# PE8402 - Fundamentals of petroleum Geology

## Unit - III.

1. **Describe about the generation of petroleum.**

**Theories for origin of petroleum:**

* Petroleum is defined as any mixture of hydro carbons that can be recovered from a drill pipe.
* It occurs in form of oil and gas which mainly have a chemical composition of hydrocarbons of various carbon chains.
* There are two types of theories
  - ✓ Abiogenesis
  - ✓ Biogenesis

**Abiogenesis origin of petroleum:**

* As the earth existence is date to 4.5 billion years, the Abiotic theory is said to occur in that time, before the appearance of any form of life.
* The tenets supporting abiogetic origin of petroleum are in the following way.

a) The existence of methane on other planets of solar system, meteors, moons and comets.

b) The biogenic explanation fails to explain some of hydrocarbon deposit characteristics.

c) The crude oil distribution of metals fits better with upper serpentinized mantle primitive mantle and chondrite patterns than the oceanic and the continental crust, and never shows any correlation with sea water.

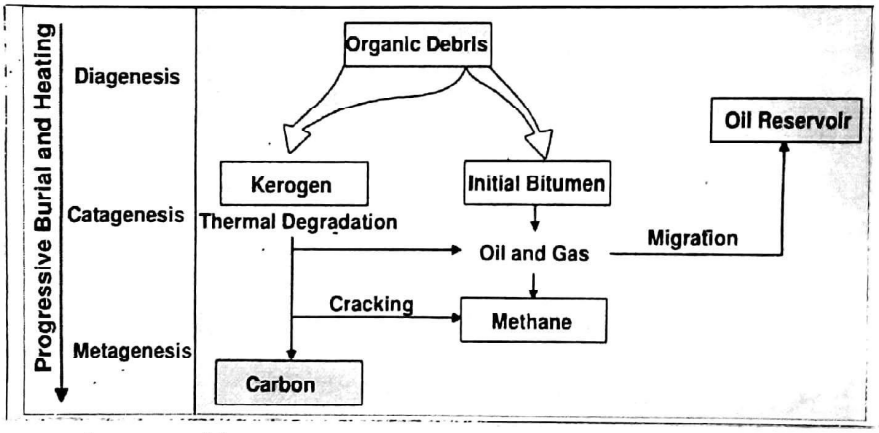
d) The helium and other noble gas association with hydro carbons.

e) Deep hydrocarbon seeps.

f) Hydrocarbon-rich areas tend to be hydrocarbon-rich at various different levels.

## Biogenesis:

* Biogenesis origin of petroleum (Hydrocarbons) suggests that petroleum come from a long time decaying of dried organisms such as planktons, Zooplankton ad other form of biological species under the subjection of high temp.




Sources of rock:

## Types of source rock

* Source rocks are classified from the types of kerogen that they contain which in run governs the type of hydrocarbons that will be generated.

Type 1: Source rocks are formed from algal remains deposit under anoxic conditions in deep lakes. They tend to generate waxy crude oil

Type 2: Source rocks are formed from marine planktonic.

Type 3: Source rocks are formed from terrestrial plant material.

* Source rocks can be divided into 4 categories

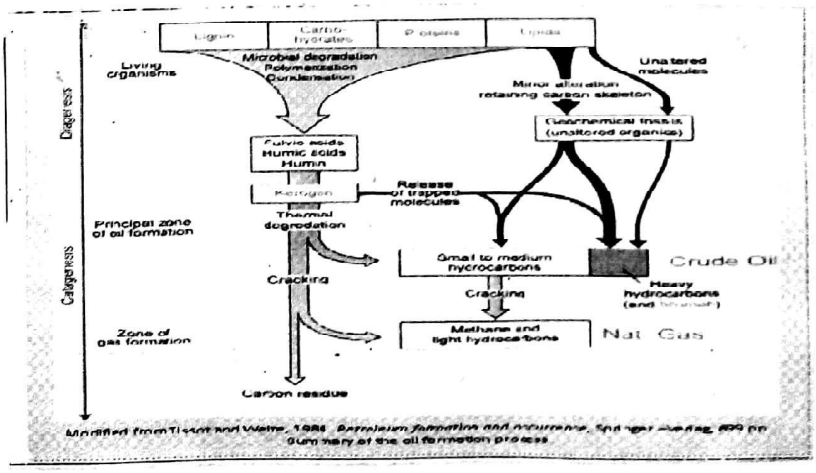
→ potential
→ Effective
→ Relic effective
→ Spent.

Chemical and temp. ↑ composition changes due to burial.

## Oil formation

Various types of kerogen

1. Algal : when matures mostly yields crude oil
2. Mixed : Also oil pro but yields more natural gas than type 1.
3. Coaly : Yields mostly natural gas. Low capacity to form oil.
4. Inert : Highly oxidized. Very rare and has no ability to generate oil or gas.




Modified from Tissot and Welte, 1984. Petroleum formation and occurrence, 2nd ed., p. 699
Summary of the oil formation process.

Kerogen:

* Heat and pressure convert organic matter into a substance called humin and then into kerogen. Time and temp. convert kerogen into petroleum.

Formation of Kerogen:

1. Diagenesis
2. Catagenesis
3. Metagenesis.

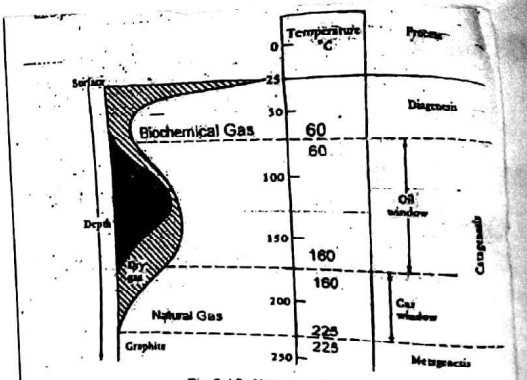



Fig.2.18 Kerogen Formation

2. Give an account on sedimentology of petroleum bearing sequences.

Depositional Sequences

* Relative conformable succession of genetically related strata bounded by unconformities

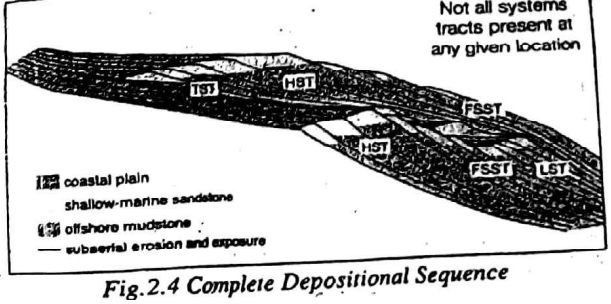



*Fig.2.4 Complete Depositional Sequence*

## Types :

1) Lowsand system tract
2) Transgressive systems Tract.
3) Highstand systems Tract

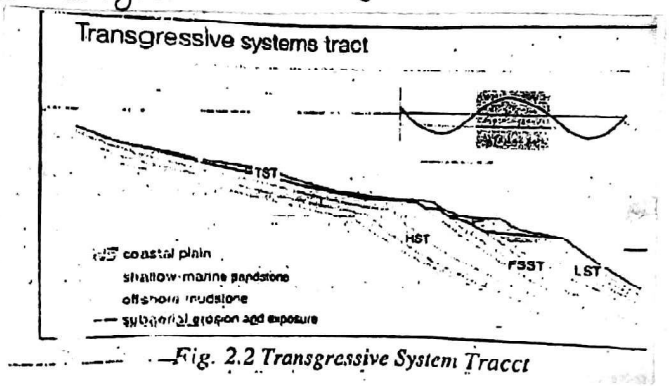
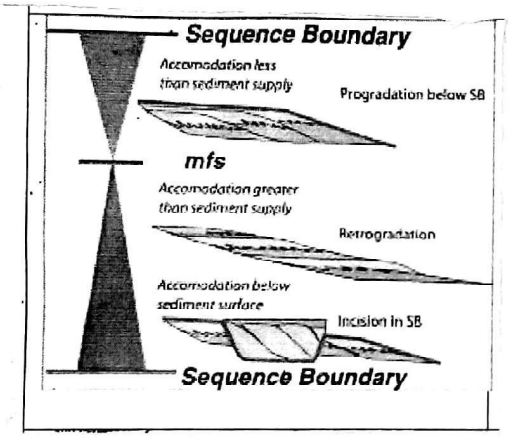



Fig. 2.2 Transgressive System Tracct




## Transisive Surface :

* The Lowsand systems tract is commonly capped by a prominent flooding surface called the transgressive surface.

Maximum flooding surface :

* The maximum flooding surface caps the transgressive systemstract and marks the turn-around from retrogradational stacking in the early high stand systems tract.

Type I & Type II Sequences:

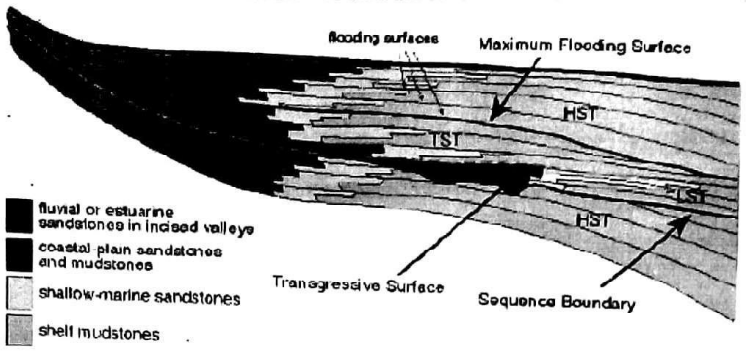
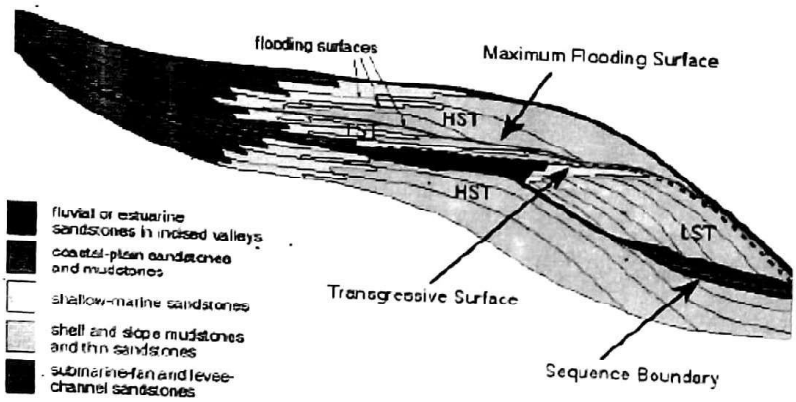



*Figure adapted from Van Wagoner et al. (1990)*

Type I




Type II

3 Describe about the migration of petroleum.

Principle of migration

*Hydrocarbons migrate as a separate phase, primarily due to buoyancy. This force causes them to move vertically at geologically rapid rates.

Migration Stages:

*Hydrocarbon migration consists of four stages.

*They are

1. primary Migration
2. Seondary Migration
3. Tertiary Migration
4. Re migration.

1. primary migration

- The proces of loss of hydrocarbons from the Source rock.

2. Secondary Migration.

- Migration from source to reservoir along a simple or complex carrier system.

3. Teritiary Migration

- Migration to the surface, either from a reservoir or Source rock. Also called dismigration

4. Remigration:

- Migration from one reservoir position through an intervening section in to an inter -venning section in to another reservoir position in the same or a different reservoir.

Migration theorem:

* Migration is controlled by the following factors or parts of the general theory

Expulsion as protopetroleum:

* The evolutionary sequence from kerogen to Crude oil and gas is very complex. Determination of whether the transformation was completed

during, before or after migration is also very difficult. In addition oil is not soluble in water so all these reasons pushed Hunt (1968) to assume that the migration process was completed before kerogen was transformed in to crude oil. While the migration was occuring, kerogen had changed in to esters, acids and ketones.

* All these components in the water so the crude oil migrates. Cordell (1975) said that this mechanism contains several problems.

1. The concentrations of esters, ketones and acids are low.
2. These components are likely to absorbed as petroleum is expelled.

Globules of oil in water and continuous phase migration

* These theories claimed that oil emigrates from the source rocks to the carrier rock as a discrete oil phase. However, there are two mechanisms for the expulsion of oil.

* These mechanisms are

1. Expulsion of discrete droplets associated with pore water
2. Expulsion of three dimentional continuous phase of oil (oil wet source rock)

## 4. Physical properties of petroleum.

1. Density
2. Specific gravity
3. Volume
4. Viscosity
5. Refractive index
6. Fluorescence
7. Optical activity
8. Colour
9. odour
10. Boiling point

### 1. Density

* The physical property density is the ratio between mass and volume. The density of crude oil can be determined from:

1. Specific gravity of the crude oil
2. Solution gas gravity
3. Solution gas - oil ratio
4. Oil formation volume from (FVF)

Under any condition, density will be defined by

$$\rho_o = \frac{W_o + W_g}{V_o + \Delta V_g} \rightarrow (1)$$

* Stated more rigorously with PVT properties, this relationship becomes

$$\rho_o = \frac{62.42796\,\gamma_o + 0.0136\,\gamma_g R_s}{B_o} \rightarrow (2)$$

* This is valid for all pressure and temperature conditions for which the pressure - Volume - Temperature (PVT properties are determined. As expressed, this equation provides density with the units of $lbm/ft^3$.

## 2. Specific Gravity:

* Specific gravity of oil generally lies in between 0.73 and very slightly above 1.0.
* Paraffin oils are commonly lies asphalt base oils almost invariably high. The gravity is conventionally signified by the Greek letter rho ρ.

* API gravity = (141.5 / Specific Gravity) − 131.5

- Light – API > 31.1
- Medium – API between 22.3 and 31.1.
- Heavy – API < 22.3
- Extra Heavy – API < 10.0

## 3. Volume:

* Oil in the reservoir contains dissolved gas, and the volume of the solution depends upon the formation gas-oil ratio and the reservoir pressure.
* Gas may be dissolved in oils under increasing pressure and increase the volume in solution.
* The volume of liquid petroleum, at constant pressure.
* The volume of surface equivalent gas will dissolve in a unit volume of reservoir oil.
* Increases as the reservior pressure increases until the oil is finally saturated with gas and no more gas will dissolve in the oil.

## 4. Viscosity:

* Viscosity is the internal friction of fluid causing it is resistant put change of form. (Viscosity is conventionally defined by the Greek letter eta, $\eta$)

* It is the ratio of stress to shear per unit time. Shear with liquid is not a constant but is proportional to time.

* Viscosity is defined by the ratio,

force * distance / area * velocity.

* The CGS unit of Viscosity is the poise which is too large unit of practical purpose in the oil industry. Viscosity of oil are therefore conventionally measured in centipoises.

SUS = Viscosity in centipoises * 4.635 / relative density

* Hydrocarbon having viscosity higher then 10,000 mPa are now to be called natural tar.

## 5. Refractive Index:

* Absolute Refractive Index (RI) of a substance is the inverse ratio of the speed of light.

* The range of refractive indices for petroleum is from 1.40 to 1.48.

* The Lower indices are the lighter oils. The RI is depends on the density of oils.

*The heavy oil (lower API Gravity) have the higher Indecies.

* Refractive Indices of Representative Oils-

| API Degrees | Density | Refractive Index. |
|---|---|---|
| 6 | 1.029 | 1.566 |
| 32 | 0.918 | 1.509 |
| 44 | 0.802 | 1.448 |
| 58 | 0.742 | 1.417 |
| 72 | 0.691 | 1.390. |

6. Fluorescence:

* The all oils show more or less fluorescence.
* The aromatic oils being the most fluorescent.
* the fluorescent colours of crude oils range from Yellow through Green to Blue.
* Fluorescence is observed under ultraviolet radiation that most generally used for petroleum having wavelength of 2.537 and 3650 angstrom unit.

7. Optical activity:

* The optical activity of petroleum is gradually degraded by maturational influence, and a decreasing trend in rotatory power is recognized in a comparison

of oils produced from rocks of progressively greater geologic age.

8. Colour

* Paraffinic oils are light color : yellow to brown by transmitted light.

* Asphalt - base oils are commonly brown to black; many of them are known as "Black oils".

* Color is commonly determined with use Saybolt Colorimeter.

9. Odor:

* Due to the light hydrocarbons some oils is agreeable like gasoline odor.

* Aromatics impart pleasant odors.

* Oils containg sulphur and certain nitrogen compounds usually a disagreeable odor.

10. Boiling point:

* Atmospheric true boiling point (TBP) data are obtained through distillation of a petroleum mixture using a distillation column with 15-100 theoritical plates a relatively high reflux ratio (1-5 or greater)

* The high degree of fractionation in these distillations gives accurate component distributions for mixtures. The lack of Standar-dized

apparatus and operational procedure is a disadvantage, but variations b/w TBP data reported by different laboratories for the same sample are small.

5 Explain in detail about chemical properties of petroleum.

* Hydrocarbons are found in nature in many different forms, mainly as :

* Liquid petroleum : known as "crude oil" to distinguish it forms "refined oil". It is most important commercially.

* Natural Gas : Which is the lighter fraction of hydrocarbons, can be free or dissolved.

* Asphalt, Tar, Pitch : These are solid or semi - solid forms of hydrocarbons, the heavy fraction.

Hydrocarbon series :

* A saturated hydrocarbon (sometime called Alkane) is one which the valence of all the carbon atoms is satisfied by single bonds for each carbon atom is connected to each other carbon atom by a single covalent bond.
eg. Parraffins.

* An unsaturated hydrocarbon is one in which the valence of some of the carbon atom is not satisfied by single bond, so that these atoms are connected to one another with two or more covalant bonds. eg: Benzene.

* It is generally agreed that Hydrocarbons of four different series or types are present in important quantities in petroleum.

Paraffins:

* It is also called alkanes and have the general formula of $C_nH_{2n+2}$, where 'n' is the number of carbon atoms.

* paraffins from $C_1$ to $C_{40}$ usually appear in crude oil and represent upto 20% of crude oil by volume. Since paraffins are fully saturated (no double bond), they are stable and remain unchanged over long periods of geological time.

Napthenes: (Cycloparaffins)

* These are cyclic or cyclic saturated hydrocarbons with the general formula of $C_nH_{2n}$

* Thermodynamic studies show that naphthene rings with five and six carbon atoms

are the most stable naphthenic hydrocarbons.

* The content of cycloparaffins in petroleum may vary up to 60%

## Aromatics

* Aromatics are an important series of hydrocarbons found in almost every petroleum mixture from any part of the world.

* This series of aromatics is called alkyl-benzenes and have a general formula of $C_nH_{2n-6}$ (where $n \geq 6$)

* Its example are Benzene $C_6H_6$

## Asphaltenes:

* They are composed of fused benzene-ring network, but they contain impurity atoms and are not true hydrocarbons. These impurities are the high molecular weight compound previously referred to as NSO compounds.

* Asphaltenes are heavy compounds of Crude oil and the major components in many natural tars and asphalts.