

## **6. GENERAL CONSIDERATIONS.**

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Along the East-Coast, thin marine beds occur as series of detached outcrops. These deposits are mostly lagoonal Mesozoic sediments which are found along the East-Coast. They are popularly called as East-Coast Gondwanas and considered as extended occurrence of Upper Gondwana.

The Upper Gondwana sediments of East-Coast occur in Krishna Godavari basin, Palar basin, Cauveri and Mahanadi basins. Each basin is represented by a typical upland flora which is called as a Ptilophyllum flora. The ecological character of this flora suggests Swampy environment associated with marine elements.

Venkatachala (1967) observed the flora includes members of Cycadophytes, Conifers and Ferns. However, difference of elements is found in different basins. This indicates a characteristic floral composition of each basin was varied from each other. Several workers have contributed to the knowledge of Upper Gondwana flora of east-coast. In Cauveri basin Sivaganga formation represents the Upper Gondwana rocks. The flora of preserved year has been studied by Feistmantel (1879), Gopal and Jacob (1957), Jeyasingh and Sudherson (1985) and Maheshwari (1986).

The Krishna-Godavari basin is represented by the Vemavaram and Raghavapuram beds. Vemavaram beds are considered as the richest fossiliferous deposits along the east-coast and has been studied by Feistmantel (1879).

Seward and Sahni (1920), Sahni (1928), Suryanarayana (1954), Bose and Jain (1967), Bose and Zeba-Bano (1978), The Raghavapuram shales also yielded an equally good floristic composition in the basin.

The Mahanadi basin is typically represented by Athgarh sandstone in Orissa. It is studied by Feistmantel (1977 b), Adyalkar and Rao (1963), Jain (1968), Pandya and Patra (1968), Pandya and Patra (1873, 1880) and Patra and Patnaik (1974). The flora is dominated by pteridophytes and hence it is distinguish from others. The Palar basin is smallest among the system and represented by green shales, clays and light weight sandstones. The beds show marine intercalations. The flora is earlier studied by Feistmantel (1879), Seward and Sahni (1920), Sahni (1928, 1931), Suryanarayana (1934, 1955).

According to Foote (1868) the flora suggests some common features with the Rajmahal flora. It consists of Conifers, Cycadophytes, Ferns, Pteridosperms and Ginkgoales. The plants are preserved both as impressions and pterifications.

The conifer woods are found as petrified material and equally distributed with impressions.

In the Palar basin, there are two important formations, the first is Sriperamatur beds which is more richer than the second called as Satyavedu beds. The survey of the four basins reveals that out of these four basins the flora of Krishna, Godavari, Sivaganga basins are extensively studied, while the flora of Mahanadi basin and Palar basin shows a scanty work in view of this situations. The present investigation was undertaken to study the fossil flora of Palar basin, which offers a larger opportunities for the workers. Therefore, plant fossil were collected at some known, little known and newly discovered places. It was found that earlier literature has little information of the fossil localities and their exact position. Therefore, the study becomes noteworthy experiment for the exploration of plant fossil found in the Palar basin.

The flora found here are equally rich like that of Krishna-Godavari and Cauveri basin. It represented by following members.

#### Morphological Studies

These include the studies of plant impressions found at Sriperamatur, Poonamali and Vellum. The present study

embodies the results of exploration and study of the elements therein.

Cycadophytes :

The Cycadophytes are divided into :

- a) Cycadiodales,
- b) Cycadales.

a) CYCADIODALES :

The group includes mostly the leaf genera. They are

- 1) Ptilophyllum, Morris
- 2) Pterophyllum Brongniart
- 3) Dictyozamites Oldham
- 4) Otozamities Braun.
- 5) Anomozamities Schimper

Presence of these genera suggests warm and moist climate were these above elements florised rapidly.

Genus - Ptilophyllum Morris 1840

It is a pinnate leaf representing pinnae covering the rachis partially showing parallel venation. It is mostly found in the Upper Gondwana rocks of India, and hence considered as a characteristic member of Upper Gondwana flora. Due to these reasons the flora is also named as Ptilophyllum flora.

Bose and Kasat (1972) have given a brief account of Ptilophyllum in India and noted that, it is represented by 15 species. Recently Mahabale and Satyanarayana (1979) have described 2 more species from the Andhra Pradesh. Hence total number of species becomes 17. Earlier work reported that only 4 species are found on the East-Coast viz.

- 1) P.acutifolium
- 2) P.cutchense
- 3) P.rarinervis
- 4) P.deodikarii
- 5) P.tenerrimum Mahabale and Satyanarayana
- 6) P.raghudevpureense Mahabale and Satyanarayana

Hence, it appear that 6 species of Ptilophyllum occur along the East-Coast. From the Palar basin the following 5 species are described in the present report.

- 1) P.rarinervis,
- 2) P.sakrigaliense
- 3) P.institacallum
- 4) P.acutifolium
- 5) P.rathudevapureense.

This indicates that Palar basin shows the presence of Ptilophyllum in moderate proportion. Out of these 5 species P.raghudevapureense and P.sakrigaliense are reported for the first time. Hence, it suggests the wider distribution

of these species for example P.raghudevapurensis is known from East-Godavari district in Andhra Pradesh, which extends upto Tamil Nadu. So this distribution again shows the presence of P.raghudevapurensis along the East-Coast. However, P.sakrigaliensis is known from Rajmahal hills in Bihar. Palar basin shows a wider vertical distribution in India. Similarly P.raghudevapurensis represents wider horizontal distribution. The abundance of Ptilophyllum in the present collection justifies the presence of Ptilophyllum flora in the Palar basin.

Genus - Pterophyllum Brongniart 1928

This is also a Cycadophytic leaf, but larger in size and characterised by lateral attachment of the pinnae to the rachis. According to Bose and Banerji (1981) 10 species of Pterophyllum are found in India. And they further noted that out of 10 species only following 3 species occur along the East-Coast.

- 1) P.footeanum from Vemavaram
- 2) P.incisum from Vemavaram
- 3) P.kingianum from Gollapalli.

Recently Vagyani and Zutting (1986) reported the occurrence of P.distans from Andhra Pradesh. Similarly Rajnikanth and Sudharsan (1989) reported the occurrence of

P.medlicottianum and P.morrisianum from Sivaganga formation in Cauveri basin of Tamil Nadu. Above report clearly indicate that out of 10 species 6 species are found along the East-Coast. Hence Pterophyllum shows common occurrence like Ptilophyllum on the East-Coast.

In the present investigation we have described following 2 species.

1. P.medlicottianum
2. P.footeanum

Occurance of these two species support their earlier occurrence along the East-Coast. However, from Palar basin they are represented by first time in the present work. One can expect more species of Pterophyllum in the flora of Palar basin. And for this intensive search of the genus is necessary.

Genus - Dictyozamites Oldham 1863.

This is also a Cycadophytic leaf characterised by auriculate base and reticulate venation. According to Bose and Zeba-Bano (1978) 6 species of the genus are found in the India. Following species are represented on the East-Coast.

1. D.falcatus.
2. D.indicus



3. D.feistmantelii
4. D.sahni

In this collection, contribution by Mahabale and Satyanarayana (1979), Vagyani and Jamane (1987) is quiet important.

Recently Sukh-Dev and Rajnikanth (1988) described a new species D.gondwanensis from Gangapur formation in Andhra Pradesh. This locality is situated in the interior part of Andhra Pradesh and quiet away from the East-Coast. Due to this addition the number of species of Dictyozamites in India becomes 7. In recent investigation following 4 species are represented viz.

1. D.gondwanensis
2. D.hallei
3. D.indicus
4. Dictyozamites sp.

The presence of first 3 species in Palar basin supports their earlier occurrence on the East-Coast. However, D.gondwanensis in first time reported from Palar basin which suggests the wider distribution of this species.

Genus - Otozamites Braun 1842

This is some what rare in India. According to Bose

(1974) following 5 species of the genus are found in India, viz.

1. O.imbricatus
2. O.vemavaramensis
3. O.exhislopi
4. O.gondwanensis
5. Otozamites sp.

Recently Bose and Banerji (1984) have described two new species from Cutch. They are-

1. O.walkmotoensis
2. O.kachchensis

Hence, the number of species of Otozamites becomes 7 in India. Out of these 7 species 4 species occur along East-Coast, while remaining 3 species are found in Cutch.

In the present work only one species i.e. O.walkmotaensis is included. This suggests the wider distribution of O.walkmotaensis ranging from Cutch to Palar basin.

Small number of Otozamites further supports it's rare occurrence on the East-Coast.

Genus - Anomozamities Schimper

This is also a Cycadophytic leaf characterised by the feature where lamina is divided into segments. Most of Indian specimen of Anomozamities were earlier included in Pterophyllum. But Bose and Banerji (1981) suggested that the leaves with segments showing squarish shape or two times longer than the breadth should be included under Anomozamities. According to these authors following 5 species are known.

1. A.crenata (McClelland) Comb.
2. A.amarjolense Sharma, Surana and Singh
3. A.fissus Feistmantel
4. A.hansapurensis
5. A.haburensis n.sp.

Out of these 5 species only 2 species have been reported from East-Coast. They are -

1. A.hansapurensis Bose and Banerji from Sivaganga by Jeyasingh and Sudharsan.
2. A.haburensis Bose and Banerji from Sivaganga by Sukh-Dev and Rajnikanth.

Hence, it appears that so far only two species are known and both of them come from Sivaganga formation in Tamil Nadu.

In the present work A.fissus Feistmantel is represented from Palar Basin. This indicates occurrence of

3 species from East-Coast. And all of them from Tamil Nadu. Further *A.fissus* is reported for first time from the East-Coast as well as Tamil Nadu. Anomozamities was dominant in the North was represented in the Southern most part of the India. And it was some what rare in Madhya Pradesh, hence distribution of Anomozamities in the Upper Gondwana beds of India shows a piculiar trend.

Genus - Pseudoctenis Seward 1911.

Pseudoctenis is closely compared with Pterophyllum. However, it can be distinguish from it in having certain characters (see Seward (1919)). It further differs from allied genus Ctenis in the absence of cross-connections between the veins. Earlier Pseudoctenis footeanum was described from India by Seward and Sahni (1920) from Vemavaram. Now it is merged under Pterophyllum footeanum by Bose and Banerji (1981).

Recently Bose and Banerji (1984) described P.fragilis from Cutch. Hence there is no doubt about presence of Pseudoctenis in India. The present investigation adds Pseudoctenis sp. which is perhaps the second report of Pseudoctenis. For the time being the specimen is referred to Pseudoctenis due to it's resembles with generic character of Pseudoctenis Seward.

Coniferales

Family - Araucariaceae

Genus - Brachyphyllum Brongniart

It is sterile vegetative shoot showing triangular or conical leaves arranged in spiral fashion. The genus is represented by more than 8 species. Some are based on cuticular features. According to Sahni (1928) 2 species are known from East-Coast viz.

1. B.rhombicum
2. B.expansum

These species are known from Vemavaram, Sriperamatur, Raghudevapuram and also Sivaganga.

Recently Sukh-Dev and Rajnikanth (1988) reported 2 more species from Sivaganga.

1. B.regularis Borkar and Chiplonkar
2. B.theraniense Sukh-Dev and Rajanikanth

Hence it appears that as many as 4 species of the genus occur along the East-Coast. In the present work only one species i.e. B.rhombicum is represented. It supports the earlier occurrence of the plant on the East-Coast.

Genus - Pagiophyllum Heer 1881.

It is also a vegetative shoot having spirally arranged leaves where the leaves are more longer than the breadth. It is some what rare on the East-Coast. According to Sahni (1928), Bakshi (1968) only two species are known along the East-Coast. They are -

1. P.perigrianum
2. P.divericatum.

In the present work P.spinosum Sukh-Dev and Rajanikanth is represented. It is earlier reported from Gangapur formation in Andhra Pradesh only. Its presence in Palar basin suggests a wider distribution of the plant and justifies it's occurrence on the East-Coast. Pagiophyllum is more common in Madhya Pradesh, Cutch and Bihar and some what restricted on the east-coast.

Family - Podocarpaceae

Genus - Elatocladus Halle 1913.

It shows equally wider distribution in Northern and Southern parts of India. More than 6 species have been reported by various workers.

1. E.plana
2. E.conferta
3. E.jabalpurensis
4. E.tenerimma

5. E. sahnii
6. E. kingianum.

Out of these E. plana appears to be a mostly widely distributed plant of the east-coast. It is represented in Andhra Pradesh at several places. Mahabale and Satyanarayana (1979) described it from East-Godavari district in Andhra Pradesh. Vagyani and Jamane (1987) described it from Prakasam district in Andhra Pradesh. Jeyasingh and Sudharsan (1989) described it from Sivaganga in Tamil Nadu. Sahni (1928) specifically mentioned the occurrence of E. plana from Sriperamatur region. Its presence here confirms this observation. The interesting feature of the present work is that, it comes from Vellum a place commonly known for petrified woods. This adds additional information about this locality as well as suggests common occurrence of E. plana in Palar basin.

Family - Taxaceae

Genus - Torreyites Seward

It is a foliage of Taxaceae resembling the leaves of living genus Torreya. Seward and Sahni (1920) and Sahni (1928) reported the occurrence of T. constricta from Vemavaram in Andhra Pradesh. Later on Ganju (1946) described the second report viz. T. sitholeyi from Rajmahal hills in Bihar. Out of these two species T. constricta occurs on East-coast and so far only known from Andhra Pradesh.

In the present work Torreyites sp. is represented and comes from Vellam. This adds a further occurrence of Torreyites on the east-coast. It is also first time reported from Palar basin.

#### Pteridophytes

Genus - Sphenopteris Sternburg 1825.

The genus is included under unclassified ferns since it's affinities with any particular families of living fern is not known. Sphenopteris is known from several places belong to Mesozoic stratas. From East-Coast following species are known -

1. S.tiruchirpalliensis Sukh.Dev and Rajanikanth.
2. S. sp. from Sivaganga.

In addition to these, there are the isolated reports of Sphenopteris sp. from Raghavapuram and Vemavaram beds. So far Sphenopteris is not known from Palar basin. In the present work it is represented by a new species viz. S.palarensis, this suggests the occurrence of Sphenopteris in Palar basin for the first time. At the same time it also indicates that 3 species of Sphenopteris occur along the east-coast.

#### Unclassified ferns

Genus - Phoenicopsis Heer

Occurance of Phoenicopsis in India is doubtful



since the earlier authors have described leaves like Phoenicopsis under Desmiophyllum. Feistmantel (1887) described Podozamities lanceolatus from Jabalpur Stage. It shows all the important features of Phoenicopsis given by Seward (1919), Seward and Sahni (1920) described as ? Phoenicopsis sp. which is also from Jabalpur Stage. Hence it appears that the new report of Phoenicopsis from Poonamali belonging to Sriperamatur beds. Hence it appears that the flora of Palar basin shows a rare element of Upper Gondwana flora, which is earlier known from Jabalpur Stage only. Further it adds to vertical wider distribution of Phoenicopsis in India.

#### Anatomical Studies

It includes the study of silicified coniferous woods collected from 3 different localities from Palar basin. Several woods were collected from these localities. And those showing promising features were selected for their anatomical characters, and included in this part. Five petrified woods which forms the second part of the dissertation belongs to 5 genera. They are -

1. Araucarioxylon Krauss 1846
2. Agathioxylon Hartig 1848
3. Planoxylon Stopes 1916
4. Circoporoxylon Krausel 1949
5. Prototaxoxylon Krausel and Dolianti 1958.

Family - Araucariaceae

Genus - Araucarioxylon Krauss 1846

The genus was instituted for the Araucarian features. Hence number of coniferous woods were described under this name. The genus Dadoxylon Endlicher was also instituted for description of Araucarian woods. Hence some authors used the term Araucarioxylon, while others used Dadoxylon for describing the Araucarian woods. This results confusion among the workers. Hence it was decided by some Palaeobotanists to use the term Araucarioxylon for Mesozoic and Cenozoic woods and Dadoxylon for Palaeozoic woods. But even this distinction was not found satisfactory due to irregular use of these terms. Finally Maheshwaril (1972) and Lepekhina (1972) tried to solve this problem by putting their own schemes. Among these two Lepekhian's classification is accepted by majority of Palaeobotanists.

Accordingly those Araucarian woods with pith, primary xylem and secondary xylem are classified as Dadoxylon. And those showing only secondary xylem are classified as Araucarioxylon. From India Araucarian woods have been described from several horizons and localities. They come from Palaeozoic, Mesozoic and also Cenozoic rocks.

Bose and Maheshwaril (1974) revised Indian coniferous wood and some species of Dadoxylon are new transferred to

Araucarioxylon. Mesozoic rocks in India have yielded large number of coniferous wood. They come from Rajmahal hills in Bihar, Kota-Maleri beds in Maharashtra and Andhra Pradesh; Palar basin in Tamil Nadu, Raghudevapuram in Andhra Pradesh and others.

In the present investigation Araucarioxylon sriperamaturensis is described as the new species which comes from Sriperamatur. Sriperamatur is mostly known for impression fossils. But woods were collected from exposures which is at a distance of 5 Km. from Sriperambadur. Due to it's distinct feature it was found different from other known species of the genus. Hence it was described as a new species.

Genus - Agathioxylon Hartig 1848

This genus also belongs to family Araucariaceae and shows close affinities with the living genus Agathis.

Hartig (1848) instituted the genus Agathioxylon to accomodate the woods of Agathis comparing to Araucarioxylon. There are very few reports of Agathioxylon. They are mostly reported from Australia, New Zealand and Germany.

Recently Vagyani and Jamane (1989) reported Agathioxylon maheshwarii from Kamthi beds of Chandrapur district in Maharashtra. The age of Kamthi's is debatable.

According to Prasad and Chandra it is considered as Upper Permian. While Vagyan and Mahabale (1972) considered it as Lower Triassic. Hence this report is almost standing at the last limit of Palaeozoic and beginning of Mesozoic.

In our work A. palarensis is described as a new species, which comes from Kota Stage of Tamil Nadu. Kota Stage is considered as an Upper Jurassic age. So it appears that in India Agathioxylon ranges from Upper Permian to Upper Jurassic. The report of Agathioxylon from Palar basin is note-worthy. Since it is reported for the first time.

The above facts reveal that woods of Araucariaceae are quiet common in Palar basin. This observation is supported by additional evidences of other members belonging to Araucariaceae in the form of impressions.

Occurance of Brachyphyllum and Pagiophyllum confirms presence of Araucariaceae in the Mesozoic rocks of Palar basin.

Genus - Planoxylon Stopes 1916.

This genus comes under a transitional conifers due to it's characters showing mixture of Araucariaceae and Pinnaceae. Different species of Planoxylon are known from Liassic and Cretaceous rocks of New Zealand, England, Japan from India.

Vagyani and Mahabale (1972) described P.indica from Lower Triassic of Chandrapur district. In the present work P.jurassicum is reported, which is a new species and comes from Vellum in Palar basin.

Sahni (1928) described coniferous woods of Podocarpaceae from this place. The occurrence of Planoxylon from Vellum shows that a rich coniferous flora was developed in this region. Further in India Planoxylon ranges from Lower Triassic to Upper Jurassic.

Genus - Circoporoxylon Krausel 1949.

Krausel (1949) instituted this genus for woods of Podocarpaceae showing simple pits in cross-field area and pit-pore is not vertical. From India only one species of Circoporoxylon has been described by Krausel and Jain (1964) which comes from Jurassic of Rajmahal hills.

In the present work it is represented by C.sriperamaturii which is a new species, and collected from a new locality also viz. Poonamali near Madras.

Occurance of Circoporoxylon in Palar basin suggests it's wider distribution in India ranging from Bihar to Tamil Nadu. Report of Podocarporoxylon in the Palar basin was already made by Sahni (1928). The present report

supports the observation and also adds additional information about Circoporoxylon in this area.

Genus - Prototaxoxylon Krausel and Dolianti 1958.

The genus was created for those woods showing combination of Araucarian and Taxanean features. The genus has wide range from Palaeozoic to Cenozoic beds. In India Prototaxoxylon is described by several workers from Palaeozoic and Cenozoic rocks. The present wood comes from Mesozoic strata viz. Upper Jurassic beds in Palar basin.

Hence it bridges the gap between the occurrence of Prototaxoxylon in India. Which now has continuous presence in Palaeozoic, Mesozoic and Cenozoic. Hence the occurrence of Prototaxoxylon in Palar basin is quite noteworthy. It is represented by a new species P. maheshwarii from a new locality Poonamali.

The 5 woods representing Araucariaceae, Taxaceae, Podocarpaceae and Pinnaceae, reveals that the Palar basin had a coniferous assemblage of this combination. This further indicates the flora of Palar basin is equally rich when compared with other Upper Gondwana floras. So far conifer elements are concerned.

Flora and it's age

On the basis of above data it is necessary to ascertain the age of fossil localities in the Palar basin. Foote (1868) was perhaps the first person who compares the floral assemblage of Sriperamatur beds with that of Rajmahal hence suggesting a Middle Jurassic age to this flora. Feistmantel (1879) also supports Jurassic affinities of this flora.

Presence of cycadophytes conifers, ferns, pteridosperms and ginkgoals gives an overall picture of the fossil flora of Palar basin. It has a typical members of Upper Gondwana flora. Perhaps the second best assemblage found on the east-coast after the famous Vemavaram beds. The most distinct feature of the flora is dominance of conifers, while the Rajmahal flora is dominated by Cycadophytes and Jabalpur flora is dominated by conifers. Hence on this single factor it resembles with the Jabalpur flora to some extent.

The presence of Anomozamities can be cited as an evidence for this purpose. The next dominant group is Cycadophytes which agrees with the fossil flora of Rajmahal. However, the abundance of ferns in Rajmahal is not observed in the Palar basin.

It is well known fact that entire east-coast is somewhat poor in the presence of fossil ferns. Baksi (1968) is of the opinion that the Raghavapuram flora shows a combination of Rajmahal and Jabalpur elements. And it is well known fact that Vemavaram and Raghavapuram both are equivalent due to affinities of Kota Stage.

Recently Sukh-Dev and Rajnikanth (1989) studied the fossil flora of Kota formation in Maharashtra. They have suggested Lower Cretaceous age to Kota Stage. But it appears that the age of Kota Stage can not reach beyond the Upper Jurassic due to absence of certain fern elements.

The flora of Palar basin on the whole appears to be homotaxial with that of Vemavaram shales, which typically shows presence of Kota Stage. Recent contribution by our school has shown that the flora of Prakasam district shows a typical Upper Jurassic age and confirms the presence of Kota Stage in Ongole area.

Considering this fact we suggest Kota Stage is also prevalent in the Palar basin showing the range between Upper Jurassic to Lower Cretaceous. To ascertain this fact intensive search for more localities in this area is necessary. It is also desirable to have additional



studies on the fossil flora of not only Palar basin, but also entire east-coast. So that an attempt can be made to correlate the different floras of east-coast which will be useful in deciding the correct age to which they belong.

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