MIGRATION

Migration

- **Migration** is the movement of petroleum from source rock toward a reservoir or seep. Primary migration is expulsion of petroleum from fine-grained source rock, while secondary migration moves petroleum through a coarse-grained carrier bed or fault to a reservoir or seep. Tertiary migration occurs when petroleum moves from one trap to another or to a seep. Hydrocarbon migration consists of four stages: primary, secondary, tertiary, and remigration.

Migration

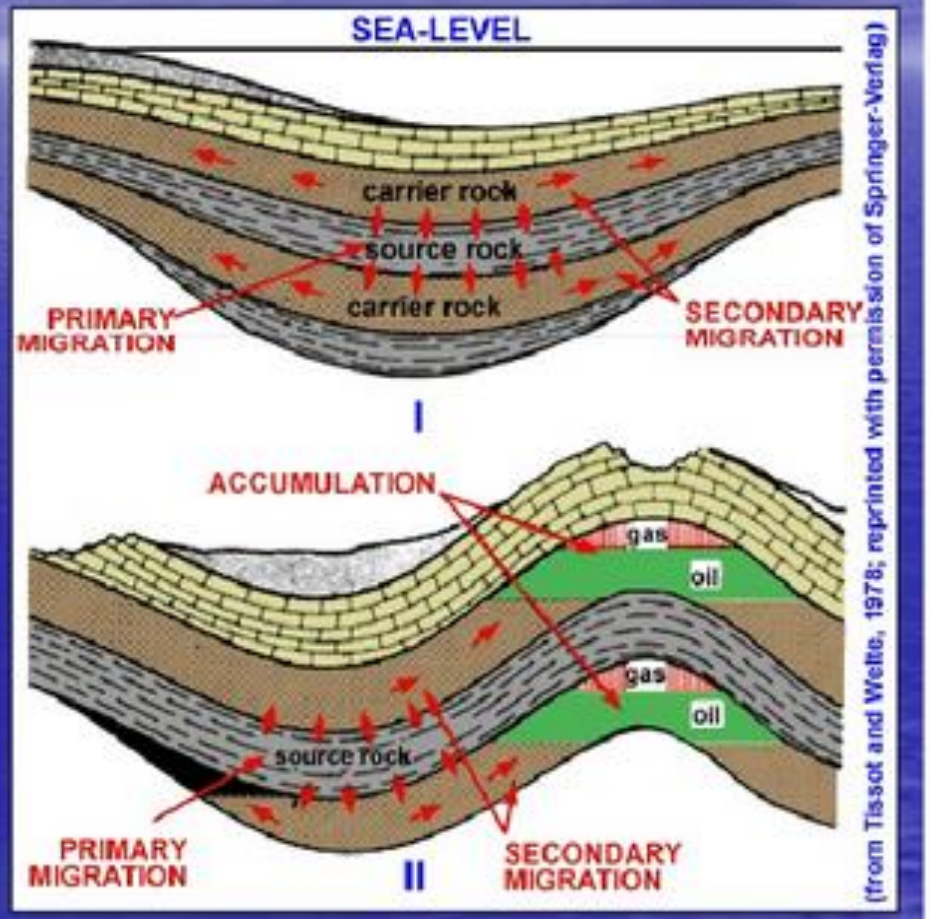
- **Primary Migration**—The process of loss of hydrocarbons from the source rock.
- **Secondary Migration**—Migration from source to reservoir along a simple or complex carrier system. Includes migration within the reservoir rock itself.
- **Tertiary Migration**—Migration to the surface, either from a reservoir or source rock. Also called dismigration.
- **Remigration**—Migration from one reservoir position through an intervening section into another reservoir position in the same or a different reservoir.

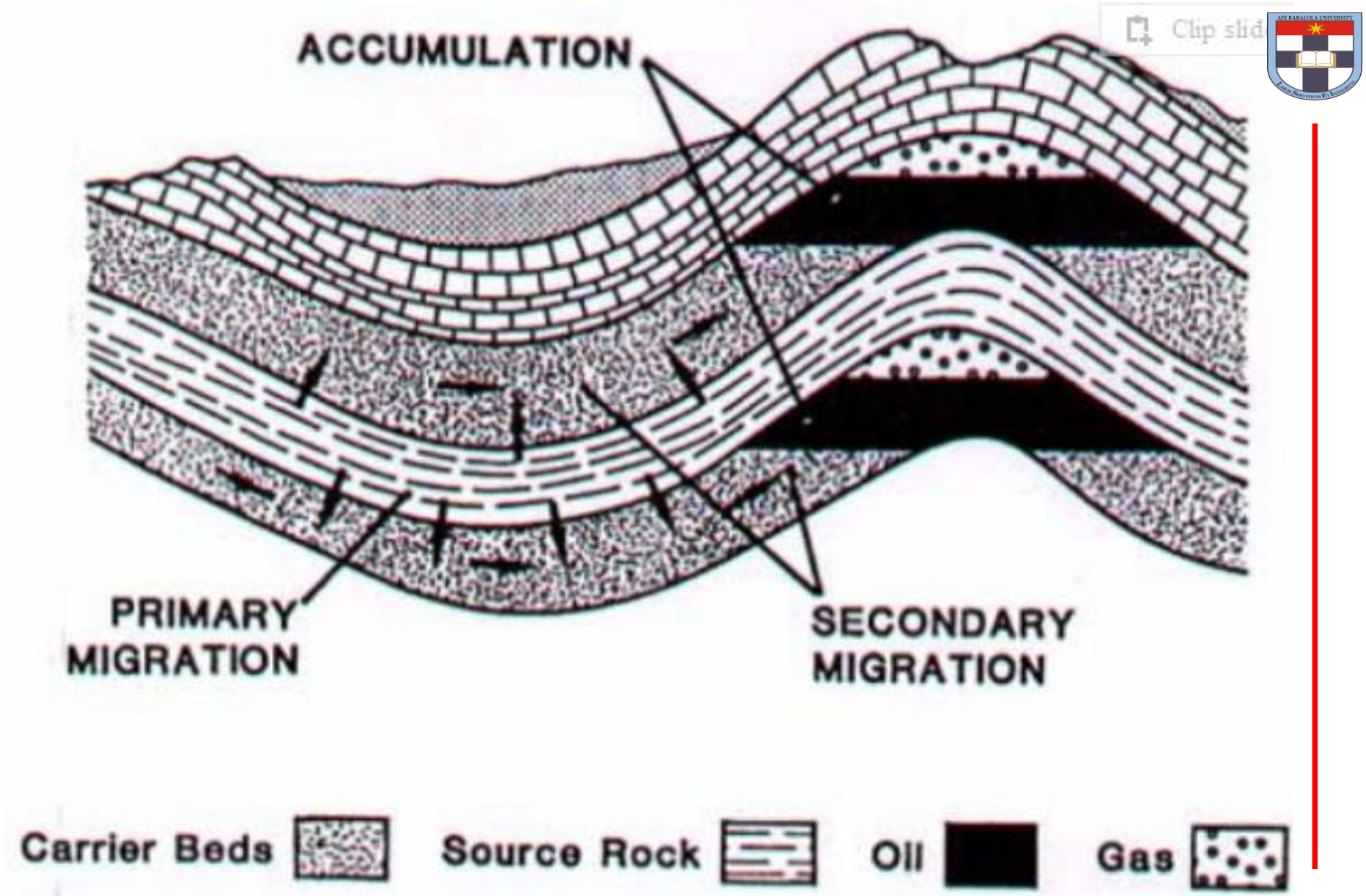
MIGRATION

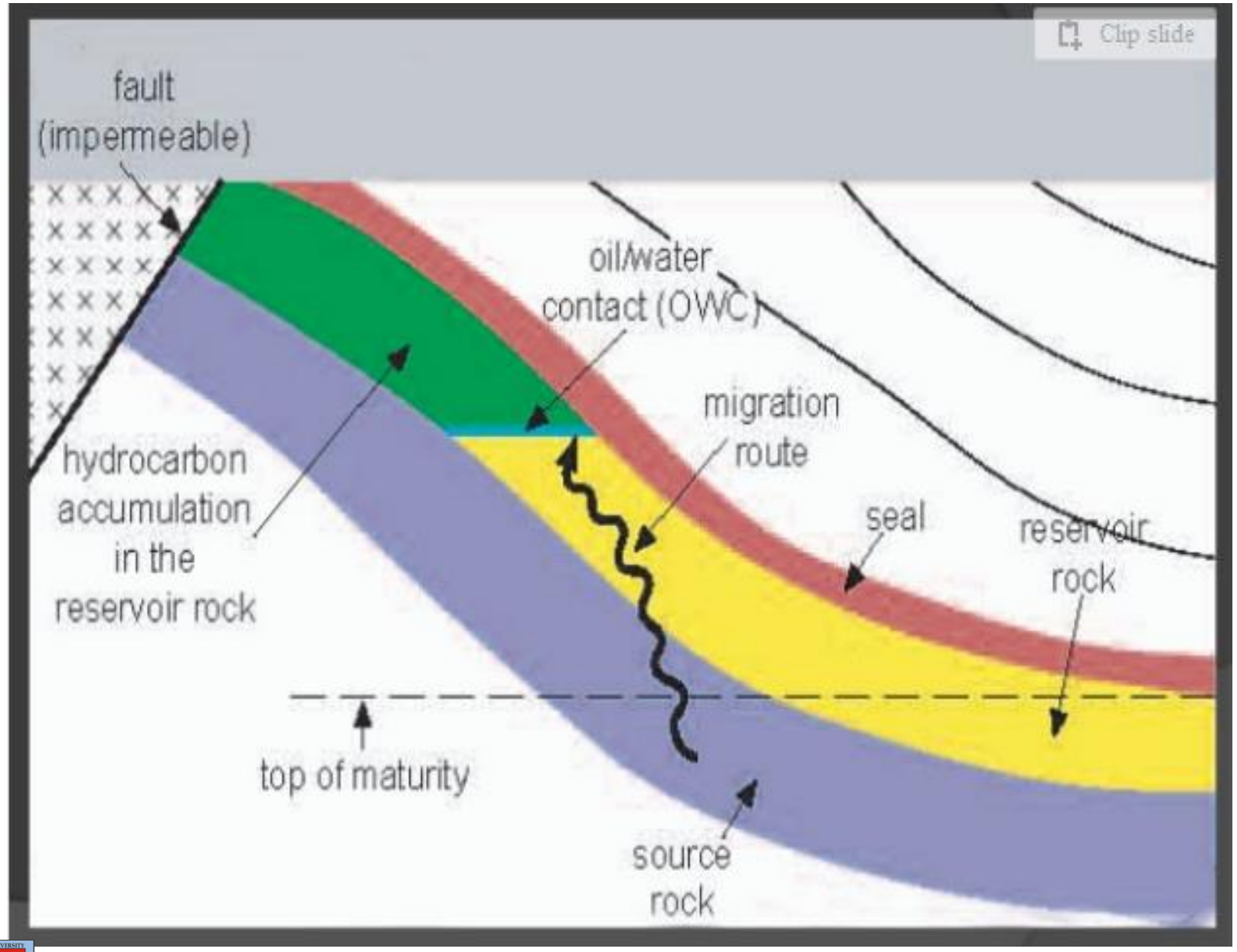
- The movement of hydrocarbons out of the source rock into the reservoir rock is called primary migration.
- The movement of hydrocarbons through the reservoir rock and into a trap is called secondary migration.
- The movement of gasses and fluids out of the trap into the surrounding rocks is called leakage.

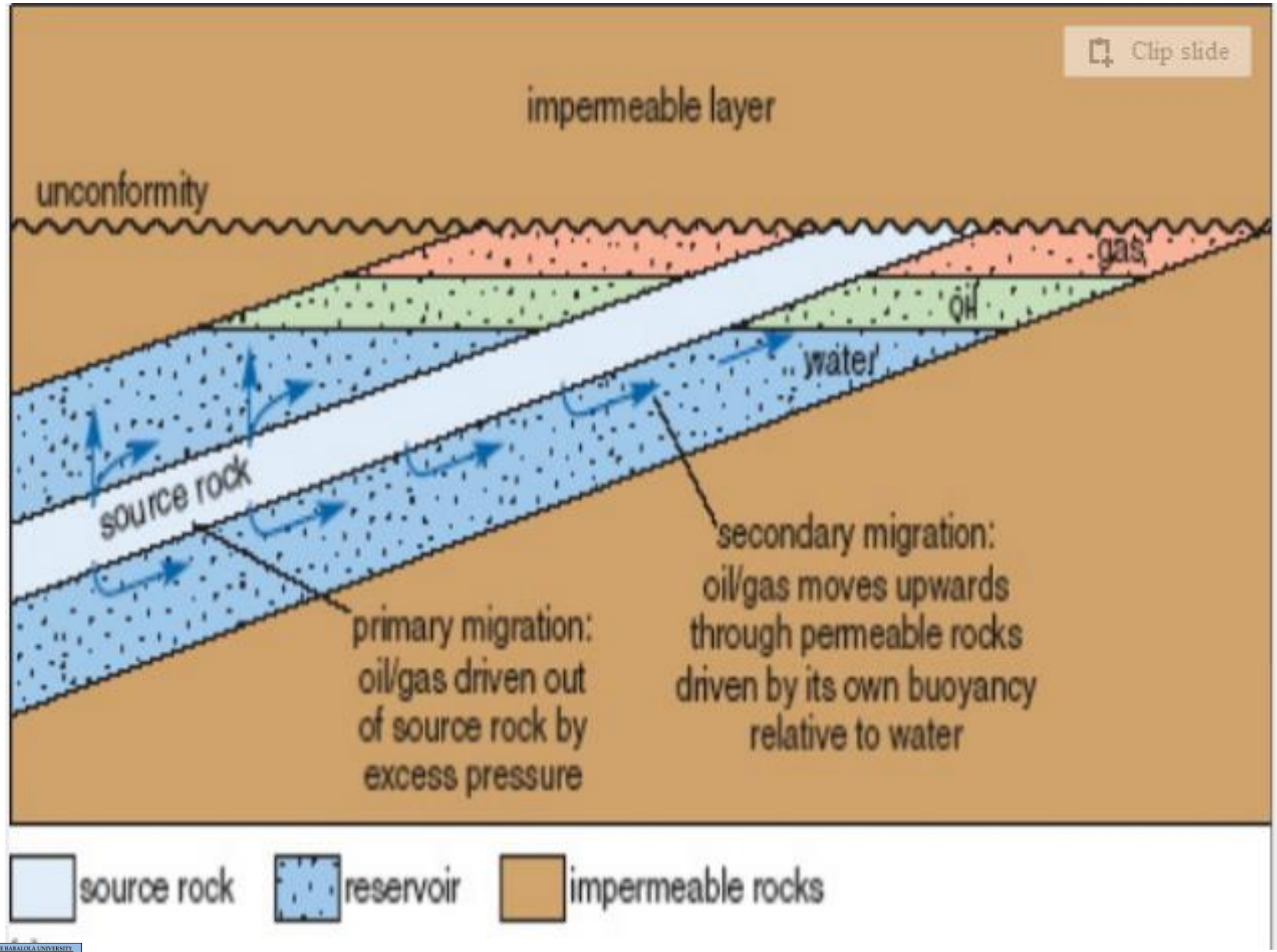
Migration Processes

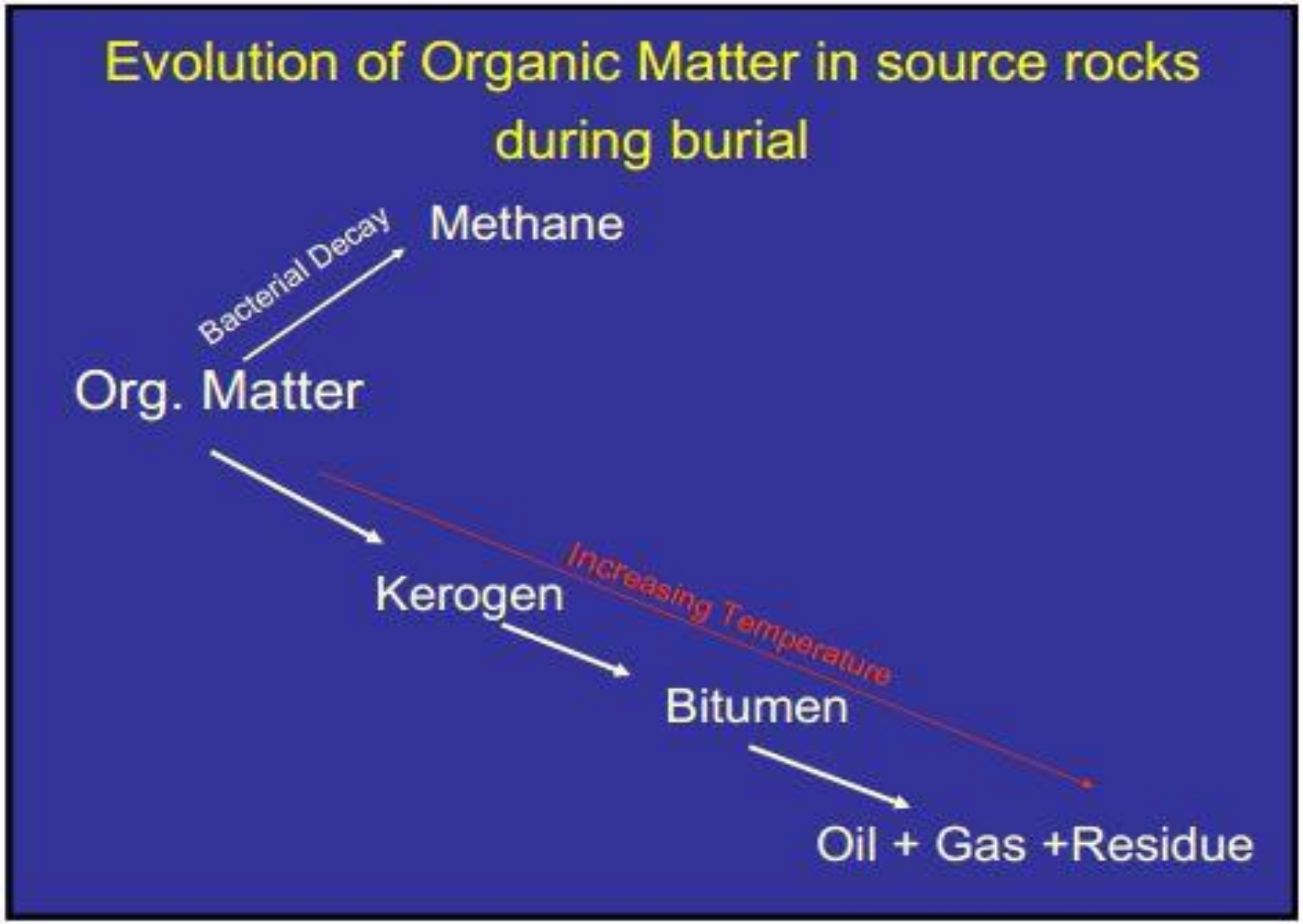
- **Primary Migration:** involves the expulsion of petroleum from the source rocks to reservoir rock.
- **Secondary Migration:** involves the movement of petroleum through permeable layers (carrier beds) to the trap.

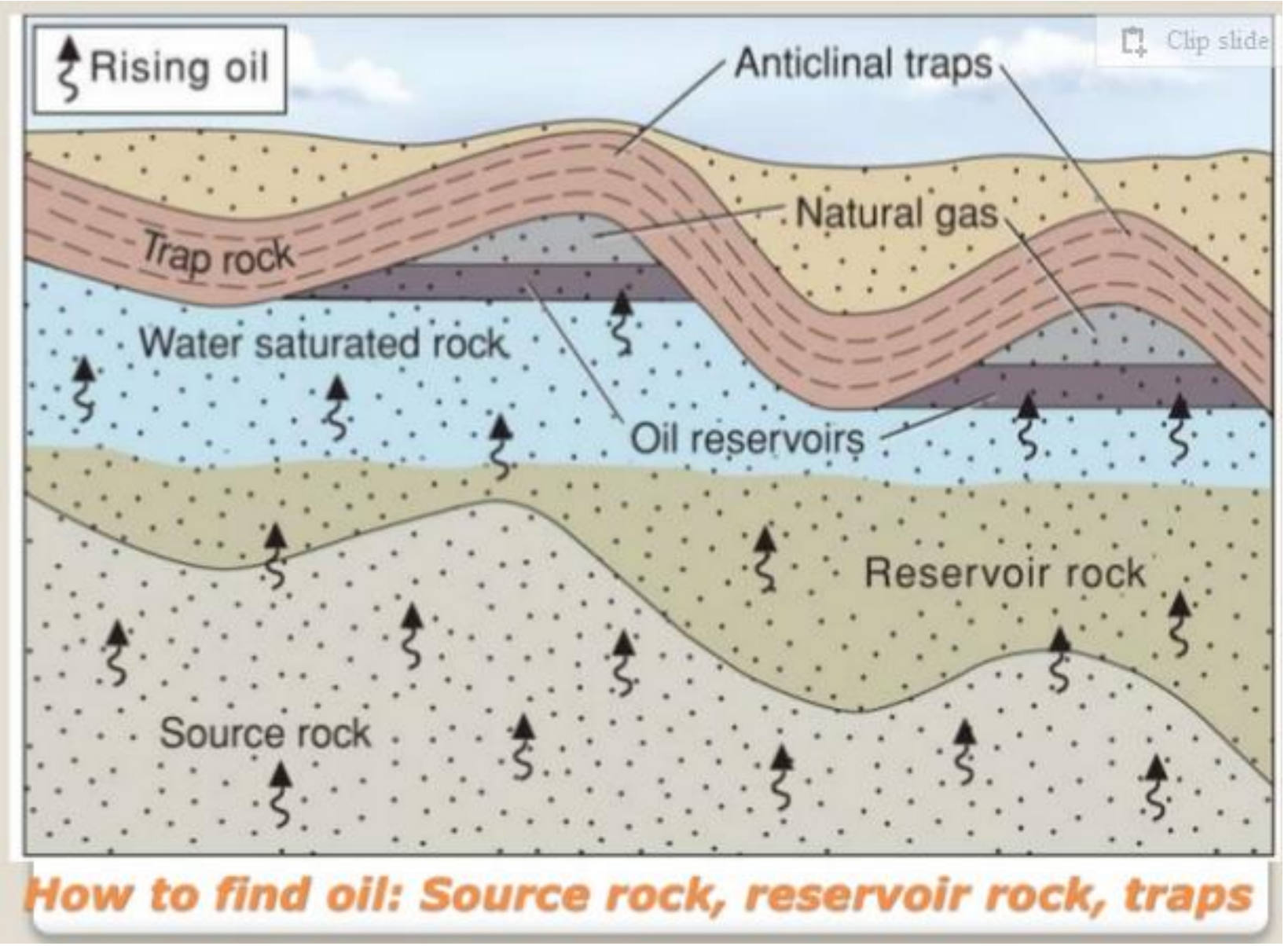



ACCUMULATION
PRIMARY MIGRATION
SECONDARY MIGRATION
Carrier Beds
Source Rock
Oil
Gas


Clip slide
fault
(impermeable)
oil/water
contact (OWC)
migration
route
hydrocarbon
accumulation
in the
reservoir rock
seal
reservoir
rock
top of maturity
source
rock


Clip slide
impermeable layer
unconformity
gas
oil
water
source rock
secondary migration:
oil/gas moves upwards
through permeable rocks
driven by its own buoyancy
relative to water
primary migration:
oil/gas driven out
of source rock by
excess pressure
source rock
reservoir
impermeable rocks


Evolution of Organic Matter in source rocks during burial
Methane
Bacterial Decay
Org. Matter
Kerogen
Increasing Temperature
Bitumen
Oil + Gas +Residue


Rising oil
Anticlinal traps
Natural gas
Trap rock
Water saturated rock
Oil reservoirs
Reservoir rock
Source rock
How to find oil: Source rock, reservoir rock, traps

TRAPPING

Traps:

- A trap forms when the buoyancy forces driving the upward migration of hydrocarbons through a permeable rock cannot overcome the capillary forces of a sealing medium. The timing of trap formation relative to that of petroleum generation and migration is crucial to ensuring a reservoir can form.
- Petroleum geologist broadly classify traps into three categories that are based on their geological characteristics: the structural trap, the stratigraphic trap and the far less common hydrodynamic trap. The trapping mechanisms for many petroleum reservoirs have characteristics from several categories and can be known as a combination trap.

(1) Structural traps

Fold (structural) trap

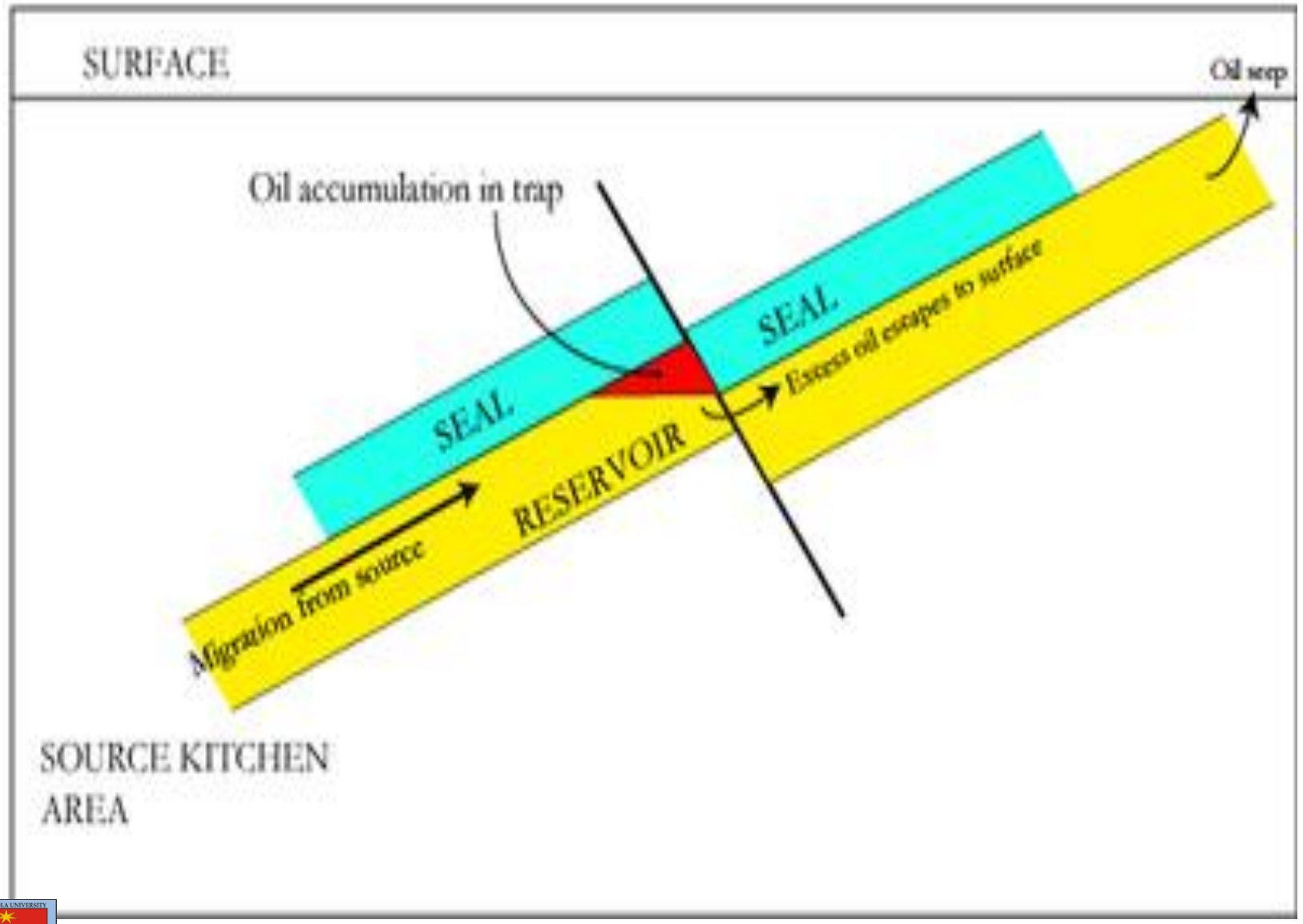
Fault (structural) trap

- Structural Trap - A structural trap, where a fault has juxtaposed a porous and permeable reservoir against an impermeable seal. Oil (shown in red) accumulates against the seal, to the depth of the base of the seal. Any further oil migrating in from the source will escape to the surface and seep.

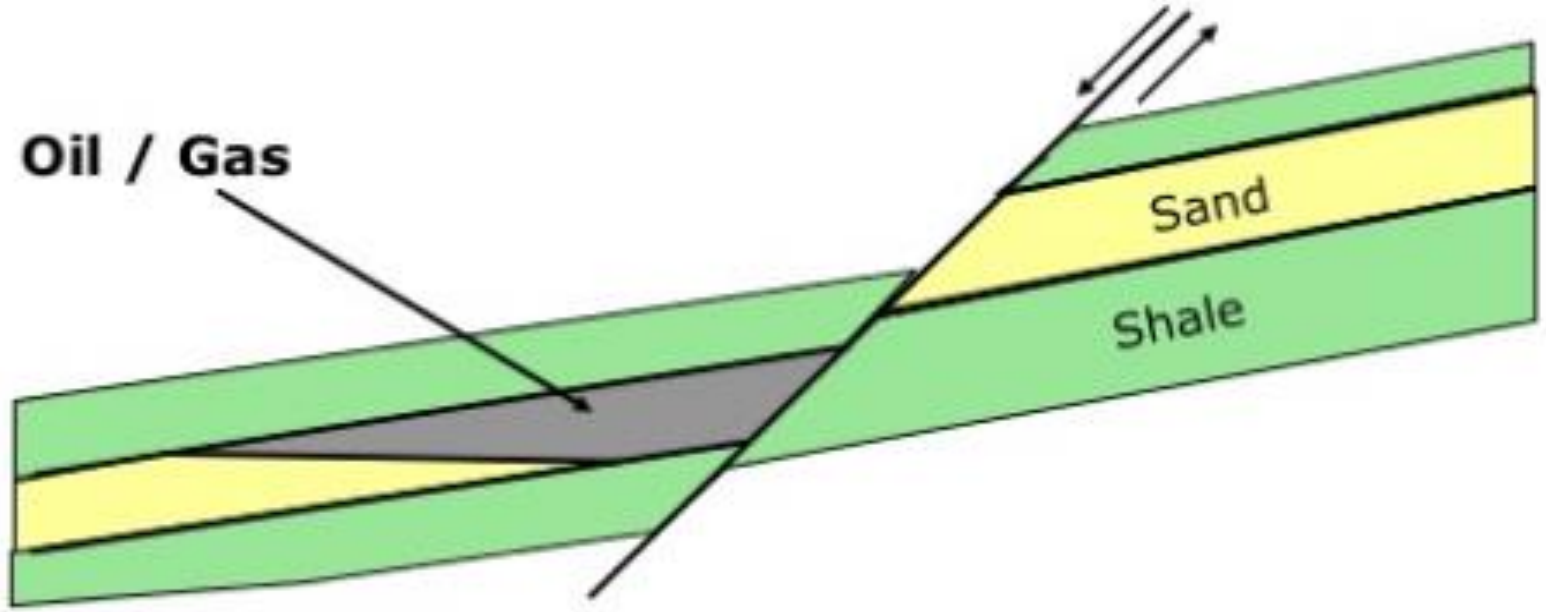
Fault and Fold (Structural traps)

Structural traps are formed by changes of structure in the subsurface such as folding and faulting, leading to the formation of domes, anticlines, and folds.
Majority of the world's petroleum reserves being found in structural traps.

Structural Trap:

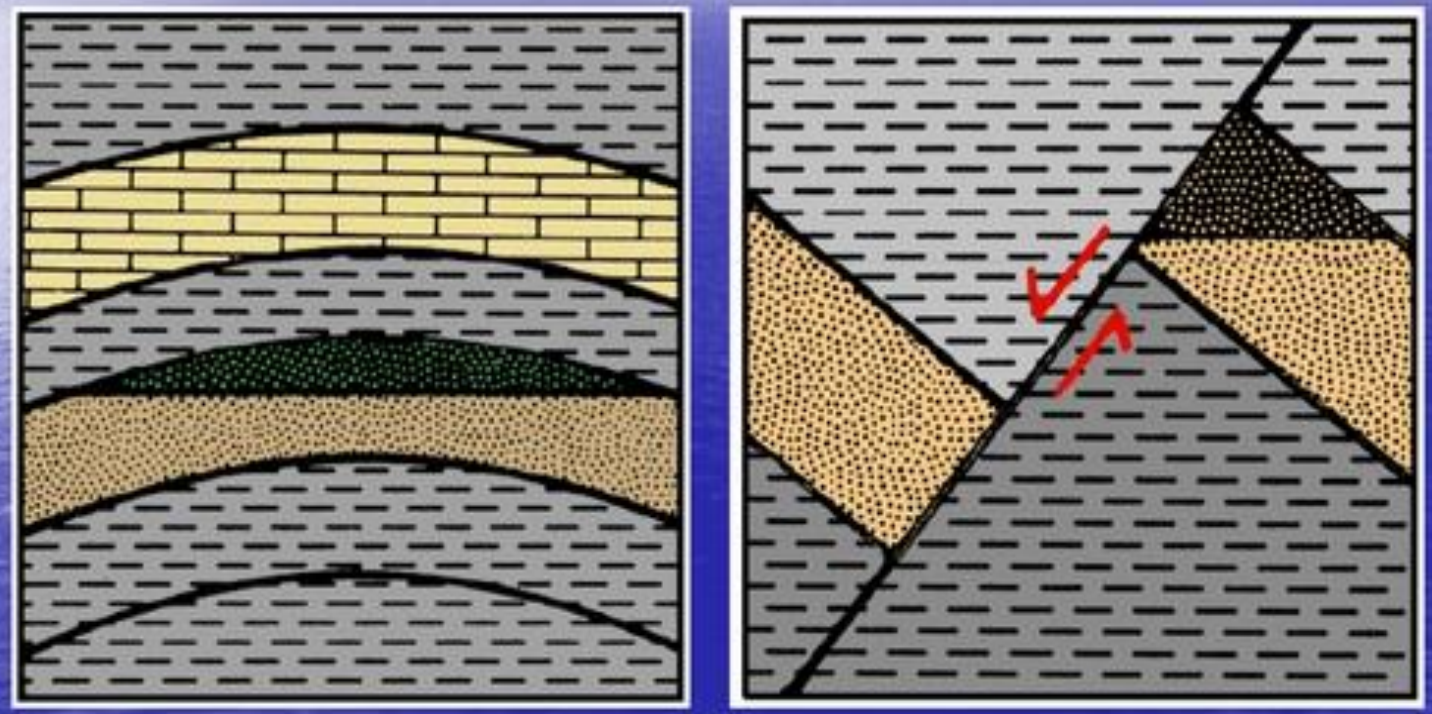


Fault Trap

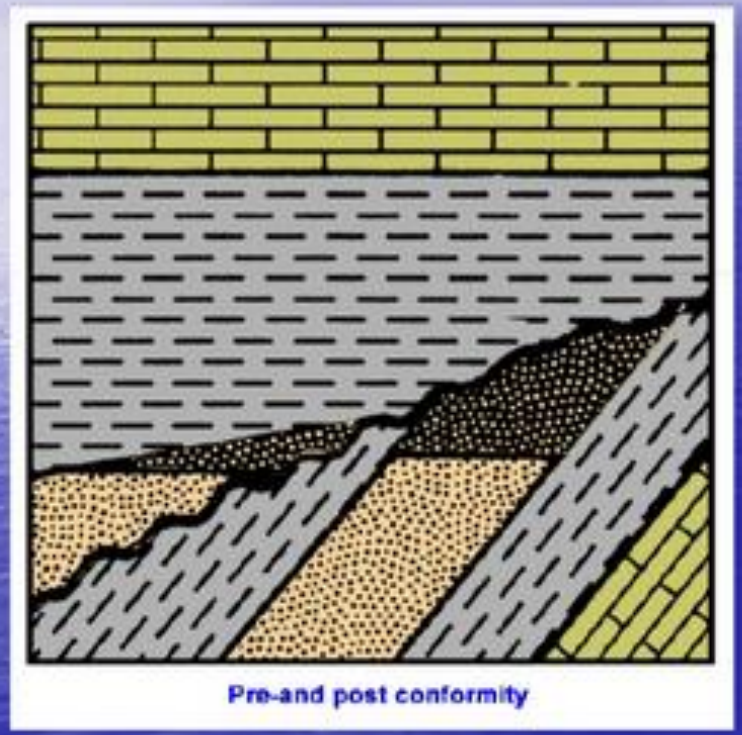


In this normal fault trap, oil-bearing sandstone is juxtaposed against impervious shale.

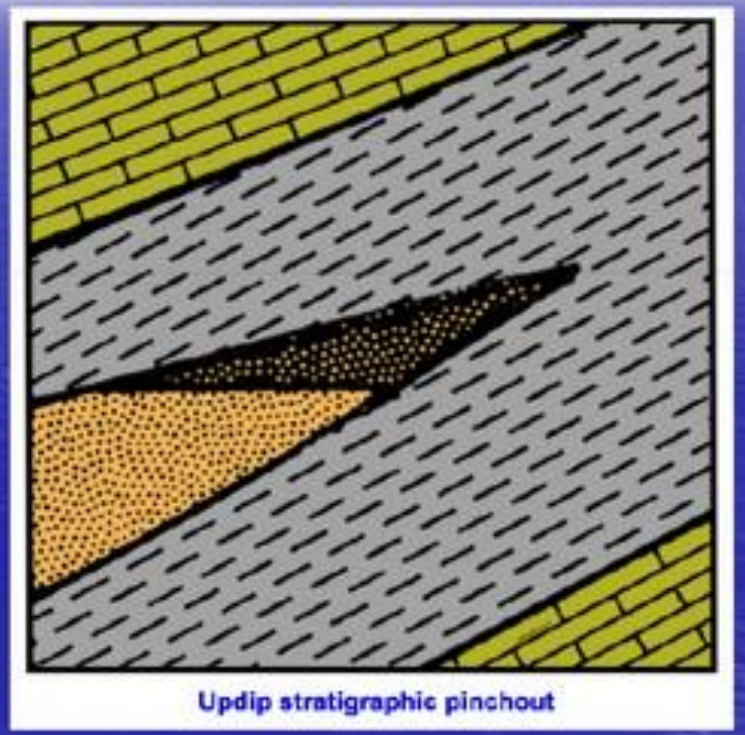
Structural Traps



Stratigraphic traps



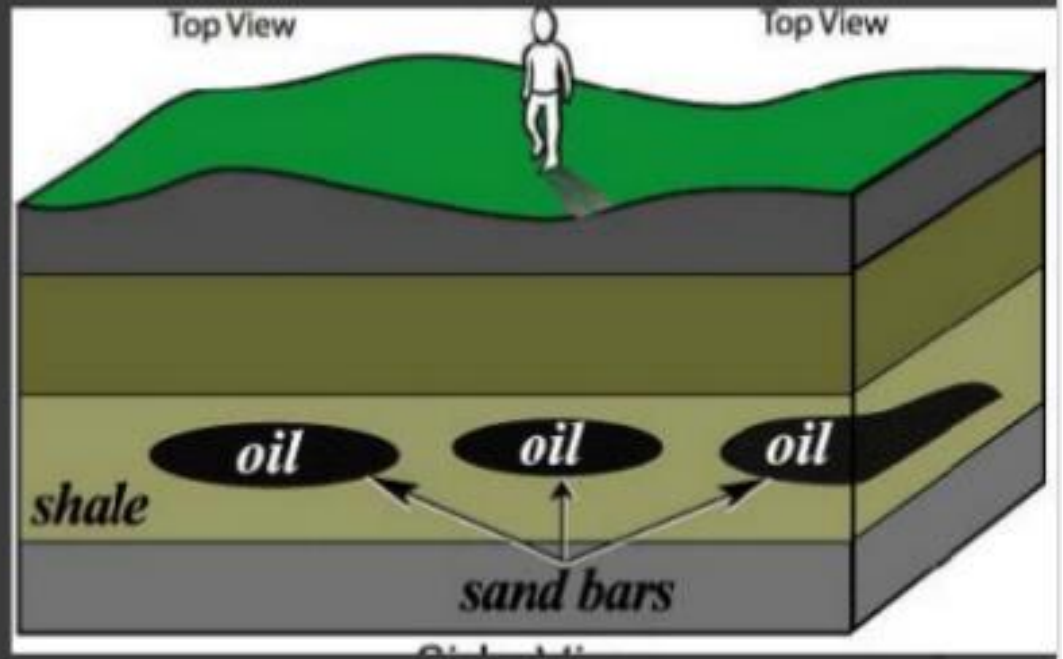
Pre-and post conformity

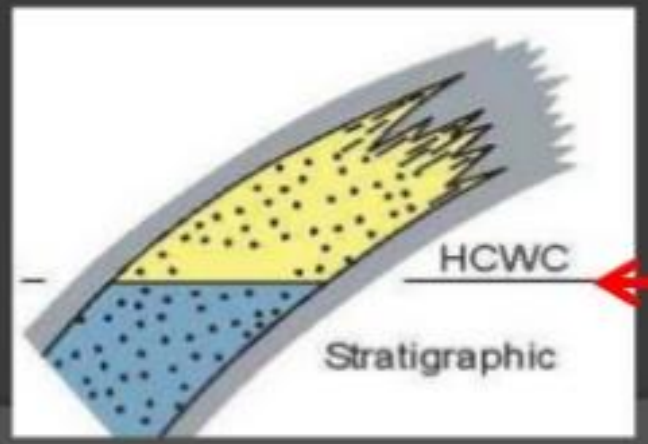


Updip stratigraphic pinchout

Stratigraphic Traps

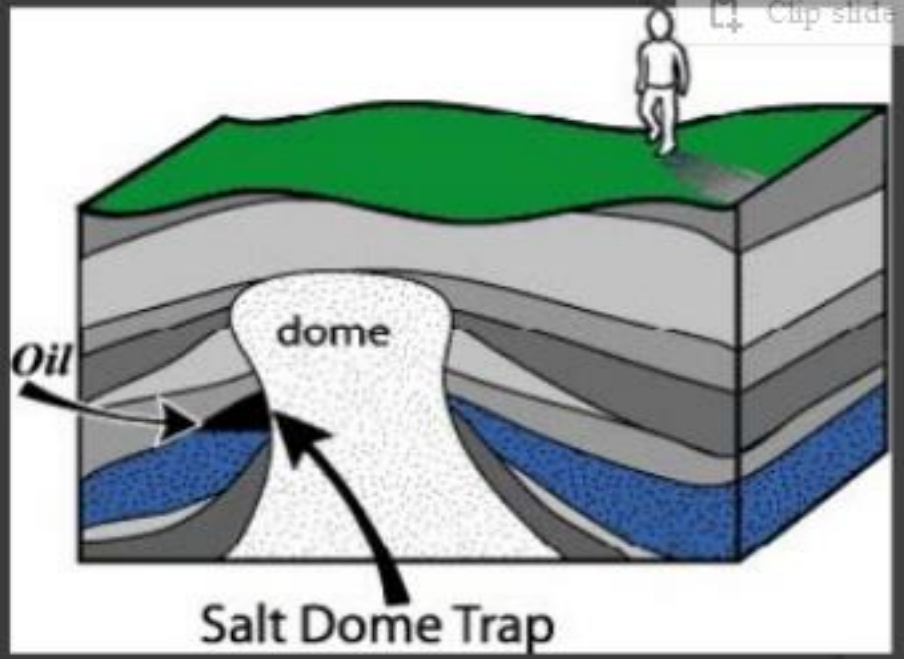
Impermeable strata seal the reservoir.





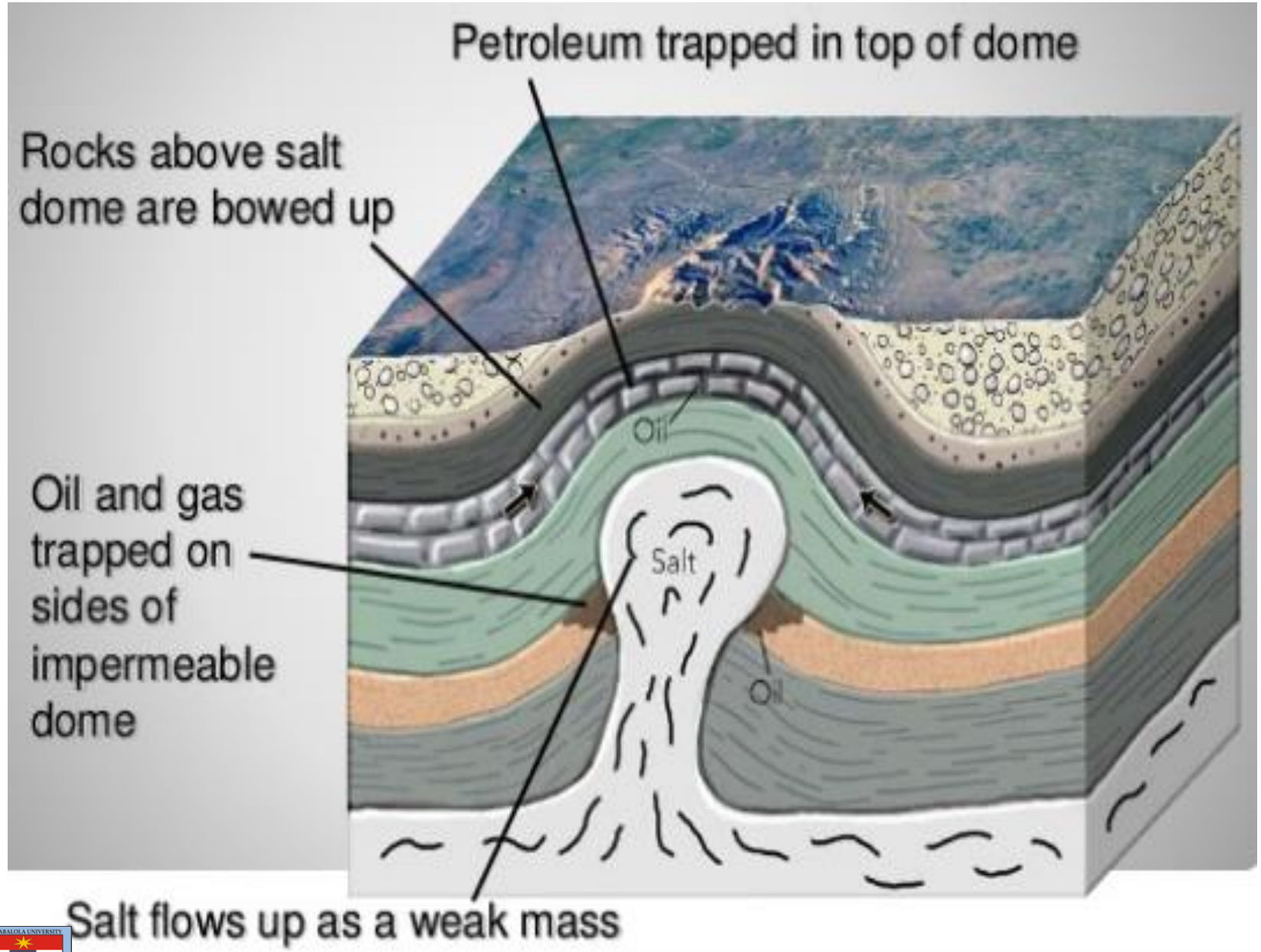
HCWC

Salt Dome Traps



Combination Traps

Fault bound anticlinal structures, i.e. combination of anticlinal & fault traps. Many global reservoirs have this type.


Petroleum trapped in top of dome
Rocks above salt dome are bowed up
Oil and gas trapped on sides of impermeable dome
Salt flows up as a weak mass
Oil
Salt
Oil

(2) Stratigraphic traps: are formed as a result of lateral and vertical variations in the thickness, texture, porosity or lithology of the reservoir rock. Examples of this type of trap are an unconformity trap, a lens trap and a reef trap.

(3) Hydrodynamic traps are a far less common type of trap. They are caused by the differences in water pressure, that are associated with water flow, creating a tilt of the hydrocarbon- water contact.

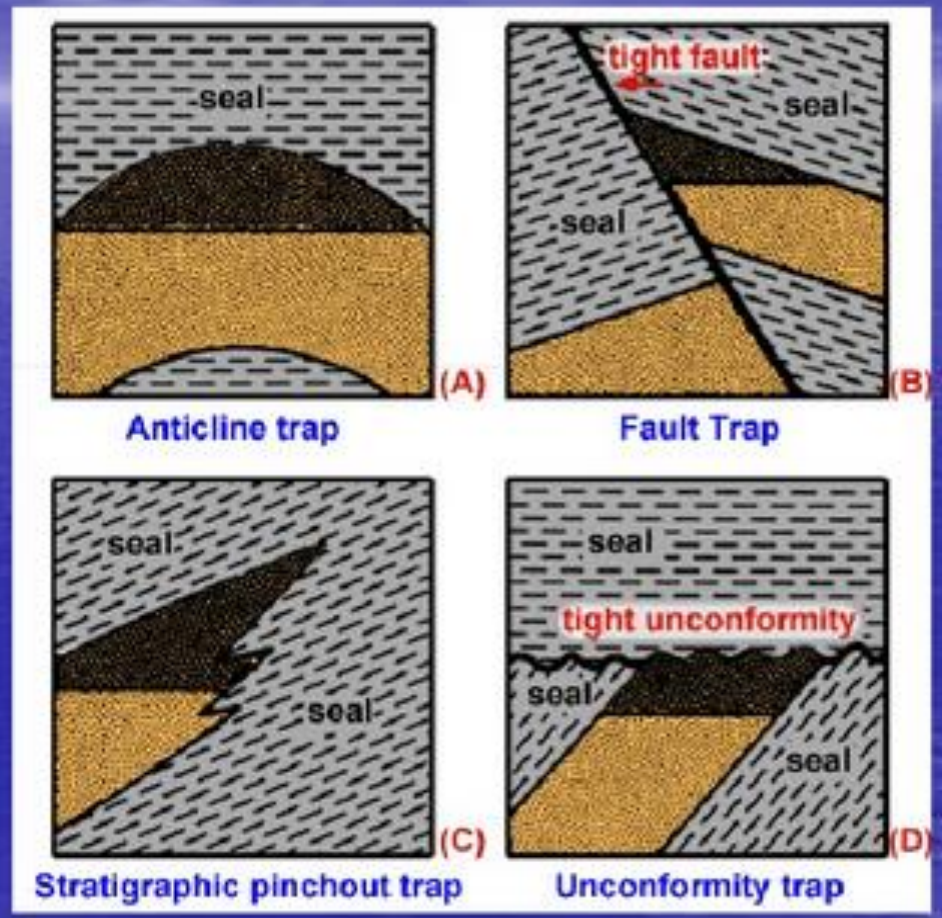
Seals: The seal is a fundamental part of the trap that prevents hydrocarbons from further upward migration. The **seal**, or *cap* rock, is a unit with low permeability that impedes the escape of hydrocarbons from the reservoir rock. Common seals include evaporites, chalks and shales. Analysis of seals involves assessment of their thickness and extent, such that their effectiveness can be quantified.

- **A capillary seal:** is formed when the capillary pressure across the pore throats is greater than or equal to the buoyancy pressure of the migrating hydrocarbons. They do not allow fluids to migrate across them until their integrity is disrupted, causing them to leak. There are two types of capillary seal whose classifications are based on the preferential mechanism of leaking: the hydraulic seal and the membrane seal.
- **The membrane seal** will leak whenever the pressure differential across the seal exceeds the threshold displacement pressure, allowing fluids to migrate through the pore spaces in the seal. It will leak just enough to bring the pressure differential below that of the displacement pressure and will reseal.

- **The hydraulic seal** occurs in rocks that have a significantly higher displacement pressure such that the pressure required for tension fracturing is actually lower than the pressure required for fluid displacement – for example, in evaporites or very tight shales. The rock will fracture when the pore pressure is greater than both its minimum stress and its tensile strength then reseal when the pressure reduces and the fractures close.

The Seal

- The seal or cap rock is an impermeable rock which don't allow the hydrocarbons to escape from the reservoir rock.
- Common examples of cap rocks are, chalks , shales, clays etc.



Petroleum reservoir:

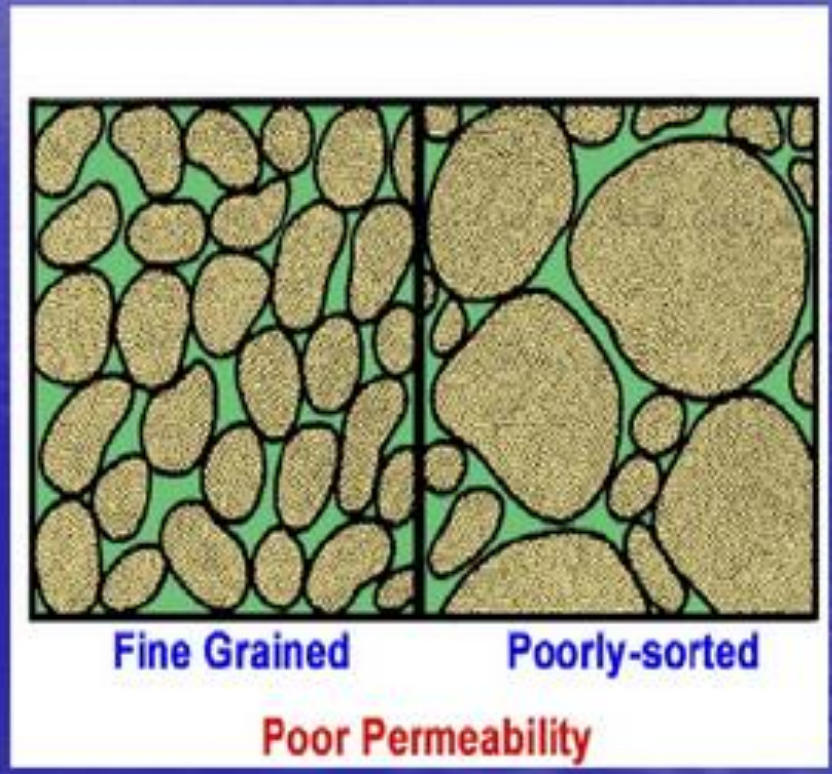
- A **petroleum reservoir** or **oil and gas reservoir** is a subsurface pool of hydrocarbons contained in porous or fractured rock formations. The naturally occurring hydrocarbons, such as crude oil or natural gas, are trapped by overlying rock formations with lower permeability. Reservoirs are found using hydrocarbon exploration methods.

Reservoir Porosity and Permeability

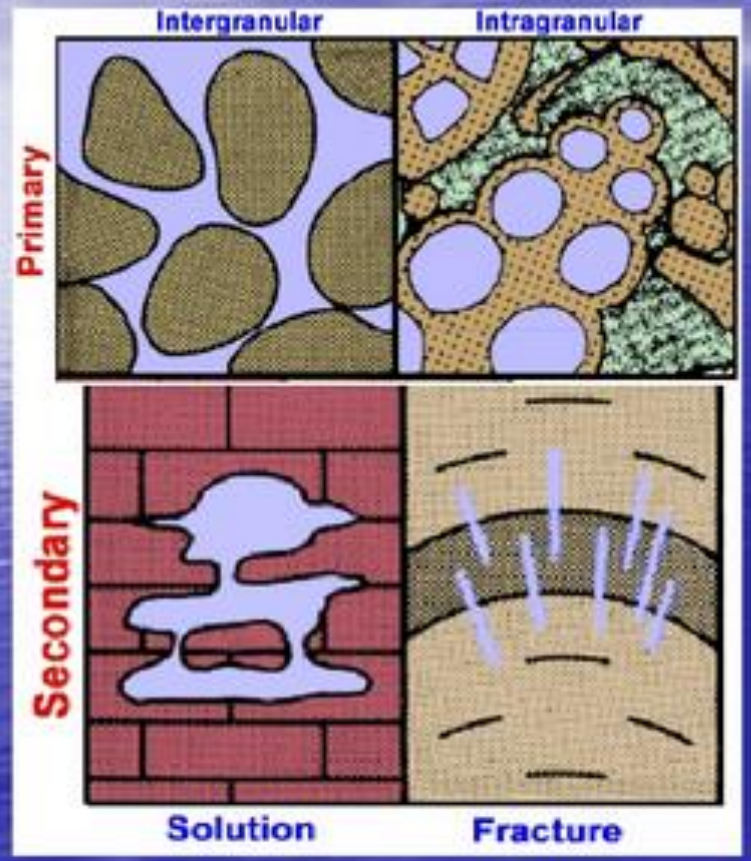
There are two fundamental physical properties that a good reservoir must have:

(1) *porosity*, or sufficient void space to contain significant petroleum.

(2) *permeability*, the ability of petroleum to flow through these voids.



Types of porosity



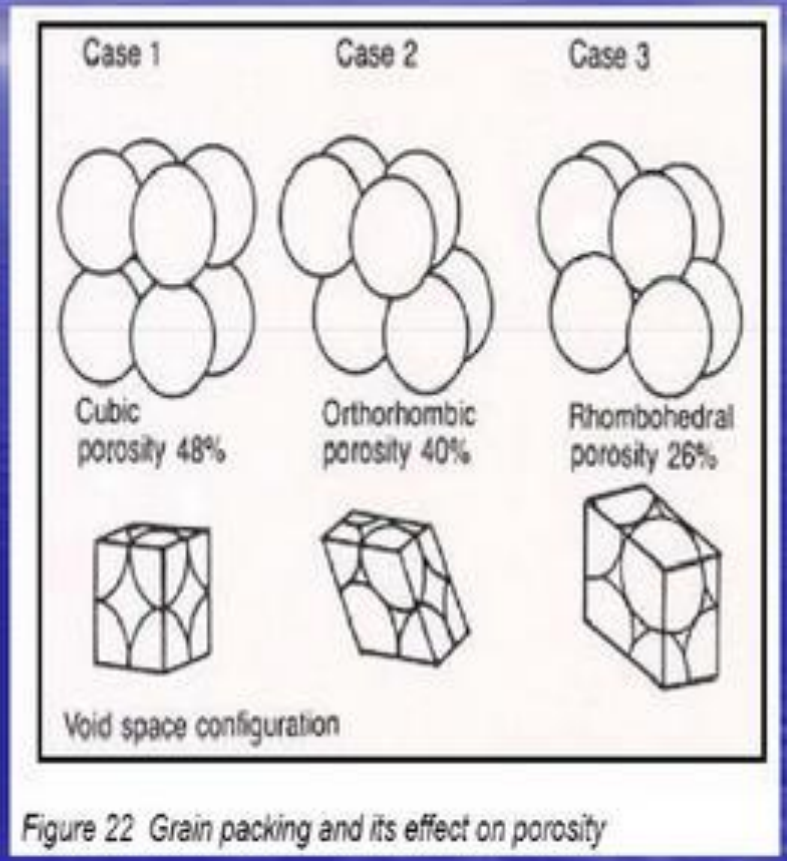


Figure 22 Grain packing and its effect on porosity

- **Organic facies** (carbon cycle, factors influencing organic richness)