ENVIRONMENTAL GEOSCIENCES

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Lecture-40

Indian Stratigraphy and Archaean Group

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. Now we will discuss the module eight, that is various stratigraphic units of India and fossils, its mode of preservation and usage. So we will start today the lecture one, Indian Stratigraphy. The important concepts of this lecture will be covered like Introduction to Stratigraphy, Principle of Stratigraphy, Chronological Subdivisions, Indian Stratigraphy and Archaean Group. Ever since the development of the solid crust of the earth, the energetic natural agencies like air, water, ice and life have been working diligently and molding the surface of the globe to an appreciable extent.

The surface of the earth has therefore been subjected to repeated cycle of changes. So this is very important. Repeated cycle of changes involving weathering and erosion of the highlands and consequent deposition of the resulting sediments within depressions of the appropriate size and location. During the whole length of the history of the earth, the natural agencies appear to have caused a gradual deposition of enormous quantities of sediments, giving rise to extensive deposits of sedimentary rocks, which constitute nearly three-fourths of the surface of the existing continents. These huge masses of sediments are sometimes very thick - so much so that they constitute the entire height of some of the lofty mountains as well.

It is however apparent that these thick column of sediments were not built up all at once. It has taken time for its composition. In each column the constituent layers were gradually formed during one period or the other of the earth history. The bottom most bed of any column was deposited first and the overlying ones were built up in succession following a definite chronological order. The subject of stratigraphy or historical geology aims at the proper understanding of the correct chronological order in which rock beds were actually formed on the surface of the globe.

From a study of the fossils contained within the rock beds, a stratigrapher may be in a position to comment on the nature of organisms that happened to exist during the geologic past. A study of the lithological characteristics of the rock beds may lead him further to infer the climate and environment under which the beds were deposited. So, in brief, a stratographer ventures to read the detailed geological history of the earth from a study of the rock beds which lie here and there on the surface of the globe. Now, with this background, we will start the principle of stratigraphy. Stratigraphy, as I have told you, it is a historical geology.

It is the study of the stratified rocks that aims at unravelling the geological history of the earth. These studies are based on the following few principles. First principle is the law of superposition. This law states that an overlying bed or lamina is younger than that underlying bed under normal conditions. Second principle is doctrine of uniformitarianism.

The study of present is a key to the study of past. And third is the geological events of the past are mostly indicated by the rock units from their lithological and palaeontological characteristics. So these are the principles through which we can know more about the geological history of the earth. Rock units are distinguished from each other by their color, by their texture, composition and fossil contents etc., The smallest rock unit is called as bed.

A number of individual beds when joined together they form a formation. A number of formations joined together constitute a group. Then finally an assemblage of groups constitute a super group. We have seen that the smallest unit is the bed. Then bed-bed joined and made formation.

Number of formations joined together to make a group. And the number of groups joined together makes a supergroup. Now fourth is the facies. Fourth principle is the facies. When a particular system, with reference to the geographical time scale, in a country is represented by different kinds of rocks in its different locality, it is said to possess different facies.

For example, the Cretaceous system of India is represented by geosynclinal deposits in the type area of Spiti, marine transgressional deposits in the Coromondal coastal areas, fluviatile and estuarine deposits in Madhya Pradesh and igneous rocks of volcanic nature in the extra-peninsular region. Next principle is the homotaxis. The similarity of position of strata or system in a sequence, not implying similarity of age, is generally termed as

homotaxis. When geological formations are equivalent in age but situated wide apart in different districts, countries or continents, they are said to be homotaxial. Next is the rock units formed at different places exactly at the same time are generally known as synchronous beds.

In these beds, same species of fossils are found. Next is the contemporaneous. Those rock units which are formed near about the same time, marked by the presence of the same genera of fossils, they are said to be contemporaneous. And geological time. Era is the largest grouping of periods of geological time and each era covers many millions of years.

The geological periods are formed of epochs. And the epochs are in turn subdivided into ages. The geologic unit is well correlated with the stratigraphic units. For example, a geological period represents a system. Rock units formed during an epoch is known as series.

And the rock units which are formed during an age are known as stages. So here we are knowing about the system, then the series and then the stages. Then the stratigraphic correlation. It is of three types. Lithostratigraphic, biostratigraphic and chronostratigraphic correlation.

Now we will understand one by one. The lithostratigraphic correlations are made of the following methods. By continuity of contacts between units, lithologic similarity, stratigraphic position of a unit in a sequence of strata, well logs, structural characteristics. The biostratigraphic correlation involves the following, that is, the stages of evolution of fauna, guide fossils, faunal resemblance, position in biostratigraphic sequence. Chronostratigraphic correlations are made with the help of methods like quantitative chronology, in which radioactive dating method is involved, eustatic changes in sea level, and the paleontology.

So these methods are helping in the different types of correlation. Now, chronological subdivisions. To establish the correct chronological order of the rock beds in any country, two important characteristics are essential. First, the lithological characteristics of the individual beds and second, the paleontological characteristics of the individual beds. These beds should be studied carefully.

The smallest lithological unit is made up of one bed only. A number of individual beds of more or less similar characteristics together constitute what is known as formation, as I have discussed in the previous slide also. Each formation should have its own

distinguishing features, both lithological and paleontological. The lithological characters are, however, not of paramount importance, since smaller rock beds may occur in the formation of widely different geological ages. Fossiliferous sedimentary formations, on the other hand, are necessarily characterized by the presence of distinct and definite sets of fossils in them.

Each formation must therefore differ from the overlying and the underlying ones, at least in so far as their palaeontological characters are concerned. In addition to the lithological and palaeontological studies, a stratigrapher should always have in his mind the principle of order of superposition of rock beds. This is very important, order of superposition of the rock beds. In any sedimentary sequence, the rock beds exist in order from the bottom to the top of the column. The bottom most bed is naturally the oldest one while the top most is the youngest.

The intervening beds are, for obvious reasons, arranged in order of their relative ages. In stratigraphy, the principle of order of superposition is looked upon as an axiom. It may not, however, be correct in few cases only where the sedimentary columns have undergone very severe diastrophism. In any column of sediments, the constituent formations may be comfortable with one another. In such cases, each formation should pass imperceptibly into the overlying and underlying ones.

In many cases, however, two successive formations are found to be related unconformably. After establishing the chronological order of the rock beds in any area, a stratigrapher should try to correlate the rock beds of one area with those of another. First of all, the correct order of superposition of beds is established in each locality. The beds of one area can then be correlated with those of another from a thorough study and a comparison of their lithological, then structural and palaeontological characteristics. Geological formations are said to be homotaxial when they are equivalent in age but are situated wide apart in different district countries or continents.

The homotaxial relation between different formations can be understood only when they have been correlated beyond doubt. While correlating sedimentary columns of adjoining areas, geologists have often observed that the same formation sometimes exhibits diverse lithological characters in the adjacent regions. Thus, a formation may be made up of limestones in one area while in another it may be composed of cell beds. Such diverse types of deposits are described commonly as different facies of the same formation. In

addition to such facies based on the lithological characters, there also exist several faunal facies which are based only on the palaentological characteristics of the rock beds.

Thus, there are marine facies containing remains of marine organisms, freshwater facies, etc., which differ radically from one another from the point of view of their fossil content. With the discovery of the radioactive elements and the phenomena relating to their spontaneous disintegration, a more accurate technique has been placed at the disposal of the stratigraphers. From a study of the spontaneous disintegration undergone by the constituent radioactive elements, the exact ages of the different formations and their correct chronological sequence can, under favorable conditions, be worked out more satisfactorily. Geologists have attempted in various ways to estimate the age of the layers of the rocks and the geological history of the earth. The entire lifespan of the earth is called the geologic time.

Since the geological formation of Western Europe was studied first by the pioneers in the field of stratigraphy, the chronological sequence of the geological formations which they had established there is accepted universally as the standard. As the geological time scale has developed and this scale within its limits gives us a pretty idea of the sequence of events in the history of the Earth. The geological time scale has been broadly divided into six major divisions known as eras. There are evidences that each era was ended by widespread geological disturbances called revolutions. Each revolution includes changes like upheaval of the earth's surface in certain regions and subsidence and the ultimate submergence of some regions beneath the seas.

In each of the eras, there were lesser events which were less widespread and less far-reaching in their effects than the revolution making the separation of eras. These events are called disturbances in the earth crust. They also mark definite breaks in the geological and fossil records and divide an era into periods, epochs, etc. Now we will know about the stratigraphic units. A thorough study of the geological formations has led the stratigraphers to classify them into six major groups like the Precambrian or Algonkian or Proterozoic.

An Archaean or azoic, then primary or palaeozoic, secondary or mesozoic, tertiary or cainozoic, and quaternary or recent. So, these are the six major groups of the stratigraphic units. The geological time scale with the evolution of life may be represented in a tabular form as below. In this table, we can see Archaean, which is azoic era, is having the

complete absence of living organisms. Then Precambrian is coming in which life is still not present.

Then here we are seeing the Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian periods in the Pelaeozoic era. Then Triassic, Jurassic, Cretaceous periods in the Mesozoic era. Then Tertiary within the tertiary period, we can see it is belonging from the cainozoic era and in it the epochs are palaeocene, Eocene, Oligocene, Miocene, Pliocene and then comes the pleistocene and recent period of the Quaternary era. So of these, Archaean group is the most ancient one and the Quaternary is the youngest. For convenience of study, each major group has been classified into several systems.

Here we can see the different types of the evolutionary change also. This Cambrian age of trilobites, then first forests come in the Devonian, then amphibians dominate in the Carboniferous, Permians, we are getting the dwindling of ancient plants and likewise the different evolutionary changes we are seeing, age of the man is coming in the recent period. Now we will discuss about the Indian stratigraphy. For the study of the various stratigraphic units of India, references are usually made to the tripartite physiographic divisions of India. We are having the three important layers, that is the top one is the extra-peninsular region, bottom most is the peninsular region, and in between peninsula and extra-peninsular, we are having the Indo-gangetic alluvial plains.

So, the peninsula is made up primarily of very ancient rocks of Archaean and Pre-Cambrian age, as well as Deccan traps and the sedimentary formations of the post-Cambrian age. The Indo-gangetic Alluvial Plains, which is the second physiographic unit of India, belongs to the Quaternary era. The extra peninsula made up primarily of sedimentary formations ranging in age from Cambrian to Pleistocene. Now we will discuss the first group that is the Archaean group. The term Archaean refers commonly to the very ancient gneisses, schists and granites which constitute the platform on which all sedimentary formations lie.

Such rocks are commonly described in India as the Dharwarian rocks. The rocks belonging to the Archaean group are characteristically devoid of fossils. In fact, there was no life in existence on the surface of the globe when the Archaean rocks were in formation. Now, the age of the Archaean group. From radiometric age dating, the age of the Archaean rocks are estimated to be above twenty five hundred million years.

Occurrences in India, the Archaeans and the associated Dharwarian rocks occur in abundance. They cover two-thirds of the peninsula. The areas occupied by the most

ancient gneiss and schist are referred to as shields as they have remained virtually undisturbed and unaffected by changes. Our peninsular India is a shield area. Now the distribution of Archaean rocks in India in peninsula

Archaean rocks are present in South India, Madhya Pradesh, Rajasthan, Shinghbhum, and Eastern ghat ranges. In extra-peninsula, the archaean gneisses and schists etc are exposed along the entire length of Himalayas from Kashmir to Burma, which is known as the crystalline axis. Important features of Archaean rocks are that they are all azoic, that is, there was no existence of life at the time of their formation. And their subsequent subsidence and deposition of sediments from neighbouring land gave rise to Eparchaean unconformity. The important rock types of Archaeans are Gneisses, Schists, Charnokites, Khondalites, Gondite, Kodurite, Pyroxenite, Hyperite, quartzite, phyllite, marble, anorthosite, etc. The structure of the Archaean rocks are very complex and therefore known as basement complex or gneissic complex.

Now the description of the Archaean and Darwarian rocks in India is generally first in South India, then Madhya Pradesh, Rajasthan and Singhbhum Gangpur. In South India, the country is made up of mainly of schists, gneisses and granites. The Dharwarian system of South India was first studied and named by R. Bruce Foote towards the end of the nineteenth century. In nineteen hundred fifteen, W.F. Smith described the sequence of Archaean Rocks of Mysore area. In Madhya Pradesh, the Archaean rocks are developed characteristically in Bastar, Rajpur, Sambalpur, Bilaspur, Balaghat, Nagpur, Bhandara, Chhindwara, Jabalpur and adjacent areas.

In Rajasthan, the Archaean Rocks and other Precambrian Rocks have formed together the conspicuous Aravalli ranges which traverse the country along a northeast-southwest direction. Singhbhum Gangpur, the Archaean Rocks of Northern Singhbhum are separated from those of Southern Singhbhum by a distinct thrust zone which is about hundred miles in length and runs approximately east to west. Now first we will discuss the Archaeans of South India. The Archaean rocks of South India are best developed in Mysore and Southern Bombay where they are commonly described as Dharwar system. The country is made up of mainly schists, gneisses and granites, country means the rock, bedrock.

The schistose rocks have been folded isoclinally and exhibit a steep dip towards east. Only the synclinal parts of the isoclinal folds could survive through ages and these exist here and there within the vast stretch of gneissose country rocks. The regional strike of

the Dharwarian rocks is North-North-West, South-South-East. In Southern Mysore, however, this strike changes over to North-South and even to North-East-South-West. The Schistoge rocks are isoclinally folded and the dip is towards East.

The regional strike is North-North-West, South-South-East. The Dharwarian system of South India was first studied and named by R. Bruce Foote, towards the end of nineteenth century. In nineteen hundred fifteen, W.F. Smith described the sequence of Archaean rocks of Mysore area. In his opinion, the Dharwar system may be regarded as the oldest formation in Mysore and the rocks constituting this system are ortho-schists and ortho-gneisses, which have been produced due to the metamorphism of pre-existing igneous-country rocks. Classification of South India you can see by W.F. Smith, Younger, Chloritic Division, Chlorite and Mica schist, Quartzite, Marble, Conglomerates etc are present there, whereas in older Hornblendic Division, Hornblende schist, calcgranulite, Hematite, quartzite, etc. are present.

Chloritic division is made up of hornblende schists, calcgranulite, hematite, quartzites, and some magnetite, while the upper dharwar, that is the chloritic division, consists of chlorite and mica schists, quartzites, marbles, conglomerates, banded ferruginous quartzites, staurolite-schists, etc. The views of Smeeth on the mode of origin and classification of dharwarian rocks were, however, modified in course of time. On the basis of the studies and observation of B. Rama Rao, it has now been established beyond doubt that a significant portion of the dharwarian rocks has been produced due to the metamorphism of pre-existing sediments, which are felsite and porphyry dykes, closepet granite, then the Charnockites, then the Norite dykes, then the Hornblendic dykes, Peninsular gneiss, Champion gneiss, etc. Distinct sedimentary structures like ripple marks and current bedding do occur in a number of rocks of the Dharwar system. After a detailed study of the Dharwarian-associated rocks, B. Rama Rao worked out the Archaean succession of Mysore in the year nineteen forty.

The exposures of Dharwarian rocks in Mysore area were classified by Rama Rao into five distinct zones or groups of which the easternmost is known as the Kolar schist-belt. It is about forty miles in length with a maximum width of about four miles. It is made up of hornblendic rocks, presumably of igneous origin, and is traversed by quartz veins or reefs containing gold. The east central zone is composed of granulites, gneisses, and schists of varying composition, while the central zone is made up of limestones, ferruginous rocks, and metamorphosed igneous rocks. The west-central zone consists of

banded-manganiferous and ferruginous rocks, and the westernmost zone is made up mainly of hornblende-schists, within which thin bands of haematite-quartzite occur.

In addition to the different types of Dharwarian rocks, mentioned earlier, some special rock types known as sakarsanite series, bandite series, kodamite series, etc. occur in few localities. The rocks known as the Champion Gneiss are younger in age than the Dharwar system. They are best developed along the eastern border of the Kolar schist-belt and are characterized by the presence of opalascent quartz grains with grayish tint. The rocks known as the Peninsular Gneiss are widely distributed in Mysore as well as in other parts of South India. They are younger in age than the Champion gneiss and are made up of gneisses, granites, granodiorites of varying composition, texture and structure.

The Charnockites or the Charnockite series named after the job Charnock are younger in age than the peninsular gneiss. They range in composition from acid to ultra-basic and are characterized by the presence of a variety of pyrogene known as hyposthene. Blueish gray grains of quartz occur commonly within the acid rocks belonging to the Charnokite series. The Charnokite possess characteristics of both igneous and metamorphic rocks. They exhibit intrusive relationship with the country rocks and are at the same time distinctly foliated.

The Chanokites are widely distributed in the peninsula and form a portion of the Nilgiris and the Eastern and Western Ghat ranges. According to T.H. Holland, R.A. Howie and W.A. Groves, the Charnockites are of igneous origin, while P.K. Ghosh, H. Ramberg, F.J. Turner and B. Rama Rao suggested that such rocks might have been formed due to metamorphism of pre-existing sedimentary rocks under deep-seated conditions. The closepet granites, which is also known as Bellari gneiss, are younger in age than the Charnockites. They exhibit intrusive relationship with the pre-existing country rocks. These granites are coarse-grained with porphyritic texture and are occasionally foliated. They are considered equivalent in age to the Bundelkhand gneiss of Rajasthan.

From the foregoing discussion, it is apparent that in South India, the Dharwarian rocks, made up mainly of metamorphosed sediments, are older in age than the gneiss and granites of the igneous origin. The Dharwarian rocks of South India exhibit the lowest grade of metamorphism, while those of the Southern Mysore are of the highest grade. In general, the whole country underwent regional metamorphism of epimeso-and hypo-grades. The general sequence of Archaean rocks which is valid for the whole of South India is placed in the table below. You can see the bottom one is the dharwar system

which consists of lower dharwar, middle dharwar and upper dharwar made up of different types of sedimentary metamorphic rocks, then the champion gneiss, then the peninsula gneiss, Charnockite series, and then at the top we are seeing the Bellary gneiss, that is the closepet granite.

Now we will discuss the Archaeans of Madhya Pradesh. In Madhya Pradesh, the Archaean rocks develop characteristically in Bastar, Raipur, Sambalpur, Bilaspur, Balaghat, Nagpur, Bhandara, Chhindwara, Jabalpur and adjacent areas. The areas where archaean rocks are developed characteristically in Madhya Pradesh will be discussed now. In Bastar and adjacent areas, The Archaean rocks are made up of schists and gneisses of both igneous and sedimentary origin and these, in their turn, have been intruded by igneous bodies of acid and basic composition. The charnockitic rocks of Bastar have, according to P. K. Ghosh, been formed due to the permeation of the invading granitic intrusives into the calc-schists.

The Archaean rocks of this area exhibit a regional strike running N.W. - S. E. and are said to be more or less similar to the Dharwarian rocks of South India. In Raipur, mica-schists, quartzites phyllites and banded-haematite-quartzites of Dharwarian age and the associated masses of granites and gneisses occupy a vast country. In Sambalpur, in this area, hornblende and biotite-schists and gneisses, quartz-schists, quartzites, etc., and the igneous bodies of granitic composition together constitute the Archaean succession. The schistose and gneissose rocks of this area are similar to those of the Dharwar system. Towards the northern and western part of Sambalpur area, the schistose and gneissose rocks and the associated conglomerates, phyllites, slates etc., together form the Sonakhan beds. They are intruded by coarse-grained prophyritic granites.

In Bilaspur and Balaghat area, the Archaean rocks were studied by W. King, R. C. Burton and L. L. Fermor. The oldest rocks of the area occur in the northern Balaghat and have been described as the Sonawani series. The Sonawani series is made up of manganese-ores, calc-gneisses, crystalline limestones, quartzites and schists. The Sonawani series is overlain by the Chilpi Ghat series, which is made up of traprocks, slaty and quartzose rocks, grits, conglomerates, greenstones, etc. The stratigraphic relation between the Chilpi Ghat series and the Sonawani series is, however, rather uncertain.

Either of them contains manganese-bearing horizons and may be equivalent to the Sausar series of Nagpur and Chhindwara. In Bilaspur - Balaghat area, the Sonawani and the

Chilpi Ghat series are associated with granitic rocks belonging to three distinct groups, of which the oldest one is made up of schistose biotite-gneisses. Of the other two groups, one is made up of porphyritic and augen gneisses while the other is composed of granites known as Amla granite. The Archaean succession of Bilaspur-Balaghat area can be shown as below. You can see the table.

The bottom most is the Chilpi Ghat series, Sonawani series. And then the biotite gneiss, porphyritic and augen gneisses and granite-amla granite. Both Sonawani and Chilpighat series contain a manganese ore horizon and in part represent the Sausar series of Nagpur-Chindwara. Next one is the Nagpur-Chindwara. In Nagpur-Chindwara area, the highly metamorphosed Archaean rocks are known as Sausar series.

The chilpi rocks continue westwards and bifurcate, the southern strip occupying parts of Nagpur and Bhandara districts are known as Sakoli series. The northern strip goes into Nagpur-Chhindwara, known as Sausar series. The rocks belonging to this series are granulites, marbles, schists, etc., which exhibit a regional dip towards south or South. South. East. The whole sequence of rock-beds has been subjected to folding, faulting and contain very useful and important deposits of manganese-ore. According to Fermor, the Chilpi Ghat series may be equivalent to or younger in age than the upper part of the Sausar series.

No geological formation older in age than the Sausar series has as yet been reported from any part of Nagpur, Chhindwara and Bhandara areas. The Sausar series has been subdivided into nine stages, of which five are well-developed in Nagpur area and four in Chhindwara area. The metamorphic rocks, belonging to the Sausar series, are associated with three sets of younger ortho-gneisses of granitic and granodioritic composition. Next is the Nagpur-Bhandara area. This is the Sakoli series.

The rocks belonging to this series are less metamorphosed than the sausar series. The rocks generally dip to the north-northwest and are made up of quartzites, dolomites, amphibolites, schists, phyllites, conglomerates etc. In Jabalpur, the Archaean rocks are made up of marbles, mica-schists, phyllites, conglomerates and ferruginous and manga-niferous ore-bodies. In addition, there are some basic igneous rocks which have been altered to a very great extent. The Archaean sequence of Jabalpur area is considered equivalent to the Dharwarian succession of South India.

Now, Archaeans of Rajasthan. The Archaean stratigraphy of Rajasthan has been studied and worked out by C. A. Hacket, C. S. Middlemiss, La Touche, A. M. Heron and many

others. In this part of India, the Archaean and the other Pre-Cambrian rocks have together formed the conspicuous Aravalli ranges, which traverse the country along a north-east-south-west direction. Archaean rocks of Rajasthan occur in the Aravalli range region in the form of a part of the very large synclinorium and in the plains lying to the east of Aravalli ranges and separated from the Vindhyan country further east by a great fault, known as 'Great Boundary Fault', which strikes approximately northeast-southwest, in the desert regions of Jodhpur and Marwar to the west. The Archaean and the pre-Cambrian rocks of Rajasthan have formed a great synclinorium, which constitutes the core of the Aravalli ranges.

In addition, there exists a very prominent fault which strikes approximately northeast-southwest and is known as the Great Boundary Fault. The Archaean succession in Rajasthan have been shown just below. You can see it consists of Banded gneissic Complex, Aravalli System, Raialo Series and Delhi System. The banded gneissic complex occurs in Mewar and Ajmer and is made up of alternate bands or layers of granite and biotite gneiss. It occasionally occurs in the form of pure granite gneiss or simple granite.

According to Heron, the banded gneissic complex is separated from the overlying Aravally system by a distinct unconformity. In the opinion of H. Crookshank and K. L. Bhola, however, the Banded Gneissic Complex is a very granitised, is a more granitised form of the rocks belonging to the Aravalli system. In that case, the Aravalli system should be older than the banded gneissic complex. The Bundelkhand gneiss occurs in Chitor and adjacent areas and from the point of view of mineral composition and texture, is a pure granite. The western part of the exposure, however, exhibits distinct foliations.

According to Heron, the Bundelkhand gneiss is older than the Aravalli system and is separated from the latter by a distinct unconformity. The rocks are, however, very much similar to the closepet granite, the Bellary gneiss and the other granitic rocks of post-Dharwar age. The Bundelkhand gneiss may possibly represent the granitic portion of the banded gneissic complex and both of them may be younger or older than the Aravalli system. The exact relation between the Banded Gneissic Complex and the Bundelkhand Gneiss could not be established directly since the boundary between these two groups of rocks is always concealed by the overlying Aravalli system. The rocks belonging to the Aravalli system are made up of mainly argillaceous materials and constitute a very thick column of sediments.

The bottommost beds of this system are quartzites, grits, etc., which are overlain by shales, phyllites, and the associated volcanic rocks or basic composition. These rocks are followed upwards by the ferruginous and argillaceous limestones and, at places, by quartzites. Reddish quartzites and sandstones, known as Ranthambhor quartzites, form the uppermost part of the Aravalli system. As a result of metamorphism, the Aravalli rocks of the main synclinorium are distinctly foliated and have been rise to mica-schists. In Rajasthan, the Aravalli system is overlain unconformably by the Raialo series, which is made up of mainly of limestones. The whole succession, which is about two thousand feet thick, generally commences with a basal conglomerate or grid bed.

This is overlaid by the limestones, while the topmost portion of this sequence is the main synclionrium. It is made up of garnetiferous biotite schists. In Alwar area, Raialo quartzites form the base and are overlain by the Raialo limestones. In Chittor area, the Raialo series is represented by the Bhagwanpura limestone and, in Mewar and Ajmer, the Raialo series is made up of the basal grits and the overlying Raialo marbles and mica-schists. The celebrated Mekrana marbles of Rajasthan belong to the Raialo series.

Above the Raialo series, there exists a distinct unconformity which, in Rajasthan constitutes the Eparchaean interval. The Raialos may be considered equivalent to the Upper-Dharwars of South India and are overlain unconformably by the Delhi system of Pre-Cambrian age. The Archaean stratigraphy of Rajasthan differs from that of South India, Madhya Pradesh and Singhbhum-Gangpur. In these three areas, the Dharwarian and the equivalent rocks form the older group while the ortho-gneisses are younger in age. In Rajasthan, on the other hand, the Banded Gneissic Complex and the Bundelkhand gneiss so-called ortho-gneisses are overlain by the younger Aravalli rocks of Dharwarian age.

Now the Archaeans of the Singhbhum Gangpur. In southern Bihar, presently in Jharkhand, the Archaean rocks of Singhbhum have been studied by V. Ball, H. C. Jones, J. A. Dunn and A. K. Dey. The Archaean rocks of northern Singhbhum are separated from those of the southern Singhbhum by a distinct thrust-zone, which is about hundred miles in length and runs approximately east-west. Towards the south of this thrust zone, there occurs a group of unmetamorphosed rocks like conglomerate, sandstone, limestone, sail, banded hematite, quartzites, which are underlain by the older metamorphic rocks. The unmetamorphosed group of rocks is associated with basic lava.

The whole sequence of rocks, in southern Singhbhum, is traversed by younger igneous bodies of ultrabasic, basic and acidic composition. The Archaean rocks of Southern Singhbhum were first studied by H. C. Jones, who worked out the succession as below you are seeing. Older metamorphics at the bottom, then the iron rocks, then the ultra-basic rocks, then the Singhbhum granites, then the newer dolerites, and then the newer dolerites. According to J.A. Dunn, however, the older metamorphic rocks constitute a portion of the iron ore series and the conglomerate, sandstone, limestone and some of the shales of the above sequence are younger in age than the iron ore series. To this group of rocks younger than the iron ore series, Dunn assigned a new name which is known as Kolhan series.

According to J. A. Dunn, however, the older metamorphic rocks constitute a portion of the Iron-ore series and the conglomerates, sandstones, limestones and some of the shales, of the above sequence, are younger in age than the Iron-ore series. To this group of rocks, younger than the Iron-ore series, Dunn assigned a new name Kolhan series. The Kolhan series of Southern Singum is said to be of the post-Archaean age. In northern Singhbhum, on the other hand, the Archaean rocks are made up of mica-schists, chlorite-schists, hornblende-schists, which contain minerals like garnet, staurolite and kyanite and, therefore, indicate a high grade of metamorphism. These metamorphic rocks appear to have been folded in the form of a geanticline and are intercalated with lava-flows and associated products of vulcanicity of more or less equivalent age. The lava-flows of northern Singhbhum are known as the Dalma traps.

The southern limb of the geanticline is considered to have been overfolded and thrusted. Unlike southern Singhbhum, the banded-haematite-quartzites are of little importance in northern Singhbhum. The metamorphic rocks of northern Singhbhum are known as the Iron-ore series and associated with younger granites and gneisses, known as the Chotanagpur granite-gneiss. Towards the eastern part of Singhbhum and in Mayurbhanj, conglomerates, sand-stones, quartzites, phyllites, and lava-flows together from the Dhanjori stage, which lies uncomfortably above the Iron-ore series. In eastern Singhbhum and Mayurbhanj, important deposits of iron-ore occur in Gorumahisani, Badampahar, and Sulaipat. The thrust-zone of Singhbhum, has been mineralised to a very great extent. Important deposits of apatite and magnetite and of copper ore are found to occur in this thrust belt. The Iron-ore series of Singhbhum area is considered equivalent to the Dharwarian rocks of South India. The Archaean succession in Singhbhum as a whole can be shown below.

In Gangpur area lying toward the west of the Singhbhum , the Archaean rocks have been folded in the form of geanticline or an anticlinorium. . The axial zone of this anticlinorium is made up of the oldest gonditic rocks, which are overlain by quartzites, phyllites, mica-schists and marbles. The gondites, belonging to the Gangpur series, which contain workable deposits of manganese ore. The calcitic and dolomitic marbles are used as flux and in the manufacture of lime. The rocks of the Gangpur series have been traversed by the Chota Nagpur granite and some sills of basic composition. . The gondites, marbles and carbonaceous phyllites and quartzites are the characteristic rock-types of the Gangpur series and do not occur in the younger Iron-ore series. The Gangpur and Iron-ore series of Singhbhum-Gangpur area are equivalent to the Dharwarian rocks of South India. They may also be considered equivalent to the Sausar and Sakoli series of Madhya Pradesh.

Now we will see the important economic mineral deposits of Archaean group. The Archaean rocks in India constitute a storehouse of important economic mineral deposits. Except coal, petroleum and sulfur, practically all other metallic and non-metallic minerals and rocks of economic importance are associated with the metamorphic and igneous rocks of Archaean age. In addition, there are deposits of chromite, molybdenite, monazite, uranium, vanadium, tin and titanium in different parts of India. The gneisses, charnockites, granites, quartzites, marbles and slates of Archaean age are utilized commonly as building and decorative stones.

Also, the Archaean rocks contain sapphire, zircon, spinel, garnet, emerald, topaz and many other minerals, which are used as precious and semi-precious gemstones. Just summarizing the lecture one, in this lecture we have discussed first in the introduction to stratigraphy, which is the study of rock layers to understand Earth's geological history, focusing on their distribution, age and composition. Then we have discussed the principle of stratigraphy, which says few principles like the law of superposition, which states that in an undisturbed sequence, older rock layers lie beneath the younger ones, aiding in chronological dating and correlation of rock formations. Next, we have discussed the chronological subdivisions in which we have seen the geological time is divided into major units such as eras, periods, epochs based on stratigraphic and paleontological studies to establish the earth history and evolution. Then, we have discussed the Indian stratigraphy.

India's stratigraphy is classified into three major stratigraphic divisions like peninsula, extra-peninsula and endogametic plains. each with distinct geological formations ranging

from pre-Cambrian to Quaternary period. Then lastly, we have discussed about the Archaean group. The Archaean group consists of ancient, highly metamorphosed rocks forming the basement of Earth's crust with varying rock types and edges across regions. It is a storehouse of important economic mineral deposits.

Thank you very much to all.