Palynology of the subsurface Mesozoic sediments in Rajmahal Basin, Bihar

Archana Tripathi, R. S. Tiwari & Pramod Kumar

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Palynological study of Mesozoic sediments (Late Triassic to Late Jurassic/Early Cretaceous) from a bore-hole RJR-2 drilled near Kazigaon Village in Rajmahal Basin has been done and 76 genera and 132 species have been recognised. Of them, one genus and 13 species are new. A check-list along with descriptions of new proposals have been given. The distribution of various species in Rajmahal and Dubrajpur formations is distinct. Palynological succession denotes three identifiable associations of the Late Carnian, Early Norian and Late Jurassic/Early Cretaceous age.

Key-words—Palynology, Dubrajpur Formation, Rajmahal Basin, Mesozoic (India).

Archana Tripathi, R. S. Tiwari & Pramod Kumar, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारांश

बिहार में राजमहल द्रोणी में विद्यमान उपसतही मध्यजीवी अवसादों का परागाणविक अध्ययन

अर्चना त्रिपाठी, राम शंकर तिवारी एवं प्रमोद कुमार

राजमहल द्रोणी में काजीगाँव के समीप आर-जे-आर०-2 नामक वेध-छिद्र से प्राप्त मध्यजीवी अवसादों (अनंतिम त्रिसंधी से अनंतिम जूराई/प्रारम्भिक क्रीटेशी) का परागाणविक अध्ययन किया गया है तथा इनमें 76 प्रजातियाँ एवं 132 जातियाँ अभिनिर्धारित की गई हैं। इनमें से एक प्रजाति तथा 13 जातियाँ नई हैं। नई जातियों सहित सभी वर्गकों की एक तालिका भी प्रस्तुत की गई है। उक्त अध्ययन से पता चलता है कि राजमहल एवं दुबराजपुर शैल-समूहों में विभिन्न जातियों का वितरण भिन्न-भिन्न है। उपलब्ध परागाणविक अनुक्रम में अनंतिम जूराई/प्रारम्भिक क्रीटेशी कालीन तीन अभिनिर्धारणीय साहचर्य प्रदर्शित होते हैं।

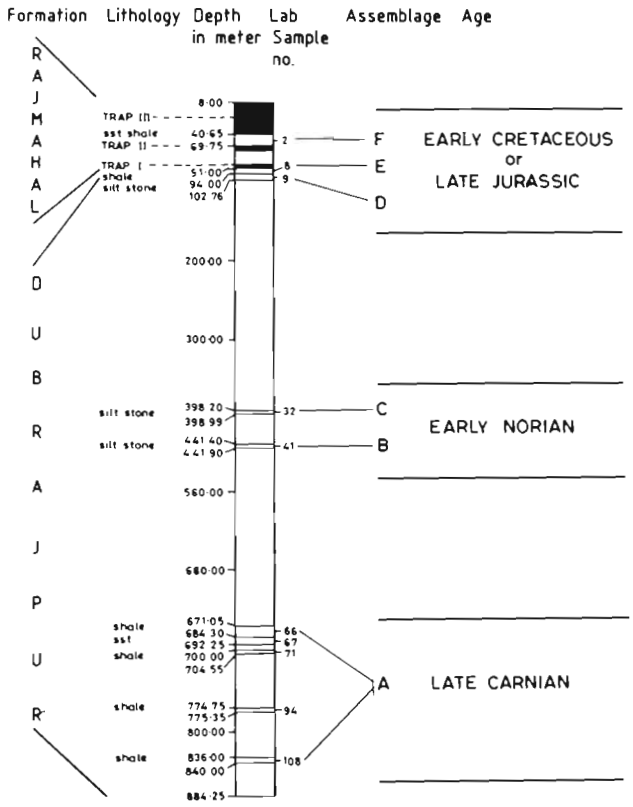
STUDY of dispersed spores and pollen in Mesozoic sediments of Rajmahal Basin dates back to nineteen-thirties when Rao (1936) analysed these strata for their palynological contents. A few more studies were made (Rao, 1943; Vishnu-Mittre, 1953, 1954) in the subsequent years till Sah and Jain (1965) systematically described spores and pollen from Rajmahal Intertrappean beds and dated it to be Late Jurassic.

Tiwari, Kumar and Tripathi (1984) analysed a palynological succession in the bore-hole RJR-2 and revealed the occurrence of five distinct assemblage zones (Text-fig. 2, p. 210) ranging in age from Late Carnian to Late Jurassic/Early Cretaceous. These palynological assemblages are highly diversified. Sequel to this study, the range of variation in delimitation of various species on the basis of finer morphological characters were recorded. The distribution of species through the succession of Dubrajpur and Rajmahal formations denotes their changing pattern which resulted in the identification of Late Triassic, Late Jurassic/Early Cretaceous strata.

The material comprises samples from the bore-hole RJR-2 (Tiwari *et al.*, 1984, table 1, samples marked with asterisks) representing Dubrajpur and Rajmahal formations (Text-fig. 1). This bore-hole is located in the north-eastern part of the basin near Kazigaon, between Rajmahal and Tinpahar, and represents a total depth of 884.25 m.

SYSTEMATIC PALYNOLOGY

A complete check-list of the palynotaxa found in assemblages A-F in bore-hole RJR-2 is given below. The taxa marked with an asterisk have been



Text-figure 1—Litholog showing various miospore assemblages recorded from yielding samples at corresponding depth levels.

commented upon in the text for their morphotaxonomy and nomenclature.

TRIASSIC ASSEMBLAGE

Todisporites major Couper 1958
Callumispora fungosa (Balme) Bharadwaj & Srivastava emend. Bharadwaj & Tiwari 1977
C. gretensis (Balme & Hennelly) Bharadwaj & Srivastava 1969 (Pl. 1, fig. 1)
Orbella indica Tiwari & Rana 1980
Converrucosisporites lunzensis Bharadwaj & Singh 1964 (Pl. 1, fig. 3; Pl. 6, fig. 7)
C. jenensis Reinhardt 1964
Guttatisporites guttatus Visscher 1966 (Pl. 1, fig. 2)
G. elegans Visscher 1966
Verrucosisporites densus Bharadwaj & Tiwari 1977
V. narmianus Balme 1970
V. carnarvonensis de Jersey & Hamilton 1967
V. bosei Maheshwari & Banerji 1975 (Pl. 1, fig. 4)
V. racemus (Peppers) Smith 1971
**V. kazigaonensis* sp. nov. (Pl. 1, figs 7, 8)
Osmundacidites senectus Balme 1963
O. pilatus Tiwari & Rana 1981 (Pl. 1, fig. 6)
Conbaculatisporites baculatus Bharadwaj & Singh 1964 (Pl. 1, fig. 10)
Convolutispora perfecta Kumaran & Maheshwari 1980 (Pl. 1, fig. 11)
Foveosporites triassicus Kumaran & Maheshwari 1980 (Pl. 1, fig. 12)
F. mimosae de Jersey & Hamilton 1967
Dictyotriletes aulius Rigby 1977 (Pl. 1, fig. 14)
Dubrajisporites triassicus Tiwari & Tripathi 1987 (Pl. 6, fig. 14)
D. bulbosus Tiwari & Tripathi 1987 (Pl. 6, fig. 4)
**D. unicus* sp. nov. (Pl. 1, figs 18, 22)
**D. isolatus* sp. nov. (Pl. 1, figs 17, 20, 21)
**Gabonisporis vigourouxii* Boltenhagen 1967 (Pl. 1, fig. 5)
**G. papillosus* sp. nov. (Pl. 1, figs 9, 13)
Densoisporites contactus Bharadwaj & Tiwari 1977
Rajmahalispora rugulata Tiwari, Tripathi & Kumar 1984 (Pl. 6, fig. 3)
R. triassicus Tiwari, Tripathi & Kumar 1984 (Pl. 6, figs 1, 2)
R. reticulata Tiwari, Tripathi & Kumar 1984
**Polycingulatisporites* sp. (Pl. 1, fig. 16)
**Indotriradites* sp. (Pl. 1, fig. 19)
Polypodiisporites mutabilis Balme 1970
Punctatosporites walkomi de Jersey 1962
**Divarisaccus* sp. cf. *D. strengeri* Bose & Kar 1966 (Pl. 2, fig. 10; Pl. 6, fig. 8)
Playfordiaspora cancellosa Maheshwari & Banerji 1975 (Pl. 1, fig. 23)
**Tetrasaccus* sp. (Pl. 2, fig. 13)
Platysaccus fuscus Goubin 1965
Podocarpidites alareticulatus Sah & Jain 1965 (Pl. 2, fig. 5)
P. rarus Singh, Srivastava & Roy 1964
P. grandis Sah & Jain 1965 (Pl. 2, fig. 2)
P. typicus Sah & Jain 1965 (Pl. 2, fig. 6; Pl. 6, fig. 11)
Alisporites landianus Balme 1970
A. grobus Bharadwaj & Tiwari 1977 (Pl. 2, fig. 4)
**Falcisporites minutosaccus* Kumaran & Maheshwari 1980 (Pl. 2, fig. 7)
F. nuthalensis (Clarke) Balme 1970 (Pl. 2, fig. 12)
F. snopkovae Visscher 1966 (Pl. 2, fig. 8)
Scheuringipollenites maximus (Hart) Tiwari 1973
Klausipollenites schaubergeri (Potonié & Klaus) Jansonius 1962
K. staplinii Jansonius 1962
K. vestitus Jansonius 1962
Brachysaccus ovalis Mädler 1964 (Pl. 2, fig. 18)

**B. triassicus* sp. nov. (Pl. 2, figs 16, 17)
Satsangisaccites nidpurensis Bharadwaj & Srivastava 1969 (Pl. 2, fig. 9; Pl. 6, figs 5, 6)
S. triassicus Bharadwaj & Srivastava 1969
Nidipollenites monoletus Bharadwaj & Srivastava 1969 (Pl. 2, fig. 1)
Staurosaccites quadrifidus Dolby 1976 (Pl. 3, fig. 5)
S. tharipatharensis Maheshwari & Kumaran 1979 (Pl. 3, fig. 2)
S. marginalis Kumaran & Maheshwari 1980 (Pl. 3, fig. 1)
**S. densus* Kumaran & Maheshwari, emend. (Pl. 3, fig. 3)
Striatopodocarpites decorus Bharadwaj & Salujha 1964
**S. dubrajpurensis* sp. nov. (Pl. 3, figs 4, 7, 8, 10)
**Striatopodocarpites* sp. (Pl. 3, fig. 13)
Labirites sp. (Pl. 3, fig. 6)
Lunatisporites pellucidus (Goubin) Maheshwari & Banerji 1975 (Pl. 2, fig. 14)
Infernopollenites claustratus Dolby & Balme 1976 (Pl. 2, fig. 3)
Chordasporites minutus Kar, Kieser & Jain 1972 (Pl. 2, fig. 15)
C. australiensis de Jersey 1962
Goubinispora indica Tiwari & Rana 1980 (Pl. 3, fig. 11)
G. morandavensis (Goubin) Tiwari & Rana 1980
Inaperturopollenites nebulosus Balme 1970
Pretricolpipollenites bharadwajii Balme 1970 (Pl. 2, fig. 11)
Incertae sedis
*Type A (Pl. 2, fig. 19)
*Type B (Pl. 1, fig. 15)

JURASSIC/CRETACEOUS ASSEMBLAGE

Concavisporites novicus Kumar 1973
Orbella colliculoides Maljavkina 1949
Dictyophyllidites haradensis Kumar 1973
Haradisporites mineri Singh & Kumar 1972
Cyathidites australis Couper 1953
C. minor Couper 1953
**C. punctatus* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes 1963 (Pl. 4, fig. 1)
Todisporites minor Couper 1958
**Divisisporites* sp. (Pl. 4, fig. 3)
Osmundacidites wellmanii Couper 1953
**Foraminisporis* sp. (Pl. 4, fig. 2)
Baculatisporites comaumensis (Cookson) Potonié 1956
Concavissimisporites penolaensis Dettmann 1963 (Pl. 4, fig. 8)
Leptolepidites verrucatus Couper 1953 (Pl. 4, fig. 20)
L. major Couper 1958
**L. rimatus* sp. nov. (Pl. 4, figs 21-23)
**Santhalisporites* gen. nov.
**S. bulbosus* sp. nov. (Pl. 4, figs 5, 6, 10, 11, 17)
**S. baskoensis* (Sah & Jain) comb. nov. & emend. (Pl. 4, figs 18, 19)
**S. imperfectus* sp. nov. (Pl. 4, figs 7, 12-14)
**Santhalisporites* sp. (Pl. 4, figs 15, 16)
Retitriletes reticulumsporites (Rouse) Döring, Krutzsch, Mai & Schulz 1963
R. austroclavatidites (Cookson) Döring, Krutzsch, Mai & Schulz 1963
Klukisporites varigatus Couper 1958 (Pl. 5, fig. 1)
**K. venkatachalae* sp. nov. (Pl. 5, figs 2, 3)
Cicatricosisporites australiensis (Cookson) Potonié 1952 (Pl. 4, fig. 9; Pl. 6, fig. 12)
C. ludbrooki Dettmann 1963 (Pl. 4, fig. 4)
Matonisporites dubius Kumar 1973 (Pl. 5, fig. 4)
**Callispora potoniei* Dev emend. Bharadwaj & Kumar 1972 (Pl. 5, fig. 5)
Contignisporites dettmannii Singh & Kumar 1966 (Pl. 5, fig. 16)
**Murospora florida* Balme emend. Dettmann 1963 (Pl. 5, fig. 8)
Gleicheniidites mundus Sah & Jain 1965 (Pl. 5, fig. 15)
Monolites indicus Kumar 1973
Alisporites grandis (Cookson) Dettmann 1963
Vitreisporites pallidus (Reissinger) Nilsson 1958
Podocarpidites ellipticus Cookson 1947 (Pl. 3, fig. 9)
P. multesimus (Bolkhovitina) Pocock 1962
P. cristiexinus Sah & Jain 1965 (Pl. 6, fig. 13)
Callialasporites dampieri (Balme) Dev 1961
C. lametaensis Kumar 1973 (Pl. 3, fig. 12)
C. segmentatus (Balme) Srivastava 1963 (Pl. 3, fig. 16)
C. circumplectus Kumar 1973
C. trilobatus (Balme) Bharadwaj & Kumar 1972 (Pl. 3, fig. 15)
Podosporites tripakshi Rao emend. Kumar 1983 (Pl. 5, fig. 12)
P. microsaccatus (Couper) Dettmann 1963
Araucariacites australis Cookson 1947 (Pl. 5, fig. 24)
A. cooksonii Singh, Srivastava & Roy 1964 (Pl. 5, figs 22, 23)
A. ghuneriensis Singh, Srivastava & Roy 1964
Classopollis indicus Maheshwari 1974 (Pl. 5, fig. 19)
Cycadopites sakrigaliensis Sah & Jain 1965 (Pl. 3,

fig. 14)
C. follicularis Wilson & Webster 1946
Monosulcites ellipticus Kumar 1973
Labiipollis mesozoicus Madler 1964 (Pl. 5, fig. 17)
L. granulatus Mädler 1964 (Pl. 5, fig. 20)
Coptospora kutchensis Venkatachala 1969 (Pl. 5, fig. 13)
**C. verrucosa* sp. nov (Pl. 5, figs 6, 9, 11)
**Cooksonites rajmahalensis* sp. nov. (Pl. 5, figs 14, 18)
Aequitriradites spinulosus (Cookson & Dettmann) Cookson & Dettmann 1966 (Pl. 5, fig. 21)
A. verrucosus (Cookson & Dettmann) Cookson & Dettmann 1961
Triporoletes reticulatus (Pocock) Playford 1971 (Pl. 5, fig. 7)

Lower Gondwana palynotaxa in Mesozoic sediments

During the course of present analysis of dispersed spores and pollen in bore-hole RJR-2, some of the taxa typical of Lower Gondwana assemblages have also been encountered, viz., *Parasaccites* Bharadwaj & Tiwari 1964, *Plicatipollenites* Lele 1964, *Densipollenites* Bharadwaj 1962, *Striatopodocarpites* Soritch & Sedova emend Bharadwaj 1962, *Crescentipollenites* Bharadwaj, Tiwari & Kar 1974 and *Lunatisporites* Leschik emend. Scheuring 1970. These genera are found in the assemblage which is dated to be Jurassic/Cretaceous by virtue of its major components; they are well-preserved with full details of exine structure and have no corrosion effect as such. The presence of similar forms in the sediments younger than the Lower Gondwana has also been recorded from other basins (Potonié & Sah, 1961, Dutta, 1979, Kar, 1980; Dev, 1961; Vijaya *et al.*, 1988), and have been considered as reworked.

DESCRIPTION

Genus—*Cyathidites* Couper 1953

Cyathidites punctatus (Delcourt & Sprumont) Delcourt, Dettmann & Hughes 1963
Pl. 4, fig. 1

Remarks—The specimens closely compare to those described by Delcourt and Sprumont (1955, pl. 1, fig. 8) and Delcourt, Dettman and Hughes (1963, pl. 42, fig. 3) in exhibiting similar nature of broadly rounded angles and concavity of the side walls but differ in being bigger in size, ranging up to 110 μm, and also in greater thickness of exine (up to 4 μm thick).

Genus—*Divisisporites* Thomson *in* Thomson & Pflug emend. Potonié 1956

Divisisporites sp.
Pl 4, fig. 3

Remarks—Subcircular spore, 58 μm, trilete in size with forked ray-ends. Exine 2 μm thick, covered with less than 1 μm verrucae. Among the comparable forms, *Divisisporites ovalis* Sah & Jain 1965 differs in being smaller in size and having less thickened, infrapunctate exine. *D. nammalensis* Jain & Sah 1969 differs from the studied specimen in showing margo along the trilete mark.

PLATE 1 →

(All photomicrographs are × 500, unless otherwise stated)

1. *Callumispora gretensis*, Slide no. BSIP 8481.
2. *Guttatisporites guttatus*, Slide no. BSIP 8472.
3. *Converrucosisporites lunzensis*, Slide no BSIP 9541.
4. *Verrucosisporites bosei*, Slide no. BSIP 8089.
5. *Gabonisporis vigouroxii*, Slide no. BSIP 8475.
6. *Osmundacidites pilatus*, Slide no. BSIP 9554.
7, 8. *Verrucosisporites kazigaonensis* sp. nov., fig. 7 Holotype, Slide no. BSIP 8474; fig. 8 Isotype, Slide no. BSIP 8475.
9, 13. *Gabonisporis papillosus* sp. nov., fig. 9 Holotype, Slide no. BSIP 9322; fig. 13 Isotype, Slide no. BSIP 9321
10. *Conbaculatisporites baculatus*, Slide no. BSIP 9543.
11. *Convolutispora perfecta*, Slide no. BSIP 8475.
12. *Foveosporites triassicus*, Slide no. BSIP 8090.
14. *Dictyotriletes aulius*, Slide no. BSIP 9323.
15. Type B showing a weak zone in the middle, Slide no. BSIP 8477
16. *Polycingulatisporites* sp , Slide no. BSIP 9541.
17, 20, 21. *Dubrajisporites isolatus* sp. nov. showing nature and arrangement of sculptures.
17. Isotype, Slide no. BSIP 9323.
20. Holotype, Slide no. BSIP 9323.
21. Enlargement of a portion of holotype showing the arrangement of ornaments, × 1500.
18, 22. *Dubrajisporites unicus* sp. nov. (composite figure) showing many big spines in one lumen, fig. 18, Holotype, Slide no. BSIP 9323 × 570, fig. 22 Isotype, Slide no. BSIP 9321, × 425.
19. *Indotriradites* sp., Slide no. BSIP 8471.
23. *Playfordiaspora cancellosa*, Slide no BSIP 8476.

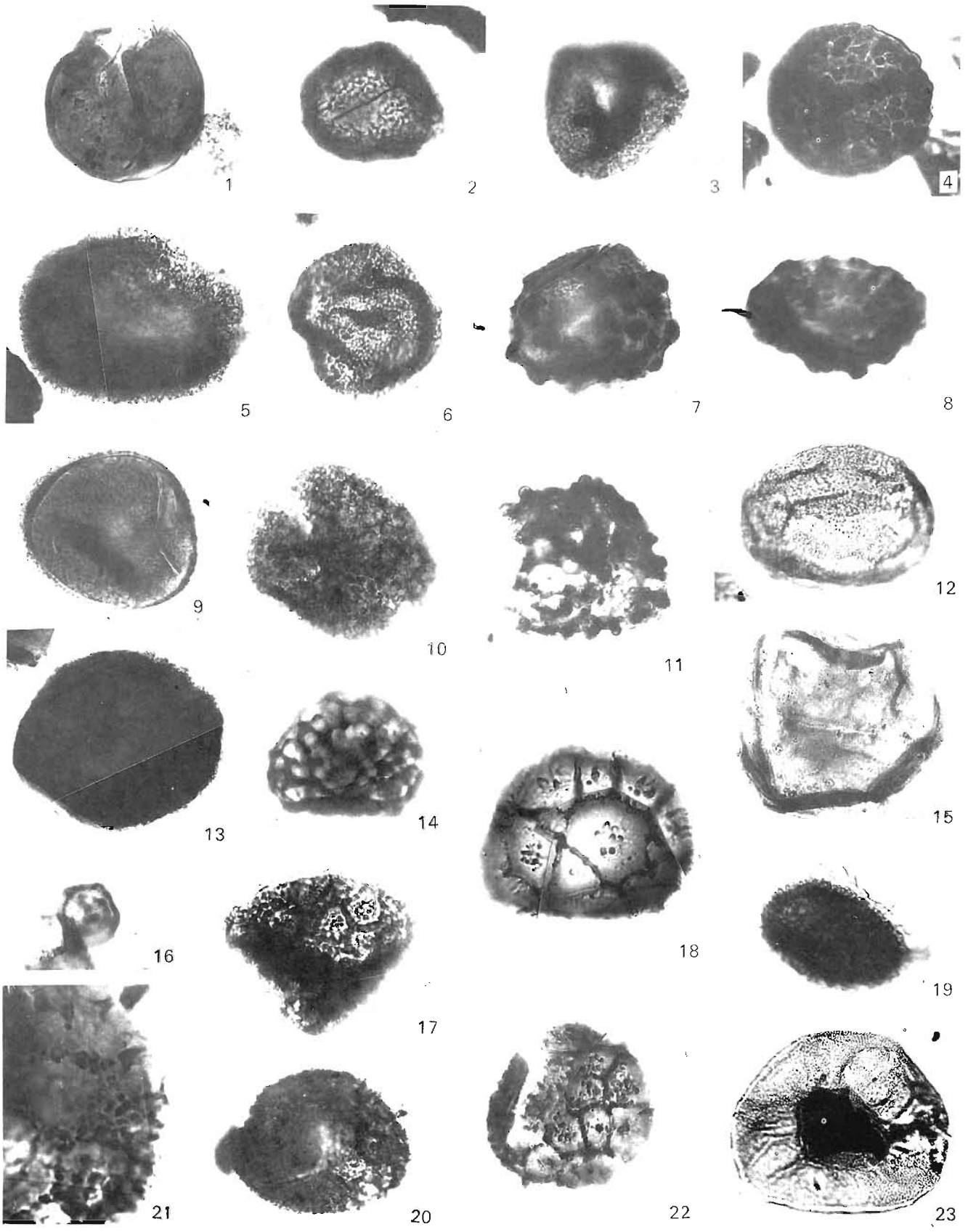


PLATE 1

Genus—*Verrucosisporites* Ibrahim emend. Smith 1971

Verrucosisporites kazigaonensis sp. nov.
Pl. 1, figs 7, 8

Holotype—Pl. 1, fig. 7; size 61.5 μm; Slide no. BSIP 8474.

Isotype—Pl. 1, fig. 8; size 71 μm; Slide no. BSIP 8475.

Type locality—Bore-hole RJR-2 (sample no. 41, depth 441.40-441.90 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Triassic.

Diagnosis—Circular to roundly triangular. Rays up to half the body radius long, thick-lipped, wavy. Exine all over covered with sparse but massive verrucae or tubercles, intermixed with small and low verrucae; at places low verrucae fuse to form a rugulate pattern; low verrucae also present on the tubercles; in the inter-ray areas only small verrucae present. Exine 2-3 μm thick.

Description—Size 61.5-71.0 μm; usually dark brown in colour. Trilete distinct, lips up to 1-2 μm thick as if formed by fusion of verrucae, slightly wavy; tubercle size 3-5 μm high, 7-11 μm wide; size of small verrucae 1-3 μm high and 1-3 μm wide; tubercles also beset with less than 0.5 μm high verrucae. On the surface verrucae and tubercles irregular in shape but at the periphery projecting out as round-headed elements. Exine unstructured.

Comparison—This species is comparable with *V. carnarvonensis* de Jersey & Hamilton 1967, *V. densus* Bharadwaj & Tiwari 1977 and *V. surangei* Maheshwari & Banerji 1975 in having robust verrucae, but differs in their being sparser and intermixed with smaller verrucae. The nature of robust tubercles which in their turn also bear low verrucae on them, and the thick-lipped trilete mark are also important distinguishing characters of *V. kazigaonensis*.

Genus—*Foraminisporis* Krutzsch 1959

Foraminisporis sp.
Pl. 4, fig. 2

Description—Roundly triangular trilete spore, 44.5 μm in size. Leasurae almost straight extending 3/4 of the spore radius with 2.5 μm thick lips. Exine 1.5 μm thick, irregularly beset with low verrucae and coni of less than 1 μm size. Sculpture reduced on proximal face; clusters of granules (each granule 1-3 μm in diameter) present on contact area.

Remarks—The genus *Foraminisporis* is a non-cingulate form (Krutzsch, 1959); however, Dettmann (1963) has assigned some cingulate specimens to this genus. Presently studied specimen conforms to the generic circumscription of the genus. It differs from the species *F. foraminis* Krutzsch 1959 in the nature of exine sculpture being verrucose and conate, and thick-lipped trilete rays, hence referred to as *Foraminisporis* sp.

Genus—*Concavissimisporites* Delcourt & Sprumont emend. Delcourt, Dettmann & Hughes 1963

Concavissimisporites penolaensis Dettmann 1963
Pl. 4, fig. 8

Remarks—Some of the presently studied specimens possess very low verrucae which do not project out prominently on the margin, unlike the specimens described by Dettmann (1963).

Genus—*Leptolepidites* Couper 1953

Leptolepidites rimatus sp. nov.
Pl. 4, figs 21-23

Holotype—Pl. 4, fig. 21; size 85 μm; Slide no. BSIP 9547.

Isotype—Pl. 4, fig. 23; size 78 μm; Slide no. BSIP 8469.

Type Locality—Bore-hole RJR-2 (Sample no. 9,

PLATE 2 →

(All photomicrographs are × 500, unless otherwise stated)

1. *Nidipollenites monoletus*, Slide no. BSIP 8471.
2. *Podocarpidites grandis*, Slide no. BSIP 9321.
3. *Infernopollenites claustratus*, Slide no. BSIP 8474.
4. *Alisporites grobus*, Slide no. BSIP 8473.
5. *Podocarpidites alareticulatus*, Slide no. BSIP 9544.
6. *Podocarpidites typicus*, Slide no BSIP 8473.
7. *Falcisporites minutosaccus*, Slide no. BSIP 8472.
8. *Falcisporites snopkovae*, Slide no. BSIP 9554.
9. *Satsangisaccites nidpurensis*, Slide no. BSIP 8474.
10. *Divarisaccus* sp. cf. *D. strengeri*, Slide no. BSIP 8475.
11. *Pretricolpipollenites bharadwajii*, Slide no. BSIP 9542.
12. *Falcisporites nuthalensis*, Slide no. BSIP 8090.
13. *Tetrasaccus* sp., Slide no. BSIP 8478.
14. *Lunatisporites pellucidus*, Slide no. BSIP 8474.
15. *Chordasporites minutus*, Slide no. BSIP 8089.
16, 17. *Brachysaccus triassicus* sp. nov., fig. 16 Holotype, Slide no. BSIP 8471; fig. 17 Isotype, Slide no. BSIP 8472.
18. *Brachysaccus ovalis*, Slide no. BSIP 8471.
19. Type-A, Slide no. BSIP 8478.

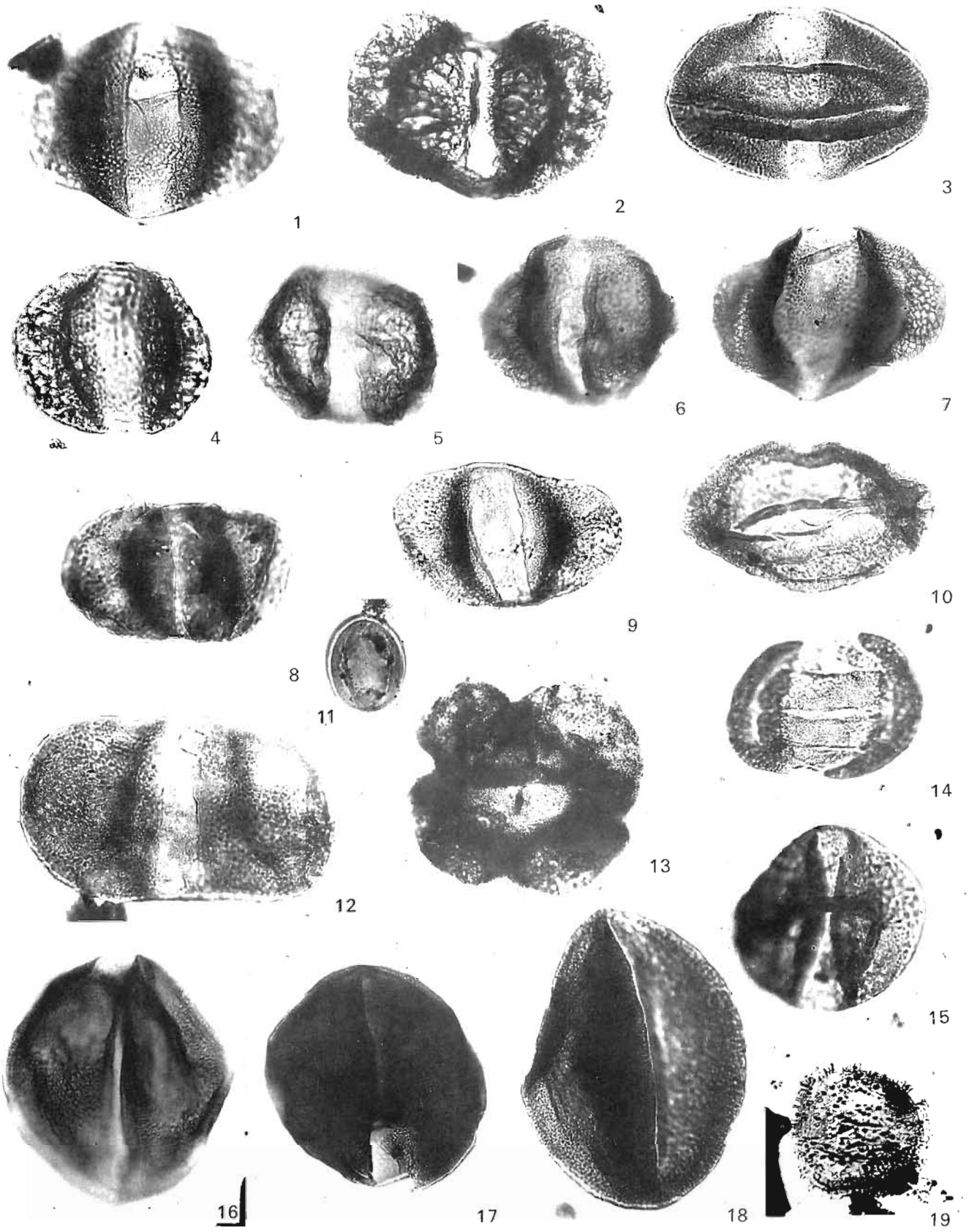


PLATE 2

depth 94-102.76 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Convexly triangular, trilete miospores. Exine verrucose, verrucae differentially disposed, closely packed simulating a rim-like structure at the equator.

Description—Miospores convexly triangular in equatorial outline. Size 78-85 μm in diameter (including sculpture). Trilete mark faintly perceptible, rays reaching up to 3/4 of the spore radius. Exine 1.5 μm thick, verrucose, verrucae at the distal and equatorial region large, 5-10 μm in diameter, and reduced at the proximal polar region, 2.5-5 μm in diameter. Equatorial verrucae closely packed forming a rim-like structure.

Comparison—Leptolepidites major Couper 1958 differs from *L. rimatus* sp. nov. in having linear arrangement of verrucae along the trilete rays, smaller size (36-50 μm) and uniform distribution of verrucae on both faces. *Leptolepidites verrucatus* Couper 1953 is distinct in being smaller in size (28-45 μm) and having smaller verrucae also (3-5 μm in diameter).

Santhalisporites gen. nov.

Type species—*Santhalisporites bulbosus* sp. nov.

Diagnosis—Roundly triangular to subcircular, trilete, curvaturate spores; trilete-mark distinct, Exine spinose all over except on the contact areas where ornament considerably reduced or even absent; spines with broad, conical or bulbous bases and long, straight or curved, hook-like apices.

Description—Miospores broadly subcircular to circulo-triangular in shape, generally with broad round angles; trilete rays reaching 3/4 or more of the spore radius but never reaching the equator, thick-lipped, sinuous, forming a well-defined contact area which being differentiated by the absence or reduced nature of ornament and occupying three-fourth of the proximal surface. Exine sculptured with straight or curved, 2-10 μm long spines having 1-5 μm wide, conical or bulbous bases and straight, hook-like or anchor-shaped apices; 1 μm high and 1 μm broad coni also present. Curvaturae well-developed, rarely faintly perceptible.

Comparison—The genus *Santhalisporites* is comparable with *Godavarisporites* Tiwari & Moiz 1971 in subcircular shape and the presence of curvaturae but differs in the nature of exine ornamentation; the exine of the former bears spines and coni while that of the latter is only conate having very short (1-2 μm high) coni. The present genus also resembles *Aneurospora* Streel 1964 in having curvaturae and sculptured exine, but differs due to the spinose rather than conate nature of the ornament. Moreover, in *Aneurospora* the contact area occupies almost the whole proximal surface and the curvaturae coincide with equator of the miospore; hence the difference is well-marked. *Brevitriletes* Bharadwaj & Srivastava emend. Tiwari & Singh 1981 is similar to the present genus in having spinose exine but can be differentiated due to absence of curvaturae as well as spines on proximal face.

Balme and Hassel (1962) instituted the genus *Pulvinispora* to include forms having depressed contact area, thickened ray-ends and scabrate or irregularly granulose exine. Obviously, the present genus differs in the nature of exine ornamentation and the trilete rays. *Carnisporites* Mädler 1964, although apparently resembling *Santhalisporites* in having curvaturae, differs in having rough to scabrate exine and prominently thickened ray-ends (*see* Holotype, Klaus, 1960, pl. 28, fig. 6). *Apiculatisporis* Potonié & Kremp 1956, although superficially appears to be similar to *Santhalisporites*, differs in the absence of curvaturae and the presence of coni rather than spines.

PLATE 3 →

(All photomicrographs are × 500, unless otherwise stated)

1 *Staurosaccites marginalis*, Slide no. BSIP 9543.
2. *Staurosaccites tharipatharensis*, Slide no. BSIP 8474.
3. *Staurosaccites densus*, Slide no. BSIP 8475.
4,7,8,10. *Striatopodocarpites dubrajpurensis* sp. nov., fig. 4 Isotype, Slide no. BSIP 8471; fig. 7 Slide no. BSIP 8322; fig. 8 Slide no BSIP 8476; fig. 10 Holotype Slide no. BSIP 9323.
5 *Staurosaccites quadrifidus*, Slide no. BSIP 8474.
6. *Labirites* sp., Slide no. BSIP 9543.
9. *Podocarpidites ellipticus*, Slide no. BSIP 8464.
11. *Goubinispora indica*, Slide no. BSIP 9541.
12. *Callialasporites lametaensis*, Slide no. BSIP 8459.
13. *Striatopodocarpites* sp., Slide no. BSIP 8471.
14. *Cycadopites sakarigaliensis*, Slide no. BSIP 8466.
15. *Callialasporites trilobatus*, Slide no. BSIP 9551.
16. *Callialasporites segmentatus*, Slide no. BSIP 9551

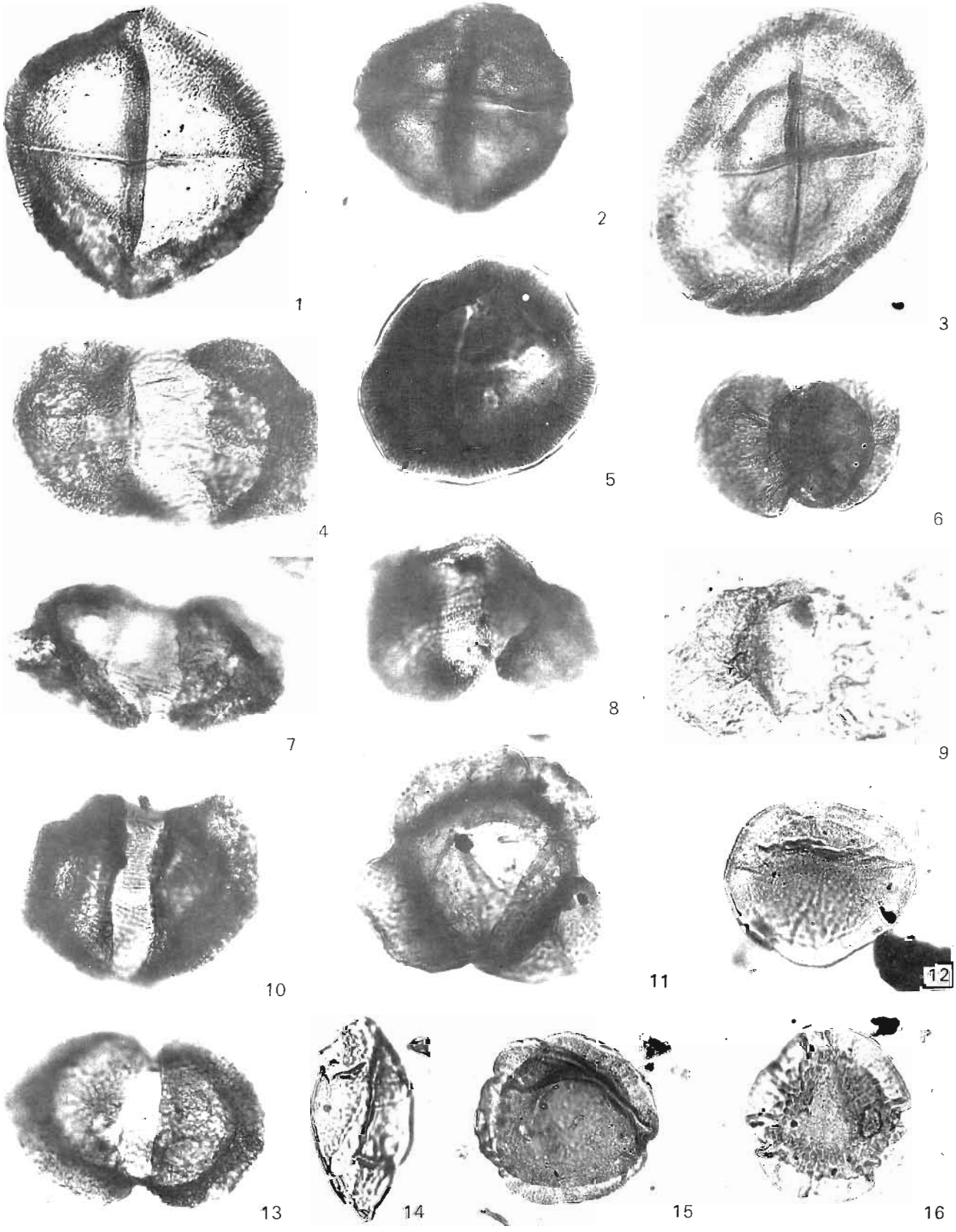


PLATE 3

Santhalisporites bulbosus sp. nov.
Pl. 4, figs 5, 6, 10, 11, 17

Holotype—Pl. 4, figs 10, 11; size 50.5 μm; Slide no. BSIP 8468.

Isotype—Pl. 4, fig. 5; size 49.0 μm; Slide no. BSIP 8466.

Type locality—Bore-hole RJR-2 (Sample no. 8, depth 91-94 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Roundly triangular spores with trilete rays ± reaching up to the equator; curvaturae distinct, demarcated with reduced and densely packed ornaments. Exine 1-2 μm thick, ornamented with hook-shaped spines having bulbous base and stretched apices with pointed or broadly rounded tips, 2.5-4.5 μm long and 1-2 μm wide at base; contact area bearing only coni.

Description—Spores measuring 40-57.5 μm in diameter, trilete rays slightly wavy with raised lips, curvaturae well-marked, rarely faintly perceptible. Contact area bearing up to 1 μm high coni; ornaments densely distributed.

Santhalisporites baskoensis (Sah & Jain) comb. nov., emend.
Pl. 4, figs 18, 19

Basionym—Acanthotriletes baskoensis Sah & Jain 1965, pl. 2, fig. 52; *Palaeobotanist* **13** (3), p. 272.

Synonym—Carnisporites spiniger (Leschik) Morbey 1975 *in* Achilles, 1981, pl. 3, figs 4, 5.

Holotype—In: Sah & Jain, 1965, pl. 2, fig. 52; Basko, Rajmahal hills, Bihar, India, Jurassic (Specimen lost).

Neotype—Pl. 4, fig. 18; size 37.5 μm; Slide no. BSIP 9549.

Type locality for Neotype—Bore-hole RJR-2 (Sample no. 9, depth 94-102.76 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis (emended)—Roundly triangular spores with well-defined curvaturae. Trilete rays slightly sinuous, ± 1 μm thick lips. Exine spinose, spines finger-shaped with straight to curved apices, 3-5 μm long and 1-2 μm wide at the base; contact area smooth.

Description—Size-range 31-50 μm in diameter. Exine ± 1 μm thick in optical section, spines sparsely distributed, contact area without sculptural elements.

Comparison—Santhalisporites baskoensis (Sah & Jain) comb. nov. differs from *S. bulbosus* sp. nov. in having long, curved spines with narrow bases, thin exine and non-ornamented contact area.

Remarks—The type specimen as well as the type material for this species is not traceable; therefore, a Neotype is proposed.

Santhalisporites imperfectus sp. nov.
Pl. 4, figs 7, 12-14

Holotype—Pl. 4, fig. 12; size 41.5 μm; Slide no. BSIP 9555.

Isotype—Pl. 4, fig. 7; size 33.5 μm; Slide no. BSIP 9551.

Type locality—Bore-hole RJR-2 (Sample no. 9,

PLATE 4 →

(All photomicrographs are. × 500, unless otherwise stated)

1. *Cyathidites punctatus*, Slide no. BSIP 9552.
2. *Foraminisporis* sp., Slide no. BSIP 9548.
3. *Divisisporites* sp., Slide no. BSIP 9550.
4. *Cicatricosisporites ludbrooki*, Slide no. BSIP 8458.

5,6, *Santhalisporites bulbosus* gen. et. sp. nov., fig. 5 Isotype.

10,11,17. Slide no. BSIP 8466. × 1000, fig. 6 portion of Isotype enlarged to show nature of spines, × 2000.

10. Holotype, proximal face showing coni in contact area, Slide no. BSIP 8468. × 1000.
11. Holotype distal face.
17. Slide no. BSIP 9595.

7,12-14. *Santhalisporites imperfectus* sp. nov.

7. Isotype, Slide no BSIP 9552.
12. Holotype—Proximal face showing smooth contact area, Slide no. BSIP 9555.
13. Holotype—distal face
14. Showing nature of sculptures in *Santhalisporites imperfectus* sp. nov. × 2500.
8. *Concavissimisporites penolaensis*, Slide no. BSIP 9549.
9. *Cicatricosisporites australiensis*, Slide no. BSIP 8468.

15,16. *Santhalisporites* sp., Slide no. BSIP 9545; fig. 16 showing anchor-shaped nature of sculptures.

18,19. *Santhalisporites baskoensis* comb. nov., fig. 18 Neotype Slide no. BSIP 9549; fig. 19 showing nature of sculptures, × 2000.

20. *Leptolepidites verrucatus*, Slide no. BSIP 9546.

21-23. *Leptolepidites rimatus* sp. nov.

21. Holotype showing nature of varrucae forming a rim like structure at the periphery, Slide no. BSIP 9547.
22. Holotype showing nature of verrucae in the centre and margin, fig. 23 Isotype, Slide no. BSIP 8469.

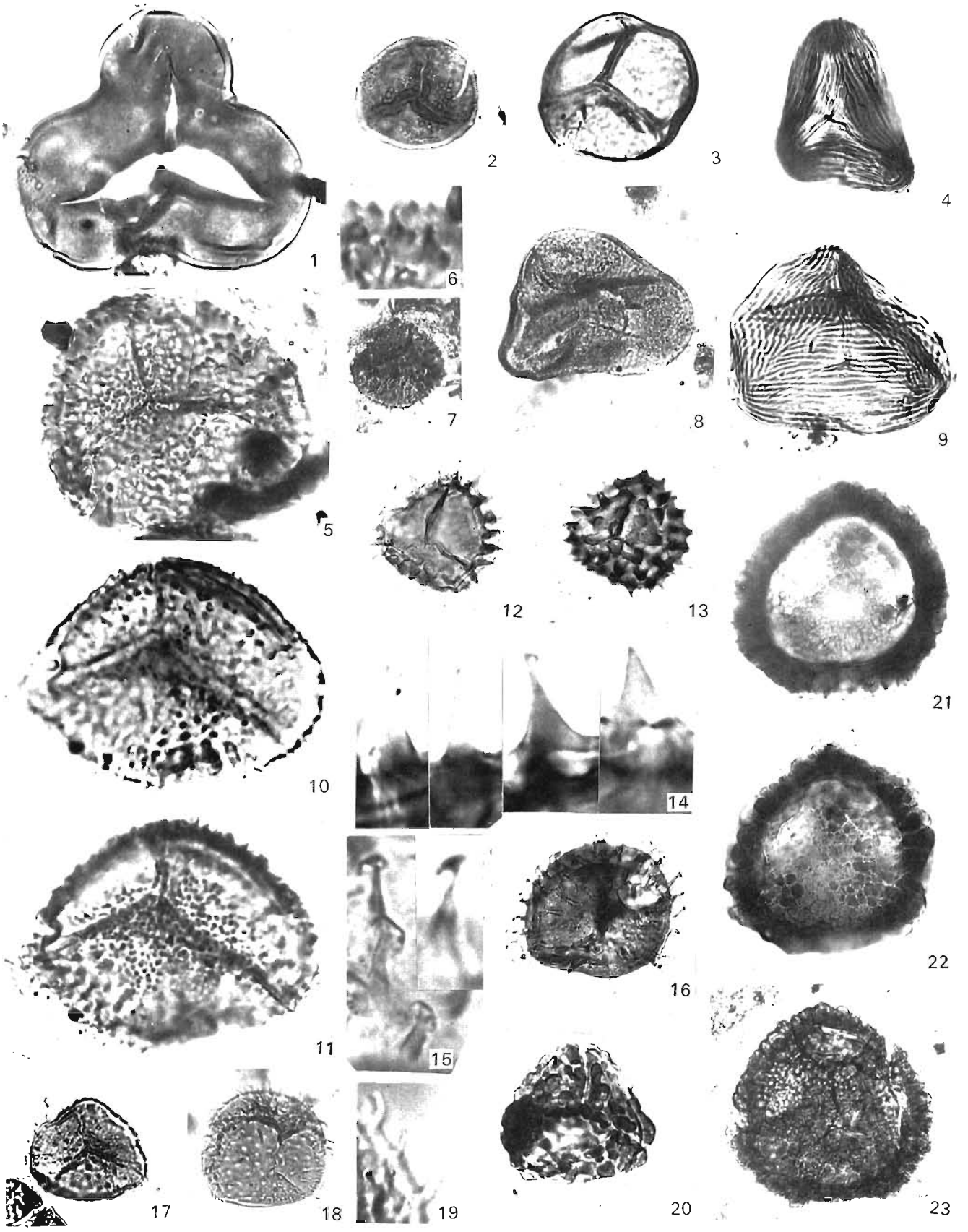


PLATE 4

depth 94-102.76 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Spores triangular to subcircular, trilete rays ± 3/4 of spore radius, sinuous. Exine covered with spines of variable shapes, conical, straight or curved with knob-shaped or blunt tips, bases of spines narrow to broad or slightly bulbous, coni up to 6 μm high and 5 μm wide at bases, spines 8-10 μm high and 2.5-3.5 μm wide at bases; curvaturae imperfectly developed and contact area smooth.

Description—Spores triangular with broadly rounded angles and convex sides, sometimes appearing as roundly triangular in shape, size 28-58 μm in diameter. Lips of trilete rays often raised, wavy, sometimes associated with folds. Exine 1-2 μm thick; characteristic nature of spines developed all over the surface but aligned densely along the margin of curvaturae.

Comparison—*Santhalisporites imperfectus* sp. nov differs from *S. bulbosus* sp. nov. in its imperfectly developed curvaturae, smooth contact area, simple, broad-based spines and coni. *Santhalisporites baskoensis* (Sah & Jain) comb. nov., although similar in having smooth contact area, can be differentiated by the presence of finger-shaped spines with narrow base, and perfect curvaturae.

Santhalisporites sp.
Pl. 4, figs 15, 16

Remarks—The anchor-shaped, 5-8 μm high and 3-5 μm wide at base, spines of these specimens restrict their placement in other newly described species. However, because of insufficient number of specimens they have been referred to as *Santhalisporites* sp.

Genus—*Dubrajisporites* Tiwari & Tripathi 1987

Dubrajisporites unicus sp. nov.
Pl. 1, figs 18, 22

Holotype—Pl. 1, fig. 18; size 58.0 μm; Slide no. BSIP 9323.

Isotype—Pl. 1, fig. 22; size 80.5 μm; Slide no. BSIP 9321.

Type locality—Bore-hole RJR-2 (Sample no. 32, depth 398.20-398.99 m) near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Subtriangular to subcircular; trilete mark distinct, rays reaching 2/3 radius, almost straight. Exine 2-3 μm thick, coarsely reticulate all over excepting contact area. Muri surmounted with finger-shaped, round-tipped spines imparting a deeply and variably dissected nature; lumen bearing many big spines intermixed with small verrucae or coni; size of bigger elements 4-7 μm high and 1.5-3 μm wide; smaller elements 1.5-2.5 μm high and 1-2.5 μm wide. Exine unstructured.

Description—Dark-coloured spores, mostly subcircular, rarely subtriangular, 58-81 μm in size. Trilete rays closed or open, straight to slightly wavy, thick-lipped. Exine reticulate, mesh-size 9-28 μm, muri 4-5 μm high as seen at the equator, their free-ends bearing spines or coni—mostly with round-headed tips. Luminar area bearing many (4-6) straight or curved, round-tipped spines, mixed with small verrucae or coni; contact area bearing isolated verrucae or coni only. Inner body not seen.

Comparison—This species differs from the type species *D. triassicus* Tiwari & Tripathi 1987 and *D. bulbosus* Tiwari & Tripathi 1987 in the nature of muri and arrangement pattern of ornament of luminar area.

Dubrajisporites isolatus sp. nov.
Pl. 1, figs 17, 20, 21

Holotype—Pl. 1, fig. 20; size 65 μm (including ornaments); Slide no. BSIP 9323.

Isotype—Pl. 1, fig. 17; size 68.5 μm (including ornaments); Slide no. BSIP 9323.

Type locality—Bore-hole RJR-2 (Sample no. 32, depth 398.20-398.99 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Subtriangular to subcircular; trilete mark distinct, rays reaching 2/3 radius, straight, thick-lipped. Exine sculptured all over with isolated coni, spines and verrucae arranged in reticuloid pattern to enclose polygonal areas. Processes sometimes fusing at basal portion on both faces, except the contact area; polygonal areas bearing number of spines, coni and verrucae, sculptural elements 2-5.5 μm long and 1-4.5 μm wide at the base. Exine unstructured. Inner body not seen.

Description—Dark-coloured spores, mostly subtriangular rarely subcircular, 53-68.5 μm in size. Trilete rays closed or open, distinctly visible in the proximally up grains only. Exine thick, inter-ray areas bearing isolated spines, coni, bacula or verrucae and rest of the surface possessing similar sculptural elements arranged in reticuloid pattern to enclose polygons of 5-15 μm diameter; a number of processes present at the junction of polygons. Sometimes elements fusing at the bases to form

muri-like, continuous but loose sculpture. Several elements including coni, verrucae and spines of variable size present within the polygonal areas.

Comparison—*Dubrajisporites isolatus* sp. nov. differs from *D. triassicus* Tiwari & Tripathi, 1987, *D. bulbosus* Tiwari & Tripathi 1987 and *D. unicus* sp. nov. in the nature of muri as it is constituted by isolated processes arranged in the form of coarse meshes thus the muri remains a loose organization and not a solid ridge as in other cases.

Genus—*Klukisporites* Couper 1958

Klukisporites venkatachalae sp. nov.
Pl. 5, figs 2, 3

Holotype—Pl. 5, fig. 2; size 52.5 μm; Slide no. BSIP 8466.

Isotype—Pl. 5, fig. 3; size 69.5 μm; Slide no. BSIP 9547.

Type locality—Bore-hole RJR-2 (Sample no. 8, depth 91.00-94.00 m), near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Triangular, trilete mark prominent, labra thick, valvae absent. Exine with irregular foveo-reticulum, prominently disposed at the angles but faintly represented on the distal polar region. Margin wavy at the angles only, sides smooth.

Description—Spore triangular with broadly rounded angles and concave sides, measuring 45-69.5 μm. Trilete rays reaching up to the equator, showing 3-7 μm thick labra, slightly narrowing down towards the end. Angular region of spores covered with irregularly reticulate ornament appearing to be formed by fusion of 2-3 μm high verrucae. Distal polar region possessing very low and indistinct reticulum. *Extrema lineamenta* at inter-radial sides smooth.

Comparison—*Klukisporites* typically represents those forms which exhibit a uniform foveo-reticulate ornamentation on distal face. In the present species the reticulate sculpture is not uniform and regular; it is more crowded and prominently exhibited at the apices. Obviously, it is a variability from the typical *Klukisporites* species but the basic nature of reticulum determined its inclusion in this genus. By virtue of the characters described above, this species differs from other known species of this genus.

Genus—*Callispora* Dev emend. Bharadwaj & Kumar 1972

Callispora potoniei Dev emend. Bharadwaj & Kumar 1972
Pl. 5, fig. 5

Remarks—Specimens of *Callispora potoniei* Dev emend. Bharadwaj & Kumar 1972 encountered in the present assemblage possess thread-like fine ridges as scultpure at the interapical region. This character becomes all the more clear in the differential interference-phase contrast. However, the punctate nature of the exine is distinctly observed on the surface as described by Bharadwaj and Kumar (1972).

Genus—*Gabonisporis* Boltenhagen 1967

Gabonisporis vigourouxii Boltenhagen 1967
Pl. 1, fig. 5

Remarks—The presently studied specimens closely answer to the specific diagnosis of the speices given by Boltenhagen (1967). However, the size-range of the spores is more (72.0-99.5 μm) than that given by Boltenhagen (30-45 μm). The genus is reported from the Senonian (Upper Cretaceous) sediments from Gabon, Africa while the present specimens are recorded from Early Norian (Upper Triassic) sediments.

Gabonisporis papillosus sp. nov.
Pl. 1, figs 9, 13

Holotype—Pl. 1, fig. 9; size 70 μm; Slide no. BSIP 9322.

Isotype—Pl. 1, fig. 13; size 78 μm; Slide no. BSIP 9321.

Type locality—Bore-hole RJR-2 (Sample no. 32, depth 398.20-398.99 m) near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Triassic.

Diagnosis—Subtriangular to subcircular, ranging 70-90 μm in size. Trilete mark distinct, rays 3/4 radius long, straight, may be thick-lipped. Perisporial covering frilly enveloping the body completely, or sometimes leaving the contact area free. Perine densely ornamented with clusters of small, tongue-shaped papillae, or verrucae, measuring 1-3 μm high and 1-3 μm wide at base. Body exine smooth to scabrate.

Description—Perinous covering imparts a frilly nature and subcircular shape to the spore and a zonate appearance at the peripheral region. Spore body roundly triangular. Trilete mark may become indistinct because of the perine, sometimes open, trilete rays slightly elevated. Perispore ornamented with compactly disposed group of tongue-shaped, spatulate, round-headed papillae and verrucae; sometimes perine absent on the contact area. In surface view round heads of papillae and verrucae clearly observed.

Comparison—The present species differs from the type species, *Gabonisporis vigourouxii* Boltenhagen 1967, in the nature of sculptural elements of perine. In the former, the elements are verrucae and papillae while in the latter they are setae described as bacula by Boltenhagen (1967).

Genus—*Polycingulatisporites* Simoncsics & Kedves emend. Playford & Dettmann 1965

Polycingulatisporites sp.
Pl. 1, fig. 16

Remarks—The specimens closely compare with *Polycingulatisporites mooniensis* de Jersey & Paten 1964. However, due to the presence of only one concentric ridge on the distal face and many verrucae on the distal polar region they differ from the latter.

Genus—*Murospora* Somers 1952

Murospora florida Balme emend. Dettmann 1963
Pl. 5, fig. 8

Remarks—Some of presently studied specimens show punctate nature of cingulum. The puncta may traverse through the cingulum thickness so as to appear like narrow canals. Such structures have not been described in *M. florida* to which these specimens resemble in all other characters.

Genus—*Indotriradites* Tiwari 1964

Indotriradites sp.
Pl. 1, fig. 19

Remarks—The presently studied specimens differ from all the described species of *Indotriradites* in having finger-shaped processes mixed with few spines.

Genus—*Divarisaccus* Venkatachala & Kar 1966

Divarisaccus sp. cf. *D. strengeri* Bose & Kar 1966
Pl. 2, fig. 10; Pl. 6, fig. 8

Remarks—The studied specimens come under the circumscription of the species *Divarisaccus strengeri* given by Bose and Kar (1966). However, the size range originally described by Bose and Kar (1966) is greater (140-214 × 98-130 μm) than the range observed here (120-125 × 70-85 μm). Similarly, the nature of intrareticulation of central body and saccus is finer in the present specimens, rather than coarse as described by Bose and Kar (1966). This species has been originally described from Permo-Carboniferous sediments of Congo while here they are being described from the Upper Triassic sediments.

Genus—*Tetrasaccus* Pant emend. Maithy 1965

Tetrasaccus sp.
Pl. 2, fig. 13

Remarks—The present specimens conform to the generic diagnosis of the genus *Tetrasaccus*. However, it differs from the type species *T. karharbarensis* Maithy 1965 in having exine with vermiculate appearance having incomplete meshes on the central body, folds on the equatorial region of central body and a subcircular saccus-free area. Only a few specimens have been found in the present assemblage.

Genus—*Falcisporites* Leschik emend. Klaus 1963

Falcisporites minutosaccus
Kumaran & Maheshwari 1980
Pl. 2, fig. 7

Remarks—In our earlier study on the

PLATE 5

→

(All photomicrographs are. × 500, unless otherwise stated)

1. *Klukisporites varigatus*, Slide no. BSIP 8465.
2,3. *Klukisporites venkatachalae* sp. nov., fig. 2 Holotype Slide no. BSIP 8466; fig. 3 Isotype, Slide no. BSIP 9547.
4. *Matonisporites dubius*, Slide no. BSIP 9549.
5. *Callispora potoniei*, Slide no. BSIP 8456.
6,9-11. *Coptospora verrucosa* sp. nov.
6. Isotype, Slide no. BSIP 9551; figs 9,10 Holotype showing nature of verrucae, Slide no. BSIP 8469; fig. 11 specimen showing ruptured area or hilum, Slide no BSIP 9550.
7. *Triporoletes reticulatus*, Slide no. BSIP 9552.
8. *Murospora florida*, Slide no. BSIP 9550.
12. *Podosporites tripakshii*, Slide no. BSIP 9553.
13. *Coptospora kutchensis*, Slide no. BSIP 9548.
14,18. *Cooksonites rajmahalensis* sp. nov., fig. 14 Holotype, Slide no. BSIP 8468; fig. 18 Isotype, Slide no. BSIP 9545.
15. *Gleicheniidites mundus*, Slide no. BSIP 8460.
16. *Contignisporites dettmanni*, Slide no. BSIP 9547.
17. *Labiipollis mesozoicus*, Slide no BSIP 8468.
19. *Classopollis indicus*, Slide no. BSIP 8466.
20. *Labiipollis granulatus*, Slide no. BSIP 9550.
21. *Aequitriradites spinulosus*, Slide no. BSIP 8469.
22,23. *Araucariacites cooksoni*, Slide no. BSIP 8467.
24. *Araucariacites australis*, Slide no BSIP 9551.

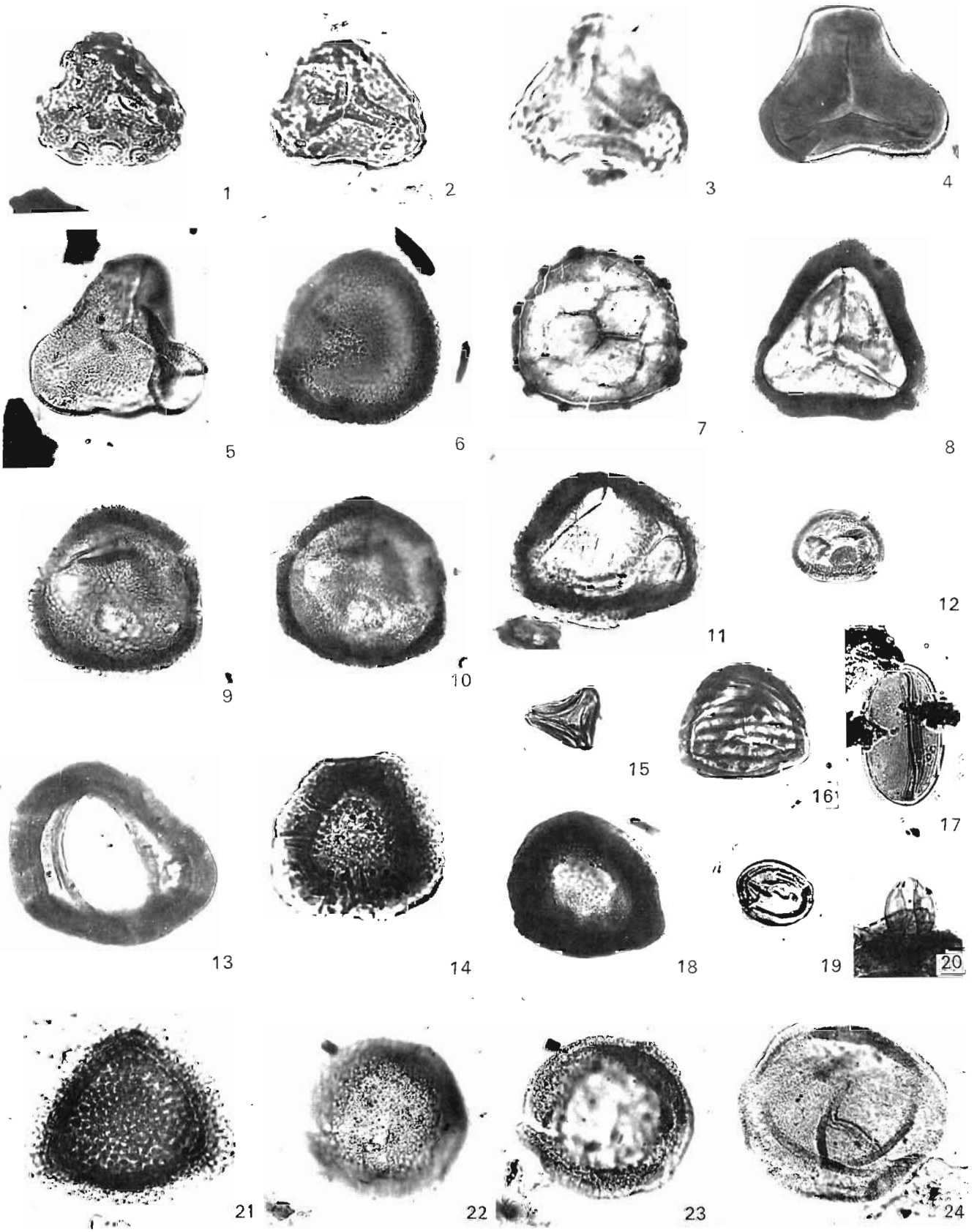


PLATE 5

palynodating of Dubrajpur and Intertrappean beds in Bore-hole RJR-2 (Tiwari, Kumar & Tripathi, 1984) similar forms were identified as *Minutosaccus* Mädler 1964. However, presently a re-allocation is made and they are referred to as *Falcisporites minutosaccus*.

Genus—*Brachysaccus* Madler 1964

Brachysaccus triassicus sp. nov.
Pl. 2, figs 16, 17

Holotype—Pl. 2, fig. 16; size 87.5 × 92.5 μm; Slide no. BSIP 8472.

Isotype—Pl. 2, fig. 17; size 110 × 110 μm; Slide no. BSIP 8471.

Type Locality—Bore-hole RJR-2 (Sample no. 32, depth 398.20-398.99 m) near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Triassic.

Diagnosis—Bisaccate pollen, broadly oval, 85-115 μm broad, 92.5-120 μm long; central body outline generally distinct, sometimes obscure; exine finely intramicroreticulate. Saccus attachment proximally subequatorial, distally bilateral and sometimes associated with folds. Saccus bearing medium-sized intra-reticulate structure with radially arranged thick muri giving a columellate appearance to the saccus at the margin.

Description—Subcircular to vertically oval pollen grains. Central body, when distinct conforming to the overall shape of the pollen, central body exine finely intramicroreticulate with relatively thick muri and small polygonal to subcircular lumen. Saccus un-notched, proximal attachment subequatorial covering a narrow peripheral area of the central body, distal attachment straight leaving a 10-25 μm broad sulcus, sometimes sulcus diverge at lateral ends. In optical section at the peripheral region of the saccus a thick zone marked by branched and unbranched radially arranged muri appearing to be columellate. Laterally preserved grains indicate a globular shape of the pollen.

Comparison— Present species is comparable to the type species, *Brachysaccus ovalis* Mädler 1964 in the overall shape. However, it differs in being smaller in size, and in having different structure of the saccus with radially arranged thick muri and elongated lumen, instead of polygonal ones.

Brachysaccus indicus Kumaran & Maheshwari 1980 is a heterogeneous taxon comprising elongate oval to spindle-shaped specimens. The holotype of *B. indicus* (pl. 7, fig. 2) is spindle-shaped, hence, only such forms should be considered in this species and the elongate oval forms should be referred to other species. Thus, *B. triassicus* differs from *B. indicus* sp. nov. in the overall shape and columellate appearance of saccus structure.

Genus—*Staurosaccites* Dolby in Dolby & Balme 1976

Remarks—A careful examination of the specimens referable to this genus clearly indicates the monosaccoidal construction of the pollen grains with a disaccate type of attachment. The central body outline is distinct or indistinct, may possess an inner body, having a long median cleft on the proximal face. The saccus is proximally sub-equatorially attached and distally reaching up to the centre of the body, forming linear saccus-free area. The scanning electron micrographs of the specimen (Pl. 6, figs 9, 10) show that the central body and saccus surface is not smooth but has chagranate appearance. Besides, small pits or depressions are also observed all over the surface of the pollen.

Staurosaccites densus Kumaran & Maheshwari emend.
Pl. 3, fig. 3

Holotype—Pl. 8, fig. 1; Kumaran & Maheshwari, 1980.

Type locality—Eastern bank of Janar Nala, about

PLATE 6 →

(Scanning electron micrographs)

1, 2. *Rajmahalispora triassica*, fig. 1. × 625.
2. Enlargement of specimen in fig. 1 proximal face showing scabrate surface with few low rugulae, × 2812.
3. *Rajmahalispora rugulata*, × 1010.
4. *Dubrajisporites bulbosus*, × 775.
5, 6. *Satsangisaccites nidpurensis*, fig. 5, × 625; fig. 6 enlargement of specimen in fig. 5 showing chagrenate nature of sulcus, × 2062.
7. *Converrucosisporites lunzensis*, × 1250.
8. *Divarisaccus* sp. cf. *D. strengeri*, × 625.
9, 10. *Staurosaccites*, fig. 9 complete grain, × 1050; fig. 10 enlargement of specimen showing chagrenate nature and presence of puncta on the surface, × 2500.
11. *Podocarpidites typicus*, × 925.
12. *Cicatricosisporites australiensis*, × 965.
13. *Podocarpidites cristiexinus*, the nature of central body exine, × 1250.
14. *Dubrajisporites triassicus*, × 1250.

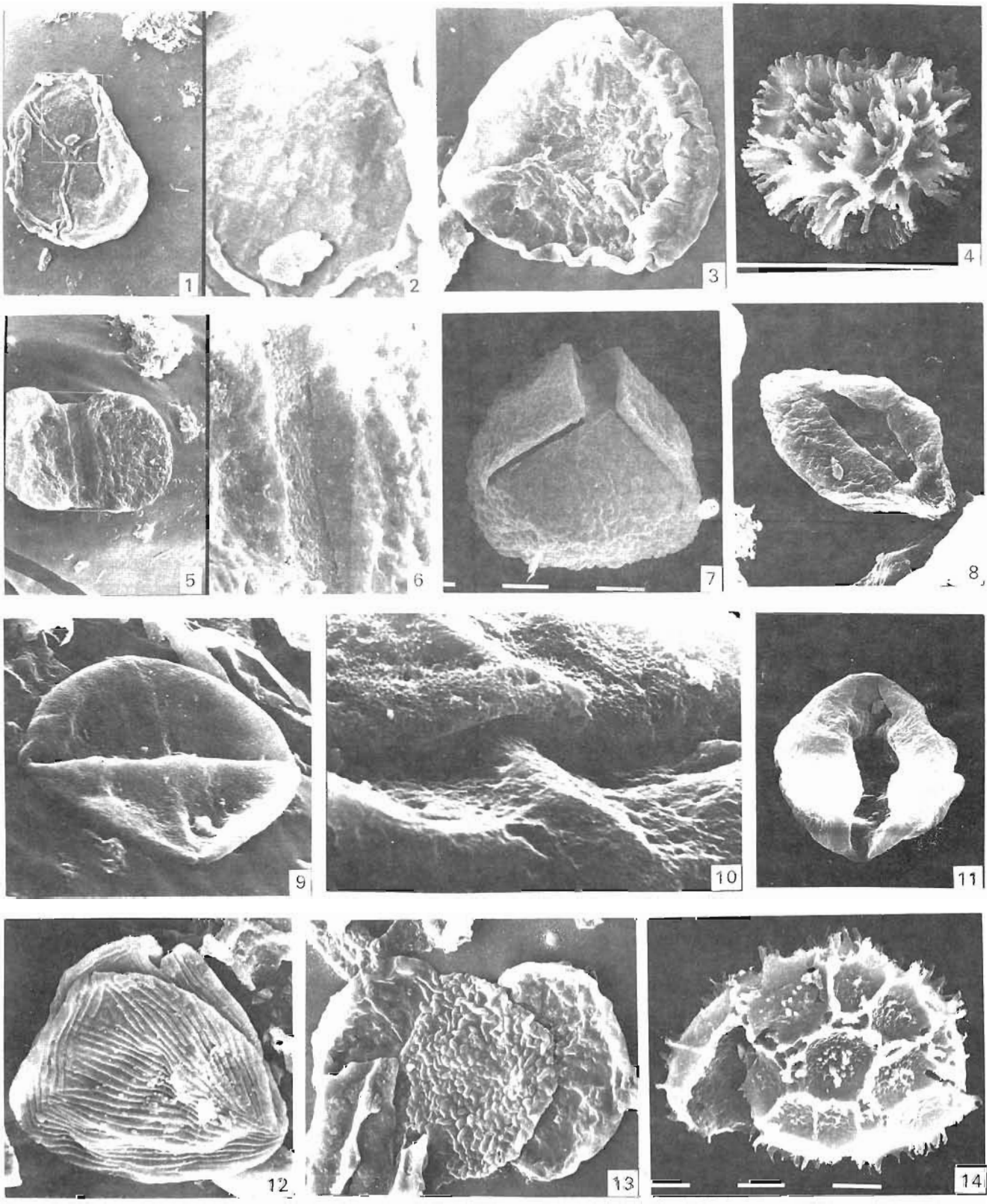


PLATE 6

2 km south east of Bijouri, district Shahdol, Madhya Pradesh.

Horizon & age—Tiki Formation, Late Triassic.

Emended diagnosis—Subcircular bisaccate pollen, central body outline indistinct, apparently conforming to the overall shape, divided by a narrow cleft; exine thick, intramicroreticulate. Inner body outline indistinct with irregular folds, laevigate. Saccus proximally subequatorially attached simulating an equatorial thick zone, distal attachment full-length. Saccus-free area making a cross-shaped pattern with polar cleft. Saccus finely intramicroreticulate.

Description—Pollen haploxylonoid, monosaccoidal subcircular in shape, size 100-128 μm. Central body appearing to be circular to subcircular, intramicroreticulate with thick muri and polygonal meshes. Inner body presented by denser area but without sharp outline, 55-75 μm in size, having many irregular folds arranged in circular pattern, laevigate. Polar cleft extending beyond the denser area. Sacci hemispherical, rigid, subequatorially attached proximally appearing as 3-11 μm wide equatorial zone, distally attached closely to each other, full length, leaving a narrow saccus-free area giving rise to a cross-shaped pattern in relation to the proximal polar cleft. In surface view saccus structure with polygonal meshes but at the peripheral region narrow elongated meshes and radially arranged thick muri impart an intrabaculate nature.

Comparison—In view of the present emended diagnosis, this species differs from the so far described species, viz., *S. quadrifidus* Dolby (in: Dolby & Balme, 1976), *S. marginalis* Kumaran & Maheshwari 1980, *S. ovalis* Kumaran & Maheshwari 1980 and *S. minutus* Kumaran & Maheshwari 1980, in having an inner body, apart from other differences. Kumaran and Maheshwari (1980) have interpreted the inner denser area as the central body. However, a re-examination of the holotype and the characters recorded from the presently observed specimens show that the polar cleft extends much beyond the outline of denser area which is difficult to explain if this denser area is considered as central body; also the full-length distal saccus attachment which makes a cross-shaped pattern with the proximal polar cleft, supports that denser area does not represent the spore body. Hence, the inner denser area is being considered here as the inner body within the central body.

Genus—*Striatopodocarpites* Soritsch & Sedova emend. Bharadwaj 1962

Striatopodocarpites dubrajpurensis sp. nov.
Pl. 3, figs 4, 7, 8, 10

Holotype—Pl. 3, fig. 10; size 91 × 71 μm, central body size 66 × 77 μm; Slide no. BSIP 9323.

Isotype—Pl. 3, fig. 4; size 112 × 67.5 μm, central body size 70 × 67.5 μm; Slide no BSIP 8471.

Type locality—Bore-hole RJR-2 (Sample no. 32, depth 398.20-398.99 m) near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Triassic.

Diagnosis—Diploxylonoid 91-126 μm; 57-57 μm. Central body distinct, dense, subcircular, 47-70 × 45-71 μm, proximally striate with 15-21 horizontal striations, finely intramicroreticulate. Sacci more than hemisphere, coarsely intrareticulate having meshes up to 6 μm wide; distal sulcus 15-30 μm broad.

Description—Bilateral, central body without an equatorial rim, exine 1.5-2 μm thick as seen at the lateral ends; some striations branched, vertical partitions absent. Exine finely intramicroreticulate, muri thick. Sacci more than hemispherical, proximally equatorially attached, distal attachment subequatorial along full length of central body, almost straight, distal saccus-free area broad and bilateral, 16 μm wide in holotype. Saccus intrareticulation coarse, mesh polygonal, 3-6 μm in size, muri thick.

Comparison—The present species is closely comparable to *S. multistriatus* (Banerji & Maheshwari) Bharadwaj & Dwivedi 1982 in having many striations, but differs in having larger size-range, and more horizontal striations (15-21), absence of vertical partitions and coarse intrareticulation of the saccus. *Striatopodocarpites auriculatus* Vijaya & Tiwari 1988 (in Vijaya *et al.*, 1988) is different from the present species due to auriculate nature of sacci and striations tending to impart an incipient taeniate appearance.

Striatopodocarpites sp.
Pl. 3, fig. 13

Remarks—Pollen measuring 100 × 64 μm with horizontally oval, 70 × 50 μm, equatorially thickened (2.5 μm thick) central body bearing 7 horizontal striations, without vertical partitions. Sacci kidney-shaped. However, the combination of the central body characters—the striations, equatorial rim and the nature of saccus reticulation with thick muri, small lumen with partial radial arrangement does not allow its assignment to any of the already described species. Therefore, it is described here as *Striatopodocarpites* sp.

Genus—*Coptospora* Dettmann 1963

Coptospora verrucosa sp. nov.
Pl. 5, figs 6, 9-11

Holotype—Pl. 5, figs 9, 10; size 65 μm; Slide no. BSIP 8469.

Isotype—Pl. 5, fig. 6; size 65 μm; Slide no. BSIP 9551.

Type locality—Bore-hole RJR-2 (Sample no. 9, depth 94-102.76 m) near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Spores hilate, subtriangular to subcircular. Exine verrucose all over except on one pole where rupturing to form subcircular area; verrucae prominent with round and conical tips.

Description—Size 63-66 μm in diameter. Hilum subcircular, measuring 25-35 μm in diameter. Exine thickness difficult to measure due to presence of prominent and densely disposed ornaments Verrucae 1-3 μm wide at base and 1.5-3 μm high. Equatorial girdle or rim broader at the angles being 3-8 μm wide.

Comparison—Coptospora verrucosa sp. nov. differs from *C. striata* Dettmann 1963 in the absence of striate pattern in the exine, beside the presence of massive verrucae; *C. paradoxa* Dettmann 1963 has scabrate exine and hence it is different from the present species. *Coptospora* sp. A, described by Dettmann (1963, pl. 20, figs 6-8) resembles the present species in having verrucose sculpture, although in the present specimens they are with round and pointed tips. *Coptospora* sp., recorded by Maheshwari and Jana (1983) from Rajmahal Basin (pl. 2, figs 26, 27), resembles the present species to a greater extent, except in the size of verrucae.

Genus—*Cooksonites* Pocock emend. Dettmann 1963

Cooksonites rajmahalensis sp. nov.
Pl. 5, figs 14, 18

Holotype—Pl. 5, fig. 14; size 66 μm; Slide no. BSIP 8468.

Isotype—Pl. 5, fig. 18; size 67 μm; Slide no. BSIP 9545.

Type locality—Bore-hole RJR-2 (Sample no. 9, depth 94-102.76 m) near Kazigaon, Rajmahal Basin.

Horizon & age—Dubrajpur Formation, Late Jurassic/Early Cretaceous.

Diagnosis—Spores roundly triangular, hilate and cingulate. Cingulum with small holes on surface appearing to be short canals, also sculptured with sparsely disposed low verrucae. Central body ornamented with verrucae.

Description—Size 66-104 μm. Hilum or ruptured area present on one face, subcircular, up to 20 μm; central body convexly triangular with rounded angles, size 60-80 μm, ornamented with low 0.5-2 μm verrucae. Cingulum 9-12 μm wide, darker near the central body equator, small hole-like structures present in cingulum simulating as short channels radiating towards the peripheral region; 1-2 μm high and 1-2 μm wide verrucae present on the cingulum projecting out from the equatorial outline.

Comparison—Cooksonites variabilis Pocock 1962 is different from the present species in having narrower, smooth or finely scabrate cingulum without any canals and showing polygonal process arranged in reticulate pattern on the polar region. *Cooksonites* sp. recorded by Bose, Kutty and Maheshwari (1982) from Gangapur Formation differs from *C. rajmahalensis* sp. nov. in having coni which extend on to the cingulum. *C. minor* Venkatachala 1969 is smaller in size (50-60 μm) having narrower and smooth cingulum.

Type A
Pl. 2, fig. 19

Description—Subcircular, oval to squarish bodies, light brown in colour, measuring 54-58.5 μm; on equator 3-5 μm wide zona-like structure present; finely laminated, bar-like thickenings run across the width of the equatorial zone; these thickenings being 3-5 μm apart from each other, sometimes shorter than the width of zona with nail-shaped organisation at their loose ends. No haptotypic mark seen on the surface; 2-4 μm long sparse bacula with round or blunt broader heads present all over the body on both the surfaces, no process projecting beyond the equator. Exine smooth, folds prominent.

Type B
Pl. 1, fig. 15

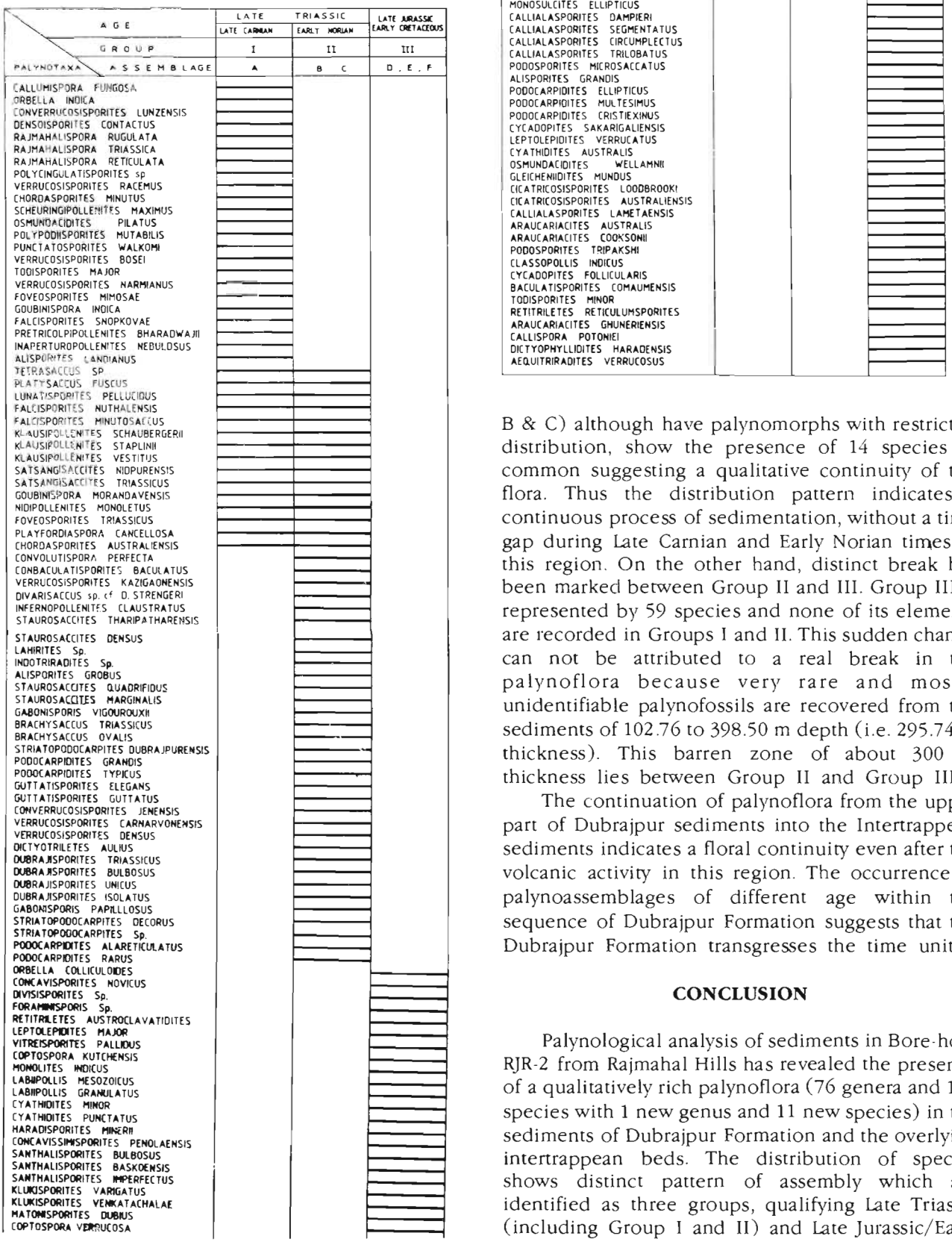
Description—Alete, subcircular to oval, light brown bodies with many folds on the equatorial region, measuring 92.5-105 μm; exine 1 μm thick, intrapunctate, puncta uniformly distributed; a weak zone present.

Remarks—It is observed that these bodies split along the weak zone.

DISTRIBUTION PATTERN OF VARIOUS PALYNOTAXA

The distribution pattern of various palynotaxa recorded in the sequential samples of Bore-hole RJR-2 is plotted in Table 1 which shows the presence of three distinct Groups, viz., Group I, II and III. Group I includes Assemblage A indicating Late Triassic (Late Carnian) age; Group II includes Assemblages B and C deciphering Late Triassic (Early Norian) age, and Group III having Assemblages D, E and F denotes Late Jurassic/Early Cretaceous age (Tiwari *et al.*, 1984). The older two groups (i.e. Assemblages A,

Table 1—Distribution pattern of palynofossils in Dubrajpur and Intertrappean sediments from bore-hole RJR-2, Rajmahal Basin



B & C) although have palynomorphs with restricted distribution, show the presence of 14 species in common suggesting a qualitative continuity of the flora. Thus the distribution pattern indicates a continuous process of sedimentation, without a time gap during Late Carnian and Early Norian times in this region. On the other hand, distinct break has been marked between Group II and III. Group III is represented by 59 species and none of its elements are recorded in Groups I and II. This sudden change can not be attributed to a real break in the palynoflora because very rare and mostly unidentifiable palynofossils are recovered from the sediments of 102.76 to 398.50 m depth (i.e. 295.74 m thickness). This barren zone of about 300 m thickness lies between Group II and Group III.

The continuation of palynoflora from the upper part of Dubrajpur sediments into the Intertrappean sediments indicates a floral continuity even after the volcanic activity in this region. The occurrence of palynoassemblages of different age within the sequence of Dubrajpur Formation suggests that the Dubrajpur Formation transgresses the time units.

CONCLUSION

Palynological analysis of sediments in Bore-hole RJR-2 from Rajmahal Hills has revealed the presence of a qualitatively rich palynoflora (76 genera and 136 species with 1 new genus and 11 new species) in the sediments of Dubrajpur Formation and the overlying intertrappean beds. The distribution of species shows distinct pattern of assembly which are identified as three groups, qualifying Late Triassic (including Group I and II) and Late Jurassic/Early

Cretaceous (including Group III). The marked continuity in the distribution pattern of Group I and II is suggestive of continuous sedimentation during Late Carnian and Early Norian times. The pattern of species distribution in the uppermost part of infratrappean and second intertrappean bed is indicative of continuation of similar vegetation inspite of the first flow which demarcates the upper limit of Dubrajpur Formation.

The barren zone of 300 m thickness contains ferruginous, green, grey, red coloured shales, clay and sandstone This zone, lithologically, is bracketted within the Dubrajpur Formation. Palynologically the base of this barren zone is marked by the Early Norian flora, while its top is delimited by a Late Jurassic/Early Cretaceous assemblage. Therefore, in all probability, this thickness of sediment represents an intervening time slot during which period the 300 m thick sediments were deposited.

Palynologically, Dubrajpur Formation encompasses the sedimentary deposits of Late Permian to Late Jurassic/Early Cretaceous age—obviously a time transgressive phenomenon.

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