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PALYNOLOGY EVIDENCES OF HITHERTO UNRECOGNISED JURASSIC SEDIMENTATION IN RAJMAHAL BASIN, INDIA

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Key- words: palynology, Jurassic, Rajmahal Basin, India.

Abstract. In Rajmahal Basin the Upper Gondwana (Mesozoic) sequences are represented by the Dubrajpur and Rajmahal Formations. Palynologically, the Dubrajpur Formation is shown to be a time transgressive unit spanning from Early Triassic to Early Cretaceous. Out of seven palynological assemblages recorded from this formation four have Early Jurassic to Early Cretaceous age. *Arcuatipollenites tethysensis* Assemblage Zone represents the Late Triassic to Early Jurassic time interval. *Callialasporites turbatus* Assemblage Zone registers presence of dinoflagellate taxon *Phallocysta* indicating Late Early to Early Middle Jurassic age. The *Contignisporites cooksonii* Assemblage Zone has Late Middle Jurassic age. The topmost *Ruffordiaspora australiensis* Assemblage Zone represents Late Jurassic - Early Cretaceous age. The palynological information from Rajmahal Basin evidently reveals presence of nonmarine Jurassic sediments on Indian peninsula, on the contrary to the old assumption of their absence.

Riassunto. Nel Bacino di Rajmahal le sequenze del Gondwana superiore (Mesozoico) sono rappresentate dalle Formazioni di Dubrajpur e Rajmahal. Dal punto di vista palinologico, la Formazione di Dubrajpur si è dimostrata un'unità cronologicamente trasgressiva, estendendosi dal Triassico inferiore al Cretaceo inferiore. Delle sette associazioni palinologiche documentate in questa formazione, quattro hanno un'età dal Giurassico inferiore al Cretaceo inferiore. La Zona d'associazione ad *Arcuatipollenites tethysensis* rappresenta l'intervallo di tempo che va dal Triassico superiore al Giurassico inferiore. La Zona d'associazione a *Callialasporites turbatus* registra la presenza del taxon *Phallocysta*, che indica un'età dal tardo al medio Giurassico inferiore. La Zona d'associazione a *Contignisporites cooksonii* ha un'età del tardo Giurassico medio. La Zona d'associazione a *Ruffordiaspora australiensis* rappresenta un'età del Giurassico superiore-Cretaceo inferiore. L'informazione palinologica del Bacino di Rajmahal rivela la presenza di sedimenti giurassici non marini sulla penisola indiana, contrariamente a quanto finora definito.

Introduction

The Rajmahal hills are well known for the fossiliferous Intertrappean beds of the north-south trending Rajmahal Basin. The Upper Gondwana sequence in the Mesozoic strata of the Rajmahal Basin are represented by Dubrajpur and Rajmahal Formations (Rajarao 1987). The Rajmahal Formation records Early Cretaceous volcanic episode as traps. The Dubrajpur Formation, which is mainly arenaceous, overlies the coal bearing Permian horizons and is in direct contact with the overlying trap in the area (Tab. 1). It has been palynologically worked out in great detail (Tiwari et al. 1984; Tripathi et al. 1991; Tiwari & Tripathi 1995; Tripathi 2000, 2001; Tripathi & Ray in press). The palynological assemblages recorded from Dubrajpur Formation indicate presence of strata referable to Early Triassic,

ERA	PERIOD	LITHOSTRATIGRAPHIC UNIT	LITHOLOGY
MESOZOIC	EARLY CRETACEOUS (UPPER GONDWANA)	Rajmahal FM	Flows of basalt, pitchstone and intertrappean beds sandstone, shale, siltstone
			Unconformity
	TRIASSIC TO EARLY CRETACEOUS (UPPER GONDWANA)	Dubrajpur FM	Pebbly and coarse- to medium grained sandstone, siltstone, clay, grey to buff coloured shale
			Unconformity
LATE PALAEOZOIC	PERMIAN (LOWER GONDWANA)	Barakar FM	Coarse- to medium-grained and pebbly sandstone, grey shale, clay and coal
		Talchir FM	Tillite, fine- to medium - grained sandstone, olive green shale
			Unconformity
Pre-Cambrian			Basement rocks: amphibolite, quartzite, gneiss and granite

Tab. 1 - Geological succession in Rajmahal Basin (adapted after Rajarao 1987; Tiwari & Tripathi 1995).

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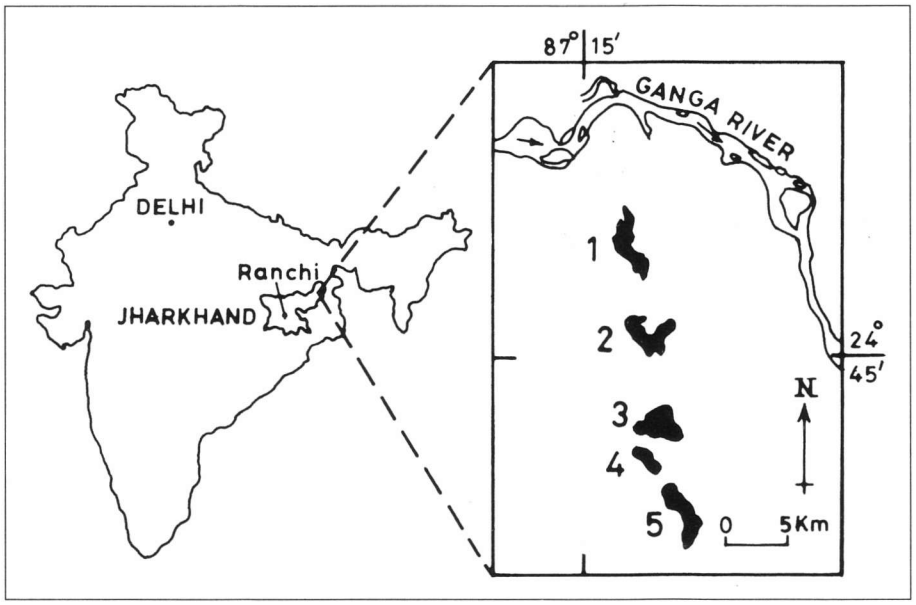


Fig. 1 - Map showing Rajmahal group of coalfields providing material for present analysis. 1 Hura, 2 Chuperbhita, 3 Pachwara, 4 Mahuagarhi, and 5 Brahmani coalfields.

Late Triassic, latest Triassic-Early Jurassic transition, late Early-early Middle Jurassic, and latest Jurassic - Early Cretaceous levels. Evidently the Dubrajpur Formation is a time-transgressive unit, ranging in age from Early Triassic to Early Cretaceous. The palynological spectrum recorded in the literature is neither continuous nor complete. The compositional change of palynoflora in various assemblages is not traceable. There are many palynostratigraphic gaps to be filled such as the palynoflora representing Early Jurassic, Middle Jurassic and Late Jurassic to understand the full spectrum through the Jurassic Period. Attempts to fill the gaps in the known palynological spectrum of Mesozoic sequence particularly Dubrajpur Formation in Rajmahal Basin have shown presence of new palynological assemblages. These assemblages significantly evidence for the presence of definite Jurassic strata in the Rajmahal Basin, which are presented in this paper.

Data base

The material for present paper originate from the following subsurface sequences (Figs, 1, 2):

1. Borehole RJMC-4, Mahuagarhi Coalfield (Present study)

2. Borehole RJKS-2, Brahmani Coalfield, Southern Extension (Present study)

3. Borehole RJR-2 , North eastern part of basin (Tiwari et al. 1984)

4. Borehole RJNE-32, Northern part of basin (Tiwari & Tripathi 1995; Tripathi 2000)

5. Borehole RCH-151, Chuperbhita Coalfield (Tripathi 2001)

6. Borehole RJP-49, Pachwara Coalfield (Tripathi & Ray in press)

Palynological analysis

The subsurface material representing Dubrajpur Formation from two boreholes RJKS-2, Brahmani Coalfield and RJMC-4, Mahuagarhi Coalfield have been analysed. The lithological units and depth from which palynomorphs were recovered are indicated in Fig. 3. The standard palynological processing techniques were used to extract the acid resistant organic matter. A variety of spores and pollen (Pl. 1, figs. 1-19) are observed. Their distribution pattern through the sequence is worked out. The quantitative analysis is based on the relative abundance of palynotaxa in a sample counted (more than 200 specimen) at random. A qualitative search for age marker spore-pollen taxa is also done to determine the First Occurrence in the studied sequence, which is evaluated for the First Appearance when rare and inconsistent. In Borehole RJKS-2 the over all composition of the palynoflora in the studied samples is the same. The lower part of the sequence is lithologically identified as of Barakar Formation (Lower Permian). But the studied material from this part shows similar spore pollen as observed in the strata pertaining to Dubrajpur Formation. The palynological constituents have dominance of gymnospermous pollen - *Podocarpidites*, *Callialasporites* and *Araucariacites* through out. However, on the basis of First Appearance as well as occurrence, determined from the rare and consistent presence of age marking taxa – *Contignisporites cooksonii* (Balme) Dettmann 1963 (at 123.70 m depth), *Ruffordiaspora australiensis* (Cookson) Dettmann & Clifford 1992 (at 105.60 m depth), and *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann 1961 (at 100.40 m depth) three assemblages – Assemblage - 1, 2, and 3 could be identified in successive order.

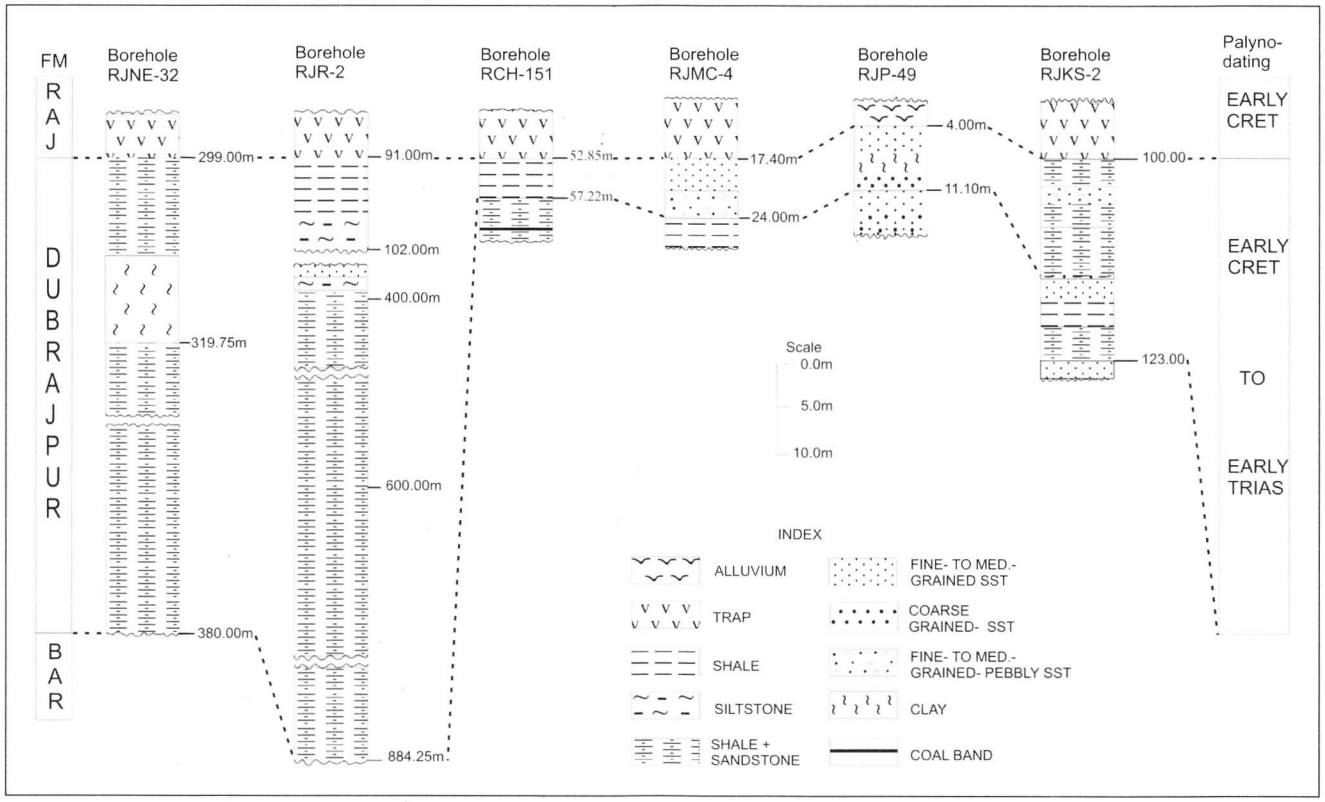


Fig. 2 - Lithological sequence in various boreholes exhibiting different lithofacies in Dubrajpur Formational Unit with palynological dating. FM=Formation, RAJ=Rajmahal, BAR=Barakar.

The Assemblage - 1 indicates Middle Jurassic while Assemblage - 2 and Assemblage - 3 indicate latest Jurassic to Early Cretaceous age, the transitional phase, when compared with Australian Jurassic palynozonation scheme (Helby et al. 1987; Burger 1995). The palynological observations made in the material from Borehole RJKS-2, Brahmani Coalfield, added new information filling the gaps- Middle Jurassic, and latest Jurassic – Early Cretaceous transition, in the palynological sequence of Mesozoic palynostratigraphy in Rajmahal Basin. Also it is significant to note that Assemblage-1 having Middle Jurassic age starts at 123.70 m depth which is lithologically referable to Barakar Formation.

The results of analysis from Borehole RJMC-4 show abundance of gymnospermous pollen *Araucariacites* in association with *Podocarpidites* and *Callialasporites*. The pteridophytic spores are rare. The age marker species *Ruffordiaspora australiensis* is recorded at 22.35 m depth while *Aequitriradites spinulosus* at 18.40 m depth (Fig. 3). On the basis of these key species the assemblage is correlated with the younger part of *Ruffordiaspora australiensis* Assemblage Zone (Dettmann et al. 1992; Burger 1995; Tiwari 1999; Vijaya 2000b; Tripathi 2002). The record from Borehole RJMC-4, new from the area, confirms the already known information in other parts of the basin (Tiwari et al. 1984; Tiwari & Tripathi 1995; Tripathi 2001).

Various palynological assemblages recovered from subsurface material in different parts of the basin are presented in Fig. 4. The characteristics of assemblages are more pronounced when analysed for the First Occurrence/Appearance of stratigraphically important taxa for the Upper Gondwana. For the precise dating and identification of stratigraphic levels the First Occurrence/Appearance Datum and proliferation of taxa (Tab. 2) at different stratigraphic levels is recorded.

The sequential occurrence of various assemblages and pattern of characteristics is shown in Fig. 5. Nine levels have been identified in terms of First Occurrence and /or Appearance, proliferation and composition of spore pollen taxa in the palynoflora of Dubrajpur Formation in Rajmahal Basin. The first level identified has dominance of taxa *Striatopodocarpites/Krempipollenites*. It is also characterised by presence of *Arcuatipollenites pellucidus*, *Alisporites asansoliensis* and *A. damudicus*, *Caytonipollenites* sp. - the Early Triassic marker species. The next level is dominated by *Satsangisaccites* associated with *Rajmahalispora* sp. The subsequent level still has dominance of *Satsangisaccites* but with different species composition. It contains *Dubrajisporites*, *Brachysaccus*, *Straruosaccites* and *Podocarpidites* spp. and shows the presence of *Infernopollenites claustratus* and *Minutosaccus* sp.

The next level is dominated by taeniate bisaccate pollen *Arcuatipollenites* associated with FAD of *Classo-*

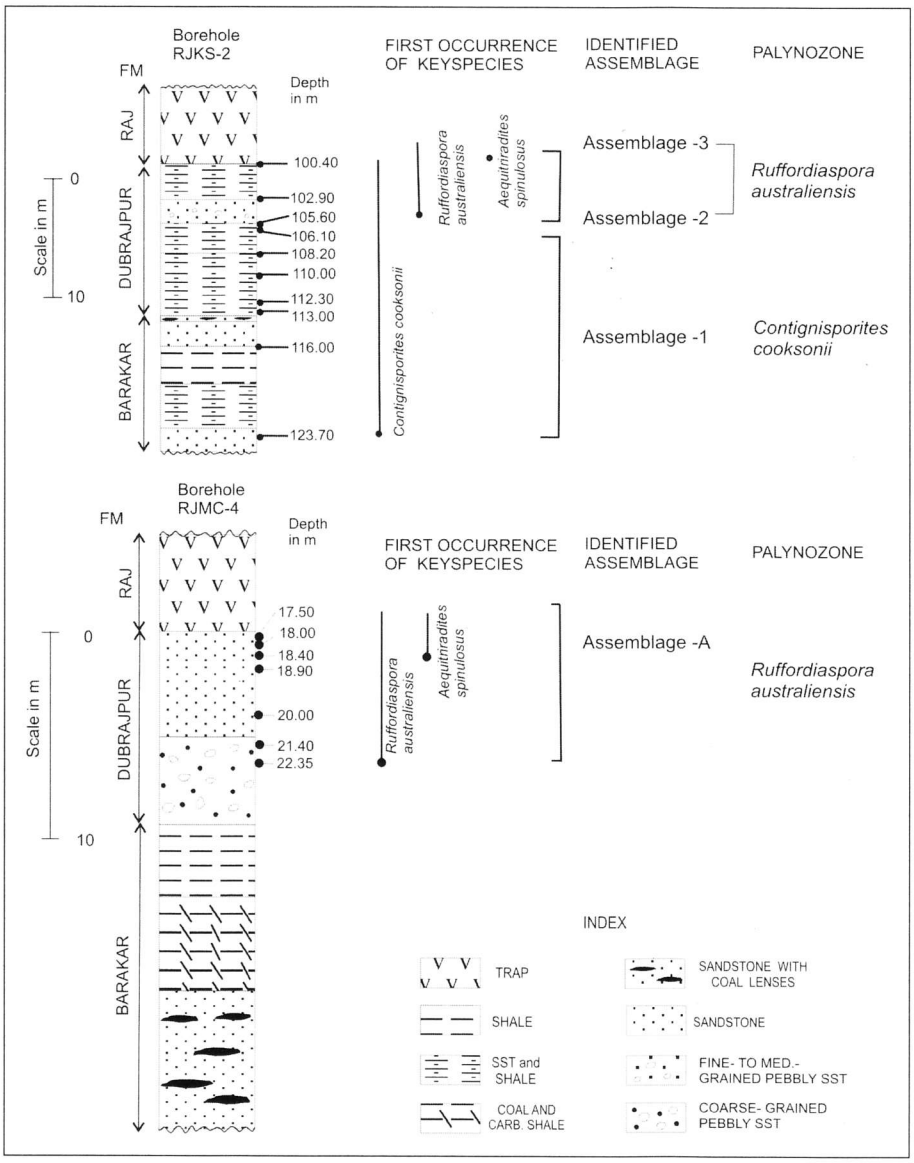


Fig. 3 - The Dubrajpur Formation in Boreholes RJKS-2, Brahmani Coalfield and RJMC-4, Mahuagarhi Coalfield, Rajmahal Basin with depth of palynological sample, First Occurrence of Key Species, palynological assemblages identified and their placement in the known Palynozones (Burger 1995) from Australia. FM=Formation, RAJ=Rajmahal.

BORE-HOLE / FORMATION	RJKS-2 (1)	RJMC-4 (1)	RJP-49 (2)	RCH-151 (3)	RJR-2 (4)	RJNE-32 (5)	GEOCHRONOLOGY
RAJMAHAL							EARLY CRETACEOUS
DUBRAJPUR	ASSEMBLAGE - 3	ASSEMBLAGE - A			ASSEMBLAGE - D, E	PALYNOLEVEL - 'O'	
	ASSEMBLAGE - 2						LATEST JURASSIC
	ASSEMBLAGE - 1						MIDDLE JURASSIC
				ASSEMBLAGE - 5			L.EARLY - E.MID JURASSIC
						ASSEMBLAGE - 1, 2	LATEST TRIASSIC / EARLIEST JURASSIC
					ASSEMBLAGE - B,C		LATE TRIASSIC
					ASSEMBLAGE - A		
			ASSEMBLAGE - II				EARLIEST TRIASSIC
BARAKAR	LATE PERMIAN PALYNOFLORA						LATE PERMIAN

Fig. 4 - Palynological assemblages recorded in Dubrajpur Formation and their placement in stratigraphic chronology. (1) Present Study, (2) Tripathi & Ray in press, (3) Tripathi 2001, (4) Tiwari, Kumar & Tripathi 1984, (5) Tiwari & Tripathi 1995.

Early Triassic	Late Triassic	Jurassic	Late Jurassic \ Early Cretaceous
Arcuatipollenites *Caytonipollenites* *Alisporites* *Krempipollenites* *Playfordiaspora* *Goubinispora* *Lundbladispora*	*Rajmahalispora* *Dubrajisporites* *Staurosaccites* *Infernopollenites* *Minutosaccus* *Enzonalasporites* *Clavatisporites* *Accintisporites* *Plicatisaccus* *Matonisporites* *Dictyophyllidites* *Classopollis*	*Callialasporites* *Trilites* *Polycingulatisporites* *Contignisporites* *Concavissimisporites* *Lycopodiacidites* *Klukisporites* *Alsophyllidites* *Boseisporites* *Biformaesporites*	*Murospora* *Ruffordiaspora* *Aequitriradites* *Coptospora* *Cooksonites* *Triporoletes* *Januasporites*

Tab. 2 - Important palynotaxa for various stratigraphic levels.

pollis meyerina de Jersey 1973 and *Callialsporites turbatus* (Balme) Schulz 1967, a latest Triassic event, and initiation of Jurassic elements respectively (Helby et al. 1987; Burger 1995). It shows the presence of other characteristic forms, such as *Enzonalasporites* spp., *Clavatisporites*, *Matonisporites*, *Dictyophyllidites*, *Accintisporites* and *Plicatisaccus*. This assemblage is suggestive of latest Triassic to earliest Jurassic age (Tripathi 2001).

After this level a change in the composition occurs. The palynocomposition is dominated by *Callialasporites*, specially *C. turbatus* - characteristic of Early Jurassic palynoflora (Filatoff 1975; Helby et al. 1987; Burger 1995) and contains also *Podocarpidites, Araucariacites, Nidipollenites, Satsangisaccites, Lundbladispora.* The last three taxa indicate continuity from Triassic palynoflora. A further change in the assemblage is seen at a still younger level. It shows the dominance of the nonstriate pollen *Podocarpidites* with species diversification in *Callialasporites* and incoming of new morphologies of trilete spores - *Biformaesporites* and *Boseisporites*. The special feature of this level is the presence of dinocyst *Phallocysta*, a marker taxon indicating late Early to early Middle Jurassic age (Tripathi 2001). The subsequent level shows continuity of *Callialasporites* dominance with species diversification. The FAD of *Contignisporites cooksonii* and species diversity in taxon *Concavissimisporites*, and *Klukisporites* characterise *Contignisporites cooksonii* Assemblage Zone, here identified, having age affinity with late Middle Jurassic (Filatoff 1975; Helby et al. 1987; Burger 1995). The next younger level shows further incoming of new pteridophytic and bryophytic (hilate) spores in *Araucariacites/ Podocarpidites* dominating assemblage. Here FAD of *Ruffordiaspora australiensis* and *Aequitriradites spinulosus* upsection suggests a latest Jurassic-earliest Cretaceous age.

Fm	Assemblage	Dominant Taxa	First occurrence of Marker Taxa	Other characteristics	Geochronology
D	*Ruffordiaspora australiensis*	*Araucariacites / Podocarpidites / Callialasporites*	*Aequitriradites*	Species diversity in costate and hilate spores, presence of *Foraminisporis, Januasporites, Triporoletes*	**Early Cretaceous**
U		*Callialasporites*	*Ruffordiaspora*	*Concavissimisporites, Klukisporites, Microreticulatisporites*	**Late Jurassic**
B	*Contignisporites cooksonii*	*Callialasporites*	*Contignisporites*	Proliferation of *Concavissimisporites, Klukisporites, Microreticulatisporites*	**Middle Jurassic**
R A	*Callialasporites turbatus*	*Podocarpidites*		Presence of dinoflagellate taxon *Phallocysta*, spore taxa *Biformaesporites* and *Boseisporites*	**Late Early to Early Middle Jurassic**
J		*Callialasporites*		Species diversity in *Callialasporites*	**Early Jurassic**
P U	*Arcuatipollenites tethysensis*	*Arcuatipollenites / Striatopodocarpites/ Satsangisaceites*	*Callilasporites turbatus, Classopollis meyerina*	Presence of *Enzonalasporites* spp., *Minutosaccus crenulatus, Accintisporites legatus Plicatisaccus badius*	**Late Triassic / Early Jurassic**
R	*Dubrajisporites triassicus*	*Satsangisaccites / Brachysaccaus*		Species diversity in *Dubrajisporites, Staurosaccites*	**Late Triassic**
	Rajmahalispora rugulata	*Satsangisaccites / Krempipollenites*		Species diversity in *Rajmahalispora*	**Early Late Triassic**
	Krempipollenites indicus	*Striatopodocarpites / Krempipollenites*		Presence of *Arcuatipollenites pellucidus, Alisporites damudicus, A. asansoliensis*	**Early Triassic**

Fig. 5 - Composite figure showing palynological assemblages recorded in Dubrajpur Formation, their characteristics in terms of dominant taxa, FAD of stratigraphically marker taxa, and their palynodating. Horizontal broken lines between the assemblages indicate the discontinuity of the palynoflora.

The occurrence of *Foraminisporis assymetricus* (Cookson & Dettmann) Dettmann 1963 and the species diversity of hilate and costate spores marks the youngest level recorded and suggests Early Cretaceous age (Tiwari & Tripathi 1995; Tripathi 2001; Vijaya 2000a).

Discussion

The palynological analysis of Mesozoic (Upper Gondwana) sequence in the Rajmahal Basin suggests a continuity of the palynoflora from the coal bearing horizon (latest Permian) in the lower part (Early Triassic) of Dubrajpur Formation and from upper part (Late Jurassic-Early Cretaceous) of Dubrajpur Formation to the intertrappean bed of Rajmahal Formation. Thus in these two levels no major palynological break is recorded despite the occurrence of lithological boundary between the coal in the lower part and the trap in direct contact with the upper part of Dubrajpur Formation. Palynologically the age of Dubrajpur Formation is inferred to be Early Triassic to Early Cretaceous (Tripathi & Ray in press; Tiwari & Tripathi 1995; Tripathi et al. 1991; Tripathi 2001). In between the two limits, lower and upper, the presence of Late Triassic-Early Jurassic and late Early-early Middle Jurassic and Late Jurassic palynoflora is recorded (Tripathi 2000, 2001; present paper). The non-yielding nature of the arenaceous lithofacies makes it difficult to understand the continuity of the palynoflora in the Dubrajpur Formation. The discontinuity of palynoflora may represent palynofloral break in between indicating hiatus in the sequence which are lithologically not very pronounced. In places it may be represented by the pebbly sandstone horizons in the Dubrajpur Formation.

The palynological information from the Jurassic deposits of India are not well known specially from Lower and Middle Jurassic. However, the record of uppermost Jurassic palynoflora is reported from different parts of India. Following Arkell (1956), the *Ptilophyllum* bearing Rajmahal Intertrappean beds were grouped into Early Cretaceous by Sarbadhikari (1978), Datta et al. (1983) and Mitra (1988), inferring the absence of non-marine Jurassic on the Indian Peninsula. With the availability of the radiometric ages of lava flows as ± 118 m.y. (Baksi et al. 1992) the emphasis on palynological dating of the underlying Dubrajpur sequence has shown presence of Jurassic deposits in the Rajmahal Basin. In contrast with the previous interpretations, but the report of Late Jurassic megafloral assemblage (Banerji 1990) from Dubrajpur Formation in the Rajmahal Basin.

Conclusion

Palynology has provided a good tool for the stratigraphic resolution of the Dubrajpur Formation. The palynological assemblages have helped to precisely correlate various portions of Dubrajpur Formation to the Mesozoic time scale. The discontinuity of the palynoflora and the non-yielding nature of the lithofacies leave a chance for further research to locate the hiatus precisely and workout the magnitude in other sequences of the Basin. This could be due to non-deposition or erosion at different levels in the sequence. On the basis of present work, the following conclusions are drawn.

(1) - The FAD of *Classopollis* and *Callialasporites* in the Late Triassic palynofloral composition, where *Arcuatipollenites* is the dominating taxon, represents a latest Triassic- earliest Jurassic age.

(2) - The occurrence of *Callialasporites turbatus*, a Jurassic taxon, suggests the onsetting of the Jurassic deposition.

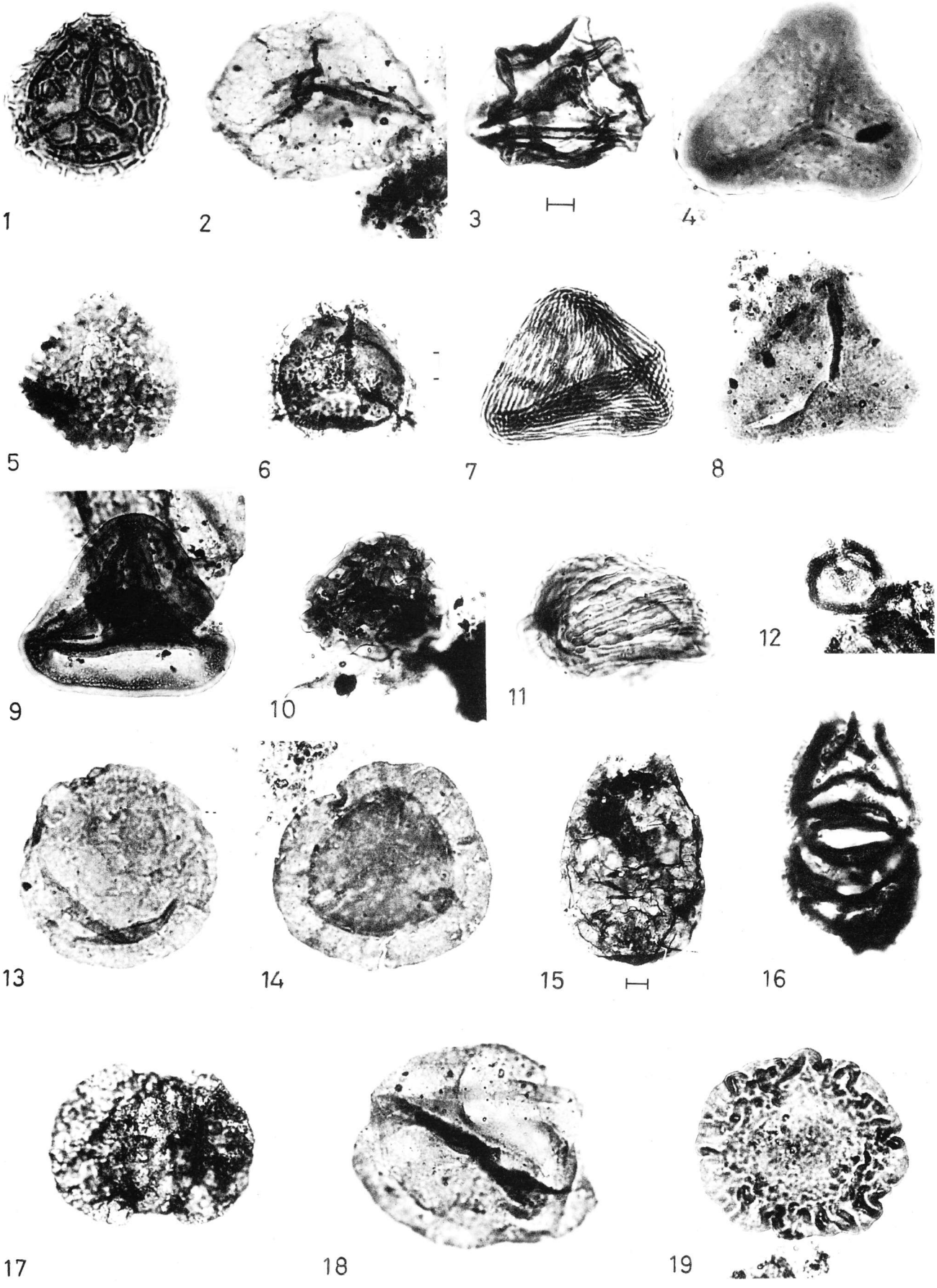
(3) - The proliferation of *Callialasporites* in terms of species diversity as well as abundance of specimens, reveals the presence of definite Jurassic deposits in the area.

(4) - The FAD of *Contignisporites cooksonii* suggests the presence of Middle Jurassic.

PLATE 1

Spore and pollen recovered from Dubrajpur Formation, Rajmahal Basin (Scale bar is 10 μm, scale in fig. 3 stands for all figures except fig.15).

Fig. 1 - *Retitriletes circolumenus* (Cookson & Dettmann) Backhouse 1978; Borehole RJMC-4, sample at 18.90 m depth. Fig. 2 - *Undulatisporites undulapolus* Brenner 1963; Borehole RJKS-2, sample at 123.70 m depth. Fig. 3 - *Duplexisporites* sp; Borehole RJKS-2, sample at 105.60 m depth. Fig. 4 - *Concavissimisporites verrucosus* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes 1963; Borehole RJKS-2, sample at 109.10 m depth. Fig. 5 - *Lycopodiacidites dettmanniae* Burger 1980; Borehole RJKS-2, sample at 109.00 m depth. Fig. 6 - *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann 1961; Borehole RJKS-2, sample at 100.40 m depth. Fig. 7 - *Ruffordiaspora australiensis* (Dettmann) Dettmann & Clifford 1992; Borehole RJKS-2, sample at 105.60 m depth. Fig. 8 - *Microreticulatisporites uniformis* Singh 1964; Borehole RJKS-2, sample at 109.00 m depth. Fig. 9 - *Dictyophyllidites venkatachalae* Ramanujam & Srisailam 1974; Borehole RJKS-2, sample at 123.70 m depth. Fig. 10 - *Klukisporites variegatus* Couper 1958; Borehole RJKS-2, sample at 123.70 m depth. Fig. 11 - *Contignisporites cooksonii* (Balme) Dettmann 1963; Borehole RJKS-2, sample at 109.00 m depth. Fig. 12 - *Classopollis meyerina* de Jersey 1973; Borehole RJNE-32, sample at 371.75-378.15 m depth. Fig. 13 - *Callialasporites microvelatus* Schulz 1967; Borehole RJMC-4, sample at 20 m depth. Fig. 14 - *Callialasporites turbatus* (Balme) Schulz, 1967; Borehole RJMC-4, sample at 20 m depth. Fig.15 - *Phallocysta* sp. ; Borehole RCH-151, sample at 52.85-53.85 m depth. Fig 16 - *Ruffordiaspora purbeckensis* (Dettmann) Dettmann & Clifford 1992; Borehole RJKS-2, sample at 100.40 m depth. Fig. 17 - *Podocarpidites ellipticus* Cookson 1947; Borehole RJKS-2, sample at 100.40 m depth. Fig. 18 - *Callialasporites trilobatus* (Balme) Dev 1961; Borehole RJKS-2, sample at 109.00 m depth. Fig. 19 - *Callialasporites segmentatus* (Balme) Srivastava 1966; Borehole RJMC-4, sample at 18.90 m depth.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(5) - The presence of the dinoflagellate taxon *Phallocysta* also confirms the dating of part of sequence to Early-Middle Jurassic and the presence of Jurassic deposits in Rajmahal Basin.

(6) - The sequential FAD of taxa *Ruffordiaspora australiensis* and *Aequitriradites spinulosus* in Dubrajpur palynoflora, which has compositional affinity with Rajmahal Intertrappean palynoflora, suggest deposition during Late Jurassic- Early Cretaceous and confirm the presence of latest Jurassic deposits in Rajmahal Basin, India.

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REFERENCES

Arkell W.J. (1956) - Jurassic geology of the world. Oliver & Boyd Ltd., London.

Baksi A.K., Tiwari R.S., Tripathi A. & Farrar E. (1992)- Geochemical, geochronological and palynological observations on Early Cretaceous lavas in the Rajmahal Basin. Symposium on Mesozoic Magmatism of the eastern Margin of India, Patna, Abstract: 16-17, Patna.

Banerji J. (1990) – Plant fossils from Dubrajpur Formation, Bihar and their significance in stratigraphy in : K.P. Jain & R.S. Tiwari (eds) –*Proc. Symp. Vistas in Indian Palaeobotany; Palaeobotanist,* 38: 122-130, Lucknow.

Burger D (1995) - Timescales: 8. Jurassic Australian Phanerozoic timescales, biostratigraphic charts and explanatory notes. Second Series. *Bureau Min. Res., Record,* 1995/37: 1-30, Canberra.

Datta N.R., Mitra N.D. & Bandyopadhyay S.K. (1983) - Recent trends in the study of Godnwana basins of Peninsular and Extra-peninsular India. In : Bhandari *et al.* (eds.) - *Petroleum Asia Journal, ONGC, India*: 169-170, Dehradun.

Dettmann M.E., Molnar R.E., Douglas J.G., Burger D., Fielding C., Clifford H.T., Francis J., Jell P., Rich T., Wade M., Rich P.V., Pledge N., Kemp A. & Rozefelds A. (1992) – Australlian Cretaceous terrestrial faunas and floras: biostratigraphic and biogeographic implications. *Cretaceous Research,* 13: 207-262, Dorchester.

Filatoff J. (1975) - Jurassic palynology of the Perth Basin, western Australia. *Palaeontographica*, 154: 1-130, Stuttgart.

Helby R.J. Morgan R. & Partridge A.D. (1987) - A palynological zonation of the Australian Mesozoic. *Mem. Ass. Australasian Palaeontologist*, 4: 1-94, Rocklea.

Mitra N.D. (1988) - Indian Gondwana plate margin and its evolutionary history. *Palaeobotanist,* 36: 302-311, Lucknow.

Rajarao C.S. (1987) - Coal resources of Bihar (excluding Dhanbad District). *Bulletin Geol. Surv. India*, Ser. A 45 (IV): 300-322, Calcutta.

Sarbadhikari T.R. (1978) - The Jurassic break in the Indian Gondwana. *Bhu-Vidya, Geol. Inst. Presidency College*, 35: 1-8, Calcutta.

Tiwari R.S. (1999) - The palynological succession and spacial relationship of the Indian Gondwana Sequence. *Proc. Indian Nat. Sc. Academy,* 65, A,3: 329-375, New Delhi.

Tiwari R.S. & Tripathi, A. (1995) - Palynological assemblages and absolute age relationship of intertrappean beds in the Rajmahal Basin, India. *Cretaceous Research,* 16: 53-72, Dorchester.

Tiwari R.S., Kumar P & Tripathi A. (1984) - Palynodating of Dubrajpur and Intertrappean beds in subsurface strata of North eastern Rajmahal Basin. In: Tiwari R.S. (ed.) V Indian Geophytological Conference, *Palaeobotanical Society Spec. Public.*: 207-225, Lucknow.

Tripathi. A. (2000) - Palynological events during Late Triasic-Early Jurassic time in India. *Palaeobotanist*, 49: 399-408, Lucknow.

Tripathi A (2001) - Permian, Jurassic and Early Cretaceous Palynofloral assemblages from subsurface sedimentary rocks in Chuperbhita Coalfield, Rajmahal Basin, India. *Rev. Palaeob. Palynology* 113:237-259, Amsterdam.

Tripathi A (2002) - Role of pteridophytic spores in Early Cretaceous stratigraphy and demarcating the Jurassic-Cretaceous Boundary in India. In: P N Trivedi (ed.)- Advances in pteridology. *Pointer Publisher*: 268-279, Jaipur.

Tripathi A.,Tiwari R.S. & Kumar P. (1991) - Palynology of the subsurface Mesozoic sediments in Rajmahal Basin, Bihar. *Palaeobotanist*, 37: 367-388, Lucknow.

Tripathi, A. & Ray A. (in press)- Palynodating of coal bearing sediments in Pachwara Coalfield, Rajmahal Basin, Santhal Pargana, Bihar. *Geol. Surv. India, Spec. Public.*, Calcutta.

Vijaya (2000a) - Recognition of potential palynoevents in the Jurassic sequence of India and their correlation in Australia. *Geo Research Forum*, 6: 237-248, Zürich.

Vijaya (2000b)-Palynology of the Jurassic-Cretaceous transition in the Rajmahal Formation, West Bengal, India. *Alcheringa,* 24:125-133, Erskineville.