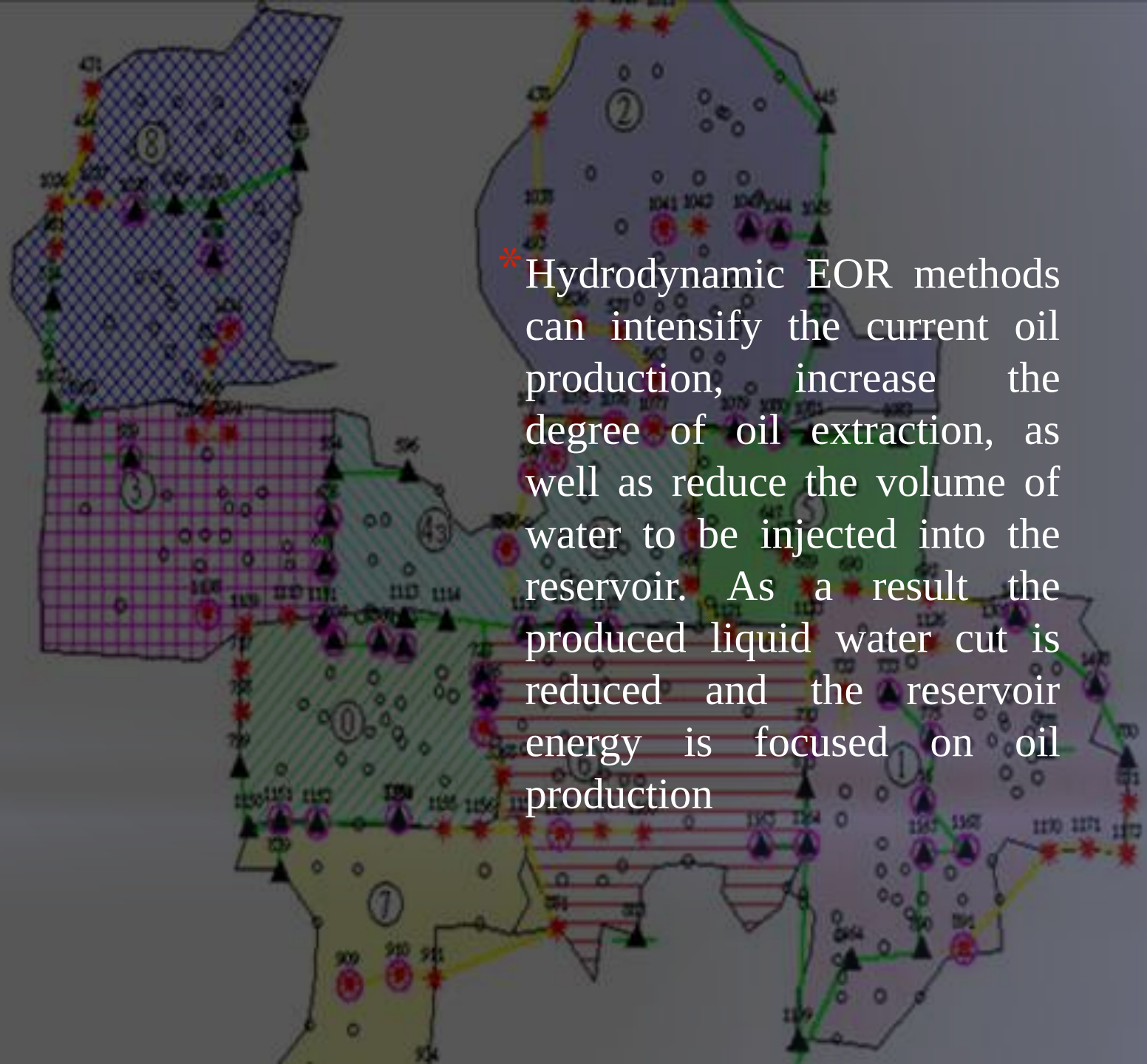
- Secondary recovery involves adding energy to the natural system by injecting water to maintain pressure and displace oil (also known as waterflood). Typical recoveries are 25-45% OIP after primary recovery (average 32%)

- Tertiary recovery includes all other methods used to increase the amount of oil recovered. Typical recoveries are 5-20% of OIP after primary and secondary recovery (average 13%).


PRIMARY RECOVERY
$
Artificial Lift
Natural Drive
<30% recovery
SECONDARY RECOVERY
$
Water Flooding
Pressure Maintenanc
20-60% recovery
TERTIARY RECOVERY / ENHANCED OIL RECOVERY (EOR)
$
THERMAL
- Steam
- In-situ combustion
CO2
GAS
- Natural Gas
- Nitrogen
CHEMICAL
- Alkaline
- Polymer
- Surfactants
- Microbial
50-80% recovery

* Hydrodynamic EOR

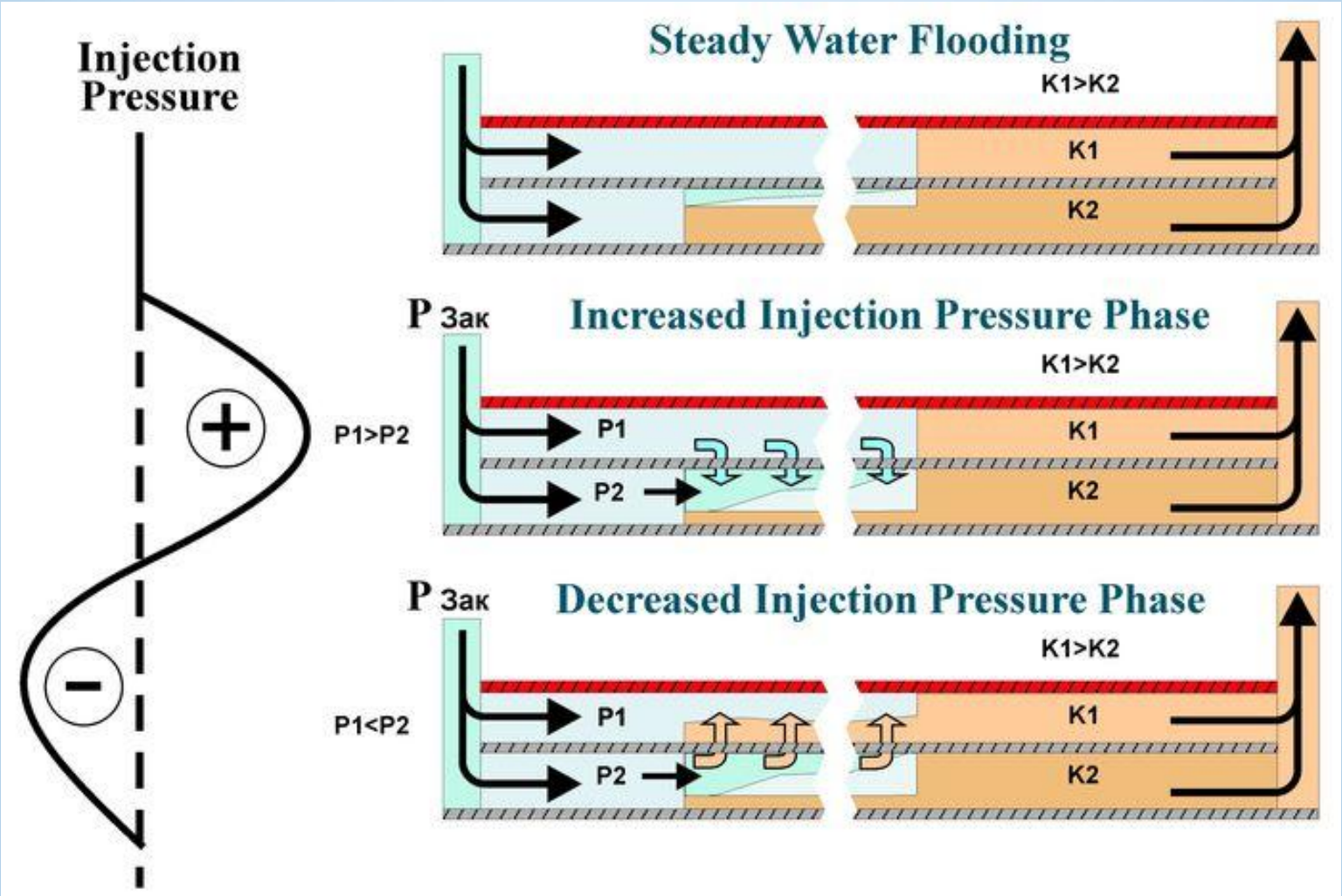
- Integrated displacement technologies;
- Development of by-passed oil reserves;
- Barrier flooding;
- Non-stationary (cyclical) flooding;
- Accelerated production;
- Stepwise-Thermal flooding.



* Hydrodynamic EOR methods can intensify the current oil production, increase the degree of oil extraction, as well as reduce the volume of water to be injected into the reservoir. As a result the produced liquid water cut is reduced and the reservoir energy is focused on oil production

*Integrated technologies

- Integrated technologies make in a separate EOR group and do not belong to the conventional water-flood methods applied to maintain oil formation pressure. These methods are aimed at selective intensification of oil production .
- The production growth is achieved due to vertical flows in homogeneous formation through low-permeable girts from low-permeable layers into high-permeable layers due to a special injection programs utilizing unsteady effects


Injection Pressure
+
−
Steady Water Flooding
K1>K2
K1
K2
P Зак
Increased Injection Pressure Phase
P1>P2
P1
P2
K1>K2
K1
K2
P Зак
Decreased Injection Pressure Phase
P1<P2
P1
P2
K1>K2
K1
K2

* Barrier flooding &Accelerated production

- Development of oil and gas fields is often accompanied by breakthrough of gas to the face of producing wells, which greatly complicates their operation due to high gas factor. The essence of the barrier flooding is that the injection wells are located in the zone of gas-oil contact. Water injection and oil&gas production are synchronized in such a special way to exclude the mutual cross-flows of oil in the gas formation area, and gas in the oil area.
- Accelerated production of liquids is usually applied at late stages of oil field development, when water cut is more than 75%. This increases oil recovery due to an increase in pressure differential and filtration speed. Areas previously not covered by the flooding are now involved in the development process as well as in the membrane separation of oil from the surface of rocks.

* Non-stationary (cyclical) flooding

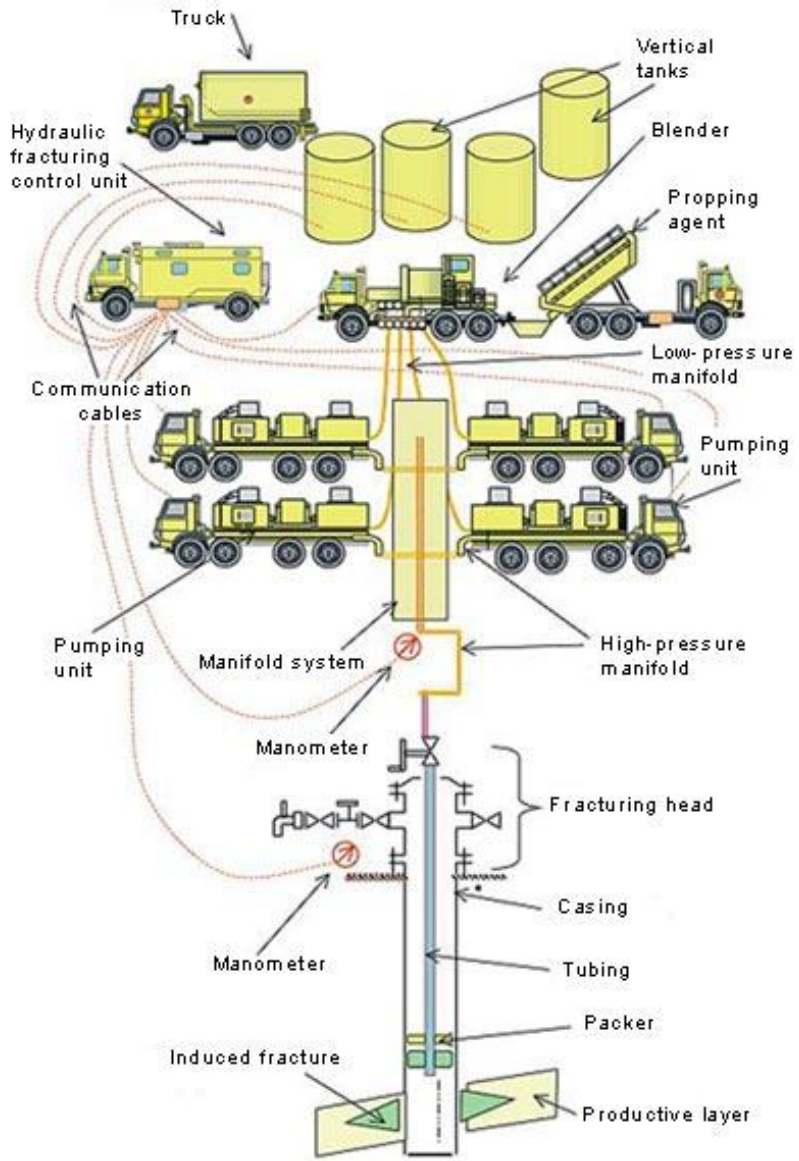
- During injection cyclic impact and the change in reservoir fluid flow directions different pressure is created in the layers with heterogeneous pore sizes, zone permeability and different oil saturation. This is achieved by changing the volume of water injection or selection of the injected liquid type.
- As a result of such non-stationary, time-varying effects of periodic waves of high and low pressure occur in the reservoir. Layers, zones and areas of low permeability and oil saturation have low conductance, and the speed of pressure spread in them is much lower than in the high permeability, saturated layers, zones and areas. Therefore, opposite pressures occur between oil-saturated and flooded areas. When the pressure in the formation rises, i.e. with the increase of water injection positive pressure difference occurs, i.e. the pressure is higher in the flooded areas and lower in oil-saturated areas.
- Redistribution of fluids in non-uniformly saturated formation under the action of alternating pressure changes takes place

* **The mainly applied Oil Production Intensification methods are as follows:**

a. Hydraulic fracturing;
b. Horizontal wells;
c. Electromagnetic treatment;
d. Wave treatment.

* Hydraulic fracturing

* Hydraulic fracturing is creating cracks in the rocks surrounding the borehole, due to the pressure at the well bottom as a result of viscous fluid injection into the rock. Viscous liquid is injected into the well at a rate which ensures the creation of downhole formation cracks.
* These cracks have vertical and horizontal orientation. The length of the crack sometimes reaches tens of meters, the width of it is usually about few mm or cm. After fracturing a mixture of viscous liquid with solid particles in it to prevent the closing of cracks under the action of rock pressure is pumped into the well.
* Hydraulic fracturing of formation is performed in low-permeability formations where the individual zones and intercalations are not engaged into active development which reduces possible oil recovery .
* Cracks, crossing the poorly drained areas and interlayers provide better production As a result oil is more easily flowing from the formation first into a hydraulic fracture and then to the well, thus increasing oil recovery


Truck
Vertical tanks
Blender
Hydraulic fracturing control unit
Propping agent
Low- pressure manifold
Communication cables
Pumping unit
Pumping unit
Manifold system
High-pressure manifold
Manometer
Fracturing head
Casing
Manometer
Tubing
Packer
Induced fracture
Productive layer

Horizontal wells

* The use of horizontal drilling has well established itself in the following increasing number of unprofitable wells: wells with marginal or watering oil and inactive emergency wells in the transition to more advanced stages of oil field development, when watering or reduce in formation pressure in many developed areas (especially in lithologically heterogeneous, difficult formation zones) is ahead of reserve recovery under the existing density of the production well grid.

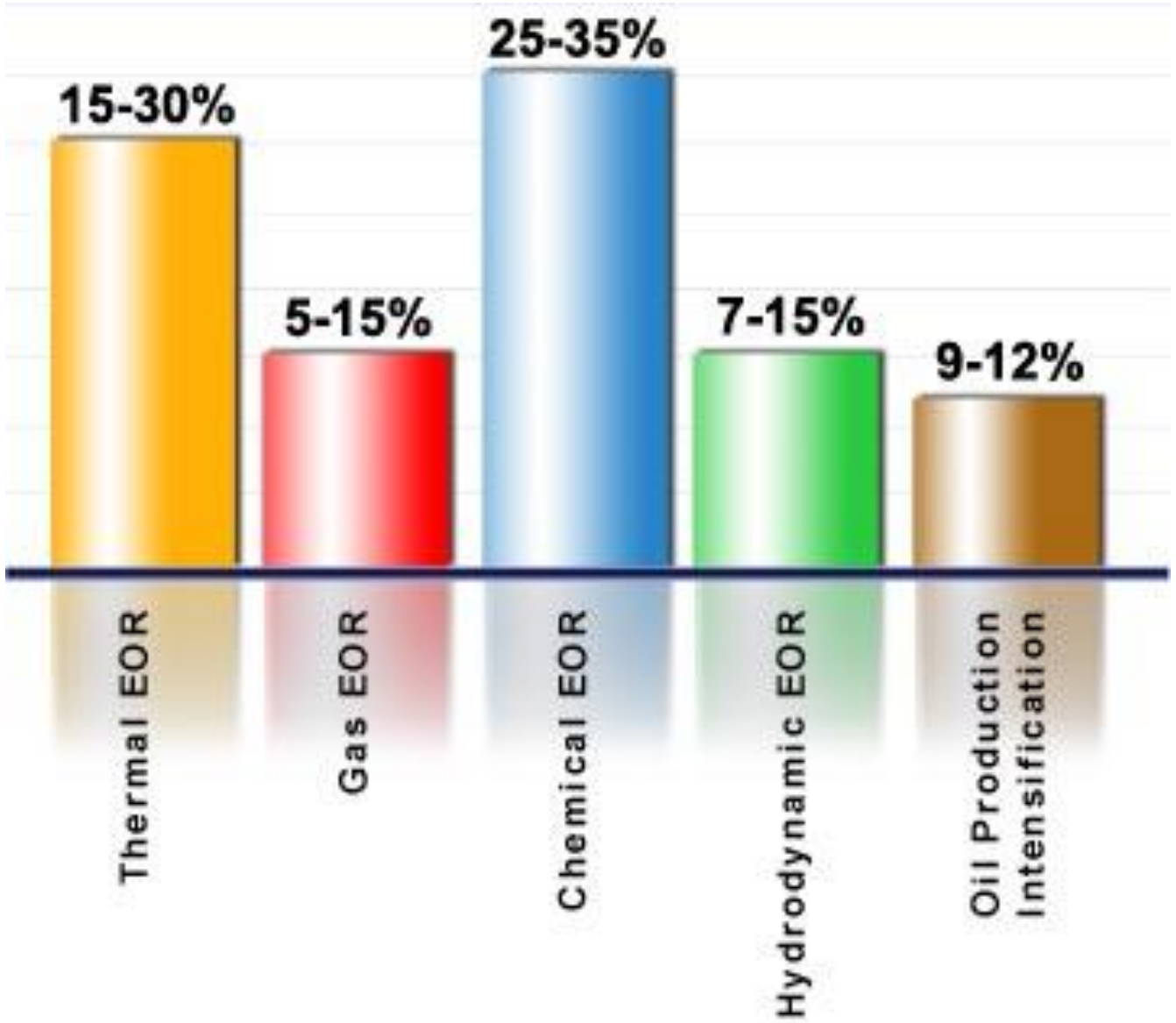
Electromagnetic treatment

* This method is based on the use of internal sources of heat, activated as a result of high frequency electromagnetic fields stimulation. The zone of influence is determined by the method of creation (in one well or between several of them), intensity and frequency of the electromagnetic field, as well as the electrical properties of the formation. In addition to the thermal effects electromagnetic exposure results in oil de-emulsification, reduce the onset temperature of paraffin crystallization and the appearance of additional pressure gradients due to the force effect of electromagnetic fields on the formation fluid.

*Wave treatment

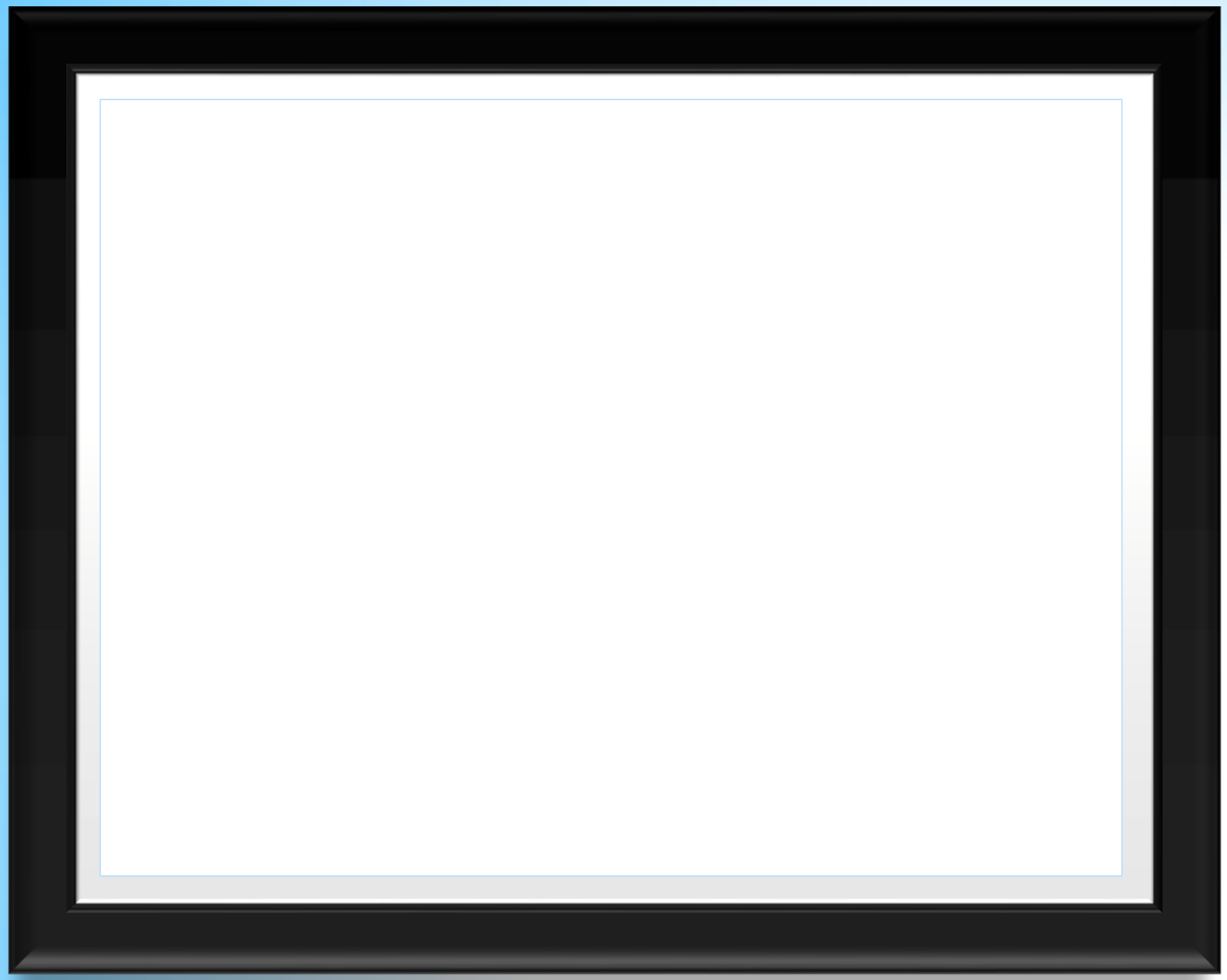
- There are several types of wave and termowave (vibration, shock, pulse, thermoacoustic) treatment of the oil-bearing formations and first of all on its bottom-hole zone.
- The main purpose of the technology is to develop low permeability and isolated formation areas by the influence of elastic waves which damp in high permeability formation areas but travel considerable distances and with sufficient intensity to put on production low permeability areas of the formation.
- Application of these methods results in a noticeable intensification of filtration processes in formation and for some period of time increase oil output. The positive effect of wave action is found both in directly treated well and in some wells situated at a considerable distance from the waxe source up to hundreds of meters or more, i.e. the wave treatment can be realized both locally and at a distance

- All the methods mentioned above are characterized by varying potential of enhanced oil recovery.
- For example, oil recovery index using thermal methods is about 15-30%, gas methods is around 5-15%, chemical methods is about 25-35%, physical methods is around 9-12%, hydrodynamic methods make 7-15%.

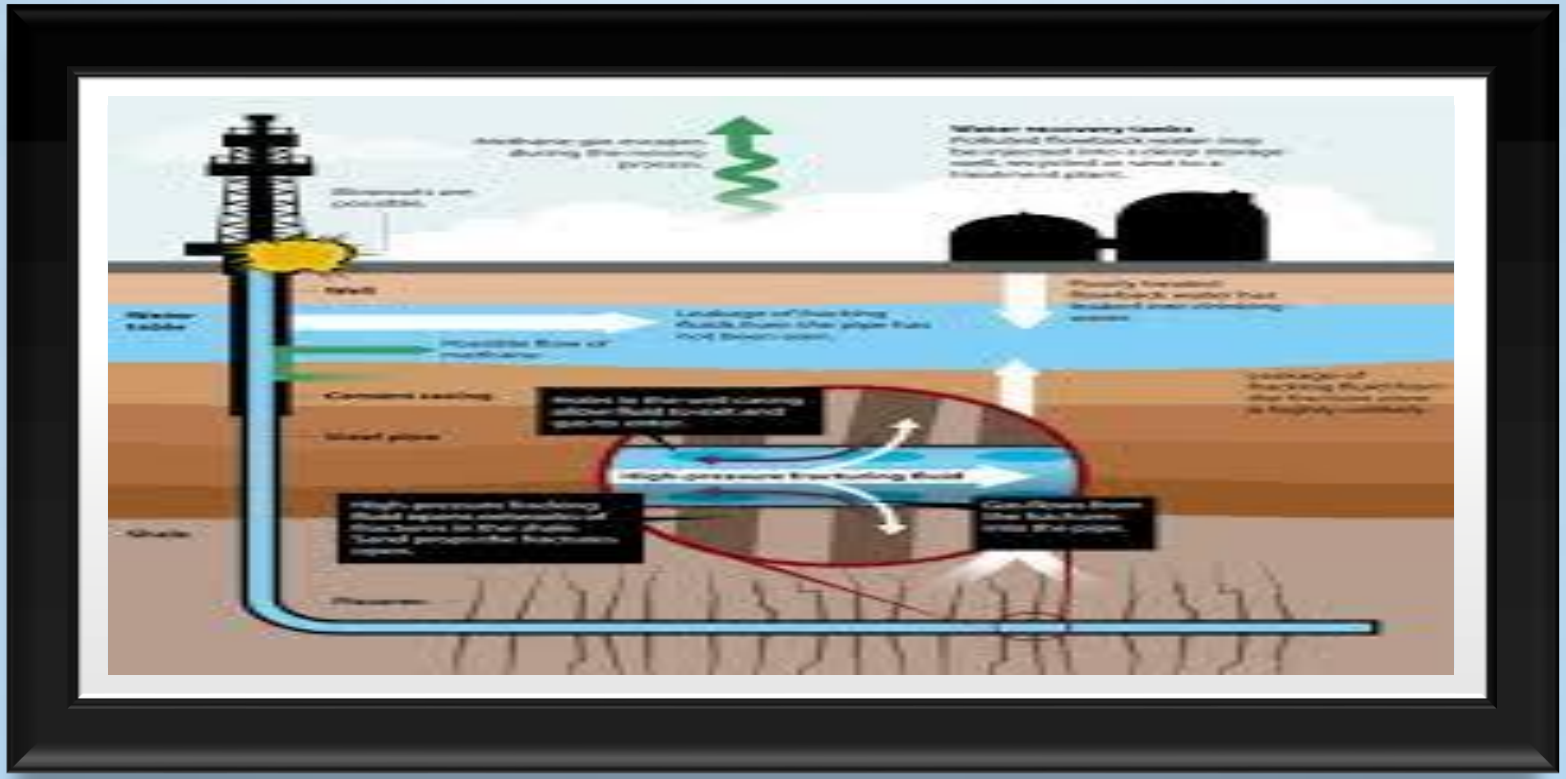

15-30%
5-15%
25-35%
7-15%
9-12%
Thermal EOR
Gas EOR
Chemical EOR
Hydrodynamic EOR
Oil Production Intensification

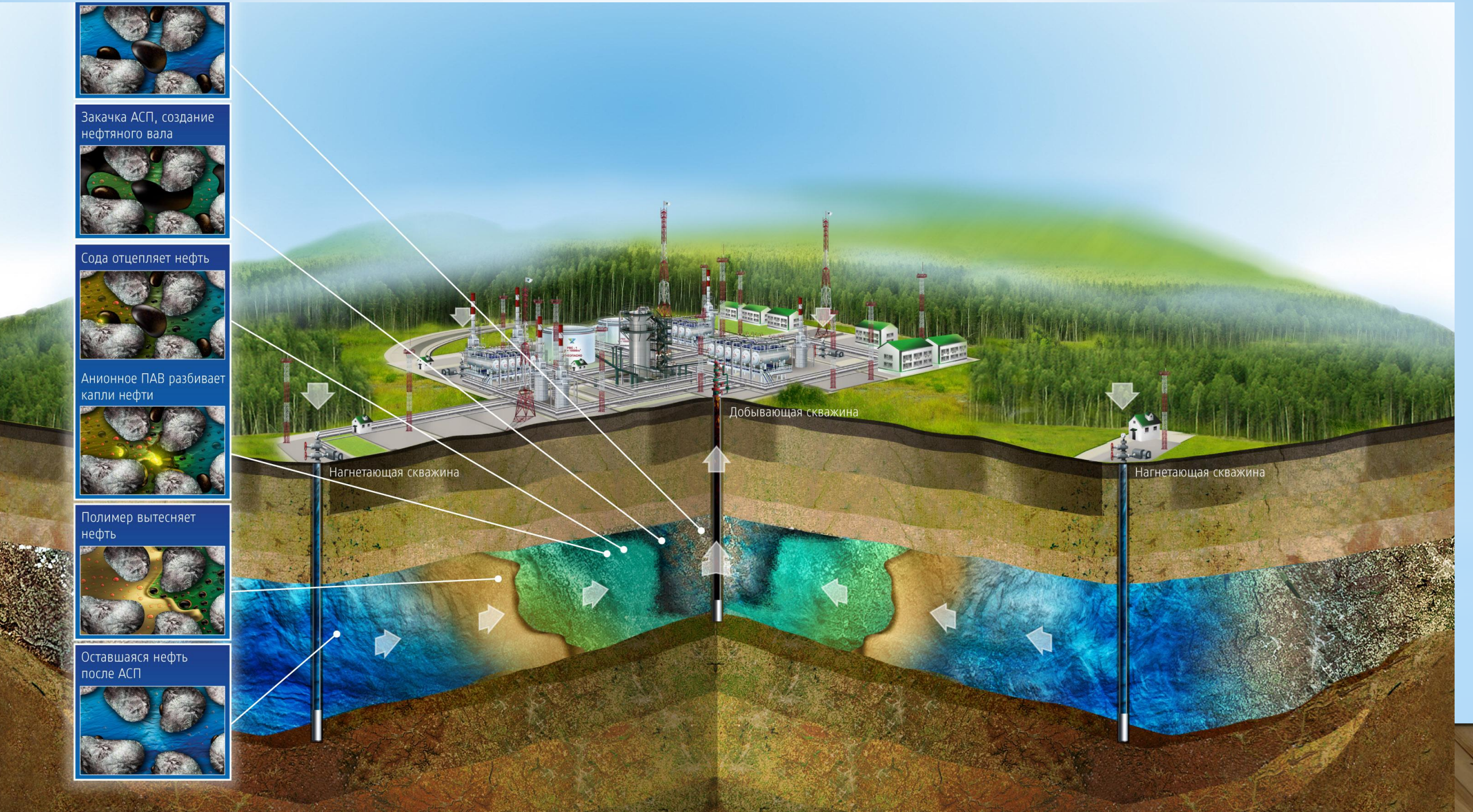
* Experience of using EOR FOR HYDRODYNAMIC methods in the world

* World oil consumption is growing continuously; over the past 20 years the average increase in oil consumption reached up to 1.45% per year. During this period there were years when oil production fell, but the general trend was to increase oil production.



*World Oil Production with the use of EOR methods, 2017


Well
Water table
Cement casing
Shale
High-pressure fracturing fluid


Закачка АСП, создание нефтяного вала
Сода отцепляет нефть
Анионное ПАВ разбивает капли нефти
Полимер вытесняет нефть
Оставшаяся нефть после АСП
Нагнетающая скважина
Добывающая скважина
Нагнетающая скважина

*Conclusions

*This approach to development of reservoirs comprising connected reservoirs allows for complete or partial isolation of reservoirs and thus solving the problem of inter-reservoir cross flows. Creation of the formation isolation reservoir ensures increased completion of the low-permeability reservoir drainage in water flooding and, accordingly, increased cumulative oil production . Relaxation in the requirements to the quality of flood water at the time of creation of the low-permeability screen between the reservoirs allows for reduction in water treatment costs. The investigated method of enhancing oil recovery is proposed for use at the later stage of development, when water content of the product is at least 75-85%, for the purpose of reducing any possible effect on recovery of residual reserves of the high-permeability reservoir due to decrease in injection capacity. This method may be applied in the wide range of reservoir temperatures and pressures. Method efficiency depends on a number of factors, including the ratio of reservoir permeability, water content of the product and ratio of thicknesses of productive reservoirs. Successful implementation of this technology requires early laboratory testing, using core samples taken from each productive reservoir.

References

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Q&A