Late Holocene environment in Coondapur area, Karnataka: Preliminary palynological results

Colette Tissot

Tissot, Colette 1990. Late Holocene environment in Coondapur area, Karnataka: Preliminary palynological results. *In* : Jain, K. P. & Tiwari, R. S. (eds)—*Proc. Symp. 'Vistas in Indian Palaeobotany', Palaeobotanist* **38** : 348-358.

Palynological studies of sediments cored between the depth of 145 to 425 cm in Coondapur area, on the west coast of India in Karnataka, produced evidence of continuous existence of a well developed mangrove forest during the recent past. The pollen spectrum is mainly constituted by mangrove species; their constant representation (always more than 50%) shows stability of the environmental conditions; beside the dominant mangrove pollen, there are also those of the local vegetation. Prevalence of marine influence has been recorded throughout. Hinterland mountain vegetation is poorly represented. Such a palynological assemblage is indicative of a lagoon environment. The almost total disappearance of mangrove vegetation at this site today may not necessarily be due to a drastic change in ecological and hydrological conditions but it is certainly accelerated because of the anthropic pressure: land reclamation as well as time honoured practice of cutting wood.

Key-words—Palynology, Mangrove, Sea level changes, Late Holocene, Karnataka (India).

Colette Tissot, French Institute of Pondicherry, P.B. 33, 10 St. Louis Street, Pondicherry 605 001, India.

साराँश

कर्नाटक में कुन्डापुर क्षेत्र में अनंतिम होलोसीन वातावरण : प्रारम्भिक परागाणविक परिणाम

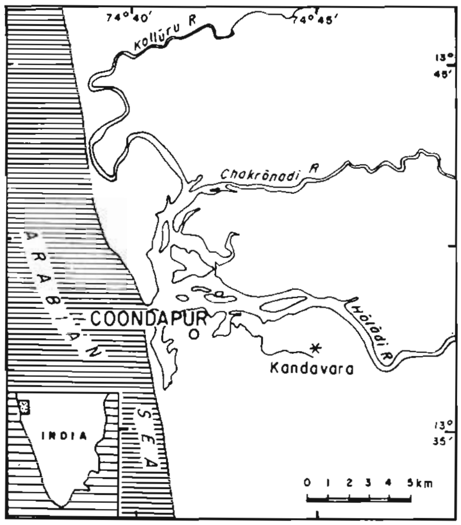
कॉलॅट तिसत

कर्नाटक में भारत के पश्चिम तट पर स्थित कुन्डापुर क्षेत्र में 145-425 सेन्टीमीटर की गहराई के बीच के अवसादीय क्रोड़ों के परागाणविक अध्ययन से इस क्षेत्र में सुविकसित मैंग्रोव वन की उपस्थिति के प्रमाण मिले हैं। परागकण स्पेक्ट्रम में मुख्यतया मैंग्रोव जातियाँ ही हैं; इनकी अविच्छिन्न उपस्थिति (50 प्रतिशत से अधिक) से वातावरणीय परिस्थितियों में स्थायीत्व प्रदर्शित होता है; मैंग्रोव वनस्पति के अतिरिक्त स्थानीय वनस्पति के परागकण भी मिले हैं। समुद्री प्रभाव समस्त क्रोड़ में देखने को मिला है। पश्चभूमि में पर्वतीय वनस्पति की बहुत ही कम संख्या है। इस प्रकार की परागाणविक समुच्चय लैगूनीय वातावरण की द्योतक है। इस स्थान पर अब मैंग्रोव वनस्पति की सम्पूर्ण विलुप्ति जलीय एवं पारिस्थितिकीय परिवर्तनों के कारण नहीं है बल्कि वनों आदि के काटने तथा खेती के लिए अधिक भूमि जुटाने के कारण सम्भवतः ऐसा हुआ है।

SINCE a long time, mangrove forests have been the subject of extensive research in various fields. Being located in the coastal regions, they are all the more interesting because they provide valuable information of sea-level changes and permit the reconstruction of the history of palaeoenvironments. The study of coastal area of Karnataka has been carried out with the purpose of reconstituting the history of forests of the Western Ghats as well as assessing the role of climatic changes and human pressure in this area in the recent past.

The coast of Karnataka is about 320 km long and consists of a narrow strip, about 20 km wide, situated between the Western Ghats and the Arabian Sea. Several rivers flow from the mountains towards the Arabian Sea, spreading out into broad estuaries or lagoons.

Kandavara bore-well has been dug in Coondapur area, at 13°37′ and 74° 45′ E (Text-fig. 1). It is located far away from the main flow, in the southern part of the Gangoli estuarine complex, at about 7 km from the coast. It has been dug near a mud flat, on the bank of a narrow channel which is linked to the Haladi River. This site presents on one hand the advantages of a regular sedimentation devoid of all detritic and coarse material, thereby



Text-figure 1—Coondapur area: Location of Kandavara bore-well.

permitting the study of a longer interval of time but its isolation, on the other, may lead to a decrease in the fluvial supplies which can reduce the number of allochthonous pollen carried by water.

PRESENT VEGETATION

Today, the mangrove vegetation grows mainly in the northern part of Gangoli estuary. Around the bore-well area, only a few remnants of the former mangroves are still seen surviving here and there: small *Rhizophora* and *Acanthus ilicifolius*. Landscap in the neighbourhood is dotted with paddy fields and grasslands. On the hinterland hills, immediately upstream from the bore-well, there spreads a low and discontinuous vegetation with *Sapium*, *Syzygium* and *Ixora*, which is succeeded by a shrubby vegetation alternating sometimes with savanna and which may also grow on the plateau and at the foot hills of the Ghats (Pascal, 1988).

POLLEN ANALYSES

In order to collect sediments, a hand borer, the "Soviet borer", specially devised to avoid risks of contamination, has been used (Thanikaimoni, 1987). This borer goes down hermetically closed and opens only at the required depth.

Kandavara bore-well registered a depth of 4.25 m, the base being a hard and sandy sediment, bright brown to yellow in colour. The whole core consists of a homogeneous dark coloured silt, containing various small plant debris. A thin layer of coarse sand occurs at a depth of 1.95 m. At the bottom of the core, sediment is more sandy, very compact and without any plant debris.

Because of the regular lithology of the sediment, samples were studied at intervals of 20 or 30 cm, fro 145 cm to the bottom (425 cm). The upper section of the core could not be investigated for pollen analyses because of its very soft and moist sedimentary texture; besides, it was likely to have been disturbed by human activity.

All the samples yielded enough quantity of pollen to enable valuable interpretations, exception being the two lower samples which were either barren, or very poor. In each sample 150 to 250 pollen and spores have been counted, and percentages were established from the total obtained, including the unidentified grains. Marine microplankton was counted separately. The percentage has been established by comparison with the continental microfossil pollen and spores using the ratio: marine microfossils number/continental + marine microfossils total. Same method was used for fresh-water organisms.

FLORISTIC GROUPS

The taxa have been grouped according to their ecology, geographic distribution, or floristics following the plant associations defined by Gamble (1967), Saldanha (1988) and Pascal (1988). A detailed composition of these groups is given in Table 1. The associations mainly concern mangrove and back-mangrove pollen, hinterland pollen, those of herbaceous taxa belonging to Poaceae and Cyperaceae families, spores of Pteridophyta, allochthonous pollen and the marine organisms. The pollen grouped under "Regional" are those derived from the hinterland vegetation. This term is used in its wide sense and includes the coastal plain as well as the hinterland hills and the western slopes of the Ghats. But most of the pollen identified in our analyses, with the exception of the mangrove and mountains pollen whose origin is very precise, may have been produced by plants growing on the plains as well as in higher zone. The heading "Regional varia" includes the pollen whose ecology is not indicative of specific environment as well as those which could be identified only up to the family level or a little higher.

POLLEN DIAGRAMS

Pollen diagrams have been established according to the associations defined earlier (Text-fig. 2). Detailed percentages are given in Table 2.

Table 1—List of taxa constituting the main floristic associations

Mangrove	Regional	Regional varia	Upland	Pteridophyta	Marine elements
Rhizophora	*Areca*	*Acacia* sp.	*Artemisia*	Monolete spores	*Leptodinium*
Rhizophoraceae	*Arisaema*	Anacardiaceae	*Ephedra*	Trilete spores	*Operculodinium*
Avicennia	*Arenga wightii*	Arecaceae	*Strobilanthes*	*Ceratopteris*	*Spiniferites* sp.
Sonneratia	*Borassus*	Asteraceae			*S. mirabilis*
Kandelia	*Calamus*	*Canthium*			*Bitectatodinium* sp.
	Caryota	*Croton*			*Tuberculodinium*
Back-mangrove	*Cocos*	Cyperaceae			Foraminifera
Calophyllum	*Phoenix sylvestris*	*Desmodium*			
Excoecaria	*Pinanga*	Euphorbiaceae			**Fresh water**
Sesuvium	*Aegle*	*Ficus*			*Pseudoschizaea*
Heliotropium	*Artocarpus*	*Hemigraphis* sp.			*Botryococcus*
	Bombax malabaricum	*Justicia*			
	Diospyros malabaricum	Malvaceae			
	Dodonaea viscosa	Melastomataceae			
	Elaeocarpus	*Mimosa* sp.			
	Emblica officinalis	Monocotyledons			
	Flacourtia indica	Myrtaceae			
	Garcinia	Periporate			
	Poaceae	*Phyllanthus* type			
	Holoptelea	*Randia* type			
	Hygrophila	*Syzygium*			
	Lannea	*Terminalia*			
	Mimusops	Urticaceae			
	Olea dioica	*Ventilago*			
	Pandanus				
	Sapotaceae				
	Schleichera				
	Trema				
	Ziziphus				

Mangrove

Mangrove is always very well represented from the bottom of the core to the top (145 cm) with percentages rarely below 50; the main pollen grains are those of *Rhizophora* which continues to be the predominant genus in Coondapur area. Some other Rhizophoraceae have been observed, such as *Ceriops, Bruguiera* and some grains of *Kandelia candel*, but their number has always been low. *Avicennia* is poorly represented and only two grains of *Sonneratia*, which, however, is reputed to be a good producer of pollen, have been recorded. The fluctuations which appear on the mangrove diagram are likely to be due to local causes and do not reveal any notable modification of the landscape.

Regional

The relatively high representation of pollen in this category is regular and no drastic changes appear in the curve representing their percentages. Its contents which are widely varied correspond to the floristic diversity of the hinterland. It is constituted primarily by pollen of Arecaceae with *Calamus, Arenga, Areca catechu, Caryota urens*, etc. Pollen of *Pandanus, Syzygium, Terminalia* and *Elaeocarpus* are also regularly observed.

PLATE 1 →

(All microphotographs are, × 1000)

1. *Rhizophora* sp. (Rhizophoraceae)
2. *Sesuvium portulacastrum* (Aizoaceae)
3. *Calophyllum inophyllum* (Clusiaceae)
4. *Pandanus* sp. (Pandanaceae)
5. *Calamus* type *rotang* (Arecaceae)
6. *Arenga wightii* (Arecaceae)
7. *Aegle marmelos* (Rutaceae)
8. *Caryota urens* (Arecaceae)
9. *Syzygium* sp. (Myrtaceae)
10. Arecaceae
11. *Diospyros* sp. (Ebenaceae)
12. *Elaeocarpus* sp. (Elaeocarpaceae)
13. *Bombax malabaricum* (Bombacaceae)

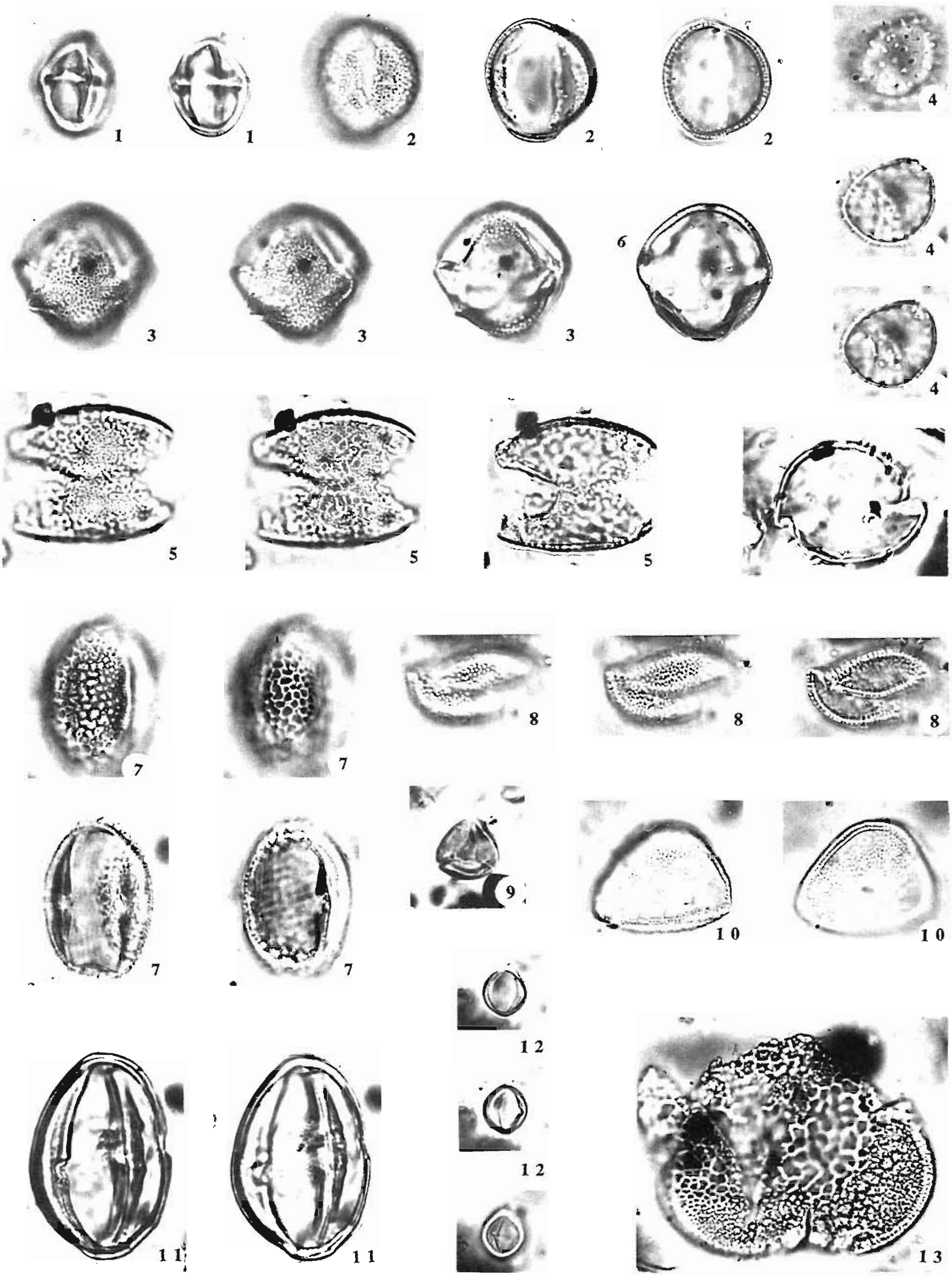
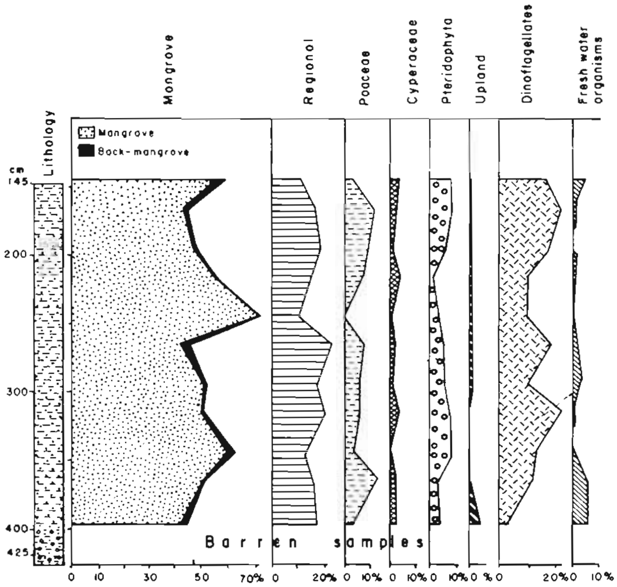


PLATE 1



Text-figure 2—Pollen diagram of Kandavara borewell.

Many small pollen, measuring about 10-12μm, smooth, with 3 colporus and 3 pseudo-colpus are also included in the "Regional" group. Although they could not be identified with certainty, they may belong to Melastomaceae or Boraginaceae, well represented in the region, and which contain several pollen with similar morphology. Their percentage in the samples, though not very high, is regular enough. Similar remarks can be made for certain small sized pollen (12 to 15 μm), reticulate, tri-aperturate, with endoaperture not well defined, and may belong to Menispermaceae (Thanikaimoni, 1984). Various other taxa, irregularly observed and sometimes with very low percentages are also included in the "Regional" group.

Some taxa whose ecology or floristic requirements correspond to a well-defined environment were used for specifying the main sources of pollen production in the region. The floristic structure to which they belong is given in

Table 2—Percentages of taxa observed in Kandavara bore-well

Level (cm)	145	165	195	215	245	265	295	315	345	365	395	425
Mangrove	**56,6**	**44,2**	**48,1**	**56,1**	**73,9**	**42,9**	**52,2**	**51,2**	**61,7**	**51,9**	**43,5**	**47,4**
Rhizophora	53,7	41,2	43,2	56,1	68,1	35,2	46,1	43,6	53,0	46,8	41,3	42,1
Rhizophoraceae	2,2	2,0	3,3		5,7	3,2	5,0	4,1	6,6	3.9	2,2	5,3
Avicennia					0,7		1,1	1,2	1,1	0,6		
Sonneratia									0,5	0,6		
Kandelia	0,7	1,0	1,6			4,6		2,3	0,5			
Back-mangrove	**3,7**	**1,5**	**1,1**			**3,7**	**1,1**	**0,6**	**2,2**	**0,6**	**2,2**	
Calophyllum	3,7		0,5			0,9					2,2	
Excoecaria						1,8	0,6	0,6	1,6	0,6		
Sesuvium		1,5										
Heliotropium			0,5			0,9	0,6		0,5			
Regional	**11,8**	**17,1**	**19,1**	**15,4**	**10,6**	**23,3**	**17,8**	**20,9**	**13,1**	**16,2**	**17,4**	**15,8**
Arisaema		1,5	1,1	2,4	0,7	2,7	2,2	1,2		3,2		
Areca					0,7	0,5						
Arenga wightii							0,6		0,5	0,6		
Borassus									0,5			
Calamus	1,5	4,0	2,2	1,6	1,4	2,3	3,9	0,6	1,1	0,6		
Caryota				0,8					0,5			
Cocos												5,3
Phoenix		0,5	1,1				1,1	0,6				
Pinanga sp.						0,5		0,6		0,6		
Arecaceae		1,0	1,1	1,6		1,4	0,6	1,2	2,2	0,6		
Acacia polyade							0,6					
Aegle						0,5						
Anacardiaceae		0,5			0,7			0,6				
Artocarpus		1,0										
Bombax malabaricum				0,8								
*Canthium**			0,5									
Asteraceae	0,7	0,5										
Croton							0,6					
Desmodium						0,5				0,6		
Diospyros malabaricum		0,5										
Dodonaea viscosa						0,5						
Elaeocarpus			1,6		0,7	2,7		1,2	0,5	1,3		

Emblica officinalis							0,6					
Euphorbiaceae		0,5						0,6	1,1			
Ficus	0,7			0,8	0,7			0,6		1,3		
Flacourtia indica							0,6					
Garcinia										0,6		
Hemigraphis sp.										0,6		
Holoptelea						0,5						
Hygrophila type							0,6					
Justicia			0,5			0,5	0,6	0,6	0,5			
Lannea			0,5									5,3
Malvaceae											4,3	
Melastomataceae	0,7		1,6		1,4	1,4	0,6	0,6	0,5		2,2	
Mimosa sp.	0,7										2,2	
Mimusops		0,5	1,1					0,6	1,6			
Monocotyledons	1,5	0,5		0,8		0,9	0,6	0,6	0,5			
Myrtaceae				0,8	0,7							
Olea dioica type	0,7	0,5				0,9		2,3				
Pandanus	0,7	1,0	1,1	0,8	1,4	0,5	1,1	1,7		1,3	2,2	
Periporate		1,5	1,1	2,4		0,9	2,2	1,7	1,1			
Phyllanthus type	1,5	0,5	0,5	0,8		2,7		1,2		0,6	2,2	
Randia								0,6		0,6		
Sapotaceae	0,7				0,7			0,6				
Schleichera										0,6		
Syzygium	0,7	0,5	1,6	1,6	0,7	2,3	0,6	1,2	1,1	1,9	2,2	
Terminalia	0,7	2,0	0,5				1,1	1,2	1,1		2,2	5,3
Trema						0,5		0,6				
Urticaceae	0,7		2,7		0,7	0,9						
Ventilago										0,6		
Ziziphus								0,6				
Poaceae	2,9	11,1	9,3	7,3		7,3	5,6	5,8	3,3	12,3	4,3	
Cyperaceae	2,9	2,0	1,1	4,1	0,7	2,3	1,1	3,5		2,6	2,2	5,3
Upland	**0,7**	**0,5**	**1,1**	**0,8**	**1,4**	**0,9**	**1,7**				**4,3**	
Strobilanthes			1,1		0,7		0,6				4,3	
Artemisia	0,7			0,8		0,9	1,1					
Ephedra		0,5										
Pteridophyta	**8,1**	**9,0**	**6,0**	**1,6**	**3,5**	**5,9**	**6,1**	**8,1**	**8,7**	**3,2**	**4,3**	
Monolete psilate	2,9	4,0	1,6	0,8	2,8	2,3	2,2	2,9	3,3	1,3	2,2	
Monolete ornamented	2,2	1,0	2,2	0,8		0,5	1,1	1,2	1,6			
Trilete psilate	1,5	1,0	1,1			1,8	2,2	2,9	2,2	1,3	2,2	
Trilete ornamented	1,5	3,0	0,5		0,7	1,4	0,6	1,2	1,1	0,6		
Ceratopteris			0,5						0,5			
Varia	2,9	9,0	6,0	6,5	2,1	4,1	7,2	5,8	6,0	5,8	13,0	15,8
Unidentifiable	10,3	5,5	8,2	8,1	7,8	9,6	7,2	4,1	4,9	7,1	8,7	15,8
Total counted	*136*	*199*	*183*	*123*	*141*	*219*	*180*	*172*	*183*	*154*	*46*	*19*
Marine elements	**11,7**	**20,7**	**14,1**	**6,8**	**9,6**	**15,4**	**5,8**	**20,7**	**9,0**	**8,9**		**5,0**
Leptodinium		0,4	0,5			0,4				0,6		
Operculodinium		0,8										
Spiniferites sp.	10,4	18,7	10,3	6,1	8,3	14,3	5,8	16,1	8,0	7,1		5,0
S. mirabilis			0,9			0,4				0,6		
Incertae sedis	1,3	0,4	2,3		1,3			1,8	0,5	0,6		
Tuberculodinium		0,4		0,8		0,4		0,5	0,5			
Unidentified								2.3				
Fresh water	**3,5**	**1,0**	**0,5**	**1,6**		**2,2**	**3,2**	**0,6**	**1,6**	**4,3**	**6,1**	
Pseudoschizaea	0,7	1,0	0,5	1,6		2,2	2,2	0,6	1,6	4,3	6,1	
Botryococcus	2,8						1,1					

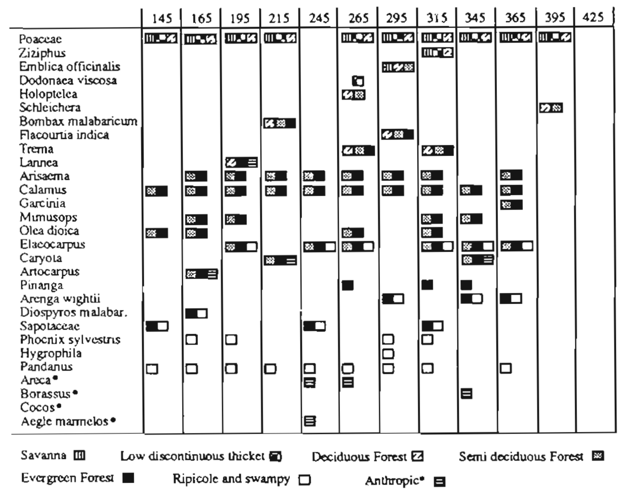
Table 3—Classification of the taxa in the different floristic structures of the region (after Pascal, 1988)

	Savanna	Low discontinuous thicket	Deciduous forests	Semi-evergreen forests	Evergreen forests	Ripicole and swampy	Anthropic
Poaceae	X	(X)	X				
Ziziphus	X						
Emblica officinalis	X		X	X			
Dodonaea viscosa		X					
Holoptelea			X	X			
Schleichera			X	X			
Bombax malabaricum			X	X	X		
Flacourtia indica			X	X	X		
Trema			X	X	X		
Lannea			X	X			X
Arisaema				X	X		
Calamus				X	X		
Garcinia				X	X		
Mimusops				X	X		
Olea dioica				X	X		
Elaeocarpus				X	X	X	
Caryota				X	X		X
Artocarpus				X	X		X
Pinanga					X		
Arenga wightii					X	X	
Diospyros malabaricum					X	X	
Sapotaceae					X	X	
Phoenix sylvestris						X	
Hygrophila						X	
Pandanus						X	
Areca							X
Borassus							X
Cocos							X
Aegle marmelos							X

Table 3. The distribution of the taxa recorded in the samples coupled with their floristic structure (Table 4) clearly shows that the pollen derived from semi-deciduous and evergreen forests and those of ripicole formations are the most frequent. Savanna, deciduous forest and low discontinuous thicket are only occasionally represented it Poaceae, which can be derived from these three formations, is excluded.

Poaceae, Cyperaceae and Pteridophyta have

Table 4



* *May be native, but widely cultivated at present*

been shown separately. They have been observed with relatively constant percentages.

Allochthonous pollen

Among the allochthonous pollen, i.e., the pollen coming from remote areas and which cannot be attributed to any of the previous associations, are those produced by the upland forests, such as *Artemisia, Strobilanthes* and *Ephedra*. These genera are very rarely observed in our sediments where they have most probably been transported by wind.

Mangrove forests constitute a closed environment where allochthonous pollen cannot easily penetrate. This phenomenon has already been observed in other mangrove sediments even where the mountain hinterland was covered by very dense vegetation (Caratini & Tissot, 1987). The poor representation of upland pollen in mangrove sediments is probably due to the high representation of mangrove vegetation which masks that of the hinterland vegetation.

Marine microplankton

Marine palynomorphs, although generally poorly represented in mangrove sediments, are common here and their percentage varies between

PLATE 2 →

(All microphotographs are, × 1000, except n° 12)

1-3. *Schleichera oleosa* (Sapindaceae)
4. *Toddalia asiatica* type (Rutaceae)
5. *Artocarpus* sp. (Moraceae)
6. *Artemisia* sp. (Compositae)
7. *Emblica officinalis* (Euphorbiaceae)
8. *Ventilago* sp. (Rhamnaceae)
9, 10. Unidentified
11. Boraginaceae type
12. *Tuberculodinium vancampoe* (× 400)
13. Incertae sedis
14. *Spiniferites bentori* type

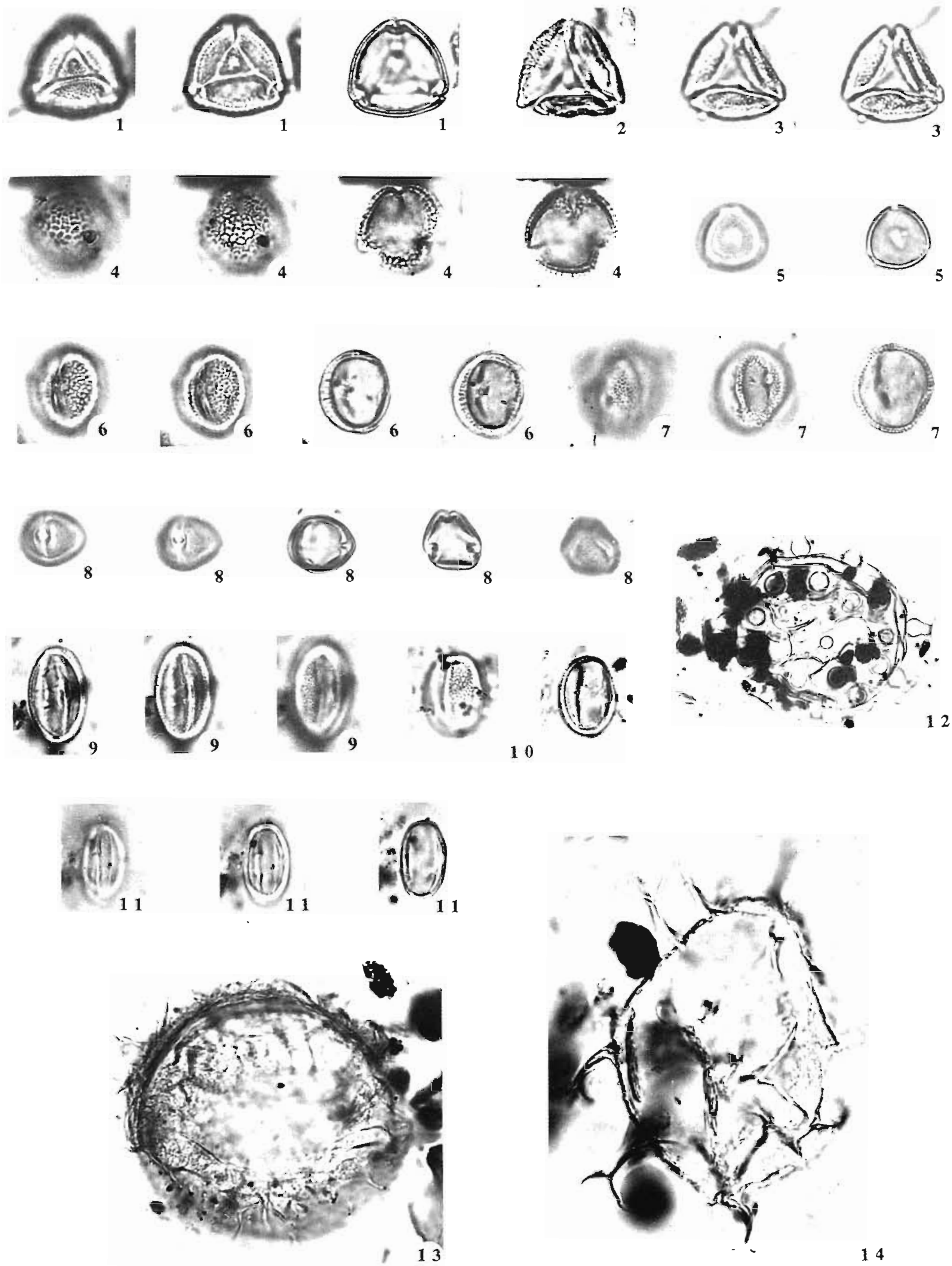
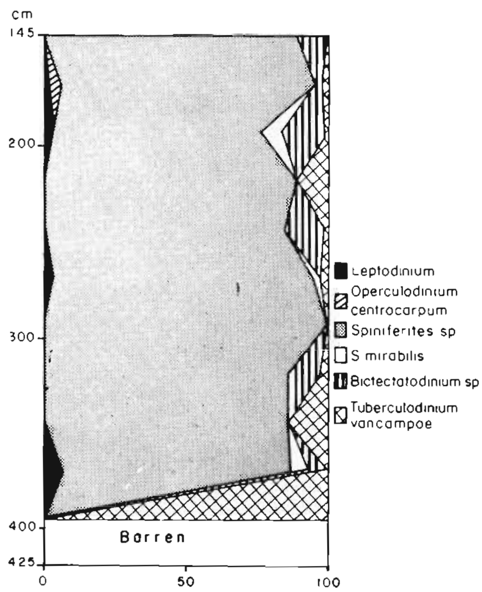


PLATE 2



Text-figure 3—Distribution of marine palynomorphs

10 and 25. They comprise the cysts of dinoflagellates and the tests of foraminifera, the latter representing only a very small part of microplankton Among the cysts of dinoflagellates, the main taxa observed are those generally recorded in deltaic environment, such as *Spiniferites* sp., *S. mirabilis, Operculodinium centrocarpum, Tuberculodinium vancampoe*, and others. Within this group, the predominance of the type *Spiniferites bentori* whose representation always above 75 per cent all along the core (Text-fig. 3) provides evidence of a constant penetration of sea water during the time of deposition Although the other organisms were observed in low percentages, their diversity testifies to an open environment

Marine/continental ratio

The occurrence of dinoflagellates in a mangrove environment provides evidence of deep and constant penetration of sea water during the time of deposition On the west coast of Karnataka, the freshwater supplies, low or totally lacking during the long period of dry season, alternate with more abundant supplies during monsoon rains. Contrary to what generally takes place in a mangrove environment, here, with the monsoon regime, the deficit of freshwater lasts for 8 to 9 months and the sea water, instead of being pushed off-shore by the strong river currents, can penetrate deeply into the estuary and stay longer in the protected areas, thereby leading to a rise in the population of marine micro-organisms, as observed in our analyses.

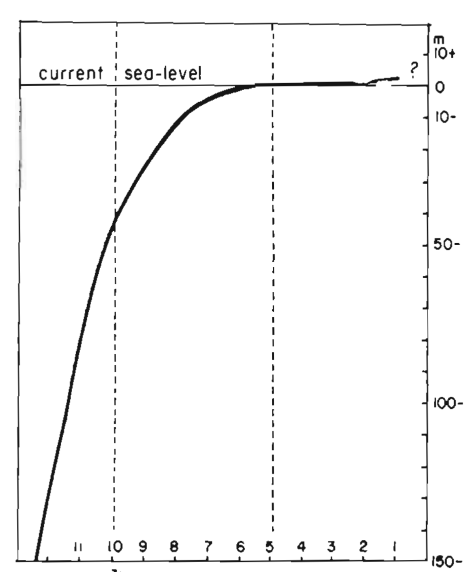
It is clear that a modification in freshwater supplies due to a climatic change liable to affect their regime should have a direct impact on the environment they drain Moreover, the study of evolution of the ratio between continental and marine microfossils can bring valuable data for the reconstruction of the climatic history of the region. In our sediments, the permanence of marine influence testifies to the stability of climatic conditions during the last millenia

Fresh water organisms

Fresh water influence is mainly represented by *Pseudoshizaea* (= *Concentricystes*) and *Botryococcus*. They are few in number and not regularly distributed in the sediments.

DATING THE EVENTS

Synthetic study of the different interpretations of sea level history in the world during the last 10,000 years (Kidson, 1986) brings out the relative stability of the sea-level from 5,000 years BP; according to this author, the fluctuations of the curves in some areas are due to eustatic regional phenomena. It is well known that during Quaternary, the Indian peninsula has remained relatively stable On the west coast of India and particularly on Kanara coast, no major tectonic activity was reported during the Late Quaternary (Dhoundial, 1987). The curve established for the west coast of India by Kale and Rajaguru (1985) from absolute dates of beach rocks, shelf surface sediments, corals and other materials from shore and coastal zone (Text-fig. 4)



Text-figure 4—Sea level curve on the west coast of India, after Kale and Rajaguru (1985) shows that the sea level has become stable at about the current sea level between 6,000 and 5,000 years BP

At present, as no radiocarbon dating has been carried out on our bore-well, the age of the sediments is not known. A synthesis of the various palynological studies carried out in mangrove environments on the Indian coasts (Thanikaimoni, 1987) reveals ages generally younger than 6,000 yrs BP, i.e., after the stabilization of the sea level. However, since the sedimentation rate in deltaic environments is closely related to the local conditions and varies according to the place in the same basin, it is not reliable to establish exact correlations with other palynological studies carried out along the Indian coasts, specially in regions known for their neotectonic activity, such as the Bengal Basin or Saurashtra (Dhoundial, 1987).

From these data we can deduce that in Kandavara the age of the deepest sample cannot be older than 6,000 to 5,000 years BP, this age corresponding to the approximate date when the sea reached the lower level of the deposit. But it could also be considerably younger since the filling up of the channel at the site may have started later, specially if the place selected for the bore-well was not the deepest in the area and therefore does not represent the longer period of time. If a drastic change of sea-level had occurred during the time of the deposition, it would have been necessarily expressed by a discontinuity in the pollen spectra. Thus the regularity of the percentages in all the assemblages, the high and constant representation of the mangrove and the marine influence observed with the same intensity all along the core are proofs of the permanence of the geomorphological, hydrodynamic and ecological conditions in this area.

COMPARISON WITH PRESENT LANDSCAPE

Mangrove forests grow in fragile environments and their disappearance is often provoked by modifications or breaks in the conditions necessary for their development. The sedimentary filling of the lagoons where they are growing and which is a natural morphological evolution of this ecosystem is often the cause of their disappearance.

It is likely that the disappearance of the mangrove in Kandavara at present is partly due to a natural process as suggested earlier, but if the present landscape is considered, it is obvious that because of the time honoured practice of cutting wood and land reclamation in this part of the estuary (Untawale & Wafar, 1986), this degradation has been hastened by man, as it has been already observed in similar coastal areas (Tissot, 1987).

CONCLUSIONS

On observing our results, we can assess that:

—the regularity of our spectra testifying to the perenniality of the environment of the site can confirm the view of a stable sea-level allowing the site to develop in similar conditions during a long time,

—the site has always been located within a well-developed mangrove forest mainly constituted by Rhizophoraceae;

—because of the constant occurrence of marine organisms, it was probably situated in a widely open lagoon where the sea water could penetrate deeply, at least during the long dry season;

—the high representation of marine microfossils attests not only to the penetration of the sea water but also to its permanence in the estuary. Such a situation can occur only in the case of a seasonal lack of fresh-water supplies.

—the regularity of the ratio between continental microfossils (pollen and spores) and marine microfossils (Dinoflagellates) observed all along the core goes in favour of the hypothesis that the region has not been affected by an important climatic change during the last millenia.

—the age of the deeper sediments cannot be older than 6,000 and 5,000 years BP, because it was approximately during this period that the area became accessible to the sea.

ACKNOWLEDGEMENTS

The author wishes to thank Dr J. P Pascal, Director of the French Institute of Pondicherry, and Dr V. M. Meher-Homji for their fruitful comments on the distribution of the regional flora and for their useful suggestions regarding the interpretation of the results.

REFERENCES

Agarwal, D. P. & Guzder, S. J. 1974. Quaternary studies on the western coast of India: Preliminary observations. *Palaeobotanist* **21** : 216-222.

Caratini, C., Blasco, F. & Thanikaimoni, G. 1973. Relation between the pollen spectra and the vegetation of a south Indian mangrove. *Pollen Spores* **15** : 281-292.

Caratini, C. & Tissot, C. 1987 Le sondage Misedor. Etude palynologique. *In: Le sondage Misedor.* Editions Technip, pp. 137-171

Dhoundial, D. P. 1987 Some aspects of Quaternary geology and neotectonics in India. *Indian J. Earth Sci.* **14**(3-4) : 227-234.

Government of India 1987 *Mangroves in India. status report.* Ministry of Environment & Forest, New Delhi. pp. 150.

Gamble. J. S. 1967. *Flora of the Presidency of Madras.* Bot. Surv India, 3 vol.

Hamilton, A. C. 1976. Identification of east African Urticales pollen. *Pollen Spores* **18**(1) : 27-66.

Joshi, R. V., Rajaguru, S. N. & Pappu, R. S. 1983. Quaternary studies in the Karnataka State. *In: Prof. Kelkar Mem.* Vol., pp. 97-106, Indian Soc. Earth Scientists, Pune.

Kale, V. S. & Rajaguru, S. N. 1985. Neogene and Quaternary trangressional and regressional history of the west coast of India: An overview. *Bull. Decc. College Res. Inst.* **44** : 153-165.

Kidson, C. 1986. Sea-level changes in the Holocene. *In:* Orson van de Plassche(Ed.)—*Sea-level research: A manual for the collection and evaluation of data*, pp. 27-64, Amsterdam.

Pascal, J. P. 1988. Wet evergreen forests of the Western Ghats of India. *Inst. fr. Pondichery, trav. sec. sci., tech.* **20bis**. 345 p.

Saldanha, C. J. 1984. *Flora of Karnataka.* Oxford & IBG Publ. Co., New Delhi, vol. 1, pp. 535.

Saldanha, C. J. & Nicolson, D. H. 1976. *Flora of Hassan District, Karnataka, India.* Amering Publ. Co. Pvt.Ltd., New Delhi, pp. 915.

Thanikaimoni, G. 1984. Menispermacees: Palynologie et Systematique. *Inst. fr. Pondichery, Tr. sec. sci. tech.* **18** : 136 p.

Thanikaimoni, G. 1987 Mangrove palynology. *Inst. fr. Pondichery, Tr. Sec. sci. tech.* **24** : 100.

Tissot, C. 1987 Recent evolution of mangrove vegetation in the Cauvery delta: A palynological study. *J. mar. biol. Assoc. India.* **29**(1 & 2) : 16-22.

Untawale, A. G. & Wafar, S. 1986. Coastal Karnataka and its eco-development. *In:* Saldanha, C. J. (Ed.)—*Karnataka, state of Environment Report, 1984-1985*, Bangalore, 17 p.

Vishnu-Mittre & Guzder, S. 1975. Stratigraphy and palynology of the Mangrove swamps of Bombay. *Palaeobotanist* **22**(2) : 111-117