ENVIRONMENTAL GEOSCIENCES

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Lecture-44

Fossils and Prehistoric Life: An Overview of Major Fossil Groups and Gondwana Flora

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. We are discussing the module eight. Today we will discuss the lecture five of module eight. In this lecture five, we will discuss the introduction of fossils, Brachiopoda, Pelsaipoda, Gastropods, Cephalopods, Corals, Trilobites, Echinodes and Gondwana flora. In this lecture, the important concepts will be covered like Introduction to Palaeontology, Conditions favourable for preservation, Mode of Preservation, Important Uses of Fossils, Brachiopoda, Pelecypoda, Gastropods, Cephalopods, Corals, Trilobites, Echinoids and Gondwana flora.

First of all we will discuss what is Palaeontology. It is well known that amongst the different types of rocks constituting the earth crust, those of sedimentary origin often contain bodies which resemble to a very great extent the organisms which live upon the surface of the globe. Such remains of plants and animals preserved by nature within the rocks are known as fossils. Therefore, Fossils are remains of organisms, both plants and animals, which has been preserved within the sedimentary rock beds under favorable geological conditions. The organisms preserved as fossils must be geologically ancient.

The study of fossil is in itself a vast undertaking and constitutes the subject matter of an important branch of geology which is known as palaeontology. All the plants and animals of terrestrial or aquatic environment have been or are likely to be preserved as fossils. Now, what are the conditions favorable for preservation of fossils? We know that millions of animals and plants have lived, died and were destroyed without leaving a trace. But it has been observed that two factors are favourable for the preservation of organisms as fossils:

So the first factor is the possession of hard parts such as shells and bones, and second factor is that quick burials of the remains by different processes to prevent destruction by

scavengers and decay. Any animal or plant satisfying the above two conditions can be preserved as fossils under normal conditions. The condition in which fossils occur depends on their original composition and on the material in which they are embedded. Sometimes the soft parts remain unaltered in fossilisation; sometimes only hard parts remains unaltered and sometimes the hard part are also altered.

Now, fossilisation may occur in several ways: The first condition is unaltered soft parts that is the actual remains. In such cases, the whole of the organism including its soft part is preserved as such. It may be possible due to entombment of the animals under a thick cover of ice. Sometimes insects become entangled in soft and sticky secretions of trees.

On exposure, this hardens and changes to amber and with it the entangled are perfectly preserved. Second condition is unaltred hard parts: Shells and internal skeletons are frequently preserved for long periods of the time. Many of the best of these are fossils of marine animals that fell into the soft sediment on the sea floor when they died. Of the land dwellers, those that live near swamps, lakes or sea are most likely to be preserved.

Corals, mollusca and protozoans are examples of this category. Third condition is altered hard parts. In this case, the actual remains of an organism are likely to undergo changes through time. These changes are fostered by the slowly circulating groundwaters that carry elements in solution. It includes few processes:

The first is the petrifaction. It is a slow process which involves removal in solution of each individual molecule of the material constituting the hard parts and simultaneous precipitation of an equivalent quantity of the replacing mineral. The molecule by molecule replacement of one substance by another helps in preserving even the most delicate organic structure, as such. In this manner, the bones, shells or plant tissues are transformed into calcite, silica or pyrite and the processes are known as calcification, silicification, and pyritization respectively. Next is the carbonisation.

In this process, the organism is decomposed and it loses nitrogen, oxygen and other volatile constituents. As a result, it is enriched in carbon and is said to have been carbonised. Coal seams are the carbonised remains of the plants. Next is the moulds and casts. Sometimes the hard parts preserved within the accumulating sediments, may be totally removed in solution.

As a result, hollows are left within the rock beds, which are called moulds. Porous and permeable rock beds are able to have seepage of subsurface water, which can remove in

solution the shells of organisms, thus facilitate the formation of moulds. When the moulds are filled up subsequently with mineral matter, it is known as cast. Thus casts only retain the external form of the hard parts. Next is the impression.

Plants and animals devoid of hard parts, do sometimes leave a record of their existence in the form of imprints within the rock beds. Impression of leaves, feathers or extinct birds are the example of this category. Then the tracks and trails. While moving on soft and damp ground, the footprints or trail of the animals are entombed in the mud and when this ground hardens into a rock the footprints present are preserved. Even though they do not form any part of the animal yet are regarded as fossils. Now mode of preservation.

Several distinct types of fossils have so far been recognized based on their mode of preservation. While some of them are no better than mere imprints, there are at least a few cases in which the organism, including its soft parts, has been preserved intact. Most of the fossils occurring in nature have, however been formed due to the preservation of the only hard parts and their subsequent conversion into mineral matter. Some of the important modes of preservation of remains of plants and animals can be explained as, first, the whole of the organism including its soft parts preserved as such. Second, only the skeleton of the organism preserved practically intact.

Third, petrifaction of the hard parts only. Fourth, carbonisation of the hard parts and, sometimes, of the soft parts as well. Fifth, only a mould of hard parts left within the rocks. Sixth, imprints marked upon the rocks. Very rarely and only under ideal conditions, the whole body of a plant or animal may be found to have been preserved.

In such cases, even the most delicate and soft parts are left unaltered. The term petrification implies conversion of the remains of plants and animals into rock. In all petrified remains of plants and animals, it has been observed that the internal organic structure as well as the external form of the preserved bodies necessarily remain unaffected. At the same time, the bodies lose their original constituents which are replaced by silica, calcium carbonate, oxides or sulphides of iron, etc. Thus, in petrified remains of trunks of trees, the internal structure of plants as also their outer appearance remain unchanged, although the organic constituents are found to have been replaced by silica.

Now important usage of fossils. The study of fossils is of absorbing interest to students since the remains of organisms preserved within the rocks furnish the scientists with many useful information. Some of the important uses of fossils can be discussed here.

The first is in the study of evolution and migration of plants and animals through ages. Next is in establishing the geological age of rock beds and their correct order of succession in any area.

Then in correlating rock beds of one area with those of the another. Then in visualizing the paleogeography, that is ancient geography of any country. Next is in ascertaining the paleoclimate, that is ancient climate of any region. Next is in investigations leading to the discovery of new deposits of coal and petroleum. Then we will discuss about the index fossils in view of the fact that plants and animals pass through different stages of evolution.

During the geological past, it is evident that the sedimentary rock beds formed during different geological period should contain remains of those organisms only which were developed characteristically at the time of formation of the respective beds. From a study of fossils, therefore it is possible to establish the geological age of the rock beds occurring in any region. Some of the ancient plants and animals existed only for a very short period and during the tenure of their life were widely distributed on the surface of the globe. The remains of such organisms constitute what are known as index fossils and these are very useful in establishing the correct age of the rock beds in which they occur. Most of the fossils offer at least an approximate idea of the age of the rock beds in which they exist.

Thus, the remains of trilobites, which is a kind of invertebrate animal, occur characteristically in the rocks of Lower Paleozoic Age, while the remains of ammonites, another kind of invertebrate animal, are abundant in rocks of Mesozoic Age. Amongst the vertebrates, remains of reptiles occur abundantly in the rocks of Mesozoic age, while the rocks belonging to the Tertiary period are dominated by the remains of mammals. After determining successfully the geological age of the individual rock beds, their order of succession in any area can be stabilized without any further difficulty. Fossils are of great use in the correlation of the rock beds occurring in different localities. Organisms living in shallow water differ from others occurring at great depths.

It is thus apparent that marine, lacustrine, estuarine, terrestrial or any other type of sediment can be identified readily from a study of its fossils content. The nature of distribution of land and sea during the earlier part of the geological history of the earth or, in other words, the palaeogeography of any country can, therefore, be visualised with the help of the fossils contained in the rock-beds. In so far as the paleogeography of India is

concerned, study of fossils has established conclusively that the region where the Himalayan mountains now lie was occupied by a shallow sea during the pre-tertiaryperiod. On the basis of evidences offered by fossils, it has further been concluded that the eastern coast of Indian Peninsula had more or less the same configuration in the geologic past and was modified only locally during a few periods of marine transgression. It is well known that the nature of plants and animals in any country is dependent largely on the prevalent climatic conditions.

The remains of organisms which occur within sediments are therefore likely to offer some indication of the climate which prevailed at the time of their existence. From the study of evidences offered by rocks and fossils, it has been possible to infer that India and some other countries experienced a few phases of advent of a very cold climate during the geologic past. The fact that the Indian peninsula passed through a rather hot and dry climate during the early Mesozoic period. In different countries all over the world, important deposits of coal are commonly associated with the sedimentary beds deposited in lake basins during the upper Paleozoic period. In addition, a few less important deposits of coal occur within the rocks of Tertiary Age.

Petroleum and natural gas, on the other hand, commonly occur in association with marine sediments of tertiary age. While in search of a new deposit of coal or petroleum, a geologist must therefore determine the age of the rocks forming the country, and this can be achieved only with the help of the fossils contained in them. Moreover, coal and petroleum occur in association with lacustrine and marine sediments, respectively, And the study of fossils is in itself sufficient to establish the nature of the environment which prevailed at the time of formation of the country rocks. It is thus apparent that the study of fossils constitutes an integral part of any investigation leading to the discovery of new deposits of coal and petroleum.

So this is all about the fossils, its preservation and uses. Now we will discuss the different fossils one by one. First is the Brachiopoda. The animals belonging to the phylum Brachiopoda are catalyzed by the presence of a cell or test composed of two valves which are of unequal nature to each other. You can see the diagram also.

The ventral valve is larger than the dorsal valve and bears a circular opening. This one is the ventral valve which is larger and the dorsal valve which is smaller. The ventral valve is also known as pedicle valve. The dorsal valve is also known as brachial valve. The important features of brachiopoda shell are the first is the shell is equilateral and unequal.

Second is both the valves are produced into what is called beck or umbo. They mark the posterior end of the shell The umbo of the ventral valve is more prominent than that of the dorsal valve. The surface of the shell is nearly smooth, but at irregular intervals, it is marked by concentric growth lines which are parallel to shell margin. Through the foramen of the ventral valve, a muscular stalk which extrudes gets attached to the substratum.

This is known as pedicle. Directly beneath the back, the internal area of either valve may be interrupted by a triangular open space termed as delthyrium in the ventral valve and nototherium in the dorsal valve. The covering of the delthyrium is called a deltidium and that of nototherium is called a chilidium. The two valves of a brachiopoda are joined together by means of hinge and in some cases they are held together by muscles. Sometimes the teeth are supported by plates known as dental plate.

Inside the shell of the brachiopods, the following organs are found to be present; besides those which have been described earlier, wise. crura, median septum, septilial plates, spondylium, brachidium which consists of a pair of simply curved on doubly bent arms known as loops and the skeletal connections joining both the arms are known as jugum. On the external surface of the valves, sometimes ridges are found which extend radically from the back. Sometimes there occurs radial ribs, spines, knobs or tubercles which ornament the external surface of the shell. The ridges on the shell of the brachiopods are known as plications or costae and shells possessing them are described as plicate or costate. The shell form of the brachiopods may be elongated, ellipsoidal, sub-circular, alate, concavo-convex, biconvex, plano-convex, resupinate etc.

When the shells are found to possess minute holes, they known as, they are known as punctate shells. The shells are mainly calcareous in composition, and are formed of three layers, Inner calcareous layer, Middle layer of flattened prisms of calcite, and Outer part consists of chitinous material. The junction between the valves is known as commissure. The initially formed cells are called protegulum. In old age, the cells become thick and their margins truncated.

The ornamentation tends to disappear. Geological range, they are confined to mostly marine environment and are found to be present in rocks of marine nature. In lower Cambrian, Lingulella, kutorgina, obolella etc. Some other species with different geological range, Productus, Carboniferous to Permian, Orthis, Ordovician to Silurian,

Spirifer, Silurian to Permian. Atrypa, Ordovician to Devonian, Rhynchonella, Jurassic, Terebratula, Eocene to Pliocene, Terebratella, Triassic to present day.

The brachiopods reached the acme of their development during the Ordovician, Silurian and Devonian periods. Within the rocks of Tertiary age, brachiopods occur only occasionally. Now we will discuss the next fossil that is the Pelecypoda, Lamellibranchs. Pelecypods belong to the phylum Mollusca. The lamellibranchs are oysters.

All are marine some live on land and others in water and many on both. The body is bilateral, symmetrical. The shell consists of two valves which are equivalves and are placed on the right and left side of the body. In the diagram also you can see. The valves are in equilateral that is a perpendicular line drawn from the umbo to the opposite margin does not divide the valve into two equal halves.

Both the valves are hinged together at their dorsal margin by means of teeth, sockets and with ligaments. Each valve has an umbo and near it the hinge line which marks the dorsal region of the animal. The region where the valves separate most widely when the shell opens is the ventral region. The margin near the mouth is anterior. Sometimes there is infront of the umbones an oval-shaped depressed area of smaller size appears like a groove, shared by both the valves. It is known as 'lunule'.

Behind the umbones there is similar somewhat larger area known as 'escutcheon'. The hinge is formed by projections known as teeth alternating with depressions of groups known as sockets. The teeth and sockets in a hinge line alternate with each other in the two halves and teeth of one valve fits into the sockets of the other valve. Depending on the nature, shape and size of the teeth and sockets, a few distinct types of dentition have so far been recognized. The surface of the shell may be smooth or may be ornamented with radiating ribs, concentric ribs and striations, tubercles and spines, etc.

The margin of the valves may be smooth or crenulated. The interior valves are marked with the impressions of the muscles. In a living animal, there are elastic ligaments which perform the function of a divaricators in case of lamellibranchs. Usually, two adductor impressions occur in the interior of each valve. One of these two is placed anteriorly and the other posteriorly.

Both the impressions are connected together by means of a linear depressions called as pallial line which runs more or less parallel to the ventral margin of the valve. Sometimes there is a notch on the pallial line known as the pallial sinus. When two adductors

impressions are found to occur the shell is called a 'Dimyarian shell'. When there is only one impression, the shell is said to be a monomyarian shell. When both the impressions are of equal size, it is known as isomyarian shell.

When the ligament lies below the hinge line, it is called the resilium. A process for lodging the resilium is called chondrophore. Where the ligament extends on either side of the umbo, it is called amphidetic ligament. But when it is entirely behind the umbo, it is called opisthodetic ligament. Byssus is a thread-like process derived from the interior portion of the foot and used to attach the shell to substratum.

The first formed embryonic shell is called the 'Prodissoconch'. The shape of the pelecypod shells may be alate, rostrate, mytiliform, quadrate, produced etc. The geological history The earliest records of the fossil lamellibranchs have been traced from the rocks of lower Ordovician Age and they reached their culmination during the Quaternary Age. Other parasite ports with the geological range, you see Arca, Jurassic to Recent. Nucula, Silurian to Recent. Pecten, Carboniferous to Recent. Ostrea, Triassic to Recent. Gryphaen, Jurassic to Eocene. Inoceramous, Jurassic to Cretaceous. Trigonia, Jurassic to Recent. Cardita, Eocene to Recent. Mya, Tertiary to Recent.

Next important fossil is Gastropods. Molluscs belonging to the class Gastropods have representatives that inhabit dry land as well as those that live in fresh and salt waters. In most gastropods, a shell is secreted by the mantle. The gastropod shells are made up of only one valve and therefore are considered univalve. The simplest form of the cell is an elliptical cone, widely open at the base, but in the great majority of cases, the cell is cone-coiled into a helicoid spiral, open at one end and tapering to a point at the other.

Each one of the individual coil is described as a whorl. All the whorls except the last together form the spire of the shell. Sometimes the inner faces of the whorls are united into a solid pillar extending from the base to the apex and is known as columella. But in other cases, instead of being united centrally into a columella, the whorls are coiled around a central cavity, which extends from the base to the apex of the shell. The cavity opens at the base of the shell called umbilicus.

The last body whorls ends in an opening which is known as the aperture of the cell. The form of the aperture varies considerably in the different genera. The margin of the aperture is called the 'peristome' consisting of an inner lip lying towards the inner side of the last whorl and an outer lip There is a horney or calcareous plate that closes the

aperture of the cell when the animal withdraws into it. That calcareous plate is known as operculum.

The angle subtended at the apex between two straight lines drawn tangentially to the last two holes on two opposite sides of the cell is known as apical or pleural or spiral angle. The coiled shells of the gastropods exhibit a variety of forms depending on the factors like arrangement of the whorls in one plane or a helicoid, then spiral angle and size of the last hole and whether it conceals the earlier. Next important fossil is the cephalopoda. The cephalopods are entirely marine and are highly organized than other mollusks. Nearly all cephalopods retain perfect bilateral symmetry and are covered by exoskeleton.

Based on morphology, the class cephalopod has been divided into three major subclasses, that is, nautiloidea, then ammonoidea, and then dibranchia. The nautiloidea and ammonoidea classes are sometimes grouped as tetrabranchia. The first is the nautiloidea. These cephalopods are characterized by a tubular cell that tapers to a point at one end and it opens at the other end. In most of the spirally coiled forms, all the whorls lie on one plane and they may or may not lie in visual contact.

Sometimes they coil so tightly that each hole nearly conceals the whorl within leaving only a very deep and narrow umbilicus on each side. Each complete turn of the spiral is termed as a whorl. Rarely has been found at the apex a more or less globular structure, the protoconch, which covers the embryo in the cephalopod. The interior of the shell is divided into several chambers, utilizing several transverse partitions known as septa. The resulting chambers are known as camerae.

The septa are generally perforated and are convex towards the protoconch. At the opposite end of the protoconch, a considerable portion of the cavity of the shell is undivided, forming the body chamber, which is larger in size and is situated towards the aperture of the cell. This chamber is occupied by the animal and the rest are gas chambers. Through the central perforation of the septa ran a living cord, the siphuncle, through all the gas chambers back to the protoconch. The calcareous tube is made up of two parts known as septal neck and the connecting ring.

While the animal grows, the new shell is continually being added to the aperture or mouth of the body chamber. While at intervals, the animals move forward in its body chamber and secrete behind it a new septum. The line of junction of the edge of the septum with the external shell is termed the suture line. or septal suture. Next is the

ammonoidea. In the ammonoid cephalopods, the shell is generally coiled into a plain spiral and as a rule, the suture lines show a complicated pattern.

The body of the typical ammonoids varies from less than than half a whorl to over two whorls in length. The lateral region seen within the encircling last whorl is called the umbilicus. The spiral line of a contact between each whorl and the next is the umbilical suture. The portions of the suture lines which are convex towards the mouth of the cell are called saddles and the intervening concave portions are known as lobes. The saddle and lobes are nearly always similar on either side.

There are three types of suture lines in different types of hominoids. The first is the goniatitic suture line. These suture lines have pointed lobes and rounded saddles. Second is a, Second is the ceratitic suture line. These suture lines are formed to consist of serrated lobes and rounded saddles. Example is ceratite.

And third is the ammonitic suture line. These are complicated types of suture lines and are formed to consist of serrated lobes and serrated saddles. And the example is the ammonites. Based on the form of the suture line, then ammonites have been classified as goniatite, serratite and ammonites. The surface of the ammonoid shell may be smooth or may be ornamented with striations, ribs, tubercles, or spines. In some ammonoids, at the internal margin of the shell, there is a ridge known as keel.

In straight, conical shell of a ammonoid cephaloid is known as bactriticone. The following features distinguish an ammonoid from a nautiloid That is, the protoconch is usually barrel-shaped. There is complexities in the form of suture line. The siphuncle migrates to one of the margins in the great majority to the periphery. The hypnomic sinus is present in most paleozoic in general, but afterwards disappears and may be replaced by roastrum.

Sometimes there is a presence of lappets. Now third is the dibranchia. These are also called as coleoidea. They either possess internal shells or have no shells at all. The well-known extinct genus Belemnites, which belongs to the subclass Dibranchia, possess an internal shell consisting of three parts:The phragmocone, Pro-ostracum and The guard or rostrum.

Of these three parts, the guard is readily preserved as a fossil, the guard is conical, more or less cigar-shaped solid. The geological history of the cephalopods. The cephalopods are exclusively marine animals. Among the cephalopods, the nautiloids are said to be the

most ancient forms, even found to occur in the lower Cambrian East. They attained their maximum during the Permian and Carboniferous.

After the Paleozoic times, they suddenly decreased in importance. The ammonoids were found in the Devonian times and the goniatites were the dominant forms. During the Triassic period, ceratites and ammonites were abundant during the Cretaceous period. But the dibranchia first appeared in the Mesozoic times and the representative form was and the representative form was the belemnite. Other fossils related to the cephalopods, Goniatites, the geological range is Carboniferous; Ceratites: Triassic; Phyloceras: Jurassic to Cretaceous ; Lytoceras: Jurassic to Cretaceous; Acanthoceras: Jurassic to Cretaceous; Peltoceras: Jurassic to Cretaceous; Schloenbachia: Jurassic to Cretaceous; Baculites: Upper Cretaceous; Turrilites: Upper Cretaceous; Belemnites: Upper Cretaceous.

Next is the corals. Corals are benthonic colenterata which commonly occur in the form of colonies. Corals belong to the class Anthozoa. The polyps are individual animals. The entire skeleton of a simple coral is described as corallum.

In the case of compound corals, the skeleton of each member of a colony is known as corallite. The body of a coral has more or less cylindrical or conical shape. The base of the cone is generally depressed and is known as the calyx. According to the nature and internal structure of the corals, there are five subclasses that is Zoantharia, Alcyonaria, Rugosa, Tabulata and Schizocorallia. Corals are sometimes extremely abundant and build up extensive reefs and banks which are known as bioherms.

Corals are known to have existed even during the early Paleozoic Era. Geological age-wise, you see Calceola: Middle devonian. Zaphrentis: Devonian to Carboniferous. Favosites: Carboniferous. Halysites: Paleozoic era Next fossil is the Trilobites. These animals belong to the subclass Trilobita, class Crustacea, or Phylum Arthropoda. In all trilobites, the body is divided into three longitudinal lobes as well as three transverse portions.

This trilobation of the body gives the name trilobite. In trilobites, the body is flattened from above downwards and is divided into three parts utilizing two furrows which extend from the anterior to the posterior extremities. The body of the trilobite is made up of three distinct parts that is the head, the thorax and the pigidium. Of the three lobes of trilobite, the lateral lobes are known as the pleural lobes, while the intervening central lobe is described as axial lobes. Each part of the body is segmented.

The dorsal surface of the body is protected by a strong calcareous exoskeleton known as dorsal shield. The part of the dorsal shield, that covers the head of the animal, is known as the cephalic shield or head shield or cephalon. Geological range of this type of fossils. Trilobites occur as fossils only with the rocks of Paleozoic ages. They suddenly appeared in the lower Cambrian and reached their maximum in Cambrian and Ordovician periods.

In Silurian they were still abundant but become less important in Devonian. With the end of Palaeozoic era they become extinct. Geological age-wise, you see the different species of trilobite, Olenellus: Low-Cambrian; Paradoxides: Mid-cambrian; Olenus: Up-cambrian; Calymene: Ordovician; Illaenus: Ordovician; Phacops: Silurian; Redlichia: Mid-Cambrian; Phillipsia: Carboniferous to Permian; Asaphus: Ordovician. Because of their wide geographical distribution and rather a limited range in geological time, trilobites are regarded as excellent index fossil. Next is the echinoids.

The echinoderms, belonging to the class Echinoidea, are also known as sea-urchins. They always possess a compact and rigid, more or less a globular, heart shaped or discoidal body covered with spines. The shell or test is covered by a layer of ectoderm and consists of numerous calcareous plates which constitute the exoskeleton. Some of the echinoids show radial symmetry and others show bilateral symmetry. The lower side of the test is known as the oral or ventral side.

The upper side of the test is generally convex in shape and is termed as dorsal or aboral side. The mouth is situated on the oral side, either in the central position or in front of the center. The anus is either at the summit of the test or posterior to it. The mouth of the animal is encircled by a number of plates which collectively constitute what is known as peristome. In the same way, the anus is surrounded by a number of plates which together constitute what is called a periproct.

Sometimes both the mouth and anus are placed at opposite posts of a test and in some other echinoids, the anus is always and the mouth is often excentric. Accordingly, the echinoids are divided into two orders like regularia and irregularia. The test or cell of an echinoids is made up of three parts, that is, apical system or apical disc, corona, and third is the peristome. The geological range, it has been recorded that the echinoids made their first appearance during the Paleozoic time, particularly in Ordovician with regular echinoids. Some other species are Cidaris. Jurassic to present day, Hemicidaris. Cretaceous; Echinus. Pliocene to present day; Pygaster, Pygaster. Triassic to cretaceous;

Echinolampas. Lower eocene to present day; Holaster. Tertiary to present day; Micraster. Triassic to tertiary; Hemiaster. Cretaceous to present day.

Next is the Gondwana flora. The Gondwana time for India ranges from Upper-Carboniferous to Lower-Cretaceous. The Gymnosperm and Pteridophytes were the predominant flora in the Gondwana time. These were vascular plants. Plumsted of Australia from the study of Carboniferous and Permian flora suggested that there were three distinct types of flora during this time.

They were Lepidodendron flora, which is oldest, Rhacopteris flora, Lower Carboniferous, Glossopteris flora, youngest. In India and other southern landmasses of southern hemisphere, the Gondwana rocks are characterized by the presence of Glossopteris flora. This flora is said to have been evolved from those plants which could survive the permocarboniferous glaciation According to D. N. Wadia, there is a correspondence of the three types of Gondwana flora with that of the three sudivisions of Gondwanaland.According to him, Glossopteris flora: Low. Gondwana of Lower-Triassic age. Dicroidium: Mid-Gondwana Lower-Jurassic age. Ptilophyllum flora: Up. Gondwana Lower-Cretaceous age Glossopteris flora. They inculde plant-fossils like vertebraria, schizoneura, buridia etc The glossopteris, vartebraria are all pteridosperms.

They are leaf genera. Glossopteris is represented by fronds. That is a leaf which bears fructification. which is called as a frond. Here midrib is well marked and there is a reticulate venation. Leaf is truncated at the base.

Gangamopteris is similar to glossopteris but is without any mid-rib. Vertebraria is thought to be the stem of glossoptris. Then dicroidium, midgondwana, The common flora is thinnfeldia. It occurs abundantly in the northern continents and dicroidium in southern continents.

Thinnfeldia flora indicates lower Jurassic age and dicroidium flora indicates lower Triassic age. Ptilophyllum flora. It is dominated by the cycads and the filicales Here the pteridosperms are of no importance while the conifers appear to have attained some amount of development. The gymnosperms and the cycates of the Mesogec era forming the Rajmal flora disappeared gradually and during the Cretaceous flowering plants began to appear on the surface of the globe.

Now conclusion of the module 8 that is India rich geological history have been discussed. We have seen that India has a diverse range of stratigraphic units from the Archean

Cretons to the Cenozoic deposits each representing different geological periods and tectonic events. These units provide crucial insights into the Earth's evolutionary history. Next, we have learned that the fossils as geological markers, fossils found in various Indian stratigraphic units, help in biostratigraphic correlation, adding in the identification of different geological ages and paleoenvironmental reconstructions. Then we have learned about the modes of fossil preservation.

Fossils are preserved through various processes such as pre-mineralization, carbonization, recrystallization and mold and cast formation. Each mode retains different degrees of details affecting their scientific value. And next we have learned economic and scientific importance. We have seen that the fossils play a vital role in petroleum exploration, coal identification and mineral prospecting. They also contribute to understanding paleoclimate changes and evolutionary biology.

And lastly, we have discussed the need for conservation and research. Indian fossil sites must be preserved for scientific study and education. Continued research and advancements in paleontology can further enhance our knowledge of India’s geological past and its implications for future resource management. The references from these test books The lectures have been prepared.

Thank you very much to all.