The Palaeobotanist, 30(2): 121-142, 1982.

PLANT FOSSILS FROM THE GANGAPUR FORMATION

M. N. BOSE*, T. S. KUTTY** & HARI K. MAHESHWARI*

*Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India

**Indian Statistical Institute, Calcutta 700 035, India

ABSTRACT

Plant fossils have been recovered from the Gangapur Formation, originally known as ' Gangapur beds ' of the Kota ' Stage '. The material was obtained from 11 localities in the vicinity of Gangapur Village, Adilabad District, Andhra Pradesh. The mega-fossils belong to the common Upper Gondwana forms. The commonest fossil is *Elatocladus*. A new species of the genus (*E. kingianus*) has been identified on the basis of epidermal features. Epidermal features of a species of *Pagiophyllum*, viz., *P. marwarensis*, have also been studied.

The palynological assemblage comprises about 64 taxa. The dominant element is the *Araucariacites-Callialasporites* complex. The stratigraphically important forms occurring in the samples are: *Trilites tuberculiformis*, *Ischyosporites crateris*, *Cooksonites variabilis* and *Microcachryridites antarcticus*.

After analysing the available palaeobotanical and palynological data, a basal Lower Cretaceous age for the Gangapur Formation is suggested.

Key-words — Plant fossils, Sporae dispersae, Gangapur Formation, Kota Stage, Upper Gondwana, India.

सारांश

गंगापुर शैल-समूह से पादपाश्म – महेन्द्र नाथ बोस, टी० एँस० कुट्टी एवं हरि कृष्ण माहेश्वरी

गंगापुर शैल-समूह, जो कि मूलत: कोटा 'चरण' के 'गंगापुर संस्तरों' के नाम से विदित थे, से पादपाश्म उपलब्ध हुए हैं। आदिलाबाद जनपद (आँध्र प्रदेश) में गंगापुर गाँव के आस-पास के क्षेत्र से 11 स्थानों से सामग्री एकत्र की गई। गुरुपादपाश्म सामान्य उपरि गोंडवाना प्ररूपों से सम्बद्ध हैं। इलेँटोक्लेँडस सामान्यतया मिलने वाला पादपाश्म है। अधिचर्मी लक्षणों के आधार पर प्रजाति की एक नई जाति (इ० किन्गिआनस) अभिनिर्धारित की गई है। पेजियोफ़िल्लम् की एक जाति, पे० मारवारेँन्सिस, के अधिचर्मी लक्षणों का भी अध्ययन किया गया है।

परागाणविक समुच्चय में लगभग 64 वर्गक विद्यमान हैं। अँराकेरिआसाइटिस-केँलिआलास्पोराइटिस सम्मिश्र प्रभावी तत्त्व है। नमूनों में स्तरिकीय दृष्टि से मुख्य प्ररूप ट्राइलाइटिस ट्युबरक्युलिफ़ॉर्मिस, इस्चिओस्पोराइटिस क्रेटेँरिस, कुक्सोनाइटिस वेरिआबिलिस एवं माइक्रोकेक्रिआइडाइटिस अँन्टार्कटिकस हैं।

सभी उपलब्ध पुरावनस्पतिक एवं परागाणविक आँकड़ों का विश्लेषण करने के पश्चात् गंगापुर शैल-समूह के लिए आधारी-अधर क्रीटेशस आयु प्रस्तावित की गई है।

INTRODUCTION

THE Gangapur Formation is known from the Pranhita Godavari Valley outcrop and was initially recognized (Kutty, 1969) in the vicinity of the village Gangapur (19° 16′ N. lat., 79° 26′ E. long.; Adilabad District, Andhra Pradesh) to represent beds previously referred to, in this area, as the 'Gangapur beds' by King (1881).

In the type area the formation consists of coarse to very coarse and sometimes pebbly sandstones below, which tend to thin to the west but become coarser and conglomeratic eastwards. These are followed by a succession of pale grey, whitish and pinkish mudstones and siltstones interbedded with beds of sandstone. In places slightly carbonaceous shales are also found. The plant fossils and palynomorphs described here were obtained from the finer lithologies,

The recognition of the Gangapur Formation and its relationship to older beds helped to resolve an almost ninety-year-old stratigraphic controversy involving it. According to King (1881), the 'Gangapur beds' formed the lower part of his 'Kota Group' while a 'limestone series' formed the upper part. The 'limestone series' was characterized by the presence of limestones yielding a fish fauna comprising *Lepidotes*, *Paradapedium* and *Tetragonolepis*, suggesting a Lower Jurassic age to it (King, 1881; Jain, 1973). The 'Gangapur beds', however, had yielded a flora containing *Taeniopteris spatulata*, *Ptilophyllum acutifolium*, *Elatocladus confertus*, *E. jabalpurensis*, *E. tenerrimus*, *Cheirolepis muensteri* and *Araucarites cutchensis*. This flora was considered by Feistmantel (1879) and King (1881) as showing a mixture of Rajmahal and Jabalpur floras and hence of an intermediate age. The 'Kota Group' thus had "plants of the Rajmahal, Jabalpur and Umia formations in what have been claimed to be lower and not higher horizons than animals which . . . are not younger than Lias" (Pascoe, 1959, p. 988).

This stratigraphic anomaly was resolved when Kutty (1969) showed that, in the area near Gangapur, the 'Gangapur beds' did actually rest with a marked unconformity on beds of the 'limestone series' and older beds. The Kota Formation with its characteristic limestones and fish fauna was redefined and the Gangapur Formation was recognized as being characterized by the 'Gangapur beds' of this area.

While the Gangapur Formation is known in the vicinity of Gangapur and to its west, its eastward extension and therefore its relationship to the Chikiala Formation are still to be fully worked out. However, Rudra (1972) recognized the Gangapur Formation around Yamanpalli in the eastern part of the outcrop, and observed that its stratigraphic position is between the Kota Formation in its revised sense and the Chikiala Formation; except for some calcareous fossil wood, no other plant fossil was reported. Thus, the post-Triassic Upper Gondwana sequence of the Pranhita-Godavari Valley, as it stands now, is as follows:

Formation	Rock types	Characteristic fossils	Age
Chikiala	Highly ferruginous sandstone and conglomerate	?	?
Gangapur	Mudstones, siltstones and sandstones with pebbly beds and conglomerates	*Gleichenia*, *Taeniopteris*, *Ptilophyllum*, *Elatocladus*, *Pagiophyllum*	Early Lower Cretaceous
	Unconformity		
Kota	Limestone, sandstone, siltstones and red clays; pebbly sandstone at the base	Fish, crocodile, sauropod dinosaur, flying reptile	Lower — ? early Middle Jurassic
	? Unconformity		
Triassic beds			

It may be pointed out that the Gangapur Formation is not strictly synonymous with the 'Gangapur beds' of King. While in the vicinity of the village Gangapur they may correspond to the same set of beds of Lower Cretaceous age, a little to the east beyond Dharmaram, what King includes in his 'Gangapur beds' are of undoubted Triassic age.

Consequent to (i) the recognition of the Gangapur Formation and its separation

from the Kota Formation by a major unconformity, (ii) the recognition of the Kota Formation, and (iii) the recognition of the Gangapur Formation in eastern part of the outcrop between Kota and Chikiala formations, it becomes difficult now to place previous reports of plant fossils in the revised stratigraphic sequence with a reasonable degree of assurance; this is particularly so in the eastern part where all the three formations occur. It would seem best to build up afresh the various floras from new collections made on the basis of remapping.

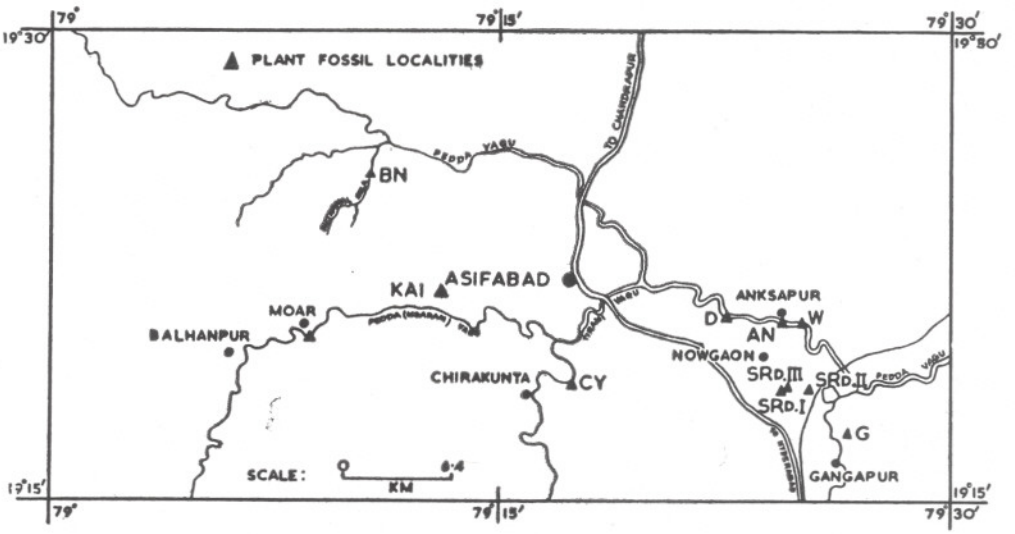
For example, Mahabale (1967) reported the following plant megafossils from the 'Kota-Maleri Stage'. The plant-bearing beds from Nowgaon and Jangaon possibly belong to the Gangapur Formation.

1. Nowgaon — *Elatocladus jabalpurensis*, *Araucarites cutchensis*.
2. Kota — *Elatocladus*, *Taxoxylon*, *Podocarpoxylon* and *Araucarioxylon*.
3. Jangaon — *Pachypteris indica*, *Ptilophyllum acutifolium*, *Taeniopteris spatulata*, *Elatocladus confertus*, *E. jabalpurensis*, *Cheirolepis muensteri* and *Araucarites*.

His statements on the age of the 'Kota Stage' are self-contradictory. In the abstract of his work (Mahabale, 1967, p. 308) he placed Kota at par with the Upper Gondwanas or the Liassic but elsewhere in the same paper (p. 312) he says that "The age of Kota stage, could not be later than Rajmahals and earlier than Jabalpur. . . . .". It is generally accepted that the Jabalpur flora is younger than even that of the Nipania plant bed of the Rajmahal Formation which is dated as Upper Jurassic in age. Probably he was influenced by the views of Wadia (1975, p. 67 and 188) that the Jabalpurs were older than the Rajmahals and the Kotas were still older.

Preliminary reports on the palynomorphs of the Gangapur Formation have been published by Shah and Singh (1974) and Ramanujam and Rao (1976). Palynologically a Lower Cretaceous age has been favoured.

A fresh attempt is made here to throw further light on the age of the Gangapur Formation from the palaeobotanical and palynological data obtained by the study of newly collected materials from a number of localities. For this work, T. S. K. made field observations and collected the material. M. N. B. and H. K. M. have worked out the megafossils and palynomorphs respectively. Conclusions have been arrived at jointly by the three authors whose names appear in alphabetical order.



TEXT-FIG. 1 — Map showing some of the plant fossil localities belonging to the Gangapur Formation.

MATERIAL AND METHODS

The localities from where the fossil collections were made are depicted in map (Text-fig. 1). The localities are:

1. Moar : on the stream bank near a bend SSE of the village Moar;
2. BN : on the bank of Butarmal Nala just south of the point where it crosses the road from Asifabad to Utnur 13 km W.N.W. of Asifabad;
3. CY : on a spur of the hill, east of the village Chirakun'a;
4. D, 5. An, 6. W : on the banks of Pedda Vagu near Anksapur;
7. S.Rd.I, 8. S.Rd.II, 9. S.Rd.III : Quarries south-south-west of the village Nowgaon;
10. G : Quarry north of Cave Temple near Gangapur Village; and
11. KAI : Reddish mudstones and siltstones near base of hill about 7 km west of Asifabad.

Plant fossils are generally found in finer sediments, viz., mudstones, siltstones and the carbonaceous shale. A few fossils have also been found in ferruginous shales. Processing of samples for palynological study was done by the orthodox HF, HNO_3, KOH method. Slides were made in polyvinyl alcohol and canada balsam. Photography was done on ORWO NP15 35 mm film. The co-ordinates of the illustrated palynomorphs refer to Amplival microscope no. 599558 of BSIP, Lucknow.

Figured specimens and slides are housed in the Museum of Birbal Sahni Institute of Palaeobotany.

DESCRIPTION

A. MEGAFOSSILS

?*Cladophlebis* sp.

Text-fig. 2A

Detached (?) pinnule, 3.5 mm long, about 2 mm broad near base, falcate; margin thick, entire, near apex minutely denticulate; apex subacute, extreme base not well-preserved. Midrib prominant, lateral veins mostly forking once slightly away from midrib, arising at an angle of 32°-35°.

The pinnule looks like the pinnule of *Cladophlebis* sp. cf. *C. longipennis* Seward described by Roy (1968, pl. 2, fig. 17) and Kasat (1970, pl. 1, figs 3, 4).

Locality — Pedda Vagu about 3 km West of Anksapur.

Gleichenia nordenskioildii Heer

Pl. 1, figs 1-3; Text-fig. 2B, C

Detached pinnae, 0.25-1.1 cm long and 1.5-4 mm broad. Rachis slightly less than 1 mm in width. Pinnules 1-3 mm long and 0.5-1.5 mm broad, substance of lamina thick, ovate or somewhat cuneate, contiguous but margins never overlapping, occasionally sparsely set, attached at an angle of about 50°-60°. Margin thick, revolute; apex obtuse or rounded; base asymmetrical, acroscopic margin rounded and making a narrow sinus, basiscopic margin rounded, prolonged downwards, mostly covering entire width of pinna rachis. Midrib of pinnules prominent, near base forming a prominent groove; lateral veins mostly obscure.

The specimens match the specimens described by Sukh-Dev (1970, pl. 1, figs 3-5), Pant and Srivastava (1977, pl. 2, fig. 2) and Appert (1973, pl. 20, figs 9, 11).

Locality — Quarry no. S.Rd.III, S.S.E. of Nowgaon on way to Kagaznagar.

?*Gleichenia* sp.

Text-fig. 2D

The collection includes a badly preserved detached pinna whose pinnules, in gross features, resemble the pinnules of *Gleichenia rewahensis* Feistmantel described by Pant and Srivastava (1977, pl. 1, fig. 5). Its venation is not preserved.

Locality — Quarry no. S.Rd.III, S.S.E. of Nowgaon on way to Kagaznagar.

Taeniopteris sp. cf. *T. spatulata* McClelland

Pl. 2, fig. 18; Text-fig. 2E-G

Description is based on three fragmentary specimens. In all the three specimens apex and base are missing.

Leaves 1.7-4.6 cm long, 0.4-0.6 cm broad, margin entire. Midrib about 1 mm wide; lateral veins arising at an angle of 85°-90°, simple or forked, when forked mostly forking just after emergence or closer to midrib, a few forking closer to margin, about 28-32 per cm.

The specimens resemble the specimens figured by Oldham and Morris (1863, pl. 6, figs 1, 2), Feistmantel (1879, pl. 1, figs 8-10, 18) and Bose and Banerji (1980, pl. 1, figs 1, 2; pl. 5, fig. 28).

Locality — Quarry no. S.Rd.III, S.S.E. of Nowgaon on way to Kagaznagar.

?*Anomozamites* sp.

Pl. 1, fig. 5; Text-fig. 2H

Fragmentary specimen showing two incomplete segments. Frond 1 cm long and 2 cm broad; rachis about 2 mm wide, lateral veins forking once. Most complete segment measuring 1 cm in length and 0.8 cm in width, distal margin seems to be deeply notched, upper lateral margin entire, lower lateral margin not preserved.

In external feature and venation pattern the segments of the present specimen resemble the segments of *Anomozamites fissus* (Feistmantel) figured by Bose and Banerji (1980, text-fig. 8A, C).

Locality — Quarry no. S.Rd.I, S.S.E. of Nowgaon on way to Kagaznagar.

Ptilophyllum cutchense Morris

Pl. 1, fig. 4

Leaves incomplete at base and apex, 2.2-11.5 cm long, 1.1 cm broad. Rachis about 1 mm wide. Pinnae attached on upper surface of rachis by their entire base, closely set but never overlapping, 4.6 mm long, 1.5-2 mm broad; apex obtuse or subacute; acroscopic margin rounded, basiscopic margin straight. Veins mostly obscure, about 5-6 veins arising from base, more or less parallel, simple or forked.

The specimen matches the specimen of *Ptilophyllum cutchense* figured by Bose and Kasat (1972, pl. 2, fig. 17) from Vemavaram.

Locality — Quarry no. S.Rd.III, S.S.E. of Nowgaon on way to Kagaznagar.

Ptilophyllum sp. cf. *P. acutifolium* Morris

Text-fig. 2I-K

Leaves 9.5-10.8 cm long, 1.8-3.6 cm broad; rachis 1.5-2 mm broad. Pinnae arising at an angle of 45°-65°, closely set on upper side of rachis, 1.1-1.9 cm long and 2-2.5 mm broad near base; apex acute; margin entire, acroscopic margin curving downwards, basiscopic margin slightly decurrent. Veins parallel, 6-7 veins arising from base, simple or forked, mostly forking once, forking at all levels.

The specimens are narrower than the type specimen of *Ptilophyllum acutifolium* (Bose & Kasat, 1972, pl. 1, fig. 1). They resemble the specimen figured by Bose and Kasat (1972, pl. 1, fig. 6) from Raghavapuram which has been doubtfully referred to *P. acutifolium*. The present specimens also look like *P. acutifolium* described by Baksi (1968, pl. 1, fig. 1A, 1b) from Raghavapuram.

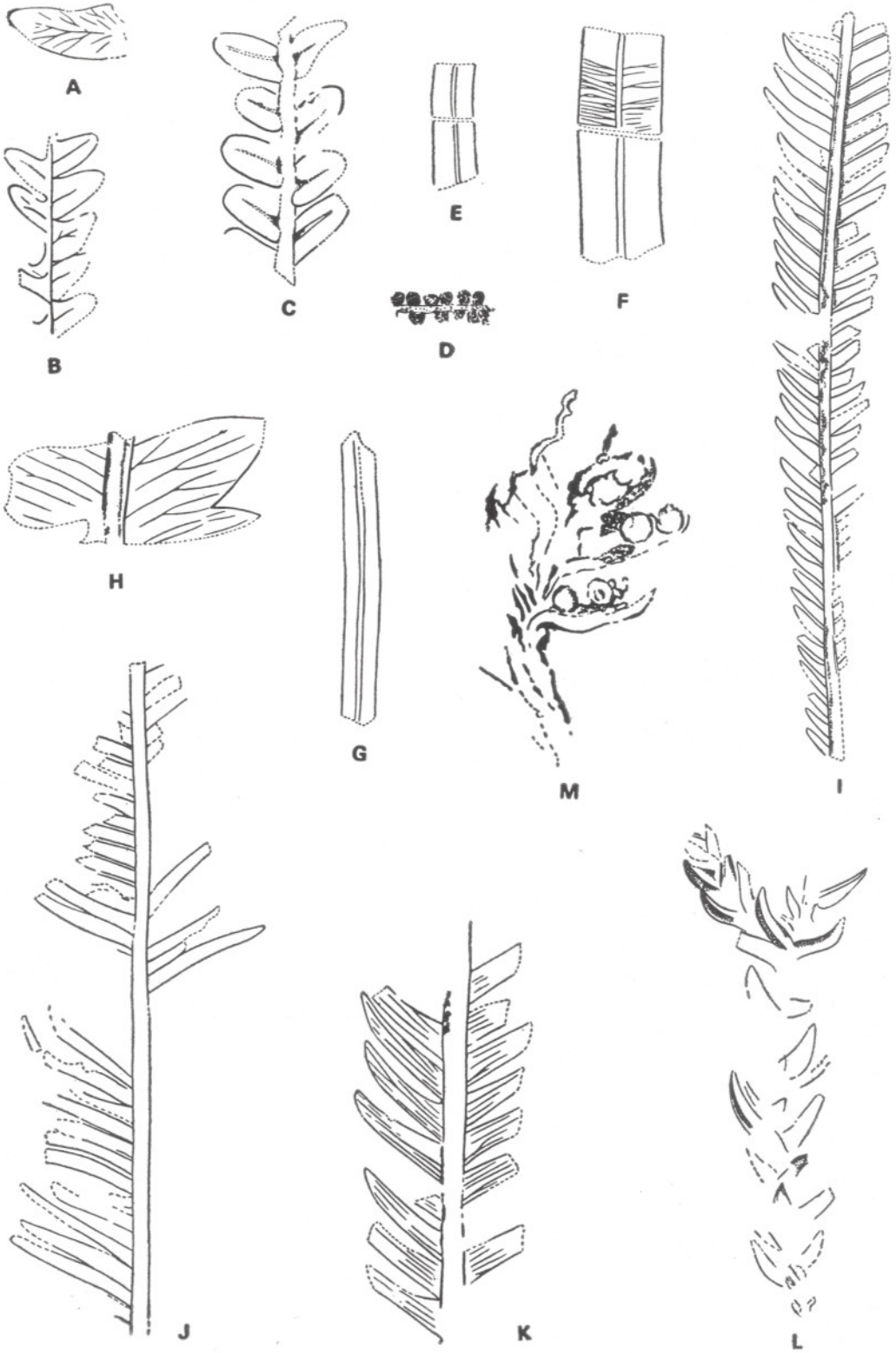
Localities — Quarry nos. S.Rd.I and III, S.S.E. of Nowgaon on way to Kagaznagar; 13 km W.N.W. of Asifabad, along the Butarmal Nala (stream); and base of hill about 7 km west of Asifabad.

Elatocladus sp.

P. 1, figs 6, 11

Shoots repeatedly branched, branchlets mostly lying in the same plane as the primary axis. Leaves helically borne, in compressed state seem to be biseriately arranged, making an angle of about 60°-90°. Leaves typically 6-8 mm long, 0.5-1 mm broad, almost uniformly broad from base to apex; margin entire; apex sub-acute or obtuse, rarely acute; acroscopic basal edge slightly constricted, basiscopic margin often slightly constricted, markedly decurrent. Midvein running from base to apex. At the point of forking branchlets covered with spirally arranged scale-like leaves which are followed by normal leaves. Scale-like leaves more or less wedge-shaped, 1.5-4 mm long, 0.5-1 mm broad near base; midvein faintly marked.

The specimens match the specimens of *Elatocladus tenerrimus* described by Feistmantel (1877) and Sahni (1928). They also



TEXT-FIG. 2

resemble the twigs of *E. pseudotenerrima* Maheshwari & Kumaran (1976), *E. sehoraensis* Maheshwari & Kumaran (1976) and *E. bosei* Maheshwari & Kumaran (1976). In the absence of cuticle the Gangapur specimens have not been referred to any of these species.

Localities — Quarry nos. S.Rd.I-III, S.S.E. of Nowgaon on way to Kagaznagar; about 13 km W.N.W. of Asifabad, along the Butarmal Nala (stream); and Pedda (Moaram) Vagu Stream, S.S.E. of Moar Village.

Elatocladus confertus (Oldham & Morris) Halle

Pl. 1, figs 7, 8, 13; Pl. 2, fig. 15; Text-fig. 2M

Branched leafy twigs, branching at different angles. Leaves spirally arranged, mostly spreading out in two rows, occasionally directed upwards or forwards, linear or linear-lanceolate, sometimes deltoid (close to base of shoot), 3-7 mm long, less than 1 mm broad. Margin entire; apex acute; base constricted or twisted, decurrent. Midrib mostly obscure, rarely visible in some.

The shoots agree with the specimens of *Elatocladus confertus* described by Halle (1913) and Sahni (1928).

Localities — Quarry no. S.Rd.III, S.S.E. of Nowgaon on way to Kagaznagar; and about 13 km N.N.W. of Asifabad, along the Butarmal Nala (stream).

Remarks — Amongst the several shoots collected, there is a branched shoot (in part and counterpart) which bears two megastrobili. The specimen (Pl. 1, figs 7, 8, 13; Text-fig. 2M) is rather badly preserved and its each branch has terminally placed megasporophylls. The megasporophylls are loosely arranged and are spirally borne. They are attached at angles of 50°-70°. In some of the megasporophylls two circular or broadly oval seeds are visible on their adaxial sides.

The specimen resembles the specimens of *Stachyotaxus sampathkumarani* Rao (1964) described from Onthea, Rajmahal Hills. The seeds in *S. sampathkumarani* Rao (1964) are pyramid-shaped, whereas, in the present specimen they are circular or broadly oval.

Elatocladus kingianus n. sp.

Pl. 1, fig. 10; Pl. 2, fig. 16; Text-fig. 3B

Diagnosis — Shoots slender and woody, irregularly or alternately branched, branches arising at angles of 40°-55°; leaves persistent, spirally borne, in compressed state seem to be biseriately arranged; attached by entire width of decurrent leaf-base. Leaves linear, 0.8-1.2 cm long, about 0.5-1 mm broad, margin entire, apex acute; leaf base contracted and twisted, acroscopic basal edge curving downwards, basiscopic basal edge markedly decurrent. Midrib mostly obscure.

Cuticle of almost same thickness on both sides of leaf, (?) upper side devoid of stomata and (?) lower side having stomata in a single band running along the midrib. Central stomatic band about 3-5 stomata wide, within the stomatic band stomata tending to form discontinuous narrow files. Stomata longitudinally orientated, distantly placed or touching each other but never sharing a common subsidiary cell. Subsidiary cells 4-6 (2 + 2 or 2 + 4), mostly 4 or 5, polar subsidiary cells smaller in size; lateral- and end-walls straight, rarely slightly undulated, surface smooth. Guard cells thinly cutinized, sunken; aperture slit-like. Encircling cells occasionally present. Cells between files and adjacent stomata mostly rectangular, rarely polygonal, smaller in size than those lying outside stomatal

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TEXT-FIG. 2 — **A**, *?Cladophlebis* sp., no. D14/67-68, × 6. **B, C**, *Gleichenia nordenskioildii* Heer, nos. S. Rd. III-21/67-68 and S. Rd. III-39/67-68, × 5. **D**, *?Gleichenia* sp., no. S. Rd. III-29/67-68, × 2.5. **E-G**, *Taeniopteris* sp. cf. *T. spatulata* McClelland, nos. S. Rd. III-44/67-68 (E, F) and S. Rd. III-12/67-68 (G), E, G, × 1, F, × 2. **H**, *?Anomozamites* sp., no. S. Rd. I-25/67, × 2. **I-K**, *Ptilophyllum* sp. cf. *P. acutifolium* Morris, nos. S. Rd. I-41b/67 (I, K) and S. Rd. III-2/67-68 (J), I, J, × 1, K, × 2. **L**, *Pagiophyllum marwarensis* Bose & Sukh-Dev, no. G3/4.2.71, × 3. **M**, *Elatocladus confertus* (Oldham & Morris) Halle showing a few megasporophylls, no. S. Rd. I-2b/67, × 4.

band; lateral- and end-walls straight, rarely slightly undulated or broken by pits. Cells outside stomatal band and cells of non-stomatic surface similar in shape and size, mostly much longer than broad, narrow, rectangular, rarely polygonal, serially arranged in longitudinal direction, lateral- and end-walls straight or rarely at places slightly undulated, or broken by pit; surface wall smooth, devoid of hair or papillae.

Holotype — No. G4/4.2.72 of Indian Statistical Institute, Calcutta, stored at B.S.I.P. Lucknow Museum.

Locality — Quarry north of Cave Temple near Gangapur Village.

Specific Name — After late Mr W. King of the Geological Survey of India, who had first worked out in detail the geology of the Gangapur region.

Comparison — In gross features *Elatocladus kingianus* resembles *E. tenerrimus* (Feistmantel) Sahni (1928), *E. pseudotenerrima* Maheshwari & Kumaran (1976), *E. sehoraensis* Maheshwari & Kumaran (1976) and *E. bosei* Maheshwari & Kumaran (1976), but it differs from all these species in having a central stomatic band on one surface only. Moreover, in the present species the ordinary epidermal cells are much longer than broad. *E. tenerrimus*, *E. sehoraensis* and *E. bosei* have stomata on both the srufaces. *E. pseudotenerrima* is hypostomatic but here the stomata are distributed within two bands leaving a central astomatic region. Most of the species of *Elatocladus* described by Harris (1935) from Greenland differ from *E. kingianus* in having two stomatal bands. Similarly the Yorkshire species of *Elatocladus* described by Harris (1979) have more than one stomatal band.

Pagiophyllum marwarensis Bose & Sukh-Dev

Pl. 1, figs 9, 12; Pl. 2, figs 14, 17, 19, 20; Text-figs 2L, 3A

Description — Unbranched, slightly curved leafy twigs, 2-8 cm long, 0.4-0.6 cm broad. Shoots bearing leaves in a spiral, spreading or directed side-ways or forwards, 3-4 mm long, 0.8-1 mm broad near base, keeled. Margin entire; apex acute; leaf base cushion rhomboidal.

Cuticle on both sides of almost equal thickness, amphistomatic. Upper side showing two broad stomatal bands leaving a central stomatic region, towards apex stomatal bands converging and joining each other. On lower side stomata confined towards lower half of leaf in two narrow, ill-defined bands. On both sides within stomatic regions stomata arranged in discontinuous files, occasionally a few lying outside files, majority transversely or obliquely orientated, rarely longitudinally placed. Guard cells thinly cutinized, not sunken, aperture slit-like. Subsidiary cells mostly 4-5, sometimes 6, slightly more cutinized than ordinary epidermal cells. Subsidiary cells surrounded by a ring of encircling cells. Ordinary epidermal cells within stomatal bands polygonal; lateral- and end-walls thick, straight, surface-wall unspecialized, rarely finely striated. Cells of non-stomatal region polygonal, more elongate.

The twigs in gross features and cuticular structure of leaves resemble *Pagiophyllum marwarensis* Bose & Sukh-Dev (1972). *P. sherensis* Maheshwari & Kumaran (1976) differs in having lesser number of stomata on upper surface. In *P. satpuraensis* Maheshwari & Kumaran (1976) on lower side, isolated stomata are found near apical region. In *P. marwarensis* such stomata are absent.

Localities — Quarry no. S.Rd.III, S.S.E. of Nowgaon on way to Kagaznagar; Quarry north of Cave Temple near Gangapur Village; Pedda (Moaram) Vagu stream, S.S.E. of Moar Village; Spur of the hill, about 2 km east of Chirakunta Village; and about 13 km W.N.W. of Asifabad, on the Butarmal Nala (stream).

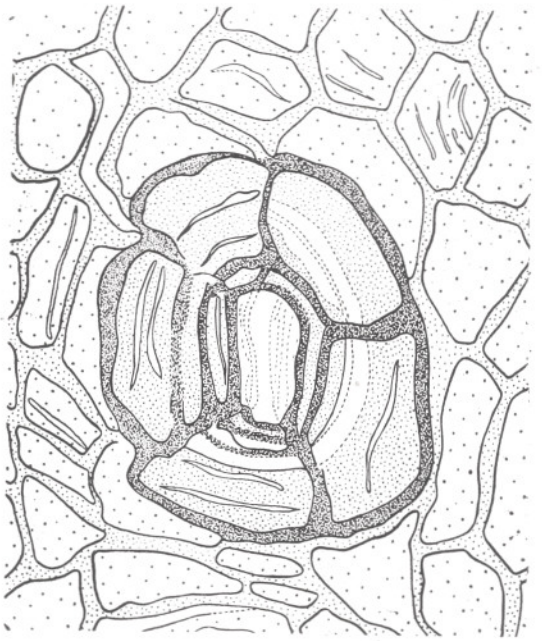
Coniferocaulon sp. cf. *C. rajmahalense* Gupta

Text-fig. 3C

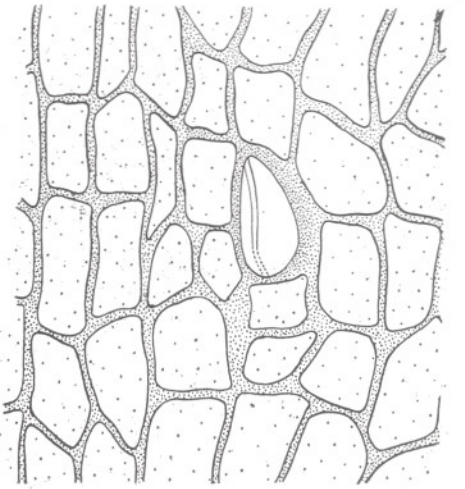
Description — Description is based on two fragmentary specimens measuring 6.4-7.6 cm in length and 9.7-12.1 cm in width. Surface showing discontinuous and irregularly running ridges and grooves, in transverse direction, within the ridges and grooves, at places, showing circular or elliptical protuberances.

The specimens resemble the specimens of *Coniferocaulon rajmahalense* figured by Bose

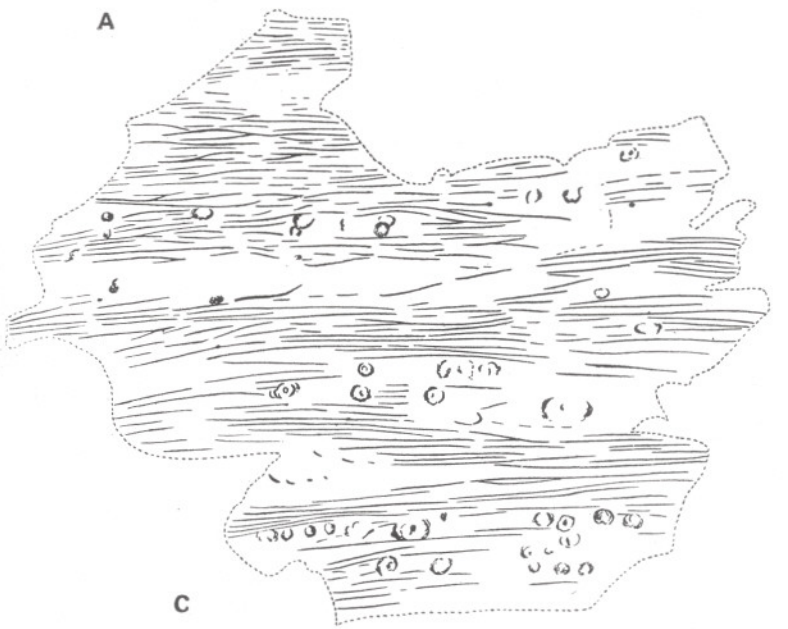
et al. (1980) from the Pariwar Formation exposed near Habur. The specimen of *C. rajmahalense* described by Gupta (1954) and Bose (1957) from the Rajmahal Hills and Sher River respectively have ridges and grooves which are more distantly placed.



A



B



C

TEXT-FIG. 3 — **A**, *Pagiophyllum marwarensis* Bose & Sukh-Dev showing a stoma, slide no. G3/4.2.71-E3, × 500. **B**, *Elatocladus kingianus* sp. nov., showing a stoma, slide no. G4/4.2.71-E1, × 500. **C**, *Coniferocaulon* sp. cf. *C. rajmahalense* Gupta, no. S. Rd. I-15b/67, × 1.

B. Palynological Assemblage

Of the several samples macerated, only three, i.e. Sample D from the bank of the Pedda Vagu and samples G3/4.2.71 and G4/4.2.71 from a quarry north of the Cave Temple near Gangapur Village yielded palynomorphs. The palynomorph content of sample D is very poor and hence the following account is based upon the study of samples G3/4.2.71 and G4/4.2.71 only. The latter two samples represent the same bed. The palynological assemblage comprises 64 taxa of trilete, zonate and monolete spores and alete, monosaccate and disaccate pollen grains. Following is a systematized list of all the palynomorph taxa recorded. Some of the important taxa have been illustrated on Plates 3 and 4.

Anteturma — *Sporites* H. Potonié, 1893
Turma — *Triletes* Reinsch emend. Dettmann, 1963
Suprasubturma — *Acavatitriletes* Dettmann, 1963
Subturma — *Azonotriletes* Luber emend. Dettmann, 1963
Infraturma — *Laevigati* Bennie & Kidston emend. Potonié, 1956

Genus — *Deltoidospora*, Miner, 1953 emend. Potonié, 1956

1. *Deltoidospora* sp.

Genus — *Cyathidites* Couper, 1953

2. *Cyathidites australis* Couper, 1953
3. *Cyathidites minor* Couper, 1953
4. *Cyathidites concavus* (Bolkhovitina, 1953) Dettmann, 1963

Genus — *Stereisporites* Pflug, 1953

5. *Stereisporites psilatus* (Ross, 1949) Jain & Sah, 1966

Remarks — Specimens assigned to the genus *Stereisporites* by Kumar (1973, pl. 1, figs 16-18) do not belong here and are best placed under the genus *Deltoidospora*.

Genus — *Todisporites* Couper, 1958

6. *Todisporites* sp.

Remarks — Spore 68 μm, trilete, rays 2/3 spore radius, labra thickened; exine smooth, infolded as in *Calamospora*.

Genus — *Callispora* Dev, 1961

7. *Callispora potoniaei* Dev, 1961

Infraturma — *Apiculati* Bennie & Kidston emend. Potonié, 1956

Genus — *Leptolepidites* Couper, 1953

8. *Leptolepidites* sp.

Remarks — Spore subcircular, 64 μm, trilete mark incipient; exine ornamented with verrucate projections, verrucae 4-5 μm in diameter, clearly seen only along the equatorial margin.

Genus — *Osmundacidites* Couper, 1953

9. *Osmundacidites wellmanii* Couper, 1953

Genus — *Baculatisporites* Thomson & Pflug, 1953

10. *Baculatisporites rotundus* Kumar, 1973
11. *Baculatisporites comaumensis* (Cookson, 1953) Potonié, 1956

Remarks — Singh, Srivastava and Roy (1964, p. 287) seem to consider *Osmundacidites comaumensis* (Cookson) Balme, 1957 and *Baculatisporites comaumensis* (Cookson) Potonié as separate taxa whereas both are same being later nomenclatural changes for *Trilites comaumensis* Cookson, 1953. Stanley (1965, p. 250, pl. 31, figs 6-9) has transferred the species to the extant genus *Osmunda* L.

Genus — *Conosmundasporites* Klaus, 1960

12. *Conosmundasporites* sp.

Remarks — Spore roundly triangular, 70 μm, trilete, rays more than 3/4 spore radius long, labra raised, distinctly thickened; exine about 2 μm thick, beset with closely placed, uniformly distributed coni.

Conosmundasporites othmari Klaus, 1960 has comparatively sparse exine ornament elements. Dettmann (1963, p. 31) considers the genus to be 'almost certainly synonymous with *Osmundacidites*'.

Genus — *Neoraistrickia* Potonié, 1956

13. *Neoraistrickia* sp.

Remarks — *Lophotriletes* sp. of Kumar (1973, p. 98, pl. 1, figs 28, 29) is comparable and should be referred to the genus *Neoraistrickia*.

Genus — *Apiculatisporis* Potonié & Kremp, 1954

14. *Apiculatisporis* sp.

Remarks — Spore circular, 32 μm in diameter, trilete, rays 2/3 spore radius long; exine beset with uniformly distributed low set coni.

Genus — *Impardecispora* Venkatachala, Kar & Raza, 1969

15. *Impardecispora* sp.

Infraturma — *Murornati* Potonié & Kremp, 1954

Genus — *Foveosporites* Balme, 1957

16. *Foveosporites* sp.

Remarks — Spores subcircular, 60-78 μm in diameter, trilete, rays 1/2 to 2/3 spore radius long; exine foveopunctate, elements less than 1 μm in diameter.

One of the specimens has an apparent appearance of *Callumispora* Bharadwaj & Srivastava, 1969.

Genus — *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont, 1955

17. ?*Lycopodiumsporites* sp.

Genus — *Klukisporites* Couper, 1958

18. *Klukisporites scaberis* (Cookson & Dettmann, 1958) Dettmann, 1963

Remarks — Spore subtriangular, 55 μm, sides concave, apices rounded, trilete prominent, rays 3/4 spore radius long, labra thick, accompanied by a row or two of foveolae; distal exine foveoreticulate, muri strong as if formed by coalescing warts. *K. haradensis* Kumar, 1973 is apparently similar.

Genus — *Cicatricosisporites* Potonié & Gelletich, 1933

19. *Cicatricosisporites australiensis* (Cookson, 1953) Potonié, 1956
20. *Cicatricosisporites typicus* Sah & Jain, 1956

Subturma — *Zonotriletes* Waltz, 1935
Infraturma — *Auriculati* Schopf emend. Dettmann, 1963

Genus — *Trilites* Erdtman, 1947 ex Couper, 1953 emend. Dettmann, 1963

21. *Trilites tuberculiformis* Cookson, 1947

Genus — *Ischyosporites* Balme, 1957

22. *Ischyosporites crateris* Balme, 1957

Remarks — Spore triangular, 54 μm; exine auriculate, 4 μm at apices, 2 μm elsewhere, distally reticulate, muri very thick, 2-3 μm, lumina polygonal, proximal exine smooth except at apices where distal muri encroach upon.

Infraturma — *Cingulati* Potonié & Klaus, 1954 emend. Dettmann, 1963

Genus — *Foraminisporis* Krutzsch, 1959

23. *Foraminisporis* sp.

Genus — *Contignisporites* Dettmann, 1963

24. *Contignisporites cooksonae* (Balme, 1957) Dettmann, 1963
25. *Contignisporites dettmannae* Singh & Kumar, 1969
26. *Contignisporites fornicatus* Dettmann, 1963
27. *Contignisporites glebulentus* Dettmann, 1963

Turma — *Monoletes* Ibrahim, 1933
Suprasubturma — *Acavatomonoletes* Dettmann, 1963
Subturma — *Azonomonoletes* Luber, 1935
Infraturma — *Laevigatomonoleti* Dybova & Jachowicz, 1957

Genus — *Monolites* Erdtman, 1947 emend. Potonié, 1956

28. *Monolites grandis* Dev, 1961

Remarks — *Monolites indicus* Kumar (1973, p. 111, pl. 4, figs 92, 93) represents better preserved specimens of *M. grandis* Dev and is considered here as a junior synonym of the latter species. *Monolites intragranulosus* Singh, Srivastava & Roy, 1964 also resembles *M. grandis* but for a smaller size range.

Genus —*Crassimonoletes* Singh, Srivastava & Roy, 1964

29. *Crassimonoletes minor* Singh, Srivastava & Roy, 1964

Infraturma — *Sculptatomonoleti* Dybova & Jachowicz, 1957

Genus — *Leschikisporis* Potonié emend. Bharadwaj & Singh, 1964

30. *Leschikisporis indicus* Singh, Srivastava & Roy, 1964

Remarks — There is a spore tetrad also in the collection. Spores oval, or subtriangular (probably preservation artefacts), two-layered, outer layer seemingly covering the central body on all sides, proximally forming a sort of longitudinal slit. These specimens probably do not belong to this species.

Genus — *Schizaeoisporites* Potonié, 1951 emend. Krutzsch, 1959

31. ?*Schizaeoisporites* sp.

Remarks — Spore oval-elliptical, long axis 60 μm, short axis 41 μm; exine ribbed, ribs running parallel to the longer axis, coalescing at poles, slightly criss-crossed.

Turma — *Hilates* Dettmann, 1963

Genus —*Cooksonites* Pocock, 1952 emend. Dettmann, 1963

32. *Cooksonites variabilis* Pocock, 1962
33. *Cooksonites* sp.

Remarks — Spore subtriangular, cingulate, cingulum comprising an inner thick zone and an outer thin zone; exine conate, coni extending upon cingulum, distal polar exine breaking down to form a distinct, subcircular hilum.

The specimen differs from *Cooksonites variabilis* Pocock in having a conact distal exine.

Genus — *Aequitriradites* Delcourt & Sprumont emend. Cookson & Dettmann, 1961

34. *Aequitriradites* sp. cf. *A. verrucosus* (Cookson & Dettmann, 1958) Cookson & Dettmann, 1961

Remarks — The specimen differs from the Australian specimens described by Cookson and Dettmann (1961) and Dettmann (1963) in having a comparatively narrow zona.

Anteturma — *Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Monosaccites* Chitaley, 1949 emend. Potonié & Kremp, 1954
Infraturma — *Prosaccites* Maheshwari, 1974

Genus — *Callialasporites* Dev, 1961 emend. Maheshwari, 1974

35. *Callialasporites baculosus* Sukh-Dev in Maheshwari, 1974
36. *Callialasporites dampieri* (Balme, 1957) Dev, 1961
37. *Callialasporites discoidalis* (Döring, 1962) Bharadwaj & Kumar, 1972
38. *Callialasporites circumplectus* Kumar, 1973
39. *Callialasporites lametaensis* Kumar, 1973

Remarks — *Callialasporites kattavakkamense* Ramanujam & Srisailam (1974, p. 86, pl. 5, fig. 41) is a junior synonym.

40. *Callialasporites rudisaccus* Maheshwari, 1974
41. *Callialasporites rimalis* Singh, Srivastava & Roy, 1964
42. cf. *Callialasporites reticulatus* Ramanujam & Srisailam, 1974
43. *Callialasporites segmentatus* (Balme, 1957) Dev, 1961
44. *Callialasporites triletus* Singh, Srivastava & Roy, 1964
45. *Callialasporites trilobatus* (Balme, 1957) Dev, 1961

Genus — *Properinopollenites* Maheshwari, 1974

46. *Properinopollenites singhii* Maheshwari, 1974

Subturma — *Disaccites* Cookson, 1947
Infraturma — *Pinosacciti* Erdtman emend. Potonié, 1958

Genus — *Alisporites* Daugherty, 1941 emend. Jansonius, 1971

47. *Alisporites grandis* (Cookson, 1953) Dettmann, 1963

Infraturma — *Podocarpoiditi* Potonié, Thomson & Thiergart, 1950

Genus — *Platysaccus* Naumova, 1937 ex Potonié & Klaus, 1954

48. *Platysaccus indicus* Sah & Jain, 1965

Genus — *Podocarpidites* Cookson, 1947 ex Couper, 1953

49. *Podocarpidites ellipticus* Cookson, 1947
50. *Podocarpidites novus* Sah & Jain, 1965
51. *Podocarpidites vermiculatus* Kumar, 1973
52. *Podocarpidites multesimus* (Bolkhovitina, 1956) Pocock, 1962
53. cf. *Podocarpidites major* Couper, 1953

Remarks — Central body rhomboid, with two vertical infolds along distal zone of saccus attachment, sacci laterally continuous, reticulation medium coarse.

Genus — *Cedripites* Wodehouse, 1933

54. *Cedripites nudis* Kar & Sah, 1970

Infraturma — *Abietosacciti* Erdtman, 1947 ex Potonié, 1958

Genus — *Abiespollenites* Thiergart in Raatz, 1937

55. *Abiespollenites* sp.

Genus — *Microcachryidites* Cookson, 1947 ex Couper, 1953

56. *Microcachryidites antarcticus* Cookson, 1947

Genus — *Podosporites* Rao, 1943

57. *Podosporites tripakshi* Rao, 1943

Turma — *Plicates* Naumova, 1939
Subturma — *Monocolpates* Iversen & Troels-Smith, 1950

Genus — *Cycadopites* Wodehouse, 1933 ex Wilson & Webster, 1946

58. *Cycadopites gracilis* Sah & Jain, 1965

Turma — *Poroses* Naumova emend. Potonié, 1960
Subturma — *Monoporines* Naumova, 1939

Genus — *Classopollis* Pflug, 1953 emend. Pocock & Jansonius, 1961

59. *Classopollis indicus* Maheshwari, 1974
60. *Classopollis* sp. cf. *C. classoides* Pflug, 1949 emend. Pocock & Jansonius, 1961

Remarks — Pollen circular, 33 μm, trilete distinct, rays ± 3·5 μm long; exine 2 μm, infrapunctate, distally aperturate.

The specimen lacks the typical equatorial arrangement of the elements and is somewhat comparable with the specimens of Dettmann (1963, pl. 26, figs 10-12).

Genus — *Exesipollenites* Balme, 1957

61. *Exesipollenites crassimarginatus* Jain & Sah, 1966

Remarks — Pollen circular, no haptotypic mark, 32 μm, central pore about 7 μm in diameter, exine differentially thickened, pitted.

Turma — *Aletes* Ibrahim, 1933
Subturma — *Azonaletes* Luber emend. Potonié & Kremp, 1954

Genus — *Araucariacites* Cookson, 1947 ex Couper, 1953

62. *Araucariacites australis* Cookson, 1947
63. *Araucariacites ghuneriensis* Singh, Srivastava & Roy, 1964

Remarks — Pollen grains apparently of *Araucariacites* type, sometimes split into

two equal halves along a median weak zone as in the case of the genus *Schizosporis*. The two hemispherical halves infold inwards along their equatorial margins and quite often become oval-elliptical in shape with a short of median pseudo-colpus. To the uninitiated eye such grains may look like those of the genus *Cycadopites*, and during frequency count one may erroneously obtain a high percentage of the genus *Cycadopites* probably at the cost of the genus *Araucariacites* (Pl. 4, figs 60-63).

Genus — *Laricoidites* Potonié, Thomson & Thiergart, 1950

64. cf. *Laricoidites communis* Sah & Jain, 1965

Sample D is very poor in number of specimens as well as that of the taxa. The important taxa identified in this sample are:

Cyathidites concavus (Bolkhovitina, 1956) Dettmann, 1963

Callialasporites dampieri (Balme, 1957) Dev, 1961

Callialasporites trilobatus (Balme, 1957) Dev, 1961, and

Araucariacites australis Cookson, 1947

ANALYSIS OF THE PALYNOLOGICAL ASSEMBLAGE

As mentioned in the earlier pages only two samples, viz., G3/4.2.71 and G4/4.2.71 have a sizable number of palynomorph taxa. There are approximately 64 species of pollen and spores, and these are referable to 39 genera. A spore-pollen count shows virtually the same quantitative representation of the genera in the two samples. This was to be expected as these represent the same bed. The minor variations in the spore-pollen content are of no significance.

The quantitative analysis shows that both the samples, viz., G3/4.2.71 and G4/4.2.71 are predominated by pollen of the genus *Araucariacites* with the percentages 57.75 and 53.00 respectively. *Callialasporites* is the next prominent genus with the respective percentages of 25.75 and 31.25. Other significantly occurring genera are *Alisporites* (3% and 3.25% respectively), *Podocarpidites* (4.75% and 3.25% respectively) and *Podosporites-Microcachryidites* (2.75% and 2% respectively). Following genera are of very rare occurrence and were not encountered in a count of 400 specimens: *Stereisporites*, *Callispora*, *Leptolepidites*, *Osmundacidites*, *Baculatisporites*, *Conosmundasporites*, *Foveosporites*, *Neoraistrickia*, *Apiculatisporis*, *Klukisporites*, *Impardecispora*, *Ischyosporites*, *Foraminisporis*, *Crassimonoletes*, *Cooksonites*, *Aequitriradites*, *Platysaccus* and *Abiespollenites*. Other genera are less than 1 per cent in occurrence.

DISCUSSION

The Gangapur Formation belongs to what is usually referred to as the Upper Gondwana or floristically as the Ptilophyllum Flora. The Upper Gondwana encompasses the time period from the Lower Jurassic to the upper part of the Lower Cretaceous. Though various authors have, from time to time, tried to palaeobotanically distinguish the Jurassic and Cretaceous parts of the Upper Gondwanas, so far no satisfactory criterion has been evolved to demarcate the Jurassic-Cretaceous boundary. For example, the Bansa Formation of South Rewa Gondwana Basin is accepted as of Lower Cretaceous age on the basis of the characteristic Wealden fern *Weichselia reticulata* Stokes & Webb (Bose & Dev, 1959) but palynologically the formation is not much different from the Jabalpur Formation (Maheshwari, 1974).

In the Jurassic-Lower Cretaceous rocks of India, two major types of megaplant assemblages are known. The older beds have mainly pteridophytic, bennettitalean and conifer remains and amongst these the Bennettitales dominate. In the younger beds the plant association is dominated by pteridophytes and conifers; the bennettitalean remains are either missing or are present only in meagre number. Here, amongst the pteridophytes the genus *Gleichenia* is common alongwith *Weichselia* and amongst the conifers *Pagiophyllum-Brachyphyllum* complex is more common. The former type of assemblage is known from most of the localities in the Rajmahal Hills (except Nipania), East Coast Gondwana, Godavari-Pranhita and Satpura basins, Pariwar Formation exposed near Habur and Kachchh. The latter type is known from Bansa, Himmatnagar, Gardeshwar and Than.

The Gangapur assemblage is characterized by the presence of *Gleichenia nordenskioildii*, *Taeniopteris spatulata*, *Ptilophyllum cutchense*, *P.* sp. cf. *P. acutifolium*, *Elatocladus confertus*, *E. kingianus*, *Elatocladus* sp. and *Pagiophyllum marwarensis*. The commonest genus amongst these is *Elatocladus*. The specimens of *Ptilophyllum* are more like the ones found at Vemavaram, Sriperumbudur and other localities in the Cauvery Basin. The overall assemblage is more like the ones occasionally found at Sivaganga and Sriperumbudur. Only *Gleichenia nordenskioildii* and *Pagiophyllum marwarensis* are not known from these localities. In India, both these species are so far known from the undoubted Lower Cretaceous beds. *G. nordenskioildii* is known from Bansa, Than and Gardeshwar, whereas, *P. marwarensis* has been reported only from Bansa. The latter species is now also known from Hard River and Parsapani in the Satpura Basin, supposed to be of Upper Jurassic age. Outside India, *G. nordenskioildii* is known mostly from Lower Cretaceous beds though recently it has been described from the Upper Jurassic of Madagascar (Appert, 1973).

The Upper Gondwana palynoflora is basically uniform and is usually dominated by the *Araucariacites-Callialasporites* complex. The palynological assemblages from eastern and central India differ little from one another (Bharadwaj, Kumar & Singh, 1972; Maheshwari, 1973, 1974, 1975). The Jurassic and Cretaceous assemblages of surface samples from Kachchh Basin have some distinctive elements but the situation is still not very clear and needs further study. Within the Lower Cretaceous of Kachchh two palynological zones have been identified. The Lower Cretaceous palynological assemblage of Section K of Venkatachala (1969) is not different from the Upper Jurassic middle palynological assemblage of the Upper Katrols (Bharadwaj, 1969). The palynological assemblages from Sections J and L of Venkatachala, on the other hand, are rich in the genus *Impardecispora*, a situation not observed so far any where else in India. In the subsurface, however, Koshal (1975) has recognized 3 distinct zones, viz. (i) *Gliscopollis-Classopollis* Zone (Lower Jurassic), (ii) *Callialasporites trilobatus* Zone (Middle-Upper Jurassic), and (iii) *Inaperturopollenites-Araucariacites*-complex Zone (Lower Cretaceous).

The Jurassic and Lower Cretaceous palynological assemblages from Rajasthan characteristically have high percentages of the genus *Classopollis* (Srivastava, 1966; Banerjee, 1972; Lukose, 1972). Such high percentages of *Classopollis* are not known so far from any other area in India.

Venkatachala and colleagues identify 3 palynological zones in the Jurassic-Cretaceous of South India. These zones are:

(i) *Callialasporites segmentatus* Zone of Upper Jurassic age, characterized by the presence of *Cicatricosisporites*, *Contignisporites*, *Callialasporites*, *Podocarpidites*, *Araucariacites* and *Classopollis* and the lack of *Trilites*, *Cooksonites*, *Aequitriradites* and *Leptolepidites*.

(ii) *Microcachryidites antarcticus* Zone of Neocomian age, characterized by the presence of *Microcachryidites*, *Podosporites*, *Trilites*, *Cooksonites*, *Leptolepidites*, *Staplinisporites* and *Aequitriradites* and by the absence of *Polypodiaceoisporites* and *Coptospora*.

(iii) *Coptospora cauveriana* Zone of Aptian-Lower Albian age, characterized by the presence of *Polypodiaceoisporites* and *Coptospora* besides other Lower Cretaceous genera.

A comparison with the various Jurassic-Cretaceous palynological assemblages reported from India shows that the Gangapur assemblage has a close affinity with the Athgarh palynological assemblage (Maheshwari, 1975) in the quantitative count of the genera *Araucariacites*, *Callialasporites*, *Alisporites* and *Podocarpidites*. But the Gangapur assemblage has certain characteristic elements, e.g. *Trilites tuberculiformis*, *Ischyosporites crateris*, *Cooksonites variabilis*, *Aequitriradites* sp. cf. *A. verrucosus* and *Microcachryidites antarcticus*. These elements characterize the Lower Cretaceous palynological assemblages of the Godavari and the Cauvery basins (Rao & Venkatachala, 1971; Venkatachala, Sharma & Jain, 1972; Ramanujam & Srisailam, 1974; Ramanujam & Varma, 1977). The Gangapur assemblage is more akin to the *Microcachryidites antarcticus* zone mioflora.

Outside India, the genera *Impardecispora*, *Foraminisporis*, *Foveosporites* and *Aequitriradites* are characteristic of the Lower Cretaceous of England and Germany (Dörhöfer & Norris, 1977). The genus *Cicatricosisporites* is believed to have

appeared only at the base of Berriasian in the Siberian and Indo-European regions of the Soviet Union (Vakhrameev, Barkhatnaya, Dobrutskaya, Pavolv, Rovnina & Fokina, 1975). In Australia this genus made its appearance almost at the end of Upper Jurassic (Balme, 1964). Of course, the genus has also been reported from the Upper Jurassic of western Canada (Pocock, 1962) and England (Dörhöfer & Norris, 1977).

Thus, considering all the available plant fossil data, the age of the Gangapur Formation seems to be somewhere near the Jurassic-Cretaceous boundary probably within the basal Lower Cretaceous.

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EXPLANATION OF PLATES

PLATE 1

1-3. *Gleichenia nordenskioildii* Heer, nos. Rd. III-39/67-68, D-6/67-68, S. Rd. III-42/67-68, figs 1 & 2.× 1, fig. 3.× 5.

4. *Ptilophyllum cutchense* Morris, no. S. Rd. III-3/69-70.× 1.

5. ?*Anomozamites* sp., no. S. Rd. I-25/67.× 1.

6. *Elatocladus* sp., no. S. Rd. II-2b/67.× 1.

7, 8. *Elatocladus confertus* (Oldham & Morris) Halle, showing a few megasporophylls, nos. S. Rd. I-2a, b/67, fig. 7.× 1, fig. 8.× 2.

9. *Pagiophyllum marwarensis* Bose & Sukh-Dev, no. CYI-3/67-68.× 1.

10. *Elatocladus kingianus* sp. nov., no. G4/4.2.71.× 1.

11. *Elatocladus* sp., no. S. Rd. III-2/67-68.× 1.

12. *Pagiophyllum marwarensis* Bose & Sukh-Dev, no. S. Rd. III-27/67-68.× 1.

13. *Elatocladus confertus* (Oldham & Morris) Halle, a part of the specimen shown in fig. 8 enlarged, no. S. Rd. I-2b/67.× 4.

PLATE 2

14. *Pagiophyllum marwarensis* Bose & Sukh-Dev, no. G3/4.2.71.× 1.

15. *Elatocladus confertus* (Oldham & Morris) Halle, no. S. Rd. III-4/67-68.× 1.

16. *Elatocladus kingianus* sp. nov., showing a few stomata on lower surface, slide no. G4/4.2.71-E1.× 200.
17. *Pagiophyllum marwarensis* Bose & Sukh-Dev, showing epidermal cells and a few stomata on lower surface, slide no. G3/4.2.71-E3.× 200.
18. *Taeniopteris* sp. cf. *T. spatulata* McClelland, no. S. Rd. III-12/67-68.× 1.
19. *Pagiophyllum marwarensis* Bose & Sukh-Dev, showing stomata on lower surface, slide no. G3/4.2.71-E3.× 200.
20. *Pagiophyllum marwarensis* Bose & Sukh-Dev, showing epidermal cells and stomata on upper surface, slide no. G3/4.2.71-E4.× 200

PLATE 3

(All figures.× 500)

21, 22. *Stereisporites psilatus* (Ross, 1949) Jain & Sah, 1966: Slide no. 4/4.2.71-2, co-ordinates 124.2× 22.6; Slide no. 3/4.2.71-5, co-ordinates 107× 11.5.
23. *Cyathidites minor* Couper, 1953: Slide no. 3/4.2.71-5, co-ordinates 99.0× 4.2.
24. *Cyathidites concavus* (Bolkhovitina, 1953) Dettmann 1963: Slide no. 3/4.2.71-1, co-ordinates 101× 23.2.
25. *Baculatisporites comaumensis* (Cookson, 1953) Potonié, 1956: Slide no. 3/4.2.71-12, co-ordinates 107.8× 10.3.
26. *Baculatisporites rotundus* Kumar, 1973: Slide no. 4/4.2.71-6, co-ordinates 106.9× 12.5.
27. *Leptolepidites* sp.: Slide no. 3/4.2.71-6, co-ordinates 126.9× 9.6.
28. *Callispora potoniaei* Dev, 1961: Slide no. 4/4.2.71-5, co-ordinates 102× 5.
29. *Conosmundasporites* sp.: Slide no. 3/4.2.71-6, co-ordinates 108.9× 8.2.
30. *Foveosporites* sp.: Slide no. 3/4.2.71-11, co-ordinates 122.3× 7.8.
31. *Todisporites* sp.: Slide no. 4/4.2.71-1, co-ordinates 110.9× 14.6.
32. *Neoraistrickia* sp.: Slide no. 3/4.2.71-6, co-ordinates 112.8× 15.7.
33. ?*Lycopodiumsporites* sp.: Slide no. 3/4.2.71-6, co-ordinates 126.3× 13.3.
34. *Apiculatisporis* sp.: Slide no. 3/4.2.71-8, co-ordinates 130.5× 20.1.
35. *Trilites tuberculiformis* Cookson, 1947: Slide no. 3/4.2.71-7, co-ordinates 113× 10.
36. *Klukisporites scaberis* (Cookson & Dettmann, 1958) Dettmann, 1963: Slide no. 4/4.2.71-4, co-ordinates 101.8× 6.4.
37. *Ischyosporites crateris* Balme, 1957: Slide no. 4/4.2.71-3, co-ordinates 108.4× 18.1.
38. *Contignisporites glebulentus* Dettmann, 1963: Slide no. 4/4.2.71-1, co-ordinates 112.2× 6.8.
39. *Contignisporites cooksonae* (Balme, 1957) Dettmann, 1963: Slide no. 3/4.2.71-3, co-ordinates 121.4× 14.8.
40. *Cicatricosisporites typicus* Sah & Jain, 1965: Slide no. 4/4.2.71-3, co-ordinates 106.4× 12.2.
41. *Cicatricosisporites australiensis* (Cookson, 1953) Potonié, 1956: Slide no. 3/4.2.71-10, co-ordinates 120.8× 18.
42. *Monolites grandis* Dev, 1961: Slide no. 4/4.2.71-1, co-ordinates 127.2× 18.7.

PLATE 4

(All figures.× 500)

43, 44. *Cooksonites variabilis* Pocock, 1962: Slide no. 3/4.2.71-6, co-ordinates 105.7× 22.5; Slide no. 3/4.2.71-10, co-ordinates 104.2× 12.
45. *Cooksonites* sp.: Slide no. 3/4.2.71-10, co-ordinates 136.4× 18.4.
46. *Properinopollenites singhii* Maheshwari, 1974: Slide no. 3/4.2.71-1, co-ordinates 131.3× 9.0.
47. *Aequitriradites* sp. cf. *A. verrucosus* (Cookson & Dettmann) Cookson & Dettmann, 1961: Slide no. 3/4.2.71-11, co-ordinates 122.8× 12.
48. *Cycadopites gracilis* Sah & Jain, 1965: Slide no. 4/4.2.71-2, co-ordinates 110× 4.7.
49. *Callialasporites discoidalis* (Döring, 1962) Bharadwaj & Kumar, 1972: Slide no. 3/4.2.71-1, co-ordinates 127.2× 17.3.
50. *Podocarpidites novus* Sah & Jain, 1965: Slide no. 3/4.2.71-2, co-ordinates 128.2× 20.
51. *Callialasporites segmentatus* (Balme, 1957) Dev, 1961: Slide no. 4/4.2.71-2, co-ordinates 121.9× 19.
52. *Callialasporites trilobatus* (Balme, 1957) Dev, 1961: Slide no. 4/4.2.71-1, co-ordinates 117.8× 11.9.
53. *Classopollis indicus* Maheshwari, 1974: Slide no. Gangapur-1, co-ordinates 108.2× 17.6.
54. *Cedripites nudis* Kar & Sah, 1970: Slide no. 4/4.2.71-2, co-ordinates 121× 17.8.
55. *Platysaccus indicus* Sah & Jain, 1965: Slide no. 3/4.2.71-3, co-ordinates 129.8× 19.
56, 57. *Podosporites tripakshi* Rao, 1943: Slide no. 3/4.2.71-2, co-ordinates 107× 15.4; Slide no. 4/4.2.71-6, co-ordinates 106× 14.6.
58, 59. *Microcachryidites antarcticus* Cookson, 1947: Slide no. 4/4.2.71-1, co-ordinates 128.9× 19; Slide no. 4/4.2.71-2, co-ordinates 122× 6.0.
60-63. ?*Araucariacites* sp.— note the splitting tendency of the pollen and the incurvation at equatorial margins of the individual halves forming pseudocolpii: Slide no. 3/4.2.71-12; co-ordinates 128.8× 20.3; Slide no. 3/4.2.71-10, co-ordinates 107.4× 12.8; Slide no. 3/4.2.71-7, co-ordinates 122.8× 7.7; Slide no. 3/4.2.71-11, co-ordinates 115.7× 7·2.

Co-ordinates of lower left corner of cover-slips of figured slides:

Slide no. 3/4.2.71-1 — 132.6 × 24.0
Slide no. 3/4.2.71-2 — 133.7 × 23.8
Slide no. 3/4.2.71-3 — 132.6 × 23.9
Slide no. 3/4.2.71-4 — 133.7 × 24.5
Slide no. 3/4.2.71-6 — 134.8 × 24.4
Slide no. 3/4.2.71-7 — 133.2 × 24.9
Slide no. 3/4.2.71-8 — 133.4 × 23.5
Slide no. 3/4.2.71-10 — 136.9 × 22.9
Slide no. 3/4.2.71-11 — 137.2 × 23.8
Slide no. 3/4.2.71-12 — 137.4 × 23.4
Slide no. 4/4.2.71-1 — 134.6 × 23.9
Slide no. 4/4.2.71-2 — 134.7 × 23.8
Slide no. 4/4.2.71-3 — 133.2 × 24.1
Slide no. 4/4.2.71-4 — 134.8 × 23.8
Slide no. 4/4.2.71-5 — 137.3 × 23.2
Slide no. 4/4.2.71-6 — 139.9 × 24.0
Gangapur-1 — 140.4 × 23.7.

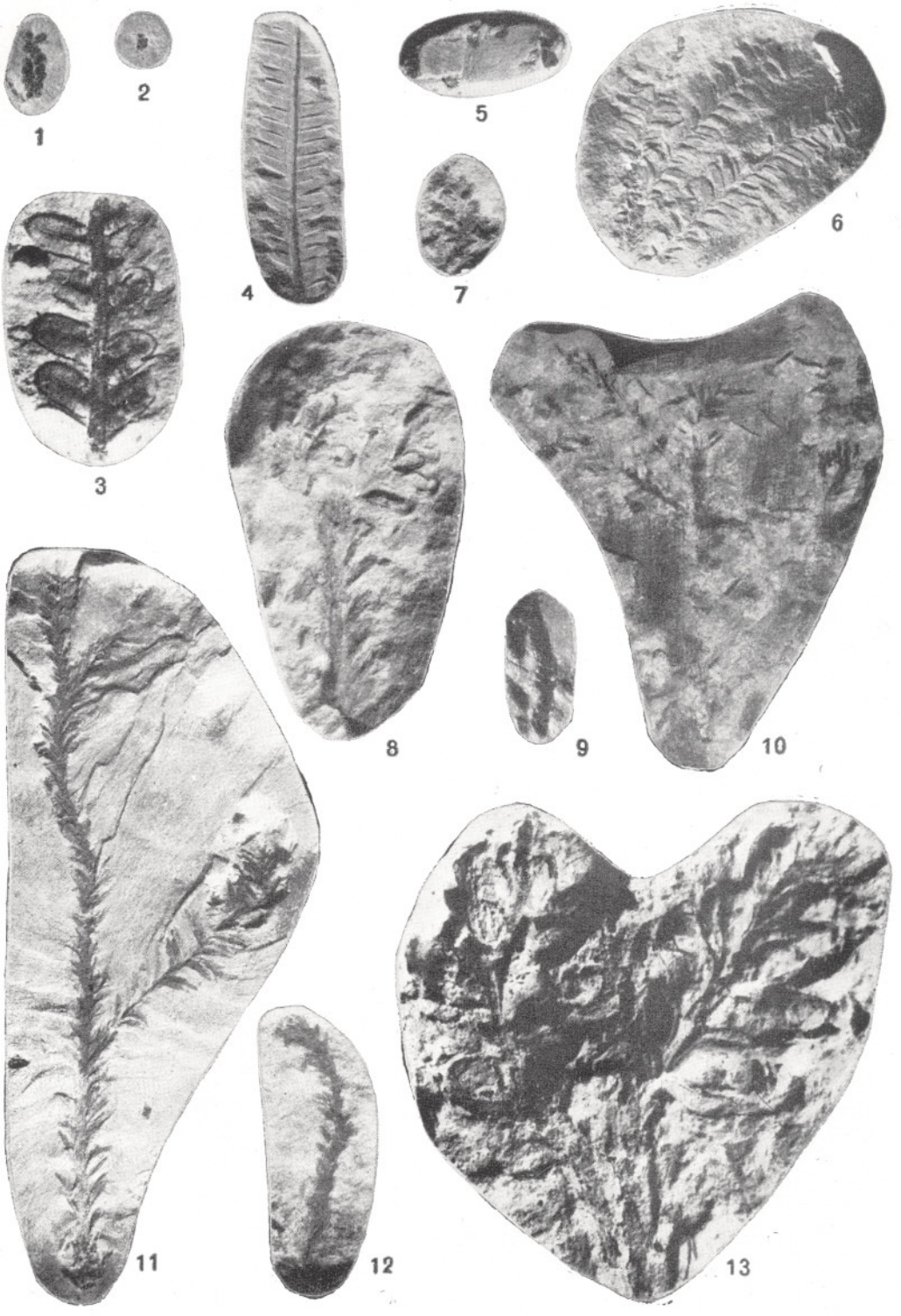
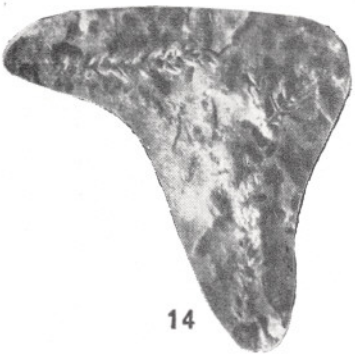
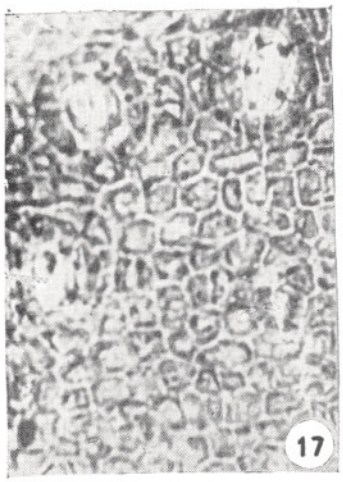


PLATE 1





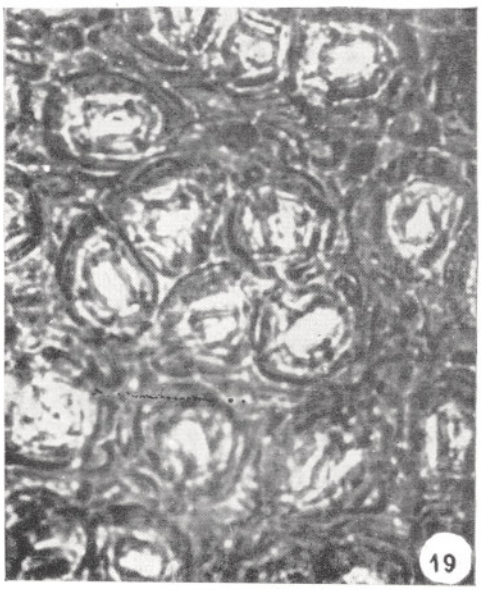


PLATE 2

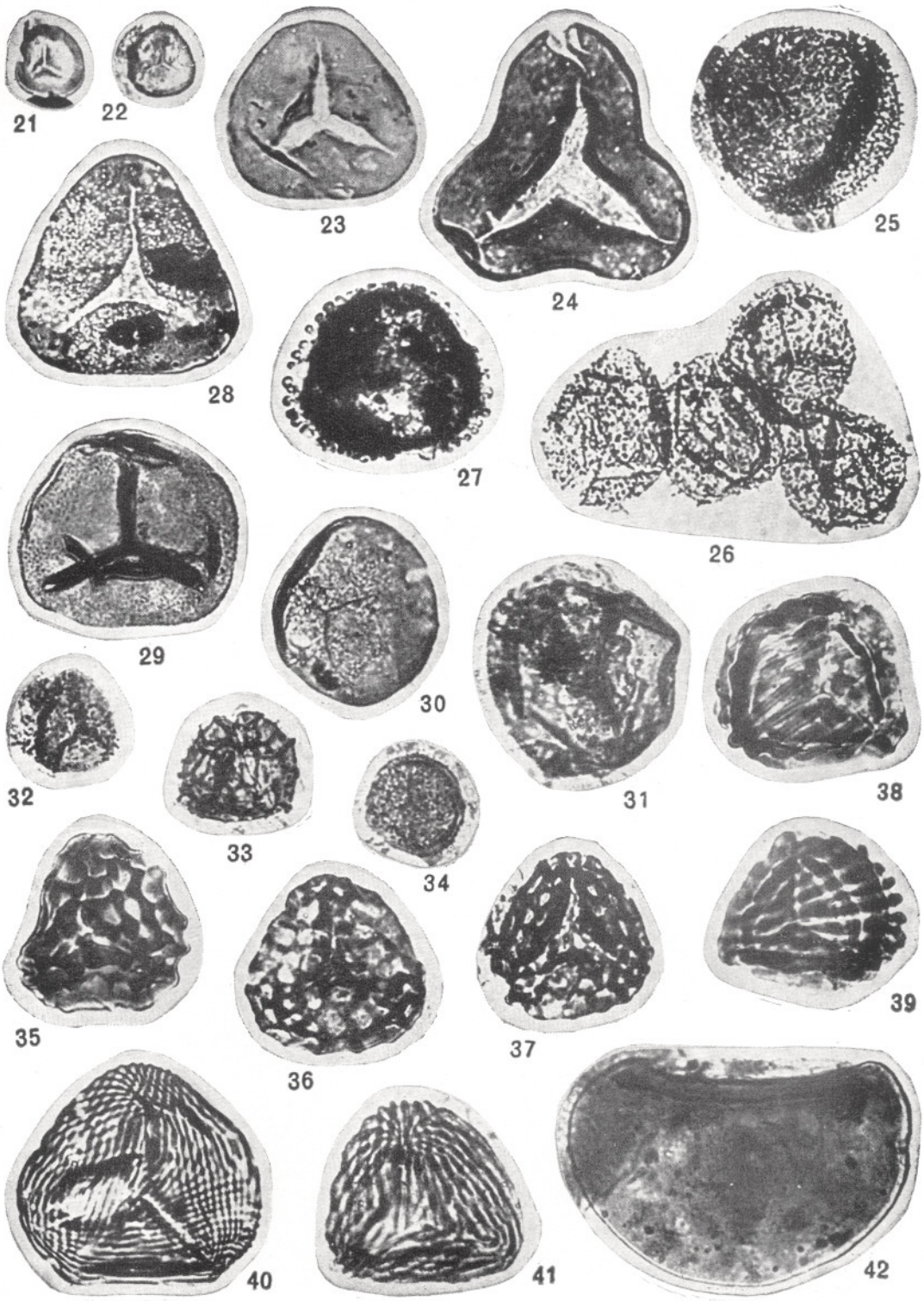


PLATE 3

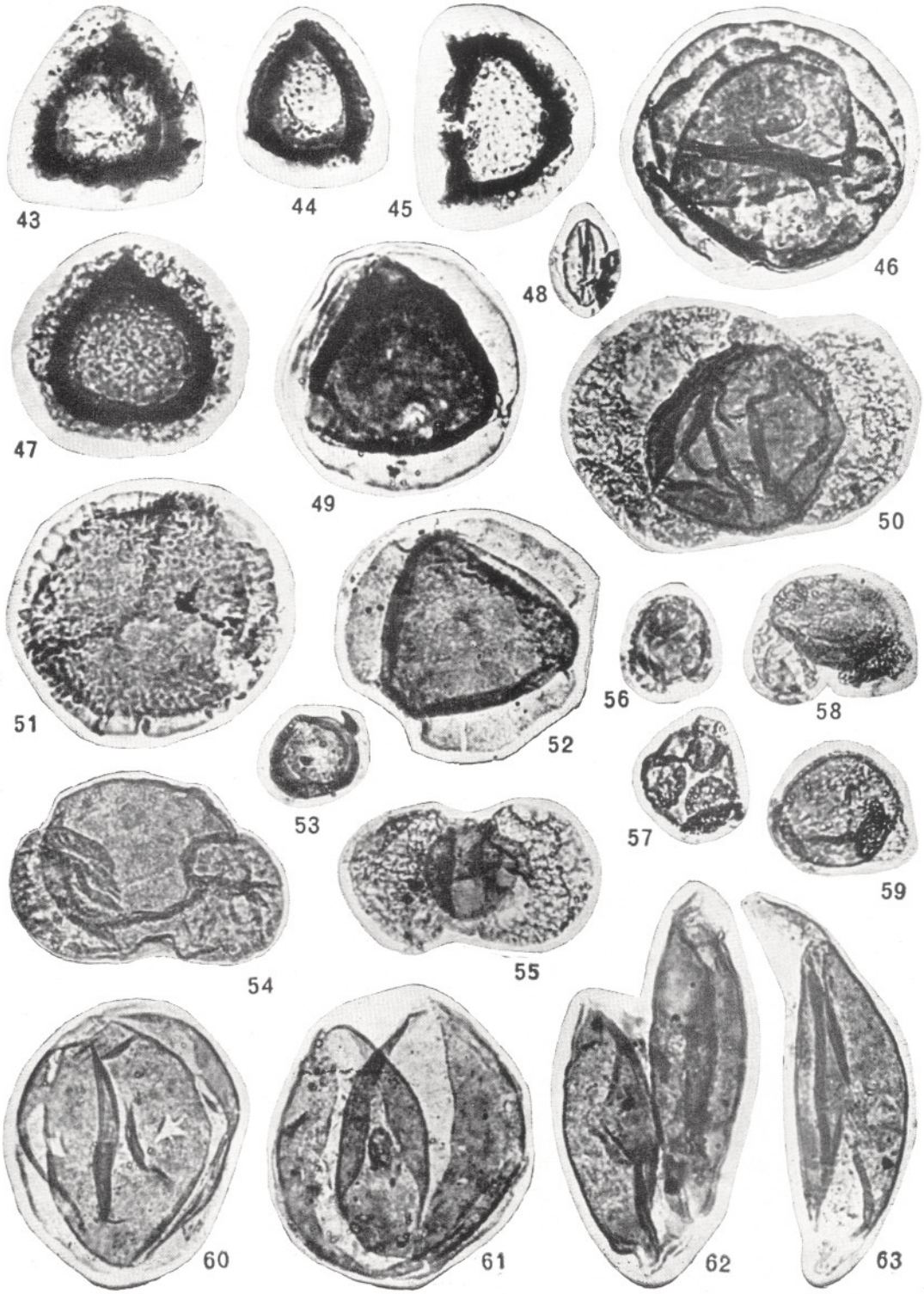


PLATE 4