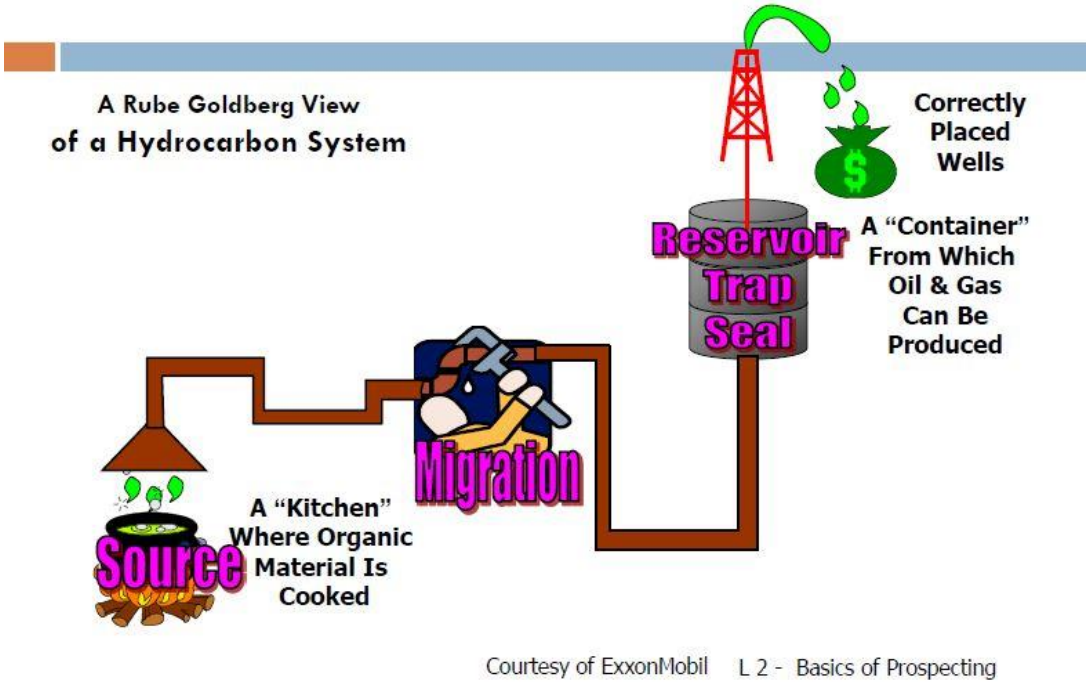
PETROLEUM SYSTEM

By Benyamin Perwira S. (HMG 2014)



- Petroleum System consist of components and process. The components are source rock, reservoir and seal, while the processes are generation, migration, trap formation, burial and preservation.

Source Rock

- "Source rock refers to the formation in which oil and gas originate" (Halliburton, 2001, basic petroleum geology).

- Types of source rock:

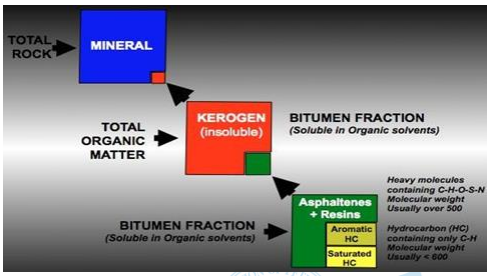
  a. **Active source rock**
  A volume of rock that has generated or is generating and expelling hydrocarbon in sufficient quantities to form commercial oil and gas accumulations.

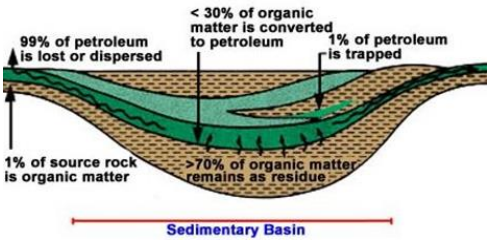
  b. **Spent source rock**
  A volume of rock that had generated, possibly long time ago, its hydrocarbons and now contains thermally altered organic matter.

c. **Potential source rock**
A volume of rock that has the capacity to generate hydrocarbons in sufficient quantities to form commercial oil and gas accumulations, but has not yet reached the state of minimum hydrocarbon generation because of insufficient organic maturation.

- There are 3 aspects of source rock, which are:

a. What kind is it? (Terrestrial, Transitional, marine)
b. How rich is it? (Poor, Fair, Good, Excellent)
c. How mature is it? (Immature, Mature, Over-mature)





ENVIRONMENT	KEROGEN TYPE	KEROGEN FORM / MACERAL	ORIGIN	HYDROCARBON POTENTIAL
Aquatic	I	Alginite	Algal bodies	Oil
		Amorphous Kerogen	Structureless debris of algal origin	
	II		Structureless, planktonic material, primarily of marine origin	
		Exinite	Skins of spores and pollen, Cuticle of leaves and herbaceous plants	
Terrestrial	III	Vitrinite	Fibrous and woody plant fragments and structureless, colloidal humic matter	Gas and some Oil / Mainly Gas
	IV	Inertinite	Oxidized, recycled woody debris	None

Merrill, 1991

Depositional environment of kerogen type
Type I:
stratified freshwater lakes
Type II:
silled, deep-water basins on continental slope and rise
outer shelf O_2-minimum layer under upwelling
Type III:
lagoonal, deltaic and coastal swamps
basins of restricted circulation on continental shelves

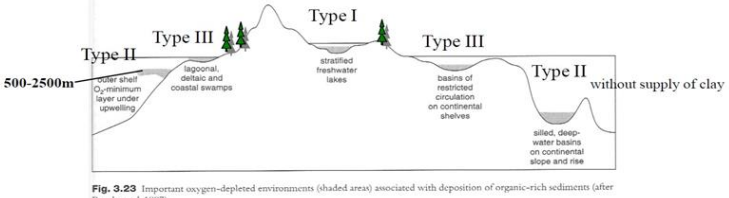


Fig. 3.23 Important oxygen-depleted environments (shaded areas) associated with deposition of organic-rich sediments (after Brooks et al. 1987).

Peters and Moldowan (1993)

Reservoir Rock

- A reservoir is a subsurface (rock) volume of porous and permeable rock that has both storage capacity and the ability to allow fluids to flow through it.
  (Halliburton, 2001, basic petroleum geology)

- Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks. They form under temperature conditions at which hydrocarbons can be preserved. A reservoir is a critical component of a complete petroleum system.

- **Porosity**
  - **Effective porosity** vs **total porosity**
  - Type:
    - Primary porosity
    - Secondary porosity
    - Porosity in Clastic rocks vs. Carbonate rocks
    - Relationship between porosity and permeability

- **Depositional Aspect**
  - Composition
  - Sorting
  - Rounding
  - Grain size
  - Rounding
  - Packing

- **Diagenesis**
  - Dewatering
  - Compaction
  - Cementation

- **Permeability**
  - This is the key parameter in determining reservoir quality. Many rocks (shales for example) have high porosity, but very low permeability. Determined from Darcy's law.

  - Main controls on permeability are:
    - Grain size (determines the size of the pore throats)
    - Pore connectivity

- **Effective Permeability**

When multiple fluids are present they interfere with each other. So that the effective permeability of the moving fluid is much lower than if a single fluid is present. In a typical reservoir, at least water and oil are present, frequently water, oil, and gas share the pore space.

- **Types of Reservoir Rock**
  - Siliciclastic
  - Carbonate (60% of reservoir in the world are carbonate reservoirs (Schlumberger)
  - Naturally fractured

Migration

- The movement of hydrocarbons from their source into reservoir rocks.
- The movement of newly generated hydrocarbons out of their source rock is primary migration.
- The further movement of the hydrocarbons into reservoir rock in a hydrocarbon trap or other area of accumulation is secondary migration.
- Migration typically occurs from a structurally low area to a higher area in the subsurface because of the relative buoyancy of hydrocarbons in comparison to the surrounding rock.
- Migration can be local or can occur along distances of hundreds of kilometers in large sedimentary basins.
- Migration Type
  - **Primary Migration**
    Primary migration is the process by which hydrocarbons are expelled from the source rock into an adjacent permeable carrier bed.
  - **Secondary Migration**
    Secondary migration is the movement of hydrocarbons along a "carrier bed" from the source area to the trap. Migration mostly takes place as one or more separate hydrocarbons phases (gas or liquid depending on pressure and temperature conditions).
  - **Lateran Migration**
    Migration ALONG chrono or lithostratigraphic bedding.
  - **Vertical Migration**
    Migration ACROSS chrono or lithostratigraphic bedding.

- Main Driving force for migration:

  Buoyancy (This force acts vertically and is proportional to the density difference between water and the hydrocarbon so it is stronger for gas than heavier oil.

Seal

- A relatively impermeable rock, commonly shale, anhydrite or salt, that forms a barrier or cap above and around reservoir rock such that fluids cannot migrate beyond the reservoir. A seal is a critical component of a complete petroleum system.

- The simple views of seal are:
  - Ductile (so that they don't fracture) and
  - Impermeable (so that fluids can't pass through) strata.

- The most common seals are shales, the most effective seals are evaporites. Sandstones, on the other hand, are reservoirs and pathways of migration.

- Type of seal rocks:
  - Shales (most cases)
  - Anhydrite/evaporite
  - Tight carbonate

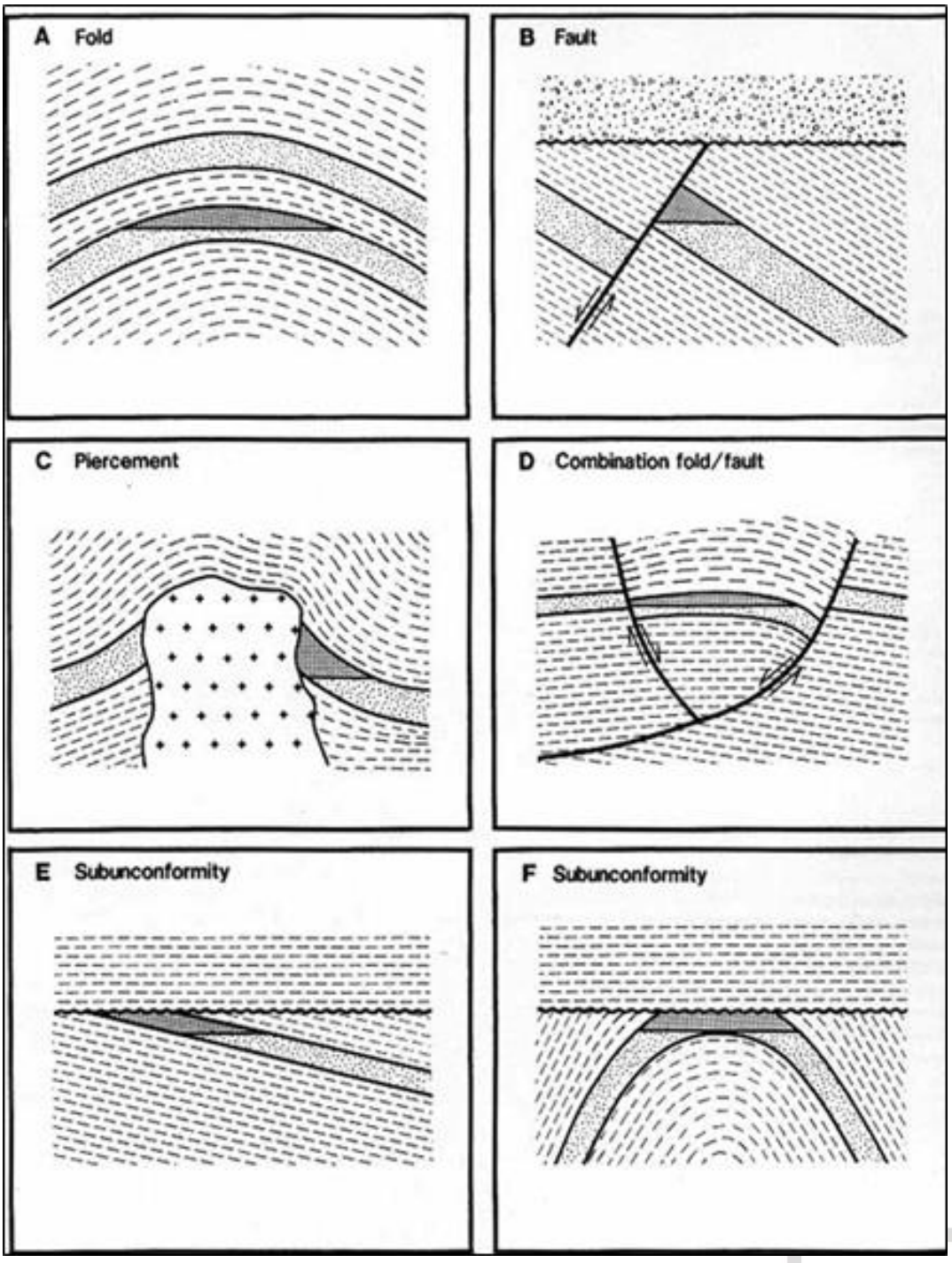
  (Schlumberger)

Seal

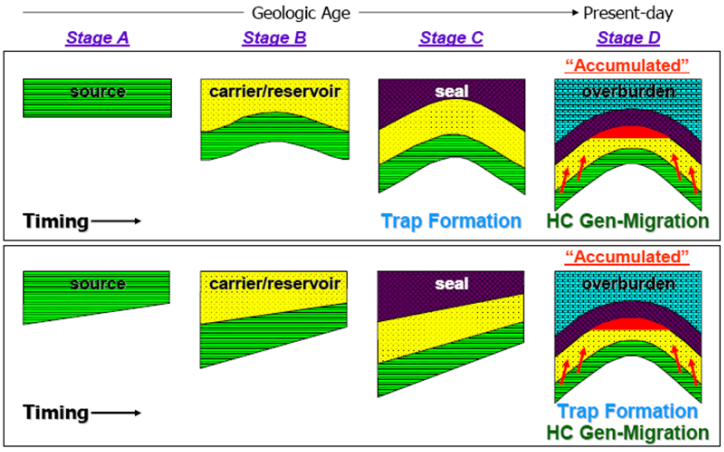
A configuration of rocks suitable for containing hydrocarbons and sealed by a relatively impermeable formation through which hydrocarbons will not migrate.

To be a viable trap, a subsurface geometric feature must be capable of receiving hydrocarbons and storing them for some significant length of time.

This requires two fundamental components; a reservoir rock in which to store the hydrocarbons, and a seal to keep the hydrocarbons from migrating out of the trap (Biddle & Wielchowsky, 1994).


A Fold
B Fault
C Piercement
D Combination fold/fault
E Subunconformity
F Subunconformity

Importance of Timing of Trap Formation and Petroleum Generation



Importance of Timing of Trap Formation and Petroleum Generation