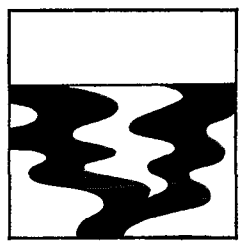

Holocene Foraminifera assemblages in the Camau peninsula (Southern Vietnam)

Bui Thi Luan (1), Jean-Pierre Debenay (2),
Jean Pagès (3)

Abstract

The Camau peninsula lies on the southern edge of the Mekong delta. Thick Holocene sediments, with a majority of clays, contain a rich fauna of Foraminifera. The sediments of this region have been studied on 2 to 6 m deep cores from 24 sites. About 70 species of benthic Foraminifera were found. These species were ordered into 5 groups corresponding to 5 definite paleo-environments, ranging from coastal marine waters to brackish swamps and salt marshes. The horizontal and vertical distributions of these environments allow us to sketch the middle and late Holocene paleogeographical evolution. The main feature is the transformation of the peninsula induced by the decrease of the relative sea level. This decrease results from the progressive aggradation of the peninsula by alluvial deposits and from the late Holocene regression.

Keywords : Foraminifera — Paleogeography — Holocene — Vietnam.

Résumé

Les associations de foraminifères holocènes dans la presqu'île de Camau (Sud Viêt-nam)

La péninsule de Camau est située au sud du delta du Mekong. Les dépôts holocènes sont épais, généralement très argileux et ils contiennent une riche faune de foraminifères. Les sédiments ont été étudiés dans 24 forages, profonds de 2 à 6 mètres. Environ 70 espèces de foraminifères benthiques ont été inventoriées. Elles ont été regroupées en cinq ensembles correspondant aux cinq paléoenvironnements définis dans la région par les auteurs précédents : rivage, côtier agité, côtier calme saumâtre, marais saumâtre, marais salé. L'étude de la répartition horizontale et de la répartition verticale de ces environnements a permis de reconstituer l'évolution paléogéographique de la péninsule pendant l'Holocène. Le trait principal de cette évolution est l'abaissement du niveau marin relatif.

Les associations prélevées à une profondeur de 4 mètres indiquent une immersion généralisée de la presqu'île. Les sédiments correspondants ont probablement été déposés durant le maximum de la transgression holocène, quand le niveau marin était 3 mètres au-dessus du niveau actuel. Par la suite, l'évolution des associations de foraminifères indique une tendance régressive qui correspond :

(1) à l'agradation progressive de la péninsule due à l'apport des alluvions ;

(2) à la régression de l'Holocène terminal.

Mots clés : Foraminifères — Paléogéographie — Holocène — Viêt-nam.

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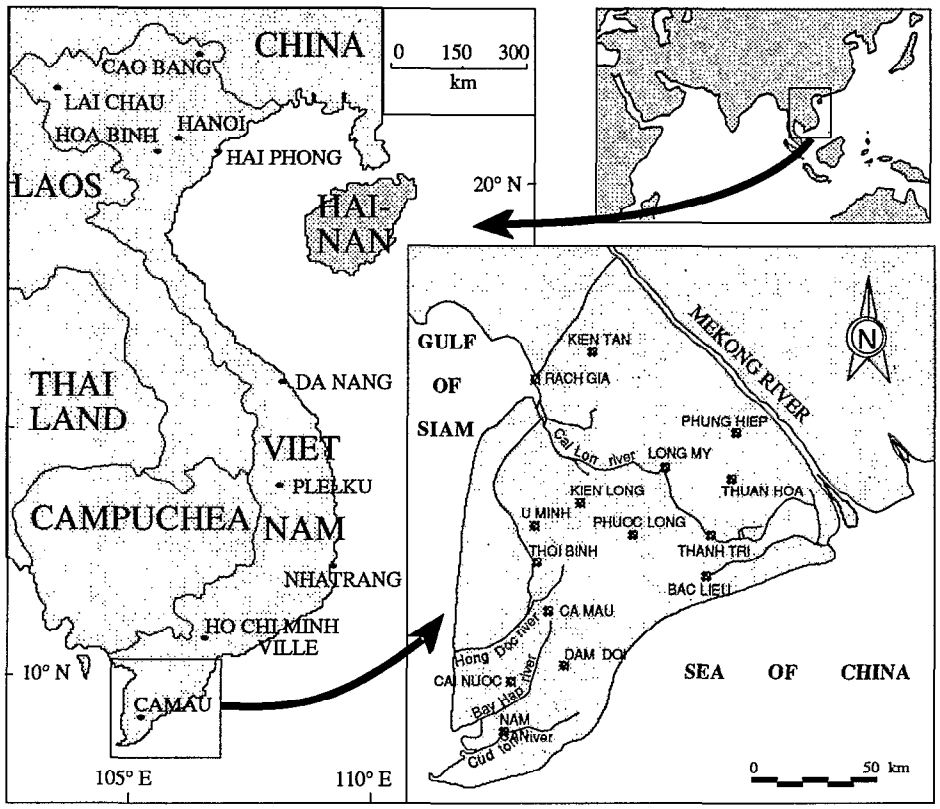

FIG. 1. — Location map.
Carte de localisation.

INTRODUCTION

The Mekong River Delta has long been a subsidence zone, owing to large-scale tectonic processes (TRAN KIM THACH, 1986). During the Quaternary, it has been affected by a series of four transgressions and four regressions, resulting in the deposition of the thickest sedimentary deposits in the southeastern Asian countries (HOANG NGOC KY, 1991 ; PHAM THE HIEN *et al.*, 1991).

Only a few works have been published regarding the Foraminifera of the Holocene deposits of Southern Vietnam (DO VAN LONG and NGUYEN NGOC, 1980). Several new species have been described (MA VAN LAC, 1985; NGUYEN NGOC, 1986). Some previous works gave a general description of Quaternary paleogeography in the Mekong plain (NGUYEN NGOC, 1981 ; DO VAN LONG, 1982).

The area studied is the southern margin of the Mekong Delta, the Camau peninsula. While sharing the overall history of the Mekong Delta, this southernmost tip of Vietnam does show some peculiarities. Our work,which was part of a general sedimentological and pedological study, with a view to an integrated development of the whole region, seeks to sketch its paleogeographical evolution during the middle and late Holocene.

GENERAL BACKGROUND

The Mekong River Delta is located in South Vietnam (fig. 1), at a latitude of about 9°N. It is bordered by the Gulf of Siam in the west and the Sea of China in the south-east. Landward, the Mekong Delta is bordered by the old alluvial terrace on the north and north-east and partly on the west. The Camau peninsula is the southwestern tip of the delta. It is a flattish and low plain (average altitude 1.0-1.5 m), gently sloping toward the west. This plain is crisscrossed by a system of rivers, channels and tidal inlets such

as the Bay Hap River and the Ong Doc River. A fault lies north of Camau, in a WNW/ESE direction.

The climate of the Camau peninsula is sub-tropical and dominated by monsoon. The rains last from May to November. Mean rainfall is around 1,500-1,750 mm, reaching more than 2,000 mm along the Gulf of Siam. Southwestern monsoon winds may be strong. The dry season lasts from December to April, with weaker NE winds. Annual evaporation is about 1,020-1,240 mm. The Camau peninsula lies outside the reach of the Mekong River floods. It can, though, be inundated by rains, owing to sluggish drainage. While the Gulf of Siam tides have a low amplitude, high tidal amplitudes in the Sea of China may lead to periodical inundations.

The mangrove forest is well developed in the southern and southeastern portions with the varied floral assemblage usual in South-East Asia (CHAPMAN, 1976). The mangrove includes *Rhizophora, Bruguiera* and *Avicennia*, with *Phoenix* and *Excoecaria* in the drier parts and *Nypa* palms in the brackish waters with wide salinity variations. Some mixed forests are found. The *Melaleuca* forest is well developed on the peaty, freshwater backswamps (PHUNG TRUNG NGAN, 1987).

MATERIALS AND METHODS

A total of 24 holes was bored throughout the southernmost portion of the peninsula (fig. 2). These holes were bored in :

+ a central-north zone (holes 6 to 11)
+ a coastal-western zone (boreholes 1 to 5) along the Gulf of Siam
+ an eastern zone (boreholes 12 to 16, plus 18 and 19)
+ a southern zone (boreholes 17 and 20 to 24).

Using a prospection hand drill, it was possible to bore hand cores down to 6 m. The different layers recognized along the core were sampled on the spot yelding a total of 300 samples.

In the laboratory, a constant weight of 150-200 g of dry sediment was soaked in 500-1,000 ml of water for at least 24 hours. Gentle manual stirring accelerated disintegration. Indurated samples had to be boiled and stirred. It was sometimes necessary to add some sodium thiosulfate (approximately 50-100 $g.l^{-1}$; NGUYEN NGOC, 1980). After complete disintegration under stirring, we allowed heavier particles to settle for 1 minute, then siphoned off the clay-laden supernatant fluid onto an 80 μm sieve. The procedure was repeated until all the clay had been removed.

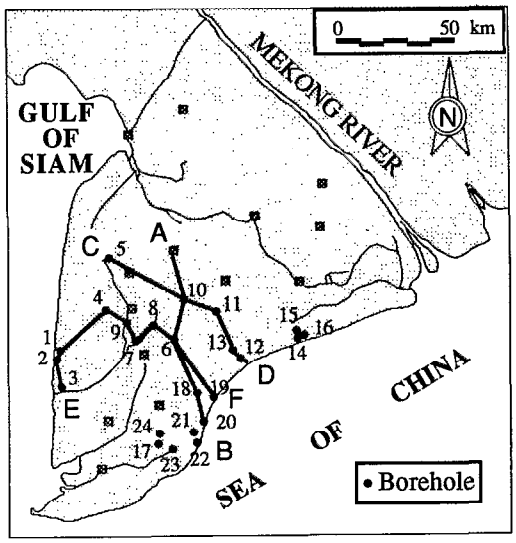

FIG. 2. — Location of the cores and of the cross sections A-B, C-D and E-F.
Localisation des forages et des transects A-B, C-D et E-F.

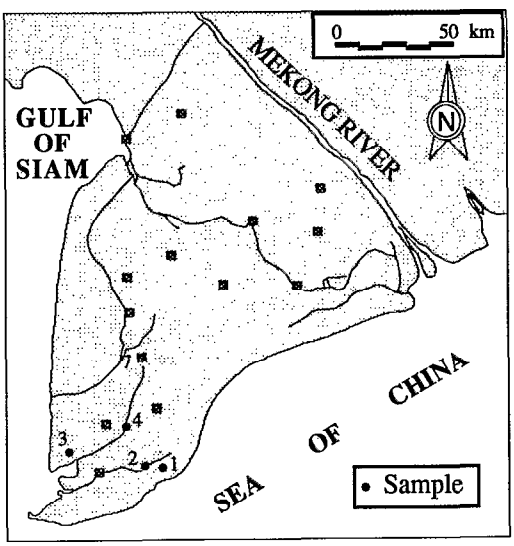

FIG. 3. — Location of the Recent sediments samples.
Localisation des échantillons de sédiments actuels.

Foraminifera were observed under a microscope at a magnification of × 50. Identification was based on ASANO's atlas (1951) and on other publications (e.g. ANDERSEN, 1951; BRADY, 1984; DEBENAY, 1990; HUANG, 1964; MA VAN LAC, 1985; NGUYEN NGOC, 1981, 1986). Specimens were counted in each sample and percentages were calculated. The species were

TABLE I

List of species found in the Recent sediments
Liste des espèces trouvées dans les sédiments actuels

Échantillons	Sed. 1	Sed. 2	Sed. 3	Sed. 4
Ammonia Parkinsoniana			2	
Ammonia tepida	10	12	62	18
Ammotium salsum		6	2	
Ammotium sp.				5
Arenoparella mexicana		6	2	11
Bigenerina sp.		3		
Elphidium		28	22	
Gaudryina exilis		3		5
Haplophragmoides wilberti	40			
Haplophragmoides sp.	10			
Jadammina macressens	10			5
Miliammina earlandi	30	3	2	
Miliammina sp.				5
Paratrochammina sp.		3		18
Quinqueloculina seminulum			trace	
Reophax sp.				5
Tiphotrocha comprimata				5
Trochammina inflata		36	6	6
Trochammina sp.				
Miscellaneous				17
Indice de confinement :	Ic > 0,9	Ic ≈ 0,8	Ic ≈ 0,6	Ic ≈ 0,9

ordered into 5 groups corresponding to 5 definite paleoenvironments, according to Anonymous (1974), DO VAN LONG and NGUYEN NGOC (1980) et NGUYEN NGOC (1981).

Four samples of surface sediment were collected in the rivers located in the southern most part of the peninsula (Bay Hap River and Cud Lon River) or in the channels (fig. 3). A volume of 50 cm^3 of sediment was washed on a 50 μm seive and the microfauna was separated by flotation on carbon tetrachloride.

A tentative sketch of paleogeographical evolution was established, considering the sediments collected at the same depth in the different cores. This method does not allow the drawing of paleogeographical maps because it is impossible to be sure that the sediments are isochronous. However, it is possible to draw schematic maps showing the general trend of paleogeographical evolution.

RESULTS

Taxonomical composition

SURFACE SEDIMENTS

Only about 20 species were recognized in the four samples of surface sediment (table I). Most of these species can be found in the paralic environnements all over the world, and especially in Africa. The confinement index based on taxonomical composition (DEBENAY, 1990) is Ic = 0,6 in sample 3, the less confined and more than 0,8 in the other samples.

CORE SEDIMENTS

Sixty nine species of benthic Foraminifera were identified (table II). The most representative families are : Rotaliidae, Miliolidae, Elphidiidae, Bolivinitidae, Nonionidae, Uvigerinidae, Textulariidae, Buliminidae, Lagenidae, Cibicididae. Some planktonic genera were found (*Globorotalia, Globigerina, Globigerinoides, Orbulina*). Their occurrence is irregular in relatively deep horizons across the northern edge of the study area (Boreholes 4, 5, 11, 12, 13 and 18). These few planktonic tests are probably allochthonous, and bear no meaning for determining paleoenvironments.

Paleoenvironmental features

In some boreholes, the upper horizon is devoid of foraminiferal remains either these locations have been under continental conditions or the tests have been destroyed, as generally happens in organic-rich sediments of mangrove swamps. These boreholes are mostly located around Camau town (the centre of Camau peninsula). In the other boreholes, five taxonomic assemblages can be distinguished, corres-

TABLE II

Species list and composition of the five assemblages: a) "Shore-line"; b) "Coastal disturbed"; c) "Coastal calm brackish"; d) "Brackish swamps"; e) "Salt marsh"

Liste des espèces et composition des assemblages : a) « Ligne de rivage »; b) « Zone côtière agitée »; c) « Zone côtière calme, saumâtre »; d) « Marais saumâtres »; e) « Marais salés »

SPECIES NAME	Assemb. a	Assemb. b	Assemb. c	Assemb. d
Ammonia beccarii (Linné, 1758)				
Ammonia sp.				
Ammotium salsum (Cushman and Brönnimann, 1948)			**	
Anomalina sp.	**			
Arenoparrella mexicana (Kornfeld, 1931)				
Arenoparrella vietnamica Ma van Lac, 1985				
Arenoparrella sp.				**
Asiarotalia holocenica Nguyen Ngoc, 1986				
Asiarotalia mekongensis Nguyen Ngoc, 1986				
Asterorotalia multispinosa (Nakamura, 1937)			**	
Asterorotalia pulchella (d'Orbigny, 1839)			**	
Asterorotalia sp.				
Biloculina sp.				
Bolivina sp.		**		
Brizalina variabilis (Williamson, 1858)				
Bulimina aculeata d'Orbigny, 1826				
Bulimina cf. *aculeata* d'Orbigny, 1826				
Bulimina sp.			**	
Cibicides sp.				
Comuspira sp.			**	
Cribrolinoides curta (Cushman, 1917)				
Cribrononion sp.				
Cyclammina sp.				
Discorbis sp.				
Elphidiella sp.				
Elphidium advenum (Cushman 1922)				
Elphidium craticulatum (Fichtel and Moll, 1803)				
Elphidium sp.				
Eponides sp.				
Fontbotia wuellerstorfi (Schwager, 1866)				
Gaudryina exilis Cushman and Brönnimann, 1948			**	
Glandulina laevigata (d'Orbigny, 1826)				
Globigerina sp.				
Globigerinoides sp.			**	
Globorotalia sp.				
Haplophragmoides sp.				
Lagena sp.				
Miliammina sp.				
Miliolinella sp.				
Nonion sp.				
Orbulina sp.				
Parrellina hispidula (Cushman, 1936)				
Pseudoeponides japonicus Uchio, 1950				
Pseudoeponides sp.				
Pseudorotalia schroeberiana (Carpenter, Parker and Jones, 1862)				
Pseudorotalia sp.				
Pygmaeoseistron hispidula (Cushman, 1913)				
Quinqueloculina boueana d'Orbigny 1846				
Quinqueloculina ferussacii d'Orbigny, 1826				
Quinqueloculina lamarckiana d'Orbigny, 1839				
Quinqueloculina philippinensis (Cushman, 1921)				
Quinqueloculina poeyana d'Orbigny, 1839				
Quinqueloculina polygona d'Orbigny, 1839				
Quinqueloculina seminula (Linné, 1758)				
Quinqueloculina tropicalis Cushman, 1924				
Quinqueloculina vulgaris d'Orbigny, 1826				
Quinqueloculina sp.				
Rotalia japonica Hada, 1931				
Rotalia cf. *japonica* Hada, 1931				
Rotalia sp.				
Rotalidium annectens (Parker et Jones.1865)				
Spiroloculina eximia (Cushman, 1922)				
Spiroloculina lucida (Cushman and Todd, 1944)				
Spiroloculina milletti (Wiesner, 1912)				
Spiroloculina sp.				
Textularia sp.			**	
Triloculina sp.				
Triloculina tricarinata d'Orbigny, 1826	**			
Trikoculina trigonula (Lamarck, 1804)	**			
Trochammina inflata (Montagu, 1808)				
Trochammina sp.				
Uvigerina sp.			**	
Virgulina ? sp.			**	

Absent | Very rare (**) | Rare | Frequent | Very frequent

ponding to five main types of aquatic environments (Anonymous, 1974; Do VAN LONG and NGUYEN NGOC, 1980; NGUYEN NGOC, 1981):

— *Group a: "Shore-line"*

This group is found only in the uppermost horizons of boreholes 20-24 (Southern zone). Numerous genera are present with a predominance of : *Asterorotalia, Quinqueloculina, Ammonia, Pseudorotalia* and *Elphidium* (Table 1). Most of the tests are well preserved; tubercular tests of *Asterorotalia* or papillate tests of *Ammonia* are only slightly broken. The calcite component has mostly remained white.

— *Group b: "Coastal disturbed"*

This group represents a coastal shallow environment with varying salinity (due to occasional continental influences) and some wave action. The main species are : *Elphidium advenum, Parrellina hispidula, Triloculina tricarinata, Triloculina trigonula* (Table I). The tests are often light-yellow to brown-yellow, owing to a coloration of calcite by dissolved substances (mainly iron) of continental origin. This group is found in upper and middle horizons of the whole central part of Camau peninsula, but is absent from the eastern coastal zone.

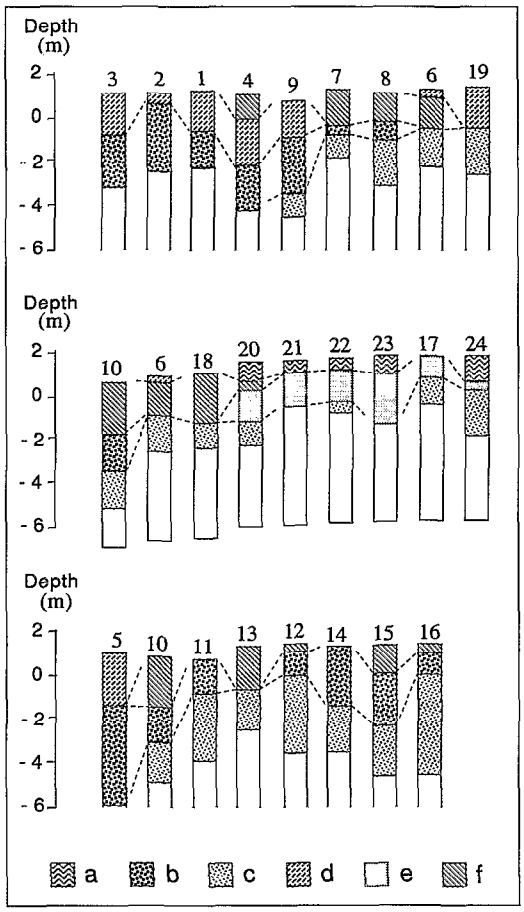

FIG. 4. — Distribution of the different facies in each core : a) "Shore-line"; b) "Coastal disturbed"; c) "Coastal calm brackish"; d) "Brackish swamps"; e) "Salt marsh"; f) sediments without foraminiferal tests.

Répartition des différents faciès dans chaque carotte : a) « Ligne de rivage »; b) « Zone côtière agitée »; c) « Zone côtière calme, saumâtre »; d) « Marais saumâtres »; e) « Marais salés »; f) sédiments ne contenant aucun test de foraminifère.

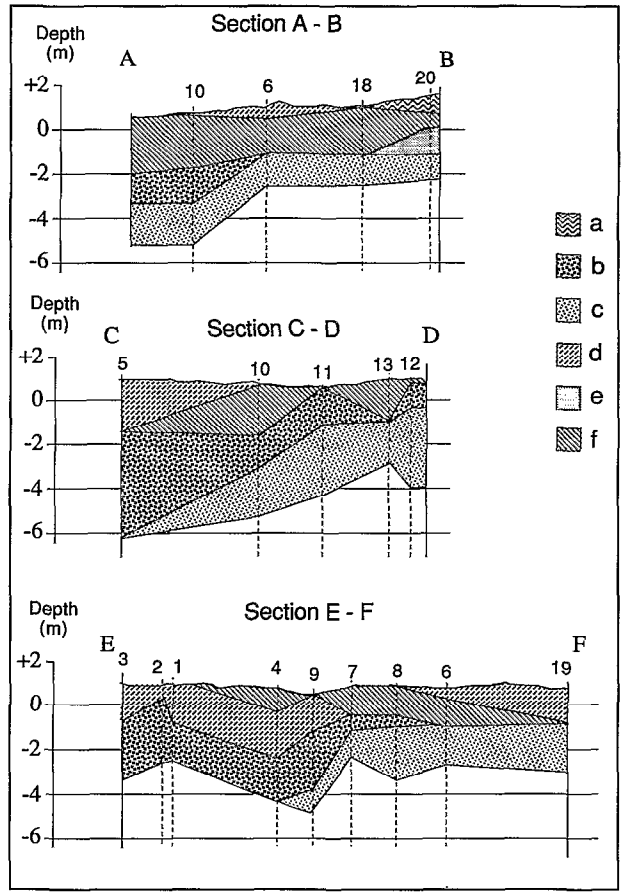

FIG. 5. — Cross sections through Camau peninsula. a) "Shore-line"; b) "Coastal disturbed"; c) "Coastal calm brackish"; d) "Brackish swamps"; e) "Salt marsh"; f) sediments without foraminiferal tests.

Transects à travers la péninsule de Camau : a) « Ligne de rivage »; b) « Zone côtière agitée »; c) « Zone côtière calme, saumâtre »; d) « Marais saumâtres »; e) « Marais salés »; f) sédiments ne contenant aucun test de foraminifère.

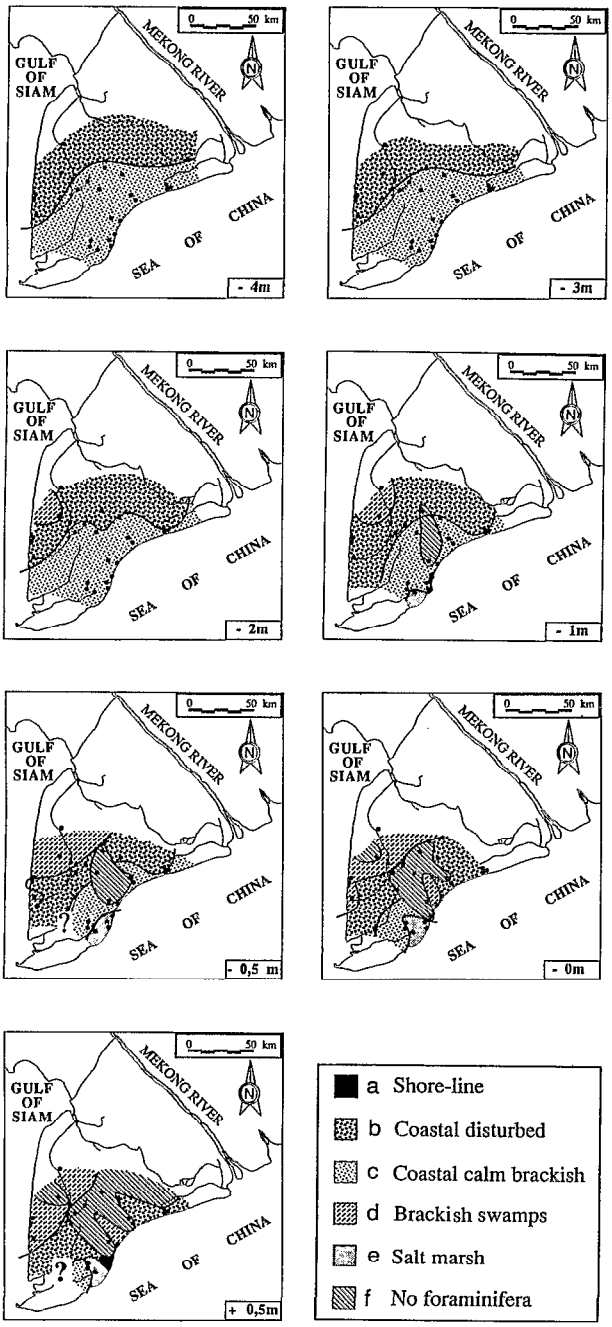

FIG. 6. — Schematic paleoenvironmental maps drawn on the basis of foraminiferal assemblages present in the sediments collected at the same depth in each core.
Cartes schématiques des paléoenvironnements, tracées sur la base des associations de foraminifères présentes dans les sédiments prélevés à la même profondeur dans toutes les carottes.

— *Group c: "Coastal calm brackish"*

This group has few species, with mainly *Ammonia beccarii* and *Quinqueloculina seminulum* (Table I). Tests are small (less than 0,5 mm); their thin walls point to reduced wave action. This group is found in the lower horizons of the whole central part of Camau peninsula.

— *Group d: "Brackish swamps"*

The main species are : *Trochammina* spp., *Haplophragmoides* spp., *Discorbis* spp., *Ammotium salsum* and *Arenoparrella mexicana* (Table I). This group is found in the upper horizons of the western coastal zone, along the Gulf of Siam coast.

— *Groupe e: "Salt marsh"*

This assemblage is poor, with only three genera: *Textularia, Rotalia* and *Quinqueloculina* (Table I). The tests are mostly badly preserved. This group is found in upper and middle horizons of the southern zone.

The vertical distribution of these five foraminiferal assemblages has been described in each borehole (fig. 4) and three schematic cross sections have been drawn through the peninsula (fig. 5).

Tentative sketch of paleogeographical evolution

The evolution of the environments has been deduced from the foraminiferal assemblages. The lowest level studied (—4 m) shows a widespread marine influence with calm coastal brackish waters over the southeastern part of the peninsula and coastal disturbed shallow environment in the north west area (fig. 6a). Brackish swamps first appear in the north west and extend eastward. Continental environments or mangrove swamps progressively spread in the central area, around Camau. Finally, marine influence remains only in the easternmost area where the shoreline assemblage can be found (fig. 6). The sediment facies then diversified, according to the varied deltaic environments.

DISCUSSION

The paleogeographical evolution of the region is particularly well shown on the flattish and low plain of Camau peninsula (average altitude 0.5 m-1.5 m). The lowest stage observed in the cores (—4 m) indicates a large extension of the sea over the peninsula.

The corresponding sediments might have been deposited during the Holocene transgression, when sea level was 3 m above the present one (HOANG NGOC KY, 1991). The following decrease of marine influence results from the combined effects of the sediment accumulation and of the regression, beginning about 3,000 years BP (fig. 7). The uppermost coastal level (+ 0.5 m, core 17) was probably deposited during the beginning of the upper Holocene. The top of the formations might have been eroded during the upper Holocene regression (NGUYEN DUC TAM, 1982). Thus, the studied sediments appear to belong to Middle Holocene (mQ^2_{IV}) and late Holocene (mQ^3_{IV}) deposit layers (HO CHIN and VO DINH NGO, 1989).

The foraminiferal assemblages previously mentioned in the literature to be characteristic of the different environments were used for this paleogeographical reconstruction. However, the study of four samples of Recent sediments shows that some species mentioned in the literature as "coastal calm brackish" can be found far inside the rivers and channels. Thus, it seems that extensive studies of Recent Foraminifera will be necessary in the Camau Peninsula to improve the knowledge on the Recent environnements, essential for valuable paleoenvironmental reconstructions.

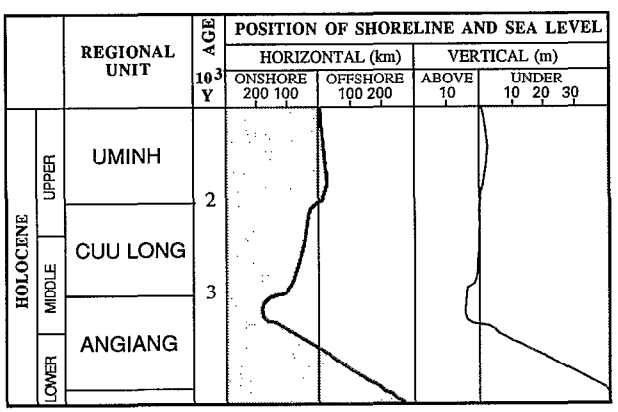

FIG. 7. — Variations of the sea level in Vietnam and adjacent countries during Holocene (after HOANG NGOC KY, 1991). *Variations du niveau marin au Viêt-nam et dans les régions voisines au cours de l'Holocène (d'après HOANG NGOC KY, 1991).*

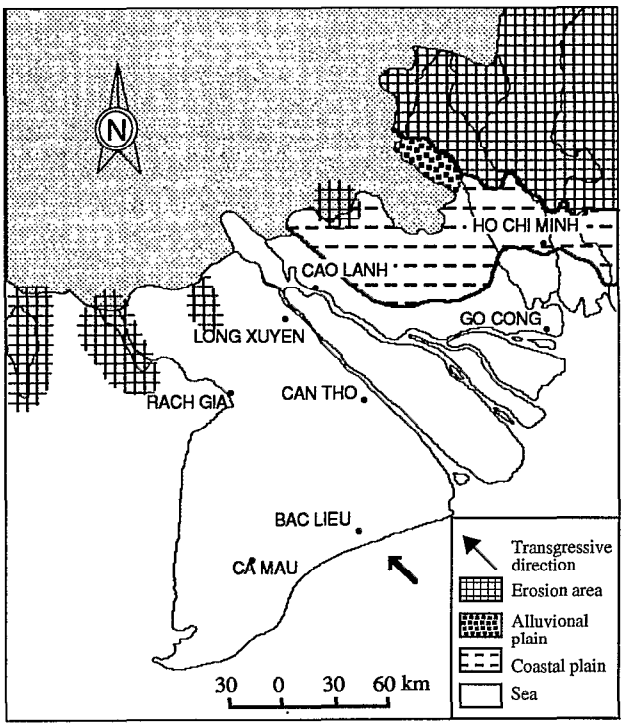

FIG. 8. — Paleogeographic map of the Nam Bo plain during the Holocene transgression (after PHAM THE HIEN *et al.*, 1991). *Cartes paléogéographiques de la plaine de Nam Bo au cours de la transgression holocène (d'après PHAM THE HIEN* et al., *1991).*

CONCLUSION

These results agree with general stratigraphic and paleogeographic documents about Vietnam and adjacent countries (HOANG NGOC KY, 1991). They allow a description of the evolution of Camau peninsula after the maximum of the Holocene transgression and thus provide a complement to the paleogeographic reconstruction of Nam Bo Plain (PHAM THE HIEN *et al.*, 1991), that ends with the Middle Holocene ($mQ^{1\text{-}2}_{IV}$) (fig. 8).

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