

# STRATIGRAPHY OF THE GONDWANA SUPERGROUP

by

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# ORGANIZATION OF CONTENTS

- INTRODUCTION
- DISTRIBUTION
- LITHOLOGY
- CLASSIFICATION
- ECONOMICC SIGNIFICANCE

# INTRODUCTION

- THE TERM GONDE OF WANA WAS COINED BY H.B. MEDLICOTT IN 1872.
- IT WAS DERIVED FROM THE KINGDOM OF GOND, AN ANCIENT TRIBE OF CENTRAL INDIA. THIS TRIBE STILL EXISTS IN THE STATE OF MADHYA PRADESH.
- THE TERM SUPERGROUP IS USED HERE FOR ITS STRATIGRAPHICAL HIEARCHY AS IT CONTAINS SEVERAL GROUPS AND FORMATIONS.
- GONDWANA TERM IS ALSO USED IN A TECTONOSTRATIGRAPHIC MANNER – **THE SUPERCONTINENT OF THE GONDWANALAND.**
- THIS SUPERCONTINENT EXISTED BETWEEN PERMIAN TO CRETACEOUS PERIOD AS THE SOUTRHERN HALF OF PANGAEA.

# INTRODUCTION

- ❑ The continent of Gondwana or Gondwanaland was named by Austrian scientist Eduard Suess, after the Gondwana region of central northern India (from Sanskrit *gondavana* - "forest of the Gonds"). The name had been used in a geological context, first by H.B. Medlicott in 1872, from which the Gondwana sedimentary sequences (Permian-Triassic) are also describe.
- ❑ Gondwana formed prior to Pangaea, then became part of Pangaea, and finally drifted after the breakup of Pangaea.
- ❑ Gondwana is believed to have sutured between about 570 and 510 Mya, thus joining East Gondwana to West Gondwana. It separated from Laurasia 200-180 Mya (the mid-Mesozoic era) during the breakup of Pangaea, drifting farther south after the split.

# THE GONDWANALAND SUPERCONTINENT



EON	ERA	PERIOD	EPOCH	Ma		
Phanerozoic	Cenozoic	Quaternary	Holocene		0.01	
			Pleistocene	Late	0.8	
		Early		1.8		
		Tertiary	Neogene	Pliocene	Late	3.6
					Early	5.3
				Miocene	Late	11.2
					Middle	16.4
					Early	23.7
			Paleogene	Oligocene	Late	28.5
					Early	33.7
				Eocene	Late	41.3
					Middle	49.0
					Early	54.8
		Paleocene	Late	61.0		
	Early		65.0			
	Mesozoic	Cretaceous	Late		99.0	
			Early		144	
		Jurassic	Late		159	
			Middle		180	
			Early		206	
		Triassic	Late		227	
			Middle		242	
			Early		248	
		Paleozoic	Permian	Late		256
				Early		290
	Pennsylvanian				323	
	Mississippian				354	
	Devonian		Late		370	
			Middle		391	
			Early		417	
Silurian	Late		423			
	Early		443			
Ordovician	Late		458			
	Middle		470			
Cambrian	Early		490			
	D		500			
	C		512			
	B		520			
	A		543			
Precambrian	Proterozoic	Late		900		
		Middle		1600		
		Early		2500		
	Archean	Late		3000		
		Middle		3400		
		Early		3800?		

Span of Gondwanaland in GTS



# THE GONDWANA BASINS

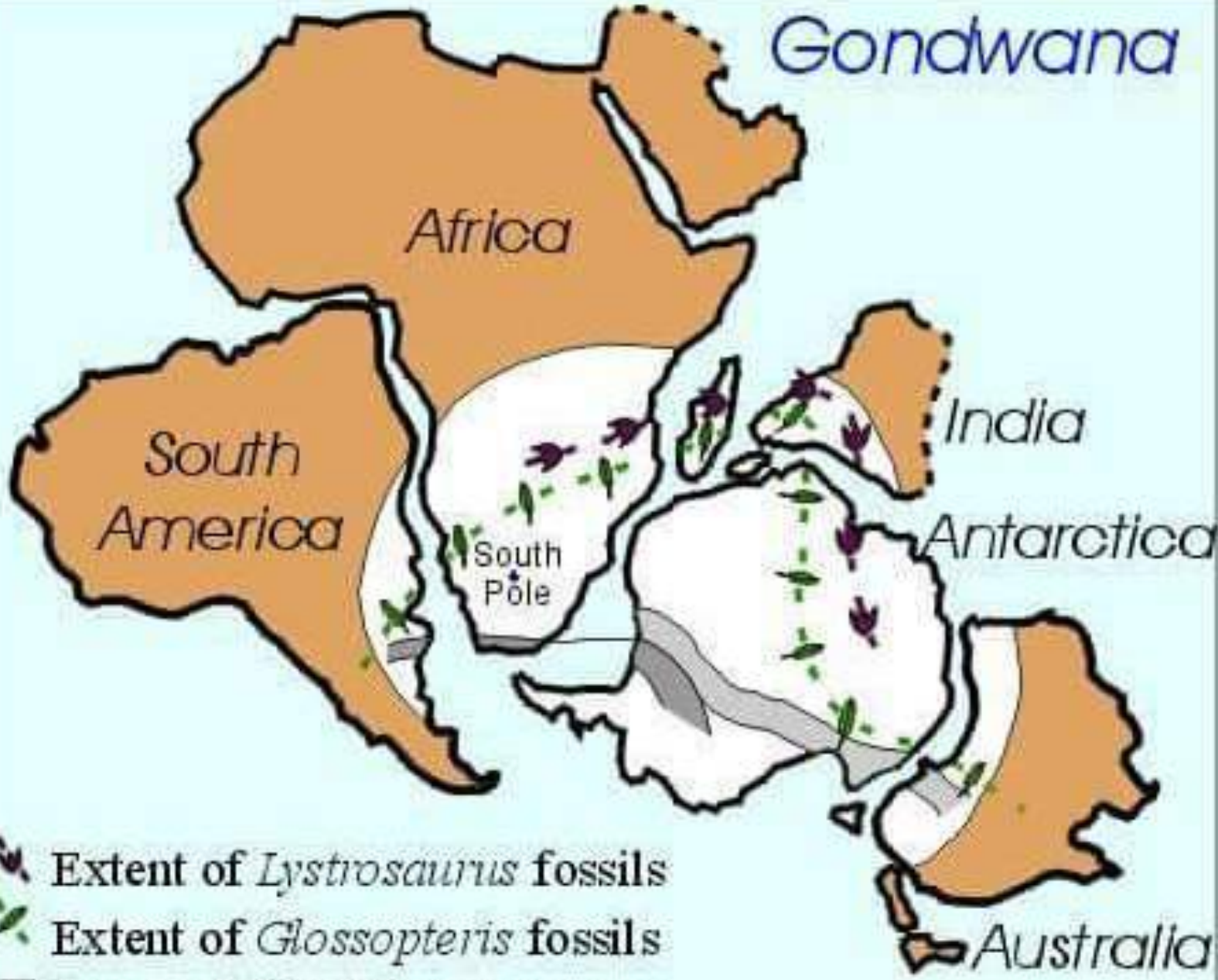
- **GONDWANA BASINS OF INDIA ACCOUNT FOR NEARLY 99% OF COAL RESOURCE OF THE COUNTRY.** THE BASINS OCCUR ALONG MAJOR RIVER VALLEYS EITHER AS DISCRETE BODIES OR ARE UNIFIED BY POST-PERMIAN STRATA AND ARE NAMED AFTER THE RIVERS DAMODAR, SON, MAHANADI, GODAVARI ETC. OR THE LINEAR HILL RANGES LIKE SATPURA AND RAJMAHAL.
- THE SEDIMENTS CONSTITUTES UPTO FIVE KM. THICK STRATA, DEPOSITED OVER 200 MILLION YEARS (FROM UPPER CARBONIFEROUS TO LOWER CRETACEOUS) WHICH ARE PRESERVED IN THESE BASINS AND ARE CLUBBED INTO **GONDWANA SUPERGROUP.**







- GONDWANA SUPERGROUP IS SUB-DIVIDED INTO PERMO-CARBONIFEROUS LOWER GONDWANA GROUP, CHARACTERIZED BY **GANGOMOPTERIS-GLOSSOPTERIS** FLORA AND MESOZOIC UPPER GONDWANA GROUP CONTAINING **DICROIDIUM-LEPIDOPTERIS-PTYLOPHYLUM** FLORA.
- THE COAL SEAMS ARE FOUND ONLY IN THE LOWER GROUP WITHIN KARHARBARI AND BARAKAR FORMATIONS OF LOWER PERMIAN AND RANIGANJ FORMATION AND ITS EQUIVALENTS OF UPPER PERMIAN AGE.
- BARAKAR FORMATION IS THE MAJOR STOREHOUSE OF COAL IN ALL THE BASINS HAVING MORE THAN 90% OF TOTAL RESOURCE OF THE COUNTRY. KARHARBARI AND RANIGANJ FORMATIONS PRESENT ONLY IN A FEW BASINS.



# Gondwana



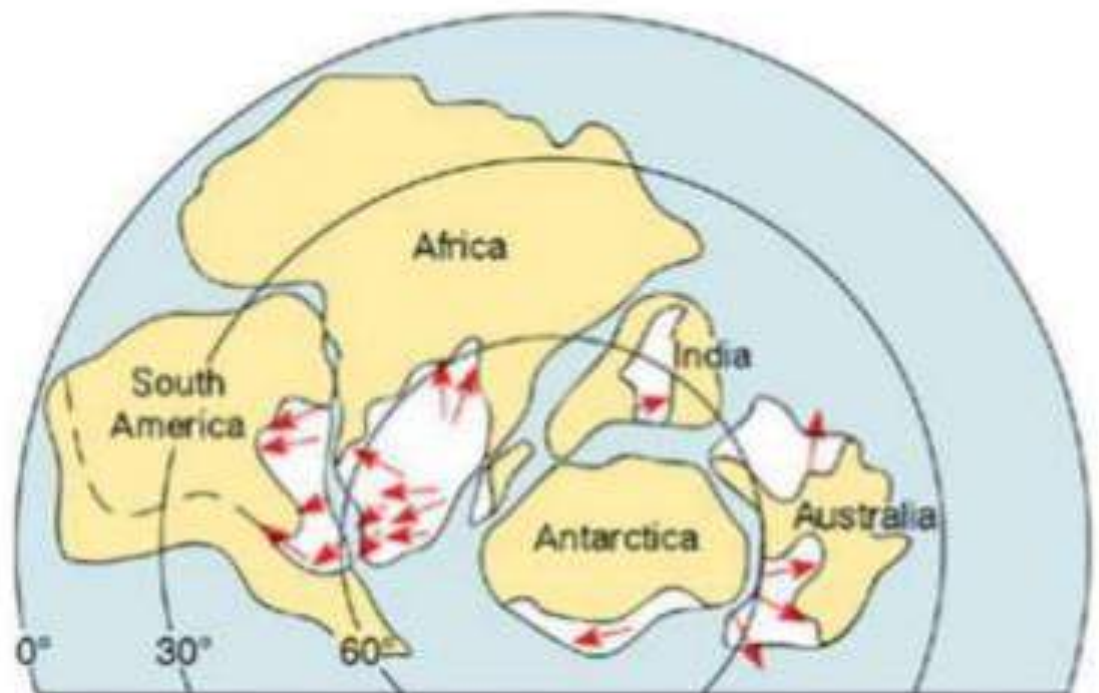
-  Extent of *Lystrosaurus* fossils
-  Extent of *Glossopteris* fossils
-  Ice cap 300 million years ago
-  Gondwana mountain belts

# Evidences that it existed...

## 1. Paleoclimatic evidence -

Ancient climatic zones match up when continents are moved back to their past positions.

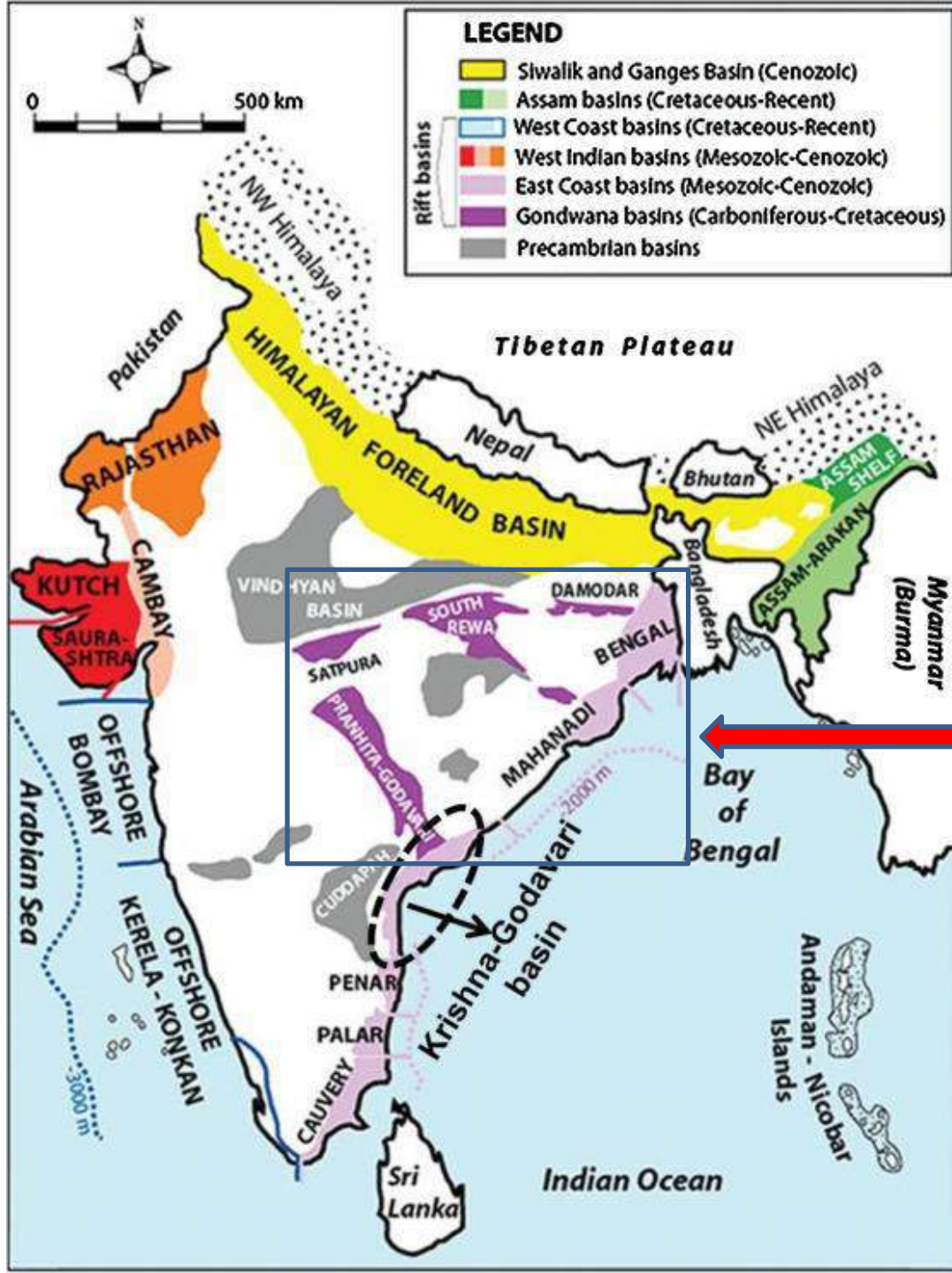
- Glacial tillites
- Glacial striations
- Carbonate deposits
- Evaporite deposits





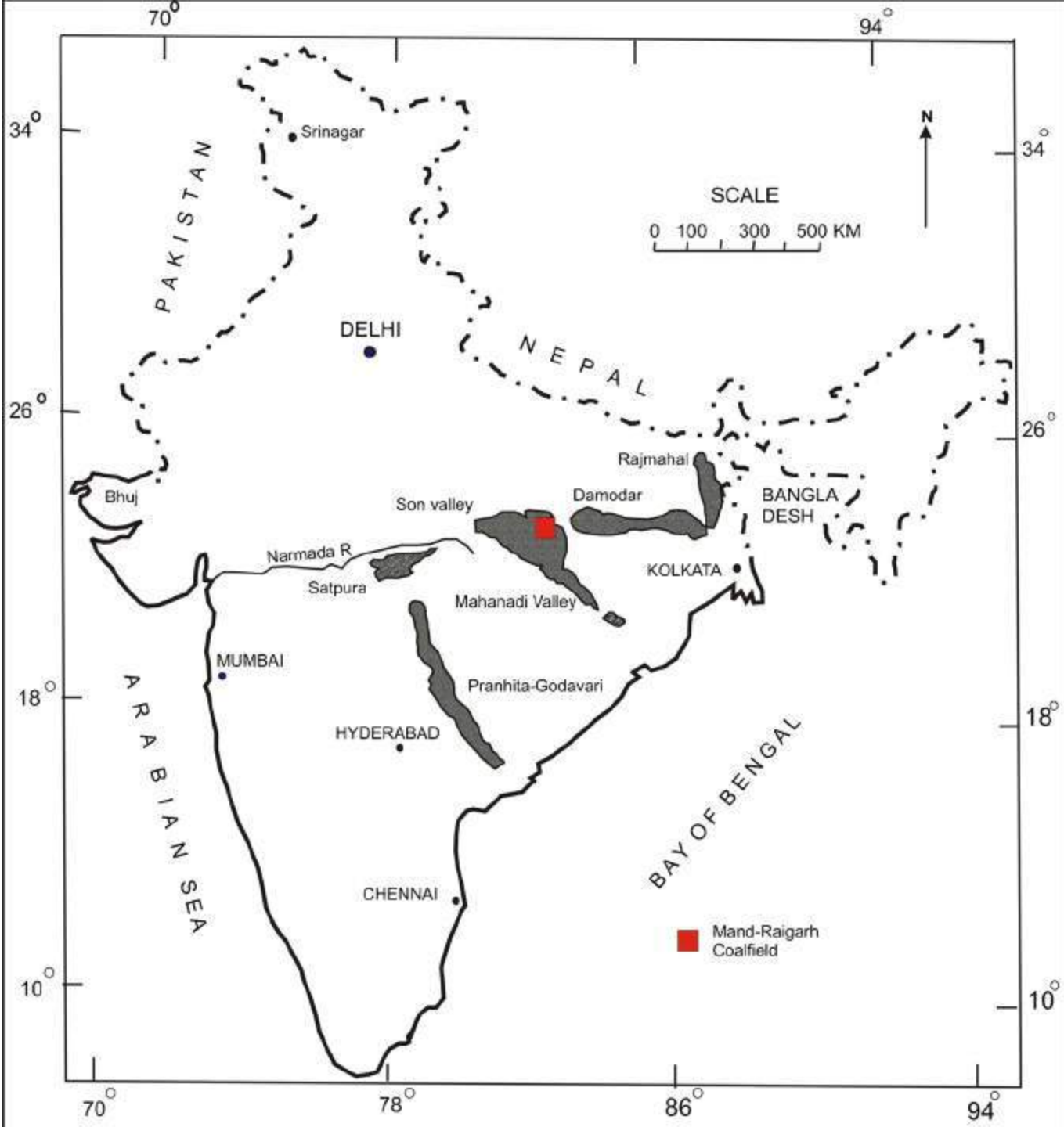
# LITHOLOGY

- The Gondwana superGroup is made up of 6 to 7 km thick succession of mainly fluvial and lacustrine deposits.
- However, a glacial deposit occurs at the base and the intercalations of the fossiliferous marine beds occur both in the lower and upper parts of the succession.
- The chief rock types are sandstones, shales, clays, conglomerates and coal seams.
- In addition to these rocks the upper Gondwana succession contain about 600 meter thick lavafloes of basalt.

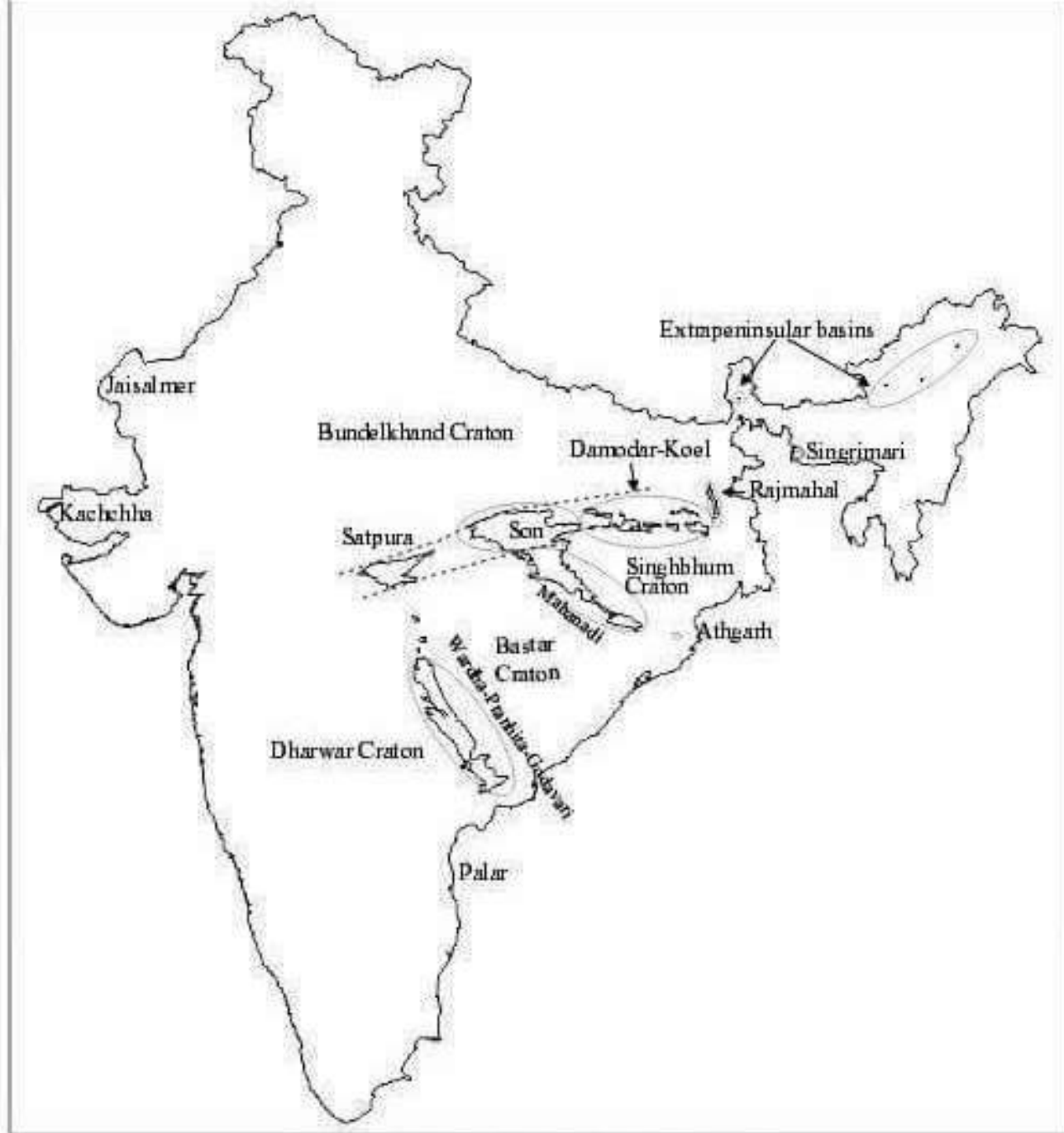


# THE SEDIEMNTARY BASINS OF INDIA

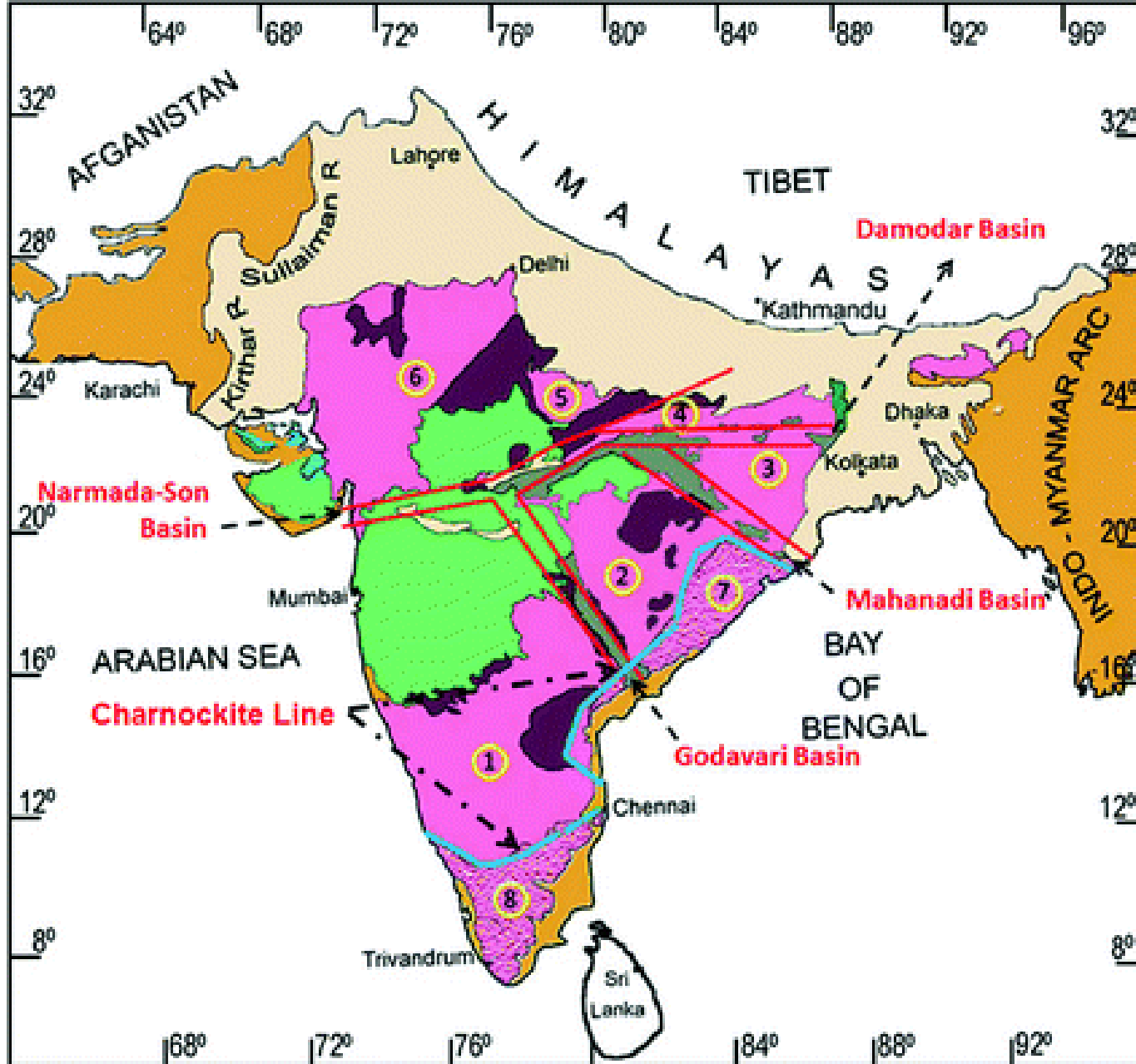
THE GONDWANA BASINS IN THREE LINEAR DEPRESSIONS





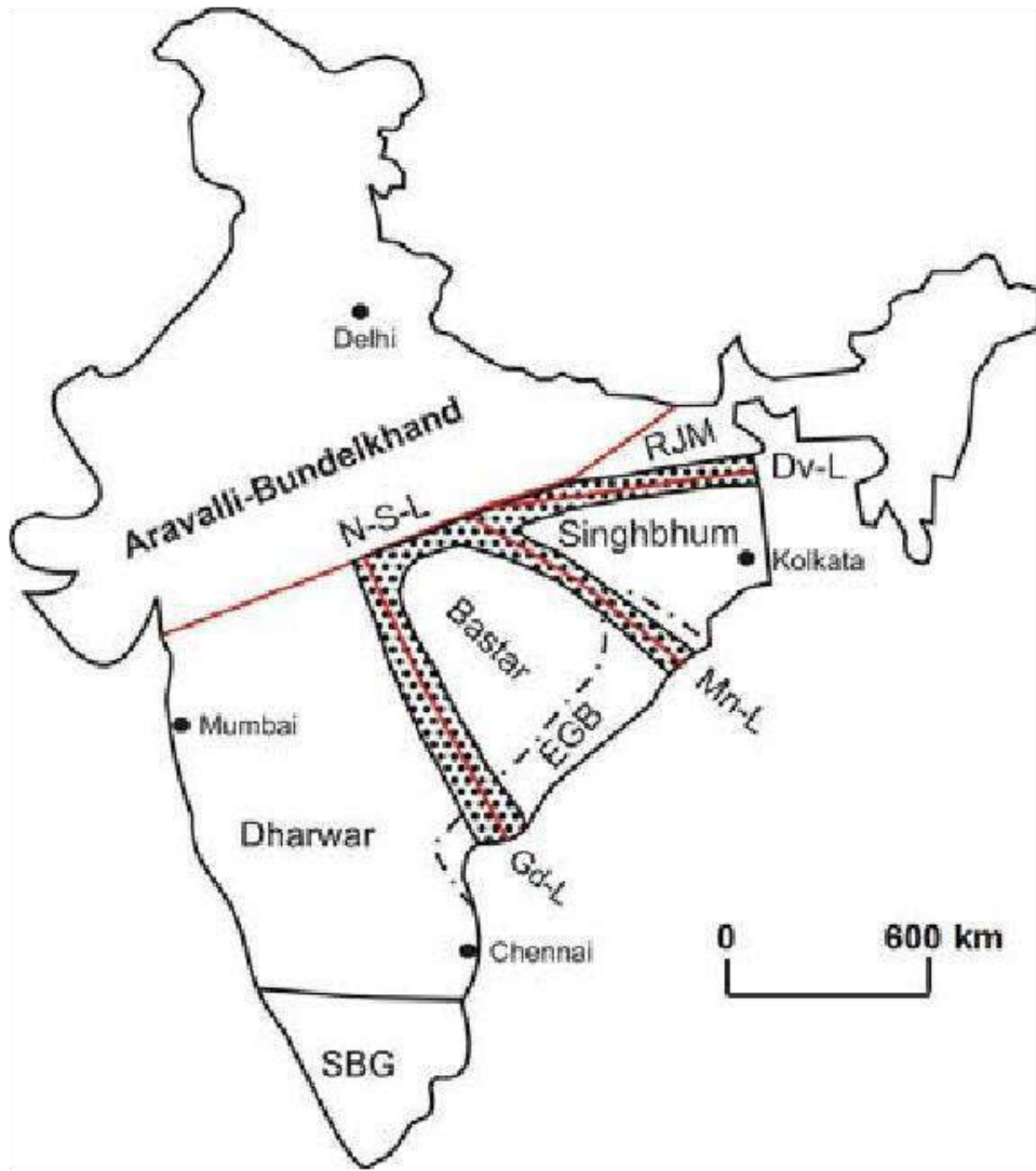


**Fig.1.** Distribution of Gondwana basin belts of India.



- |                             |                             |                             |
|-----------------------------|-----------------------------|-----------------------------|
| Quaternary deposits         | Tertiary & Pleistocene      | Deccan Trap                 |
| Rajmahal Trap               | Mesozoic Formations         | Gondwana Supergroup         |
| Proterozoic Cratonic basins | Precambrian Protocontinents | Precambrian granulite belts |





# Stratigraphic Classification

- A major part of the Gondwana sediments are confined to the three tracts, which include Koel- Damodar, Son-Mahanadi and Pranhita - Godavari basins.
- The Gondwana Supergroup is divided into two major divisions based on their lithological and palaeontological evidences.
  - (i) Two-fold classification by W.T. Blanford, divided into lower and upper Gondwanas, characterised by the *Glossopteris* and *Ptilophyllum*.
  - (ii) Three-fold classification by Hughes, who identified a mixed flora called *Dicroidium* in between the *Glossopteris* and *Ptilophyllum* floras.

Table 1 : Two-fold classification of Gondwana Rocks (after Meddlicott and Blanford, 1879).

Lower Cretaceous		Umia plant beds	)	
	Upper	Jabalpur stage	)	
Jurassic	Middle	Kota stage	)	Upper Gondwana
	Lower	Rajmahal (inter-trappean plant beds)	)	
Triassic	Rhaetic	Bagra ) stage )	)	Mahadeva series
		Denwa )	)	
	Keuper	Pachmarhi	)	
	Bunter	Panchet series	)	
Permian	Upper	Raniganj	)	Damudas
	Middle	Barren measures	)	
	Lower	Barakar series)	)	
Upper Carboniferous		Talchir series with glacial boulder beds	)	Lower Gondwana

Table 2 : Three-fold classification of Gondwana Rocks  
(after Feistmantel, 1882).

	Umia		Lower Cretaceous
Upper Gondwanas	Jabalpur		Upper Jurassic
	Rajmahal		
	Kota		Lias
Middle Gondwanas	Maleri		Keuper and Rhaetic
	Mahadeva		Muschelkalk
	Panchet		Bunter
Lower Gondwanas		(Raniganj	Upper Permian
	Damuda	(	
		(Barren Measures	Middle Permian
		(	
		(Barakar	
	Talchir		Upper Carboniferous



# Three fold classification

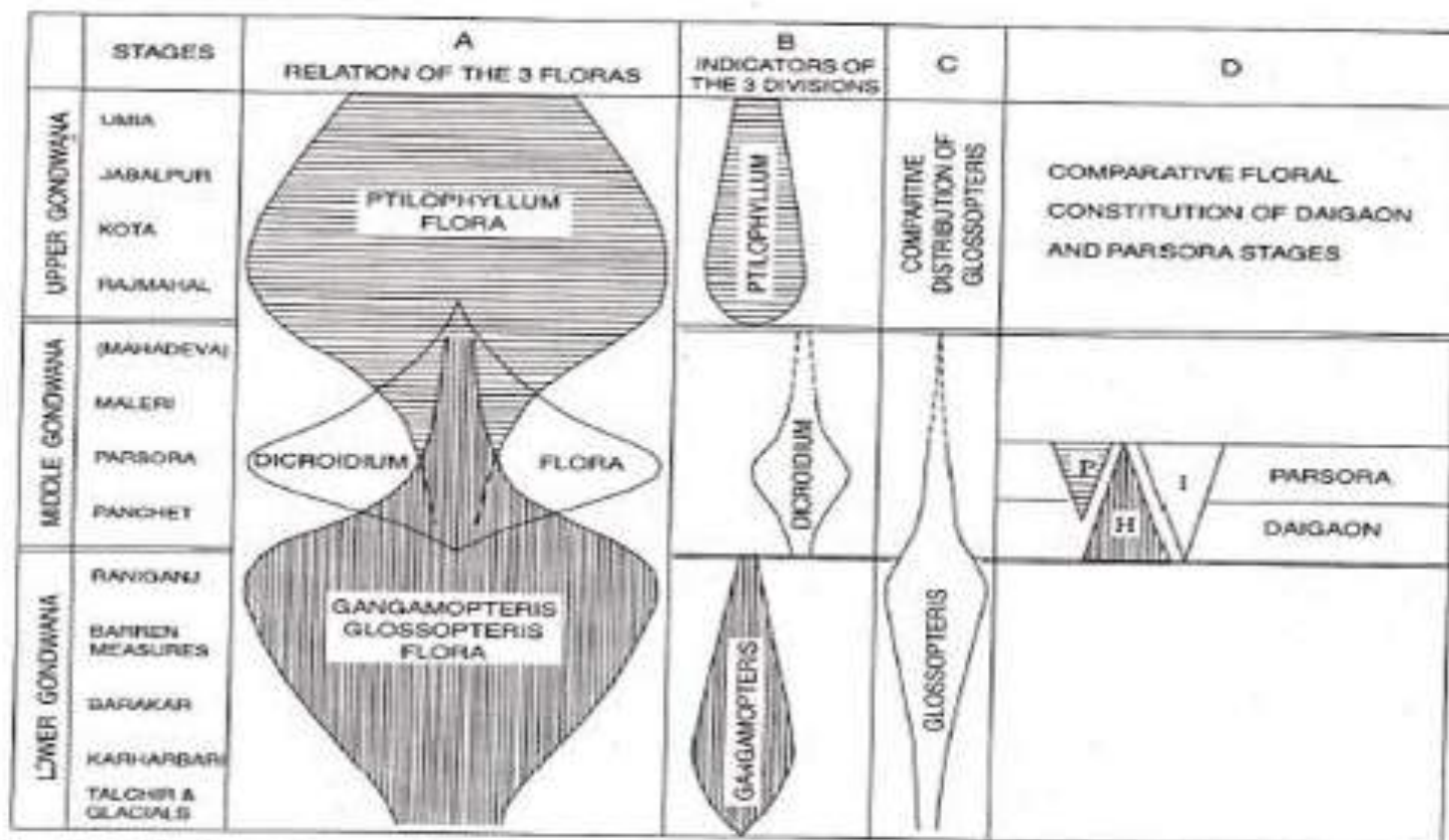


Fig.7.12. A. Semidiagrammatic representation of the relation between the floras of the Lower, Middle and the Upper Gondwana showing the overlap of the Permian 'Hold-overs' and the Jurassic 'Precursors' with *Dicroidium* in the Middle Gondwana times'. B. Index plant genera of the three floras which serve to delimit the Lower, Middle and Upper Gondwana divisions. C. Vertical distribution pattern of *Glossopteris* (as contrasted with *Gangamopteris*) showing its transgressive tendency and unreliability for delimiting the Lower Gondwana. D. Diagrammatic representation of the floral constitution of the Daigaon and Parsora Stages in terms of the so-called 'Hold-overs' (H), the so-called 'Precursors' (P) and the Index plant (I). (after Lele, 1964).

**CORRELATION OF  
DIFFERENT  
GONDWANA  
FORMATIONS**

**Table 1.** Existing scheme of correlation of Gondwana Formations

		<b>Damodar-Koel valley</b>	<b>Rajmahal</b>	<b>Mahanadi</b>	<b>Son</b>	<b>Satpura</b>	<b>Godavari</b>		
Cretaceous	Lower				Bansa bed	Jabalpur	Chikiala/ Gangapur		
	Upper								
Jurassic	Middle		Dubrajpur			<i>Bagra</i>			
	Lower				Bandhavgarh			Kota	
					<i>Parsora</i>				
Triassic	Upper	SupraPanchet			<i>Tiki</i>		Dharmaram	Maleri Group	
							Maleri		
	Middle					Denwa	Bhimaram		
							Yerrapalli		
	Lower	Panchet		Kamthi	Pali	Panchmarhi	<i>Upper Kamthi</i>	Kamthi Group	
							Middle Kamthi		
Permian	Upper	Raniganj		Raniganj	Raniganj	Bijuri	Lower Kamthi	Barakar	
		Barren Measures		Barren Measures	Barren Measures	Motur	Barren Measures		
	Lower	Barakar	Barakar	Barakar	Barakar	Barakar	Barakar	Barakar	
		Talchir	Talchir	Talchir	Talchir	Talchir	Talchir	Talchir	
	Late Carboniferous								



# Talchir Formation:

- This formation rests unconformably over the basement of either Archaean gneisses and schists or Proterozoic age.
- Boulder bed/ tillite, rhythmite, khaki green needle shale and light green sandstone are constitute in this formation.
- Presence of a few plant fossils of seed ferns *Gangamopteris cyclopteroides* and *Glossopteris indica*.

# Karharbari Formation:

- Conglomerates, pebble beds, coarse to very coarse grained pebbly sandstone, siltstone, shale and thin streaks and bands of coal are present.
- Contains of coal seams in a few basins and the plant fossil *Gondwanidium burriada* biozone is considered as characteristic of this formation.



## Barakar Formation

- A 250m thick Barakar Formation
- The china-clay deposits of the formation are often of economic significant.

## Barren Measures Formation

- It is represented by alternating units of cross-bedded ferruginous sandstone, micaceous siltstone and ferruginous shale.
- The latter rock unit is called Ironstone Shale in the Raniganj coalfield.

## Raniganj Formation:

- Consists of sandstones, shale and coal seams, the sandstones being fine-grained than those in the Barakar Formation.
- Valuable coal-seams occur in these strata only in the Raniganj coalfield.

## Panchet formation:

- The formation comprises of greenish, buff and brownish sandstones and shales in the lower part, and greyish micaceous and feldspathic sandstones and shales in the upper part.
- The lower sandstones are often false-bedded and contain no coal seams or carbonaceous matter.



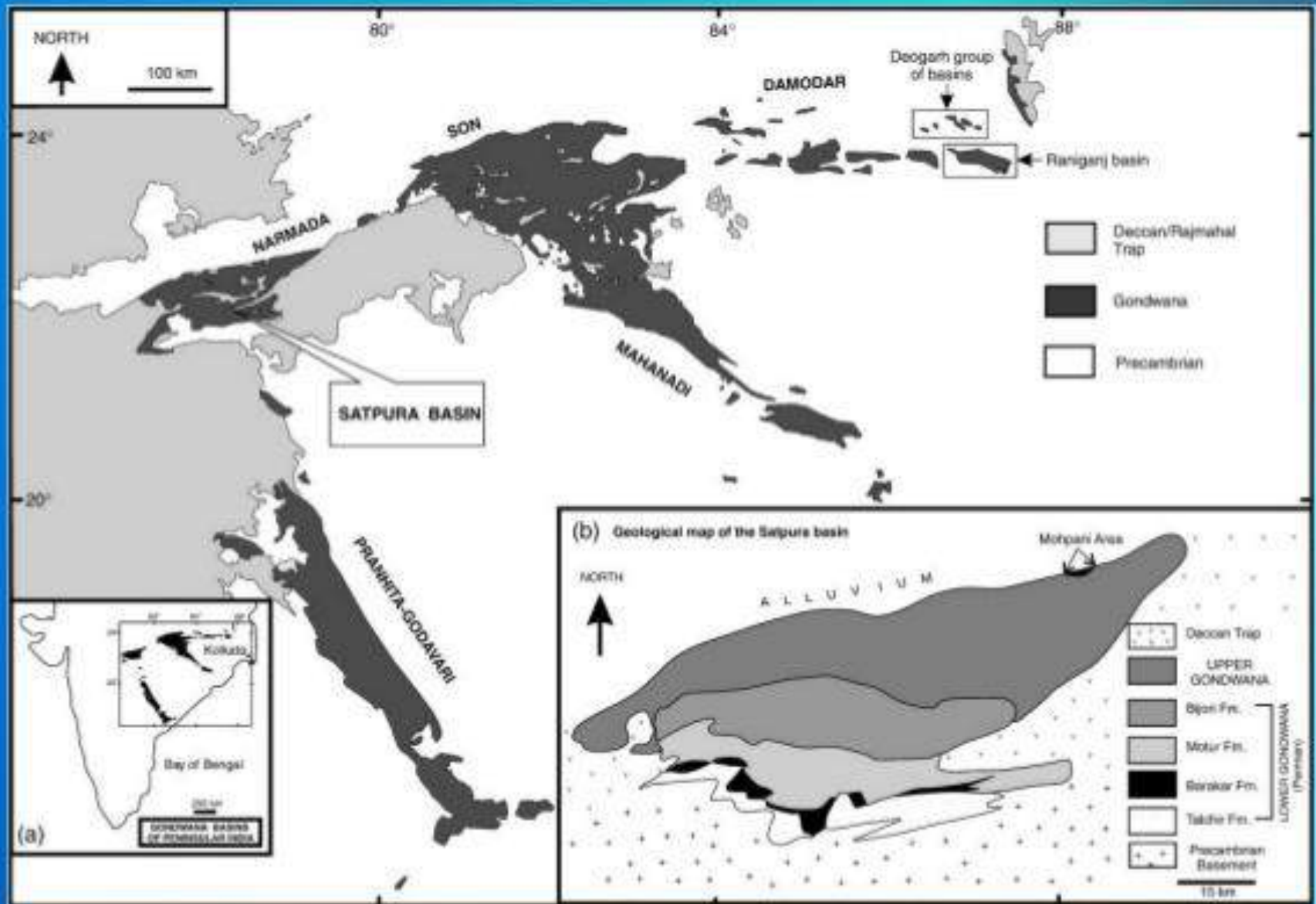
## Supra -Panchet (Mahadeva):

- Maximum development of Supra -Panchet is found in the Bokaro basin, where it attains a thickness of 600m in the Luga Hill section.
- Ferruginous sandstone, conglomerate, pebble beds and red clay are prominent rock units of this formation.

## Satpura Basin:

- The Satpura basin is spindle-shaped with a length to breadth ratio of 4:1.
- The entire area is about 1200 sq. km.
- It constitutes of sandstone, coal, carbonaceous clay, shale etc.

# Satpura basin





# Son- Mahanadi valley

- About 575 km long funnel-shaped Gondwana tract of Son Valley basin in the northwest and NW-SE trending Mahanadi Valley basin in the SE.
- Most of the coalfields are located in Rewa-Chattishgarh areas.
- The coalfields of Son Valley part include Singrauli, Sohagpur, Sonhat, Ramkola, Tatapani etc.
- The coalfields of Mahanadi Valley are Korba, Hasdo-Arand and Mand-Raigarh.



# Wardha Valley

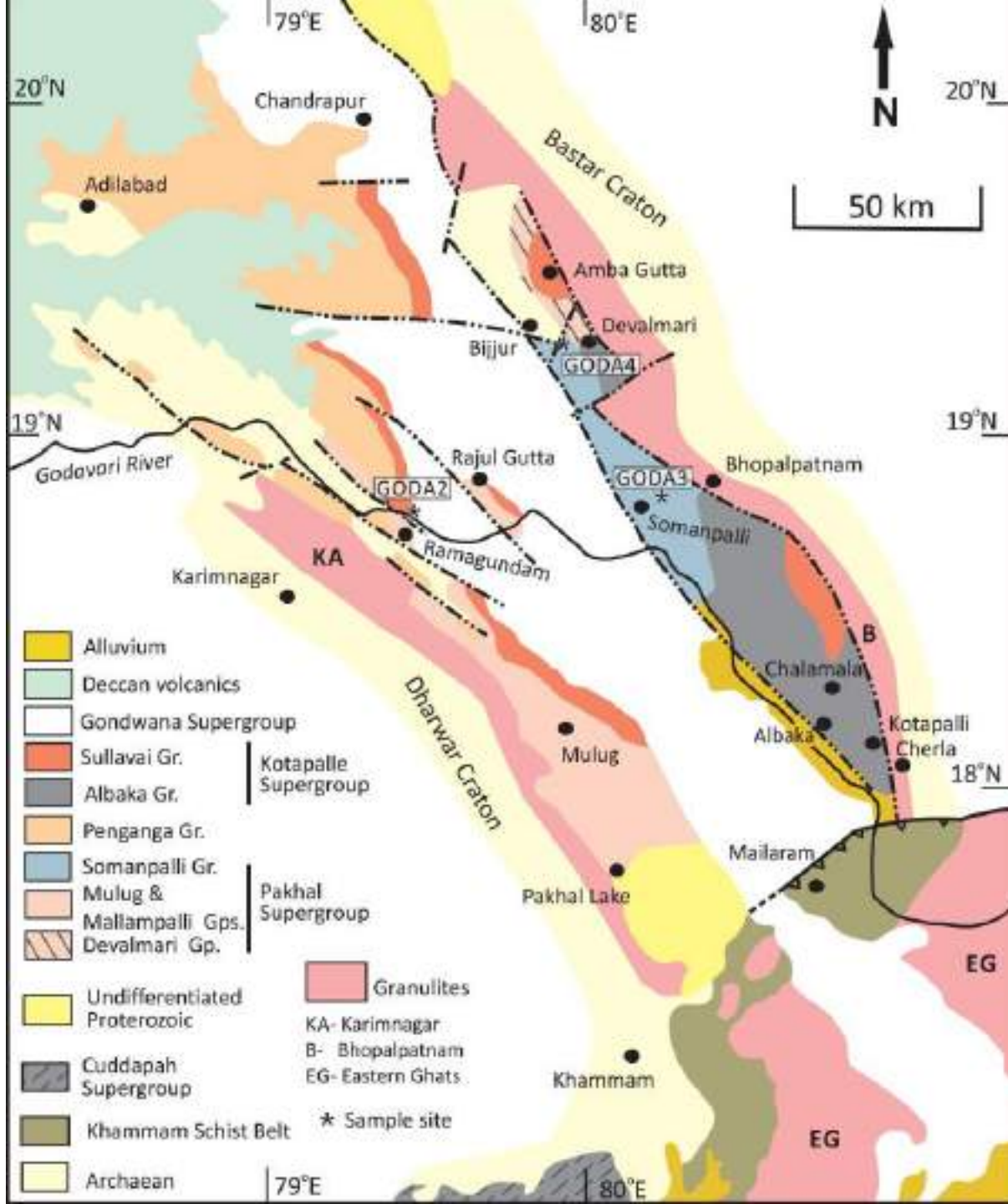
- The Gondwana rocks of the Godavari Valley extend northwest ward into the Wardha valley of Maharashtra.
- Important coalfields are located in an area of about 4150 sq. km. having similar geological succession to that of the Godavari Valley.
- The Wardha coal field is a broad anticline plunging NNW.

# Pranhita-Godavari Valley

- The NW-SE trending Pranhita- Godavari Valley is unique as it preserves about 3000 m thick sediments deposited in a time span of 200 Ma from late Carboniferous/ early Permian to Cretaceous.
- Most of the coalfields are located along the western margin at Sirpur, Chelpur, Pasara, Lingala, Bellampalli, etc. whereas Cherla and Manuguru are located in the east.
- Three prominent faults pattern are identified in the Pranhita-Godavari Gondwana basin -
  - (i) NNW-SSE trending syndepositional faults that controlled sedimentation and grabens/ half-grabens development.
  - (ii) NW-SE faults that imparted echelon fabric to south western margin, and
  - (iii) the NE-SW transverse faults, oriented parallel to the grain of the eastern Ghat Mobile belt transecting the Godavari valley basin into different sub-blocks.



# THE PRANGHITA-GODAVARI PART OF THE GONDWANA BASIN



# Rajmahal Hills

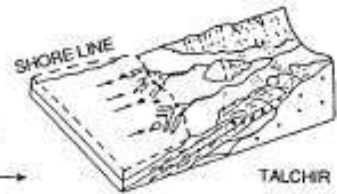
- It is situated in the north eastern part of the Jharkhand State, preserve Gondwana Formation comprising Talchir, Barakar and Dubrajpur Formations.
- These are overlain by the Rajmahal Formation made up of a series of basaltic lava flows and associated inter-trapping beds.
- The Rajmahal Traps are predominantly composed of fine grained to coarsely crystalline dolerite.
- These Traps are plateau basalts characterised by the absence or rare occurrence of olivine.

**DEPOSITIONAL  
ENVIRONMENT OF THE  
GONDWANA BASIN**



RAPID TRANSPORT AND DEPOSITION  
IN UNEVEN GLACIATED VALLEYS AND  
WATER BODIES

**A**

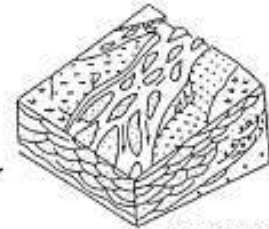


TALCHIR



EARLY PERIODIC UPLIFTS, GENERALLY  
RAPID TRANSPORT ON STEEPER  
SLOPES, RAPID SUBSIDENCE AND  
RAPID TO SLOW DEPOSITION

**B'**

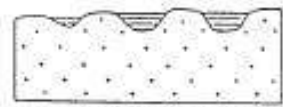


KARHARBARI

**B''**



BARAKAR



GENERALLY SLOWER TRANSPORT BY  
SINUOUS RIVERS WITH GENTLE SLOPES,  
RAPID SUBSIDENCE AND SLOW TO RAPID  
DEPOSITION, OCCASIONAL MARINE  
INGRESSION IN LOW LYING TERRAIN

**C**

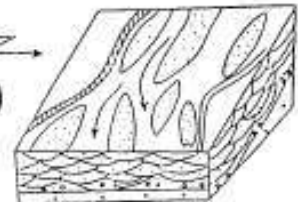


RANIGANJ/BARREN MEASURES



UPLIFT, RAPID TRANSPORT, RAPID  
SUBSIDENCE AND GENERALLY  
RAPID DEPOSITION

**D**



PANCHET/SUPRA-PANCHET



# FLORA OF THE GONDWANA

## Flora

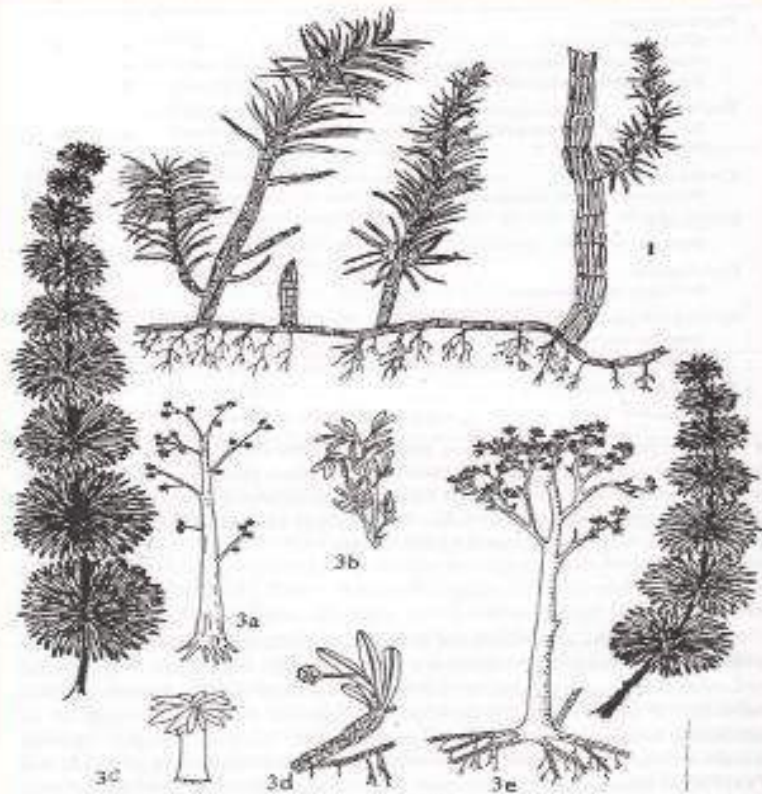


Plate 7.1. 1 - Reconstruction of the plant *Phyllothea indica* (Lower Gondwana). 2a-b, Reconstruction of the plant *Raniganjia bengalensis* (Lower Gondwana). 3a-e, Reconstruction of the plant *Glossopentis* (Lower Gondwana). (Courtesy: B.S. Venkatachala and N.C. Meisra), (reproduced with permission from the Editor of the Palaeobotanist).

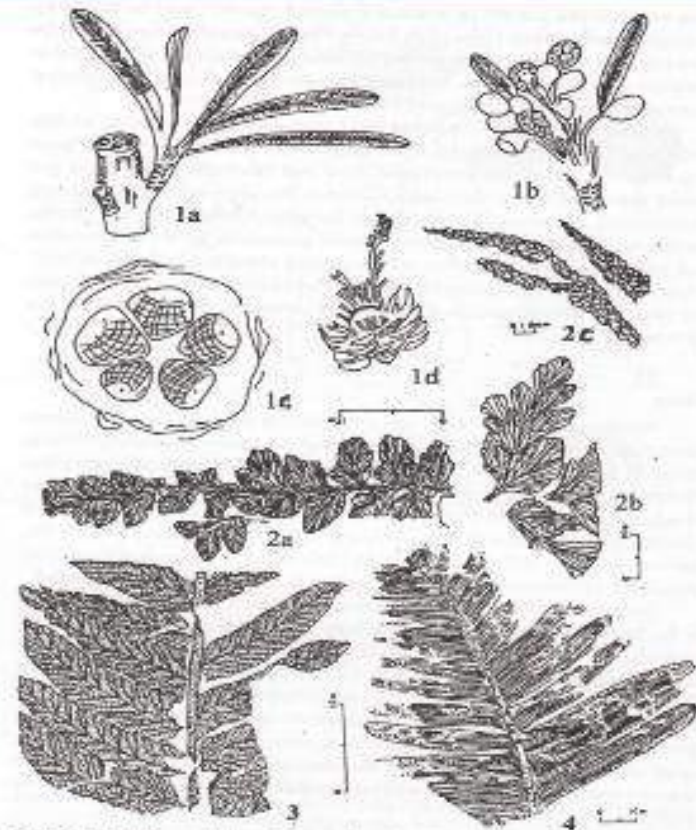
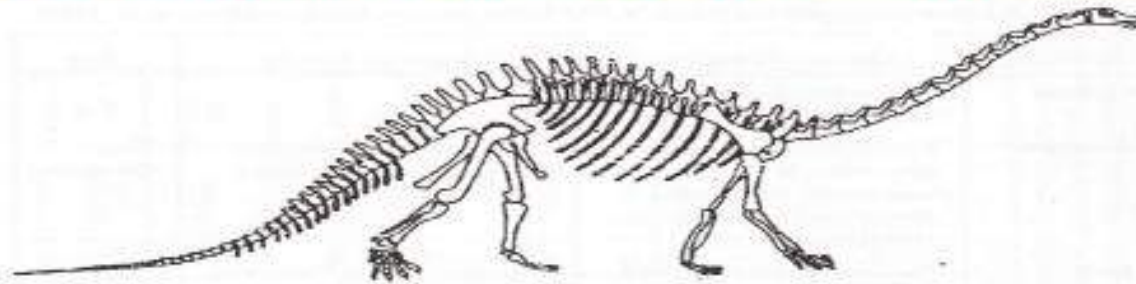


Plate 7.2. 1a-d - Reconstruction of *Psittacium sabulii* (Upper Gondwana). 2a, *Thrinaxella thronoxylonii* (Upper Gondwana). 2b, *Sphenopteris hirsuta* (Upper Gondwana). 2c, *Brachyphyllum mantillou* (Upper Gondwana). 3, *Cladophlebis indica* (Upper Gondwana). 4, *Psittacium moritzianum* (Upper Gondwana). (Courtesy: B.S. Venkatachala and N.C. Meisra), (reproduced with permission from the Editor of the Palaeobotanist).

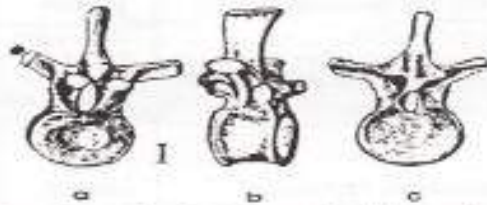


# FAUNA OF THE GONDWANA

## Fauna—reported from Kota Formation of Krishna-Godavari tract



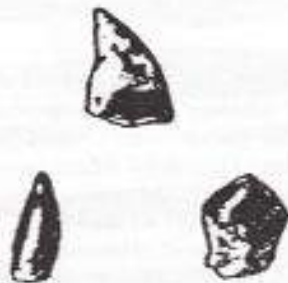
*Kotasaurus Yamanapalliensis*, a sauropod dinosaur skeleton reconstructed and mounted by the Geological Survey of India at Birla Museum, Birla Science Centre, Hyderabad.



Dorsal vertebra in (a) anterior (b) anterior-lateral (c) posterior views. The bar is 5 cm



A molar tooth of a micromammal from lower Jurassic Kota Formation



Teeth of dinosaurs, lower Jurassic Kota Formation



A complete humerus (fore limb element) of Sauropod dinosaur





*Dropstone in Talchir Formation, Gondwana Supergroup, Khirsadoh village.*



## Economic significance in the Gondwanas

- **Coal.** The Barakar and Raniganj Formation of the Damuda Group constitute the most important coal bearing rock formations. All of the Gondwana coal is of bituminous variety.
- **Iron Ore.** About 760m thick ferruginous shales, known as the "Iron stones shales". These shales form a deposit of sideritic iron ore which contains about 40-50% iron.
- **Clay.** The clays of various types are found in abundance in the Gondwana rocks. These clays are used for making refractory bricks, pottery and china ware.
- **Stone Buildings.** The Gondwana sandstones is generally of inferior quality. However, some of it is being used as building stone.



Cont.....

- Most of the Gondwana coal is found in the Damuda series.
- Gondwana land comprises India, Australia, Africa, S. America and Antarctica
- Reserves of grade- A in Gondwana coalfields on India. Non- cooking coal production in almost all the states other than Assam, Arunachal Pradesh, Meghalaya, Nagaland are graded on the bases of useful heat value in kcal/ kg. coal from Assam, Arunachal Pradesh, Meghalaya, Nagaland are not graded.

**Table 1. Generalised tectono-stratigraphic-sedimentary events of Gondwana succession of Peninsular India**

Stratigraphic events	Dominant lithofacies and facies models	Dominant paleoslope
Late Gondwana Facies (Late Jurassic-Early Cretaceous)	Largely Alluvial Fan Dominantly conglomerate and coarse to medium sandstone and subordinate red shale	Southerly and southeasterly directed palaeoslope
----- Unconformity -----		
Main Gondwana Facies (Early Permian-Late Triassic and Early Jurassic)	Braided and Meandering Streams Fining upward fluvial cycles of conglomerate, coarse to medium sandstone interbedded fine sandstone-shale, shale with or without coal	Northwesterly directed paleoslope through space and time
----- Gradational contact -----		
Early Gondwana Facies (Permo-Carboniferous)	Glacial and Fluvio-glacial Tillite, conglomerate, coarse to medium sandstone, varve, shale	Palaeoic transport was directed towards northwest and northeast, and locally towards east and west
----- Unconformity -----		
Late Archaeans / Middle to Late Proterozoics		



TABLE 4. DIAGNOSTIC FEATURES OF GONDWANA STAGES/FORMATIONS\*

Stage/Palynol. Composition	Formation	Region	Characteristics
—	Kota	Pranhita-Godavari	Top: limestone and calcareous shale; middle: red mudstone; base: sandstone with pebbles of banded chert.
	Dharmaram	NW Pranhita-Godavari	Alternating pebbly coarse crossbedded sandstone and red mudstone.
	Parsora	Umaria	Medium to coarse sandstone with micaceous mudstone mottled in violet and red; distinguished from Pall and Tiki Formations by presence of mottled mudstone and absence of feldspar.
Supra-Panchet	Supra-Panchet	All except Rajmahal, Umaria, Pranhita-Godavari, Krishna-Godavari	Febbly to conglomeratic coarse sandstone with ferruginous siltstone and clay beds.
	Dubrajpur	Rajmahal	Same as Supra-Panchet Formation but with rare carbonaceous shales.
	Tiki	Umaria	Red mudstone and sandstone.
	Maieri	NW Pranhita-Godavari	Red and green mudstone with lenses of sandstone, in places distinctly white.
	Unnamed in Kom-mugudem-A	Krishna-Godavari	Sandstone, minor shale.
—	Unnamed in Kom-mugudem-A	Krishna-Godavari	Sandstone, minor shale
	Bhimaram Sandstone	NW Pranhita-Godavari	Coarse sandstone with red clay.
	Yerrapalli	NW Pranhita-Godavari	Red or green mudstone.
	Denwa	Satpura	Red clay and subordinate yellow sandstone.
	Panchet / VI	Panchet	All except Umaria, Satpura, Kamptee, Wardha, Pranhita-Godavari
Upper Pall		Umaria	Interbedded chocolate to green shale and sandstone.
Pachmarhi Sandstone		Satpura	Coarse white crossbedded sandstone with layers of pebbles.
Upper Kamthi		Kamptee, Pranhita-Godavari	Coarse argillaceous sandstone with abundant quartz and quartzite pebbles in the upper part, and brick-red siltstone.
Middle Kamthi		Kamptee, Pranhita-Godavari	Coarse argillaceous sandstone with clasts and lenses of purple siltstone.
Raniganj / V	Raniganj	All except Umaria, Ib River, Satpura, NW Pranhita-Godavari	A return to the style of deposition of the Barakar Formation: fining-upward cycles of coarse to medium sandstone, interbedded with fine sandstone or siltstone and carbonaceous shale, and coal.
	Middle Pall	Umaria	Green to reddish shale and white sandstone with interbedded coals.
	Kamthi	Ib River	Barren redbeds.
	Lower Kamthi	NW Pranhita-Godavari	Grayish-white calcareous sandstone and coal.
	Bijori	Satpura	Sandstone, carbonaceous shale, and coal.
Barren Measures / IV	Barren Measures	All except Umaria, Satpura, Kamptee	Repetitions of channel-shaped crossbedded coarse to medium sandstone interbedded with siltstone and ironstone shale; no coal.
	Lower Pall	Umaria	Red-brown clay and sandstone with carbonaceous shale.
Barakar / III	Motur	Satpura, Kamptee	Coarse sandstone with occasional clays and calcareous nodules.
	Barakar	All	Finning-upward cycles of coarse to medium sandstone interbedded with fine sandstone or siltstone and carbonaceous shale, and coal.
Karharbari / II	Karharbari	All	Top: fining-upward cycles surmounted by coal; middle: multistory and multilateral coalescing channel-shaped bodies of pebbly coarse and medium sandstone; base: clast-supported conglomerate.
Taichir / I	Taichir	All	Tillite associated with conglomerate and sandstone, interbedded with rhythmite (fine sandstone-siltstone and shale) and greenish shale. In places, the rhythmite contains ripple- and flaser-bedding, in others dropstones; in others again, it contains turbidites deposited by underflow in lakes.

\*Tiwari and Tripathi, 1988, and Gastry et al., 1977, updated by references cited in the text.



# NOTES

Gondwana Basins of India account for nearly 99% of coal resource of the country. The basins occur along major river valleys either as discrete bodies or are unified by post-Permian strata and are named after the Rivers Damodar, Son, Mahanadi, Godavari etc or the linear hill ranges like Satpura and Rajmahal. Upto five km thick strata, deposited over 200 million years, from Upper Carboniferous to Lower Cretaceous, are preserved in these basins and are clubbed into Gondwana Supergroup. Upper Cretaceous Lameta-Bagh beds and Deccan Trap have not been included within Gondwana Supergroup since by that time India was completely separated from the rest of Gondwanaland and moved far towards north. Gondwana Supergroup is sub-divided into Permo-carboniferous Lower Gondwana Group, characterized by Gangopteris-Glossopteris flora and Mesozoic Upper Gondwana Group containing Dicroidium– Lepidopteris-Ptylophylum flora. The coal seams are found only in the lower group within Karharbari and Barakar Formations of Lower Permian and Raniganj Formation and its equivalents of Upper Permian age. Barakar Formation is the major storehouse of coal in all the basins having more than 90% of total resource of the country. Karharbari and Raniganj Formations present only in a few basins.

# GEOLOGICAL SETUP

The Gondwana Basins of Peninsular India occur along four major linear belts namely (1) Trans-Indian basin belt that include ENE-WSW trending Satpura and Son Valley Basins and EW to WNW-ESE trending Damodar-Koel Valley Basins (2) NNW -SSE trending Wardha-Pranhita-Godavari Valley Basin belt, (3) NW-SE trending Mahanadi Valley Basin belt that swerves to WNW-ESE direction in southernmost Talcher coalfield and (4) NNW-SSE trending Purnea-Rajmahal-Galsi basin belt. The Gondwana Basins of Bangladesh are often considered to be part of this fourth belt with easternmost exposure of Gondwana sediments at Singrimari in Meghalaya.

- In addition, in the eastern part of Extra-Peninsular India some isolated outcrops of Lower Gondwana Group occur as thrust sheets overriding the Neogene-Quaternary sediments extending from Arunachal Pradesh in the east to central Nepal in the west. Presence of Gondwana sediments have also been established in boreholes drilled in the offshore Bay of Bengal along the extension of Godavari and Mahanadi Rivers.

Apart from these traditional coal-bearing Gondwana Basins, sediments identical to the non-coal bearing basal part of Lower Gondwana Group of rocks are present in Jaisalmer Basin of Rajasthan, Salt Range in Punjab (Pakistan), along the Palaeo-Tethyan margin (stretching from Kashmir to Garhwal Himalaya) and along East Coast (in Palar and as a number of detached outliers).

Besides, the Mesozoic basins of Kachchh and Eastern Pericratonic basins have temporally overlapping relation with Gondwana Basins.

Although these basins are not generally included in the traditional Gondwana Basins, their geological history throws important light in the evolutionary history of Gondwana geology of India. Special emphasis needs to be given to Salt Range in Punjab (Pakistan),



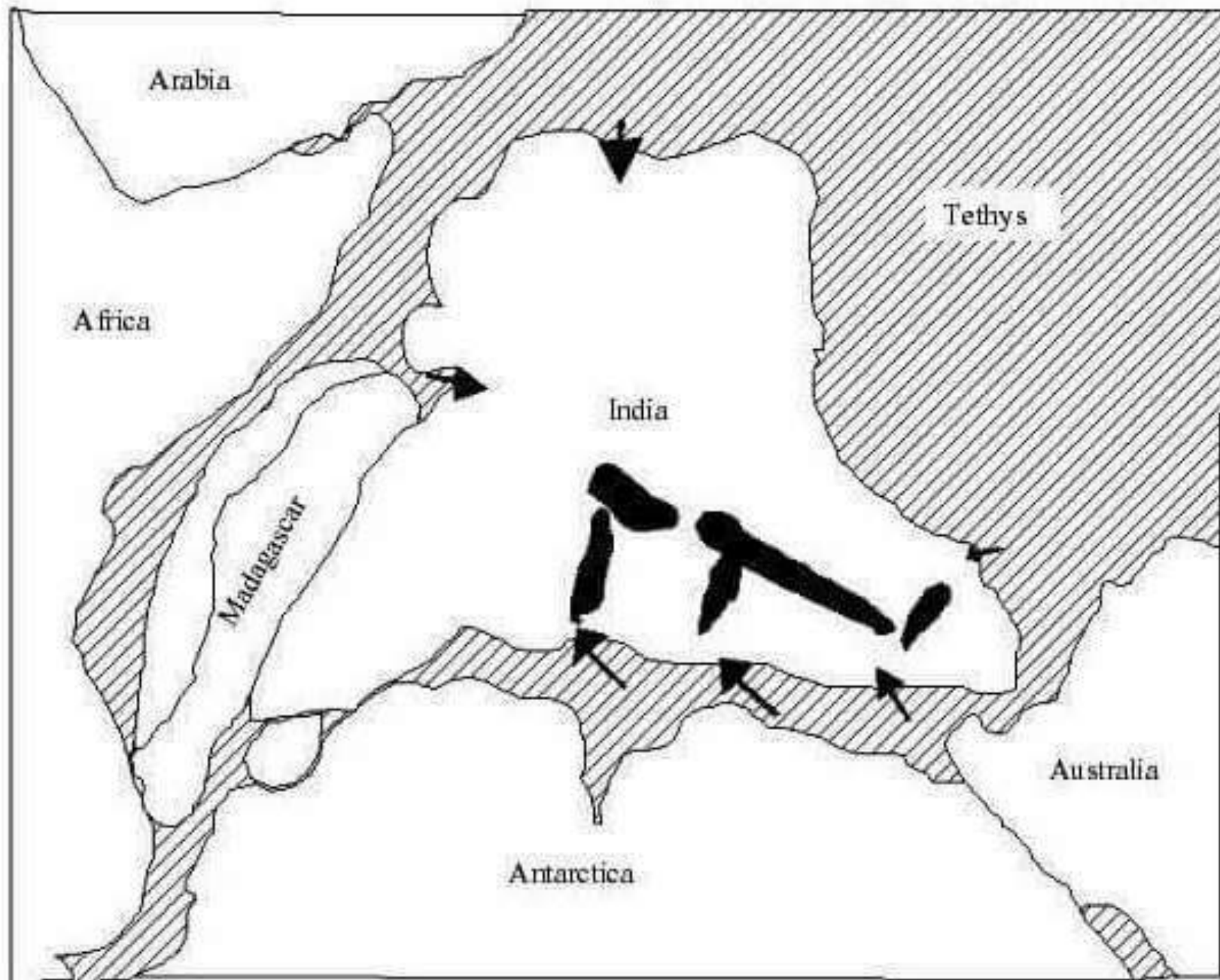
# MARINE INTERCALATIONS

Marine beds in association with Lower Gondwana rocks are known to occur at Umaria.

In Umaria Marine Beds, 3 meters shelly limestone containing fossils of shells of *Productus*, *Spiriferina*, *Reticularia* and others. The Umaria Marine Beds overlies the Talchir Boulder Beds but passes upwards without any visible break into the overlying Barakar rocks.

The fossil assemblage is suggestive of Lower Permian age and warmer climate. In Rajasthan marine beds equivalent to Umaria Marine Beds are known as Bap Beds after Bap village near Jaisalmer.

The marine beds also occur in several patches near Manendragarh in CG. The marine rocks occur in the basal part of the Talchir succession. The fauna includes *Protoretrepora*, *Spirifer*, *Aviculopecten*, *Eurydesma*, *Hyperammia* and *Glomospiria*. The total absence of *Productus* and abundance of *Eurydesmids* make these beds distinctly different from those at Umaria.



**Fig.2.** Likely pathways for Permian marine incursions