

FOSSIL PLANTS FROM RAGHAVAPURAM MUDSTONE, WEST GODAVARI DISTRICT, A.P., INDIA

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ABSTRACT

A fairly rich collection of plant fossils, collected exclusively from Raghavapuram mudstone¹ of the East Coast Upper Gondwana rocks, has been systematically studied. Most of these fossils are new occurrences to this formation. The local and regional aspect of this flora has been briefly discussed.

INTRODUCTION

A SURVEY of the published previous works reveals that the major bulk of the East Coast Upper Gondwana plant assemblage comes from Vemavaram shales and Sriperumbudur (Sripermatūr) beds, the two fossiliferous horizons near Ongole and Madras respectively correlated (KRISHNAN, 1960, p. 277) with Raghavapuram mudstone. In the richness of the plant fossils, as well as in the potentiality of the latter's further occurrence, Raghavapuram mudstone did not draw much attention from the previous workers. Feistmantel (1879) remarked, "..... Vemavaram has the greatest share with 30 species, then follows the Sripermatūr group with 25, the Raghavapuram shales with 10.....". The present search during the field seasons 1962-1965 for plant fossil in the formation has been rewarded with many new occurrences and has brought out the fact that this formation also deserves careful attention for further palaeobotanical work on the coastal Gondwana sediments.

Footé (1879) just recorded the occurrence of plant and animal fossils from the "Upper Gondwana rocks" near Ongole without giving any description and illustration. It is Feistmantel (1879) who systematically described and identified the plant remains of this formation, as well as of other 'outliers on the Madras coast'. King (1880) just reproduced the latter's work in his publi-

1. Because of the lack of fissility in these rocks, the term 'Shale' as given by King (1880) has been replaced here by 'Mudstone'.

cation. Since then, no work has been done on the plant fossils, ever collected exclusively from Raghavapuram mudstone.

In connection with the revision of Indian Gondwana plants, Seward and Sahni (1920) and Sahni (1928, 1931) made some taxonomic improvements of some of the fossils, previously collected from the East Coast Gondwana formations in general. Work of Suryanarayana (1953, 1954, 1955) may be mentioned in this connection to complete the list of all the works done to date in the whole of the East Coast Upper Gondwana sediments.

The leaves, stems (including woods) and fructifications as fragmentary bodies of plants comprise, as usual, the plant fossils of Raghavapuram mudstone.

PRESERVATION AND RECOVERY

The leaves which constitute the most important form-genera of the plant fossils are in general well-preserved as impressions in Raghavapuram mudstone. Unfortunately, these being the impressions have ruled out the scope of cuticular studies. The leaves are mostly found to be fragmentary in preservation, although, during the process of recovery from a lithology like highly cracked and jointed mudstone (as exposed), the fossil generally gets badly mutilated. The smaller leaves are somewhat more completely preserved. Many tiny pinnules and other fragmentary parts of the plants are found to be disseminatedly preserved in the mudstone. The fructifications are also mostly the impressions, rather ill-preserved, with only a few being highly ferruginized solid ones. The stems and woods are also the impressions which are defaced in many occurrences but are recognizable as such. There are solid woods, either ferruginized or silicified. The former is generally very ill-preserved in contrast to the latter, of which the preservation is

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generally very satisfactory. No plant microfossil could be recovered from such a highly bleached lithology (mudstone).

Most of the leaves that are described here are recovered from the mudstone by chance-splitting the lithology either at the instance of the surface indication or without it. A few of them are picked up from the surface of the exposure which are found sometimes to be very well-preserved. Natural weathering, not too much protracted, of the embedding lithology may sometimes cause better preservation of these impressions than those which are freshly dug out. The reason may be three-fold—(1) the weathering is guided in these cases by a planar surface on which the fossil was originally laid down, (2) long exposure has hardened the impression, sometimes accompanied by slow permineralization, and (3) manual handling, which is at many times responsible for incompleteness of these impressions when dug out and splitted up, is absent. The freshly dug-out mudstone which appears wetty does not reveal the impressions prominently until it is well dried up. In a few cases, of course, these show up the impressions on wetty condition because of ferrugination, reflected in colouration.

DESCRIPTION

The plant fossils which are new occurrences to this formation are preceded by asterisk marks. *Otozamites* sp. cf. *O. (Cyclozamites) bunbaryanus*, *Mesembrioxylon* sp., *Dadoxylon agathioides*, *Ginkgoites* sp. cf. *G. crassipes*, *Ginkgoites* sp. and *Desmiophyllum indicum* do occur in Raghavapuram mudstone but are not described herein. Except the wood fossils which will be described in a separate publication, the others are too ill-preserved to be reproduced for systematic descriptions. All the specimens are preserved in the depository of the Geological Studies Unit, Indian Statistical Institute, Calcutta. The localities are mentioned herein with their respective spot heights, all located near the village Raghavapuram (81°19'42" E: 17°02' N, G.T.S. 65 G/8).

Genus *Cladophlebis* Brongn.

**Cladophlebis* sp.

Pl. 2, Figs. 10a, 10b

Description — Fragmentary frond, pinnae alternately disposed, attached by whole base

to a narrow but thick rachis at an acute angle; mid-vein arising from base of pinnule, giving off at an acute angle forked veinlets towards margin; margin entire.

Remarks — On the basis of the habit and the venation of the pinnae, it compares very well with *Cladophlebis whitbyensis* Brongn. 1828.

Locality — Eddla Gattu (Δ564').

Figured specimen — SKB 26/2/4/63.

Genus *Dicroidium* Gothan.

**Dicroidium* sp.

Pl. 2, Figs. 11a, 11b

Description — Lamina roughly four-lobed, 1.45 cm. long with a small petiole of about 0.25 cm. length. Veins originating from middle (mid-vein not visible), then diverging and forking towards margin.

Remarks — The general form and venation strongly match those of the apical portion of a pinna of *Dicroidium*. Suryanarayana (1954) reports *Sphenopteris* sp. from Vemavaram shales which somewhat resembles this in venation but widely differs in the habit of the leaflets. Feistmantel (1879, p. 13) records almost identical form from Sriperumbudur group under the name of *Thinnfeldia* sp. (or ? *Dichopteris* sp.); in the latter, the mid-vein is clearly shown to be present.

It has also good similarity with the tip of a pinna of an Australian species *Microphylopteris pectinata* (Hector) Arber (1917, PL. 7, FIG. 5) which frequently occurs in the Neocomian deposit of New Zealand.

Locality — Eddla Gattu (Δ564').

Figured specimen — SKB 1/1/1-2/63.

Genus *Taeniopteris* (Brongniart) Harris

Taeniopteris spatulata McCl.

Pl. 1, Fig. 9

Description — Fragmentary frond, length about 3.8 cm., widest part (at the top) 0.6 cm., narrowed down towards the base to 0.1 cm.; mid-rib conspicuously quite wide in proportion to the total width of the blade, widest part 0.25 cm., veins almost perpendicular to mid-rib, mostly forked.

Locality — Narsimha meta (Δ512').

Figured Specimen — SKB 13/12/4/62.

Genus *Ptilophyllum* Morris*Ptilophyllum acutifolium* Morris

Pl. 1, Figs. 1a, 1b

Description — The fronds obtained from this formation are of varying size. The pinnae are also of varying shape and size. Best frond (Specimen SKB 1/1/1/63) is about 11 cm. long; pinnae arising at an angle of nearly 35° with a moderately wide (about 0.1 cm.) rachis, about 2 cm. to 1.5 cm. long, base about 0.12 cm. wide attenuating to obtusely acuminate apex; veins diverging sub-parallel, 6-8 in number present in each pinna.

Locality — Eddla Gattu (Δ564').

Figured Specimens — SKB 1/1/2A/63 and 1/1/2B/63 (counterparts).

****Ptilophyllum catchense* Morris**

Pl. 1, Figs. 2a, 2b

Description — Frond pinnate, narrowing towards base as well as apex; pinnae short, obliquely arranged, alternate, imbricate; apex obtuse; veins radiating from base, forked towards apex.

Length of the recovered frond (SKB 1/1/3/63) 2.8 cm., rachis about 0.1 cm. in width; length of pinnae between 0.3 to 0.5 cm., width about 0.16 cm.

Locality — Eddla Gattu (Δ564').

Figured Specimens — SKB 1/1/3A/63 and 1/1/3B/63 (counterparts).

****Ptilophyllum tenerrimum* Feistm.**

Pl. 1, Fig. 3

Description — Frond 2.8 cm. in length, length of a pinna about 0.4 cm. width < 0.1 cm. Pinnae very narrow and closely adjacent to one another.

Remarks — The distinguishing feature of this species is the delicate and slender nature of the leaf with very narrow leaflets, very closely adjacent to one another.

Feistmantel (1877, p. 118) himself admits that this species can hardly be erected as a separate one in the context of its very much similarities with *P. acutifolium*. He advocates for naming it as a variety of *P. acutifolium*, i.e. *P. acutifolium* var. *tenerrimum*. Later, Jacob and Jacob (1954) erected, on the basis of cuticular study, a new species, viz. *P. jabalpureense* which

externally shows good comparison with this slender species *P. tenerrimum*.

Locality — Eddla Gattu (Δ564').

Figured Specimen — SKB 1/1/3/63.

Genus *Otozamites*****Otozamites rarinervis* Feistm.**

Pl. 1, Fig. 4

Description — Frond 2.9 cm. long; pinnae attenuating, closely set, 0.5 cm. to 0.7 cm. in length, width in general about 0.25 cm.; apex obtusely rounded, base sub-auriculate; veins diverging, sub-parallel, rare, between 4-5.

Remarks — The characteristic of this species name indicates, is the small number of veins. But, the absence of a *sensu stricto* auriculate base and the presence of sub-parallel alignment of the veins might go in favour of emending the genus under *Ptilophyllum*. It is known (by personal communication) that Dr. Bose (of Birbal Sahni Institute) is emending this species under the genus *Ptilophyllum*.

Locality — Immediate adjoining North valley of Bara Konda (Δ437').

Figured Specimen — SKB 21/12/5-2/62.

***Otozamites abbreviatus* Feistm.**

Pl. 1, Fig. 5

Description — Frond about 3 cm. long, pinnae conspicuously short (longest axis 3 mm.) with distinct auriculate base and very faint divergent veins.

Remarks — It is almost identical with the type specimen, Feistmantel (1879, PL. VII, FIG. 9).

Locality — Eddla Gattu (Δ564').

Figured Specimen — SKB 1/1/2/63.

Genus *Dictyozamites* Oldham****Dictyozamites falcatus* (Morris) Medlicott & Blanford**

Pl. 1, Figs. 6a, 6b

Description — Rachis about 2.2 cm. long, width about 0.16 cm., deeply grooved; pinna about 3 cm. long × 0.7 cm. wide, vein meshes smaller in border region of pinna than those in middle, total number of such meshes about 15-20 in each pinna.

Remarks — Sahni and Rao (1933) separated the larger forms already described

as *D. indicus* (Feistm.) from Vemavaram shale under *D. falcatus*. The present specimen shows more similarity with the type specimen than the specimens described by Sahni and Rao in size-variation of vein-meshes from the border to the middle of the pinna.

Locality — Immediate adjoining North valley of Bara Konda ($\Delta 437'$).

Figured Specimen — SKB 21/12/7/62.

Genus *Williamsonia* Carruthers

**Williamsonia blanfordi* Feistm.

Pl. 1, Fig. 7

Description — An incomplete mould, a flower with bracts radiating from a central axis, partially closed, length approx. 3.6 cm., approximate girth 3.2 cm., receptacle not preserved; bracts linear and curved, 10 in number (originally, probably 20), width of bract between 0.5-0.8 cm.

Locality — Janda Meta ($\Delta 280'$).

Figured Specimen — SKB 16/3/4/64.

Genus *Cycadolepis* Saporta

**Cycadolepis indica* Gupta

Pl. 1, Fig. 8

Description — Leaf (probably a scale-leaf) thick, subtriangular in shape, 3.1 cm. long and 3.1 cm. broad at the broadest region, base quite broad, margin entire, apex broadly round. Mid-rib absent, veins radiating from base, sub-parallel for a short distance in the middle and then diverging, forking twice or thrice before reaching margin of the apex.

Remarks — In the description given by Bose and Jain (1963), it appears that there is little difference between *Cycadolepis indica* Gupta 1954 and *C. oldhami* (Feistm.) Bose & Jain 1963 so far as the venation is concerned. The present specimen also fully agrees with either of them in the nature of venation but it shows more resemblance to the former in shape and size but is not identical with the same. Such a broad-base scale-leaf of this type is rather a new one, if the shape becomes a characterizing feature of these scale-leaves. More collection of similar types would justify the inclusion under the Rajmahal species, *C. indica*.

Locality — Bara Konda ($\Delta 437'$).

Figured Specimen — SKB 27/12/1/62.

Genus *Ginkgoites* Seward

**Ginkgoites feistmantelii* Bose & Sukh Dev

Pl. 3, Figs. 18a, 18b

Description — Lamina reniform, about 1.5 cm. long \times 1.2 cm. broad, border thick (? revolute), margin entire all throughout except a conspicuous apical notch in the upper margin, the lower margin continued as a narrow neck forming a short petiole of about 0.5 cm. length; veins few in number, about four, originating from the petiole diverge towards the lamina dichotomizing two to three times.

Remarks — It compares well with an upper Cretaceous *Ginkgoites*, viz. *G. minor* Hollick 1930 (BOSE & SUKH DEV, 1958, p. 153).

Locality — Bara Konda ($\Delta 437'$).

Figured Specimen — SKB 19/11/1/62.

**Ginkgoites* sp.

Pl. 3, Figs. 19a, 19b

Description — A very young leaf of the shape of a 'parachute', of about 1.35 cm. length, of maximum width of about 0.8 cm., margin entire, with a faint notch in the upper margin; petiole, although not completely visible, appears to be short; veins about 7-8 in number, originate from the petiole region, diverge towards the upper part of the leaf, dichotomizing mostly for once.

Remarks — The shape and the venation differ to some extent from *G. feistmantelii* Bose & Sukh Dev 1958. Pending further collection of such a type, this is provisionally kept as a *G. sp.*

Locality — Narasimha meta ($\Delta 512'$).

Figured Specimen — SKB 14/12/9/62A.

Genus *Elatocladus* Halle

Elatocladus plana (Feistm.) Sahni

Pl. 2, Figs. 12a, 12b

Description — Sterile shoots, bearing biserially arranged, characteristic, narrow, linear leaves. Leaves having strong decurrent bases, attached spirally by their full width, gradually tapering towards apex. Apex is acute in most cases but obtuse termination is also seen in some. Both types of apex are not found to be present in one and the same shoot. Although

compressional effects during preservation play a major role in the mode of arrangement of leaves with stem, as now seen, leave-attachment with stem is found to vary from perfectly perpendicular to highly angular one even in the same shoot.

A strong median vein is conspicuously visible in the leaf but there are suggestions of faint, parallel, two more veins in some of the leaves.

In most of the fossils found here, the leaves at the base of the shoot are found to be reduced in size and this feature has been attributed to the phenomenon of seasonal growth by Sahni (1928, p. 11).

Length of the figured specimen here is 8 cm., longest leaf is 3 cm., mostly 2.6 cm., basal one 1.6 to 1.9 cm., width of leaf at base generally 0.1 cm.

Locality — Eddla Gattu ($\Delta 564'$).

Figured Specimens — SKB 7/2/2/A/63 and SKB 7/2/2/B/63 (counterparts).

Genus *Brachyphyllum* Brongn.

**Brachyphyllum rhombicum* (L. & H.) Sahni

Pl. 2, Fig. 13

Description — A rarely branched shoot of 2.7 cm. length, with a rudimentary branch of about 0.3 cm. length; leaves small, closely packed, almost flattened against the stem and limited within the girth of the stem (not projected beyond), markedly of rhomboidal habit.

Locality — Narasimha meta ($\Delta 512'$).

Figured Specimens — SKB 18/12/2A/62.

**Brachyphyllum feistmantelii* (Halle) Sahni

Pl. 3, Fig. 14

Description — Repeated branching (ramification), the lateral axes originating at about 90° ; four in one, six in the other counterpart, 0.3 and 0.8 cm. wide, longest branch 1.6 cm., leaves ovately rhomboidal, broad, pointed (not lozenge-shaped), marginal ones showing distinct curved apex; leaves of comparatively larger size found towards apex of leaf branch, no fruit cone seen.

Remarks — In external morphology, this compares very well with the description given by Halle (in SAHNI, 1928, p. 20). The leaves here are more ovoid than 'triangular'.

Locality — Bara Konda ($\Delta 437'$).

Figured Specimen — SKB 29/12/1A/62.

Genus *Pagiophyllum* Heer

**Pagiophyllum* sp. cf. *P. peregrinum* (L. & H.) Sahni

Pl. 3, Figs. 15a, 15b

Description — A shoot of about 2.6 cm. length with spirally arranged leaves; leaves sickle-shaped and falcate in nature, originating at an acute angle, tips slightly curved upward, showing longitudinal markings which are probably the replica of parallel grooves containing the stomata (SAHNI, 1928, p. 23).

Remarks — The epidermal organization of this species is already known from the study by Sahni (1928) and unless that is known of any specimen which appear to be *P. peregrinum* on external morphology, full identification should be awaited. So, this specimen is relegated to cf. *P. peregrinum* as it is only an impression.

Locality — Immediately adjacent valley North of Bara Konda ($\Delta 437'$).

Figured Specimen — SKB 20/12/2A/62.

Genus *Araucarites* Presl

**Araucarites catchensis* Feistm.

Pl. 3, Figs. 16a, 16b

Description — Cone-scale of about 1.4 cm. length. Upper part of scale broadest, measuring roughly 1 cm., broadly curved, ending in a median, narrow, short appendage of about 0.2 cm. length; seed single, deltoid shape, rather large, the broader part being towards the apex of the scale, with a few longitudinal striations.

Remarks — There is another type occurring in this formation (specimens SKB 13/12/2/62A and 13/12/2/62B counterparts from Narasimha meta) which are exactly similar in measurement and other aspects with the present one but differs in having a distinct, truncated apex.

Locality — Immediate valley north of Bara Konda ($\Delta 437'$).

Figured Specimen — SKB 21/12/7/62.

Genus *Conites* Sternberg

**Conites* sp.

Pl. 3, Figs. 17a 17b

Description — Appearance of a transverse section of a cone in both the counterparts,

sessile cone-scales overlapping each other by their lateral edges, lying flat on the same plane around a small circular axis. Diameter of the cone about $2\frac{1}{2}$ cm., length of the cone not possible to know because of preservation as sections. Total number of scales 8-9, shape of the scale broadly cuneate, truncated at the apex and tapering towards the axis, the individual scale measuring about 1 cm. long and 0.4 to 0.5 cm. wide along the distal edge. Axis about 0.4 cm. wide in diameter.

Remarks — Both the counterparts of the fossil appear as transverse sections and as such, it seems that the cone had already shed off the fertile scales (or had already been broken) and attained a disc-like form before compression and fossilization.

Very small bodies resembling seed-sacs (within which very small globular impressions are present) are irregularly spread over the fossil, as well as in the surrounding matrix outside the fossil. It may or may not be endemic to this cone.

So far as the comparable fructifications from Indian horizons are concerned, *Conites verticillatus* Sahní 1928 (pp. 39-40, PL. VI, FIG. 95) from Sriperumbudur compares this specimen very well in the shape, number and measurement of the cone-scales. The possession of additional whorls of cone-scales in the present specimen — thus defining the length of the cone — would perhaps have shown complete identity with the former. It has some similarities also with *Strobilites sewardi* Sahní 1928 (pp. 40-42, PL. V, FIG. 72) but differs from it in the shape, size and number of the scales.

The fructification described by Kendall (1952) as *Araucarites phillipsi* Carruthers from Yorkshire Deltaic series compares well with the present specimen in the nature of preservation (as transverse section) of the cone and in the shape and size of the individual cone-scale.

Affinity — Since this is an impression, there is no scope of cuticular study for directly establishing the affinity with its living counterparts. But, its very strong resemblance with the Yorkshire specimen (of which, the affinity is established with the Araucarian cone on the basis of cuticular study), together with its association with the other definite Araucarian element such as *Araucarites cutchense* in the same horizon more or less confirms its affinity with the conifer *Araucaria*.

Locality — Bara Konda ($\Delta 437$).

Figured Specimen — SKB 27/12/1-3/62A and SKB 27/12/1-3/62B (counterparts).

DISCUSSION

(a) *Local Assemblage* — A comparison of the present and previous findings of plant fossils will reveal that a good many new occurrences have been added to the Feistmantel's list (1879, pp. 1-2). *Pecopteris reversa*, *Pachypteris (Dichopteris) ellorensis* and *Taxites tenerrimus* of the latter list are found to be missing from the present collection. Of these, *Pachypteris (Dichopteris) ellorensis* which is said to be 'peculiar to the Raghavapuram shale' could not be found despite intensive search for the same. *Taxites tenerrimus* is now revised to be *Elatocladus plana* (SEWARD & SAHNI, 1920, p. 36). Generawise, the remaining one has also been found (some of the non-fertile *Pecopteris* are now regarded as *Cladophlebis*, Krishnan, 1960, p. 300), although the respective species is missing.

Locally, within the area under consideration, the Raghavapuram plant fossil assemblage could be differentiated from that of the underlying Gollapilli sandstone only in the following — (a) *Ptilophyllum cutchense* more frequent in Raghavapuram mudstone than in Gollapilli sandstone, (b) *Elatocladus plana* predominant in Raghavapuram mudstone, not found in the other, (c) *Araucarites cutchensis* frequent in Raghavapuram mudstone, not recorded in the other, (d) *Ginkgo* species although less frequently occur in Raghavapuram mudstone, not recorded so far from the other, (e) the conifer fructifications, *Conites* species occurring in Raghavapuram mudstone, not recorded in the other, (f) the conifer woods *Mesembrioxylon* and *Dadoxylon* occurring in Raghavapuram mudstone so far not reported from Gollapilli sandstone and lastly, (g) *Pachypteris (Dichopteris) ellorensis*, although not found in the present collection, is claimed to be characteristically occurring only in Raghavapuram mudstone. This distinction is also applicable for the Gollapilli sandstone occurring beyond this area. Additionally, a few genera and species occurring in the type fossil localities of Gollapilli sandstone like Buravanča, Ravacherla, etc., which are located beyond the area under consideration, are not found in the Raghavapuram mudstone. The

genera and species are respectively the following — *Nilssonia*, *Retinosporites*, *Marattiopsis* and *Taeonopteris ensis*, *Williamsonia indica*, *Elatocladus conferta*, *Brachyphyllum expansum* and *Araucarites macropterus*. The overlying Tirupati sandstone in this region, as well as in its whole extent, is very poorly fossiliferous. Only a few woods and stems which are again mostly impressions, a few being highly ferruginized solid ones, a few leaves like *P. acutifolium*, and *P. cutchense* and a fructification, *Williamsonia blanfordi* constitute what may be described as Triupati plant assemblage, the distinction of which with Raghavapuram plant assemblage is obvious. This is all about the distinction of the assemblages as per collected and studied from different formations in this patch of upper Gondwana deposits.

This apparent distinction of the distribution of different floral elements seems to be the result of limited paleobotanical work on these formations concerned and also, preservational variations in them rather than the actual vegetational differentiation during comparatively shorter interval of time. The role of relative frequency of occurrences of a few elements over the other in distinguishing the concerned assemblages does not appear to play any important part as known from other instances discussed later.

(b) *Regional comparison of the flora* — Of the series of small exposures, lying near the Coromandel coast that have shown the presence of upper Gondwana floral elements, those near Vemavaram and Sriperumbundur are by far the most important for plant fossil contents. As remarked earlier, the coastal upper Gondwana flora, as now known, practically came from those two places. The plant assemblages of the three principal plant-fossil producing east coast formations have remarkable similarity in the constituents of the flora. All the individual floras show the dominance of *Bennettitales*, *Cycadales* and *Coniferales* with minor amount of *Filicales* and *Ginkgoales* elements. It is believed that still-missing-element from one or the other floras of these places is rather a result of incomplete search, study and nomenclatural synonymy than actual absence of it. It may therefore be concluded that the flora recorded in these east coast formations was one and the same during the deposition of the latter,

Up in the central tract of Pranhita-Godavari valley, the flora described from Kota formation (FEISTMANTEL in KING, 1881, pp. 277-280, 289-290; PASCOE, 1959, p. 988) shows equivalency with that of the coastal upper Gondwana sediments. Excepting the two conifer elements, viz. *Athrotaxites feistmantelii* Sahni and *Mesembrioxylon godavarianum* Sahni, the exact horizons of occurrences of which are again doubtful (KING, p. 277; SITHOLEY, 1963, p. 73 & 76), all the other *Cycadales* and *Coniferales* elements (totally about eight in number including the nomenclatural adjustment of '*Cheirolepis*' to *Brachyphyllum*/*Pagiophyllum*) are common to both the floras.

This coastal upper Gondwana flora is now compared with the other three 'principal Mesozoic floras of India'. These are Rajmahal flora, Jabalpur flora, and Umia (Cutch) flora, all of which have been worked out in detail by Feistmantel (1876, 1877, 1879). Because of the mixture of components of Rajmahal and Jabalpur flora, he designated this East Coast flora as a 'mixed flora'. He noted that 'amongst 47 forms that have been recovered from the East Coast Upper Gondwana, there are 12 species of the Jabalpur group and 14 of the Rajmahal group...'. Since then, a considerable amount of work on these floras (particularly the Rajmahal one) has been done by Late Birbal Sahni (1920-1943) and his associates (see Sitholey, pp. 57-68). This has revealed a number of taxonomical changes, particularly, adjustment of nomenclatural synonyms, arising out of better and new collection of complete fossils and cuticular studies. Palynological studies, during the recent years, have established the presence of many elements which are apparently absent in the flora. These have also helped better understanding of natural affinities of some floral elements and also the correlation of floras.

In the light of the recent knowledge as outlined above, if the correlation of different floras is examined afresh, it is felt that the floral distinctions so far made to the extent of establishment of biostratigraphic stages like Rajmahal stage, Jabalpur stage, Umia stage, etc. would lose the significance given so far in the mesozoic stratigraphy of India. By the conventional ways of the correlation of floras, based principally on the presence or absence of the elements and the frequency of occurrences of one or

the other elements in the assemblage, the foregoing discussions on correlations of the floras have been made. But the trend of recent collections in general shows that the presence or absence of any element in the upper Gondwana flora is more related to chance-finding than the absence of it. Of course, it is admitted that there might be some restricted elements in the flora. Regarding frequency of occurrences, it is also observed (Bose, personal communication) that there could hardly be any generalized mode in the frequency, which distinguishes one flora from the other. For example, in the same formation, *Ptilophyllum acutifolium* may be found in extreme abundance in one particular locality while *Elatocladus plana* is found in the other. It is agreed that there might be some factors controlling this sort of geographical segregation of vegetation but this does little contribute to the distinction of the flora across the time. Strictly speaking, the East Coast Upper Gondwana flora may now be equally correlated with the other three floras. Equation with Rajmahal flora and Jabalpur flora has already been made by Feistmantel (1876). Recent work on the Umia (Cutch) flora (Roy, 1963, unpublished thesis) shows the presence of many common elements between the two floras except in the presence of two very diagnostic Wealden mega plant fossils and some macro- and mio-spores. The two plant fossils are — *Onychiopsis psilatoides* Yokoyama 1889 and *Weichselia reticulata* (Stokes & Webb) Ward 1905. Forty-eight genera and 82 species of mio- and macro-spores have been described from the Umia beds (SINGH *et al.*, 1963) of which about five megaspores and five to six miospores are characteristic of (at least) Wealden age. The above two mega plant fossil genera have been recorded also from Jabalpur (Narasingpur dt.) and Bansa (S. Rewah) by Bose (1958) and Bose and Sukh Dev (1959), besides the occurrence of *Weichselia* and *Matonidium* from Himmatnagar sandstone of Wealden age. The occurrence of these characteristic Wealden elements in Jabalpur, Rewah and Cutch area is very significant in extending the age of the flora from the threshold of jurassic. In the context of the evidence of animal remains on the age of formation, it is believed that more search might reveal the presence of these (at least) Wealden elements also in the East Coast Upper Gondwana patches.

In the Indian mesozoic stratigraphy, the fixation of the age through the evidences of mega-plant fossil appears to be still a remote possibility. Excepting the Wealden and Triassic Middle Gondwana flora (WADIA, 1961, pp. 194-195), the two other *Glossopteris* flora and *Ptilophyllum* flora are extremely long-ranging. It is known that the only two elements cited above to recognize Wealden are not prolific in their occurrences in any of the Indian localities so far reported. Moreover, they are small in size. So, careful searches should be made for finding them in coastal Upper Gondwana sediments. As told earlier, no plant microfossil could be recovered from Raghavapuram mudstone, although Ramanujam (1957) reports some miospores from its equivalent Vemavaram shale. It is unfortunate to record herewith that the present author had been to the locality at Vemavaram to search for 'Carbonaceous shale' which produced the said miospore assemblage. Vigorous search over such a small terrain did not yield any piece of the same. A number of other lithologies both from Vemavaram and Raghavapuram were tried in vain for the recovery of plant microfossils.

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POSTSCRIPT

After this manuscript was submitted for publication, Bose (1966, *Sci. & Cult.*, Vol. 32, pp. 532-534) has made valuable remarks on the significance of the plant fossils in the Gondwana stratigraphy, a relevant part of which widely endorses the present author's observations on the status of mega-plant fossils in biostratigraphic subdivisions of the Upper Gondwana sediments.

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EXPLANATION OF PLATES

PLATE I

- 1a. *Ptilophyllum acutifolium* Morr. × 1, SKB/1/1/2A/63.
- 1b. *P. acutifolium* Morr. × 1.3, No. SKB1/1/2B/63, counterpart to 1a.
- 2a. *P. cutchense* Morr. × 1, No. SKB 1/1/3A/63.
- 2b. *P. cutchense* Morr. × 1, No. SKB 1/1/3B/63, counterpart to 2a.
3. *P. tenuerrimum* Feistm. × 1, No. SKB 1/1/3/63.
4. *Otozamites varinervis* Feistm. × 1, No. SKB 21/12/5-2/62.
5. *O. abbreviatus* Feistm. × 1, No. SKB 1/1/2/63.
- 6a. *Dictyoamites falcatus* (Morr.), × 1, No. SKB 21/12/7/62.
- 6b. Same as above, × 2.
7. *Williamsonia blanfordi* Feistm. × 1, a silico-rubber cast of the original fossil No. SKB 16/3/4/64.
8. *Cycadolepis indica* Gupta × 1, No. SKB 27/12/1/62.
9. *Taeniopteris spatulata* (McCl.), × 1, No. SKB 13/12/4/62.

PLATE 2

- 10a. *Cladophlebis* sp. × 1, No. SKB 26/2/4/63.
- 10b. Same as above, × 10.
- 11a. *Dicroidium* sp. × 1, No. SKB 1/1/1-2/63.
- 11b. Same as above, × 10.
- 12a. *Elatocladus plana* (Feistm.) Sahni × 1, No. SKB 7/2/2A/63.
- 12b. *E. plana* (Feistm.) Sahni × 1, No. SKB 7/2/2B/63, counterpart to 12a.
13. *Brachyphyllum rhombicum* (L. & H.) Sahni × 2½, No. SKB 18/12/2A/62.

PLATE 3

14. *Brachyphyllum feistmantelii* (Halle) Sahni × 1, No. SKB 29/12/1A/62.
- 15a. *Pagiophyllum cf. peregrinum* (L. & H.) Sahni × 1, No. SKB/20/12/2A/62.
- 15b. Same as above, × 3.6.



1a



1b



2a



2b



3



4



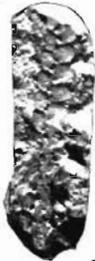
8



6b



6a



5



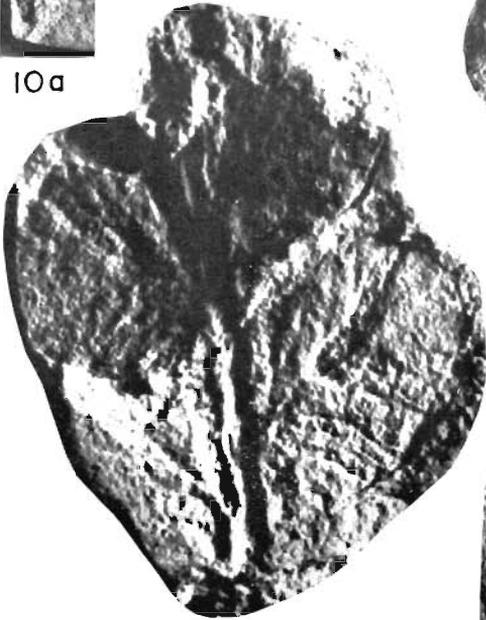
9



7



10a



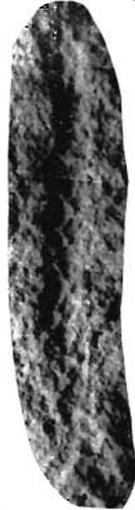
10b



11a



11b



13



12a



12b



14



17a



17b



15a



18b



18a



15b



16b



16a



19a



19b

- 16a. *Araucarites cutchensis* Feistm. × 1, No. SKB 21/12/7/62.
16b. Same as above, × 1·9.
17a. *Conites* sp. × 1, No. SKB 27/12/1-3/62A.
17b. *Conites* sp. × 1, No. SKB 27/12/1-3/62B, counterpart to 17a.
- 18a. *Ginkgoites feistmantelii* Bose & Sukh Dev × 1, No. SKB 19/11/1/62.
18b. Same as above, × 6.
19a. *Ginkgoites* sp., × 1, No. SKB 14/12/9/62A.
19b. Same as above, × 4·3.