1. STRATIGRAPHY

*** Describe Principles of Stratigraphy:

There are some major principles which are used to determine the relative ages of strata. These principles are as follows:

Law of Superposition:

In a series of undisturbed beds, a bed that overlies another bed is always the younger. The youngest bed will be at the top of the sequence.

Law of Lateral Continuity:

Layers are continuous until encounters solid body that block their deposition.

Fossil Content:

It is possible to assign relative ages to the strata containing fossils. The relative age of the rock can be measured by the flora & fauna fossils ~~on~~ present in that rock.

Lithological Character:

A sedimentary bed may be identified by its distinct lithological character. But as similar rock beds are known to occur in formations of widely different geological ages, the lithology is not of much use for determining relative ages.

*** DESCRIBE THE STRATIGRAPHIC SEQUENCE, LITHOLOGY, DISTRIBUTION & ECONOMIC MINERAL DEPOSITS OF IRON ORE SERIES.

Iron ore series are mostly found in Archeozoic Time deposited rock throughout India. The different groups where Iron is found are Middle Dharwar Divisions and Singhbhum area of Bihar and Odisha.

→ Stratigraphic Succession of Middle Dharwars.

Division	Rock Formation
Igneous Intrusion	
~~ U.C ~~~~~~~~~~	
Upper Dharwar	
Middle Dharwars	Granitic rocks with Gneissose structure Banded - Hematite - Quartzite, (crystalline) Limestone, Chlorite - schist Quartzite and Conglomerate
Lower Dharwar	
	Base not known

→ Stratigraphic Succession of Singhbhum Area

Groups	Formation
Kolhan Group	
~~ U.C ~~~~~~~~~~	
Igneous Bodies	
~~ U.C ~~~~~~~~~~	
Singhbhum Group	Dalbhum Formation Chaibasa Formation
~~ U.C ~~~~~~~~~~	
	Singhbhum Granite
Iron - Ore Group	Upper Lava Formation Upper Phyllites Banded Hematite Quartzite Lower Phyllites Lower Lava Formation Sandstone and Conglomerate
~~ U.C ~~~~~~~~~~	
	Biotite - Tonalite Gneiss
Older Metamorphic Group	

* Lithology, Distribution & Economic Mineral Deposits:

In Dharwar:

- This Middle Dharwar division is mainly made up of rocks of sedimentary origin.
- The typical rocks are Banded-hematite-quartzite, limestone, chlorite-schist, micaceous-quartzite and conglomerate.
- Bosses of granite-porphyry have been introduced in these rocks.
- The conglomerate contains pebbles derived from different rock types and the quartzites contain current beddings.

In Singhbhum Succession:

- In this succession the Older metamorphics are overlain unconformably by the rocks of the "Iron-ore group". The rocks show a low grade of metamorphism.
- The succession of this Group starts with the basal sandstone and conglomerate.
- The basal beds are then followed by lower lava, lower phyllites, banded hematite quartzite, upper phyllites and upper lava formations.
- The beds of the banded hematite quartzites are over 300 meters thick. This formation has given rise to rich iron-ore deposits.
- The rocks of the Iron ore group have been folded and the fold axes trend in the NNE-SSW direction. They are intruded by the Singhbhum granite:

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* DESCRIBE THE STRATIGRAPHIC SEQUENCE, LITHOLOGY, DISTRIBUTION & ECONOMIC MINERAL DEPOSITS OF CUDDAPAH SUPERGROUP:

- The Cuddapah Supergroup has been named after the Cuddapah basin of Andhra Pradesh where it is best developed.

Stratigraphic Sequence:

Group	Formation
Kurnool Group (Age Lower Vindhyan)	
~~ U.C ~~~~~~~~~~	
	Srisailam quartzite
Kistna Group (600 m)	Kolamnala Shale
	Irlakonda quartzite
~~ U.C ~~~~~~~~~~	
Nallamalai Group (1000 m)	Cumbum shales
	Bairenkonda quartzites
~~ U.C ~~~~~~~~~~	
Cheyair Group (3300 m)	Tadpatri Shales
	Pulivendla quartzite
~~ U.C ~~~~~~~~~~	
Papaghani Group (1400 m)	Vempalle shales and limestones
	Gulcheru quartzite
~~ U.C ~~~~~~~~~~	
Archean Schist & Gneisses	

Lithology:

- This is composed of mainly quartzites and slates or shales.
- The limestones occur only in subordinate amounts.
- The total thickness of the succession is over 6 kilometers.
- The Cuddapah rocks are mostly unfossiliferous.
- However the presence of stromatolites have been reported from the Vempalle limestones.

Distribution:

These occur mainly in four areas:

i) Cuddapah basin of Andhra Pradesh
ii) Bijapur district of Maharastra
iii) Chattisgarh area
iv) Along Aravalli mountain in Rajasthan

- In the main Cuddapah basin, the rocks occupy an area of about 35000 sq. kms.
- The shape of the basin is crescentic, the concave side is towards the east.
- The length of the basin in the N-S direction is about 300 km and its maximum width is about 140 kms.

Economic Mineral Deposits:

- In Papaghani Group comprises quartzite, ~~and~~ shale and limestone, deposits of asbestos and barytes are found.
- In Cheyair Group major rocks are shale and quartzites where chert and jasper are also found.
- In Nallamalai Group major ores are lead and copper.
- In Kistna group mostly quartzites and shales are found.

*** DESCRIBE THE STRATIGRAPHIC SEQUENCE, LITHOLOGY, DISTRIBUTION & ECONOMIC MINERAL DEPOSITS OF VINDHYAN SUPERGROUP:

The Vindhyan supergroup has been named after the great "Vindhya Mountains" of Madhya Pradesh where it is well developed.

Stratigraphic Sequence:

Groups	Formations
	Upper Bhander Sandstone
Bhander Group (1000 m)	Sirbu Shales
	Lower Bhander Sandstone
	Bhander Limestone
Diamond Bearing Conglomerate	
	Upper Rewa Sandstone
Rewa Group (2000 m)	Jhiri shales
	Lower Rewa sandstone
	Panna Shales
Diamond Bearing Conglomerate	
	Upper Kaimur Sandstone
Kaimur Group (400 m)	Bijaigarh Shales
	Lower kaimur Sandstone
	Suket Shale
Unconformity	
	Rohtas Formation
Semri Group (1300 m)	Kheinjua Formation
	Porcellinite Formation
	Basal Formation

Lithology:

- Chief rock types are sandstone, shales and limestones.
- Total thickness of the succession is about 4500 meters.
- The Vindhyan rocks contain ripple marks, current bedding and other sedimentary structures which suggest that they are of shallow water origin

Distribution:

Occur in four areas:

i) Main Vindhyan basin in central India
ii) Cuddapah dist, Andhra Pradesh
iii) Bhima and Godavari River valleys
iv) NW side of the Aravalli ranges in Rajasthan.

The 'Main Vindhyan basin' is very large and is situated to the north of the Narmada and Son rivers.

It extends E-W for about 650 kms and N-S about 160 kms covering a total area of 100000 sq. kms.

Economic Mineral Deposits:

- Diamonds: The 3 groups of the 'Upper Vindhyan are separated from one another by two horizons of diamond bearing conglomerate. Panna diamond field of M.P is only diamond producing area in India.
- Limestone: Limestones of good quality are found abundantly in the Vindhyan rockformations.
- Pyrite: Kaimur Group contain a bed of pyrite which is about one meter thick contains about 41% sulfur. This pyrite is used mainly in the manufacture of sulfuric acid.
- Building Stone: Excellent building and ornamental stones are significance of Vindhyan rocks. Pink Sandstones have been used extensively as building stone in Northern India.
- Glass Sand: Good sands are available, which can be used in the manufacture of glass. Vindhyan sands are being mined for this purpose.

** DESCRIBE THE STRATIGRAPHIC SEQUENCE, LITHOLOGY, DISTRIBUTION & ECONOMIC MINERAL DEPOSITS OF GONDWANA SUPERGROUP :

This supergroup has been named after the Gond kingdom of Madhya Pradesh where the rocks are first studied.

Stratigraphic Sequence:

2-fold classification:

Division	Group	Formation	Lithology
Upper Gondwana	Jabalpur	Umia	Sandstone, shale
		Jabalpur	Clays, sandstone
		Chaugon	Clays, sandstone
	Rajmahal	Kota	Sandstone, grit, coal bands
		Rajmahal	Basaltic Lavaflows
	Mahadeva	Maleri	Red clays, sandstone
		Pachmari	Red sandstone, clays
U.C			
Lower Gondwana	Panchet	Panchet	Brown sandstone, shale
	Damuda	Raniganj	Sandstone, shale, coal seam
		Barren measures	Sandstone, ironstone, shale
		Barakar	Sandstone, shale, coal seam
		Karaharbari	Sandstone, grits, coal seam
	Talcher	Rikba	Sandstone
		Talcher	Greenish shale
		Boulder bed	Boulder bed

Lithology:

- It is made up of a 6-7 kms thick succession of mainly fluviatile and lacustrine deposits.
- A Glacial deposit occurs at the ~~base~~ base, and the intercalations of the fossiliferous marine beds occur both in the lower and upper parts of the succession.
- The chief rock types are sandstones, shales, clays, conglomerates

and coal seams.

- Upper Gondwana succession contains about 600 m thick lava flows of Basalt.

Distribution:

The Gondwana rocks arranged mainly along three linear tracks:

i) Along the Son-Damodar valley

ii) Along the Mahanadi valley

iii) Along the Godavari-Wardha valley

In addition, the Gondwana rocks are also found in the Sub-Himalayan regions of Kashmir, Sikkim and Assam.

Economic Mineral Deposits

Coal: All of the Gondwana coal is of bituminous variety. The ash percentage in this coal is very high.

Iron Ore: About 760 m thick ferruginous shales, known as the "Iron stone shale" ~~are~~ occur in the Barren measure. The total reserves of iron ore are estimated at about 2000 ml. tonnes.

Clay: Good quality of clay, used for making refractory bricks, pottery and chinaware are found in abundance in the Gondwana rocks.

Building Stone: The Gondwana sandstone is generally of inferior quality. However some of it is being used as building stone.

Approximate time in Ml years	EON/ Eonthem	ERA/ Erathem	PERIOD/ System	EPOCH/ Series	Evolutionary Changes	Indian Equivalence
0.01	PHANEROZOIC	CAINOZOIC	QUATERNARY	Holocene or Recent	Age of Man	Recent Alluvium Sand dunes, Soils
1.8				Pleistocene	Extinction of Large mammals Age of Man	Older Alluvium, "Karewa" Formation of Kashmir
23.8			TERTIARY – NEO -GENE	Pliocene	Man evolving Mammals abundant	Siwalik Super Group Rajmundry Sandstone Varkala Sandstone
				Miocene	First man like Apes	
64-65			TERTIARY – PALAEO -GENE	Oligocene	Appearance of Modern Mammals	Muree Formation, Peru Formation, Narl Formation, Gaj Formation, Ranikal Formation (PMNR)
				Eocene	Diversification of placentals mammals	
				Palaeocene	Evolutionary explosion of Mammals	
136		MESOZOIC	CRETACEOUS	Late	Dinosaurs reached peak & became extinct Modern birds & common rise of flowering plants	Deccan Traps
				Early		
90-195			JURASSIC	Late	Appearance of 1st tooth birds, Dominance of dinosaurs 1st flowering plant appearance	Kitolimestone, Spitisnale, Jabalpur Formation, Rajmahal Formation (JSR)
				Middle		
				Early		
230			TRIASSIC	Late	Extinction of Primitive Amphibians, Transition of reptiles to mammals, Gymnosperms dominant	Lailang Group, Mahadeva Formation, Punchet Formation (LMP)
				Middle		
				Early		
280		PALAEOZOIC	PERMIAN	Late	Extinction of Ammonites & Trilobites Dwindling of Ancient Plant	Damuda Group
				Middle		
				Early		
320-345			CARBONIFEROUS	Late	Amphibians dominant	Talcher Formation Lipak & Po Formation
				Middle		
				Early		
395			DEVONIAN	Late	1st Forest, 1st Gymnosperms Diversification in Fishes	Muth Quartzite
				Middle		
				Early		
430-440			SILURIAN		Arthropods abundant 1st land plants	Silurian of Himalayas
500			ORDOVICIAN	Late	1st tree corals It is the age of 'Graptolites'	Ordovician of Himalayas
				Early		
570			CAMBRIAN		Age of Trilobites	Haimanta Group Grab-Yang Group
2500	PRECAMBRIAN	PROTEROZOIC			Life is still not prominent	Cuddapah, Vindhyan, Kurnool, Delhi Super Group, Aravali Super Group
4500		ARCHEOZOIC			Complete absence of Life Organism	Similipal Iron Ore Group Dharwar Super Group

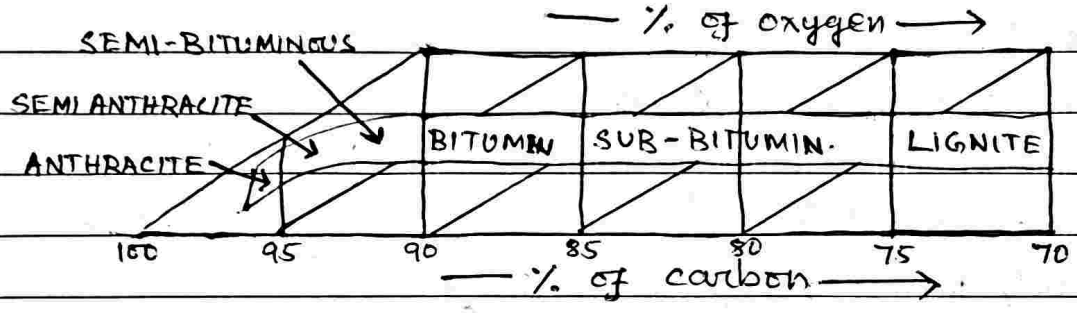
GEOLOGICAL TIMESCALE

2. FOSSIL FUELS

COAL

*** Describe the different ranks of coal.

The process of conversion of vegetable matter to coal involves loss of oxygen and hydrogen and concentration of carbon.
The chief stages of coal formation are, (i) peat, (ii) lignite, (iii) bituminous coal and (iv) anthracite.
Peat is not a coal through it is fuel.
The rank of coal is its position in the lignite-anthracite series.



(Rank classification of coal)

From lignite to anthracite there is a progressive elimination of water, oxygen and hydrogen and an increase in carbon.
In coals carbon occurs in two forms (i) as fixed carbon
(ii) as volatile matter
The ratio of these two (fuel ratio) determines the rank of coal.

On the basis of rank and quality, the coals are classified into four main groups: lignite, bituminous coal, anthracite & cannel coal.
Peat lies above lignite & graphite below anthracite.

Peat:

- It represents the 1st stage of coal formation.
- It is brown porous mass
- contains 85% moisture, 10.4% volatile matter, 6.4% carbon.
- Dry peat burns readily with the long smoky flame.
- Calorific value is very low.

Lignite:

- It is also called 'brown coal'.
- represents second stage in coal formation.
- contains 25-45% moisture.
- Because of high water ~~contain~~ content, it shrinks, cracks, and often disintegrates when dried in air.
- burns freely with a long smoky flame.
- Low calorific value (11000 - 12500 B.T.U)

Bituminous Coal:

- It is dense coal of black colour.
- shows banded structure of dull & bright bands alternate.
- Its moisture content is low.
- burns easily with a smoky yellow flame.
- Its calorific value ranges between (13500 - 16000 BTU)

Anthracite:

- Hard coal with an iron-black colour and submetallic lustre.
- contains about 92-94% carbon and 3-8% volatile matter.
- Difficult to ignite but burns with a short blue flame and gives little smoke.
- Calorific value ranges between (15000 - 15600 BTU)

Cannel Coal:

- It is a special variety of bituminous coal.
- Fine grained and is of uniform texture.
- It has no bounded structure like ordinary bituminous coal.
- Black in colour and has dull lustre.
- Cannel coal is essentially a drift deposit laid down in shallow lakes.

*** Describe different grades of coal:

In India the gradation of coking coal is based on ash content and for semi coking/weakly coal it is based on ash plus moisture content and non-coking coal is based on Gross Calorific Value (GCV):

Grades of Coking Coal:

Grade	Ash content
Steel Grade-I	< 15%.
Steel Grade-II	15% – 18%.
Washery Grade-I	18% - 21%.
Washery Grade-II	21% - 24%.
Washery Grade-III	24% - 28%.
Washery Grade-IV	28% - 35%.
Washery Grade-V	35% - 42%.
Washery Grade-VI	42% - 49%.

Grades of Semi-coking and Weakly Coking Coal:

Grade	Ash + Moisture
Semi Coking Grade-I	< 19%.
Semi Coking Grade-II	19 – 24%.

Grades of Non-coking coal:

Grade:	GCV Band (k.cal/kg)
G-1	> 7000
G-2	6700 – 7000.
G-3	6400 – 6700
G-4	6100 - 6400
G-5	5800 - 6100
G-6	5500 - 5800
G-7	5200 - 5500
G-8	4900 - 5200
G-9	4600 - 4900

G-10	4300 - 4600
G-11	4000 - 4300
G-12	3700 - 4000
G-13	3400 - 3700
G-14	3100 - 3400
G-15	2800 - 3100
G-16	2500 - 2800
G-17	2200 - 2500

*** ORIGIN OF COAL:

Coals are sedimentary rocks formed by accumulation of plant materials in swamps. Hence the source material of coal requires a large accumulation of vegetation matter. This implies large vegetation growth which is possible only in subtropical climate with heavy rainfall.

There are two theories to explain the mode of accumulation of plant materials to give rise to coal seams:

i) In situ theory
ii) the drift theory

In-situ Theory:

→ The vegetable matter was accumulated in the coal forest itself.
→ As the land was sinking slowly, the accumulated plant material was kept saturated with water and therefore it was not decomposed and destroyed.
→ In the course of time, the rate of sinking of land was increased and the coal forest was submerged under water which buried below sand and mud layers.
→ Then uplifting took place and the land emerged out

of water. The coal forests came into existence again and the above said cycle of coal formation was repeated. In this way alternation of strata and coal seams were found.

Evidences:

- A huge amount of plant material is accumulating in-situ in the swamps that exist today.
- In coal seams, the stems of fossil trees are found standing erect with their roots, penetrating into the underclays.
- The underclays which are found beneath the coal seams are supposed to represent the original soils on which the vegetation grew.
- The coal seams contain coal which is relatively pure and free from shale bands.
- The uniformity in thickness and composition of coal seams over wide areas suggests that the deposition of the plant material took place in still waters.

Drift Theory:

The coal seams of India are of drift origin.

- The plant material from the coal forest was transported by water and deposited in lakes or sea just like other sediments.
- During transportation the various materials were sorted out as usual, in accordance with their specific gravity.
- The pure coal seam was formed in places to which only the lightest material (plant material) had access.
- A stream with shale bands was formed in places where a temporary change in the water currents.
- Rapid & frequent oscillatory earthmovements had given rise to several coal seams one above the other separated by sediments.

Evidences:

- Rocks associated with coal seams are distinctly sedimentary. The coal seams itself behaves like a sedimentary bed.
- In some cases, the underclays which represent the soil at the root, are not found below the coal seams.
- The fossil trees are more usually found lying at angles other than the vertical.

*** Describe various important Lower Gondwana Coalfields of India:

- About 98% of the coal produced in India comes from the rock formations of Permo-Carboniferous age, that is Lower Gondwana System, while the rest is obtained from the Tertiary rocks.

Most of the Gondwana coals are non-coking bituminous coals. The coking coals are found only in Jharia, Giridih and Bokaro coalfields.

Lower Gondwana Coalfields:

These are situated chiefly in river valleys.

1. Damodar Valley Region: Coal fields of West Bengal and Bihar
   (i) West Bengal: Raniganj coal fields
   (ii) Bihar: Jharia, Giridih, Bokaro, Karanpura, and Daltonganj coal fields

2. Son-Mahanadi Valley Region: Coal fields of Madhy Pradesh and Odisha.
   (i) Madhy Pradesh: Umaria, Singrauli, Korba, Chirmiri, Sohagpur, Bisrampur, Mohpani and Pench-Kanhan coal fields.
   (ii) Odisha: Talcher coal fields

3. Wardha - Godavari Valley Region : Coal fields of Andhra Pradesh and Maharashtra.

(i) Andhra Pradesh : Singareni coal fields

(ii) Maharashtra : Wardha valley coal fields.

PETROLIUM

Introduction:

The Liquid gold "Petroleum" (petra rock & oleum = oil). is the general term refers to all the natural hydrocarbon found in rocks that may be gas, liquid or solid. This is one of the imp. mineral fuel, is a complex mixture of hydrocarbon compounds, with minor amount of impurities like nitrogen, sulphur and oxygen. The liquid petroleum is called crude oil. Petroleum gas is called natural gas and semisolid to solid form of petroleum are commonly known as Asphaltar, Peat, Bitumi nous etc. Crude oil may be classified in to paraffins. (a thin oil made from petroleum)

Chemical composition:

Petroleum is a compound of Carbon and Hydrogen is known as Hydrocarbon.

→ Carbon percentage 83.5% to 11.5%

→ Hydrogen percentage 11.9% to 13%

Petroleum mainly consist of

Alkanes - 30% to 70%

Cyclo alkanes - 16% to 4%

Aromatic hydrocarbon - 8% to 15%

Origin:

It is usually believed that oil and gas are of organic origin. A no. of theories have been put forward for the origin of natural petroleum & depending upon the primary source material, the theories may be grouped as

1 Inorganic theory 2. Organic theory

The theory of Origin of petroleum should explain the following:

1) The nature of parent substance producing the oil

The cause of and the manner of transformation.
The type of environment favouring the change.
The complexity of the chemical content of the oil.

Inorganic Theory:

According to this theory oil is produced by reaction between substances of inorganic nature without any organic activity. The different theories are described below

Berthelot's alkaline Carbide theory:

According to Bre-thelot, Carbondioxide reaction with Alkaline metals contained in the interior of the earth at high temp. with the form of alkaline Carbides. These on contact with water liberate Acetylene which, through subsequent process of polymerisation & condensation forms petroleum,

CO_2 + alkaline metals → Alkaline Carbides.

Water liberate
Acetylene → Polymerisation
Condensation.

2. Mendeleef's Carbide theory:

Mendeleef's profound that Iron Carbides with the earth on contact with percolating water form acetylene or liquid petroleum, which escape through fissures to the overlying porous rocks & there condence.

This theory is based on laboratory experiment but the presence of Iron carbide within the earth has not been established definitely.

Mendeleev's Volcanic theory:

He suggests that volcanic explosions may sed by the action of water on subterranean rbides and may lead to the formation of petrol-

osmic theory:

Taking in to account the presence of all quantities of hydrocarbon occasionally in meteo-es. So, Kolar consider petroleum to be an original duct, resulting from the combination of Carbon and ydrocarbon on the cosmic and mass during consoli-dation of the earth.

Organic theory:

Most of the petroleum theories believed that etroleum is derived from organic matter. These naterials may be earlier vegetables or animal in nature & they pass through a long series of complex process, such as bio-chemical geological etc.

a) This organic theory has been put forward by Engler. This theory is based on the fact that by destructive distillation of fish bladder a product (similar to natural petroleum could be obtained.

b) Vegetable organic theory

On the basis of certain facts as depos-its of petroleum found in close association with sed-deposits, containing diatom sea weed, peat, lignite, coal, oil shale of known vegetable origin, this theory has been profound besides the above other facts also support the theory:-

1. Oil & Coal appear to have close relationship indicating a vegetable origin.

The large amount of methane in natural gas can be explained as produced by the decay of vegetable matter.

Oils, closely resembling petroleum can be distilled from coal, lignite etc.

1. Microscopic vegetable remains have been noted in crude oil even though it is rare.

Animal Organic theory:

Since 95% of the oil fields occur in marine sediments it is assumed that oil was formed from marine organisms buried in sediments. It have been suggested that bacterial action plays the most effected role in the conversions of organic material in to oil.

It is now commonly preserved that the primitive forms of life like atoms algae etc which were mixed up unclosed with in the sediments in the sea bed the primary source material for petroleum.

Mode Of Occurance:

4 prerequisites are necessary for petroleum to accumulate in accommericiable quantities in the area.

The porous reservoir rocks must have favourable structures as anticlinal fold or dome to hold oil.

2. There must be an impervious cap rock to check the upward migration of oil.

3. The oil originates in a source bed and a marine shale once a black mud rich in Organic compound is thought to be a common source rock.

4. The oil then migrates to permeable reservoir rock & to do this, it may travel for long distances both vertically or horizontally the source bed and the [illegible]

Oil is found ... carbonate rocks which are like grit, sandstone & limestone & have served as reservoir for oil and are called as reservoir rocks. They must have migrated out of some rocks called "source rocks". The fine grained muddy sediments in which petroleum originate by droplets of oil.

The migration of dispersed droplets of oil generated within the source rock is caused due to

1. Compaction of sediments or source rock.
2. Capillarity
3. Buoyancy effect.
4. Lower sp. gravity than water, current of subsurface water.

Accumulation of Oil:

Migration of oil generally leads to accumulation which is the collection of droplets in to pools. Concentrated accumulation is essential to produce Commercial oil pools and this is intern is dependent upon requisite reservoir rocks & traps.

Reservoir Traps:

It holds the oil and gas in place so that they do not escape until released by drilling. It is also known as "Cap rock", which is containing impervious rock which retain oil in a reservoir rock. Shale, clay, dense Limestone, well cemented fine grained or shally sandstone are most effective cap rocks & they seal the reservoir trap.

The occurrence of petroleum deposits are.

1. Surface occurrence
2. Subsurface occurrence

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1. Surface occurrence:

Petroleum occurs at the surface of the ground in following type.

1. seepages, springs, bitumen
2. Mud flows and mud volcanoes
3. Oil shales & reshales.

2. Subsurface occurrence:

Petroleum mostly occurs under the impervible cap rock of a reservoir. The barrier which helps in the accumulation of petroleum is called an Oil trap are classified in to the following 3 types.

1. Structural trap.
2. Stratigraphic trap.
3. Combination of Structural & stratigraphic trap.

9.24.2. Migration of Petrolium

The fine grained muddy sediments in which petrolium originates are called "*source rocks*". The source rocks of petrolium are generally shales, silts, and limestones. The petrolium migrates from the source rock into adjacent porous and permeable rocks and accumulates there to form a pool. Such permeable rocks are called "*reservoir rocks*". The common reservoir rocks are sandstones, conglomerates, porous limestones, fractured shales, and jointed igneous and metamorphic rocks. The causes for the migration of petrolium are : (*i*) compaction of the source rock, (*ii*) bouyancy effect, (*iii*) capillary effect, and (*iv*) water flushing. In an oil pool, the oil floats on the top of water and above the oil there is usually a lens of natural gas (Fig. 9.17)

9.25. OIL TRAPS

The oil migrates outward and upward from the source rock and passes into the porous reservoir rock. The migration of oil continues until it meets a suitable structure where its lateral as well as upward movement is checked. At such a place the oil accumulates to from an oil pool. Such places are called "*oil traps*". The conditions necessary for the formation of an oil trap are as follows.

(*i*) The porous reservoir rocks must have a favourable structure such as an anticlinal fold or dome, to hold oil.

(*ii*) There must be an impervious cap rock to check the upward migration of oil. The common cap rocks are shale, clays, salt, gypsum, and dense limestone.

(*iii*) The structural deformation of rocks must not be very severe. Intensely fractured rocks may render traps ineffective by causing leakage.

9.25.1. Types of Oil Traps

The oil traps are classified into two groups : (*i*) Structural traps, and (*ii*) Stratigraphic traps.

Structural Traps. The structural oil traps are formed as a result of folding, faulting and igneous intrusions. The description of some of the important structural traps are as follows.

(*i*) **Anticlines and Domes.** The anticlines and domes are the most important because they form oil traps in practically all the large oil fields of the world. Here the oil and gas migrate up the limbs and collect at the crest below a cap rock [Fig. 9.17. (*a*)].

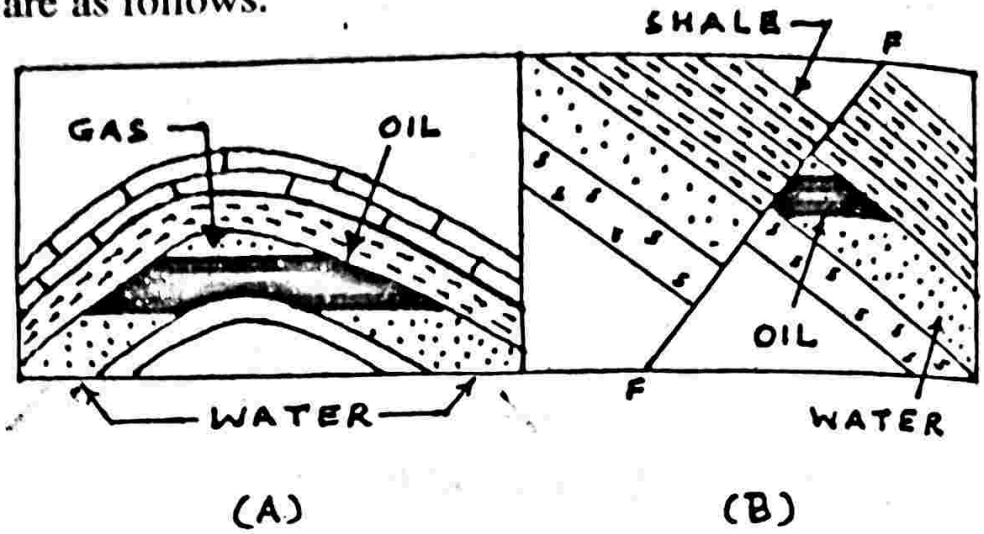

Fig. 9.17. (*a*) Oil trap in an anticline, (*b*) Oil trap along a fault.

(*ii*) **Faults.** When a fault affects inclined strata, a reservoir rock may be blocked off by an impervious shale thereby creating an oil trap [Fig. 9.17. (*b*)].

(*iii*) **Salt Domes.** Where salt domes intrude into the sedimentary rocks, good oil traps are formed. Here the oil accumulates near the upturned edges of the reservoir rock which are sealed by the salt [Fig. 9.18. (*a*)].

(*iv*) **Igneous Intrusions.** The volcanic necks and dykes may seal the upturned edges of the reservoir rock to form oil traps.

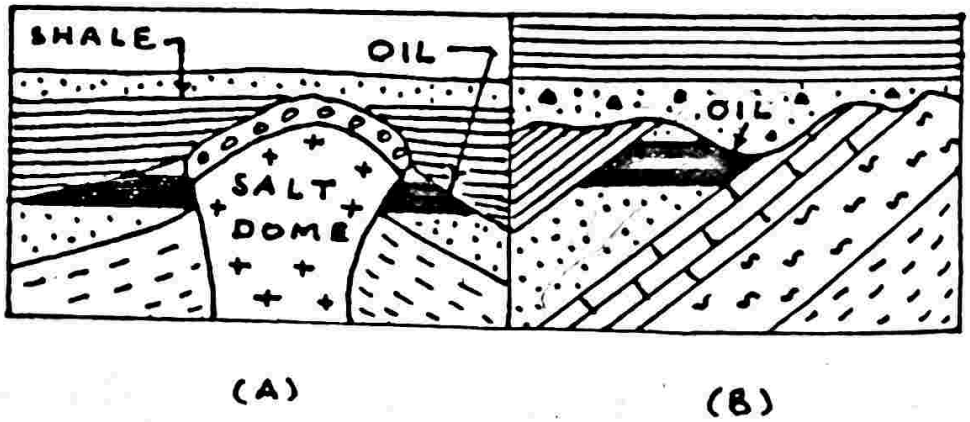

Fig. 9.18. (*a*) Oil trap near a salt dome, (*b*) Oil trap along an unconformity.

Stratigraphic Traps. The stratigraphic oil traps are formed as a result of lateral and vertical changes in the permeability of the reservoir rocks. These changes are caused by variations in the conditions during the deposition of rocks. Some of the important stratigraphic oil traps are as follows.

9.26. PETROLIUM DEPOSITS

In India, resrvoirs of petrolium and natural gas are found in the belts of Tertiary rocks of Assam, Gujrat, Offshore region of Bombay High, and in the Cauveri and Godavari deltatic areas.

9.26.1. Oil Fields of Assam

The chief oil fields of Assam are : (*i*) Digboi, (*ii*) Nahorkatiya, (*ii*) Moran, (*iv*) Rudrasagar, and (*v*) Lakwa.

Digboi Oil Field. This oil field is situated in the Lakhimpur district of Assam. It is 13 km. long and about one kilometer wide. It lies on a tightly folded anticline. The steeper flank of this anticline has been cut by the Naga thrust in the northwest. The Oil bearing formation is the Tipam sandstones of Miocene age. The source rocks in this case are probably Barails. In the Digboi oil field, there are several oil sands and about 400 producing wells of which only 30 are good producer.

Nahorkatiya Oil Field. This oil field is situated in the Brahmputra valley of upper Assam. It lies about 40 km. southwest of Digboi. The oil deposits occur in an anticlinal structure. There are about 5 oil bearing sands all lying within the upper part of the Barail sandstones of Oligocene age. In the overlying Tipams only gas is found. This oil field is cut into a number of blocks by faults.

Moran Oil Field. This oil field lies about 41 km. WSW of Nahorkatia. Here the oil bearing formation are the Barails of Oligocene age. A major fault divides this field into two halves.

Rudrasagar Oil Field. This oil field lies about 40 km. southwest of Moran. Here deposits of oil are found in a gentle dome which is cut by several faults. The oil bearing formations are the Barails of Oligocene age.

Lakwa Oil Field. This oil field is situated about 20 km. SSW of Moran. Here the oil pools are found in the anticlinal structure which is cut by a number of faults. The oil bearing horizons occur both in the Tipams of Miocene age and Barails of Oligocene age.

9.26.2. Oil Fields of Gujrat

The important oil and gas fields of Gujrat are : (*i*) Ankleshwar oil field, (*ii*) Cambay gas field, (*iii*) Kalol oil field and (*iv*) Nawagam oil field.

Ankleshwar Oil Field. This is the most important oil field of Gujrat. It is situated to the south of Narmada river near Broach. The oil pools occur in the anticlinal structure. The oil bearing formations are sands of Eocene age. The oil field is about 20 km. long and its maximum width is about 4 km.

Cambay Gas Field. The Cambay gas field is situated about 9 km. NNW of Cambay town. Huge gas deposits are found in a north-south trending anticline which is faulted on both flanks. The oil and gas bearing sands which are about 150 meters thick, occur in the formations of Oligocene age.

Kalol Oil Field. The Kalol oil field is situated about 25 km. north of Ahmedabad. The deposits of oil are found in an elongated dome trending in the NNW-SSE direction. This dome is cut by a longitudinal fault.Here the oil pools occur in the rock formations of Eocene age.

Nawagam Oil Field. This oil field is situated about 24 km. south of Ahmedabad. The oil pools occur in an anticlinal structure in the Eocene formation.

9.26.3. Bombay High

A huge deposits of oil has been found on the west coast of India, in the offshore structure, called "*Bombay High*". The Bombay High lies in the Arabian sea, about 160 km., NW of Bombay. This has proved to be the richest deposit in the country.

The Bombay High structure covers an area of about 2500 square kilometers. Here the oil bearing rocks are the limestones of Miocene age. The estimated reserves of petrolium in this structure are of the order of 4 billion tonnes.

9.26.4. Other Areas

In addition to the above mentioned oil deposits, there are possibilities of getting oil and gas in the deltas and alluvial troughs of Indus, Ganges, Brahmputra, Cauvery and Godavari. Besides these, other promising areas are offshore region of Tamil Nadu and Andhra Pradesh, and states of Tripura and West Bengal.