GENERAL CONSIDERATIONS :

On the East-Coast of India, several exposures of Upper Gondwana rocks occur at different places. They are found in Cuttack district of Orissa, Krishna, Godavari Guntur and Prakasam district of Andhra Pradesh and Chingleput, Tirucherapalli and Ramanathapuram districts in Tamilnadu. They contain plant fossils associated with marine animals. Among all these exposures, Ongole area in Prakasam district is rich in its fossil contents. Earlier workers have made contributions on fossil plants of Vemavaram only. Recently, Vagyani (1985, 1986) discovered a new locality Uppugunduru in Prakasam district and brought to light fossil plants from this area. Subsequently, Vagyani and Zuting (1986) and Vagyani & Jamane (1987) have added further information of fossil plants of this area. Hence, from 1985 onwards this department have added more information on the fossil plants from Ongole area. In one of the collection tours we came across a new fossiliferous area found at Chinna-Ganjam. It showed several fossil plant impressions with a good amount of diversity of genera. Therefore, the present investigation was undertaken to study the fossil flora of this area and its age.

BENNETTITALES :

Presence of this group suggests warm and humid climate on the East coast. In our collection the group is represented by following leaf genera :

Genus I. Ptilophyllum Morris 1840

Recently monographic account of this genera is given by Bose & Kasat (1972). According to them, following 15 species are found from various localities in India. They are-

1) P. acutifolium
2) P. cutchense
3) P. rarinervis
4) P. tenerimmum
5) P. oldhamii
6) P. indicum
7) P. horridum
8) P. sakrigaliersis
9) P. distans
10) P. institacallum
11) P. jabalpurense
12) P. gladiatum
13) P. amarjolense
14) P. sahnii
15) P. nipanica

Out of these 15 species - 1) P. acutifolium 2) P. cutchense and 3) P. rarinervis occur on the East Coast.

Baksi (1968) reported P. tenerimmum from Raghavapuram in the West Godavari district of Andhra Pradesh. Hence, the number of species occurring on the East Coast becomes 4. Mahabale & Satyanarayana (1979) recently added two new species, namely - P. raghudevapurense and P. deodikarii to above list. Hence, it appears Ptilophyllum is represented by 17 species in India, which further supports its dominance among the Bennettitales.

Mahabale & Satyanarayana (1979) further reported occurrence of P. distans, P. institacallum, P. horridum, P. jabalpurense, P. gladiatum, P. sahnii and P. amarjolense. Therefore, total number of species present on east coast become 12.

In our work, we have reported 10 species of Ptilophyllum, which supports the dominance of Ptilophyllum in this area and also supports the observation of Mahabale and Satyanarayana. Occurrence of P. rarinervis at Sriperamatur, Vemavaram and Chinna-Ganjam shows that it is a characteristic species of the East Coast. Next to it, P. cutchense is found in large proportion. For identification of Ptilophyllum species the morphological characters given by Bose and Kasat (1972) were used. Since, the cuticle is not preserved among the plants found here, the species are identified on morphological characters only, where the importance is given to the angle of divergence of pinnae, shape, nature of the apex, number of veins etc.

Genus II - Pterophyllum Brongniart, 1928

This is another common plant found here having 3 species. Bose (1974) stated that, this is the only genus which is also reported from Triassic of India. 9 species of Pterophyllum were described from the Rajmahal Hills by Oldham & Morris (1863). Feistmantel (1877b) reported following 4 species from Golapalli, namely -

1) P. morrisianum
2) P. carterianum
3) P. distans
4) P. kingianum

Feistmantel (1879) reported P. footeanum from Vemavaram. Later on, Seward & Sahni (1920) transfered these species under Nilsonnia. Bose (1974) had critically examined the characters of Nilsonnia and Pterophyllum and showed Nilsonnia is absent in India. Recently, Bose & Banerji (1981) have given a brief account of Cycadophytic leaves from India. According to them, 10 species of Pterophyllum are found in India, They are -

1) P. distans
2) P. kingianum
3) P. footeanum
4) P. sp.
5) P. medlicottianum
6) P. rajmahalense

7) P. guptai

8) P. princeps

9) P. incisum

10) ? Taeniopteris/Pterophyllum

Out of these 10 species following 3 species are found on the East Coast namely - 1) P. footeanum, 2) P. kingianum and 3) P. incisum.

Again, from Vemavaram 2 species are reported namely P. footeanum and P. incisum while P. kingianum is reported from Golapalli. At Chinna-Ganjam we have reported (1) P. footeanum, (2) P. kingianum, (3) P. morrisianum. Occurrence of P. morrisianum at this place is a new addition to species on East Coast.

Recently, Vagyani (1986) described P. footeanum from Uppugunduru is Prakasam district of Andhra Pradesh. Vagyani & Zuting (1986) reported P. distans from the same locality. Hence it appears that in this area Pterophyllum is represented by several species. Intensive search in future may yield occurrence of other species also. Therefore, it is suggested that Pterophyllum is one of the common plant here and shows its frequent occurrence with several species.

Genus III : Dictyozamites Oldham 1863

According to Bose (1974) 5 species of Dictyozamites have been reported from the Mesozoic rocks of India. They are -

1) D. falcatus

2) D. indicus

3) D. hallei

4) D. bagjoriensis

5) D. sahnii

Further, he pointed out that only. D. falcatus is known from Golapalli and Vemavaram on the East Coast. Most of the species come from Rajmahal Hills and Madhya Pradesh. Recently, Bose & Seba-Bano (1978) have given a brief account of this genus from India. According to them following 6 species are found in India, namely -

1) D. falcatus

2) D. indicus

3) D. hallei

4) D. sahnii

5) D. feistmantelli

6) D. sp.

D. bagjoriensis is merged with D. hallei by these authors. They have also reported a new species D.feistmantelli which is reported from Golapalli, Vemavaram, Raghavapuram and Sriperamatur in the East Coast, Jatmao in Madhya Pradesh. The sixth species is not specifically named but it deserves a new name, since it is distinct from all others. D. indicus and D. feistmantelli from these author account appears only to occur in the East Goast. Mahabale & Satyanarayana (1979)

recently reported D. falcatus and D. sahnii from East Gadavari district in Andhra Pradesh. Therefore, the total number of species found on the East coast becomes three. In the present work 4 species have been reported namely - D. feistmantelli, D. falcatus, D. indicus, D. hallei. Hence Dictyozamites is not rare plant of East coast but it is found abundantly having representation of 4 species. More intensive search for other species may bring new data on this genus and perhaps number of species will be much more than those found in the Rajmahal Hills and elsewhere in other parts of India. We can also presume that along with Ptilophyllum and Pterophyllum, Dictyozamites may be another characteristic member of Bennettitales of the East coast flora. According to Jacob (19 ) it is the middle Jurassic genus. But its presence on the east coast particularly in the Ongole area which belongs to Kota stage (Upper Jurassic) shows that it was much more common the Upper Jurassic period than the Middle Jurassic. Recently, Bose & Banerji (1984) have reported Dictyozamites in Kutch and these localities said to have Lower Cretaceous age. The evolution of Dictyozamites in India have taken as follows - resumed in the middle Jurassic (Rajmahal stage), climaxed in the Upper Jurassic (Kota stage) and declined in Lower Cretaceous (Umia stage). In cretaceous it is not altogether rare in other parts of the world particularly it is found in the Lower Cretaceous of U.S.S.R. and Argentina and also found in the Liassic of Iran. Hence, it is proposed that on the East Coast flora Dictyozamites was a dominant element in the

Upper Jurassic (Kota stage).

Genus IV. Otozamites Braun 1843

According to Bose (1974) following 5 species of Otozamites have been reported from India :

1) O. imbricatus
2) O. sp.
3) O. vemavaramensis
4) O. exhislopii
5) O. gondwanensis

Feistmantel (1877 c) reported O. hislopii, O. gracilis, O. augustus, O. distans. Recently, Bose & Kasat have transferred all these species to the various species Ptilophyllum. From Kutch Feistmantel (1876a) reported 3 species O. contigus, O. imbricatus and O. conf. goldiae except O. imbricatus other two species are transferred to Ptilophyllum by Bose & Kasat. From the East Coast Feistmantel (1879) described 7 species of Otozamites, namely

1) O. abbreviatus
2) O. rarinervis
3) O. bunburyanus
4) O. parallelus
5) O. hislopii
6) O. sp.
7) O. aeutifolium

Out of these 7, only following 3 are real Otozamites namely - O. bunburyans, O. hislopii other are Ptilophyllums. Hence, it appears that most of the earlier species of Otozamites were not correctly identified and later on, they are merged with the Ptilophyllum. Bose (1974) gave a brief account of this genus in India and stated that it is a rare plant with 5 species but surprisingly Bose & Banerji (1984) have added following new species from Kutch they are - O. walkamotaensis and O. kachehhensis. Therefore, the total number of species of India have gone upto 7. Out of which 4 are known from Kutch 2 are known from East Coast and one is known from East coast and Rajmahal. This shows that Otozamites was absent in Madhya Pradesh and also a rare plant in Rajmahal. In our work 4 species of Otozamites namely -

1) O. imbricatus
2) O. vemavaramensis
3) O. kachchhensis
4) O. sp.

have been reported. It supports the above findings and suggests that Otozamites is moderately present on the East coast while it was dominant in the Kutch and rare in the Rajmahal. Further, intensive search for it on the East Coast may add one or two species. And then the position will be showing equal representation of it in the East Coast as well as in the Kutch area. Bose (1974) further pointed out that it is common in the Middle Jurassic but from its occurrence in Vemavaram and our locality

suggest that it is much more common Upper Jurassic. Patra (1973) recently reported it from Orissa, also belonging to Upper Jurassic. So far this genus is not known from localities in Jabalpur and Lower Cretaceous rocks of India.

CYCADALES

In the Mesozoic rocks of India cycadales are represented by following genera :

1) Taeniopteris Brongniart
2) Morrisia Bose
3) Cycadites Sternberg

In the present collection only Taeniopteris is present. According to Bose & Banerji (1981) following 5 species of the genus are found in India.

1) T. spatulata
2) T. kutchensis
3) T. haburensis
4) T. oldhamii
5) T. baskoghatensis

According to these authors T. spatulata is the only species on the East Coast. But in our collection we have described T. kutchensis which is a typical plant from Kutch and not found in other Upper Gondwana localities. Therefore its presence at Chinna-Ganjam is quite significant suggesting wide distribution of this species from Kutch to East coast

of Andhra. Further intensive search in this area may bring to light other species of Taeniopteris in this area. T. spatulata is found in all the East Coast localities except Golapalli. This indicates the abundance of Taeniopteris on the East Coast. Therefore, it is quite probable that in the East Coast flora Taeniopteris must have more than one species. Report of T. kutchensis from Chinna-Ganjan supports this view and gives clue of presence of other species.

CONIFERALES :

Coniferous fossils have been found abundantly on the Upper Gondwana beds of East coast. The majority of this belongs to Podocarpaecae and Araucariaceae. Members of Taxaceae and Taxodiaceae are few in number. In the present collection following members are present.

Genus I - Elatocladus Halle

According to Bose & Maheshwari (1974) following species are found in India -

1) D. plana, 2) E. conferta, 3) E. jabalpurensis 4) F. tenerimma, 5) E. sahnii.

Recently, Bose et al. (1981) have reported E.kingianus from Gangapur bed of Andhra Pradesh. Hence, it appears that Elatocladus is quite common in the Mesozoic rocks of India. In the present collection following 5 species are reported :

1) E. plana

2) E. conferta

3) E. sp. cf. E. tenerimma

4) E. jabalpurensis

5) E. vemavaramensis sp. nov.

Vagyani & Jamane (1987) reported E. plana from Uppugunduru from Prakasam district of Andhra Pradesh, Mahabale & Satyanarayana reported it from East Godavaridistrict of Andhra Pradesh. Earlier it was also reported from Sriperamatur and Raghavapuram beds. Hence, it appears that among all the species of this genus E. plana is a characteristic plant of the East coast. E. conferta is another widely distributed plant found in Rajmahal Hills, Madhya Pradesh, Kutch, Golapalli, Nellore and Chirakunt in Andhra Pradesh. Its presence here further supports its wide distribution in India. E. tenerimma was earlier reported from Sriperamatur on the East Coast, Madhya Pradesh and Kutch. Its presence here widens its distribution on the East Coast. Besides it is collected from a new locality in Andhra Pradesh. E. jabalpurensis is earlier reported from Madhya Pradesh, Kutch and Vemavaram in Andhra Pradesh. Its presence here supports the earlier finding and further adds one more place for its presence suggesting its wider distribution on the East coast. E. vemavaramensis is a new species, which shows distinct characters than other species. Thus it appears that at Chinna-Ganjam, Elatocladus is abundantly found having maximum number of species present in a single locality.

Further search may add more data to the richness and variety of this genus in this area. Genus Elatocladus belongs to family Podocarpaceae. Woods belonging to this family are abundantly found at a little known place Vellum near Sriperamatur in Tamilnadu. This locality also belongs to Kota stage (Upper Jurassic). It is also possible cones described under the genus Conites may be collected in this area. Hence, it appears that on the East coast of Andhra and Tamilnadu family Podocarpaceae was abundantly present in the Upper Jurassic.

Genus - Brachyphyllum Brongniart 1828

The genus represent detached leafy twigs of the family Araucariaceae. In the Upper Gondwana rock of India Araucariaceae is represented by petrified wood, male and female cones and detached leafy twigs. Following species of Brachyphyllum are known from India :

1) B. expansum
2) B. rhombicum
3) B. mamillare
4) B. feistmantelli
5) B. florinii
6) B. spiroxylum
7) B. sehoraensis

Recently Bose & Banerji (1984) have described B.royii from Mesozoic rocks of Kutch. Hence, it appears that genus

Brachyphyllum is another prominent element in the Mesozoic flora of India.

In the present collection we have described following 5 species :

1) B. rhombicum
2) B. expansum
3) B. mamillare
4) B. feistmantelli
5) B. sp. cf. B. royii

B. rhombicum is earlier reported from Madhya Pradesh and Sriperamatur on the East Coast. Its presence here indicates that it is widely distributed on the East Coast of India and further adds new information to its presence on the East Coast. Further it is suggested that it is first reported from East Coast of Andhra Pradesh. Further search for it may yield many more localities in this area. B. expansum is earlier reported from Madhya Pradesh, Kutch, Golapalli and Vemavaram on the East Coast. Its presence in Chinna-Ganjam shows that it has wider distribution on the East Coast of Andhra Pradesh besides it is found from a new locality in this area. B. mammilare is earlier reported from Rajmahal Hills and Madhya Pradesh. Our report of this plant here is rather significant since it is a first report from the East Coast. Another important feature of the distribution is that its earlier report is from Rajmahal stage and Jabalpur stage.

The present report is from Kota stage, which further links the bridge between the lowermost Rajmahal and upper-most Jabalpur. B. feistmantelli is earlier reported from Madhya Pradesh and Vemavaram on the East Coast. Present report further supports its occurrence in this area and shows that it was widely distributed in the Jurassic beds of Prakasam district. B. royii is a recently discovered species reported from Kutch by Bose and Banerji (1984). Its occurrence here indicates that this plant ranges from East Coast of Andhra to Kutch suggesting wider distribution. Further intensive search for this plant in future may bring to light new localities in this area. Among all the species of Brachyphyllum, B. expansum has wider distribution on the East Coast. Therefore, it may prove another characteristic plant of East Coast Upper Gondwana flora, such as Elatocladus plana. This situation suggests equal distribution of both conifer families Podocarpaceae and Araucariaceae on the East Coast.

III. Genus - Pagiophyllum, Heer

Genus Pagiophyllum represents the vegetative shoots of Araucariaceae and differs from Brachyphyllum in having the free part of the leaves always exceeds the width of the leaf base cushion. Sahni (1928) described P. perigrinum Later on, Vishnu-Mittre (1959) reported P. araucaroides from Rajmahal Hills. Bose & Sukhdev (1972) recorded from Bansa 3 species namely - P. bansaensis, P. marwarensis and P.

rewaensis. Recently, Bose & Banerji (1984) have described following 3 new species from Kutch, namely - 1) P.chawadensis, 2) P. morrisii and 3) P. grantii. Hence, it appears that genus Pagiophyllum is represented by more number of species in India than Brachyphyllum namely 8.

In the present collection it is represented by two species (1) P. sp. cf. P. morrisii, & 2) P. sp. Out of these two P. morrisii is earlier reported from Kutch only. Its presence here indicates wide range of its distribution from Kutch to East Coast of Andhra. P. sp. is earlier reported from Vemavaram by Jain (1967). Its presence here supports the occurrence of P. sp. in Prakasam district and also suggests that it frequently occurs in this area in more than one place. Further intensive search in this area may bring to light more species. From the East Coast out of 8 species earlier report shows only 1 species is present but this is due to meagre work in this area and it is quite probable along with Brachyphyllum this genus must have flourished in the Upper Jurassic period on the East Coast. And, therefore, we have suggested occurrence of more species.

INCERTAE SEDIS :

I. Genus - Desmiophyllum Lesquereux 1878

It represents linear leaf with parallel veins, where mode of attachment is not known. According to Sahni (1928) it comes under the range of various distinct groups such as

conifers, cycads, Ginkgoales and Cordaitales suggesting the open affinities. From India only 2 species have been reported, one from Trrassic - namely Desmiophyllum sp. by Lele and second D. indicum Sahni from Madhya Pradesh and Raghavapuram in the Godavari district belonging to Kota stage. Vagyani (1984) recently reported D. indicum from Vemavaram in Prakasam district. Its presence here supports the above report and further indicates that it is widely distributed in Prakasam district at more than one place. Further its occurrence at Raghavapuram and these places indicates that it was a common member of the Upper Gondwana flora of the East Coast of Andhra. Surprinsingly it is not reported from other places on the East Coast. Perhaps it was thriving in a restricted area namely East Coast of Andhra in the past.

PTERIDOSPERMS :

Pteridosperms in India range from Triassic to Cretaceous. Compared to other groups they are meagrely known from the Mesozoic strata of India. They are represented by following 5 genera, namely -

1) Dicroidium
2) Lepidopteris
3) Thinnfeldia
4) Pachypteris
5) Cycadopteris

From the East Coast only three genera are known namely - Dictiodium, Thinnfeldia and Pachypteris.

Genus - Dicroidium

It represents pinnate to bipinnate leaves with forked rachis having Odontopteriod or alethopteroid to sphenopteroid venation. In India it is quite dominant in the Triassic period and considered as an index fossil of the Triassic. It is the chief element of the Middle Gondwana flora and hence the flora is named as Dictrodium flora. In the Mesozoic its record is rather doubtful and meagre. Earlier, Feistmantel described ?Dicroidium from Vemavaram and Sriperamatur in the East Coast. Jain (1968) reported Dicroidium from Vemavaram and Rao (1959) reported D. feistmantelli from Vemavaram while Baksi (1967) reported D. sp from Raghavapuram. In the present investigation D. sp is reported from Chinna-Ganjam which supports its earlier occurrence on the East Coast. It appears that Dicroidium was dominant in the Triassic and began declining in the earlier Jurassic and finally disappeared at the end of Jurassic. Its appearance is rather scanty and scattered on the East Coast which indicates that it could not withstand the climate of the Jurassic period. So far, no large and complete specimen with forked rachis have been reported from the East Coast. Therefore, the workers have described the plant as ?Dicroidium

or D. sp and occasionally giving the particular specific identity. It is possible to bring more specimen of this genus with complete preservation if intensive search for it could be done.

II. Genus - Pachypteris

Holden (1905) described Retinosporites indica from Kutch. Sahni (1928) recorded it from Vemavaram. Bose & Roy (1968) revised the names as P. indica. Further they have described a new species P. holdenii from Kutch. Feistmantel (1876b) described P. specifica and P. brevipinnata from Kutch. Bose & Banerji (1984) reported P. cf. elegans from Kutch. Hence, it appears that 5 species of this genus are known from India and all of them come from Kutch while P. indica is the only species known from Vemavaram on the East Coast.

In the present work P. sp. cf. P. specifica is reported from Chinna-Ganjam. This suggests the wide distribution of P. specifica ranging from Kutch to East Coast of Andhra. Further it is observed that in the Prakasam district of Andhra Pradesh P. indica and P. specifica are found. This suggests that Pachypteris is not a common element in the Upper Gondwana flora of the East Coast. It shows restricted distribution i.e. only in the Prakasam district of Andhra Pradesh. Therefore, much work is necessary to ascertain this observation.

Flora and its age :

The Upper Gondwanas of the East Coast in Andhra Pradesh are well exposed in the Ongole area. According to Pascoe (1959) several small outcrops are found in the Prakasam district. Vemavaram is one of the well known locality having rich fossil flora and good amount of work has been done on it, Kandkur is another place, 32 K.M. West of Ongole also has fossiliferous shales but not studied extensively. Vagyani (1984-1987) has described several fossil plants from newly discovered locality Uppugunduru having rich fossil flora. In the process of searching for new places we came across the place Chinna-Ganjam which is equally rich in its fossil contents.

The flora found here indicates that it consists of Bennettitales, Coniferales, Pteridosperms and Filicales. Bennettitales form the major constituent of the flora suggesting that somewhat tropical climate was prevailing here. Genus Ptilophyllum is abundantly found here having several species. It is a representative of Upper Gondwana flora suggesting the Upper Jurassic age. Another genus Pterophyllum is a common plant here supporting the Upper Jurassic age. Genus Dictyozamites is considered as a representative of Middle Jurassic by Jacob (1951). But in India it has a range from Upper Jurassic to Lower Cretaceous. Outside India it is also found in the Cretaceous of Japan and Iran. Hence, it appears that Dictyozamites was more dominant in the Upper Jurassic while it declined in the

Lower Cretaceous. Hence, Jacob's interpretations is not a proper one. According to Bose (1974), genus Otozamites is a rare plant in India. He further suggested that it was more common in the Middle Jurassic and lasted upto Upper Jurassic. It is not known from Lower Cretaceous horizons of India. All these above four genera are present at Chinna-Ganjam and therefore, Upper Jurassic age is suggested for this locally on the basis of presence of these elements.

Conifers in India shows a wider range. In the present collection it is represented by Elatocladus, Brachyphyllum, Pagiophyllum. Genus Elatocladus is represented by 5 species and it is a typical representative found in the Rajmahal flora and Jabalpur flora suggesting the range from Middle Jurassic to Upper Jurassic. Brachyphyllum also having 7 species at this place forms another important conifer member. Brachyphyllum ranges from Triassic to Upper Jurassic but it is more common in the Middle and Upper Jurassic. B. expansum is a characteristic plant of the East Coast and its presence here supports the Upper Jurassic age (Kota Stage). Genus Pagiophyllum with 3 species shows that it is not much common plant. The genus has range from Kutch to East Coast. But presence of 3 species at Chinna-Ganjam shows that it is not a rare element and shows close association with Brachyphyllum suggesting Upper Jurassic age.

Genus Desmiophyllum is another member found at Raghavapuram and Vemavaram and now at this place suggests that it has

frequent occurrence on the East Coast and was flourishing along with Brachyphyllum and Pagiophyllum. Phylogenetically, it is also nearer to Brachyphyllum and Pagiophyllum having affinities of the family Araucariaceae.

Pteridosperms is a small group in the fossil flora of India ranging from Triassic to Cretaceous. From the East Coast only 3 genera are known - (1) Dicroidium, (2) Thinnfeldia and (3) Pachypteris. Genus Dicroidium is an index fossil of the Triassic period and its presence in Jurassic was of little significance. It appears that the plant got reduced here. Therefore, presence of Dicroidium has little importance on the age of the flora. Thinnfeldia is absent here. Pachypteris which is earlier known from Vemavaram and Kutch is reported here. It suggests the Upper Jurassic age of this flora.

In general composition the flora indicates a mixture of Rajmahal and Jabalpur elements besides some of the members are characteristic of the East Coast flora. Therefore, it is necessary to have detailed studies on the fossil plants in this area for which intensive search is necessary. This may bring to light new localities and more material and then perhaps proper determination of the age can be done. On the basis of our investigation Upper Jurassic age is suggested to this flora.

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