COAL

1. Definition of coal
2. Varieties of coal
3. Rank of coal
4. Formation/Origin of coal

HISTORY OF COAL

- Coal was first mined in the Raniganj Coal field field in the year 1774 by the East Indian Company.

- We needed to fuel steam engines, and coal was a readily available fuel.

- Fuel was burned to create steam to turn a turbine in power plants.

- Today 72% of Indian electricity comes from coal. We have 300 years’ worth of coal!

Definitions of coal:

- Sedimentary rock composed of combustible matter derived from the partial decomposition of plant material.

- A generic term applied to carbonaceous rocks that were formed by the partial or complete decomposition of vegetation. These stratified carbonaceous rocks are either solid or brittle and are highly combustible.

- A combustible rock of organic origin composed mainly of carbon, hydrogen and oxygen with lesser amounts of nitrogen, sulphur and other elements.

Definitions of coal:

- Coal is formed from accumulated vegetable matter that has been altered by decay and by various amounts of heat and pressure.

- A black or brownish-black solid, combustible substance formed by the partial decomposition of vegetable matter without access to air.

Coal Ranking & Quality

- The rank of coal, which includes anthracite, bituminous coal, sub-bituminous coal, and lignite are based on fixed carbon, volatile matter, and heating value.

- Coal rank indicates the progressive alteration, or coalification, from lignite to anthracite.

- The heat contents of Lignite contains approximately 9 to 17 million British Thermal Unit (BTU) per ton.

- The heat contents of subbituminous and bituminous coal range from 16 to 24 million BTU per ton.

Coal Ranking & Quality

High quality coal:

- **high gas capacity**
- **high Vitrinite Reflectance**
- **high carbon content**

Lower quality coal:

- **low gas capacity**
- **high volatile matter**
- **high moisture content**

Carbon Content in Coal

❑ Peat	Less than 50% C
❑ Lignite	71% C
❑ Sub-Bituminous	80% C
❑ Bituminous	90% C
❑ Anthracite	More than 93% C

Coal is a dirty fuel and contains abundant pyrite, which when burned creates SO_2. In the atmosphere the SO_2 combines with water to form sulfuric acid (acid rain) that acidifies our lakes and streams.

Coal Ranking & Quality

1. Peat
2. Lignite
3. Subbituminous
4. Bituminous
5. Semi-anthracite
6. Anthracite

1. Peat

- Not really a coal
- It is undeveloped
- Soft & Spongy
- Carbon content : 20-25%
- Deposited during last 100 years by decomposed plant remains.


1. Peat

2. Lignite

- The first real coal
- Low heating value
- Often found near the earth surface
- Loses moisture when exposed to air

2. Lignite

3. Sub-bituminous

- Lower carbon content than bituminous

- It also loses moisture when exposed to air

3. Sub-bituminous

4. Bituminous

- High carbon content (65-85%)
- Low oxygen content (5-12%)
- It usually burns with a yellow flame

4. Bituminous

5. Semi-anthracite

- Hard coal but softer than Anthracite
- Fixed Carbon Percentage (80-85%)
- Contains more volatile matter than anthracite
- Burns freely

5. Semi-anthracite

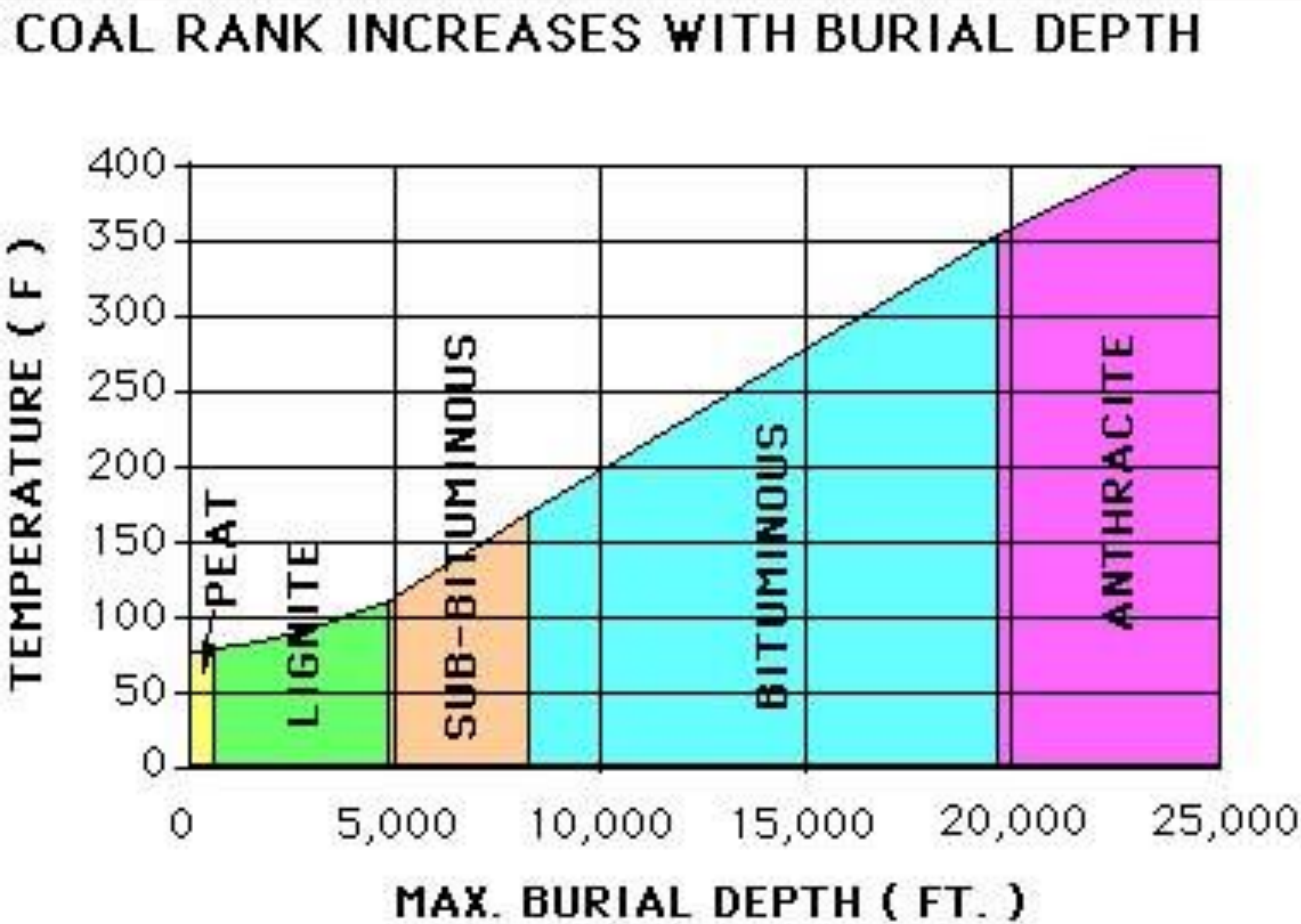
6. Anthracite

- Hard
- Durable
- High Density
- Low Volatile matter
- Fixed Carbon Percentage (85-98%)
- Burns slowly with little smoke

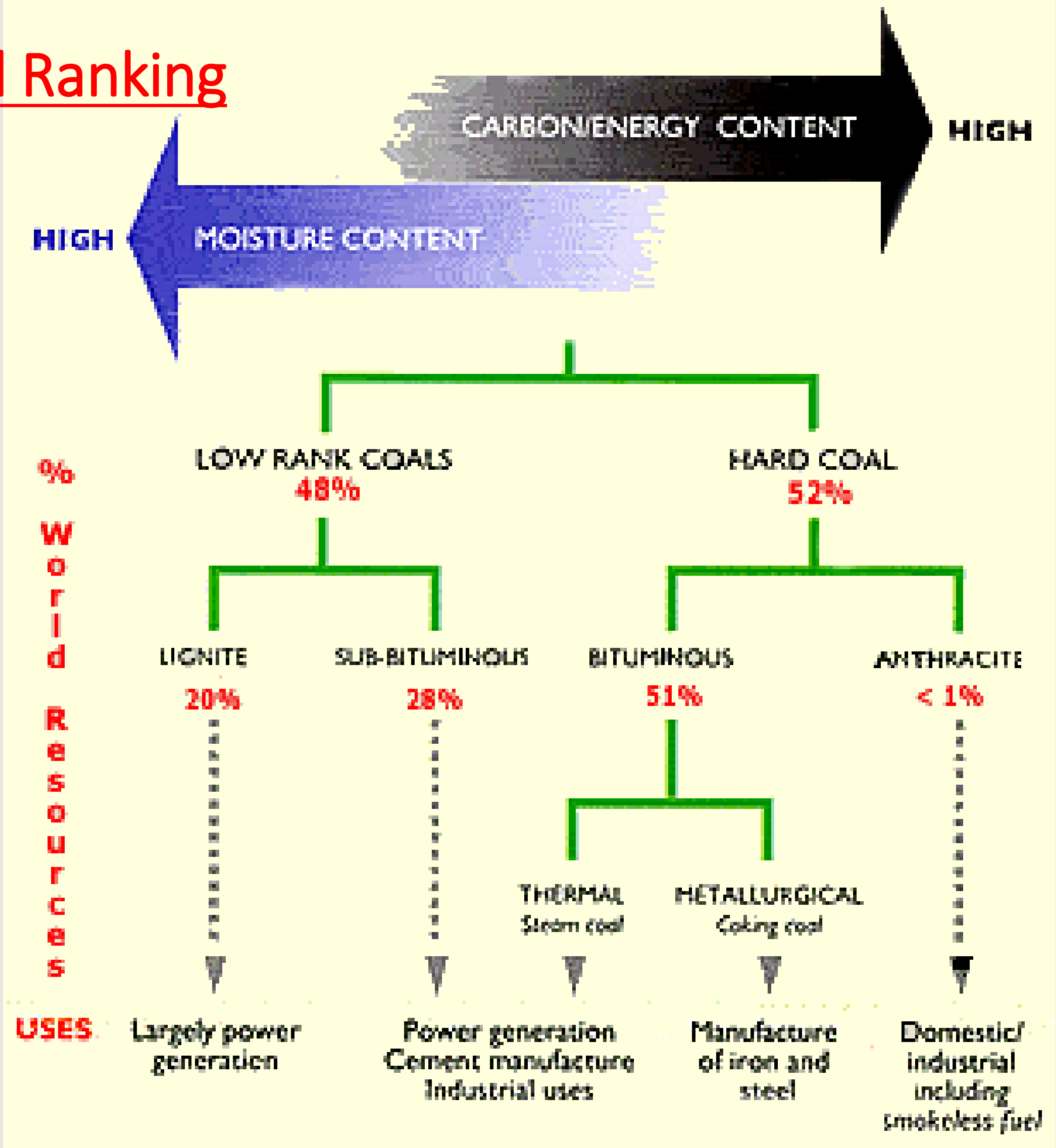
6. Anthracite

Coal Ranking & Quality

Coal Rank	% Carbon	Specific Energy (MJ/Kg)
Anthracite	**95**	**35.2**
Semi-Anthracite	**92**	**36**
Bituminous	**90**	**36**
Sub-bituminous	**80**	**33.5**
Lignite	**71**	**23**


COAL RANK INCREASES WITH BURIAL DEPTH
TEMPERATURE (F)
400
350
300
250
200
150
100
50
0
PEAT
LIGNITE
SUB-BITUMINOUS
BITUMINOUS
ANTHRACITE
0
5,000
10,000
15,000
20,000
25,000
MAX. BURIAL DEPTH (FT.)

Coal Ranking



THE FORMATION OF COAL

The origin of coal involves

1. Burial

2. Compaction

3. Induration (baking) of plant material

Coalification Sequence

Living Plants

↓

Dead Organic Matter

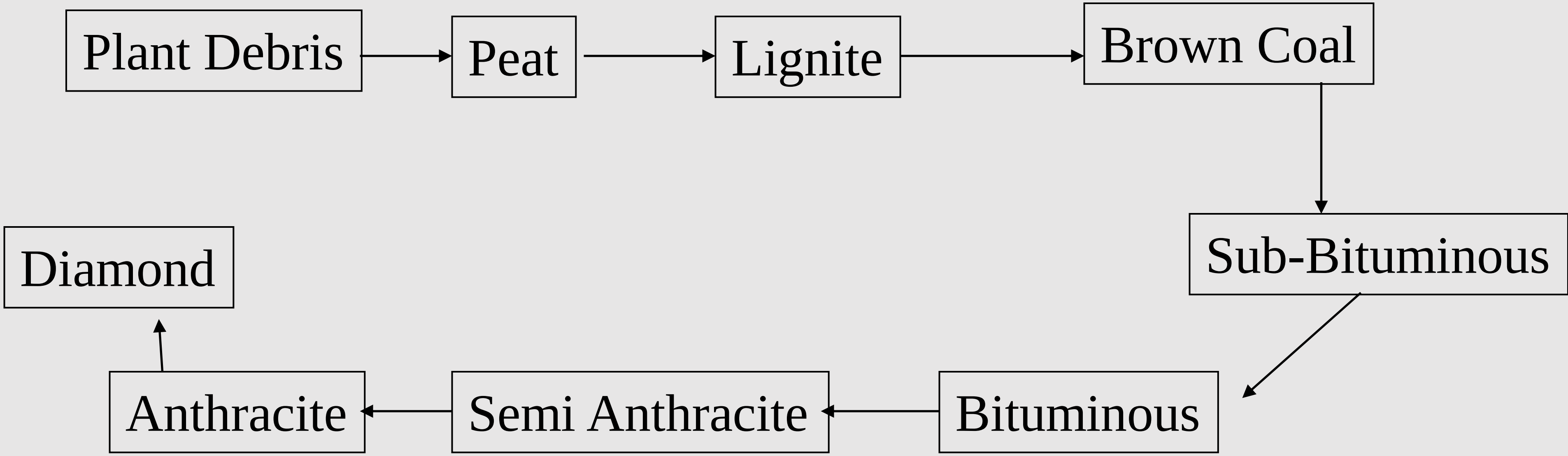
↓

Biological and Chemical Degradation of Organic Material to Peat

↓

Thermal Conversion of Peat to Coal

Formation of Coal



FORMATION OF COAL

- The formation of coal begins in a waterlogged environment (Swamps) where plant debris accumulated

- In such an environment, the accumulation of plant debris exceeds the rate of bacterial decay of the debris.

- The bacterial decay rate is reduced because the available oxygen in organic-rich water is completely used up by the decaying process.

- Anaerobic (without oxygen) decay is much slower than aerobic decay.

FORMATION OF COAL

- Peat is an accumulation of partially decayed vegetation matter.

- For the peat to become coal, it must be buried by sediment.

- 10 vertical feet of original peat material is required to produce 1 vertical foot of coal.

Formation of Coal

Phase 1. Aerobic decay

- In the first few inches of peat, aerobic (oxygen needing) bacterial decay reduces the volume by as much as 50%.
- Because the water is stagnant and the peat is almost impermeable, the bacteria soon use up all the available oxygen and die, ending the first stage of decay.

Formation of Coal

<u>Phase 2. Anerobic decay</u>

- A second type of bacteria exists in the swamp that requires no oxygen. These anerobic bacteria continue the decay process reducing the volume still further.
- Anerobic decay produces more acids and when the acidity gets too high, it kills off the remaining bacteria ending all decay.

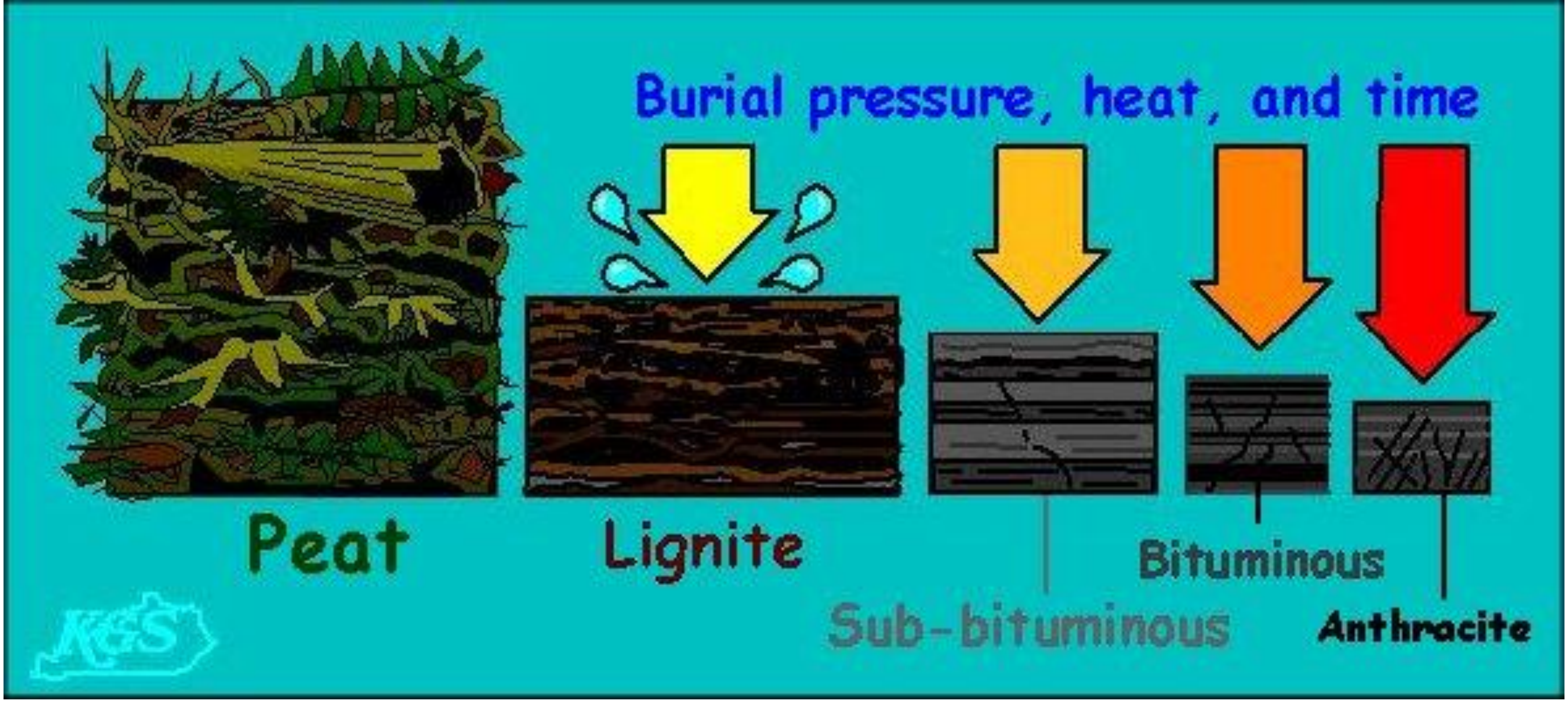
Formation of Coal

Phase 3. Bituminization

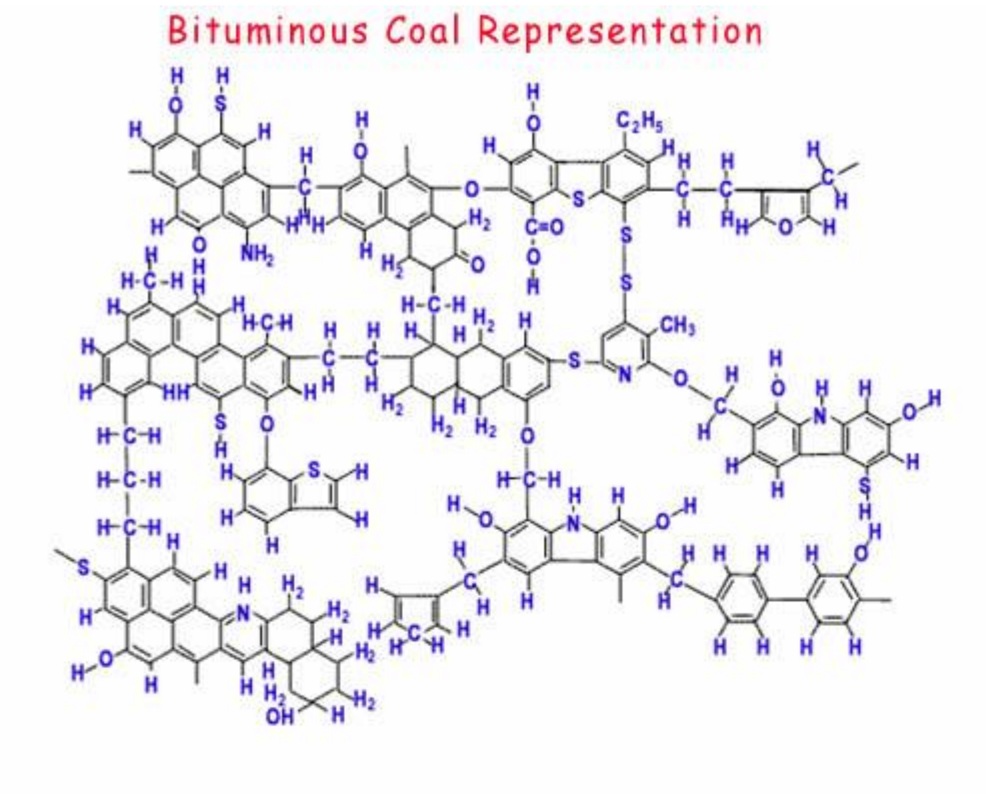
- After the bacterial decay stages, the peat must be buried under thousands of feet of sediment that provides an insulating blanket trapping the natural heat rising to the surface.
- Once the temperature reaches 100°C, (212°F) the bituminization process begins.
- Chemical reactions drive off water, oxygen and hydrogen which raises the percentage of carbon.

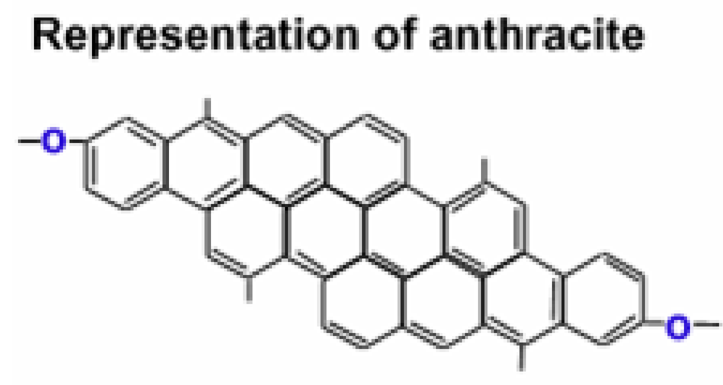
Formation of Coal

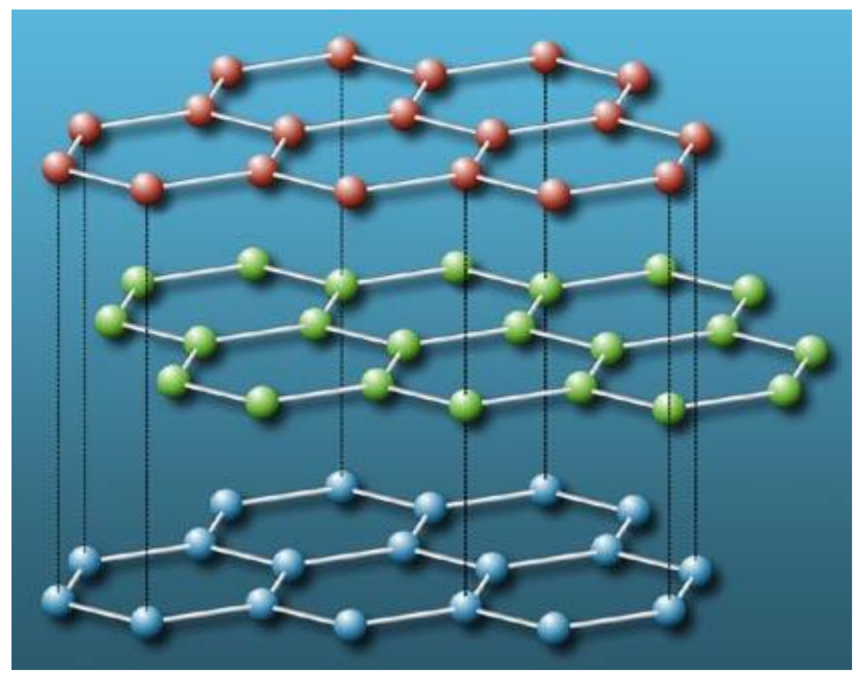
- The stages of this trend proceed from plant debris through peat, lignite, sub-bituminous coal, bituminous coal, to anthracite coal.
- Takes millions of years to convert peat to anthracite caol.


Burial pressure, heat, and time
Peat
Lignite
Sub-bituminous
Bituminous
Anthracite

Chemical Structure of Coal







The factors determining the composition of coal.

- Mode of accumulation and burial of the plant debris forming the deposits.
- Age of the deposits and the geographical distribution.
- Structure of the coal forming plants, particularly details of structure that affect chemical composition or resistance to decay.
- Chemical composition of the coal forming debris and its resistance to decay.
- Nature and intensity of the peat decaying agencies.
- Subsequent geological history of the residual products of decay of the plant debris forming the deposits.

COKE

- Coke is produced by partially burning coal in a reduced oxygen atmosphere.
- This removes most of the gasses leaving a solid that burns with a higher temperature than coal.

Gondwana Coal

- Gondwana coal makes up to **98 per cent of the total reserves and 99 per cent of the production of coal in India.** Satpuras, denudation [weathering + erosion] has exposed coal bearing Gondwana strata.
- The carbon content in Gondwana coal **[250 million years old]** is less compared to the Carboniferous coal **[350 million years old][Almost Absent in India]** because of its much younger age.
- Gondwana coal forms India's metallurgical grade as well as superior quality coal.
- The **Damuda series (i.e. Lower Gondwana)** possesses the best worked coalfields accounting for 80 per cent of the total coal production in India. 80 out of 113 Indian coalfields are located in the rock systems of the **Damuda series [**lower Gondwana Age**]**.
- Coking as well as non-coking and bituminous as well as sub-bituminous coal are obtained from Gondwana coal fields.
- **Anthracite** is generally not found in the Gondwana coal fields.
- The volatile compounds and ash (usually 13 – 30 per cent) and doesn't allow Carbon percentage to rise above **55 to 60 per cent.** [It requires few million years more if the quality has to get better. Remember Gondwana coal is 100 million years younger than Carboniferous coal].
- Gondwana coal is free from moisture, but it contains **Sulphur** and **Phosphorous.**
- These basins occur in the valleys of certain rivers viz., the Damodar (Jharkhand-West Bengal); the Mahanadi (Chhattisgarh-Odisha); the Son (Madhya Pradesh Jharkhand); the Godavari and the Wardha (Maharashtra-Andhra Pradesh); the Indravati, the Narmada, the Koel, the Panch, the Kanhan and many more.

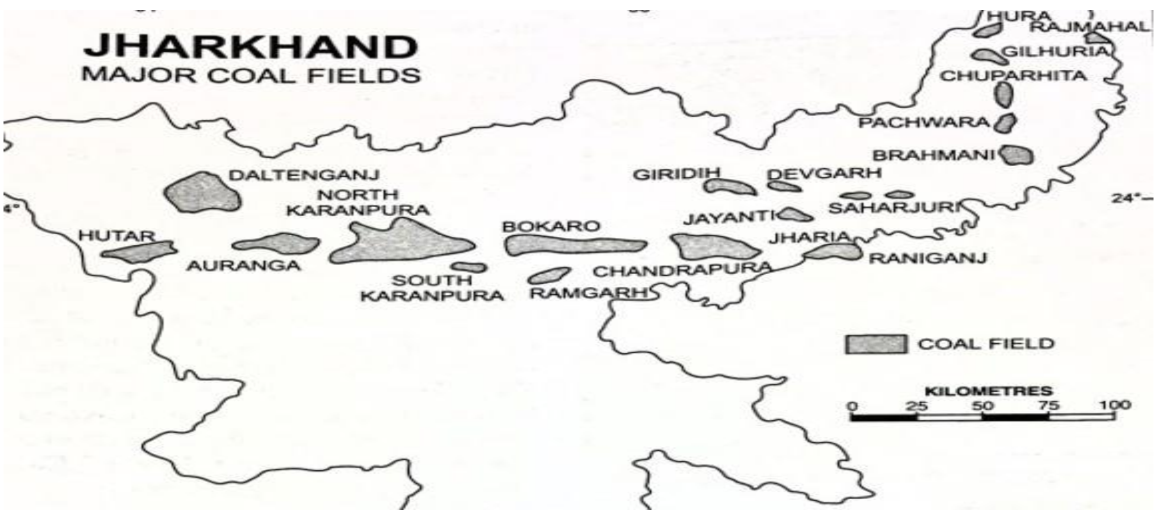
Distribution of Gondwana Coal in India

- First coal mine was opened in 1774 at **Raniganj in West Bengal.**
- Coal industry was nationalized in 1973-74. [The present government made some serious changes during the last year [2015] by allowing private sector to play a bigger role in coal production].
- India is now the **third largest coal producer** in the world after **China and the USA**.
- Coal industry provides employment to nearly seven lakh persons.
- Gondwana Coalfields == exclusively found in the Peninsular plateau of India.

Gondwana Coalfields in Chhattisgarh

Coalfield	Extent
Korba coalfield	Korba district.
Birampur coalfield Hasdo-Arand coalfield Chirmiri coalfield Lakhanpur coalfield	Surguja district.
Jhilmili coalfield	Shandol district & Koriya district
Johilla coalfield	Johilla valley
Sonhat coalfield	Surguja district
Tatapani-Ramkota coalfields	Surguja district

Gondwana Coalfields in Jharkhand



- 1st in reserves [28%].
- 2nd in production [20%].
- Most of the coal fields are located in a narrow belt running in east-west direction.
- Major coalfields are present in Dumka (Santhal Parganas), Hazaribagh, Dhanbad and Palamu.
- **Jharia, Bokaro, Girdih and Karanpura** are the major coal fields

Gondwana Coalfields in Odisha

Talcher field	Talcher town to Rairkhol in Dhenkanal and Sambalpur districts	Ranks **second in reserves** (24,374 million tonnes) after **Raniganj**; Coal from this field is most suitable for steam and gas production.Most of the coal is utilised in **thermal power and fertilizer plants at Talcher.**
Rampur-Himgir coalfields	Sambalpur and Sundargarh	Coal occurs here in middle and lower Barakar seams. inferior quality
Ib river coalfield	Sambalpur and Jharsuguda district	Much of the coal is of inferior quality.

Gondwana Coalfields in Madhya Pradesh

Singrauli (Waidhian) coalfield	Sidhi and Shandol districts	largest coalfield of Madhya Pradesh Jhingurda, Panipahari, Khadia, Purewa and Turra are important coal seams Jhingurda with a total thickness of 131 m is the richest coal seam of the country. thermal power plants at Singrauli and Obra
Pench-Kanhan-Tawa	Chhindwara district	Ghoravari seam in Kanhan field is 4.6 m thick and contains coking coal
Sohagpur coalfield	Shandol district	
Umaria coalfield	Umaria district	inferior quality with high percentage of moisture and ash.

Gondwana Coalfields in Andhra Pradesh

- 6th in reserves [7.07 %].
- 5th in production [9.69 %].
- Most of the coal reserves are in the **Godavari valley.**
- Adilabad, Karimnagar, Warangal, Khammam, East Godavari, and West Godavari.
- The actual workable collieries are situated at **Singareni and Kothagudam.**
- Almost the entire coal is of **non-coking variety.**
- These are the southern most coalfields of India and a **source of coal supply to most of south India.**

Gondwana Coalfields in Maharashtra

- 3 per cent reserves.
- 7 per cent of the production.

Gondwana Coalfields in West Bengal

- 4 % of India's coal.
- 11 % of the coal reserves.
- **Darjeeling** and **Jalpaiguri** are the chief producing districts.
- **RANIGANJ** is the largest coalfield of West Bengal.
- Raniganj == Barddhaman, Bankura and Purulia districts; Small part of this field is in Jharkhand state.
- The coal here is non-coking steam coal.
- Dalingkot coalfield == Darjeeling district.

Gondwana Coalfields in Uttar Pradesh

- Do not possess coal reserves.
- A small portion of the Singrauli field of Madhya Pradesh falls within Mirzapur district.
- A high grade coal seam, about 1 to 1.5 m thick occurs near Kotah.

In petroleum geology, a trap is a geological structure affecting the reservoir rock and caprock of a petroleum system allowing the accumulation of hydrocarbons in a reservoir.

Traps can be of two types: stratigraphic or structural. Structural traps are the most important type of trap as they represent the majority of the world's discovered petroleum resources

Oil or petroleum pools are local accumulations of natural oils filling the fine capillary tubes, fractures, and other openings of certain relatively porous rocks at various depths beneath the ground water level.

Oilfields: Major Oilfields found in India

On-shore Oil Production. One-shore oil fields are located in the Brahmaputra valley of north-east India, Gujarat coast in western India and Cauvery on-shore basin in Tamil Nadu. Besides Andhra Pradesh has both on-shore and off-shore oil reserves.

Oilfields in North-East India:

The major oilfields in north-east India are those of the Brahmaputra valley in Assam and its neighbouring areas including Arunachal Pradesh, Nagaland, Meghalaya, Tripura, Manipur and Mizoram.

Assam:

Assam is the oldest oil producing state in India. The main oil bearing strata extend for a distance of 320 km in upper Assam along the Brahmaputra valley. Following are some of the important oilfields of Assam:

1. The Digboi field:

Located in the north-east of Tipam hills in Dibrugarh district of Upper Assam, Digboi is the oldest oil field of India. The oil bearing strata cover an area of about 13 sq km where oil is available at 400 to 2,000 metre depth.

Over 800 oil wells have been drilled so far. Before the opening of the oil fields of west India, Digboi used to account for three-fourths of the total oil production of India. The most important centres are Digboi, Bappapang, Hassapang and Paintola. Most oil is sent to oil refinery at Digboi.

2. The Naharkatiya field:

It is located at a distance of 32 km southwest of Digboi at the left bank of Burhi Dibing river. Here oil was discovered in 1953 and production started in 1954. Oil is available at depths varying from 4,000 to 5,000 metres. Out of the 60 successful wells drilled so far, 56 are producing oil while the remaining 4 are producing natural gas.

The annual production is 2.5 million tonnes of oil and one million cubic metre natural gas. Oil from this area is sent to oil refineries at Noonamati in Assam (443 km) and Barauni in Bihar (724 km) through pipeline.

3. The Moran-Hugrijan field:

It is located about 40 km south-west of Naharkatiya. Oil at Moran- Hugrijan field was discovered in 1953 and production started in 1956. Drilling has proved an oil bearing Barail horizon at a depth of 3,355 metre. Moran s potential may be estimated at one million tonnes per annum. As many as 20 wells have been drilled which yield oil as well as gas.

Other fields have been discovered at Rudrasagar, Sibsagar, Lakwa, Galeki, Badarpur, Barholla and Anguri.

Oilfields of Assam are relatively inaccessible and are distantly located from the main consuming areas. Oil from Assam is, therefore, refined mostly in the refineries located at Digboi, Guwahati, Bongaigaon, Barauni and Nomaligarh.

Arunachal Pradesh has oil reserves at Manabhum, Kharsang and Charali. In Tripura, promising oilfields have been discovered at Mamunbhanga, Baramura-Deotamura Subhang, Manu, Ampi Bazar, Amarpur-Dambura areas. Nagaland also has some oil bearing rock strata.

On-Shore Oil Fields of Western India:

Gujarat:

Explorations by Oil and Natural Gas Commission (ONGC) have yielded valuable findings of oil bearing rock strata over an area of about 15,360 sq km around the Gulf of Khambhat. The main oil belt extends from Surat to Amreli. Kachchh, Vadodara, Bharuch, Surat, Ahmedabad, Kheda, Mehsana, etc. are the main producing districts.

In 2002-03, Gujarat produced over 60 lakh tonnes of crude oil which accounted for over 18 per cent of the total oil production of India. Ankleshwar, Lunej, Kalol, Nawgam, Kosamba, Kathana, Barkol, Mehsana and Sanand are the important oilfields of these regions.

1. Ankleshwar:

The first major oil-find came in 1958 with the discovery of Ankleshwar field located about 80 km south of Vadodara and nearly 160 km south of Khambhat. Ankleshwar anticline is about 20 km long and 4 km wide. Oil is available at depths varying from 1,000 to 1,200 metres. It has a capacity of 2.8 million tonnes per annum.

It is such a prolific oilfield that Pt. Jawahar Lai Nehru called it the fountain of prosperity. As many as 170 oil wells have been bored so far. It is estimated that 25 lakh tonnes per year of oil can be obtained from this field. Oil from this field is sent to refineries at Trombay and Koyali.

2. Khambhat or Lunej field:

The oil and Natural Gas Commission drilled test wells in 1958 at Lunej near Ahmadabad and confirmed the occurrence of a commercially exploitable oil field. Oil was obtained on 4th Sept. 1959. Till 1969, a total of 62 wells were drilled out of which 19 yielded gas while 3 yielded oil. The annual production is 15 lakh tonnes of oil and 8-10 lakh cubic metres of gas. The total reserves are estimated at 3 crore tonnes.

3. Ahmedabad and Kalol field:

It lies about 25 km north-west of Ahmedabad. This field and a part of Khambhat basin contain 'pools' of heavy crude trapped in chunks of coal. Nawgam, Kosamba, Mehsana, Sanand, Kathana, etc. are important producers.

Oil has also been struck in Olkad, Dholka, Kadi, Asjol, Sandkhurd, Siswas, Nandesan, Bandrat, Sobhasan and Vadesar areas.

Rajasthan:

One of the largest onland oil discoveries was made in Banner district of Rajasthan in 2004. The oil block covers an area of approximately 5,000 sq km. State-of-the-art technology with innovative geological modeling was used in discovering this oil field. Initial estimates of the oil in place of this discovery range from 63 to 153 million tonnes.

Two important discoveries, viz., Sarswati and Rajeshwari, with a total 35 million tonnes of inplace oil reserves were made earlier in 2002. The Sarswati discovery had found 14 million tonnes of in place oil reserves for which drilling upto 3,476 m was done. The commercial production is expected to commence in 2007.

Western Coast Off-Shore Oilfields:

Extensive surveys have been conducted by ONGC in the offshore areas of Kuchchh, Khambhat, Konkan, Malabar and Coromandal coasts, Krishna-Godavari delta and Sunderbans. Success on commercial scale has been achieved at Mumbai High, Bassein and Aliabet.

1. Mumbai High:

The greatest success achieved by the ONGC with respect to offshore surveys for oil was that of Mumbai High in 1974. It is located on the continental shelf off the coast of Maharashtra about 176 km north-west of Mumbai.

Here the rock strata of Miocene age covers an area of 2,500 sq km with estimated reserves of about 330 million tonnes of oil and 37,000 million cubic metres of natural gas. Production on commercial scale began in 1976. Oil is taken from a depth of over 1,400 metre with the help of a specially designed platform known as Sagar Samrat.

The discovery of Mumbai High has revolutionised the oil production in India. The share of Mumbai High in the total oil production of India has shot up considerably. This area produced 85 lakh tonnes of oil in 1982 which rose to over 189 lakh tonnes or over 62 per cent of all India in 1991-92.

Production from this field declined between 1989-90 and 1993-94 due to over exploitation. Remedial measures have been taken to enhance the production and the declining trend has been reversed since 1994-95. In 2002-03 this area produced 215.73 lakh tonnes of oil which was about two-thirds of total production of India.

2. Bassein:

Located to the south of Mumbai High, this is a recent discovery endowed with reserves which may prove to be higher than those of the Mumbai High. Huge reserves have been found at a depth of 1,900 metre. Production has started and is expected to pick up fast.

3. Aliabet:

It is located at Aliabet Island in the Gulf of Khambhat about 45 km off Bhavnagar. Huge reserves have been found in this field. A sum of Rs. 400 crore has already been spent on this field. Commercial production is expected to start soon.

East Coast:

The basin and delta regions of the Godawari, the Krishna and the Cauvery rivers hold great potential for oil and gas production. As such these are both on-shore and off-shore areas where extensive exploration has been conducted during the last few years. The Rawa field in Krishna- Godawari off-shore basin is expected to produce 1 to 3 million tonnes of crude oil annually.

In 2002-03, Tamil Nadu produced 3.95 lakh tonnes of oil which was slightly more than the one per cent of the total oil production of India. The Narimanam and Kovilappal oilfields in the Cauvery on-shore basin are expected to produce about 4 lakh tonnes of crude oil annually. A 5 lakh tonne refinery is being set up at Panaigudi near Chennai to refine crude oil from this area.

Andhra Pradesh produces less than one per cent of the total crude oil of India. Oilfields have recently been discovered in the Krishna-Godavari basin. The oilfield near Amolpur is expected to yield 3,600 barrels of crude oil per day

MINING GEOLOGY

(THEORY 3)

Chapter -3:: Prospecting And Exploration

Prospecting.

Prospecting means looking for ores minerals of value of importance. Prospecting is a sum total of systemic process under taken in a sequential manner to discover new ore deposit.

Differentiate between prospecting & exploration.

Prospecting	Exploration
Prospecting is a sum total of systemic process under taken in a sequential manner to discover new ore deposit.	Exploration is a incorporates set of operation take drilling, trenching keeping sampling assaying, core, ranger, estimated of determining the availability of the ore deposite.

Various criteria for geological exploration.

Geochemical prospecting :

This method aims of plotting on suitable map such dispersion pattern of farce metal in sample of soil ground water or vegetation (usually leaves) collected of suitable interval from the area to be prospected aromatizes are indicated by a marked in the concentration of farce metal from the back ground valve. It deals with examination with the earth crush consist of not only rock but also water & gases.

It is divided into two primary and secondary processes. Primary process are connected with magnetism. Metamorphism. Secondary process are associated with superegos agent of rock degradation of water.

On primary geochemical prospecting important to dated difference in the distributor of element in the earth crust. Dispersion is influenced both mechanical as well as chemical process, primary cone of mineral is due to pressure and temperature condition.

Element under normal differentiation separate group oxy phallic, chalo phyllic (sulpher) phylllic side rophyllic (iron) and phylllic.

Methods of Geophysical prospecting.

Geophysical exploration :

It take the help of natural physical parameters of earth side like gravity magnetism or natural electric field. Artificial physical field is created by electrical radioactivity.

There are major type of geophysical exploration method such as

(a) Gravity Method, (b) Magnetic Method, (c) Seismic Method,

(d) Geothermal Method, (e) Radiometric Method (f) Electrical Method.

Gravity Method :

1. It represented a set of geophysical method which makes use of the natural gravity field of the earth. Density is the physical prospers which helps in gravity method.
2. In gravity method the nature of distribution of gravity on the surface is analyzed. The gravity influenced positively by heavier longer & shallow depth ore bodies.
3. If the gravity field deviates from the normal value then bodies can be present below the surface.
4. The geophysical unit of gravity is villigals & cotors.
5. The different kinds of gravity methods are gravity prospecting gravity logging air born gravity & sea burn gravimetric.
6. It fonds application for exploration of ore deposit oil & natural gas regional geological structure sub surface geology solving engineering problems etc.

Magnetic Method :

1. It makes use of the natural magnetic field of the earth.
2. The physical properties with operates upon his method is based on the fact.
3. The magnetic method is based on the fact that magnetic bodies present in the earth sub surface continue to the magnetic field of the earth.
4. When the magnetic field of the earth is measured on the surface bodies processing magnetic moment different form those of surrounding rock contribute.

5. Magnetic instrument use are magnetic meter tension magnetometer & fluxgate magnetometer.

6. Unit Gamma & Orestar.

7. It is used for locating iron nickel, tin chromites.

Seismic Method :

1. The elastic property, difference in rocks the controlling properties.

2. It is based on the principled that sub surface rock formation bear different elastic properties.

3. The velocity of propagation of seismic ways through them changes with change in lithology.

4. In seismic method artificial explosion are made in ground.

5. The waves this practice travel through the sub surface layer critical refraction.

6. With the help of geophones fixed suitable intervals on the ground, the different seismic way reaching the surface are recorded & from the time of the arrival time distance curve are constructed.

7. These graph known as hodographs seismic waves are of 4 types, (a) Primary wave, (b) Secondary wave, (c) Long wave, (d) Reflected wave.

Radiometric Method :

1. The controlling parameter is the natural radioactivity of rock & ore.

2. The normal radioactivity is different types of rocks.

3. If rock contains radioactive are bodies such area will show very high radioactivity given rise to anomalies.

4. Igneous body have relatively more radioactivity than basic & ultra basic roads.

5. There are two types of natural radiometric method employed in the field. These are (a) Gamma method and (b) An Emanation method.

Gamma method : In which the intensity of gamma rays from rocks or ores in a area is measured.

A Emanation method :

1. In this method the concentration of radioactive emanation of solid & air are measure.

2. The instrument used as Geiger miller counter or scintillation counter or Gamma ray spectrometer.

3. Unit : Milicurie or Microcurie

4. It is used in exploration of uranium theorirare earth metal like Berrilium. Lithium, Tanteium, Neobium.

5. In the exploration of oil & natural gas the radioactive tracer techniques is utilize to measure velocity of ground water direction of flow & salt water instruction.

Geothermal Method :

1. Here the controlling factors thermal conductivity.
2. The temperature distribution on the surface of the earth is occurred in three sources.

   (a) Insulation : in coming solar radiation.

   (b) Heat conveyed from the intercoring earth by conduction & convention.

   (c) Due to radioactive mineral.
3. The reodual value of temperature distribution on the earth surface can be interrupted in forms of sub surface geology.
4. The instrument used as thermister thermometer, platinum thermometer, radiometer and crystal defector.
5. It used in deep structural ore deposite and ground water.

Electrical Method :

It is based on the fact that the sub surface formation & ore deposite contain different electrical properties. The different methods are as follows :

(a) Electrical resistivity method : Electrical resistivity is of sub surface formation varies from one another.

(b) Werrer : Unit – ohm x meter, Instrument used is electrical resistivity meter.

(c) Electromagnetic Method :

- The alternative emf is established ground using an artificial source.
- The electromagnetic field unduces feddy current is the conducting ore body.

- The different method includes (a) Sargram, (b) Enslin, (c) Turam, (d) Sundberg.

(d) **Self potential** : It uses the natural method electric field of the earth sulphide one like pyrite, pyrchilite, chaleophrite. The instrument used a pair of non pollarisable electrodes & potentiometer. Unit is Millivolt.

(e) **Induced pollarisation** : Based on the study of secondary electro chemical process that takes place on the sub surface due to flow of electric current. When direct electric current is passed in the ground the current is ionic electrolyte & electric solid minerals. Thus at the electrolyte conducting particle boundary the change is transformed from ion to the particle. Thus (+ve) ion change pole of at the particle boundary when the current is stopped the accumulated charge is the material give rise to reodual voltage which decrease with time. Unit is Millivolt. It is used in exploration of sulphide & ground water.

Geochemical prospecting.

It deals with the examination of the earth crust consisting not only of rocks but also water gases. Geochemical processes are divided into primary & secondary processes. Primary processes are connected with magnetism and metamorphism. Secondary processes are associated with super gane agent rock degradation as well as magnetic water. In primary geochemical prospecting it is important to detect difference in the distribution of elements in the crust. Dispersion in influence by both mechanical as well as chemical. Primary concentration of ore minerals is due pressure & temperature condition. Element under normal condition magnetic differentiation separate out as group like oxy phyllic, chalcophyllic, lethophyllic, sidenophyllic, atmophyllic, which plug a significant path lock for emplacement and concentration of economic mineral deposit.

Biogeochemical & Geobotanical prospecting.

<u>Biogeochemical Prospecting:</u> Roots, barks, leafs, concentrate, elements from the ground uniform of nutrient elements like as CO, Zn, Ca, K, P, Fe, Mg, Mn, etc are important for the growth of plants to be surveyed to be assayed using various chemical and weight chemical method. First this plant parts are dry in the sun burnt under errabic condition. Then the ash is finaly powdered & leached with hydrochloric & hydrogen sulphide. The organic part are washed a ray leaving behind elements residue. Then this residue are analysed or assyed using weight chemical & instrumental techniques. The concentration of a particular element in the plant parts we give the picture about the concentration the element below.

Geobotanical Prospecting : Plants depend for their growth on geological CO_2 moisture and mineral nutrients. Certain elements are essential & important for its growth & development where as some elements are toxic to plant growth the different morphological modification are visible.

For Cu, osmium humble is a indicator of Cu mineralization in below. A crocephylus Roberto, polycarpea, spira styles, poly, carpea, corymboso are indicator of Cu.

For CO, Critotoria cobalticola & silence cobalticola.

For Pb & Zn, Plantgo lanceolate, lobilla inflate, sorghustram Neutrons (grass)

For Mo, Molitus alba, trifolium repens, lotus carniculates.

Chapter 4:: Economic Geology

Tenor :

The metal content of an ore is called the tenor of the ore. It is generally expressed in percentage of the metal. It say pays for the extraction cost of the ore.

Grade :

Signifies the commercial classification of an ore where by the physical and chemical parameters are taken into account beside its qualitative aspect.

Mineralogy, mode of occurrence, distribution & use of iron ore deposits in India.

Mineralogy :

The chief economic iron ore minerals are :

Magnetite	Fe_3O_4	(containing 72.4% of iron)
Hematite	Fe_2O_3	(Fe=70%)
Limonite	$2Fe_2O_3, 3H_2O$	(Fe=59.8%)
Goethite	Fe_2O_3, H_2O	(Fe=62.9%)
(Spathic ore)		
Siderite	$FeCO_3$	(Fe=48.2%)
Pyrite	FeS_2	(Fe=46.2%)

Chamosite and thuringite are examples of iron silicate minerals.

Mode of occurrence :

Iron ore deposite occur as magma tic deposits, as bedded deposits, as residual concentration deposits or sometimes as nodules and concretions in shales associated with coal-seams.

Distribution in India :

1. The biggest iron ore field of India is situated in the Singhbhum district of Bihar and the adjoining districts of Keonjhar, Sundergarh and Mayurbhanj of Odisha. The important mining centres of Odisha and Bihar are Barbil, Gua, Bonai, Joda, Kiriburu, Suleipat, Gorumahisani, Noamundi, Barajamda etc.
2. Madhya Pradesh: In the Bailadila hill ranges.
3. Maharashtra: Ratnagiri district.
4. Goa: Bicholim- Pale in Goa.
5. Karnataka: Bananudan hills in Chikmagalur district, and in Sandur, Bellary, Hospet districts as well as Shimoga and Chitaldrug districts. Important one is that of Kudermukh.
6. Andhra Pradesh: Cuddapah, Kurnool, Chitnoor, Nellore, Anantapur, Warangal and Adilabad districts.
7. Tamilnadu: Salem district, and Tiruchirapalli district.
8. West Bengal: Deposit of lateritic ores mostly occur in West Bengal.
9. Assam: Iron stone clay are found as nodules and thin beds in the coal measures of Eocene age and in the Tipam series of Miocene age.

Use of Iron :

1. Smelting for steel.
2. Srenge iron.
3. Rail, coaches, wagons, ships.
4. Heavy machineries.
5. Koaol breezes & buldings dums.
6. Weapons and reaitors.
7. High speed steel.
8. Utensils & forming equipments.

9. Coal iron, Pig iron, wrought iron.

Mineralogy, mode of occurrence & description of Chromites deposits in India & its uses.

Mineralogy:

It is an important alloying element in the manufacture of steel Chromite is the only ore-mineral of chromium.

Chromite – FeO, Cr_2O_3, Cr_2O_3 = 68.0% and Cr = 46.66%.

Mode of occurrence:

Chromite deposits occur as lenses, masses, veins and disseminated grains in host rocks. The deposits are regarded as the early or late magma tic segregation or injection product.

Distribution in India:

The largest shromite deposit in the country is located in the Sukinda ultrabasic belt of Cuttack and Dhenkanal district of Odisha, and also in the Keonjhar district of the state. The belt extends over a distance of about 20km, the width of the belt is about 2km. the ore bodies are lenticular in shape and occur as lenses and patches within the lateritised ultrabasic rocks.

The other important deposits occur in:

(i) Andhra Pradesh: Kistna district (Kondapalle)

(ii) Bihar: Singhbhum district.

(iii) Karnataka: Chitaldrug, Hassan and Shimoga districts.

(iv) Tamil Nadu: Salem districts (Sittampundi).

(v)

Economic uses:

1. In the metallurgical industries in the production of various non ferrous alloys of chromium and also in the form of ferro chrome for manufacturing chrome steel.
2. In refractory industries, due to its high resistance against corrosion, high temperature and sudden temperature changes and its chemically neutral character.
3. In chemical industries, for the manufacture of chromium compounds like chromates and bi-chromates and chrome acid etc.

Mineralogy, mode of occurrence & distribution of copper deposits in India & uses of this metal.

<u>Mineralogy:</u>

It is the most important non-ferrous metal and was the earliest metal used by man. In nature copper occurs in four principle formes, sulphides, carbonates, oxides and as native copper. Of these the bulk of cooper is obtained from the sulphide ores. To be economically exploited a cooper ore should contain at least 2.5% of copper. In modern times ores with 1% of copper are also used.

<u>Mode of occurrence:</u>

Copper deposits may occur as.

(a) Disseminated ore bodies: Where the copper minerals are generally dispersed in a large volume of rock. They are generally of low grade. The porphyry copper deposits of USA are of this type.

(b) Massive, irregular or lenticular ore bodies, which are formed by the process of replacement.

(c) Vein deposits or lodes: In which the copper hearing solutions percolating along shear zones and rock fractures deposit copper mineral with changes of temperature and pressure forming fissure veins, copper deposits of Singhbhum.

(d) Deposits following stratigraphic beds, as is the case with the deposits of Khetri (Rajasthan).

<u>Distribution in India :</u>

1. In Andhra Pradesh, the most important copper deposits are the Agnigundla deposits.

2. In Bihar, in the Singhbhum district, a copper bearing belt of about 80 miles long occurs. Here the copper ores occur as veins in the country rock consisting of mica achists, quartz-schists, chlorite-schists, biotite-schists, granite and granite-gneisses.

3. In Madhya Pradesh, the important deposit is the Malan Jhakhand copper deposit, where copper ores occurs in the form of veins within dolomitic limestone.

4. The Khetri copper deposit of Rajasthan is one of the important copper deposit in the country. This belt has 3 richly mineralized sections - Madhian, Kolihan and Akhwali.

5. Other important copper deposits of the country are as follws

(a) Himachal Pradesh: Kangra, Kulu valley.

(b) Mysore: Chittaldrug, Hassan, Bellary districts.

(c) West Bengal: Darjeeling, Jalpaiguri districts.

(d) Sikkim: Rangpo and Dickchu deposits which are found to occur in association with the metamorphic rocks belonging to the Daling series.

Economic Uses:

The metal is of great industrial importance, because of its high electric conductivity, high ductility and malleability. Thus it is mostly used in electrical manufactures. Besides, the copper alloys are used in buildings, automobiles, air planes, naval ships, house hold utensils as well as in metallurgy and paints.

Mineralogy, mode of occurrence, distribution of lead & zinc deposits in India & the uses of these metals.

Mineralogy:

The two metals lead and zinc rarely occurs in native state, they generally occur in combination with other elements. The ore minerals of lead and zinc are usually found to occur in association with each other. The following are the important minerals of lead and zinc:

Lead	Zinc
Galena-PbS-Pb 86.6%	Sphalerite or zinc blende – ZnS, Zn – 67%.
Cerussite-$PbCO_3$-Pb 77.5%	Smithsonite or Eng. Calamine – $ZnCo_3$, Zn-52%.
Anglesite-$PbSO_4$, Pb 68.3%	Hemimorphite or Americanname Calamine Zincite- ZnO – $2ZnO_2SiO_22H_2O$, Zn– 54.2%

Mode of occurrence:

Most of the lead ore mines of the world are also zinc ore producers and nearly all zinc ore deposits carry lead ore. Both lead and zinc ore bodies usually occur as veins and massive or tabular lodes, and as disseminations, mostly in limestone or dolomites. Majority of these ores occur as cavity fillings and replacements formed by low temperature hydrothermal solutions.

<u>Distribution in India:</u>

The most important lead zinc deposits of economic value in India is the Zawar deposit of Udaipur district of Rajasthan. India' s reserve of these ores is meager compared to her needs.

In the Zawar area, the Mochia Marga, Barai Magra and Zawar Mala hills contain most extensive deposits.

The ore minerals consist of argentiferous galena associated with sphalerite and chalcopyrite. The ore contains 1.5 to 2% of lead and 4.5 to 5% zinc.

Other important occurrences in the country are as follows:

(a) Lead copper ore deposits in Agnigundla area of Guntur district of Andhra Pradesh.

(b) Lead zinc copper belt of 3 km long in Ambamata Devi area of Gujarat and Rajasthan.

(c) Sargipalli area in the district of Sundergarh (Odisha).

<u>Economic uses:</u>

(i) Lead is used in the construction of accumulators, for lead piping and sheeting cable covers, as pigments in glass making, in medicine etc.

(ii) Zinc is used for coating, galvanizing iron and steel products, in the manufacture of pigments and alloys with other metals, in the manufacture of batteries and electric appliances. Besides they are widely used in textile industry, timber preservation etc.

Methods of sampling as outlined by Bureau of Indian Standards. (BIS).

The different methods of sampling are as follows:

1. **<u>Grab sampling:</u>**

- It is the random collection of broken chips from the expose surface of an out crop from the mine working or from stock material.
- The material from the stock can be obtained by a small hand shovel.
- Grab sample is generally obtained during the preliminary survey.
- The grade of the deposit can' t be relied upon from the assay valve of such sample.

2. **<u>Chip Samples:</u>**

- Chip samples closely resemble grab sampling accept that the sample is collected from a fresh rock surface.
- The surface of an ore body is first clean by a wire brush and then a chip or fragment is broken by a hammer.
- This is also used in preliminary survey.

3. **<u>Channel or Groove Sampling:</u>**

- It is collected from groove cut systematically across the exposure of the ore body.
- It is used in sampling of frenches, pits, drifts, winzes, raises, shafts.
- The purpose of cutting a groove or channel is to ensure that uniform quantity of material is drawn the entire ore body.
- A channel of 10cm with and 2.5cm depth is cut.
- After cutting a groove across the ore body parallel to the true with samplers drawn by further deepening the groove by means of a chisel to a uniform depth.
- When the ore body consists of a alternate bend if reached and liner and each type is separately sample.

4. **<u>Bore Hole Sampling:</u>**

- It is carried out by drilling bore & hole in the leased hole area.
- It is the most modern method of examination of mineralization under neat the surface of the earth.
- The horizontal extension and the vertical persistency of ore body is easily de-marketed by bore hole sampling.
- Drill holes are place at suitable intervals preferably on a grid pattern to determined on easy valve of the ore.
- Bore hole cores are taken out and preserved in core box.

5. **<u>Bulk Sampling:</u>**

- A few tones of the ore either from the French pit channel or from run of mine ore taken out all are collected to determined ore for its physical properties and its accumulative to beneficiation techniques by pilot plant foot.

- For iron ores the bulk sample is taken to examine the ratio of fines to total mass of core mines.

6. **Car and Wagon Sampling:**

- It is obtained by taking a predetermined on quantity of run off mine from each car load or wagon load.
- It is done to determine the quality of ore dispatched to the mill of beneficiation.

SAMPLING

What is a sample?

- **A sample** is a finite part of a statistical population whose properties are studied to gain information about the whole (Webster, 1985).

What is sampling?

Sampling is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population.

This is achieved by taking samples from natural exposures, bore holes and mine openings.

Introduction

- Sampling methods vary from simple grab samples on existing exposures to sophisticated drilling methods.

- As a rule, the surface of the mineralization is obscured by various types of overburden, or it is weathered and leached to some depth, thereby obscuring the nature of the mineralization."

Objective Based Sampling

- Sampling may be chemical, mineralogical, technical and technological.
- **1. Chemical:** Samples are taken for determining the content of useful and secondary components.
- **2. Mineralogical:** It is done to ascertain the mineral and petrographical composition of the mineral. It helps to establish the origin of the deposit, the dependences governing grade variations and also to plan the ore dressing and beneficiation.
- **3. Technical:** Samples are taken to study the technical properties of the raw material, which does not require metallurgical or chemical treatment. The factors are strength and flexibility of fibres; mica – the size; sand and gravel – grain size distribution.
- **4. Technological:** Samples are collected for the study of the technological properties of the raw material in the course of its beneficiation and processing.

- The process of sampling falls into several stages

  1. Collecting samples,
  2. Their processing,
  3. Laboratory studies of the sample (assaying),
  4. Analysis/Interpretation of the laboratory findings.

Sampling During Large-scale and Detailed Mapping

i) to identify and pigeon-hole the rock type;

ii) to gain an understanding of geological events;

iii) in laying plans for more thorough sampling;

iv) to delineate and narrow down mineralized zone; and

v) to elucidate the type and nature of mineralization and for possible extension along strike and at depth

Types of Sampling

(i) spot samples;

(ii) serial samples to test hypotheses;

(iii) sampling to find variations;

(iv) sampling for bulk composition; and

(v) sampling for distribution of compositions.

SAMPLING OF ORE MINERALS

- Grade of a mineral and metal values vary in proportion from one place to another.
- One single sample taken from one part of the ore body generally does not provide a representative picture of the grade of the entire ore body
- Some degree of error between the actual value and the value computed from the samples.
- The aim of sampling is only to reduce the error to the minimum possible level.

SAMPLING OF ORE MINERALS

- Sampling also reveals the pattern of mineralisation within the ore richer and leaner ore portions.
- The limits of mineralisation towards both the hanging and footwall contacts can also be precisely defined by careful sampling.
- Determine the processing the extractability characteristics of the ore

PRINCIPLES OF SAMPLING

- True representative of the entire ore body.
- It is necessary to choose proper places for sampling.
- Different samples collected from various parts of the ore body can be combined into a single composite sample to give the most representative picture of the whole ore body.
- This is never done because it is also necessary to know the average grade of the rich and lean portions or the ore body separately. Samples are spaced at regular intervals
- The actual intervals cannot be determined arbitrarily, but have to be arrived at based on the experience gained in similar deposits in the past
- Any interval which minimizes the error is justified in sampling.
- Fixed minimum width or their multiples for each sample, depending upon the complexity of value distribution visualized

TYPES OF SAMPLING

- **Grab Sampling**
- **Chip Sampling**
- **Channel Sampling**
- **Bulk Sampling**
- **Dump Sampling**
- **Trench Sampling**
- **Pit Sampling**

GRAB SAMPLING

Grab sampling is done at random over the mineralized zone on account of certain distinct features such colour, texture, weight or any other striking feature.

Analysis of grab sample gives a preliminary idea about the nature and grade of the ore mineral.

However it is not representative of any large volume or bulk of the deposit.

GRAB SAMPLING

- Richards – Chechette formula

$$Q = KD^2$$

- **Where Q = the reliable weight of the worked down (also initial) sample in Kg.**
- **D = the diameter of the largest particle in the sample in mm, and**
- **K =a factor depending on the homogeneity of the mineral.**
- **The values of k which may be used in most cases**

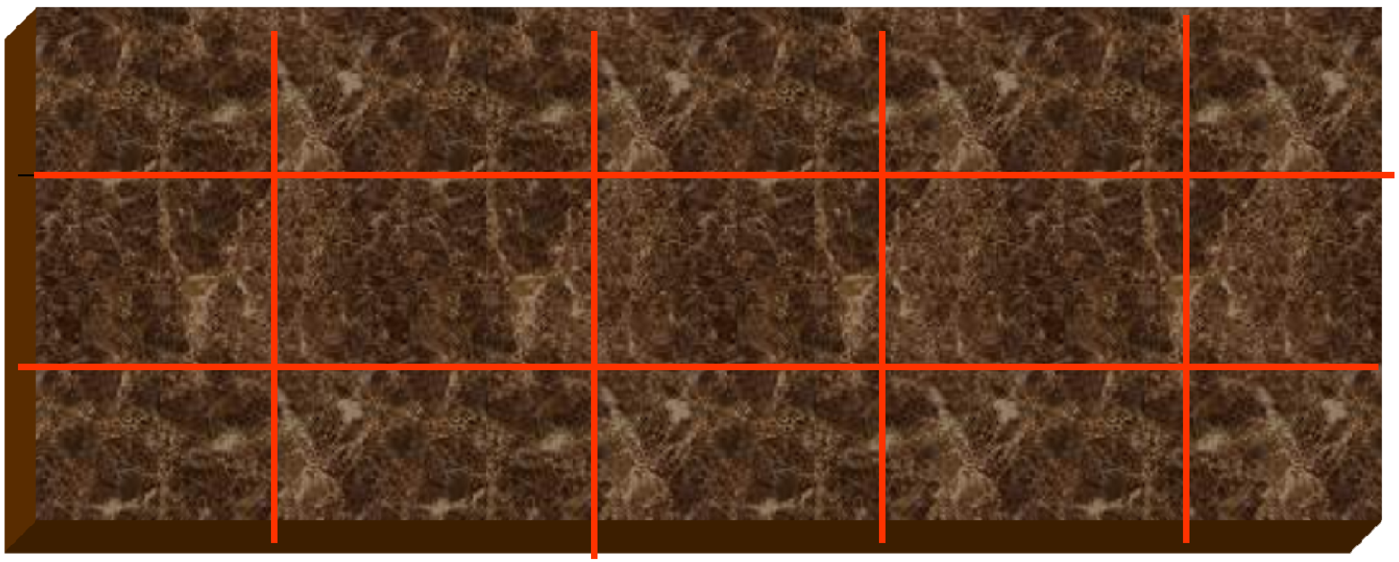
Ore type	Value of k
Homogenous	0.05
Non-homogenous	0.10
Very non-homogenous	0.20 to 0.30
Extremely nonhomogeneous	0.40 to 0.50

CHIP SAMPLING

Chip sampling is done for rapid assessment to determine general grade of deposit.

Chip samples are collected at suitable intervals, in equal size and weight, along a line covering the width of the mineralized zone.

The sample chipped along a line should be suitably sub-divided based on nature of ore and grade variation of the deposit.



CHANNEL SAMPLING

- It consists of cutting across the mineralized zone, collecting resultant material like chips, dust, etc and combining them together to form one sample.

- Channel cutting is to be along the direction of maximum variability and is normal to the planar surface of the mineral zone disposition, which usually coincides with the thickness of the ore body.

- Normally, channels are 3 to 6 cm wide and 1 cm thick.

BULK SAMPLING

- Bulk sampling is done in two specific cases. One situation is when a pilot plant test is to be done on an ore determined accurately
- Bulk samples may be made by collecting a portion from every blast continuously, or from shovels or cars in the case of mines. Bulk samples may be collected from a series of pits or number of trenches, adits or underground drives in the case of prospects
- For technological studies covering laboratory scale benefaction tests, the bulk sample may be 100 to 250 kg. In weight .In some complex ores, upto 1000 kg. May be necessary whereas for pilot plant tests 50 tons of material would be usually required

DUMP SAMPLING

- Dump sampling can be done by systematically driving auger into the dumps and collecting the augured material.
- Benches may be prepared on the dumps and, from the benches, pits can be drived to collect samples.
- If a shovels is available,. Shovels can be deployed to take out representative bulk samples

SELECTION OF SAMPLING METHOD

When the ore body is thick and the values of mineralisation are uniformly distributed, sampling can be done by chip or grab sampling.

- **When the ore body is of medium size and mineralisation is uniform, a combine chip and channel sampling will give the best results.**
- **Where the ore body is too thin but occurs in benches or layers, sampling of various layers can be done by chip sampling.**

SELECTION OF SAMPLING METHOD

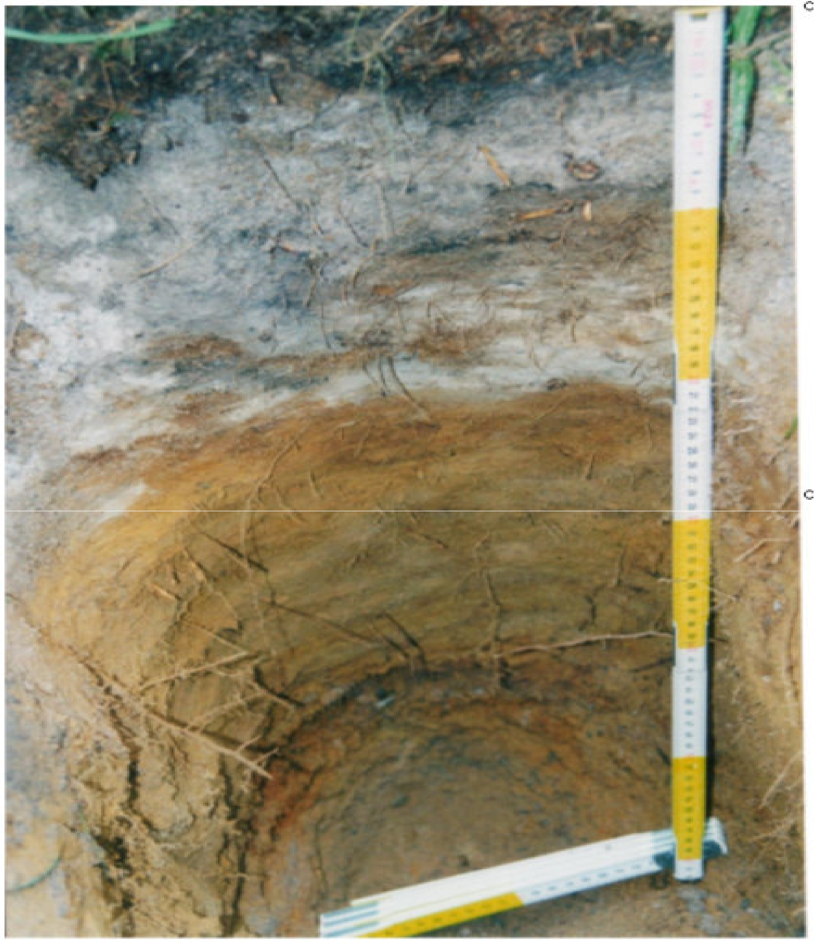
When a deposit is of very large dimension, it becomes necessary to collect a large number of samples. In such cases, a large number of chip samples would give reliable results. Here, the quicker and not necessarily the most accurate method should be preferred.

- With minerals like gold, rare metals, etc . Where values are too spotty and irregular, bulk sampling would give the best results.
- Wherever the ore is banded, channel sampling would give the best results, and very hard ore, particularly massive types of iron ore, would require to be sampled by blast hole cuttings

Surface Sampling Methods

- Near-surface samples can be collected with a spade, scoop
- Sampling at greater depths or below a water column may require a hand auger, coring device, or dredge.
- As the sampling depth increases, the use of a powered device may be necessary to push the sampler into the soil or sediment layers.

Surface Sampling



The soil sample pit

The alluvial horizons at the floodplain sediment sampling

Recommended Cross-Section of Channel Sampling, cm^2

Distribution of components	Thickness of ore bodies, m		
	> 2.5	0.5-2.5	< 0.5
Strong Mineral Deposits			
Highly homogenous and homogenous (regular)	2x5	2x6	2x10
Inhomogenous	2.15x8	2.5x9	2.5x10
Extremely inhomogenous (non-uniform)	3x8	3x10	3x12
Soft Mineral Deposits (without consideration of thickness of ore bodies)			
Highly homogenous and homogenous	(2-5)x(5-10)		
Inhomogenous and highly inhomogenous	(5-10) x (10-20)		

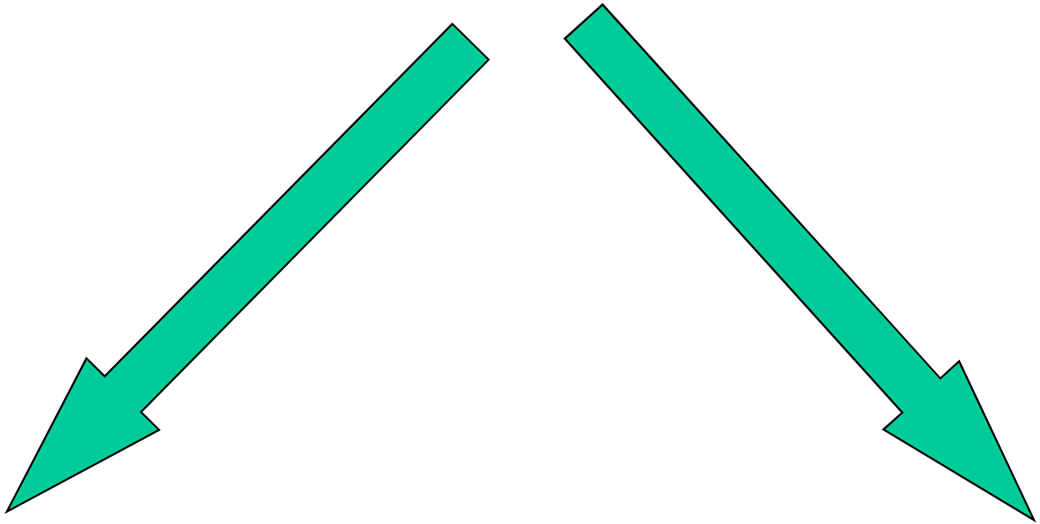
Group	Metal Distribution	Coefficient of variation in metal content, %	Type of deposit	Sample spacing
I	Very regular	Up to 20	Marine sedimentary deposit of Fe and Mn	50-15
II	Regular Irregular	20-40	Sedimentary deposits of Fe, Mn, bauxites; some metamorphic occurrences of Fe	15-4
III	Very Irregular	40-100	Most occurrences of non-ferrous metal deposits, some deposits of rare metals	4-2.5
IV	Extremely	100-150	Predominantly non-ferrous metal deposits and also occurrence of Au	2.5-1
V	Irregular	>150	Some Au and rare metal deposits	1.5-1

Sampling of Exploratory Bore Holes

sampling material comes from the core, core and sludge, and sludge

Core Recovery (C.R.) = l/L * 100%
Where l = length of the core, and L = bore hole length

SAMPLING ERRORS



RANDOM **SYSTAMATIC**

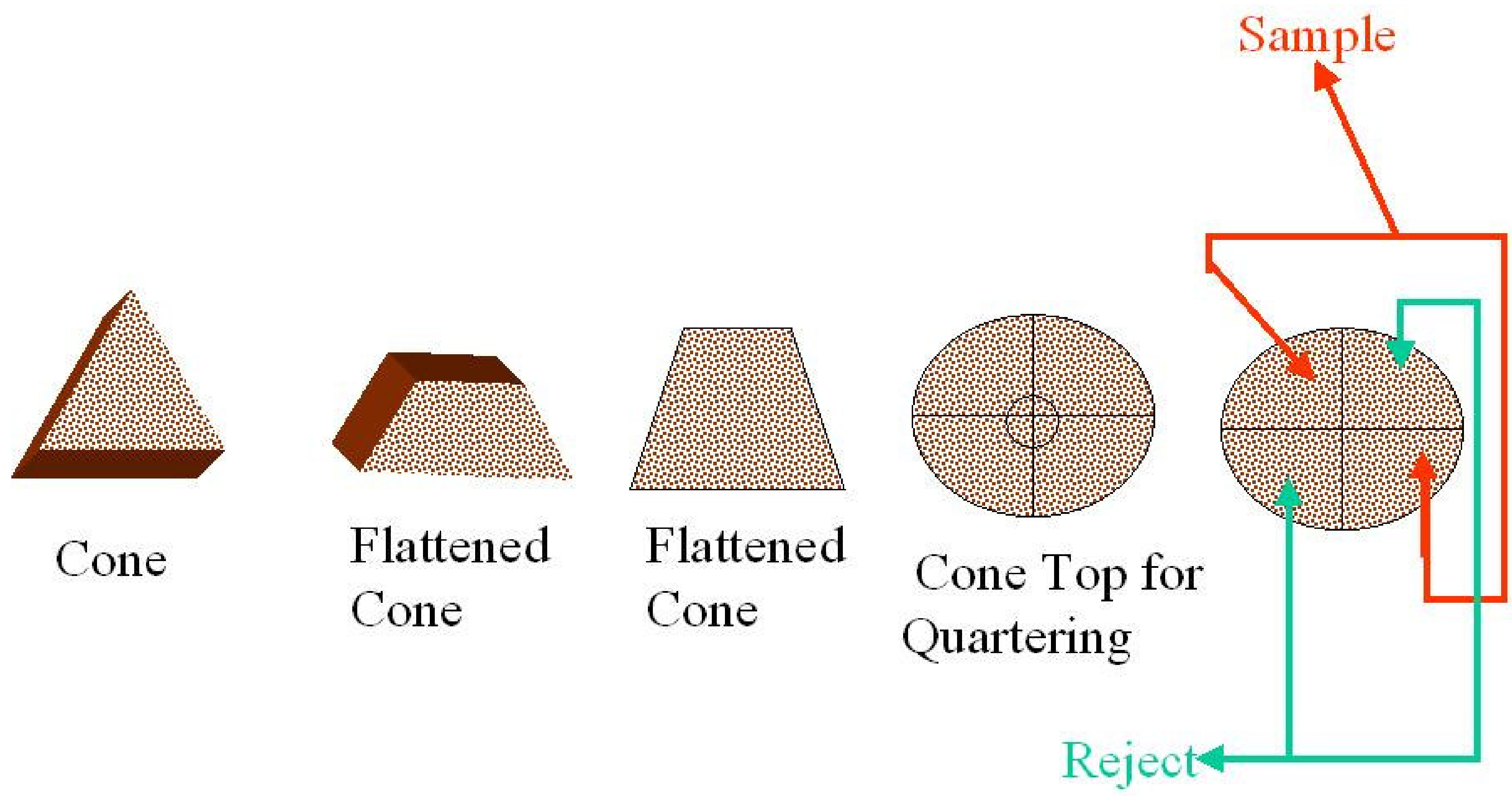
RANDOM ERRORS

- When check samples are taken from the same spot, there will be natural divergence between the value of the principal sample and the control sample. This cannot be overcome.
-
- Errors accumulated due to measurement errors, poor facilities and equipment, and poor eye judgment of the sampler

SYSTEMATICAL ERRORS

- Errors due to mistaken of calculations, misprints and poor numbering
- Limitations of the assay technique itself

CONING AND QUARTERING



TESTING OF SAMPLES

- Assay of useful constituents and harmful ingredients.
- Mineralogical investigations to ascertain mineral composition, grain size, texture and structure.
- Semi-quantitative spectral analysis to determine all the elements present in the ore.
- Technological tests to establish the most efficient method for treating the mineral.
- Tests to determine certain physical properties of the mineral to establish the grade and mining methods and to estimate the reserves

LABORATORY-SCALE EXAMINATION

- Testing physical characteristics
- Petrological tests
- Chemical analysis
- X-ray and spectroscopic and other method