Origin of coal:

Although there are divergent opinions about details, there seems to be a general agreement on the main processes involved in the formation of coal. The vegetation, the like of which may not be seen today but must have existed ages ago, was first submerged in a body of stagnant water. The cellulose of the plants was then subjected to bacterial attack. Peat was the product of such bacterial action on the plant material. Different types of peat were produced depending upon the original character of the vegetation and the intensity of the bacterial attack. Besides, the vegetal matter was substantially compacted to form peat, the precursor of coal.

Peat is generally deposited in slowly sinking basins where mineral matter input is very small and where ground water table can keep abreast with the formation of peat.

Commonly two theories of accumulation of peat have been recognized, they explain the formation of coal seams.

Drift Theory: As per this, coal seams are believed to be formed out of plants and trees which grew millions of years ago and fell down due to earth quake and tectonic activities, ground subsided and the plant material drifted, to considerable distances from their original site of growth and re-deposited as peat, to lakes, river valleys, etc., by flow of water, covered by sediments of sand and earth. The process of deposition continued for millions of years in layers and undergone geo-chemical changes such as heat, bacterial decay, pressure, etc., to form coal seams. Such coals are considered as **allochthonous** coals, which are usually very rich in mineral matter.

In Situ Theory: the plants, where it grew, subsided under the earth, which after death formed peat, submerged in the water at the same place. The process of deposition continued in layers and undergone geo-chemical changes as explained above to form coal seams. Such coals are considered to be a**utochthonous** coals, which generally have relatively much less mineral matter.

Further more, according to the mode of decay of the original plant material, coals can be grouped broadly into the following two categories:-

1. HUMIC COALS :- Resulting from plant decay under aerobic (in presence of oxygen) conditions. This group included coal seams.

2. SAPROPELIC COALS :- Resulting from plant decay under aerobic (in absence of oxygen) conditions. These coals are characterized by a non-banded appearance. The sapropelic coals are of two types, 1) the cannel coals and 2) the boghead coals. The former are dullish black, with a slightly greasy appearance and conchoidal fracture; the latter are more brownish in color.

Geological and Geographical variation in petrologic characteristics of coals:

The world coal is divided into three categories as per their geological age of formation:

1. Carboniferous coals: These are the earliest coal deposits of commercial importance formed during carboniferous age, about 360 million years ago. These deposits are widespread in the countries of Northern Hemisphere. These coals are of superior quality because of low ash content.
2. Gondwana coals: These are of less commercial importance formed mainly during permian age, about 270 million years ago. These deposits are widespread in the countries of Southern Hemisphere.
   Some marked petrologic differences are apparent between coals of carboniferous coals and gondwana coals. The main macroscopic differences are that the gondwana coals are usually comparatively dull in overall luster, and occur in seams in which dull bands are commoner and sometimes much thicker than in the carboniferous coals. These differences result from the two groups of coals having being derived from contrasting plant assemblages that grew under different

climatic conditions; the plants that gave rise to the gondwana coals grew in a considerably colder atmosphere.

Gondwana coal generally contain higher proportion of intertinite and minerals and a lower proportion of vitrinite and exinite, a fact which accounts for generally dull macroscopic appearance of these coals. Gondwana coals generally have higher mineral matter content when compared with carboniferous coals. Although the same minerals are found in each of these two groups of coals, the proportions of many minerals show marked differences between the coal groups. In particular, pyrite is generally present in much smaller amounts in gondwana coals, giving rise to lower sulfur contents than those of most, carboniferous coals.

3. Tertiary coals: They are less matured than carboniferous or gondwana coals. These are high moisture brown and sub-bituminous or lignite coals.

Coal Rank:

Coal rank implies the degree of coalification. It is a measure of the maturity of coal and is assessed in terms of moisture and carbon content, volatile matter and Vitrinite reflectivity. While peat and lignite are essentially low rank coals, anthracite are in the last stage of coalification and form the highest rank of coals.

All coals are rockes formed form the altered remains of what was arginally luscriant vegetation. The variety of coals encountered relates to the amount of alteration that the original material has undergone and the conditions that have influenced its formation into rank. The concept of rank is used by coal of highest rank are those coals which have under gone the greatest change – metamorphosis, as it is termed, Transformation stage gives us one of the varities of coal. by rearranging the various types of coal in an ascending order of rank, we achieve what is known as the coalification series.
In proceeding up this series from low to high rank, the character and composition of the material changes. The following table describes some of the major variations that occur with changes in rank. The concept of coal rank is used to indicate the stage of alteration attained by a particular coal; the greater the alteration, the higher the rank of the coal.

Coal rank and process of coal formation: The transformation of plant material to peat is a biochemical process, the earlier stage of this being due largely to the activity of bacteria (aerobic and anaerobic) and fungi. The transformation of peat to coal, or coalification, is a geochemical process, being dependent upon the effects of heat and pressure acting over periods of time.

Effects of geological factors on coal rank:

1) Age :- A common misconception is that the rank of a coal is a measure of its age. A relatively young coal may attain higher rank due to have been subjected to greater depth of burial or more severe earth movements. It follows that coals of the same geological age may show wide difference in rank geographically (e.g. lretaceous age show wide difference in rank from lignite to anthracite).
2) Heat & Pressure :- Resulting from difference in the depth of burial and intensity of earth movements to which they have been subjected, coals within a particular coalfield often exhibit significant variation in rank. In a seam of a particular locality, a general increase in coal rank from upper to the lower seams can frequently be demonstrated, and this relationship has been termed as hit's low.
3) Igneous activity :- In some coalfields, the normal course of coalification due to above factors has been modified locally by the effects of igneous of coalfication fue to rocks have been through or extruded in the prosaimity of , pre-existing coal semas, VM is driven from the coal, the devolatilization is accompanied by reduction or complete destruction of any swelling and coking properties the coal nay have possessed. Such coals are frequently described as heat altered or brunt coals.

STAGES OF COAL FORMATION:

On the basis of physical and chemical changes that have taken place in the transformation of the vegetable matter into coal, the varieties like Peat; Lignite; Sub-Bituminous; Bituminous; Semi-Anthracite and Anthracite are formed depending on the nature and composition of the organic matter, its volatile matter, calorific value and moisture content.

FOREST AND BOG: In the earlier stage, huge thick forest were present. The land in which these forest grew slowly subsided. Being low land water accumulated above the trees and vegetation. This was then attacked by aerobic and anaerobic fungus under oxidizing and reducing atmosphere alternately. The whole mass was converted into semi-gel type material, which was very fertile. This high fertility again resulted in very quick development of forest. Again the earlier process was repeated. This repeated subsidence and growth of forest caused formation Bog.

It contains, 20 – 30% of carbon; 6-8 % of hydrogen and traces of Nitrogen, sulfur and phosphorous. Oxygen was the predominant constituent in the bog. High volatile matter; High moisture.
It does not have any definite shape. It is jelly like material. It is grayish in color. It does not have any structure because it is not solidified. All the structure that are present in the original plant are present in the bog mass. Heat and pressure have not been exerted on the bog. Very similar to wood but it contains much more water being in gel-stage. Bog is economically not exploited.

PEAT: Peat has been formed at a stage later than bog. Chemically peat is very similar to Bog, except that the carbon is between 30 to 35 percent, hydrogen about 5 – 7 % and other traces of constituents like, nitrogen, sulfur, phosphorus. Carbon and hydrogen are present mostly as aliphatic compound and with combination of nitrogen as amino acids, very to what is obtained by distillation of plant vegetation. It contains approximately 35% moisture, about 10% volatile matter. Calorific value is about 3500 B.Th.U (2000 K.Cal/kg)

It has not yet attained the hardness as coal, is friable in nature. It does not have any definite structure. Peat has not yet been affected by heat and pressure. It is purely sedimentary in nature. It is light, porous and fibrous substance light grayish brown to dark brown color. Original plant structures are visible when viewed under the microscope. It is more compact than bog and thus moisture content is much less. It is uniform in color. It is easily ignitable. During its formation, lots of hydrocarbon gases escape. It is used as a fuel in those places where wood or coal is not available.

Presently day peat deposit have been studied by Moore (1989)* indicating that 8m of peat in the tropical Batang Hari River deposit in Sumatra has been deposited at the rate of about 1 m in 500-600 years whereas peat in a cold temperate deposit in Maine, USA, has been accumulating at a rate of 1 m in 1500-1700 years.

LIGNITE: It is third stage in the formation of coal. Being in first stage of coalification it resembles some of the properties of very low rank coal. Its carbon content varies from 40-55 %. Comparatively oxygen and moisture are much less than peat. It contains about 25-35% of moisture. It is mostly consist of aliphatic compound with smaller quantities of hydro-aromatic compounds and amino acids. Calorific value ranges between 6000-7000 B.Th.U (3300-3900 K.Cal/kg)

It is fragile and breaks into powder on handling. It is dull brown to blackish brown in color. It does not have any clear structure. Since it is very little affected by heat and pressure, it has not attained and design. Some much more matured lignite has within it the macerals. Some of the lower rank lignite possesses clear remains of plant structures. Since it is very near to low rank coal, its heat value is quite substantial. Its ash content varies from 10-20%. It is found in very thick seams and beads.

SUB-BITUMINOUS: In real terms, it is first stage of coal formation. It is formed due to heat and pressure. Being more matured than lignite and having been affected by heat and pressure for shorter periods, the carbon content shoots up to 65 – 80%. The oxygen is also very much less. Auromatic compounds are abundantly present with comparatively lesser amount of aliphatic compounds. The

moisture is much less and varies between 8 –25%. Calorific value ranges between 8000-10000 B.Th.U (4450-5500 K.Cal/kg)

Various constituents such as macerals can be clearly identified. This is lowest rank of bituminous coal and has developed a clear structural pattern in the form of cystallian vitrain, clarain, and non-cystallian durain and fibers fusain. The ash percentage varies from 15-45%. Being subjected to heat and pressure it has developed all properties of coal expect caking property. It is easily affected by spontaneous combustion. It has volatile matter. It has developed strength and cannot be broken easily.

BITUMINOUS: It has been formed due to slow application of heat and static pressure. Since it is older than sub-bituminous coal, it contains approximately 80-85% carbon and hydrogen from 4 – 6%. The volatile matter varies from 15- 45% and moisture from 1-10%. The ash forming material, i.e. mineral matter, also varies from 10-45%. Some bituminous coals have developed, an intrinsic coking property.

It has developed a clear and distinctive structure, such as vitrain, clarain, durain and fusain. This coal is much harder from its predecessors. It is pitch to dark black in color. The physical properties of bituminous coal are determined by the percentage distribution of macerals groups, such as vitrain, clarin, durain and fusain. Plant structure are not readily visible under the microscope because of its greater compactness. Bituminous coal covers a wide range of variety, from low volatile, low moisture to high volatile; high moisture. The high volatile bituminous coals are tougher to break (low HGI) than low volatile coals(high HGI). As it is harder and denser, it can stand exposures. It is considered as all purpose coal because of its excellent heating quality. Calorific value ranges between 11000-15000 B.Th.U (6100-8300 K.Cal/kg).

SEMI-BITUMINOUS COAL: This is superior grade of bituminous coal containing 11 –18% of voaltile matter and Calorific value ranges between 12000-15400 B.Th.U (6600-8550 K.Cal/kg).

SEMI-ANTHRACITE & ANTHRACITE: This is the last stage of coalification. The anthracite has been formed as a result of acute geological disturbances in and around the deposits of coal. The volatile matter is hardly 4-5% with moisture less than 1%, carbon content is around 90-98%. Hydrogen is less than 2%. It is hard coal with iron black color and sub metallic to brilliant luster. Calorific value ranges between 14000-15000 B.Th.U (7700-8300 K.Cal/kg). This coal does not soil the finger. It is non-caking in nature. In this coal, various constituents are not clearly identified.