EARLY CRETACEOUS PALynomorphs, DINOFlagellates AND PLANT MEGAFOSSILS FROM THE RAJMAHAL BASIN, JHARKHAND, INDIA

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ABSTRACT

Palynomorphs, dinoflagellates and plant megafossils are recorded from the intertrappean beds of the Rajmahal Basin, Jharkhand, India. These beds are exposed at Moti Jharna, Sakrigali Ghat, Marari Pahar, Sonajuri and Kalkipara sites. The palynomorphs include Aracnariacites, Podocarpidites, Callialasporites, Coptoaspora, Cyathidites and Balmeiosporites. The dinoflagellate taxa observed are Batiacaspheara sp., Dissiliodinium sp. etc. Type A. The floral assemblage consists of Elatocladus sp., Ginkgoites, Sphenopteris, Pachypteris sp., Pterophyllites, Araucaria and Ptilophyllum. The composition of the present assemblage suggests the Early Cretaceous age for these intertrappean sites.

Keywords: Palynology, Megaflora, Early Cretaceous, Rajmahal Basin, India

INTRODUCTION

The Gondwana sediments of the Rajmahal Basin are a part of North-South trending Rajmahal-Purnea graben which extends over a large area of Jharkhand and West Bengal states, Eastern India. The associated intertrappean beds of Rajmahal Traps have been studied in detail due to its rich plant megafossil assemblage of Ptilophyllum flora (Sahni, 1932, 1948; Sahni and Rao, 1933; Rao, 1943; Vishnu-Mittre, 1956, 1958; Sharma, 1967, 1969, 1974, 1997; Sengupta 1988, Banerjee, 1993, 1995, 2000; Banerji and Jana 1996; Tiwari and Tripathi, 2008; Baksi et al., 1992). As a result, numerous genera of plant fossils belonging to the ferns, cycads and conifers have been reported from the Rajmahal Formation (Sengupta, 1988 and references therein). Among these Ptilophyllum, Pterophyllum, Dictyozamites, Taeniopteris, Williamsonia, Brachyloma, Thinnfeldia and Cladophlebis are the most common genera of plant fossils. The Rajmahal intertrappean beds are known with very poor animal fossil content, except one report of clupeiformes fish (Jhingrania roonwali) from the siliceous shales of an intertrappean bed exposed at Sakrighat (Mishra and Saxena 1964).

In the present study, an attempt has been made to undertake an integrated palynological and palaeobotanical study on the intertrappean sedimentary beds exposed in the northern and central part of the basin. The main aim of the present communication is to describe the new palynomorphs, dinoflagellate cysts and megafossil assemblage and discuss their implications for understanding the age of the intertrappean beds.

GEOGRAPHIC AND GEOLOGICAL SETTING

The Rajmahal Basin has one of the best developed sequence of the Upper Gondwana sediments which is known for its rich wealth of plant fossils since 1850. The basin comprises a series of volcanic lava flows (Rajmahal Traps) and associated intertrappean sedimentary beds. It is located in eastern Jharkhand, dominantly composed of basalt, occupies a surface area of about 4100 km2 and attains a maximum thickness of 600 meters (Fig. 1). Bull (1877) first conducted systematically geological mapping of the Rajmahal Basin and adjacent areas. Later, Sengupta (1988), Tiwari and Tripathi (1995), Tripathi (2008) presented a detailed account on litho- and biostratigraphic aspects of the Rajmahal Basin (Table 1).
The extent of the Rajmahal lava flow is not limited to the Rajmahal area only but drilling data have proved this to be extending up to the Burdwan, Galsi, Jalangi and Panagarh areas of West Bengal (Sengupta, 1988). Ramaswamy (1958) identified fifteen lava flows with eleven intertrappean beds in the Rajmahal Basin. Ghose et al. (1996) mentioned the occurrence of fifteen surface basaltic flows and twenty-eight subsurface lava flows that have been identified in the boreholes. The Rajmahal Formation is overlain at some places by the Dubrajpur Formation (Early Triassic-early Cretaceous), whereas in other places by the Barakar Formation (Early Permian) and with the Precambrian basement.

The intertrappean beds are very thin as compared to the thickness of individual lava flow in which thickness of intertrappen beds vary from a few centimeters to about 11m, whereas in subsurface these are up to 100m thick (Tripathi, 2008). These sedimentary beds are composed of sandstone, siltstone, arenaceous clay, white and grey colour baked shale, carbonaceous shale, tuffite and chert bed with *Ptilophyllum* flora. The intertrappean beds are well exposed in the southern, central and northern regions of Rajmahal areas.

For the present study, a number of intertrappean sites exposed at northern (e.g. Sakrigali Ghat, Mahadevganj, Moti Jharna, Mahraipur, and Murli Pahar) and central (e.g. Malipara, Nipania, Sonajurui, Amtala, Kalkipara, Amarjola and Gumapahar) regions of the Rajmahal basin have been investigated (Fig. 1). During the investigation, samples for palynofoils and plant megafossils were collected.
recovery of spore and pollen is rare and in few localities only. Similarly, the plant megafossils are either fragmentary, rare or totally absent. In none of the sections, fauna is observed. Table 2 gives the details of sections considered in the present study. The locality-wise details are described below.

**Moti Jharna, northern Rajmahal basin**

The scattered outcrops of the intertrappean beds are present near a locally famous Moti Jharna waterfall at Maharajpur village about 9.7 km southeast of Sahibganj town, Sahibganj District, Jharkhand. This section could be observed in the gorge at the Moti Jharna waterfall. It is difficult to find the base of the section and contact of trap and intertrappean bed. However, Ghose et al. (1996) observed two lava flows at Moti Jharna and an intervening intertrappean bed. A patch of greenish grey colour intertrappean consisting of green siltstone is exposed at a height of 102 m above the mean sea level (Pl. I, fig. A). The samples collected from the site have yielded some plant megafossils, palynomorphs, and dinoflagellate cysts.

**Sakrigali Ghat, northern Rajmahal basin**

The intertrappean section is exposed in a hillock under the Pir Baba’s Mazar, near the Sakrigali Ghat, on the right bank of the River Ganga around 5.9 km from northeast of Sahibganj town. The small hillock at Sakrigali Ghat was traversed from both side, i.e. towards river and village. One intertrappean bed could be located in the section towards river side. The base of
Table 2: Details of intertrappean sites, Rajmahal Formation, Jharkhand considered for the present study.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Locality</th>
<th>Elevation</th>
<th>Co-ordinates</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moti Jharna</td>
<td>102 m</td>
<td>N 25°12'25.6&quot; E 87°45'35.4'</td>
<td>Consist of khaki green siltstone, exact position of the beds is not clear, overlain and underlain by lava flows. Plant fossil present. One sample taken for palynology, rare yield</td>
</tr>
<tr>
<td>2</td>
<td>Sakrigali Ghat</td>
<td>--------</td>
<td>N 25°22'7&quot; E 87°15'5&quot;</td>
<td>Five samples 1 from sandstone and 4 from siltstone were taken for palynology study</td>
</tr>
<tr>
<td>3</td>
<td>Murali Pahar</td>
<td>94 m</td>
<td>N 25°12'36.0&quot; E 87°45'31.0&quot;</td>
<td>Mudstone, clay, plant fossils present, 9 samples were taken for palynology</td>
</tr>
<tr>
<td>4</td>
<td>Sonajuri</td>
<td>--------</td>
<td>----------------------</td>
<td>Hard chert rich in petrified woods, appears as if forest is preserved</td>
</tr>
<tr>
<td>5</td>
<td>Kalkipara</td>
<td>132 m</td>
<td>N 24°32'11.1&quot; E 87°35'07.1&quot;</td>
<td>Consist of medium to fine grained sandstone fossiliferous followed by hard siltstone, one sample for was collected for palynology</td>
</tr>
</tbody>
</table>

The intertrappean sequence is not exposed and overlain by the lava flow No. 2 (Pl. I, fig. B). The intertrappean beds consist of bluish grey siltstone, grey shales, and coarse grained grey sandstone (Fig. 2a). The grey siltstone of the sequence has yielded very few palynomorphs, but we could not find any megafloral remains from the site.

**Murali Pahar, eastern Rajmahal basin**

The Murali Pahar intertrappean site is located about 7.3 km east of Tinpahar village. Here intertrappean beds are exposed in front of Murali Mission Church (Pl. I, fig. C). The four lava flows with three intervening intertrappeans could be observed (Fig. 2b). The base of lava flow No. 1 is unexposed and is followed by 0.9 m thick sedimentary unit consisting of mudstone. The mudstone unit is succeeded vertically by basaltic lava flow No. 2 of about 8.5m thick. A thin, less than 1m thick sedimentary sequence is overlying the lava flow No. 2. This sequence is dominantly composed of clay and mudstone and overlain by very thin lava flow No. 3. A nearly 4.2m thick sedimentary sequence consisting of mudstone, siltstone and clay is intercalated within flows No. 3 and 4. Sediments from all these intertrappean beds were collected and processed; however, some palynomorphs and plant megafossils are recorded only from the clayey unit of the uppermost intertrappean bed.

**Sonajuri, eastern Rajmahal basin**

The Sonajuri locality is situated about 2.9 km west of Pakur town, Pakur District, Jharkhand. Here intertrappean beds, dominantly composed of hard chert have a very few scattered surface exposures. This site yields diverse remains of plant fossils and is especially rich in petrified woods.

![Fig. 2. Lithounits of the investigated sections of the Rajmahal Basin exposed at Sakrigali Ghat (a), Murali Pahar (b) and Kalkipara Pahar (c).](image-url)
EARLY CRETACEOUS PALYNOLOGICAL STUDIES OF THE RAJMAHAL BASIN

Plate II

EXPLANATION OF PLATE II
(All figures are ca 500X)
(1-14) Palynomorphs recovered from the intertrappean beds of Rajmahal Traps, Rajmahal Basin, eastern Jharkhand. 1-4, Type A; 1, showing granulose wall; 2, showing archaeopyle and the lid; 5-7, Batiacasphaera sp. 8, Dissilodinium; 9-10, Batiacasphaera levigata; 11, Podocarpidites grandis; 12, Callialasporites trilobatus; 13, Podocarpidites ellipticus; 14, Araucariacites australis.

Kalkipara Pahar, southern Rajmahal basin

This section is exposed about 1 km north of Kalkipara village and is located about 2.8 km northeast of Amrapara, Pakur District, Jharkhand. At Kalkipara Pahar, three lava flows and two intertrappean beds could be recognized (Fig. 2c). The base of lava flow No 1 is not exposed (PI I, figs. D-F). The intertrappean beds mainly comprise hard siltstone and medium to fine-grained fossiliferous sandstone. In this site, the plant fossils are very rare.
PALYNOLOGICAL AND PALAEOBOTANICAL OBSERVATIONS

The samples collected from various intertrappean beds are not rich in palynomorphs, dinoflagellates cysts and plant megafossils. The preservation of fossils is bad to fair. Following taxa are recorded in the present study.

Palynomorph Taxa
Cyathidites australis Couper, 1953
Cyathidites sp.
Callialasporites trilobatus (Balme) Dev, 1961
Callialasporites segmentatus (Balme) Srivastava, 1963
Podocarpidites ellipticus Cookson, 1947
Podocarpidites grandis Sah and Jain, 1965
Podocarpidites multesimus (Bolkhovitina) Pocock, 1962
Podosporites sp.
Araucariacites australis Cookson, 1947
Coptospora kutchensis Venkatachala, 1969
Balmesporites sp.

Reworked Palynotaxa
Callumispora Bharadwaj & Saluja, 1969
Densipollinotes Bharadwaj, 1962
Scheuringipollinotes Tiwari, 1973
Faunipollinotes Bharadwaj, 1962
Striatites Pant emend Bharadwaj, 1962
Striatopodocarpites Soritsch & Sedova emend Bharadwaj, 1962

Dinoflagellate Taxa
Batiacasphaera sp.
Batiacasphaera laevigata (Smelror) Feist-Burkhardt & Montell, 1997
Dissiliodinium sp.
Type A

Plant Megafossils
Ginkgoites rajmahalensis Sah and Jain, 1965
Elatocladus sp.
Sphenopteris sp.
Pachypteris sp.
Pterophyllum Brongniart, 1828

The assemblages are locality wise described below.

Motijharna Intertrappean Site

This is the first report of palynomorphs, dinoflagellate cysts and plant megafossils from this locality.

Palynomorphs: The yield of palynomorphs is rare to common and is shown in Pl. II, figs. A-N. The taxa recorded are Araucariacites australis Cookson, 1947; Callialasporites trilobatus (Balme) Dev, 1961; C. segmentatus (Balme) Srivastava, 1963; Podocarpidites ellipticus Cookson, 1947; P. grandis Sah and Jain, 1965; P. multesimus (Bolkhovitina) Pocock, 1962; Podosporites sp., Cyathidites australis Couper, 1953. Besides palynomorphs, some dinoflagellate cysts are also observed. These taxa are described below.

Batiacasphaera Drugg emend Dorhoffer & Davies, 1980
Batiacasphaera compta Drugg, 1970
Batiacasphaera laevigata (Smelror) Feist-Burkhardt & Montell, 1997.

(Pl. II, figs. 9, 10).

Discussion: Size 73.5-70.5 X 66.5-60.5 µm, spheroidal cyst without any inner body, exine 2.8 µm thick, scabrate and pitted, apical archaepyle, paratabulation indicated along archaepyle margin by zig-zag splitting.

Dissiliodinium Drugg, 1978
(Type species: Dissiliodinium golobulus Drugg, 1978)
Dissiliodinium sp.
(Pl. II, fig. 8)

Description: Cyst spherical in shape, wall is thin less than 1 µm and granulate, sculptural elements less than 1 µm, paratabulation lacking, compound archaepyle, apical paraplate remain attached to the hypocyst.

Remarks: Only one specimen is observed in the present assemblage.

Type A
(Pl. II, figs. 1-4)

Description: Size 76-100 µm, subspherical to lenticular in shape, single walled, with slight thickening on the margin, wall granulo-punctate, a subcircular to round angular archaepyle is present on one side, a circular to sub-circular area present beneath the opening, in compressed specimens it may be centric or eccentric.

Plant megafossils: The plant fossils recorded from this intertrappean bed include leaf impression of Ginkgoites rajmahalensis Sah and Jain, 1965; and Elatocladus sp. (Pl. IV, figs. A, B) with carbonized cast. However, no cuticular details could be recovered from it. It represents the first report of plant fossils from this locality.

Discussion: The pollen taxa recorded here are long ranging and occur from Jurassic to Early Cretaceous. No significant age marker taxa could be observed. Hence, precise age could not be defined on the basis of spore and pollen. However, the dinoflagellate taxa (Batiacasphaera, Dissiliodinium) are recorded in abundance together with above-mentioned palynomorphs. These indicate Early Cretaceous age to the intertrappean beds exposed at Motijharna site.

Palynofacies analysis: In the present study, amongst the palynofacies constituents following types of organic matter debris were identified (Pl. III, figs. A-H)

1) Black oxidized: black opaque organic matter debris, also known as inertinite in coal maceral terminology is derived from the hard plant part, produced by oxidation of terrestrial plant tissues. On the basis of their mode of genesis they are of two types.
   i) Unsorted semi-oxidized organic matter debris: mostly of in-situ origin, formed due to intermittent aerial exposure of depositional surface, derived from the nearby vegetation source indicating proximity to the shoreline.
   ii) Well-sorted equidimensional terrestrial woody particles: indicates physical reworking during transportation process, undergoes mechanical abrasion and biotic degradation resulting in rounding and sorting of the particles. They signify long distance transport and high energy conditions.

2) Brown degraded debris: poorly oxidized translucent to opaque higher land plant tissue where the cellular structure is not clearly visible. It originates due to incomplete oxidation of terrestrial plant litter. They occur in abundance in the coal and lignite bearing lithofacies and are indicative
of terrestrial nature of the depositional environment.

3) Structured, well-preserved organic matter debris: It is usually derived from the cuticle of higher land plants. Light yellow fragments with clear cellular structures are commonly designated as cutinite in coal maceral terminology. Its dominance is indicative of proximal depositional environment, rapid burial and good accommodation potential.

Palaeoecology: In the present palynological assemblage, dinoflagellate cysts are present in large numbers along with terrestrially derived organic matter (Fig. 3) indicating shallow marine environment of deposition. Though they are present in abundance, their diversity pattern is low with only three morphotypes indicating restricted marine setting and highly stressful environment of deposition. The well-sorted, equi-dimensional particles occur in large proportion suggesting hydrodynamic conditions of river channels or long distance transport. However, presence of well-preserved cuticle in the assemblage points to proximity to shoreline.

Sakarigali Ghat Site

Palynomorphs: The samples collected from this site yielded rare spore and pollen. These are Araucariacites australis Cookson, 1947; Podocarpidites ellipticus Cookson, 1947 and Callialasporites trilobatus (Balme) Dev, 1961. All the palynomorphs are long ranging from Jurassic to Early Cretaceous. Hence precise dating could not be achieved. The intertrappean bed exposed in the section towards the river did
not yield spore and pollen.

**Remarks:** Sah and Jain (1965) reported a rich assemblage of spores and pollen from the intertrappean bed exposed on the river side section. This has the composition of typical Early Cretaceous palynoassemblage consisting of taxa *Gleicheniidites mundus* Sah and Jain, 1965; *Deltoideospora triangularis* Sah and Jain, 1965; *Callispora bacularinux* Sah and Jain, 1965; *Conocavissiminispores minor* Sah and Jain, 1965; *Ceratosporites sp.*, *Paiciculuisporites increascence* Sah and Jain, 1965; *Cicatricosisporites australiensis* (Cookson) Potonie, 1956; *Ischyosporites irregularis* Sah and Jain; *Trilobosporites purvrollulentus* (Verbitskaya) Dettmann, 1963; *Foraminisporis sp.* cf. *asymmetricus* (Cookson and Dettmann) Dettmann, 1963, and species of *Callialasporites*, *Podocarpidites*, *Podocarpites*, *Araucariaeites*. It is to be noticed that the intertrappean beds analyzed by Sah and Jain (1965) is now under alluvium and the bed studied at present is quite high up in the succession.

**Plant megafossils:** The plant megafossils could not be observed in the presently traversed intertrappean beds.

**Discussion:** Sakrigali Ghat is one of the richest localities that yielded a variety of megafossils such as *Sphenopteris sakrigalensis* Sah (1966), *Ginkgoites* (Sah 1952), *Williamsonia santalensis* Sithole and Bose (Sithole and Bose 1953), and *Weltrichia santalensis* Sithole and Bose (Sithole and Bose, 1971). These megafossils have been recovered from a lower intertrappean bed adjacent to river water current. This fossiliferous bed is present under alluvium. The present intertrappean bed is younger to the one from where the plant megafossils were described by Sah (1966).

**Murali Pahar Intertrappean Site**

**Palynomorphs:** Rare yield of palynomorphs records taxa *Araucariaeites australis* Cookson, 1947; *Podocarpdites ellipticus* Cookson, 1947; *P. grandis* Sah and Jain, 1965; *P. multesusmus* (Bolkhovitina) Pocock, 1962; *Callialasporites trilobatus* (Balme) Dev, 1961; *Coptospora cutkhenensis* Venkatakshala, 1969; *Cyathidites sp.*, *Balmeisopites* sp. and microphyrocarpus. Again in the absence of marker taxa no precise age could be determined except the Early Cretaceous age.

**Remarks:** Besides above mentioned taxa, reworked Permian spore and pollen are also recorded. These are *Faunipollenites*, *Striatites*, *Striatopodocarpites*, *Scheuringipollenites*, *Densipollenites* and *Callumispores*.

**Plant Megafossil:** The strata in this bed are very uneven and with irregular surface. Here the assemblage consists of the taxa *Sphenopteris sp.*, *Pachypterus sp.* and fragmentary pieces of *Pterophyllum Brongniart* (Pl. IV, fig. D). The details of venation are not distinct due to uneven surface and comparatively coarse nature of the sediments.


**Discussion:** The above account does not provide precise age to the intertrappean bed except Early Cretaceous.

**Sonajuri Intertrappean Site**

**Palynomorphs:** The material did not yield spores and pollen.

**Plant megafossils:** The petrified ovulate *Araucarian cones* have been found from this locality in the present collection (Pl. IV, fig. C). The specimens of araucarian cones were small one and do not have enough site to add further morphological characteristics. The seed-bearing scales of *Araucaria* are not having any further detail than as described by Bohra and Sharma (1980) and Banerji and Jana (2003).

**Discussion:** The ovulate cones of *Araucaria* are known from Early Cretaceous. No precise age could be assigned to these beds.

**Kalkipara Intertrappean Site**

**Palynomorphs:** No palynomorphs could be seen.

**Plant megafossils:** From this area several petrified wood pieces were collected. But unfortunately in thin section none of the wood shows preservation. The taxa *Ptilophyllum* sp. is found here as impression from the Upper intertrappean bed.

**Discussion:** In the absence of palynomorphs and presence of woods and *Ptilophyllum* sp., no precise age could be assigned except broad Early Cretaceous age.

**CONCLUSIONS**

- This is the first report of palynomorphs, dinoflagellates and plant megafossils from Moti Jharna locality.
- Presence of taxa *Batiacasphaera Dissilodinium* indicates Early Cretaceous age.
- The palynofacies analysis indicates deposition at proximity to nearshore.
- Identification of a sequence of four traps and three intertrappean beds at Murali Pahar section and occurrence of fossils from third intertrappean bed was reported.
- Two intertrappean beds at Kalkipara were identified having scanty plant megafossils.

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EXPLANATION OF PLATE IV


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