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# Palynological events during Late Triassic-Early Jurassic time in India

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## ABSTRACT

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Recently acquired palynological data from Dubrajpur sediments show the presence of spore-pollen taxa diagnostic of the Late Triassic-Early Jurassic. The change in palynofloral composition is gradual and not abrupt. This palynosequence has been evaluated in terms of dominance/sub-dominance, overall composition and First Appearance Datums of specific biomarker genera, viz., *Stereisporites, Foveosporites, Dictyophyllidites, Nevesisporites, Lundbladispora, Enzonalasporites, Classopollis, Playfordiaspora, Striatopodocarpites, Arcuatipollenites, Infernopollenites, Staurosaccites, Minutosaccus, Podocarpidites, Araucariacites* and *Callialasporites*. On the basis of the changing pattern of palynological characteristics, seven palynoevents have been identified in the Late Triassic-Early Jurassic strata in Borehole RJNE-32, Rajmahal Basin, Bihar. The present palynoassemblages are compared with those published previously from the Late Triassic and Early Jurassic of India. The palynofloral transition from late Late Triassic to early Early Jurassic is reported in the Dubrajpur sequence.

**Key-words**— Palynology, Late Triassic-Early Jurassic, Dubrajpur Formation, Rajmahal Basin, India.

## भारत में अन्तिम ट्रायसिक-प्रारंभिक जुरासिक कल्प के दौरान घटित परागाणविक घटनाएँ

अर्चना त्रिपाठी

## सारांश

दुबराजपुर अवसादों से अभी हाल ही में प्राप्त किए गए परागाणविक आंकड़े अन्तिम ट्रायसिक-प्रारंभिक जुरासिक के बीजाणु-परागकण वर्गकों की निदानसूचक उपस्थिति प्रदर्शित करते हैं. परागाणुवनस्पतिजात संघटन में परिवर्तन अत्यन्त शनैः शनैः हो रहा है तथा आकस्मिक नहीं है. यह परागाणु अनुक्रम प्रभाविता/उपप्रभाविता, सम्पूर्ण संघटन तथा कुछ विशिष्ट जैव सूचक वंशों जैसे- *स्टीरेइस्पोराइटीज़, फोवियोस्पोराइटीज़, डिक्ट्योफ़िल्लीडाइटीज़, नीवेसिस्पोराइटीज़, लुण्डब्लेडाइस्पोरा, एन्ज़ोनालास्पोराइटीज़, क्लॉसोपोलिस, प्लेफ़ोर्डायास्पोरा, स्ट्रायाटोपोडोकार्पाइटीज़, आर्क्यूआटीपोलेनाइटीज़, इनफ़र्नोपोलेनाइटीज़, स्टाउरोसैक्काइटीज़, माइन्यूटोसैक्कस, पोडोकार्पाइडाइटीज़, अराउकेरियासाइटीज़* एवं *केलियालेस्पोराइटीज़* के आधार की प्रथम प्राप्ति के आधार पर मूल्यांकित किया गया है. परागाणविक अभिलक्षणों के परिवर्ती विन्यास के आधार पर बिहार की राजमहल द्रोणी के वेध छिद्र आर.जे.एन.ई.-32 में स्थित अन्तिम ट्रायसिक-प्रारंभिक जुरासिक स्तर में सात परागाणविक घटनाएँ अभिनिर्धारित की गयी हैं. वर्तमान परागाणु समुच्चय की तुलना भारत के अन्तिम ट्रायसिक एवं प्रारंभिक जुरासिक कल्प से पूर्व में प्रकाशित किए जा चुके समुच्चय के साथ की गयी है. दुबराजपुर अनुक्रम में अन्तिम-अन्तिम ट्रायसिक से प्रारंभिक-प्रारंभिक जुरासिक कल्प के बीच परागाणुवनस्पतिजातीय संक्रमण पाया गया है.

**संकेत शब्द**—परागाणुविज्ञान, अन्तिम ट्रायसिक-प्रारंभिक जुरासिक, दुबराजपुर शैलसमूह, राजमहल द्रोणी, भारत.

## INTRODUCTION

IN the earth's history, periodic events in Gondwana basins in India have left stratigraphic imprints from Early Permian to Early Cretaceous. The strata have been classified variously with different formational names (Fig. 2) in different basins (Sastry *et al.*, 1977). These formations have distinctive lithological and palaeontological characteristics. The Dubrajpur Formation of the Rajmahal Basin overlies the coal-bearing Permian sequence and is capped by the volcano-sedimentary pile of the Rajmahal Formation. The Dubrajpur beds consist of mainly coarse pebbly clastics with thin impersistent shale bands (Sengupta, 1985). Palynological analysis has shown it to be a time transgressive unit spanning the Triassic to Late Jurassic/Early Cretaceous (Tiwari *et al.*, 1984; Tripathi *et al.*, 1992; Tripathi, in press; Tripathi & Ray, in press). The present palynological data from subsurface Dubrajpur sediments reveal the presence of spore-pollen taxa diagnostic of Late Triassic - Early Jurassic age. The studied material comes from Borehole RJNE-32, in the northern part of the Rajmahal Basin (Fig. 1) drilled by the Geological Survey of India.

## PALYNOLOGICAL OBSERVATIONS

A variety of palynotaxa occur in the productive samples (Pl. 1, Figs 1-24). Qualitative as well as quantitative analysis of spore and pollen distribution through the Dubrajpur beds shows a sequential change which is gradual and not abrupt. The following observations are made at different depth levels in the Borehole RJNE - 32 (Fig. 3).

### 376·15-380·75 m depth

The poor yield of palynofossils permits qualitative assessment only and evidence for continuation of Permian forms with admixture of definite Triassic elements, viz., *Lundbladispora, Brachysaccus, Staurosaccites, Callumispora* and *Guttulapollenites*.

### 371·75-376·15 m depth

The assemblage is dominated by *Arcuatipollenites* together with *Lundbladispora*. Other associated taxa are *Matonisporites, Clavatisporites, Densoisporites,*

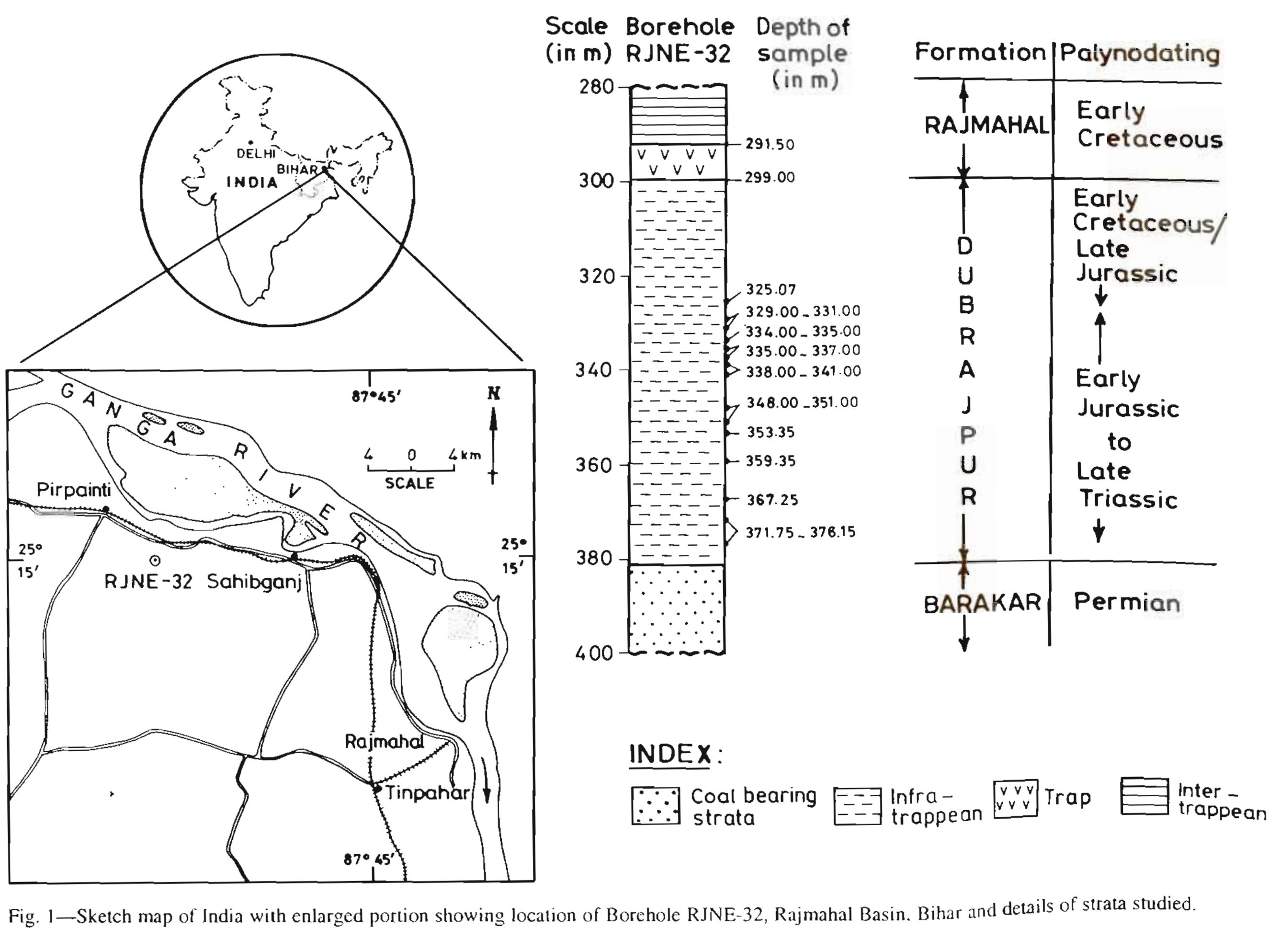


Fig. 1—Sketch map of India with enlarged portion showing location of Borehole RJNE-32, Rajmahal Basin, Bihar and details of strata studied.

| AGE \ AREA | | DAMODAR | RAJMAHAL | MAHANADI | SON | SATPURA | WARDHA GODAVARI |
|---|---|---|---|---|---|---|---|
| LOWER CRETACEOUS | | | RAJMAHAL | ATHGARH | | | |
| JURASSIC | UPPER | DURGAPUR BEDS | | | | JABALPUR | GANGAPUR / CHIKIALA |
| | MIDDLE | | | | | CHAUGAON | KOTA |
| | LOWER | | | | | | |
| TRIASSIC | UPPER | MAHADEVA | DUBRAJPUR | MAHADEVA | PARSORA | BAGARA | DHARMARAM |
| | MIDDLE | | | KAMTHI | | DENWA | MALERI BHEEMARAM |
| | LOWER | PANCHET | | | PALI | PACHMARHI | YERRAPALLI MANGLI |
| PERMIAN | UPPER | RANIGANJ | PACHWARA | RANIGANJ | | BIJORI | KAMATHI |
| | | BARREN MEASURES | | BARREN MEASURES | | MOTUR | MOTUR |
| | LOWER | BARAKAR | BARAKAR | BARAKAR | BARAKAR | BARAKAR | BARAKAR |
| | | KARHARBARI | KARHARBARI | KARHARBARI | KARHARBARI | KARHARBARI | |
| | | TALCHIR | TALCHIR | TALCHIR | TALCHIR | TALCHIR | TALCHIR |

Fig. 2—Showing various Permian-Jurassic formational units in various sedimentary basins in India.

*Ringosporites, Dictyophyllidites, Classopollis, Minutosaccus, Staurosaccites, Araucariacites* and *Callialasporites*.

## 367·25 m depth

The assemblage contains *Satsangisaccites* and *Arcuatipollenites* as dominant genera. Associated taxa include *Striatopodocarpites, Goubinispora, Converrucosisporites, Araucariacites, Callialasporites* and *Podocarpidites*.

## 353·35 and 359·35 m depth

The assemblage is dominated by *Striatopodocarpites* with abundant *Arcuatipollenites*. These are associated with *Satsangisaccites, Minutosaccus, Podocarpidites, Staurosaccites, Infernopollenites, Converrucosisporites, Triplexisporites, Ringosporites, Densoisporites, Enzonalasporites, Stereisporites* and *Foveosporites*.

## 338·0-341·50 and 348·00-351·00 m depth

The yield of palynofossils is poor. However, *Lundbladispora, Satsangisaccites, Minutosaccus* and *Podocarpidites* are identifiable. The presence of *Parasaccites* and *Plicatipollenites* indicate reworking from Permian sediments.

## 335·00-337·00 m depth

The genus *Arcuatipollenites* (particularly *A. tethyensis*) dominates the assemblage. Associated forms are *Striatopodocarpites, Lundbladispora, Densoisporites, Playfordiaspora, Satsangisaccites* and *Callialasporites*.

## 334·0-335·00 m depth

Among the poor yield of palynofossils, the genus *Callialasporites* is prominent, with *C. turbatus* as an important

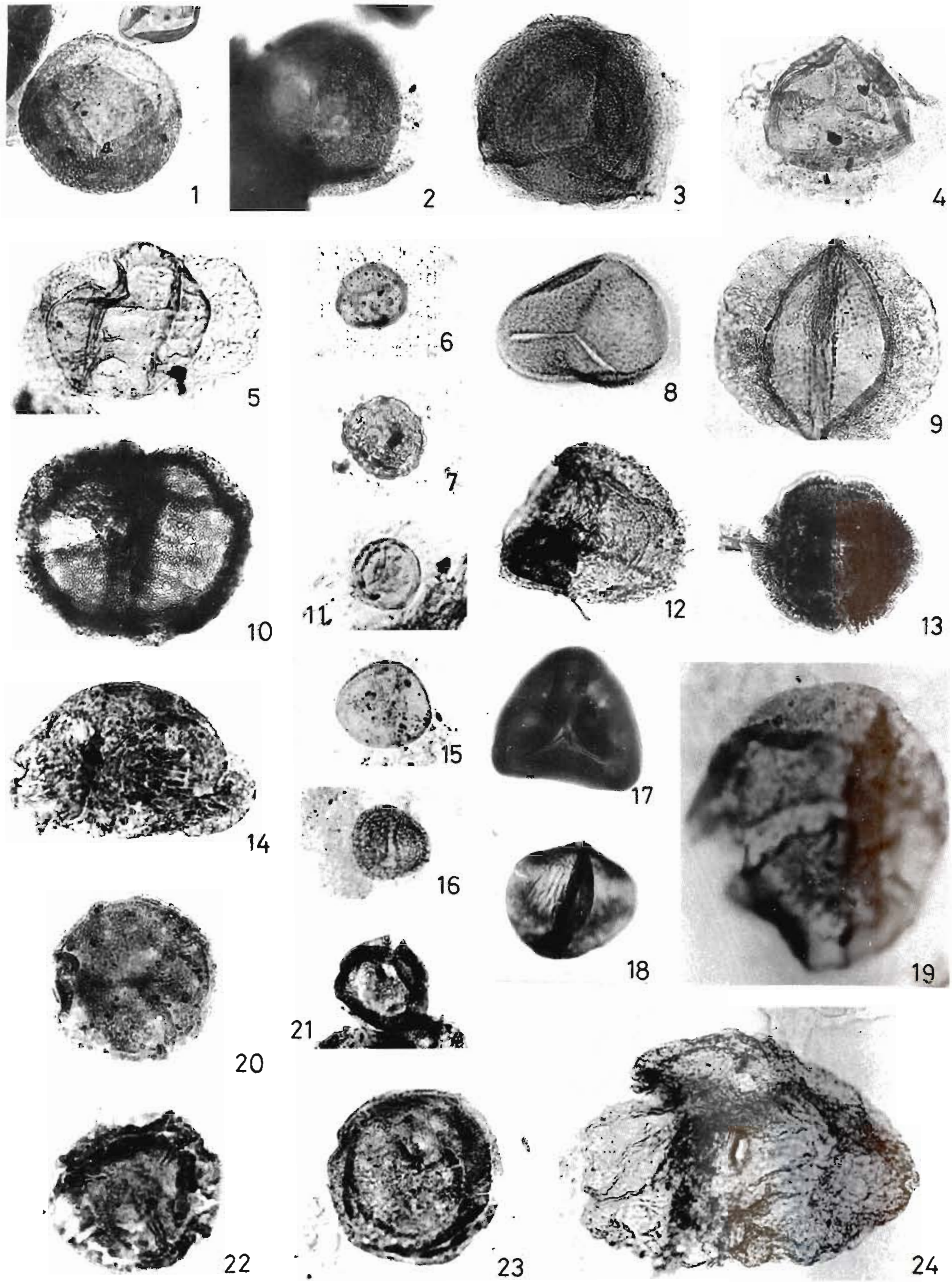


**PLATE 1**

species. Other taxa recorded are *Podocarpidites*, *'Nidipollenites*, *Satsangisaccites*, *Araucariacites*, *Osmundacidites* and *Lundbladispora*.

## 329·0-331·00 m depth

The meagre yield of palynomorphs includes *Callialasporites*, *Lundbladispora* and *Striatopodocarpites*.

## 325·07 m depth

The assemblage is dominated by *Araucariacites*. Also present are *Callialasporites*, *Podocarpidites*, *Osmundacidites*, *Gleicheniidites* and *Cycadopites*.

The assessment of the above palynofloral information permits identification of three assemblages in the Dubrajpur sequence.

1. Assemblage 1, designated as the *Arcuatipollenites tethyensis* Assemblage, is recorded from the 376·15-335 m interval. The FAD of *Classopollis* and *Callialasporites* is recorded at 371·75-376·15 m depth. The dominance of *Arcuatipollenites tethyensis* reflects a Late Triassic palynofloral composition.

2. Assemblage 2, designated as the *Callialasporites turbatus* Assemblage, occurs at 334-335 m depth. The dominant *C. turbatus* is associated with *Podocarpidites* and *Araucariacites* in the continuing Late Triassic palynofloral composition.

3. Assemblage 3, recorded from 325·07 m, is dominated by *Araucariacites* in association with other Late Jurassic - Early Cretaceous components. It is difficult to date Assemblage 3 in the absence of age diagnostic taxa. Hence the assemblage is not formally named.

## AGE DETERMINATION

A comparison of the present palynofloras with others published from Indian Late Triassic and Early Jurassic strata (Koshal, 1975, 1984; Lukose & Misra, 1980; Misra *et al.*, 1996; Maheshwari *et al.*, 1978; Tiwari & Tripathi, 1992; Prasad, 1997; Prasad *et al.*, 1995; Kumar, 2000) is shown in Figure 4 and is discussed below.

The composition of the palynoflora is definitely Triassic – Early Jurassic due to the presence of *Arcuatipollenites*, *Minutosaccus*, *Staurosaccites*, *Matonisporites*, *Clavatisporites*, *Dictyophyllidites*, *Triplexisporites*, *Ringosporites*, *Nevesisporites*, etc. The presence of *Enzonalasporites*, *Stereisporites*, *Foveosporites* and *Arcuatipollenites tethyensis* imparts a Late Triassic aspect at 371·75-376·15 m depth. *Minutosaccus crenulatus*, *Dictyophyllidites mortonii* and *Polycingulatisporites crenulatus* suggest a still younger aspect, i.e., Late Triassic (Norian-Rhaetic) to Early Jurassic (Hettangian). The appearance of *Classopollis* and *Callialasporites* at 371·75-376·15 m depth heralds a change in the palynological composition. Their introduction suggests a still younger dating. The presence of *Callialasporites* suggests the onset of Jurassic sedimentation. The establishment of *Callialasporites* in the older palynofloral association at 334·00-335·00 m depth indicates an Early Jurassic age (Helby *et al.*, 1987; Burger,

←

**PLATE 1**

(All photomicrographs x 500)

1 *Enzonalasporites vigens* Leschik 1955; sample depth 359·35 m; BSIP Slide No. 12424.
2. *Enzonalasporites densus* Dolby & Balme 1976; sample depth 359·35 m; BSIP Slide No. 12421
3. *Densoisporites velatus* Weyland & Krieger 1953; sample depth 353·35 m; BSIP Slide No. 12426.
4 *Playfordiaspora cancellosa* (Playford & Dettmann) Vijaya 1995; sample depth 353·35 m; BSIP Slide No. 12426.
5 *Arcuatipollenites tethyensis* (Vijaya & Tiwari) Tiwari & Vijaya 1995; sample depth 371·75-376·15 m; BSIP Slide No. 12420.
6. *Polycingulatisporites crenulatus* Playford & Dettmann 1965; sample depth 359·35 m; BSIP Slide No. 12422.
7. *Foveosporites moretoensis* de Jersey 1964; sample depth 353·35 m; BSIP Slide No. 12425.
8. *Cyclotriletes oligogranifer* Mädler 1964; sample depth 359·35 m; BSIP Slide No. 12423.
9. *Alisporites* sp., sample depth 353·35 m; BSIP Slide No. 12426.
10. *Plicatisaccus badius* Pautsch 1971; sample depth 353·35 m; BSIP Slide No. 12426.
11 *Ringosporites fossulatus* (Balme) Tiwari & Rana 1981, sample depth 359·35 m; BSIP Slide No. 12424.
12. *Lundbladispora brevicula* Balme 1963; sample depth 371·5-376·15 m; BSIP Slide No. 12418.
13. *Infernopollenites janarensis* Kumaran & Maheshwari 1980; sample depth 353·35 m; BSIP Slide No. 12426.
14. *Minutosaccus crenulatus* Dolby in Dolby & Balme 1976; sample depth 371·5-376·15 m; BSIP Slide No. 12419.
15. *Nevesisporites vallatus* de Jersey & Paten 1964; sample depth 359·35 m; BSIP Slide No. 12421
16. *Accinctisporites legatus* Leschik 1955; sample depth 359·35 m; BSIP Slide No. 12421
17 *Dictyophyllidites mortonii* (de Jersey) Playford & Dettmann 1965; sample depth 359·35 m; BSIP Slide No. 12422.
18. *Triplexisporites playfordii* (de Jersey & Hamilton) Foster 1979; sample depth 359·35 m; BSIP Slide No. 12424.
19. Granulate alete; sample depth 371.75 - 376.15m; BSIP Slide No. 12418.
20. *Callialasporites microvelatus* Schultz 1966; sample depth 334-335 m; BSIP Slide No. 12427.
21 *Classopollis meyerina* de Jersey 1973; sample depth 371·75-376·15 m; BSIP Slide No. 12418.
22. *Callialasporites dampieri* (Balme) Dev 1961, sample depth 371·75-376·15 m; BSIP Slide No. 12427
23. *Araucariacites australis* Cookson ex Couper 1953; sample depth 371·75-376·15 m; BSIP Slide No. 12419.
24 *Goubinispora morondavensis* (Goubin) Tiwari & Rana 1981, Sample depth 371·75-376·15 m; BSIP Slide No. 12420.

| Depth of yielding sample | Dominant Taxa | Other significant taxa | Characteristic feature of event | Event |
|---|---|---|---|---|
| 325.07 | *Araucariacites* | *Callialasporites, Podocarpidites, Osmundacidites, Gleicheniidites, Cycadopites* | Established Late/Early Jurassic Palynoflora | |
| 329.00 to 331.00 | Poor yield | *Striatopodocarpites, Plicatipollenites, Parassacites* | Reworking of Permian Palynomorphs | |
| 334.00 to 335.00 | *Callialasporites* | *Podocarpidites, Araucariacites, Nidipollenites, Satsangisaccites, Lundbladispora, Osmundacidites* | Proliferation of *Callialasporites turbatus* | 7 |
| 335.00 to 337.00 | *Arcuatipollenites* | *Striatopodocarpites, Lundbladispora, Densoisporites, Playfordiaspora, Satsangisaccites, Goubinispora, Callialasporites* | Proliferation of *Arcuatipollenites tethyensis* | 6 |
| 338.00 to 341.50 | Poor yield | | Reworking of Permian taxa | 5 |
| 348.00 to 351.00 | | *Lundbladispora, Minutosaccus, Satsangisaccites, Podocarpidites, Striatopodocarpites, Plicatipollenites, Parasaccites* | | |
| 353.35 | | *Arcuatipollenites, Satsangisaccites, Podocarpidites, Staurosaccites, Infernopollenites, Playfordiaspora, Nevesisporites, Ringosporites, Orbella* | | |
| 359.35 | *Striatopodocarpites* | *Arcuatipollenites, Satsangisaccites, Minutosaccus, Podocarpidites, Enzonalasporites, Triplexisporites, Ringospora, Cyclotriletes, Staurosaccites, Stereisporites, Foveosporites* | Striate bisaccate phase | 4 |
| 367.25 | Satsangisaccites | *Arcuatipollenites, Striatopodocarpites, Goubinispora, Podocarpidites, Araucariacites, Callialasporites* | Proliferation of nonstriate bisaccate | 3 |
| 371.75 to 376.15 | *Arcuatipollenites* | *Lundbladispora, Matonisporites, Clavatisporites, Ringosporites, Dctyophillidites, Classopollis, Minutosaccus, Staurosaccites, Araucariacites, Callialasporites* | FAD of *Callialasporites*, diversification of taeniate bisaccate and granulose alete | 2 |
| 376.15 to 380.15 | Poor yield | *Brachysaccus, Staurosaccites, Lundbladispora, Gutullapollenites, Callumispora* | Presence of Late Triassic palynotaxa | 1 |
| 381.00 | Typical | Late Permian Palynoflora | | |

1990, 1995). Thus the sequence under consideration contains a palynofloral transition from Late Triassic to Early Jurassic.

## PALYNOEVENTS

The palynoassemblages exhibit a gradual compositional change within which seven palynoevents are identifiable (Fig. 3).

**Palynoevent 1**-shows presence of *Brachysaccus*, *Staurosaccites* and *Lundbladispora*.

**Palynoevent 2**-is marked by dominance of *Arcuatipollenites*, FAD of *Callialasporites* and *Classopollis*, and abundance of microgranulate alete forms. *Minutosaccus crenulatus* and *Dictyophyllidites mortonii* are present.

**Palynoevent 3**-has abundant *Satsangisaccites* and *Arcuatipollenites*.

**Palynoevent 4**-shows abundance of *Striatopodocarpites* in association with *Arcuatipollenites*, *Minutosaccus* and *Enzonalasporites*.

**Palynoevent 5**-records reworking of Permian sediments.

**Palynoevent 6**-shows abundance of *Arcuatipollenites tethyensis* and absence of *Staurosaccites*, *Minutosaccus* and *Enzonalasporites*.

**Palynoevent 7**-records proliferation of *Callialasporites turbatus*.

## THE TRIASSIC-JURASSIC BOUNDARY

The Triassic-Jurassic boundary is less clarified than the Permian-Triassic, Jurassic-Cretaceous and Cretaceous-Tertiary, principally because of the floristically defined hiatus between Late Triassic and Early Jurassic sequences identified in various basins (Maheshwari *et al.*, 1978; Prasad *et al.*, 1995). The Geological Survey of India has opined that the Triassic-Jurassic boundary passes imperceptibly through the Dubrajpur Formation and the present palynological study confirms that view.

From the Indian Peninsula, there is no prior palynological report of the transition from the late Late Triassic to early Early Jurassic; rather, the hiatus has been observed (Prasad *et al.*, 1995). Kaushal (1975) described Rhaetic-Liassic — Late Triassic and Early Jurassic palynoassemblages from the borehole in Banni, Kachchh. That report does not provide enough details to comment on the palynological transition from the Late Triassic to Early Jurassic. However, the published palynological data from Australia clearly indicate that the latest Triassic palynofloras are rich in bisaccate pollen with the inception of *Classopollis* and the Early Jurassic palynofloras are either rich in or have dominance of the *Classopollis* group of pollen (Helby *et al.*, 1987; Burger, 1995). That taxon has palaeoenvironmental significance, showing diversification in coastal environments (Vakhrameev, 1981). Its occurrence as rare element in bisaccate dominated palynoflora may reflect a non-coastal (hinterland) situation for the presently studied Dubrajpur sequence. The Triassic/Jurassic boundary is drawn in Australia within the *Polycingulatisporites crenulatus* Zone (Helby *et al.*, 1987; Burger, 1990, 1995) which ranges from late Early Norian to early Late Hettangian. The present *Arcuatipollenites tethyensis* zone is comparable to the *Polycingulatisporites crenulatus* Zone of Australia (Fig. 5) in having *Polycingulatisporites crenulatus* and *Classopollis meyeriana*. Thus, the transition of Late Triassic-Early Jurassic palynoflora is evidenced in the presently identified *Arcuatipollenites tethyensis* Assemblage - I in the Dubrajpur Formation of the Rajmahal Basin. The current palynological observations made in the Dubrajpur sediments are indicative of a gradual transition of palynofloral composition particularly with reference to gymnospermous elements. The broad sequential order of palynofloral change, from oldest to youngest within the Late Triassic to Early Jurassic of the Rajmahal Basin is as follows:

MONOSACCATE POLLEN

↑

TAENIATE BISACCATE POLLEN

↑

STRIATE BISACCATE AND TAENIATE BISACCATE POLLEN

↑

TAENIATE BISACCATE POLLEN + CINGULATE TRILETE SPORE

## CONCLUSIONS

The palynological analysis of Dubrajpur sediments leads to the following conclusions:

1. The palynofloral composition indicates a Late Triassic-Early Jurassic age affiliation filling a previously unrecorded gap in the time transgressive Dubrajpur Formation.

2. Seven palynoevents are identified, based on abundances and appearances of particular palynotaxa and on the overall composition of assemblages.

3. The palynofloras of the Late Triassic and Early Jurassic are dominated by striated or taeniate bisaccate and

←

Fig. 3—Details of palynofloral compositions and palynofloral events recognised in Borehole RJNE-32, Rajmahal Basin, Bihar.

| SERIES | STAGES | SOUTH REWA (1) | SATPURA (2, 3) | KRISHNA GODAVARI (4) | JAISALMER (5) | KUTCH (6) | RAJMAHAL (7) |
|---|---|---|---|---|---|---|---|
| EARLY JURASSIC | HETTANGIAN | | | | Early Jurassic Palynozone | *Gliscopollis-Classopollis* Assemblage Zone | *Callialasporites turbatus* Assemblage Zone |
| LATE TRIASSIC | RHAETIC | | Palynoassemblage C | | Sumarwali Talai-2 Palynozone | *Rhaetipollis germanicus* Assemblage Zone | *Arcuatipollenites tethyensis* Assemblage Zone |
| | NORIAN | *Tikisporites balmei* Zone | Palynoassemblage B<br>Palynoassemblage A<br>Assemblage Zone I | *Enzonellasporites ignacii-Minutosaccus crenulatus* Assemblage Zone | | | *Dubrajisporites triassicus* Assemblage Zone<br>*Brachysaccus ovalis* Assemblage Zone |
| | CARNIAN | *Rimaesporites potoniei* Zone | Assemblage Zone II | *Rimaesporites potoniei Samaropollenites speciosus* Assemblage Zone | | | *Rajmahalispora rugulata* Assemblage Zone |

<table>
<tr><th colspan="2">Series</th><th>Stages</th><th>Rajmahal Basin<br>(1)</th><th>Australia<br>(2,3)</th></tr>
<tr><td rowspan="2">EARLY</td><td rowspan="2">JURASSIC</td><td>Sinemurian</td><td>Callialasporites turbatus Zone</td><td>Corollina torosa Zone</td></tr>
<tr><td>Hettangian</td><td rowspan="2">Arcuatipollenites tethyensis Zone</td><td rowspan="2">Polycingulatisporites crenulatus Zone</td></tr>
<tr><td rowspan="2">LATE</td><td rowspan="2">TRIASSIC</td><td rowspan="2">Rhaetic</td></tr>
<tr><td></td><td>Craterisporites rotundus Zone</td></tr>
</table>

Fig. 5—Correlation of Late Triassic-Early Jurassic palynological assemblages from Rajmahal Basin, India and Australia. (1) Present Study (2) Helby *et al.*, 1987 (3) Burger, 1990, 1995.

monosaccate taxa in the Rajmahal Basin in contrast to nonstriate bisaccate and *Classopollis* group respectively.

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Fig. 4—Comparison of Late Triassic and Early Jurassic palynological assemblages known from Indian Peninsula. (1) Maheshwari, Kumaran & Bose, 1978. (2) Nandi, 1996, (3) Kumar, 2000, (4) Prasad, 1997, (5) Misra, Prasad & Rawat, 1996, (6) Koshal, 1975, 1984, (7) Present study.

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