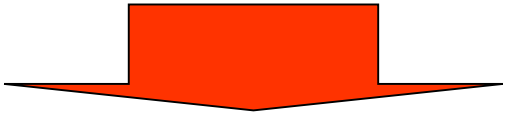
Migration

Velledits Felicitász

Migration

- Migration is essential because most source rock is too fine grained to enable easy extraction of the oil.
- Newly generated HC is too dispersed (in the form of small droplets) in the source rocks.
- Source rock consists of too fine grained rock, it has no permeablity.

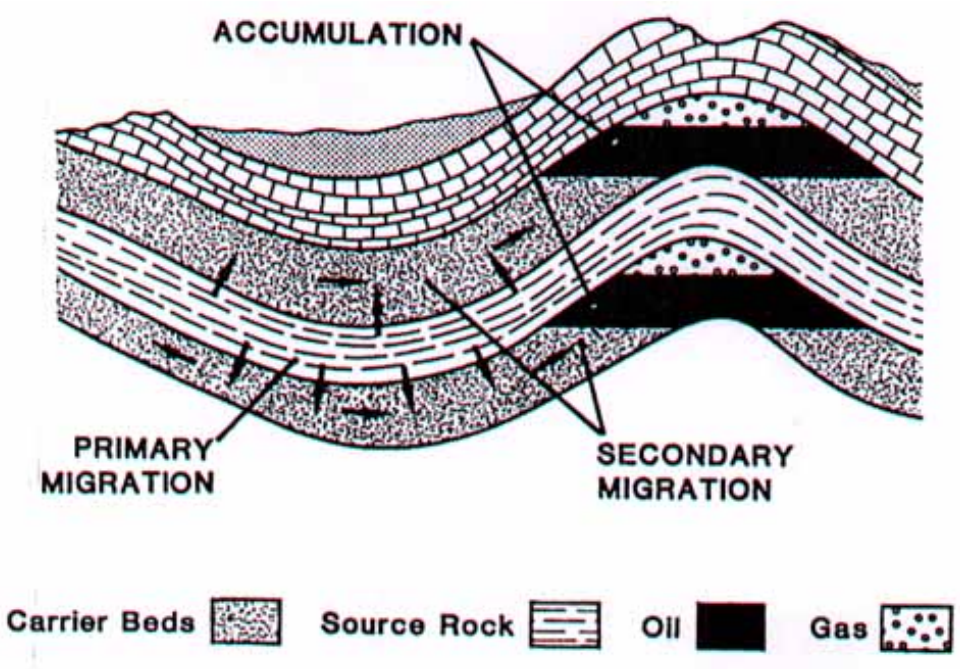


- HC can’t be produced from the source rocks.
- **Migration**: source rock → carrier rock → reservoir rock: HC concentrates in a rock with high porosity and permeability → from which HC is extractable.

Types of migration

- ***Primary migration:*** expulsion from the fine-grained source rock
- ***Secondary migration:*** movement in carrier beds

  Tertiary migration: movement of a previously formed oil and gas accumulation

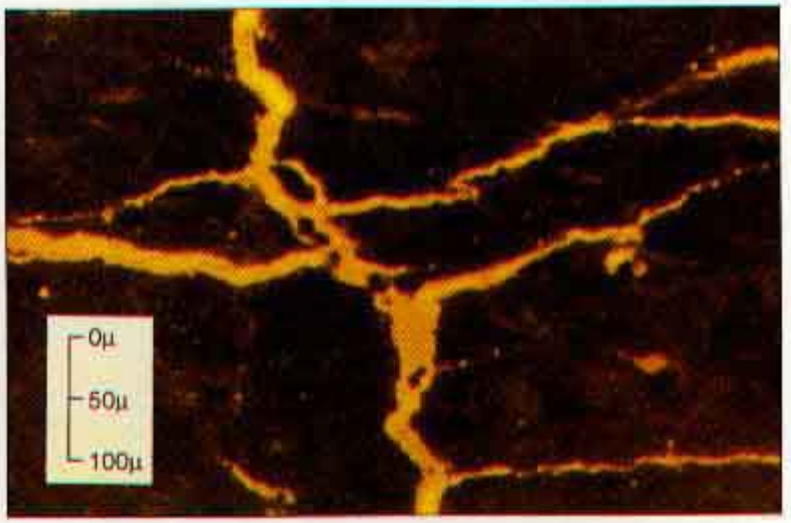


Migration

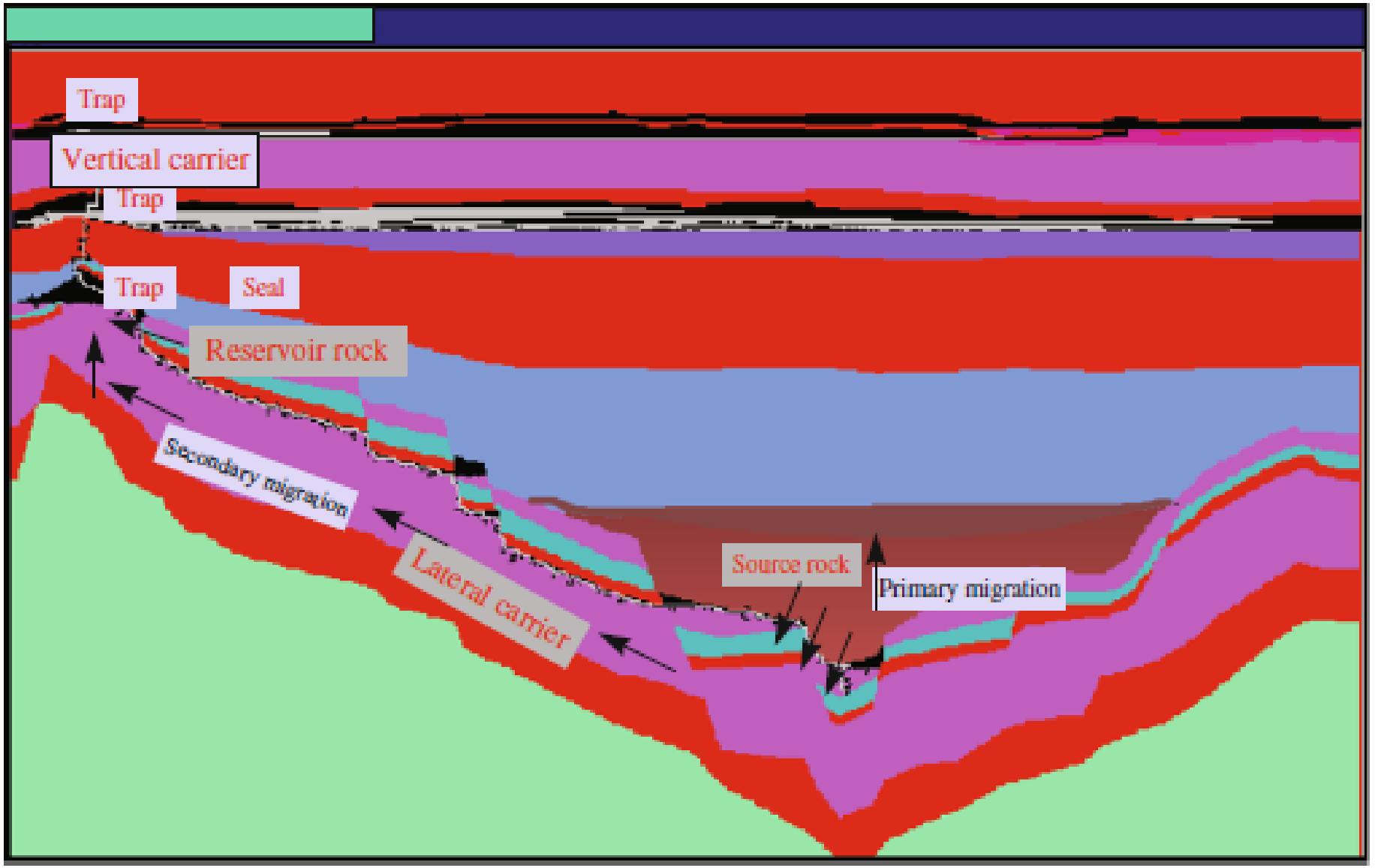
Primary migration:

the expulsion of newly generated hydrocarbons from a source rock into adjacent rock.

The generation of a liquid (oil) or gas from a solid (organic matter) causes a large increase in volume, and it will generate fractures in the source rocks.



Microfractures in organic rich shale. Hunt, 1995.



Petroleum migration

Secondary migration: the flow of petroleum from source rock to reservoir rocks

Oil and gas is lighter than water. They flow **upward** along faults and fractures and though permeable carrier beds.

They can flow laterally and upwards along unconformities and through carrier beds.

Carrier beds are rock layers that are very permeable beds and transmit fluids.

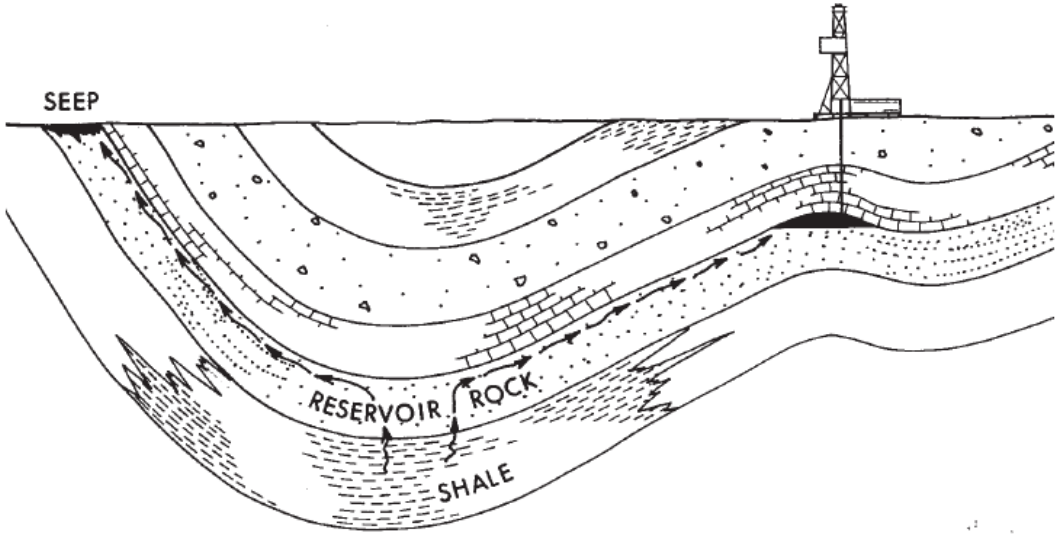


Fig. 9–2. Migration of gas and oil in a sedimentary rock basin

Hyne 2001

If there is a trap along the migration route, the gas and oil will accumulate in the trap. Only ca. 10% of the hydrocarbon is ever trapped.

The rest of gas and oil either

1) did not get out of the source rock
2) was lost during migration
3) seeped into the earth's surface.

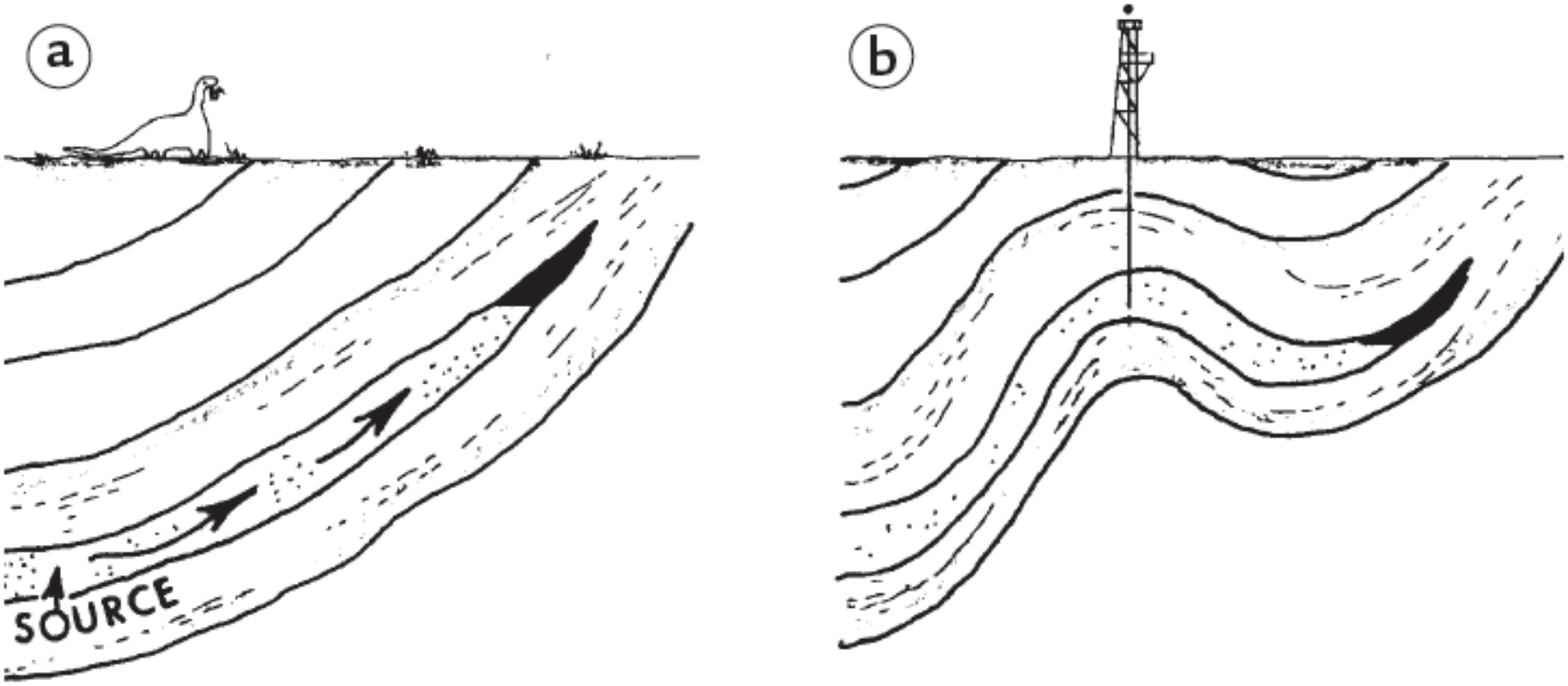


Fig. 9–3. (a) Generation, migration, and accumulation of oil in a sandstone pinch-out and (b) later formation of an anticline that is barren of oil

Hyne 2001

- The trap must be in position before the gas and oil migrates through the area.
- If the trap forms after the migration, no gas and oil will occur in the trap.

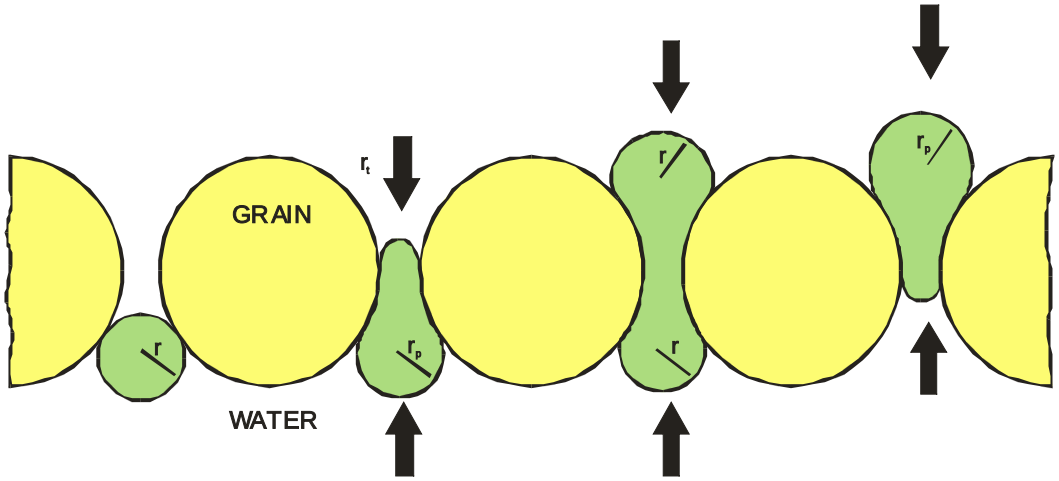
Secondary migration

Factors of secondary migration:

- **Buoyancy:** oil droplets move upward by the force of density difference between oil and formation water.

  All crude oils float on saline water, nearly all on freshwater. Similarly oil in the carrier bed tends to migrate upwards through the heavier water.
- **Capillary pressure**: is the resistent/retardant force in secondary hydrocarbon migration.
- **Hydrodynamic gradient**: originates from the flow of subsurface water

Buoyancy



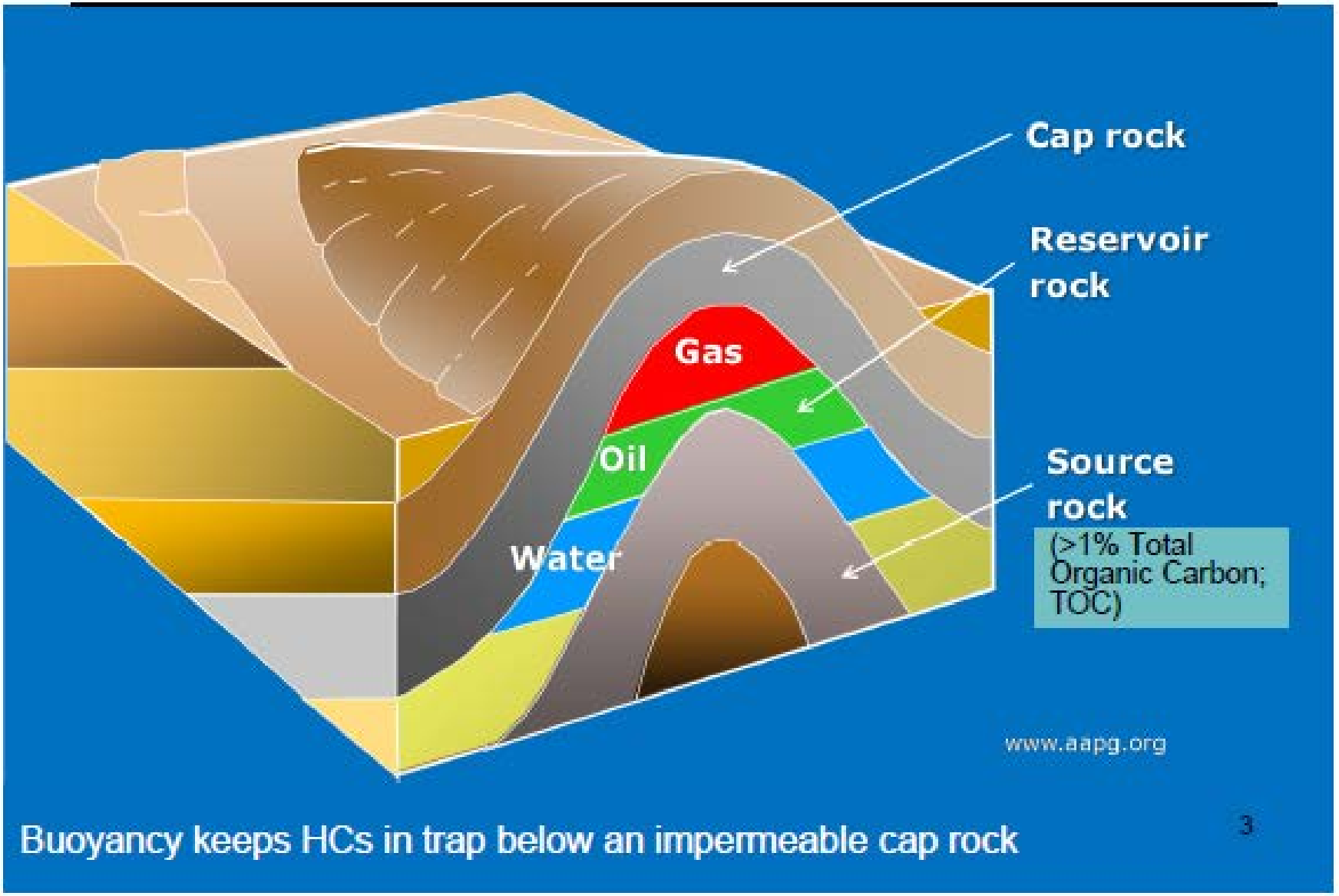
Oil and gas are lighter than water.

s = INTERFACIAL TENSION

The main **driving force** behind secondary migration is buoyancy.

Buoyancy is caused by the density difference between oil or gas and pore water.

Conventional HC-accumulation in structural trap

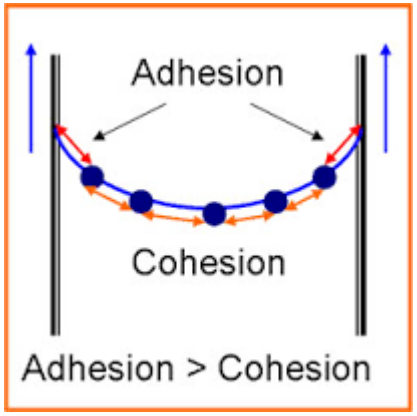


Sachsenhofer 2017

Capillary pressure

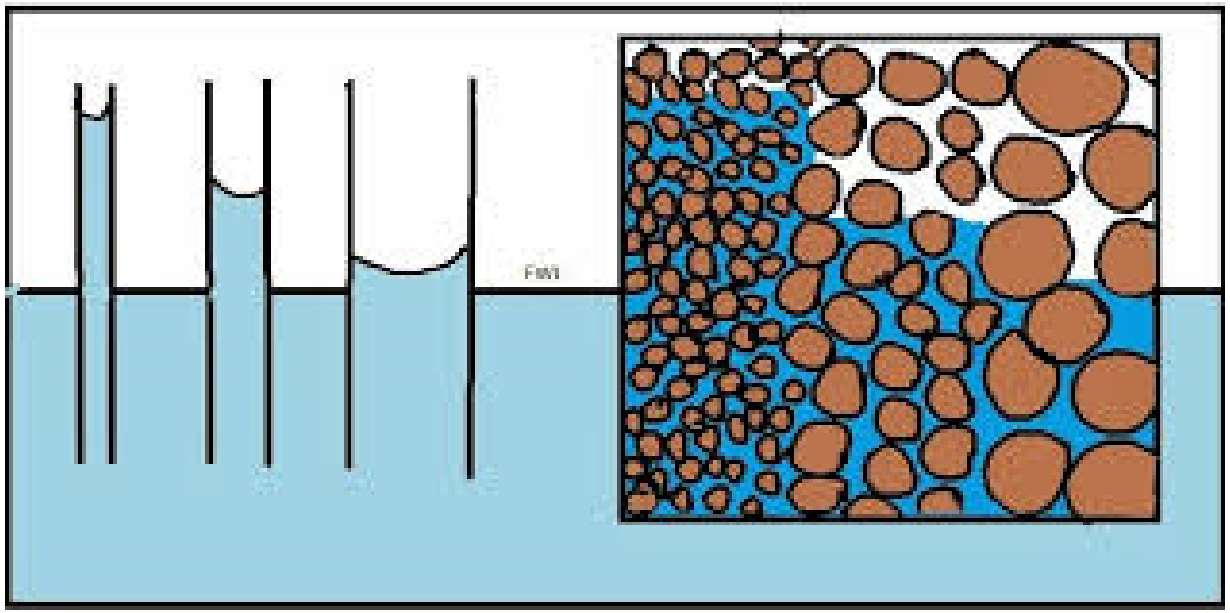
(or displacement pressure, or injection pressure)

- is the resistent/retardant force in secondary hydrocarbon migration.



- **<u>Capillary attraction</u>**: *is the force that results from greater adhesion of a liquid to a solid surface than internal cohesion of the liquid itself. That causes the liquid to be raised against a vertical surface, as water is in a clean glass tube. It is the force that allows a porous material to soak up a liquid* .

- Reservoir rocks are composed of varying sizes of grains, pores, and capillaries (channels between grains which connect pores together, called pore throats).
- The smaller the opening, the greater the capillary pressure. With respect to a reservoir, this may be thought in terms of pore throat diameters.
- If the bouyancy of the oil drop is less than the capillary forces at the pores throat, then it will stop migrating.



Tertiary migration

- Petroleum can escape from trap structures along fractures
- Appear on surface as natural seeps
- Migration can also occur after reservoir abandonment

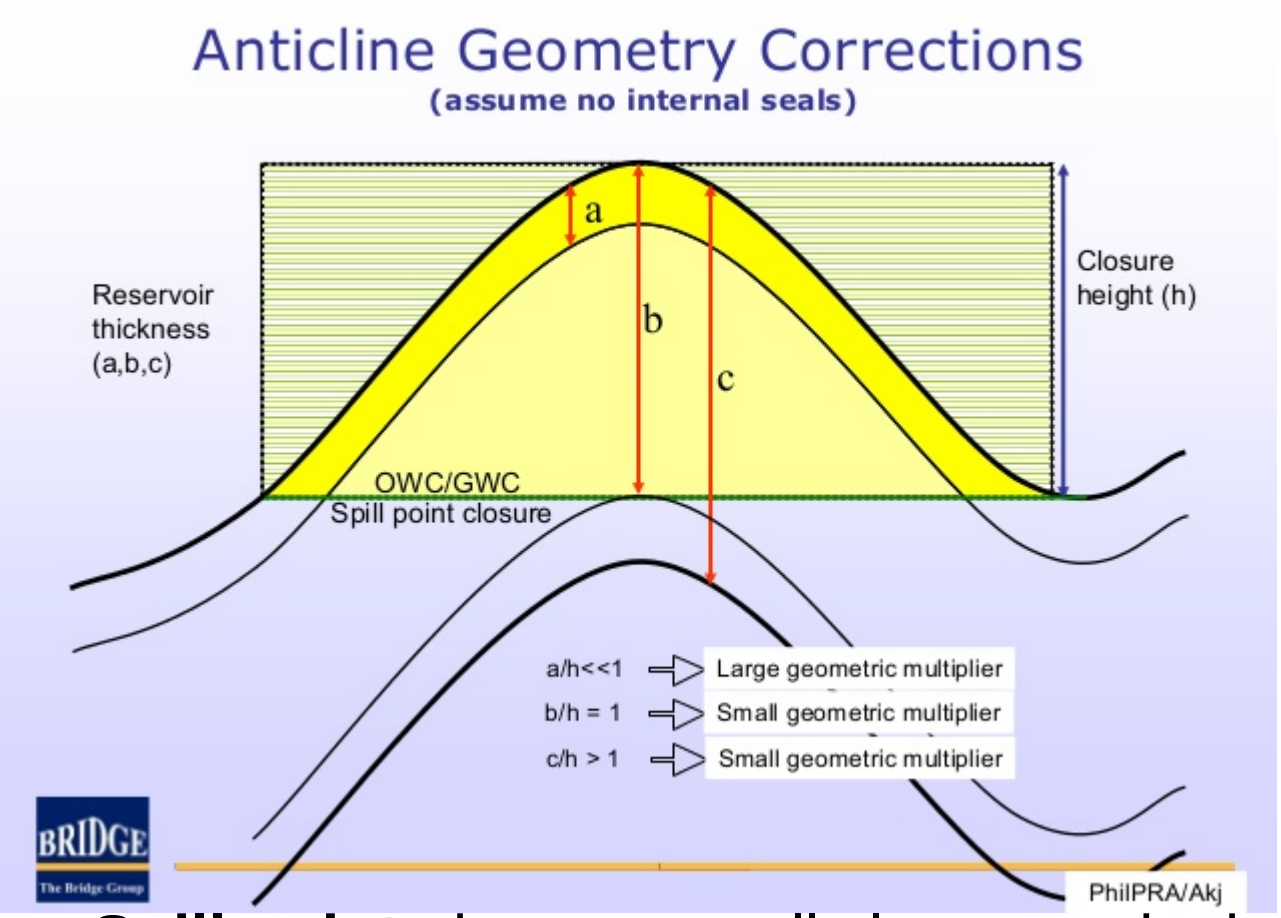




Seal

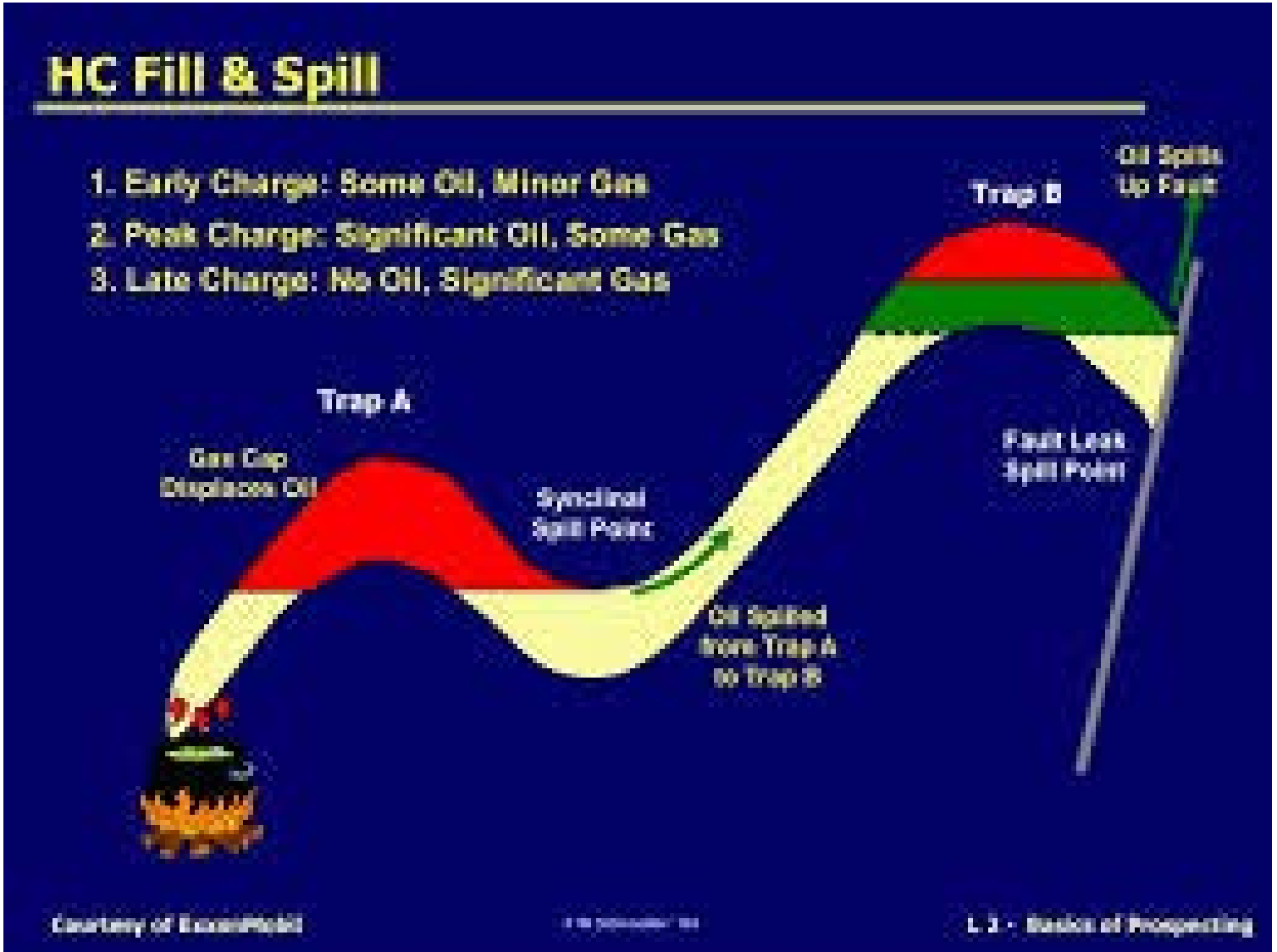
- The upward movement of the hydrocarbon is stopped when a smaller pore system is encountered whose capillary pressure exceeds the upward-directed buoyancy of the petroleum column.

Spill point

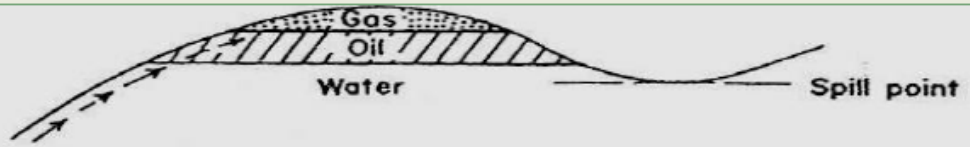


- **Spill point**: the structurally lowest point in hydrocarbon trap that can retain hydrocarbons.
- Once a trap has been filled to its spill point, further storage of hydrocarbons will not occur for lack of reservoir space within that trap. The hydrocarbons **spill or leak out**, and they continue to migrate until they are trapped elsewhere.

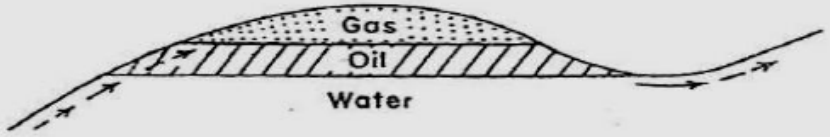
Accumulation



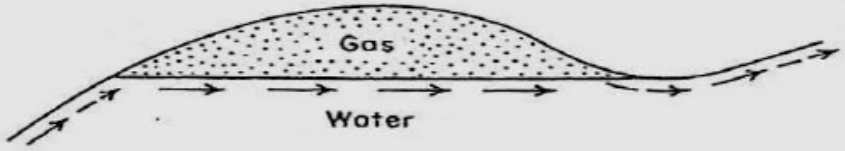
Anticline Fill and Spillpoint



Stage 1. Gas, oil, and water above spill point. Both oil and gas continue to be trapped while water is displaced. This stage ends when oil-water interface reaches spill point.



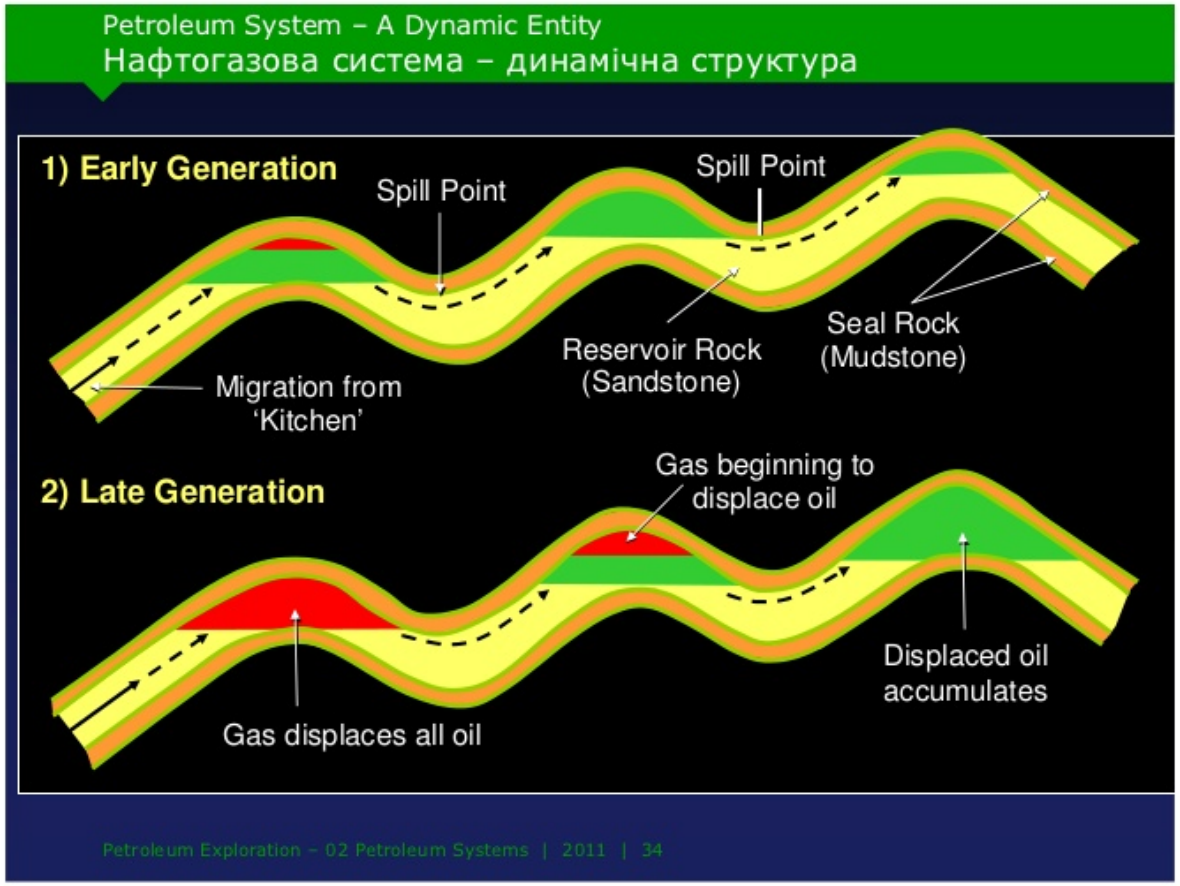
Stage 2. Stage of selective entrapment and gas flushing. Gas continues to be trapped but oil is spilled up dip. This stage ends when oil-gas interface reaches spill point.



Stage 3. End stage. Trap filled with gas. Excess gas spills up dip as more gas enters trap. Oil by-passes trap and continues upward migration.

Fig. 2.1. Illustration of differential entrapment principle, showing various stages of hydrocarbon accumulation in an anticline. Solid and dashed arrows denote oil and gas movement respectively. After Gussow,[4] courtesy AAPG.

Gussow's principle



Early Generation: left trap is filled to spill point and has a gas cap; only oil is spilling updip.
Late Generation: Left trap is completely filled with gas, all its oil is now by-passing.
Increase in density with migration distance
Decrease in density with depth