Geography Optional - 2025

GEOLOGICAL STRUCTURE & SOIL OF INDIA

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Geological history of India corresponds with that of the earth. Rock formations ranging from Pre-Cambrian to recent times, are found in the country. The geological records of the world are classified on the basis of geological scale devised in Europe. The geological history of the earth is divided into five eras: (i) Neozoic, (ii) Cenozoic, (iii) Mesozoic, (iv) Palaeozoic, and (v) Proterozoic. However, the geological records of India do not fully conform to European.
Sir T. Holland of the Geological Survey of India has suggested four geological ears (Aryan, Dravidian, Purana and Archaean) on the basis of major unconformities between them.

The complex and varied geological history of India begins with the first formation of the earth's crust and extends upto the recent laying down of alluvial deposits. **R.L. Singh** (1971) has recognised the following major geological phases in India:

- The first phase is characterized by the cooling and solidification of the earth's crust during the Pre-Cambrian era (600 million years ago). Archaean gneisses and granites exposed on the peninsula, were formed during this phase. Aravallis were folded at this time.
- The second phase is marked by the undulations and crumpling of the Dharwarian sediments along with igneous activities and intrusions.
- The third phase is characterized by deposition of calcareous and arenaceous sediments in the Cuddapah and Vindhyan basins bordering or lying within the ancient landmass and its upliftment during the Cambrian period (500 million years ago).
- During the fourth phase, Permo-Carboniferous glaciation and extensive glacio-fluvial deposition in the depressions and their subsequent faulting marked the formation of Gondwana rocks (270 million years ago) which contain 95% of the coal resources of the country.
- During the fifth phase, the Gondwanaland was ruptured and the Peninsula drifted northward (200 million years ago). This led to the uplift of the Vindhyan sediments and the formation of the Western Ghats.
- Cretaceous lava flows led to the formation of the Deccan Trap (135 million years ago).
- Tertiary orogeny due to the collision of the Indian Plate with the Asiatic Plate took place in three phases, thereby forming three parallel ranges of the Himalayas – (i) Himadri or Greater Himalayas during the Oligocene (25-40 million years ago), (ii) Himanchal or lesser Himalayas during mid-Miocene (14 million years ago), and (iii) Siwalik or outer Himalayas during post Pliocene (750 thousand years ago). The Indo-Gangetic trough was also formed during this phase.

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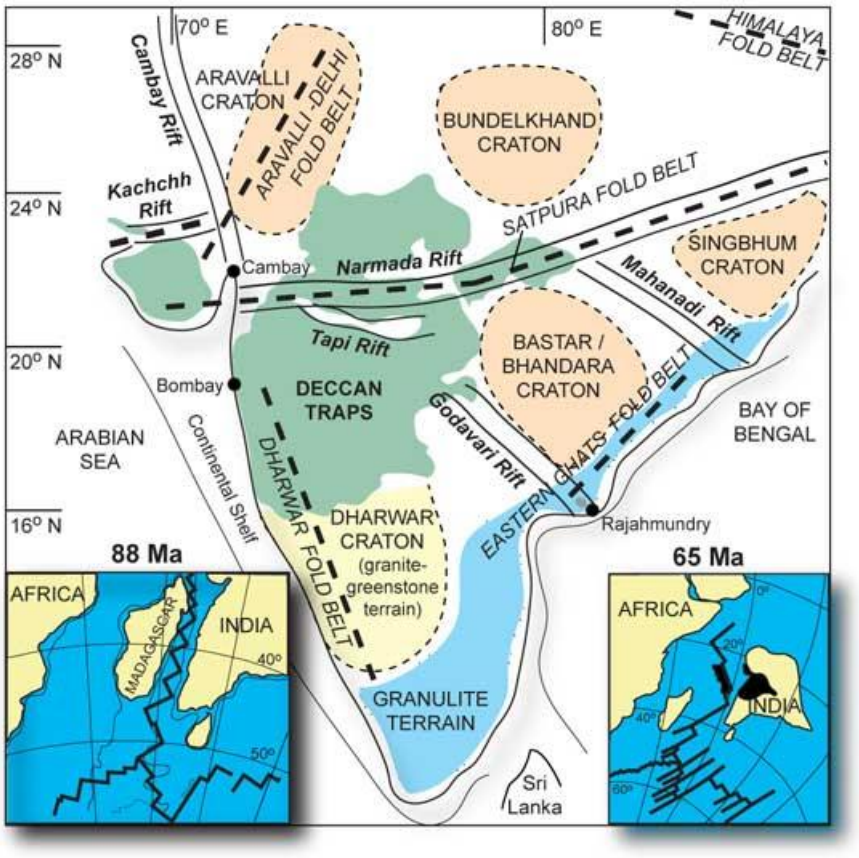
- During the Pliocene-Holocene, sedimentation occurred in the Indo-Gangetic trough.
- The Pleistocene period is characterized by many geological events, e.g. down warping of the Rajmahal Garo gap or the Malda gap, upheaval of the Indo-Ganga divide (Potwar Plateau), which disrupted the old channel of the Indo-Brahma or Siwalik river and led to the evolution of the present drainage pattern of the Northern Plains of India, and the formation of the Narmada – Tapti troughs; and the foundering of the west coast.

STRUCTURAL DIVISIONS OF INDIA

On the basis of above lithological, sedimentation and tectonic history, Wadia recognised three distinct structural units in India – (i) the Peninsular block, (ii) the extra Peninsula (Himalayan region), and (iii) the Indo-Gangetic trough (Plain).

The Peninsula

Stratigraphicaly, speaking, the Peninsula represents an old stable mass, which has existed since the Cambrian period. It has never been submerged beneath the sea except locally or temporarily. Tectonically speaking, the Peninsula is composed of ancient complex rock beds that rest upon a stable and firm foundation unaffected by the great revolutions of the earth's surface. Mountain building forces could not displace the original basement of the Peninsula. However, the Deccan has experienced fracturing and vertical movement of blocks due to tension and compression. Physiographically speaking, the Peninsula exhibits a topography marked by relict mountains, denuded hills and huge rounded 'tors'. The Peninsular rivers have flat and shallow valleys with low imperceptible gradients and their channels have reached the base level of erosion. Overall, the Peninsula may be described as a 'horst', i.e. a solid and stable land mass of great rigidity. During the Gondwana period, however, the Peninsula experienced block movement resulting in the formation of fissures or faults.



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The Peninsular massif, a part of the super-continent of Gondwana land, is formed essentially by a great complex of rocks ranging from the Archaean to the Aryan groups. The Peninsular India has passed through the following landscape cycles, which have greatly affected the geomorphology of this region.

- **Pre-Dharwar Landscape** – The primeval original solid crustal surface of the Peninsula was exposed to the forces of denudation and sedimentation for a long time. These pre-Dharwarian sediments were buckled, folded and metamorphosed several times and ultimately formed the basal rocks of granites and gneisses. Magma intrusions occurred in these rocks, as preserved in the Charnokites of Nilgiri, Palni and Shevaroy. Five ancient geosynclines are believed to exist before the Cambrian period – (i) Dharwar geosynclines, (ii) Eastern Ghats geosynclines, (iii) Satpura geosynclines, (iv) Aravalli geosynclines, and (v) Delhi geosynclines.
- **Dharwar Landscape Cycle** – Initial mountains were formed in the geosynclines. Prior to the Pre-Cambrian period, these mountains were reduced to peneplains. The Aravallies were peneplaned during the Mesozoic era. The activities of erosion, sedimentation, magmatic intrusions and lava flows continued for a long time. During Dharwar, there existed three transgressional seas – Cuddapah, Vindhyan and Bijawer.
- **Cuddapah-Vindhyan Landscape Cycle** – Cuddapah and Vindhyan formations were uplifted. Rivers descending from the Western Ghats and the southern slopes of the Satpuras deposited sediments into the Cuddapah sea, while those originating from the Aravallis and the northern slopes of the Satpuras deposited their sediments into the Vindhyan sea.
- **Vindhyan Glaciation** – The upper parts of the Vindhyan ranges were covered with glaciers. After the removal of the glaciers, the gneissic peneplain surface was covered by marine deposits due to the transgression of the sea during the Pleistocene period. Raised beaches, sand dunes, lagoons and alluvial deposits were formed in the coastal zone of the Cambay region.
- **Cambrian Landscape Cycle** – By the end of the Cambrian period, the Vindhyan glaciation obliterated. Aravallis suffered intensive denudation, but could not be peneplained until the beginning of the Cretaceous period. The relief of the Peninsula was significantly reduced.
- **Carboniferous Landscape Cycle** – Extensive glaciation occurred in the entire Gondwanaland. The axis of this glaciation was over the Aravallis. Sea level also fluctuated many times due to advancement and retreat of ice sheets resulting into transgression of sea on land. The previous cycle of erosion was terminated. Thick boulders were deposited in the Talcher basin. The Hercynian orogeny caused the rupture of the Peninsular gneissic surface. Several tectonic troughs were formed in the basins of the Mahanadi, Damodar and Godavari rivers and sedimentation in these valleys took place.
- **Gondwana Landscape Cycle** – The Carboniferous glaciation was followed by Gondwana cycle when sedimentation occurred in the tectonic basins. Outpouring of lava caused the formation of the Rajmahal basalt. Much of the Peninsula was peneplained upto the end of the Mesozoic era (early Cretaceous period). The general slope of the Peninsula at this time was from south to north, which later got changed due to tilting.
- **Post Gondwana Landscape Cycle** – During the mid-Mesozoic era, the Gondwanaland disrupted. Peninsular India drifted northward and joined the Asiatic landmass. Transgression of sea occurred in the marginal areas of the Peninsula. New landforms were created over the Gondwana surface.
- **Cretaceous-Eocene Lava Flow** – During the Cretaceous period, extensive lava flows occurred in the Rajmahal area covering

an area of 3.97 lakh sq km, while another lava flow occurred in Maharashtra region in the Eocene period, covering an area of 5.18 lakh sq km. These lava flows buried the earlier landforms and topography. Denudation of basaltic surface by fluvial processes resulted into the formation of hills, ridges, valleys and plains.

- **Cenozoic Landscape Cycle** – The Peninsular India was peneplained before the Tertiary epoch. During Cenozoic cycle, the Western Ghats were formed due to subsidence, which also gave birth to the Arabian Sea. Some of the rivers were rejuvenated due to Tertiary upheaval.

The Himalayas (Extra Peninsula)

Stratigraphically speaking, the Himalayas have remained under the sea for the greater part of their geological history and have been covered by marine sediments of various periods beginning with the Cambrian. Tectonically, the Himalayas represent a weak and flexible unit that has undergone large scale crumpling and deformation. Physiographically, they may be termed as the real or 'tectonic' mountains. The fast flowing rivers of this region are still in their youthful stage of development, and are continuously degrading their channels. These rivers have cut deep gorges through the mountains.

The Himalayas were formed due to the uplift and folding in the Tethyan geosynclinals sediments during the Tertiary period. According to **Chengappa** (1993), the Gondwanaland finally broke away 100 million years ago and coasted northward on the ancient Tethys geosynclines (Sea) at a fast speed of 12 cm annually before crashing into the Asiatic continent. According to **Sharma** of Wadia Institute Dehradun, the first collision took place near Lato in Kashmir region and the Indian Plate rotated in an anti-clockwise direction. The Indian plate is still moving north-eastward at a rate of 5 cm per year.

The deposits of the marine sediments in the bed of the Tethys, accumulated since the Permian period, began to be uplifted and folded due to the northward movement of the Indian plate and consequent shrinkage of the Tethys. This upheaval has been a slow process starting from the mid-Eocene period to mid-Pleistocene period. **Wadia** has identified three phases of the rise (uplift) of the Himalayas – (i) the post-Nummulitic phase culminating in the Oligocene period ridging up the central axis of ancient sedimentary and crystalline rocks, (ii) about the middle of the Miocene period, the second phase saw a movement of greater intensity, and (iii) During the post-Pliocene period, maximum elevation was caused in the central part of the range and outlying zone of the Siwaliks.

According to the recent views, after the first collision of the Indian Plate with the Asian Plate nearly 60 million years ago, the Indian Plate did not slide easily under the Asian landmass. Instead, the intense strain caused upwarping on its northern frontiers. It bent out like an arc, and part of its northern crust buckled under the strain. The fractured sheet was then thrust upwards. The Pressure of the northward movement caused three such fractures. Under the intense compression, the mountains got uplifted. The northward movement of the Indian Plate has caused one more fracture on the outer fringes of the Siwalik Hills. Geologists opine that a newer mountain chain would be formed in the Ganga basin forcing the rivers of this region to migrate southward. The mountain peaks of the Himalayas are raising their heights as a result of the continuing upheaval.

Different views have been expressed about the forces responsible for the uplift and folding of the Tethys sediments. **Suess** suggested compressional force generated by the southward movement of the Angaraland and the stationary nature of the Gondwanaland, whereas **Kober** believed in the movement from both sides and folding in the peripheral areas, with Tibet acting as the median mass.

Indo-Gangetic Plain

Stretching from the Indus basin in Punjab to the Brahmaputra Valley in Assam, the Great Northern Plains of India have been the principal theatre of Indian history. Geologically, however, this unit is the least interesting part of India, as it is of recent origin only. These plains were originally a deep depression lying between the Peninsula and the Himalayas. **Edward Suess** called it a 'foredeep' fronting the high crust waves of the Himalayas. **Burrard** considered it as a 'rift valley' formed due to sinking of a portion of the land between two parallel faults (along the Siwalik and along the northern boundary of the Peninsula). According to **Blanford**, it is a shallow sea surface resulting due to the withdrawal of the Bay of Bengal and the Arabian Sea. According to recent views, this depression is merely a sag in the crust. These plains were formed by the thick alluvial deposits of the rivers of the Indo Gangetic systems, borne down from the Himalayas and deposited at their foot. These plains are covered with a deep mantle of clays and silts.

MAJOR ROCK SYSTEMS OF INDIA

Rocks of India are classified into various categories, the broader ones being 'group' and their divisions are 'system', and subdivisions as 'series'. These rocks belong to different periods of the earth's geological history. The major rock groups and rock systems have been organized into four groups: (i) Rocks of Pre Cambrian Era (Archaean and Dharwar Systems), (ii) Rocks of Purana group (Dharwar and Cuddapah Systems), (iii) Rocks of Dravidian group (Vindhyan System) and (iv) Rocks of Aryan group (Gondwana, Deccan Trap, Tertiary and Quaternary Systems).

The Archaean System

The Archaean rocks are the oldest rocks of the earth. The term 'Achaean' literally means the most ancient or belonging to the earliest geological period. These rocks form the foundation of ancient plateaus and cores of mountains and are found in several parts of Peninsular India, Siberia, Canada, Brazil, South Africa, etc. As such, these rocks are called the 'Basement Complex'. They are azoic, thoroughly crystalline, extremely faulted and foliated and largely intruded by plutonic intrusions. These features have given them extremely complex character. These rocks are so much metamorphosed that they have lost their original characteristics.

The gneisses and schists of the Archaean system form the oldest and the largest segment of the surface of India, and occupy two thirds of the Peninsula in Orissa, Madhya Pradesh, Chhattisgarh, Jharkhand, Bundelkhand, Rajasthan, Tamil Nadu, Karnataka, Andhra Pradesh etc. In the Himalayan region, these rocks occur in exposed form along the whole length of the Central Himalayan ranges.

The gneissic Archaean rocks of India are generally described as Bengal gneiss, Bundelkhand gneiss, and Nilgiri gneiss (Charnokite series).

- **Bengal Gneiss** – It is named Bengal gneiss because of its first study in the Medinipur district of West Bengal. It is also known as 'dome gneiss' because of its peculiar ellipsoidal or dome shaped masses. It is mainly found in West Bengal, Jharkhand (Chhotanagpur, Ranchi, and Hazaribagh districts), Orissa, and Karnataka. It also occurs in the Son Valley and Assam. It is a highly foliated rock varying in composition from granite to granodiorite, or even amphibolites with abundant epidote, apatite, garnet, sphene, tourmaline, magnetite, ilmenite etc.
- **Bundelkhand Gneiss** – It occurs in the Bundelkhand region and states of Maharashtra,

Rajasthan, Andhra Pradesh and Tamil Nadu. It is coarse-grained gneiss, which looks like granite. It differs from Bengal gneiss due to the absence of accessory minerals and rocks such as dolomites, marbles and quartzites.

- **Charnokite or Nilgiri Gneiss** – The name charnokite is given after **Job Charnock**, the founder of Kolkata whose tombstone is made of this rock. It occurs widely in Tamil Nadu, Andhra Pradesh, Karnataka, Kerala, Orissa, Bihar, Jharkhand, Madhya Pradesh and Rajasthan. It is a bluish-grey to dark coloured rock, medium to coarse grained in texture, composed of hypersthenes, enstatite, quartz, microline, plagioclase, hornblende, augite, with some accessories like zircon, magnetite, ilmenite, graphite and garnet.

The Himalayan Archaeans – The central ranges of the Himalayas are mainly composed of granites, gneisses, schists, phyllites etc. According to **Wadia,** orthogneiss and granite build the substratum of the Himalayas, while the peaks rising above there are of stratified fossiliferous sediments.

The Dharwar System

The system has been named after the Dharwar district of Karnataka where these rocks were first discovered. The system represents rocks that were formed from the eroded materials of the Archaean gneisses and schists. These rocks generally overlie the Archaeans. But at other places, they are largely interbedded with gneisses and in some cases even older than gneisses. The Dharwar system consists of metamorphosed Archaean sediments, greatly deformed by tectonic activities, and therefore, bear no traces of sedimentary character. This system is a complex of rocks mainly schists, phyllites and slates. These rocks are very much intruded by plutonic masses such as tourmaline-granites, dunites, etc. Their pegmatite veins are rich in minerals like muscovite, beryl, pitchblende, columbite etc. These rocks occur in narrow elongated synclinal outcrops and are rich in minerals.

The Dharwar rocks occur in scattered patches in southern Deccan, central and eastern parts of the peninsula, north western region, and the Himalayas. They are best represented in the Dharwar region of Karnataka, and were first named by **Brucefoot** in the last part of the 19th century.

The Purana Group

The Purana group coincides with the Proterozoic period (600 million years ago) of the earth's geological history. Intense earth movements towards the close of the Dharwar period caused folding in the Dharwar sediments into mountain ranges, especially the Aravallis. Thereafter, the Dharwar landscape was eroded down to the base level stage. Local warping and subsidence caused the formation of new basins in which eroded material was accumulated. Thus, rocks of the Purana group were formed. It consists of two rock systems – the Cuddapah and the Vindhyan (lower).

The Cuddapah System

This rock system has been named after Cuddapah district of Andhra Pradesh where these rocks occur in a semi-circular basin extending over Cuddapah and Kurnool districts. These rocks were deposited from Cambrian period to pre-Algonikan period in the Cuddapah basin, Godavari basin, and Narmada-Son-Damodar basin.

There are four main areas of their occurrence – (i) Cuddapah and Kurnool districts of

Andhra Pradesh, (ii) Madhya Pradesh-Chhattisgarh, Orissa and Maharashtra, (iii) Rajasthan-Delhi region, and (iv) Lesser Himalayas in the extra Peninsula.

(a) **Cuddapah region** – The Cuddapah system is best developed in the Cuddapah basin. These rocks occur in four main series – (i) Papaghani series in the Papaghani Valley, (ii) Cheyair Series in the Cheyair Valley, (iii) Nallamalai series in the Nallamalai Hills, and (iv) Kistna series in the Krishna valley.

(b) **Madhya Pradesh, Chhattisgarh, Orissa and Maharashtra** – In this region, Cuddapah rocks occur in five main series – (i) Bijawar series in Chattarpur and Panna districts of Madhya Pradesh, (ii) Gwalior series in the vicinity of Gwalior in Madhya Pradesh, (iii) Raipur series in the upper Mahanadi Valley in Durg, Raipur, Bilaspur districts of Chhattisgarh and Sambalpur district of Orissa, (iv) Kaldgi series in Bijapur district of Maharashtra, and (v) Pakhal series in the Godavari Valley and Pranhita valley.

(c) **Rajasthan and Delhi region** – In this region, the Cuddapah rocks are designated as the Delhi system. **Heron** has classified the Delhi system into five series – (i) Ajabgarh series, (ii) Delhi system, (iii) Alwar system), (iv) Raialo series and (v) Malani series (in the central and southern Rajasthan).

(d) In the **extra Peninsular region**, outcrops of the Cuddapah system are also noticed in Kashmir, Shimla and Nepal Himalayas where slates and quartzites are the major rocks.

The Cuddapah rocks are azoic (unfossiliferous). They contain iron and manganese ores, barites, asbestos, copper, nickel, cobalt and slates, marble, steatite and jaspers (used as building materials).

The Vindhyan System

This system derives its name from the Vindhyan hills where these rocks occur prominently. The system covers an extensive area of more than one lakh sq km from Chittadurgarh in Rajasthan to Sasaram in Bihar. The deposits are more than 4270 m thick with sedimentary rocks like limestones, shales and sandstones. At places, these rocks are buried under the Deccan lava.

The Vindhyan system has been divided into the lower and upper divisions. The rocks of the lower Vindhyan depict marine influences, while the rocks of the upper Vindhyan are riverine and estuarine in origin.

The **Lower Vindhyan** system is divided into four series: (a) Semri, (b) Kurnool, (c) Bhima, (d) Malani and Jalor/Siwana.

(a) **Semri Series**: It occurs in the Son Valley region and studied in detail by Auden.

(b) **Kurnool Series:** This series is found in Kurnool district in Andhra Pradesh.

(c) **Bhima Series**: It occurs in the Bhima Valley in Gulbarga and Bijapur districts of Karnataka.

(d) **Malani Series**: It occupies in the Malani region (Jodhpur) in Western Region.

Lower Vindhyan rocks also occur in scattered patches in the Godavari valley, near Hyderabad.

The **Upper Vindhyan** System is separated from the Lower Vindhyan by the unconformity, which denotes the change in physical landscape of the Peninsula. These rocks were formed under dry climatic conditions. *This system is divided into three series*: (a) Kaimur, (b) Rewa, and (c) Bhander.

(a) **Kaimur Series:** It extends over the eastern parts of the Chhotanagpur region and consists mainly of sandstone, conglomerates and shales.

(b) **Rewa Series:** It lies north west of the Kaimur series, and consists of shales at the base, and sandstones of coarser grains.
(c) **Bhander Series:** It extends over the western parts of the Vindhyan ranges. It is arenaceous as well as argillaceous. It mainly consists of sandstones, shales and limestones.

In the **extra-Peninsula**, the Vindhyan rocks are designated by various local names. These rocks occupy the area between the central and outer Himalayas and consist mainly of slates with some sandstones and limestones. These rocks occur in Meghalaya also. In the extra Peninsula, the Vindhyan rocks are un fossiliferous as they have been subjected to folding and metamorphism.

The Vindhyan rocks contain precious stones, ornamental stones, diamonds, building materials, and raw materials for cement, glass, and chemical industries. They also yield inferior quality of iron ore and manganese. The Panna and Golcunda mines famous for diamonds are associated with the Vindhyan conglomerates. Many historic buildings like the Red Fort of Delhi, Agra Fort, Jama Masjid, etc. have been built from Vindhyan sandstones.

The Dravidian Group

The Dravidian Era is marked with the beginning of life on the earth, corresponding with the Cambrian Period (600 million years ago) and lasting upto the Middle Carboniferous period (300 million years ago). The rock formations of this era are almost absent in the Peninsular region, which experienced a period of quiescence. The extra Peninsular region, on the other hand, underwent subsidence and developed marine conditions in some planes.

The Dravidian group of rocks are grouped into the Cambrian, Ordovician, Silurian, Devonian, and Lower and Middle Carboniferous systems.

- The **Cambrian rocks** including shales, sandstones, slates, clay, salt, marl etc. Occur in Baramulla and Anantnag districts and Pir Panjal area in Kashmir, and Spiti in Himachal Pradesh.
- The **Ordovician rocks** are mainly found in the Lidar Valley and the Handwara basin in Kashmir and Spiti basin in Himachal Pradesh.
- The **Silurian rocks** mainly occur in Handwara and the Lidar valley in Anantnag (Kashmir), and Spiti area (Himachal Pradesh).
- The **Devonian rocks** consist of thick quartzites occurring in the Lidar Valley and in the Pir Panjal and in Spiti.
- The **Lower Carboniferous** system includes limestones in the Lidar Valley and quartzites of the Lipak series (Spiti basin). These areas also have **Middle Carboniferous** systems.

The Aryan Group

The Aryan Era of the Indian geology began with the Upper Carboniferous period. The major events of the era included the following:

- During the Upper Carboniferous period, a vast geo-synclinal sea called Tethys existed at the place of the Himalayas. It was connected to the Atlantic through the present Mediterranean Sea, and to the Pacific through China.
- The Kashmir Himalayan region experienced intense volcanicity. The Peninsula developed faults in which fluvial and lacustrine sediments were deposited to form Gondwana rocks.
- Hercynian orogeny occurred in different parts of the earth.

- The super continent of Gondwanaland disrupted and its parts started drifting away. The Indian Plate drifted northward and collided with the Asian landmass (Angaraland).
- Extensive basalt flows formed the Deccan Trap.
- During the Tertiary period, the Alpine orogeny took place and young folded mountains, i.e. Rockies, Andes, Alps and the Himalayas were formed.
- The Indian subcontinent assumed its present shape.
- During the Pleistocene period, large parts of the earth were covered by thick ice sheet.
- Evolution and spread of man took place.
- The rocks of the Aryan era belong to the following major systems: (i) Gondwana, (ii) Upper Carboniferous and Permian, (iii) Triassic, (iv) Jurassic, (v) Cretaceous, (vi) Tertiary, (vii) Eocene, (viii) Oligocene and Miocene, and (ix) Pleistocene.

Gondwana System

The system is named after the ancient Gond Kingdom in Madhya Pradesh where these rocks were first studied. These rocks also occur in the constituents of the super continent of Gondwanaland. The Gondwana system represents the last massive formation of the stratified sedimentary rocks in the Peninsular basins formed during the middle Carboniferous period. Their formation took a long period from Upper carboniferous to the Jurassic period during which many climatic changes occurred.

The Gondwana rocks occur in four main areas: (a) Damodar Valley, (b) Mahanadi Valley, (c) Godavari, Venganga and Wardha Valleys, and (d) Kachchh, Kathiawar, western Rajasthan, Kashmir and Sikkim.

The Gondwana system may be divided horizontally into two parts – Lower and Upper, which contain coal seams. According to **Fox**, **Krishnan** and **Mehdiratta**, the lower Gondwana contains glossopteris flora, while the upper Gondwana has ptilophyllum flora.

The **Lower Gondwana System** includes three series – (a) Talcher, (b) Damuda and (x) Panchet.

- **Talcher Series** – It is named after the Talcher area in Dhenkanal district of Orissa. It consists mainly of sandstones and fossiliferous shales.
- **Damuda Series** – It is the most important series of the Gondwana system and is well developed in the Damuda area of West Bengal. It contains coal seams especially in Raniganj and Barakar areas. Iron stone, shales and sandstone also occurs here.
- **Panchet Series** – It is the youngest series of the Lower Gondwana system and is named after the Panchet Hills, south of Raniganj. It contains sandstone and shales, while coal seams are absent.
- The **Upper Gondwana System** includes four series – (a) Mahadev, (b) Rajmahal, (c) Jabalpur, and (d) Umia.
- **Mahadev Series** – It is also known as Pachmarhi series named after the hills in the Satpura Range. It contains thick beds of sandstones and shales and is devoid of coal seams.
- **Rajmahal Series** – It is named after the Rajmahal hills. It contains dolerites, clays, sandstones, shales and haematitic.
- **Jabalpur Series** – It is extensively developed in the Satpura and Madhya Pradesh and consists of limestones, clays, sandstones, shales and lignite.
- **Umia Series** – This series is named after Umia village in Gujarat, and consists of marine conglomerates, sandstones and shales.

In the **extra-Peninsular region**, Gondwana system occurs in salt Range, Hazara, Afghanistan, Kashmir, Nepal, Sikkim, Bhutan, Assam and Abor.

The Gondwana system of rocks yields over 95% of the coal of the country. The sandstones are used as a building material and as a millstone. Fire clay is used as refractory. Iron ore, lime, and raw material for ceramic industry also occur in this system.

The Upper Carboniferous and Permian System

During this period, the Tethys Sea existed between the Angaraland and the Gondwanaland. Two geologic events occurred during this period – (i) shallowing of the Spiti basin and (ii) outpouring of immense lava in Kashmir, obliterating the previous topography and formation of rocks of Pir Panjal. These rocks are found in the Spiti basin, Kashmir, Shimla, Hazara, etc.

The Triassic System

This system is well developed in Kashmir, Himachal Pradesh and Kumaun region, particularly in the Spiti-Kumaun region, where it is known as **Lilang** system. Variation in thickness and lithology exists in the lower, middle and upper systems.

The Jurassic System

Jurassic system occurs in Spiti (shales and limestones), Salt Range (sandstone, clay, limestone, and shale), Baluchistan (limestones), Hazara (shales), Kashmir (limestone), Kachchh (sandstone, shales and limestones), Rajasthan (limestone, sandstone, grits, and conglomerates), and Tamil Nadu coast. During this period, transgression of the sea occurred in Rajasthan, Kachchh and along the east coast.

The Cretaceous System

This period is marked by outpouring of huge quantity of basalt, which formed the Deccan Trap, and by the transgression of the sea on the Coromandel coast and the Narmada Valley.

The rocks of this system are widely distributed in the country with the most varied faces of deposits. In the Peninsular region, these rocks occur in the Deccan Trap region. The Deccan Trap is a volcanic plateau formed through fissure eruptions with step-like slope. ('Trap' in Swedish language means star or step). It covers over 5 lakh sq km of area in Gujarat, Maharashtra, Madhya Pradesh and northern Karnataka. Isolated patches of lava are found in distant localities in Rajamundry (Andhra Pradesh), Jharkhand, and Sindh (Pakistan). The maximum thickness of the Deccan Trap is 3000 m along the coast of Mumbai. The rocks of the Trap contain minerals like anorthite, albite, hypersthenes, diopside, magnetite, orthoclase, quartz, ilmenite, apatite, and olivine. The Trap overlies the Bagh and Lameta Beds, and is overlain by the Nummulitic limestone.

In the extra-Peninsular region, the Cretaceous rocks are developed in the Spiti area, Kashmir, Hazara, Sindh, Baluchistan, Assam, etc.

The Deccan Trap yields basalts, which are extensively used for the construction of roads and buildings. Besides, quartz, agate, amethyst etc. Are semi-precious stones. Magnetite supplies iron ore. Bauxite is also a useful mineral. The decomposition of basalt yields regur soil, which is rich in calcium, magnesium, carbonates, potash, and phosphates. It is highly useful for the cultivation of cotton.

The Tertiary System

The Tertiary epoch is important in the geological history of India for two reasons – (i) Gondwana land was finally fragmented and large parts of it got submerged under the sea, and (ii) Uplift of the Tethys geosynclinals sediments formed the lofty ranges of the Himalayas.

Rocks of the Tertiary system occur in a long belt stretching from Sindh and Baluchistan (in Pakistan), running along the Himalayas upto Assam and Myanmar. Tertiary rocks are also found in Kathiawar, Kachchh, Rajasthan, and along the Malabar and the Coromandel coasts.

The tertiary system is sub-divided into three systems: (a) Eocene system, (b) Oligocene and lower Miocene system and (c) Middle Pleistocene and Recent system.

Eocene System

The rocks of this system comprise three series – the Ranikot (lower), the Laki (middle) and the Kirthar (upper) series. The Ranikot series have sandstones, shales and clays overlain by limestones and shales. The Laki series consists of limestones and shales, and the Kirthar series have mainly nummulitic limestones. The Kirthar series occurs in Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rajasthan, Assam and Gujarat. Near Riasi and Jammu, the shales contain some coal and graphite seams.

In Assam, these rocks are represented by the Barail series on both sides of the Haflong-Disang fault, the upper part containing coal. The Jaintia series in Meghalaya, and the Subathu series of Shimla and Garhwal Himalayas also belong to the Eocene system.

Oligocene and Lower Miocene System

These rocks were laid down in the basins of the Tethys formed after the first upheaval of the Himalayas. The Oligocene rocks are of shallow water origin and are poorly developed in the country except in the Barail series of Assam.

The lower Miocene deposits occur in the Dagshai and Kasauli beds in Shimla, Surma series of Assam, Nari and Gaj beds in Kachchh and Saurashtra, Baripada beds in Orissa, and Quillon beds in Kerala.

Middle Miocene and Lower Pleistocene System (The Siwalik System)

The Siwalik system is found along the foothill zone of the Himalayas. It is called the Dihing series in Assam. The rocks of this system are mostly arenaceous and were deposited by rivers in lagoons and lakes. These are composed of coarse materials like gritstone, sandstone, conglomerate, clays, etc. Of 5000 m thickness. The Siwalik system is divided into three groups – lower, middle and upper. Due to their coarse composition, these rocks have been much denuded and weathered in the Himalayas.

In the Peninsular region, the Siwalik rocks are found in Kachchh and Saurashtra overlying the Gaj Series. In the south, the rocks exist as a the Karaikal beds in Thanjavur district (Tamil Nadu), as Warkalli beds near Varkala (Kerala) in Kuddalore and Rajamundry in Andhra Pradesh and in South Arcot district of Tamil Nadu.

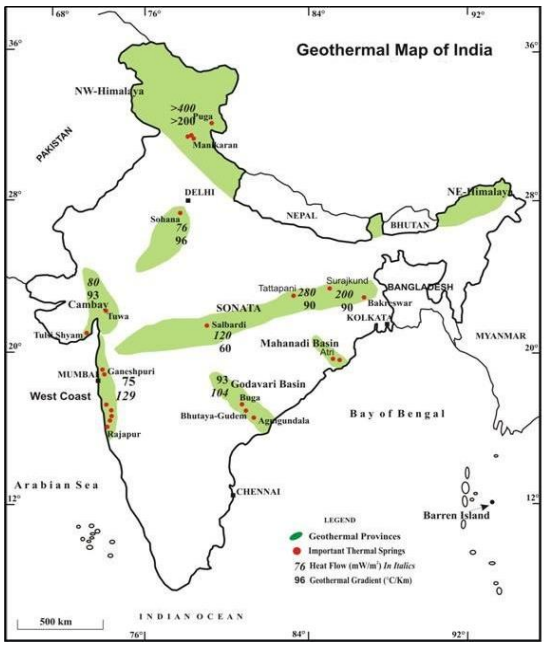
Lower Siwalik overlies the upper Muree sandstones and shales. The main rocks are micaceous sandstones and clays. The middle Siwalik rocks are largely sandstones with an abundance of mica. The Upper Siwalik consists of very coarse conglomerates, grits and clays. They are highly fossiliferous.

The Middle Pleistocene and Recent System

The term 'Pleistocene' was first used by **Charles Lyell** for those rock formations which are newer than Pliocene but older than Recent. The Pleistocene system in India has an extensive and varied development, covering 6.50 lakh sq km of North India under river deposits. These rocks are also found in the ice-deposits in the Middle and inner Himalayas, and deserts and lacustrine and littoral deposits of the country. According to **Wadia**, extensive linear faulting along the west coast and tectonic disturbance of gravel beds, Karewas, and upper Siwalik strata are the other major events of this period. In fact, the present landscape of the country was determined during this period.

Hot Springs in India

Hot springs are generally associated with water present in the earth crust and volcanicity. Igneous rocks like granite, gneiss and metamorphosed rocks often contain hot springs.



Hot springs are widely distributed in India, especially in the following regions;

- Kashmir Valley, Puga Valley and Panamic in Ladakh.
- Manikarna in Kulu, Jwalamukhi in Kangra and Sutlej Valley in Himachal Pradesh.
- Sohna in Haryana.
- Talbreach near Alwar and Narayani in Jaipur in Rajasthan
- Sahasra Dhara in Dehradun, and Gangotri and Yamunotri in Uttaranchal
- Rajgir and Mungher in Bihar
- Hazaribagh and Santhal Pargana in Jharkhand
- Hoshangabad and Gwalior in Madhya Pradesh
- Panch Mahal and Vadodara in Gujarat
- Thane district in Maharashtra

Assam, Orissa, West Bengal, and Kerala also have hot springs at many places.

INDIAN SOIL

India being large country exhibits variety of soil types. Due to diversity of parent rock material, variation of climatic conditions and soil forming processes, soil character varies from region to region. The soils of peninsular India are mostly zonal soils formed by disintegration and decomposition of rocks in situ. On the other hand soils of plains are azonal soil transported and deposited by rivers. The major classification of soil includes –

(a) Alluvial – developed due to process of deposition of sand, silt and clay in layers. These are found along river courses in low lying tracts. Alluvial soils are classified into newer alluvium (**Khader**), older alluvium (**Bhanger**) and pebble sand deposits (**Bhaber**). Bhanger marks their development only in the regions where flood water do not reach pronouncedly. A few metres below the surface, the bhanger has bed of fine nodules or **Kankar**.

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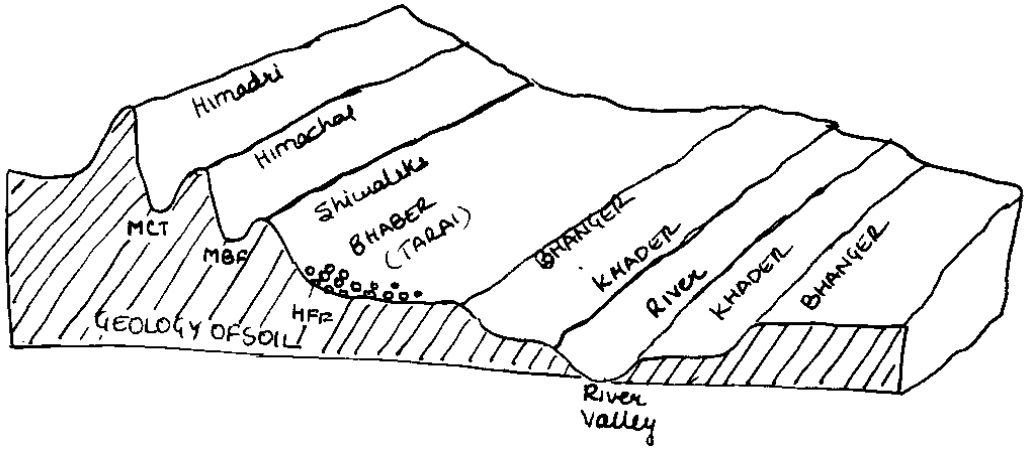
There are other variants regionised like **Usar** soil in Ganges Ghaghara doab, **bhur** soil in Ramganga

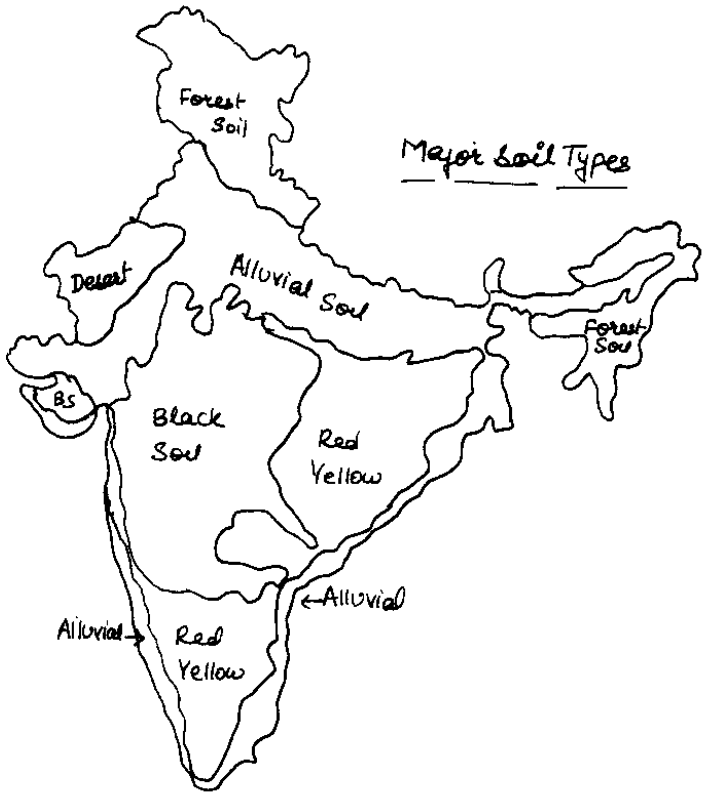
tract, **bhat** soil in lower Gandak valley **Bhaber** and **terai** at the foot of Shivalik. Bhur is sandy in character; bhat is a whitish calcareous soil while bhabar is a sandy soil with a high porosity and



low moisture retaining capacity. Although fertility of alluvial soil is dependent on many factors like texture, organic matter and mineral content, these are the best agricultural soils in India. This occupies all the plains of India.

(b) Black soil – is dark color soil due to high content of humus calcium, magnesium carbonates and iron oxides. These are developed from basaltic rocks and are commonly known as regur or black soil. They are prominent over Maharashtra, Malwa, Khahawar, Telengana, Malnads, Piedmont uplands of Tamil Nadu.

(c) Red – is formed by weathering of ancient crystalline and metamorphic rocks.These are found in areas of low rainfall and high temperature. These are less leached than laterite. The colour is due to high iron content. Red soil covers large parts of Tamil Nadu, southern Karnataka, Andhra Pradesh, Madhya Pradesh and Orissa. The soils are poor in phosphorous, nitrogen and lime content.



(d) Laterite – are constituted of ferruginous aluminous elements formed in regions of heavy seasonal rainfall accompanied by high temperature conditions for most part of the year. The top soil is completely leached out leaving a high proportion of iron and aluminium as residue. Laterite soil is poor in phosphorous, potassium lime and nitrogen. The PH ranges from 4.5 to 5.5 and the base exchange capacity is low. The soil is reddish in color due to presence of iron oxides. Laterite soils are found in Orissa, western West Bengal, in some parts of Andhra Pradesh, Meghalaya and Bihar Jharkhand plateau.

(e) Desert soil – are characterized by sandy texture. They are usually adequate in

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mineral status but poor in organic matter. The pH value is high. These are typical of Rajasthan, parts of Guajarat, Punjab and Haryana where annual rain is less than 40 cm which does not encourage chemical decomposition of crystal elements.

(f) Montane soil - are found in Himalayas and hills of drier regions of peninsula and in parts of Andaman islands. The terai soils of Himalayan foothills are rich in nitrogen and organic matter. In coniferous forest belt of Jammu & Kashmir, Himachal Pradesh, Uttranchal and Sikkim, brown podzol soils are found. Alpine meadow soils are located at further higher altitudes. Further mountain soils having good vegetation cover its rich in organic matter. But their base status varies depending on the degree of leaching.

(g) Saline and Alkaline – are found in drier parts of country. Being deficient in underground drainage capillary action during summer brings the concentrated dissolved salts to the surface where they form a white crust.

(h) Peat and Bog – These are found in humid regions as a result of accumulation of a large amount of organic matter in the soil. The soil is deep black is color with a high clay content and is rich in nitrogen adequate in potash, but deficient in phosphorus and are poorly drained.

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