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Program : **B.Tech**

Subject Name: **Engineering Geology and Remote Sensing**

Subject Code: **CE-405**

Semester: **4th**

**Unit 3**

**Petrology: rock cycle, composition, classification and structures of igneous, sedimentary and metamorphic rocks of civil engineering importance, study of common rock types, brief geological history of India.**

**Petrology is the branch of geology that studies rocks and the conditions under which they form. Petrology has three subdivisions: igneous, metamorphic, and sedimentary petrology.**

**Rock cycle**

**The rock cycle is a basic concept in geology that describes the time-consuming transitions through geologic time among the three main rock types: sedimentary, metamorphic, and igneous.**

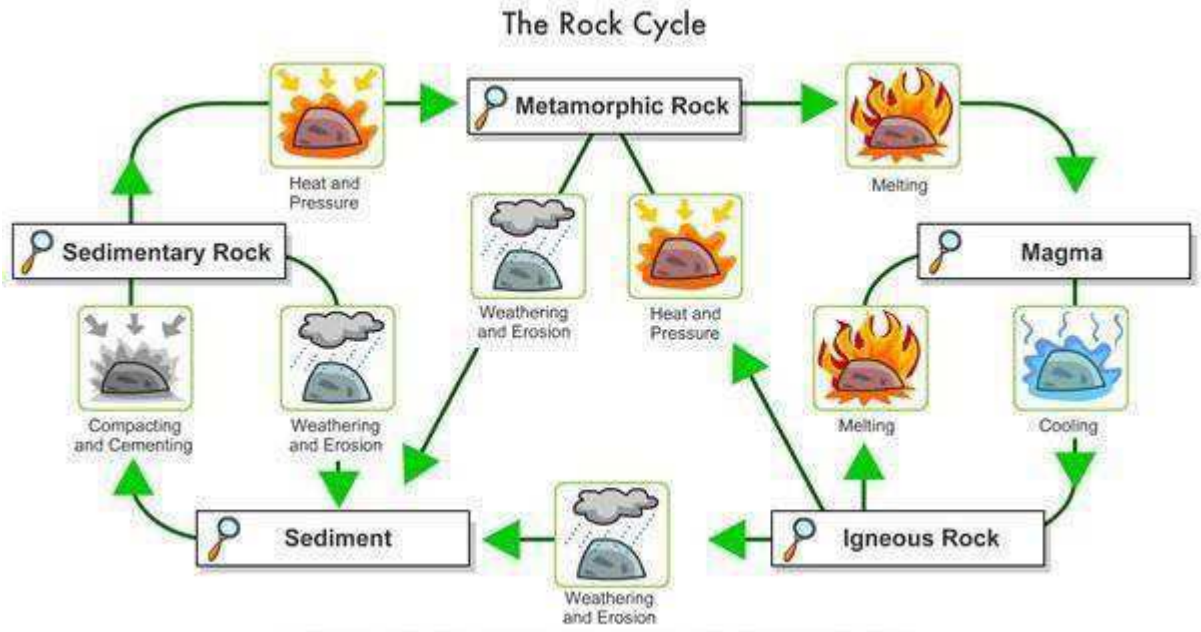


**Fig. 6 Rock Cycle**

**The Rock Cycle is a group of changes. Igneous rock can change into sedimentary rock or into metamorphic rock. Sedimentary rock can change into metamorphic rock or into igneous rock. Metamorphic rock can change into igneous or sedimentary rock.**

**Igneous rock forms when magma cools and makes crystals. Magma is a hot liquid made of melted minerals. The minerals can form crystals when they cool. Igneous rock can form underground, where the magma cools slowly. Or, igneous rock can form above ground, where the magma cools quickly.**

**When it pours out on Earth's surface, magma is called lava. Yes, the same liquid rock matter that you see coming out of volcanoes.**

**On Earth's surface, wind and water can break rock into pieces. They can also carry rock pieces to another place. Usually, the rock pieces, called sediments, drop from the wind or water to make a layer. The layer can be buried under other layers of sediments. After a long time the sediments can be cemented together to make sedimentary rock. In this way, igneous rock can become sedimentary rock.**

All rock can be heated. But where does the heat come from? Inside Earth there is heat from pressure (push your hands together very hard and feel the heat). There is heat from friction (rub your hands together and feel the heat). There is also heat from radioactive decay (the process that gives us nuclear power plants that make electricity).

Baked rock does not melt, but it does change. It forms crystals. If it has crystals already, it forms larger crystals. Because this rock changes, it is called metamorphic. Remember that a caterpillar changes to become a butterfly. That change is called metamorphosis. Metamorphosis can occur in rock when they are heated to 300 to 700 degrees Celsius.

When Earth's tectonic plates move around, they produce heat. When they collide, they build mountains and metamorphose (met-ah-MORE-foes) the rock.

The rock cycle continues. Mountains made of metamorphic rocks can be broken up and washed away by streams. New sediments from these mountains can make new sedimentary rock.

Classification of Rocks

This classification is based on the mode or process of formation of a rock. Thus, some rocks may be formed from natural hot molten materials. Others may be formed at ordinary temperatures from compaction of particles or sediments, and still. Therefore, in the geological classification of rocks following three types of rocks are recognized.

(I) Igneous Rocks:



All those rocks that have been formed by cooling and crystallization from an originally hot and molten material are grouped as Igneous Rocks. They are the most abundant rocks of the crust depth-wise. The hot molten material occurs below the surface of the earth and is known as Magma. Quite Often, it erupts out at the surface as Lava from cracks in the crust called volcanoes. Magma may cool and crystallize below the surface and change it into solid rocks. Similarly, lava flowing over the surface (even underwater in oceans) may also change it into rocks.

Three different types of igneous rocks are thus formed:

1) Plutonic: Formed at great depths, generally from 210 km below the surface. These have coarse crystals.

Examples: Granites, Syenite', Gabbros.

2) Hyppabyssal: Formed at the intermediate depth below the surface generally up to 2 km. These have mixed characters.

Examples: Porphyries of various types.

*Note: The platonic and Hyppabyssal are sometimes grouped as intrusive rocks*

3) Volcanic: These are formed on the surface of the earth, even underwater in oceans from the cooling of lava from volcanoes. They are also called extrusive rocks and are commonly made up of very fine crystals.

Examples: Basalts and Traps.

**(II) Sedimentary Rocks:**

**These Types of Rocks are also called secondary rocks. The existing rocks on the surface of the earth are being broken into smaller particles by the natural process of decay and decomposition called weathering and erosion. Atmospheric gases, temperature variation, wind, water, and ice are some natural agencies which break the existing rocks into small fragments and sediments. These particles are then carried away and deposited at other places such as at sea-bed, lake-bed, and river-bed and so on. Gradually, the accumulated particles get compressed and compacted under their own load and are thereby transformed into rock-solid cohesive masses of particles.**

**In some cases, the particles may be bound together by some natural cementing material; with or without any pressure. These are also sedimentary rocks. In seas and oceans, a large number of sea-organisms live and die. Their hard parts also accumulate at the sea-bed and are gradually transformed into rocks. Since the particles in such rocks are derived from organisms, they are called organically formed sedimentary rocks in comparison to the mechanically formed sedimentary rocks of the first type. The third category of sedimentary rocks is formed due to chemical processes like evaporation and precipitation. Naturally, they are designated as chemically formed sedimentary rocks. The sedimentary rocks are very widespread, area wise, on the surface of the earth. Depth-wise, however, they form only a small proportion of the crust. Common sedimentary rocks are Sandstones, Quartzite, Limestone's, Dolomites, and Shale's.**

**(III) Metamorphic Rocks:**

**This rock type is originally either igneous rocks or sedimentary rocks which have undergone some change in their structure, shape or composition. The change might have been due to an increase in temperature or pressure or both. Sometimes, the change is due to some chemically active fluids that act on the pre-existing rocks.**

**The nature of change in the rock will depend on;**

- **(i) The nature of existing rock.**
- **(ii) The type of factors operating on the rock (temperature, pressure, fluids).**
- **(iii) The intensity of factors.**
- **(iv) The duration of action.**

**Very interesting new rock type may be formed from pre-existing igneous or sedimentary rocks depending upon the above conditions.**

1. **Thus limestone, a sedimentary rock, may change to a variety of Marbles.**
2. **Similarly, sandstone, again a sedimentary rock, may change into a very hard Quartzite.**
3. **Granite (igneous rock) changes to Gneiss and shale, a sedimentary rock, into the so well known metamorphic rock Slate.**
4. **Another very important fundamental fact about these metamorphic changes in rocks is that they all take place essentially in a solid state.**
5. **The original rocks are heated and compressed but seldom melted. (Once melted and recrystallized, they form igneous and not metamorphic rocks).**
6. **Distinction between Igneous, Sedimentary and Metamorphic rocks.**

 

**1- Formation**

**Igneous rock is formed through the cooling and solidification of magma or lava. Igneous rock may form with or without crystallization, either below the surface as intrusive (plutonic) rocks or on the surface as extrusive (volcanic) rocks.**

**Sedimentary Rocks formed by the deposition of material at the Earth's surface and within bodies of water. Sedimentation is the collective name for processes that cause mineral and/or organic particles (detritus) to settle and accumulate or minerals to precipitate from a solution.**

**2- Abundance on the earth crust**

**The sedimentary rock cover of the continents of the Earth's crust is extensive, but the total contribution of sedimentary rocks is estimated to be only 8% of the total volume of the crust.**

**Igneous and metamorphic rocks make up 90–95% of the top 16 km of the Earth's crust by volume.**

**3-Mineralogical contents**

**Felsic Igneous rock, highest content of silicon, with predominance of quartz, alkali feldspar and/or feldspathoids the felsic minerals; these rocks (e.g., granite, rhyolite) are usually light colored, and have low density. While mafic Igneous rock, lesser content of silicon relative to felsic rocks, with predominance of mafic minerals pyroxenes, olivines and calcic plagioclase; these rocks (example, basalt, gabbro) are usually dark colored, and have a higher density than felsic rocks, ultramafic rock, lowest content of silicon, with more than 90% of mafic minerals.**



**Most sedimentary rocks contain either quartz (especially Siliciclastic rocks) or calcite (especially carbonate rocks). In contrast with igneous and metamorphic rocks, a sedimentary rock usually contains very few different major minerals. However, the origin of the minerals in a sedimentary rock is often more complex than those in an igneous rock. Minerals in a sedimentary rock can have formed by precipitation during sedimentation or digenesis. In the second case, the mineral precipitate can have grown over an older generation of cement.**

**4- fossils**

**Among the three major types of rock, fossils are most commonly found in sedimentary rock. Unlike most igneous and metamorphic rocks, sedimentary rocks form at temperatures and pressures that do not destroy fossil remnants. Often these fossils may only be visible when studied under a microscope (microfossils).**

**5- Structures**

**Structures in sedimentary rocks can be divided into 'primary' structures (formed during deposition) and 'secondary' structures (formed after deposition). Structures are always large-scale features that can easily be studied in the field.**

**The structures of igneous rocks are large scale features, which are dependent on several factors like: (a) Composition of magma. (b) Viscosity of magma. (c) Temperature and pressure at which cooling and consolidation takes place. (d) Presence of gases and other volatiles.**

 

**6- Classification**

**Igneous rocks are classified according to mode of occurrence, texture, mineralogy, chemical composition, and the geometry of the igneous body.**

**Based on the processes responsible for their formation, sedimentary rocks can be subdivided into four groups: Clastic sedimentary rocks, biochemical (or biogenic) sedimentary rocks, chemical sedimentary rocks and a fourth category for "other" sedimentary rocks formed by impacts, volcanism, and other minor processes.**

**7- Importance**

**Sedimentary rocks host large deposits of SEDEX ore deposits of lead-zinc-silver, large deposits of copper, deposits of gold, tungsten, Uranium, and many other precious minerals, gemstones and industrial minerals including heavy mineral sands ore deposits. Petroleum geology relies on the capacity of sedimentary rocks to generate deposits of petroleum oils. Coal and oil shale are found in sedimentary rocks. A large proportion of the world's uranium energy resources are hosted within sedimentary successions. Sedimentary rocks contain a large proportion of the Earth's groundwater aquifers. Our understanding of the extent of these aquifers and how much water can be withdrawn from them depends critically on our knowledge of the rocks that hold them (the reservoir).**

**Many types of igneous rocks are used as building stone, facing stone and decorative material, such as that used for tabletops, cutting boards, and carved figures. Pumice is used as an abrasive material in hand soaps, emery boards, etc.**



**Description, occurrence, engineering properties, distribution and uses**

**1. Granit: It's a common type of felsic intrusive igneous rock that is granular and phaneritic in texture. Granites can be predominantly white, pink, or gray in color, depending on their mineralogy.**

**Occurrence: Granite containing rock is widely distributed throughout the continental crust. Much of it was intruded during the Precambrian age; it is the most abundant basement rock that underlies the relatively thin sedimentary veneer of the continents. Outcrops of granite tend to form rounded massifs. Granites sometimes occur in circular depressions surrounded by a range of hills, formed by the metamorphic aureole or hornfels. Granite often occurs as relatively small, less than 100 km2 stock masses (stocks) and in batholiths that are often associated with orogenic mountain ranges. Small dikes of granitic composition called aplites are often associated with the margins of granitic intrusions. In some locations, very coarse-grained pegmatite masses occur with granite.**

**Uses: Engineers have traditionally used polished granite surface plates to establish a plane of reference, since they are relatively impervious and inflexible. Sandblasted concrete with a heavy aggregate content has an appearance similar to rough granite, and is often used as a substitute when use of real granite is impractical.**

**2. Diabase (/ˈdaɪ.əbeɪs/) or dolerite or microgabbrois: A mafic, holocrystalline, sub volcanic rock equivalent to volcanic basalt or plutonic gabbro. Diabase dikes and sills are typically shallow intrusive bodies and often exhibit fine grained to aphanites chilled margins which may contain tachylite (dark mafic glass).**

 

Diabase is the preferred name in North America, yet dolerite is the preferred name in most of the rest of the world, where sometimes the name dia base is applied to altered dolerites and basalts. Many petrologists prefer the name micro gabbro to avoid this confusion.

Uses: These are used as construction stone, or polished and used as architectural stone. Diorite was used as a structural stone by the Inca and Mayan civilizations of South America and by many ancient civilizations in the Middle East.

3. Sandstone is a Clastic sedimentary rock composed mainly of sand-sized (0.0625 to 2 mm) mineral particles or rock fragments. Most sandstone is composed of quartz or feldspar (both silicates) because they are the most resistant minerals to weathering processes at the Earth's surface, as seen in Bowen's reaction series. Like un-cemented sand, sandstone may be any color due to impurities within the minerals, but the most common colors are tan, brown, yellow, red, grey, pink, white, and black. Since sandstone beds often form highly visible cliffs and other topographic features, certain colors of sandstone have been strongly identified with certain regions. Rock formations that are primarily composed of sandstone usually allow the percolation of water and other fluids and are porous enough to store large quantities, making them valuable aquifers and petroleum reservoirs. Fine-grained aquifers, such as sandstones, are better able to filter out pollutants from the surface than are rocks with cracks and crevices, such as limestone or other rocks fractured by seismic activity.

Uses: Sandstone was a popular building material from ancient times. It is relatively soft, making it easy to carve. It has been widely used around the world in constructing temples, homes, and other buildings. It has also been used for artistic purposes to create ornamental fountains and statues.

Origin: Sandstones are Clastic in origin (as opposed to either organic, like chalk and coal, or chemical, like gypsum and jasper). They are formed from cemented grains that may either be fragments of a pre-existing rock or be mono-minerallic crystals. The cements binding these grains together are typically calcite, clays, and silica. Grain sizes in sands are defined (in geology) within the range of 0.0625 mm to 2 mm (0.0025–0.08 inches). Clays and sediments with smaller grain sizes not visible with the naked eye, including siltstones and shales, are typically called argillaceous sediments; rocks with larger grain sizes, including breccias and conglomerates, are termed rudaceous sediments.

4. Limestone is a sedimentary rock, composed mainly of skeletal fragments of marine organisms such as coral, and molluscs. Its major materials are the minerals calcite and aragonite, which are different crystal forms of calcium carbonate ($CaCO_3$).About 10% of sedimentary rocks are limestone's. The solubility of limestone in water and weak acid solutions leads to karst landscapes, in which water erodes the limestone over thousands to millions of years. Most cave systems are through limestone bedrock.Limestone has numerous uses: as a building material, an essential component of concrete (Portland cement), as aggregate for the base of roads, as white pigment or filler in products such as toothpaste or paints, as a chemical feedstock for the production of lime, as a soil conditioner, or as a popular decorative addition to rock gardens.

Uses: Limestone is very common in architecture, especially in Europe and North America. Many landmarks across the world, including the Great Pyramid and its associated complex in Giza, Egypt, were made of limestone. So many buildings in Kingston, Ontario, Canada were, and continue to be, constructed from it that

 

it is nicknamed the 'Limestone City'. On the island of Malta, a variety of limestone called Globigerina limestone was, for a long time, the only building material available, and is still very frequently used on all types of buildings and sculptures. Limestone is readily available and relatively easy to cut into blocks or more elaborate carving. Ancient American sculptors valued limestone because it was easy to work and good for fine detail. Going back to the Late Pre-classic period (by 200–100 BCE), the Maya civilization (Ancient Mexico) created refined sculpture using limestone because of these excellent carving properties.

5. Laterite: Soil layer that is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidizing and leaching conditions. It forms in tropical and subtropical regions where the climate is humid. Lateritic soils may contain clay minerals; but they tend to be silica-poor, for silica is leached out by waters passing through the soil. Typical laterite is porous and claylike. It contains the iron oxide minerals goethite, $HFeO_2$; lepidocrocite, FeO (OH); and hematite, Fe2O3. It also contains titanium oxides and hydrated oxides of aluminum, the most common and abundant of which is gibbsite, Al2O3•3H2O. The aluminum-rich representative of laterite is bauxite.

6. Gneiss: Gneiss is a foliated metamorphic rock made up of granular mineral grains. It contains a lot of feldspar minerals and bands of quartz and sometimes mica. It normally has a banded appearance and is sort of laminated. It appears similar to granite.

7. Marble: Marble is among the non-foliated metamorphic rocks produced from the metamorphism of dolostone or limestone. It takes high polish and is often used for sculpture and as building material. Marble is mainly composed of calcium carbonate.



Uses: Slabs and blocks of marble are used for stair treads, floor tiles, facing stone, cemetery stones, window sills, ashlars, sculptures, benches, paving stones and many other uses some marble is heated in a kiln to drive off the carbon dioxide that is contained within the calcite.

8. Schist: Schist is a foliated metamorphic rock that is well developed and contains substantial amounts of mica. Because of the high concentrations of mica, schist can readily split into thin layers. Geologists say it represents the intermediate metamorphic grade between gneiss and Phyllite. Sometimes schist might contain high amounts of chlorite.

9. Slate: Slate is a low-grade and fine-grained metamorphic rock that can be separated into thin pieces. It is a type of foliated metamorphic rock that is produced by the metamorphism of shale. Slates are predominantly realigned clay minerals.

10. Quartzite: Quartzite is a hard metamorphic rock consisting essentially of interlocking quartz crystals. It is a non-foliated metamorphic rock formed during the metamorphism of sandstone.

Uses: Because of its hardness and angular shape, crushed quartzite is often used as railway ballast. Quartzite is a decorative stone and may be used to cover walls, as roofing tiles, as flooring, and stair steps. Its use for countertops in kitchens is expanding rapidly. It is harder and more resistant to stains than granite. Crushed quartzite is sometimes used in road construction. High purity quartzite is used to produce ferrosilicon, industrial silica sand, silicon and silicon carbide. During the Paleolithic quartzite was used, in addition to flint, quartz, and other lithic raw materials, for making stone tools.

**Brief geological history of India**

**Theories related to the origin of the Earth have put forth various intuitions such as one that said the earth originated from the sun. It was earlier a hot gaseous mass which on cooling first turned into a liquid and then a solid. This was the gaseous hypothesis put**

**A more popular theory was proposed by Laplace known as the Nebular hypothesis. This proposed that the Earth was formed from the solidification of a ring thrown away by a cooling and rotating Sun. This ring was one of the several ones that condensed to form the various planets.**

**Another theory known as the Tidal hypothesis put forth by Jenny and Jeffrey's assumes the presence of two nebulas instead of one as assumed by Laplace. According to this theory a large nebula wandering in space came close to a smaller nebula. As the larger nebula wandered away from the smaller one, the matter rising in the form of a tidal wave from the smaller nebula was pulled towards it. This matter was pulled so much away from the smaller nebula that it could not go back to the parent nebula.**

**However it could not follow the larger nebula also and as the larger nebula pulled away, the matter was detached from the smaller nebula. On cooling the matter condensed to form the planets and they started revolving around the sun. This hypothesis is more closer to reality due to the structure of our solar systems with smallest planets located far away from the sun and larger ones located at intermediate positions.**

**200 million years ago India was a part of Gondwana. Indian peninsular block is a fusion of three blocks Aravali, Singbhum and Dharwad.**



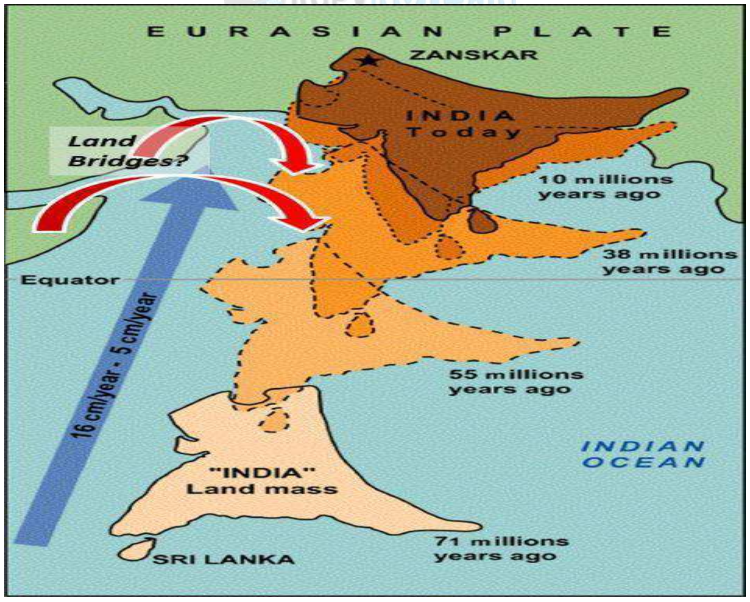


**Fig 7: Gondwanaland and India**

**Indian plate tectonics**

**The Aravallis, Satpudas, Eastern Ghats, Vindhyans and Bijjawals are remnants of it. Rift valleys which are formed are Godavari, Mahanadi, and Damodar towards the Bay of Bengal. The Narmada and son rift valleys are towards the Arabian Sea. Rift valley and peninsular blocks**

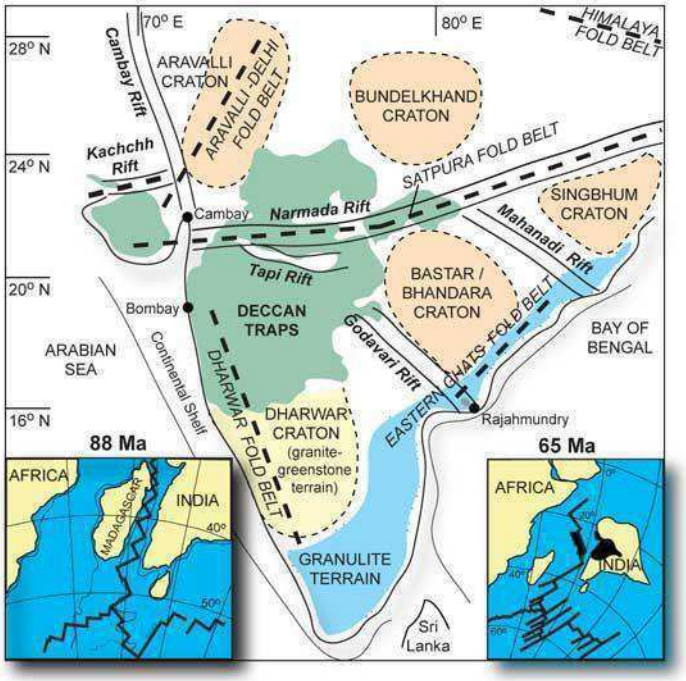


**Fig 8: Rift valleys and Peninsular block**

**The Indian plate separated from Gondwana and then Madagascar. It moved over Reunion Island and due to hotspot volcanism developed the Deccan lava plateau. The collision between Indian plate and Eurasian plate led to formation of Himalayas.**

**Archaen Formation (Pre Cambrian)**

**Geologically, the subcontinent of India was a part of the Gondwanaland (the Southern Continent). The geological history of India is described in the below sections:**

**Archaen Formation (Pre Cambrian)**

**87% of the Earth's history is of this period (4.6 billion years ago till 570 million years ago). Archean means "oldest rocks of the Earth's crust". This period saw the development of the Earth's atmosphere, the first photosynthesis, first chemosynthesis and formation of the life supporting atmosphere. Throughout the world the rocks of this period are called as "Fundamental Geinesses" OR "Basement complex". They are devoid of any form of life or sediment and form the core of all great fold mountain ranges of the world. The In the Peninsular region, the archaean rocks are known to be of three well-defined types:**

**The Bengal Gneiss**

**The Bengal gneiss is highly foliated. It occurs mostly in the Eastern Ghats. The Bundelkhand Gneiss it is coarse grained in structure and found mostly in southern India. It occurs mostly in Bundelkhand (UP), Baghelkhand (MP), Maharashtra, and Rajasthan.**

**The Nilgiri Gneiss**

**It is criss crossed and has quartz veins and is mostly like granite.**

**Dharwar System**

This geologic time extends from 2500 million years ago to 1800 million years ago. These are the first metamorphosed sedimentary rock systems in Indian geological time scale.

The Dharwar rocks are highly metaliferous. They are rich in iron ore, manganese, lead, zinc, gold, silver, dolomite, mica, copper, tungsten, nickel, precious stones and building materials. Some of the important series of the Dharwar System are:

Champion Series:-

Its gold mines are one of the deepest in the world.

Champaner Series:-

It is an outlier of the Aravallis system in the vicinity of Vadodra. An attractive green variety of marble is obtained from this series

Chlipi Series:-

It occupies parts of Balaghat, Jabalpur and Chhindwara districts of Madhya Pradesh. Close pet Series, Iron-Ore Series, Khondolite Series, Rialo Series, Sakoli Series, and Sausar Series.

The Cuddapah System (The Purana Group)

The Cuddapah system is made of shales, slates, limestone and quartzite. The rocks are generally without fossils. The Cuddapah formations, named after the district of Cuddapah in Andhra Pradesh, are sedimentary-metamorphic formations.



At places the Cuddapah formations are 6000 m in thickness. The enormous thickness of these rocks indicates the Sinking of beds of the basin with growing sedimentation.

The metallic contents in the ores of Cuddapah rocks are, however, low and at places uneconomical for extraction.

The Vindhyans System

The Vindhyans System derives its name from the Vindhyans Mountain. This mountain forms a dividing line between the Ganga Plain and the Deccan Plateau.

It has enormous sedimentary deposits and at places their depth is more than 4000m. In some tracts, the Vindhyans rocks are buried under Deccan lava. The Great Boundary Fault (GBF) separates the Vindhyans System from the Aravallis for a distance of about eight hundred km

The Vindhyans system is well known for red-sandstone, sandstone, building material and raw materials for cement, chemical industries.

The historical buildings of Qutab Minar, Humayun's Tomb, Fatehpur Sikri, Agra Fort, Red Fort, Jama-Masjid, Birla Mandir, the Buddhist Stupa of Sanchi, etc. have been constructed from the red-sandstone obtained from the Vindhyans Ranges.

The Palaeozoic Group (Cambrian To Carboniferous Period)

 

This is known as the Dravidian Era in the Indian Geological Time Scale.

The Palaeozoic Era extends from 570 million years ago to 24.5 million years ago. It marks the beginning of life on the Earth's surface.

The formations of this period are almost absent in the Peninsular India except near Umaria in Rewa.

It was during this period that the Pangaea was broken and the Tethys Sea came into existence.

The Mesozoic Era (The Gondwana System)

The term is used for a period of geologic time in which the presence of fossil invertebrates dominated the rocks.

In the Indian Geological Time Scale, these periods extend from the Upper Carboniferous up to the beginning of the Cenozoic Era or the Aryan Era.

Most of the good quality coal deposits (bituminous and anthracite) of India are found in Gondwana formations.

The Gondwana System of rocks provides over 95% of the coal of India.

India's best and largest coal deposits are found in the Gondwana System mainly in the Damodar Valley of West Bengal, Jharkhand, the Mahanadi valley of Odisha and Chhattisgarh, the Godavari valley of Andhra Pradesh and the Satpura basin of Madhya Pradesh.



Aryan period (Beginning of the Upper Carboniferous Period )

The Upper continent of Gondwanaland developed fissures and its broken parts started drifting away from each other. The Subcontinent of India drifted towards north and north-east to collide with the Asian land mass

The Tertiary mountain building gave birth to Himalayas.

The Subcontinent of India assumed its present shape.

Evolution and spread of man in different parts of the world. The development and expansion of the Arabian Sea and the Bay of Bengal.

The Cretaceous System (The Deccan Trap)

This period is marked by the transgression of the sea (Coromandal coast, Narmada valley) and outpouring of huge quantity of lava (basalt) so as to form the Deccan Trap.

During this period, enormous quantity of basaltic lava was poured out to the surface assuming a great thickness of over 3000 m. The Lava Plateau (the Deccan Trap) is the result of that lava eruption.

The lava plateau of India (Deccan Trap) has a maximum thickness of about 3000 m along the coast of Mumbai from where it decreases towards south and east.

**The Tertiary System (The Cenozoic Era)**

**Cenozoic means recent life. The beginning of the Tertiary Period is about 65 million years ago. Fossils in these rocks include many types, closely related to modern forms, including mammals, plants and invertebrates.**

**During this Period, as India collided with Tibet, the sediments which had been accumulating in the Tethys basin had begun to rise by a slow rise of ocean bottom. The upheaval of the Himalayas altered the old topography of the subcontinent.**

**There is enough evidence to prove that the Himalayas are still rising.**

**The Quaternary Period (The Pleistocene and Recent Formations)**

**The Northern Plains of India came into existence during the Pleistocene Period**

**The Pleistocene period is marked by Ice Age and glaciations on a large scale in the Northern Hemisphere. The moraine deposits and the karewa formations of Kashmir Valley are of the Pleistocene period. The river terraces of the Narmada, Tapi, Godavari, Krishna, and Kaveri, etc. are also of the Pleistocene Period.**

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