Petroleum Geology lectures

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LECTURE3
PETROLEUM SYSTEM ELEMENTS
(Reservoir rock types and properties&
Cap rocks(seal rocks))

Reservoir Rock Definition

- **Reservoir Rock:** Any rock contains connected pores that may be sedimentary igneous or metamorphic but mainly sedimentary.

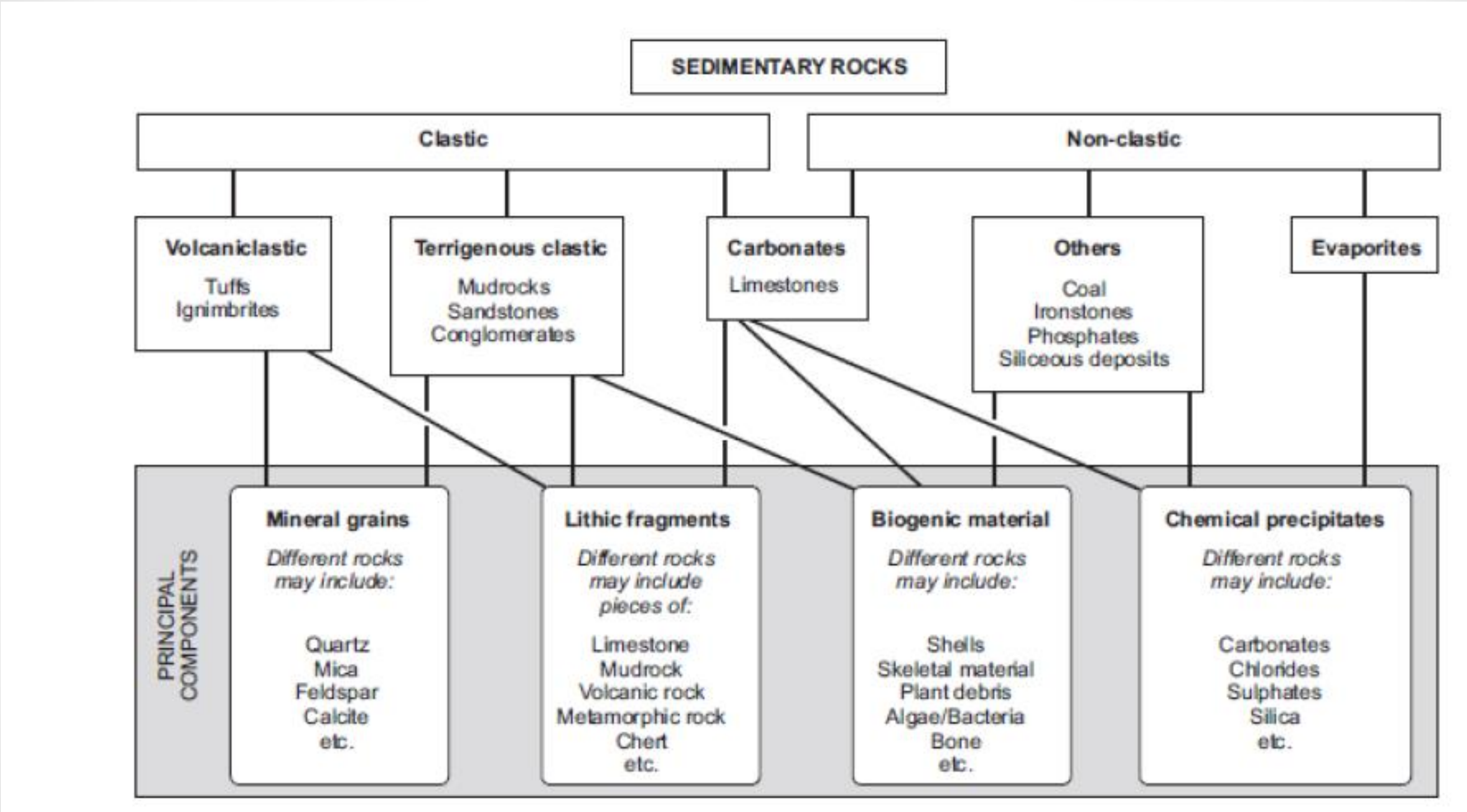
➢ **Types of reservoir rocks:**

a. Fragmental or clastic reservoir rocks.

b. Non clastic reservoir rocks (chemical and biochemical).

c. Miscellaneous reservoir rocks.

Classification of Sedimentary Rocks



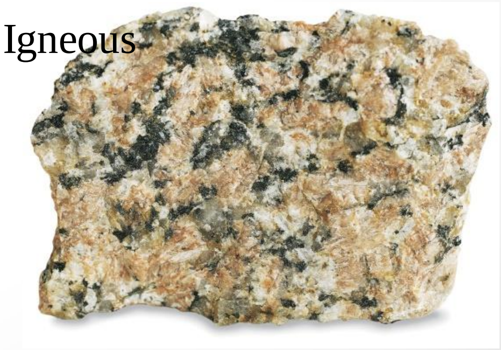
Classifications of sedimentary rocks

- ✓ Clastic Reservoir Rocks

Mainly sandstone or may be siltstone and conglomerate.

- ✓ Non-clastic Reservoir Rocks

Such as limestone, dolomite and reefs.



- ✓ Miscellaneous Reservoir Rocks

Such as fractures in igneous and metamorphic rocks.

Reservoir Rock Nomenclature

1. Color: Red beds, Red Sandstone Reservoirs
2. Fossils Content: Globogerena sandstone reservoirs
3. Lithology : dolomite reservoirs
4. Time: Aptian dolomite reservoirs
5. Type_Locality: Zubiar reservoirs
6. Environment of deposition: Fluvial reservoirs
7. Depth: ZubiarA, B, C reservoirs.

Reservoir Rock Properties

Porosity of reservoir rock: **is defined as the pore fraction of the rock-that is , ratio pore space volume to bulk volume of the rock. Porosity is usually expressed as a percentage:**

$$Porosity = \varphi = \frac{V_p}{V_b}$$

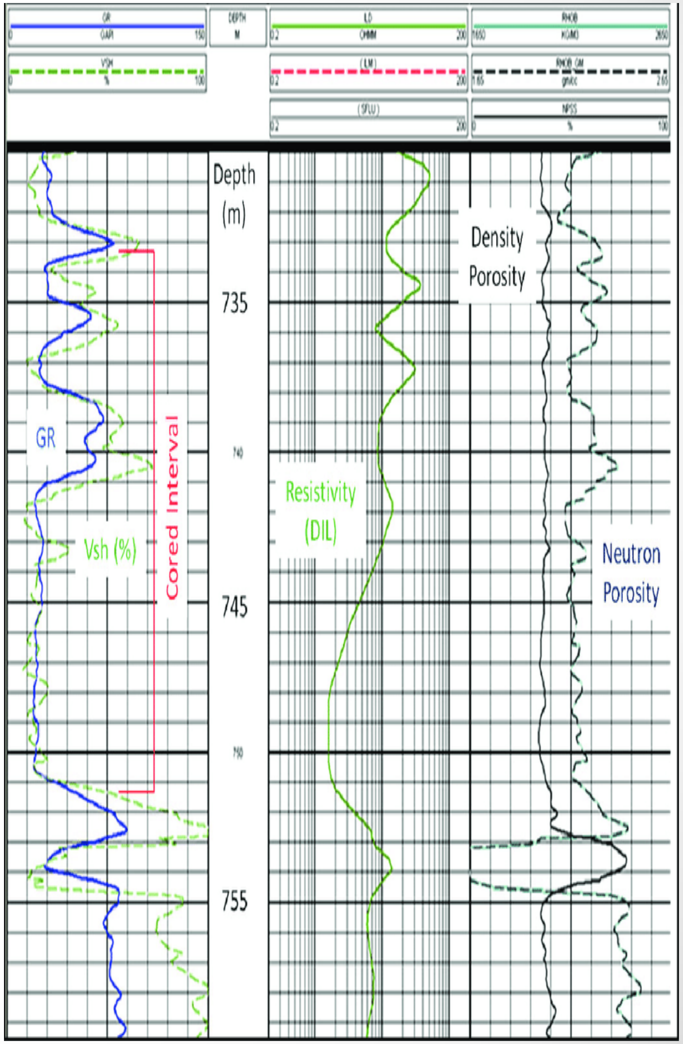
Permeability: **is a measure of the ease of passage of liquids or gases or specific chemicals through the material.**

Reservoir Rock Calculations

- Volume of clay or shale (Vsh) determination.

$$V_{sh} = \frac{GR_{\log} - GR_{\min}}{GR_{\max} - GR_{\min}}$$

Where;
V(sh)= shale volume (%),
GR(log)= GR value from log,
GR(max)=GR value from log at shale line,
GR(min)= GR value from log at sand line



Reservoir Rock Calculations

- Total porosity (Øt) determination

Determination of porosity can be created by manual technique using direct observation from average reading between density and neutron logs.

Or by using density log

$$\phi_{den} = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}$$

Where :

Φ_{den} = density derived porosity

ρ_{ma} = matrix density (see Table)

ρ_b = formation bulk density (= density log reading)

ρ_f = fluid density

(1.1 salt mud, 1.0 fresh mud, and 0.7 gas)

Or by using sonic log

Øsonic=C *(1- $\Delta T\ ma/\Delta T log$)

C= constant (0.625-0.7) for gas(0.6)

$\Delta t\ ma$ = Matrix sonic log
For sandstone= 55.5-51.3

$\Delta T\ log$ = Sonic log slowness time in the zone of interest

Reservoir Rock Calculations

- Effective porosity (Øeff) determination

Correction of total porosity for shale effect by determination of effective porosity is important to remove the effect of shale content.

Effective porosity (Øeff) calculation equation:

$$\boldsymbol{\emptyset_{eff} = \emptyset_t - (V_{cly} * \emptyset_{sh})}$$

$\emptyset_{eff}$ = Effective porosity (fractional).
$\emptyset_t$ = Total porosity from neutron or any method (fractional).
V_{cly} = Volume of clay from non-linear equation or any (fractional).
$\emptyset_{sh}$ = Neutron porosity reading in 100% shale or clay.

Reservoir Rock Calculations

- Water saturation (S_W) determination

$$(S_W)^n = \frac{a * Rw}{\Phi^m * Rt} \quad \text{.......................... } \textit{Archie Equation}$$

Assumption:

- Sw = water saturation of the uninvaded zone (Archie method)
- Rw =resistivity of formation water at formation temperature
- Rt =true resistivity of formation (i.e. Rlld or Rlld corrected for invasion)
- Ø = porosity
- Cementation exponent (m) models how much the pore network increases the riesistivity (m=2).
- Saturation exponent (n)models the dependency on the presence of non-conductive fluid (hydrocarbons)in the pore space, and is related to the wettability of the rock. Water – wet rocks will , for low water saturation values ,maintain a continuous film along the pore walls making the rock less conductive.(n=2)
- Tortuosity factor (a) is meant to correct for variation in compaction, pore structure and grain size and clearly is related to the path length of the current flow.(a=1).

Reservoir Rock Calculations

- Procedure for Sw manual calculation

1. Measuring of Ro : from resistivity log at 100% water saturation of reservoir measure the Rt which in this case equal Ro.
2. Measuring of Ø : from dens-neu. Log at the mid point between the two curves consider the reading from neutron scale and record it as Ø .
3. Measuring of Rw: from the formula

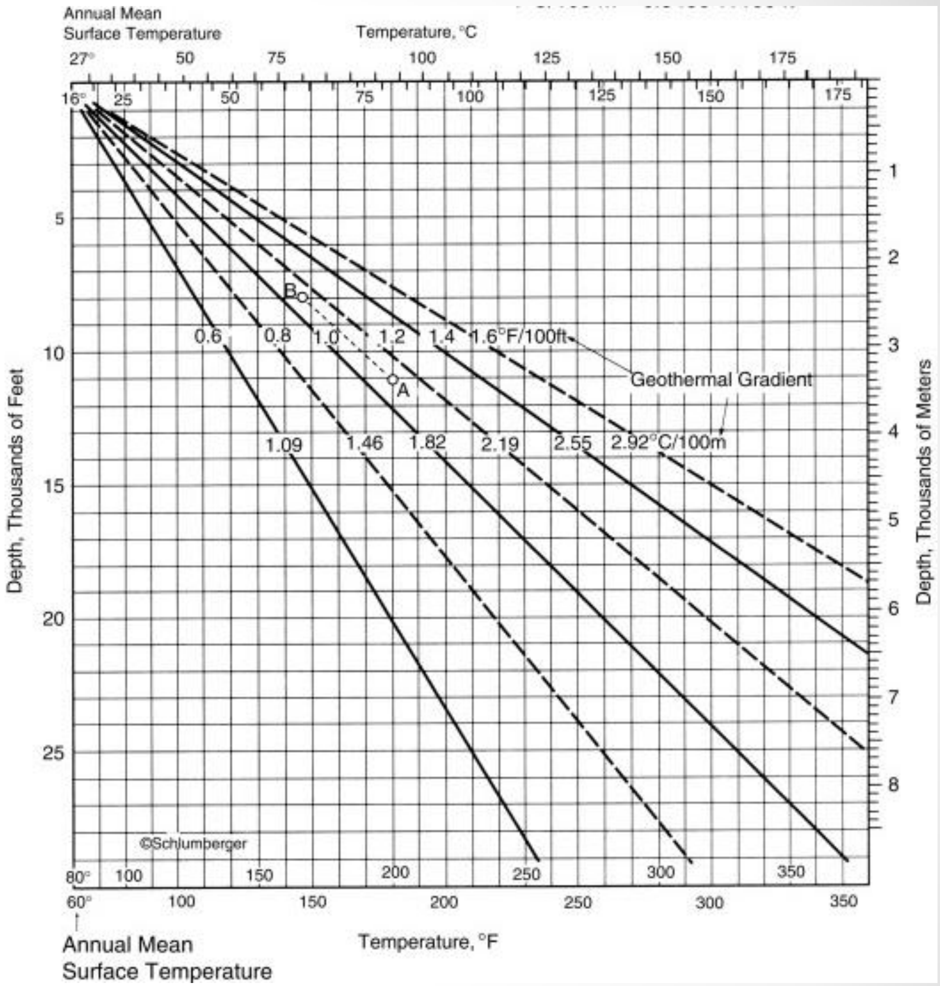
$$Rw = Ro * \emptyset^{m}$$

4. Measuring of Fm. Temp: by using schlumberger Gen-6chart.

Reservoir Rock Calculations

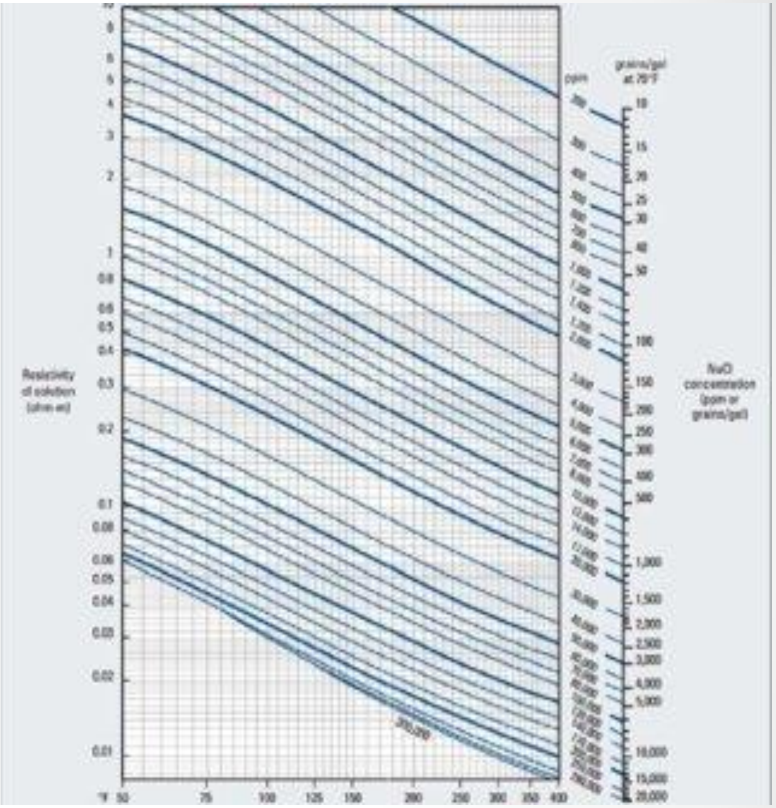
The giving values are:

Rmf	0.04@75 F
TD	7000 ft
BHT	160 F
Res.Depth	6000 ft



Reservoir Rock Calculations

5. Measuring of Rw at Temp: by using Schlumberger Gen-9 chart.



The giving values are:

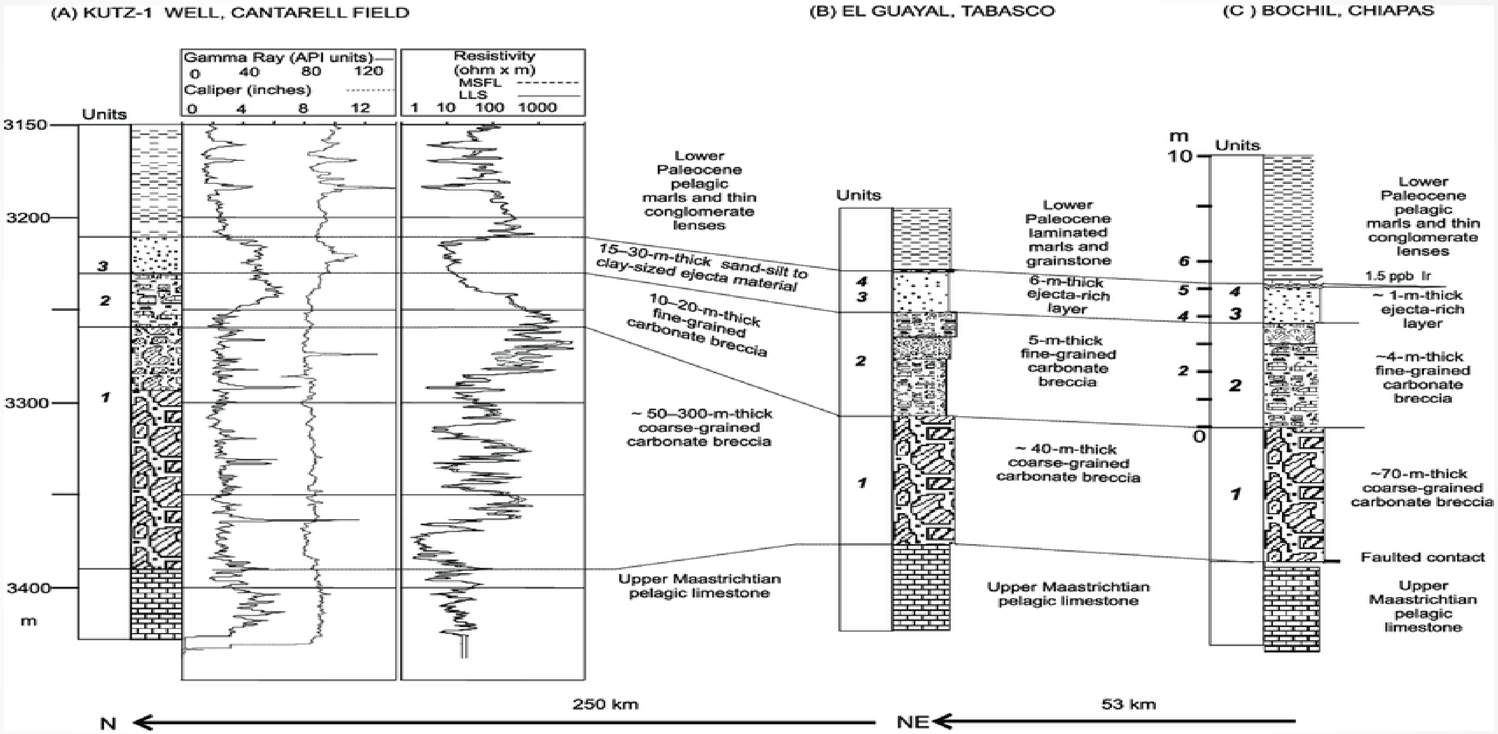
Rmf	0.04@ 75F
TD	7000 ft
BHT	160 F
Res.Depth	6000 ft
Res.Temp	150 F
Rw@TD (After OWC)	0.025

6. By using the equation we can get the Sw.

$$(S_W)^n = \frac{a * Rw}{\Phi^m * Rt}$$

Reservoir Rock Evaluation

1. Stratigraphic Correlation of the sequences



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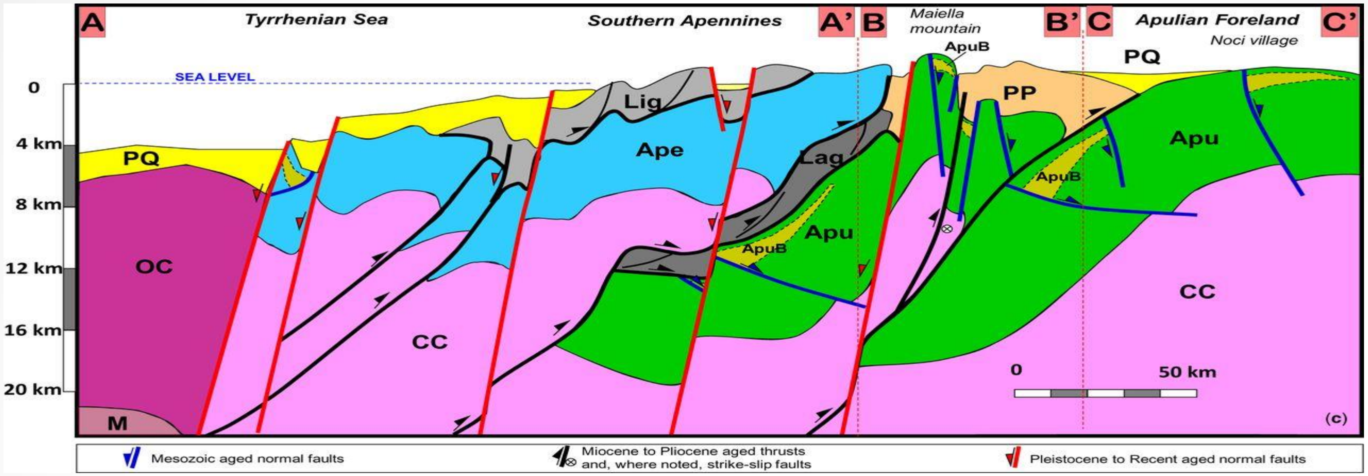
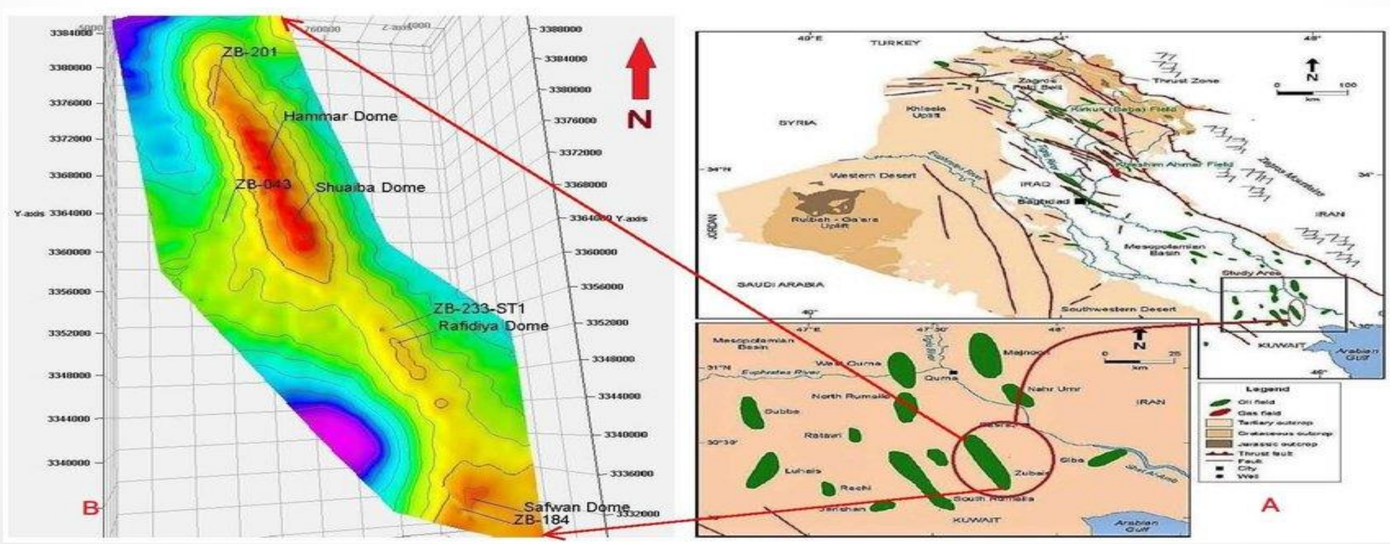
2. Structural X-sections to depict the structure

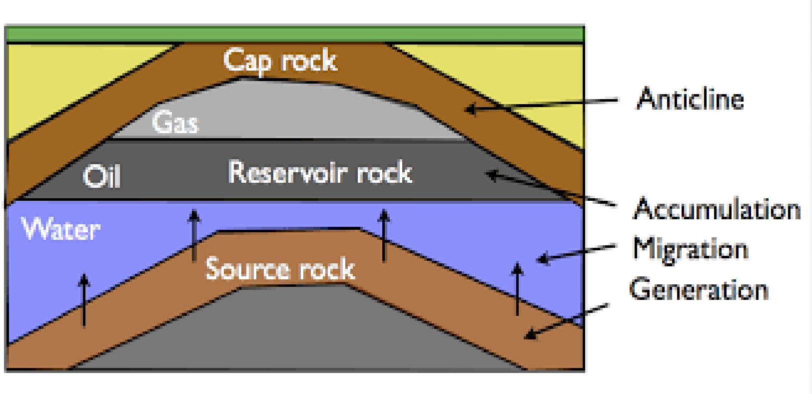


2. Structural Mapping



CAP ROCK = ANTICLINE CREATES A SEAL

- An impermeable rock , commonly shale, anhydrite or salt.

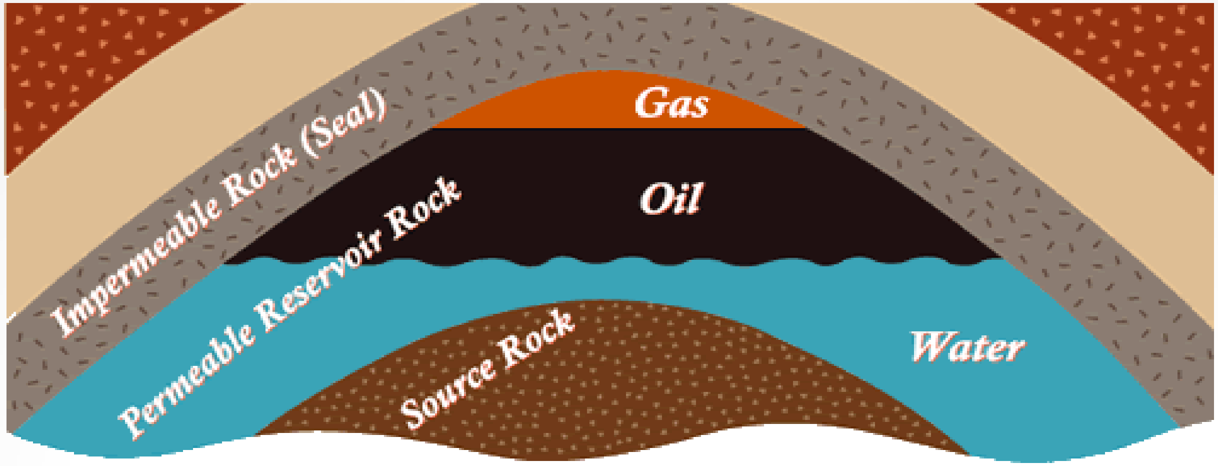


- It forms a barrier or seal above and around reservoir rock so that fluids cannot migrate beyond the reservoir.

- Without a cap rock, hydrocarbon fluids will continue migrating upwards from the source rock, to the reservoir rock and upwards until they get to the surface.

The clays,shales,carbonates,evaporites,and their combinations can form caprocks.the same rock react differently to different fluids. In some cases,rocks serve as satisfactory or good conduits for water, but form barriers for oil or gas movement.

Therefore, the necessary properties of a rock to act as a seal will be different for different fluids.the same rock with different fluids may or may not have sealing properties up to a complete inversion(cap rock-reservoir).



THE SEAL ROCK TYPE

- **Type I**

Sealing properties of these rocks are determined by the amount of capillary pressure at the contact of the reservoir and cap rock. The oil and gas accumulations have higher potential energy is equal to or less than the cap rock breakthrough energy.

- **Type II**

There are no clear-cut overpressure environment there, but there is a relatively clear hydrodynamic subdivision in the section.

- **Type III**

With no detectable hydrodynamic breakdown of the section. Formation water potential in such regions is partically equal throughout the section and corresponds to the calculated hydrostatic potential.