

PART II

A - INDIAN COALS

Coals of India belong to two principal geological periods - the Lower Gondwana coals of Permian age, and Tertiary coals of Eocene to Miocene age. Of these, the Lower Gondwana coals are the most important both as regards their wide distribution as well as their quality, and at present they account for nearly 99 percent of the total coal produced in India. The Tertiary coals, though not of much significance in the context of their share in the total production, are of great economic importance in the regions where they occur. In addition to these, coals occur in some of the Jurassic formations, though they are not of such commercial importance. Among the various ranks of coal, Bituminous coals in the Gondwana coalfields and Lignite in Tertiary coalfields predominate. Peat, excepting that of the present day origin, and Anthracite, excepting that found in the sub-Himalayan region of Kashmir and Assam, are practically absent. The distribution of coals in various geological periods in India, is shown in Table No.9.

GONDWANA SYSTEM

As already stated the Gondwana Formation is the chief source of coal in India and it will not be out of place to give at first a brief account of the geological history of this system. The name 'Gondwana' formation refers in Indian Geology to a very thick group (6000-7000 metres) of distinct freshwater sedimentary rocks of lacustrine, fluvial or estuarine origin, widely occurring in the Peninsular and ranging in age from upper Carboniferous to Lower Cretaceous periods.

DISTRIBUTION - The main outcrops of Gondwana rocks are now seen to occupy restricted areas in the Peninsula and these are mainly arranged along three linear tracts of land correspondingly roughly to (i) Damodar-Sone-Warhada Valley, (ii) Mahanadi valley, and (iii) Godavari-Wardha Valley. In addition they are also found in the Chattisgarh-Rewa region; in the Satpuras; and in the Sub-Himalayan region of Kashmir, Sikkim and Arunachal Pradesh. The present outcrops represent the erosional remnants of the original Gondwana sediments which were presumably laid down in a number of fresh water basins that were then existing in these regions and occupied much larger areas.

CLASSIFICATION - The Gondwana system has been classified into a Lower and an Upper division mainly on the basis of plant fossils found in them, each of these divisions being characterised by a distinct group of plant fossils. The most common plant fossils in the Lower Gondwanas are, *Glossopteris*, *Gangamopteris* and *Leptopteris* (belonging to an extinct group of plants called *pteridosperms*) - commonly called "Glossopteris flora". The upper Gondwanas are characterised by *Ptilophyllum* and *Nilssonia* (belonging to the group Cycads) - commonly called "Ptilophyllum flora" or "Rajmahal flora". The two divisions are again classified into Secondary and Tertiary Stages based on various factors, as indicated in Table No.10.

Table No. 9 : Geological succession of strata in which potentially workable coal seams occur in India

Coalfields	Geological systems	Localities
Tertiary Coalfields	Early Pleistocene to Upper Pliocene	Lignites in the Karawa tions of Kashmir valley.
	Miocene	Lignites in the Cuddalore series of South Arcot, <u>Nadu</u> , and <u>Varkala</u> and <u>Quilon</u> in Kerala.
	Oligocene to Upper Eocene	Lignites in the Barail in Jaipur, <u>Nazira</u> , <u>Mazera</u> and <u>Makum</u> coalfields of <u>Upper Assam</u> and <u>Nagaland</u> .
	Middle Eocene	Lignites of <u>Palana</u> , <u>Rajasthan</u> ; Lignites of <u>Kutch</u> .
	Lower Eocene	Coals in the Jaintia series of <u>Cherrapunji</u> , <u>Mawlong</u> , <u>Shillong</u> in the <u>Khasi</u> and <u>Jaintia hills</u> , <u>Garo</u> and <u>Assam hills</u> , <u>Daranggiri</u> , <u>Rongrai</u> <u>giri</u> in the <u>Garo hills</u> of <u>Assam</u> , <u>Meghalaya</u> and <u>Mizoram</u> .
Upper Gondwana Coalfields	Upper Jurassic	<u>Chikiala</u> and <u>Kota</u> in the <u>Udaipur</u> stage in <u>Maharashtra</u> ; <u>Satpura</u> region, <u>Madhya Pradesh</u> , <u>Jabalpur</u> stage; and <u>Ghunge</u> in <u>Kutch</u> below the <u>Umia</u> stage.
	Upper Permian	<u>Raniganj</u> , <u>Jharia</u> , <u>Bokaro</u> and <u>Karanpura</u> coalfields of the <u>Damodar</u> valley in <u>West Bengal</u> and <u>Bihar</u> . <u>Talchir</u> & <u>Singrauli</u> .
Lower Gondwana coalfields	Lower Permian	All Lower Gondwana coalfields of the Peninsula, including <u>Damodar</u> valley, <u>Mahanadi</u> valley, <u>Brahmani</u> valley, <u>Sone</u> valley, <u>Pench</u> valley, <u>Pranhita-Godavari</u> valley and <u>Wardha</u> valley coalfields.
		Coalfields of the Eastern Himalayas - <u>Darjeeling</u> district of <u>West Bengal</u> ; <u>Ranjit</u> valley in <u>Sikkim</u> ; <u>Abor</u> , <u>Daphla</u> and <u>Aka</u> hills of <u>Arunachal Pradesh</u> .

Gondwana

Basement of Arunachal Pradesh

DESCRIPTION OF STRATA

TALCHIR SERIES - The basal bed of this series, called the Boulder bed or Tillite consists of boulders and pebbles of glacial origin and is developed to a thickness of 15-60 m and is generally overlain by a group of shales and fine sandstones which are characteristically khaki-green in colour and contain undecomposed shales. They generally break into thin pointed fragments called 'bedding shales'. They also often show typical concretionary or nodular weathering. (These beds are devoid of any coaly matter and are unfossiliferous. The topmost beds have yielded some plant fossils like Rikba in the Karapura coalfield. They include Glossopteris and Ganganopteris etc. This stage is called the Rikba plant bed. The equivalents of this stage have been reported from Auranga, Hutar, Sohagpur and other parts of the Talchirs. The age of the Talchir Series was generally thought to be Upper Carboniferous but recent studies of plant fossils, particularly the spores and pollens indicate a younger age. The evidence from fossils of the intercalated marine beds at Umaria, Manendragarh, Daltongarj and Arunachal Pradesh support this view and it has been suggested that the Talchirs may be even of early Permian age.

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DAMUDA GROUP - This is the most important formation of the Lower Gondwaras, because it was during this period that all the economically important coal seams were formed. The oldest member of this group is represented by the Karharbari Stage, typically developed in the Giridih coalfield, where it is made up of 60-120 m of pebble beds, grits, sandstones and shales. Extensive occurrences of this stage have now been reported from Karapura, Daltongarj, Talchir, Korba, Hasdo-Arand, Sohagpur, Mohpani, Shahpur and Singrauli basins. In the Giridih coalfields, this stage includes two coal bearing zones, the coals of which are among the oldest of the Lower Gondwaras and are of very good quality. This shows that the cold conditions ended with the Talchirs and gave place to warm and humid climate that could support luxuriant plant growth in the succeeding period. This stage overlies unconformably the Talchirs and is separated from the typical Barakars by a band of barren sandstones at Giridih.

Barakar Series - This is typically developed along the Barakar river, a tributary of Damodar, where it attains a thickness of over 60 m. It comprises of typically falsebedded sandstones, conglomerates, grits and carbonaceous and micaceous shales. It is the chief coal-bearing series in the Damuda group and contains workable coal seams wherever it occurs in the Peninsula. The Barakars consist of a regular sequence of sandstones, shales, carbonaceous shales, and coal seams repeated over and over again. The best development of Barakar coals is in the Jharia coalfield where it includes about 70 m in thickness. Occasionally very thick seams are found viz.

Kargali seam (45 m thick) in Bokaro coalfield, Korba seam (30 m thick) in Hasde valley coalfields and the Argada seam (35 m thick) in S.Karanpura coalfield. The coals of the Darjeeling, Buxa Duars and Jor hills in the foot-hills region of the Eastern Himalayas also belong to this series. This indicates that during the early Permian times extensive coal forming process took place in various parts of the Peninsula.

Barren Measures - These were the next group of rocks to be deposited and they are developed to thickness of about 610 m in the Jharia coalfield. They are composed of fine sandstones and shales and though they contain carbonaceous material and thin partings of coal they are devoid of workable coal seams. This was presumably due to the fact that the climate became arid and hot during the middle Permian times so that vegetation became less luxuriant and sparse and not in sufficient abundance to build up thick coal seams. In the Raniganj coalfield the equivalents of this formation are called 'Ironstone Shales', as these shales enclose numerous nodules or concretions of clay ironstone which are sideritic at depth but limonitic at the surface due to oxidation. This abundance of ferruginous matter would also indicate dry and arid conditions during this period. The equivalents of Barren measures are called Motur Beds in the Satpuras.

Raniganj Series - Subsequent to the deposition of the Barren Measures, conditions appear to have again become warm and moist as to support enormous plant life which again has been preserved as thick coal seams in the succeeding strata. These upper coal-bearing strata have been called the Raniganj Series because of their best development in the Raniganj coalfield where they are over 1035 m thick. They consist of grey and greenish felspathic sandstones and shales and include within it a number of workable coal seams. Production coal seams from this series were originally reported from Raniganj and Jharia fields only. However subsequent work has shown that workable coal seams of this stage are also present in Bokaro, Karanpura, Talchir and Singrauli coalfields. The thickest coal seams in India, the 131.5 m Jhingurda seam occurs in this stage in the Singrauli coalfield.

The Damuda group particularly the Barakar and Raniganj Series has afforded abundant plant fossils, the more important of which belonging to the following groups are given below :-

Pteridosperms : { Glossopteris (many species)
Gangamopteris (many species)
Versebraria
Gondwanidium

Equisetales : Schizoneura }
Phyllotheca }

Cordaitales : Neoggerathopsis,
Dadoxylon (Fossil wood)

The equivalents of the Raniganj strata are called Himgir beds in Mahanadi valley, Bijori beds in Satpura, Kamthi beds in Wardha-Godavari valley, and Pali beds in Rewa. The Correlation of the Lower Gondwana Strata of the Peninsula is shown in Table No. 11.

PANCHET SERIES - The period succeeding the Raniganj Measures is represented by a series of 450-610 m of brown buff or brown sandstones and shales, lying with a slight unconformity over the Damudas and designated the Panchet Series because of its good development in the Panchet hills. This series is devoid of coal seams or even of carbonaceous matter, suggesting that at the close of the Damuda times the climate again became dry and hot with the result that the rich 'flora' of the Damuda times practically died out during this period. This is also suggested by the fact that plant fossils (except a few from the lower part) are practically absent in this series. On the other hand, remains of land animals like Labyrinthodonts (an extinct group of Amphibia), Reptiles and Crustacea are found in these rocks. ~~The Raniganj~~ These fossils indicate a Lower Triassic age for the Panchet series. But the plant fossil evidence particularly from their equivalent beds in the other parts of the Peninsula indicate a Middle Triassic age.

MAHADEVA SERIES - This series constitutes the lowest member of the upper Gondwanas and builds up the Mahadeva hills in Madhya Pradesh. The lower part of this series called the Pachmarhi stage reaches a thickness of over 760 m and builds up the hills on which the town of Pachmarhi is situated. The rocks are mostly red and buff coarse sandstones along with plenty of ferruginous clays and without any carbonaceous matter, indicating that the climate continued to be hot and desiccated during this period. The upper portion, called the Maleri Stage, has yielded fossil reptiles, fishes, freshwater lamellibranchs and fossil wood. The equivalent of Mahadeva Series in the Damodar valley is called Supra-Panchet and in the Rajmahal hills, Dubrajpur sandstones. The age indicated by the fossils is from Middle to Upper most Triassic.

RAJMAHAL SERIES - The Rajmahal Series overlies the Mahadevas and in the type area of the Rajmahal hills consists of a number of intertrappean sedimentary beds, each a few metres thickness and occurring in between basaltic flows called Rajmahal Traps. These intertrapean beds constituting the Rajmahal Stage are made up of carbonaceous shales and clays and reach a total thickness of about 30m. These beds are highly fossiliferous and have yielded abundant plant fossils which are quite distinct from the Damuda flora. They are distinguished as "Rajmahal flora" and include the following principal groups of fossils:-

Filicades : Pecopteris,

The abundance of plant remains would indicate a return to the mild climate as to give rise to a rich vegetation during these times. The upper part of the Rajmahal series -- The Kota stage -- is well developed in the Godavari valley and contains a few thin coal seams. The evidence of plant fossils indicates an upper Jurassic or even Younger age. This means that there has been a big hiatus or break above Mahadevas, the Lower and Middle Jurassic not being represented in the sequence.

JABALPUR SERIES - The lower part of this series comprises of white or light coloured clays, soft sandstones carbonaceous shales and is called the Jabalpur Stage. It contains a few coal seams now seen along the Hard and Mc rivers in the Satpura region. The plant fossils are similar to those of the Rajmahals. The upper beds of this series called the Umia stage, contain typical upper Gondwana plant fossils and are well developed in Kutch, where they are found intercalated with marine fossiliferous beds of Lower Cretaceous age. So the upper age limit of the Gondwana is Lower Cretaceous.

STRUCTURE OF THE GONDWANA BASINS - The Gondwana