SEDIMENTOLOGY AND STRATIGRAPHY OF THE HOLOCENE FORMATIONS OF THE FRENCH GUIANA COASTAL PLAIN

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ABSTRACT

The Holocene coastal plain of French Guiana is a chenier plain. The shoreline is composed of extensive shore-face-attached mudflats and characterized by waterfront mangroves and by sub-coastal swamps and marshes. The cheniers, recording former coastlines, form a series of elongated narrow sandy ridges across the inner portions of the coastal plain.

The analysis of the present-day morphodynamic conditions brings to light the significance of Holocene evolution. Its major stages are presently well-known particularly thanks to the sedimentological research and radiocarbon dating that have been carried out in Suriname. In French Guiana there are only very scarce absolute datings.

The Holocene sediments belong to the Demerara Series. The deposits are composed of the Mara Phase (Early to Middle Holocene), the Moleson Phase (Late Holocene) and the Comowine Phase (Recent to Present). These phases, composed of fine grained marine and fluvio-marine deposits, are separated each other by the chenier sandy ridges.

RÉSUMÉ

La plaine côtière holocène de la Guyane française, ouverte vers l'Atlantique équatorial, est une vaste plaine à cheniers. La ligne du rivage est caracterisée par la présence de grands bancs de boue qui migrent vers l'Ouest sous l'action des courants et des vagues. Cette côte, basse et uniforme, est bordée par la mangrove de front de mer derrière laquelle s'ouvrent

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d'immenses espaces amphibies. Les cheniers, témoins d'anciennes lignes de rivage, forment un système de rides sableuses disposées, grosso modo, parallèlement à la côte actuelle. Ils s'étendent par des dizaines de km, interrompus seulement par les estuaires et, beaucoup plus rarement, par des affleurements du socle.

L'analyse de la dynamique côtière actuelle éclaire celle du passé holocène. Les etapes majeures de cette évolution sont connues, grâce notamment aux recherches surinamiennes, appuyées sur des datations absolues. En Guyane française, par contre, ces datations restent très rares.

Les sédiments holocènes appartiennent à la série Demerara composée des différentes phases: la phase Mara (Holocène Inférieur et Moyen), la phase Moleson (Holocène Supérieur) et la phase Comowine (Récent et Actuel). Ces phases de sédimentation fine sont séparées les unes des autres par les cheniers.

RESUMO

A planície lamosa holocênica da Güiana Francesa é baixa e uniforme. A monotonia da paisagem só é quebrada pela presença de cheniers que constituem uma das feições morfológicas fundamentais. Imensos manguezais emolduram a fachada atlântica da planície; grandes espaços palustres seguem aos mangues para o interior das terras.

Os cheniers, testemunhos de antigas linhas da costa, formam sistemas de cristas arenosas espaçadas e retilíneas, cuja base encontra-se próxima ao nível do mar atual e está em contato com um substrato argiloso. Parte integrante do sistema de acreção e de abrasão costeiras, os cheniers acompanham a direção da costa atual por dezenas de quilômetros, só sendo interrompidos pelos estuários ou, muito mais raramente, pelos afloramentos do escudo cristalino quando este aproxima-se do mar.

A análise da dinâmica atual esclarece a evolução holocênica pré-atual. As etapas principais desta última são conhecidas sobretudo graças às pesquisas feitas em Suriname com base em datações absolutas. Na Güiana Francesa este tipo de datação ainda é muito raro.

Os sedimentos holocênicos pertencem à Série Demerara, formada pelas seguintes fases de acumulação: fase Mara (Holoceno Inferior e Médio), fase Moleson (Holoceno Superior) e fase Comowine (Recente e Atual).

Os depósitos marinhos e flúvio-marinhos são predominantemente lamosos e são separados uns dos outros pelos cheniers.

INTRODUCTION

The coastline in French Guiana is low-lying and homogeneous for 320 km from the Oyapock River in the east to the banks of the Maroni in the west (fig. 1). Bordered by the waterfront mangrove it formes a part of the extensive mudflats and sub-coastal swamp-lands of the Guianas' region (fig.2).

The Quaternary littoral formations generally separate the crystalline basement from the ocean all along the Atlantic coast, the only discontinuity being composed of basement rocks just out between Cayenne and Organabo. These lowlands are only a small fraction (3,700 km^2) of the total surface area of French Guiana (90,000 k^2). Their width varies between a maximum of 50 km at Pointe Behague and a minimum of 5 km east of Cayenne. The slopes are very low and these lowlands play in part the role of intercepting fluvial deposits under the coupled effect of the diminished river slopes and a lower speed of flow.

Two important morphological units have been distinguished between the ocean and the shield (CHOBERT, 1957; BOYE, 1959; BRINKMAN & PONS, 1968; TURENNE, 1978) (fig. 3), namely:

- the "Young Coastal Plain" (Holocene) situated roughly between 0 and 5 m and composed of saline marine clays, waterfront mangrove and swampland. The latter are crossed by straight narrow sandy ridges having one or several sandy crests and more or less parallel to the shoreline. These ridges are separated from each other by phases of fine-grained sedimentation and sit upon marine clays, their base being very close to the present-day average sea level.

- the "Old Coastal Plain" (Pleistocene), situated roughly

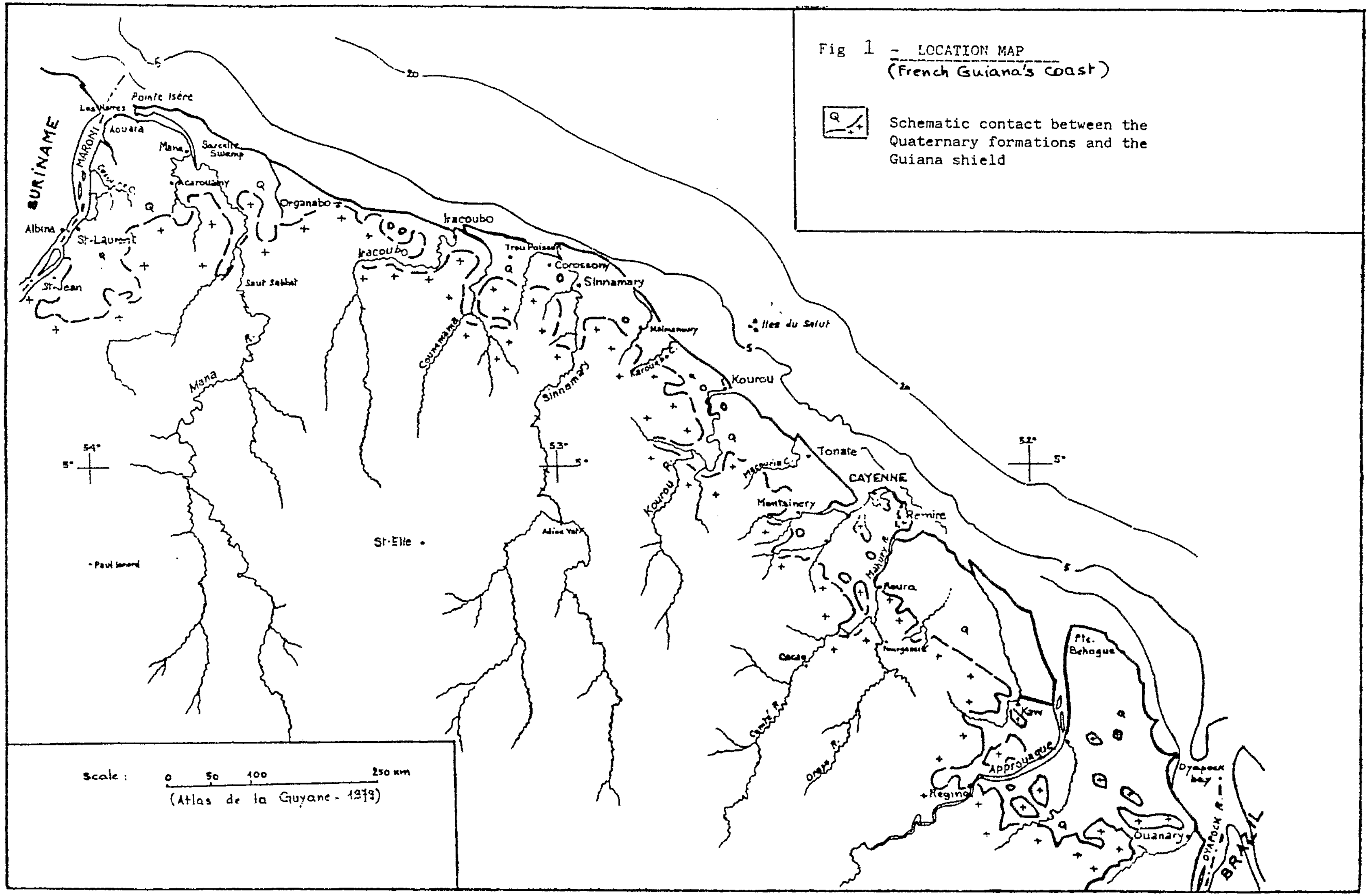


Fig 1 - LOCATION MAP
(French Guiana's coast)

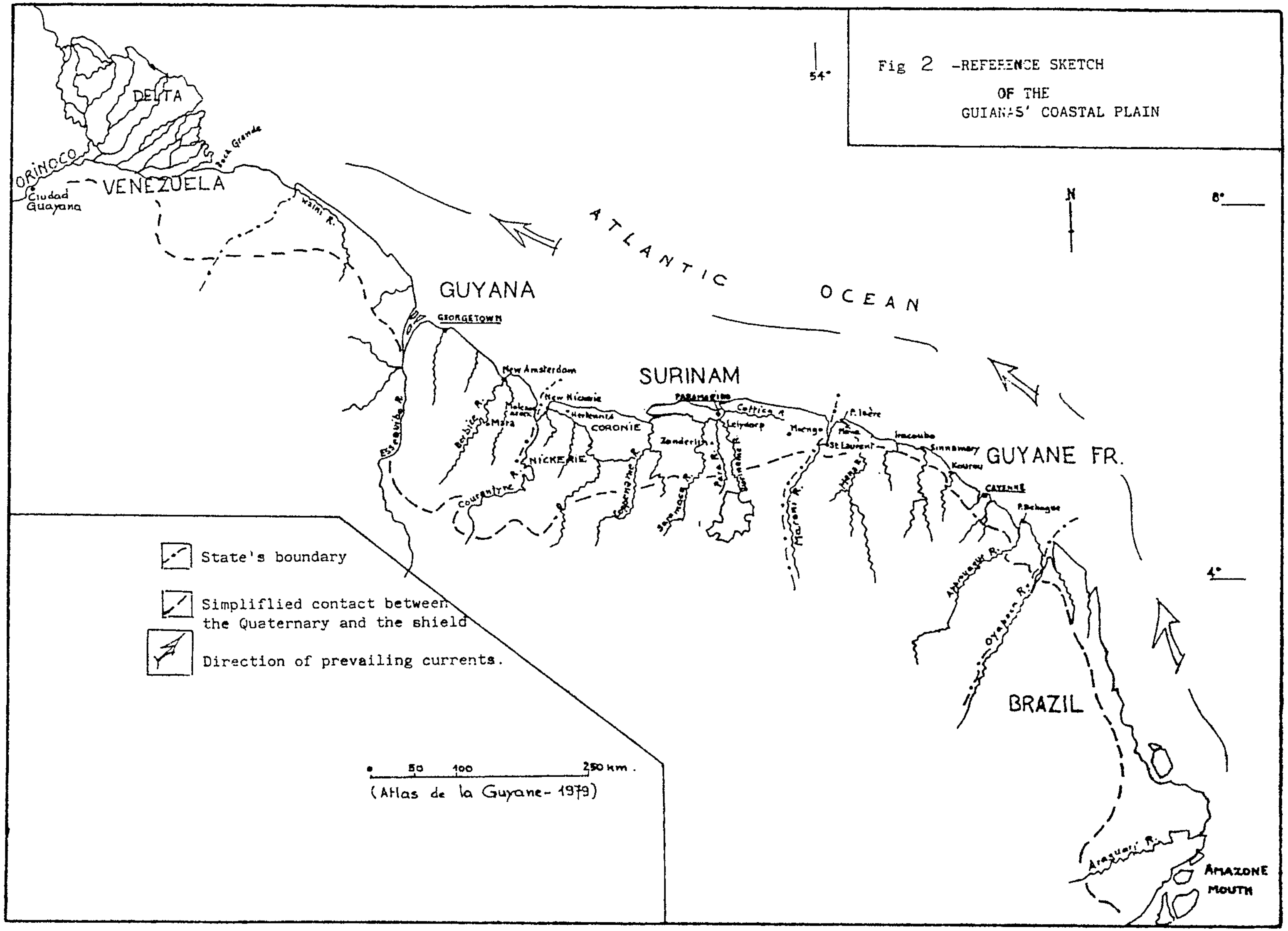
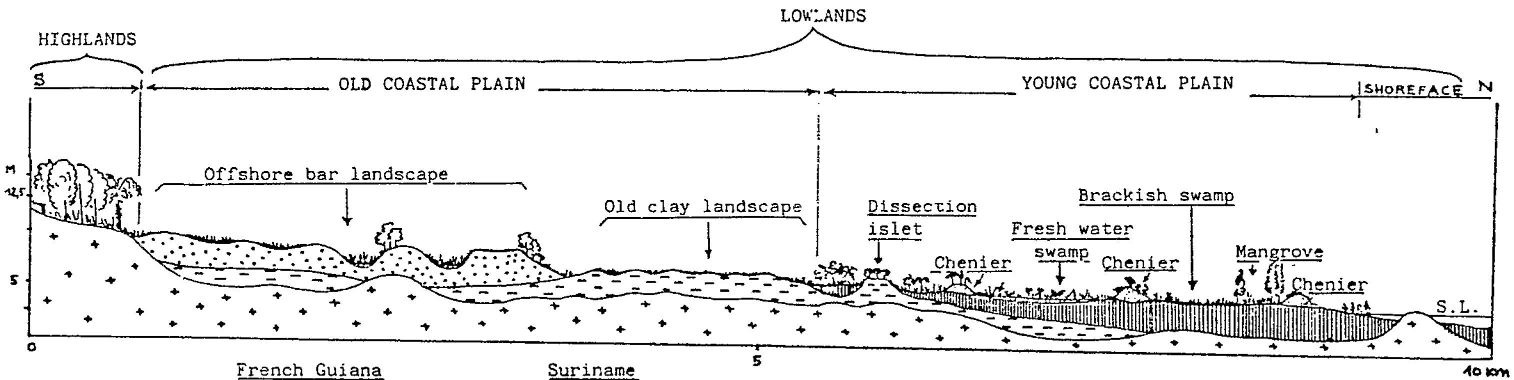


Fig 2 -REFERENCE SKETCH OF THE GUIANAS' COASTAL PLAIN

Fig 3 - Diagrammatical section of the French Guiana's coastal plain.



French Guiana		Suriname
DEMERARA clay (HOLOCENE)	⟶	DEMERARA clay (Holocene) - MARA and CORONIE deposits.
COSWINE sand (PLEISTOCENE)	⟵	LELYDORP sand (Lower Coropina Serie - Pleistocene)
COSWINE clay (PLEISTOCENE)	⟶	PARA clay (Upper Coropina Serie - Pleistocene)
Crystalline basement		

between 5 to 25/30 m, is composed of savannas and some swamps. The plain is also marked by sandy ridges, wider and flatter than those of the Holocene plain. These ridges, with multiple crests, are found in close proximity to each other and are separated by narrow hydromorphic depressions; these ridges represent an old offshore bar landscape which sits on a substratum of developped desalinated marine clays.

This study concerns the Holocene plain. After a brief look at the present-day coastal dynamics, which sheds a light on those of the recent past, an analysis of the sedimentation and stratigraphy of the Holocene formations will be presented allowing somme concluding comparisons with the neighboring regions.

PRESENT-DAY CHANGES OF THE SHORELINE

Unerstanding of the dynamics in the present coastal environment is important for two reasons: the obvious relation to the economic interest of the countries concerned on the one hand; and the lights it sheds on the changes in the recent past long-term evolution, on the other hand.

During the last 20 years, research done on the Guianas' shoreline attained considerable progress. It has become clear that there are extremely active coastal dynamics. The major factors responsible for morphological modifications have been defined. However, the problem has arisen to determine the range of these variations as well as the critical values of activity and a total assessment of sedimentation. Another problem concerns the correlation of results within the region: although many studies have been done in Suriname and French Guiana, but there is little data for the Brazilian territory of Amapá, where such studies are much fragmented.

Given points

The most striking phenomenon influencing the coastal evolution is the longshore supply of the enormous mass of fine-grained sediments discharged by the Amazon River (100 to 200 million tons per year),carried steadily westward by the combined action of waves and currents (Guiana Current and longshore current created by trade-wind driven waves). Clays, silts and fine-grained sands are transported partially in suspension by the current and partially by means of westward migrating shoreface-attached mudbanks. The tidal currents (ebb and flow tides at river mouths) also play an important role in the transportation of sediments. However, the amount of sediment load carried down by the rivers in French Guiana is very small in comparison with that from the Amazon River.

The French Guiana coastline is presently constituted by 6 large mudflats 20 to 40 km long (fig. 4) prograding towards the ocean and forming an oblique angle to the coast. They are separated from each other by deeper parts: the troughs (or inter-bank zones) where erosion is dominant.

These banks migrate westward owing to the abrasion of the flat eastern border and the accretion of the west side (fig. 5). Accumulation is due to the presence of a semi-fluid mud, "slingmud"(1), which causes wave dampening, particularly during the low water slack, when the silt concentration in the seawater is the highest(2). During the next flood, "slingmud" may be transported in a fluidized state but only for short distances and always in the immediate environment. After the tide has receded once more the soft silt is exposed to the air and the consolidation accelerated (AUGUSTINUS, 1978). These events may be repeated several times.

The accumulation diminishes towards the middle and eastern flank of the mudbanks with increasing consolidation of mud and the emergence of sediments. Little by little, they lose their original capacity to subdue wave action, because there is hardly any "slingmud" in this sector. The energy of the waves is greater and they acquire an increased power of erosion. For this reason, in contrast with the smooth surfaces of the west side the eastern flank appears in aerial photos as an irregular and discontinuous surface, marked by a system of gullies. Finally, in the interbank zones where the water is

(1) "Slingmud" is a gelatinous agglomerate of clayed particles in water which develops when concentrations exceed a critical value (between 5,00 and 10,0 mg/l) (AUGUSTINUS, 1982).

(2) "Slingmud" deposition takes place especially during periods of strong winds and during low tide (AUGUSTINUS, 1986 - in press).

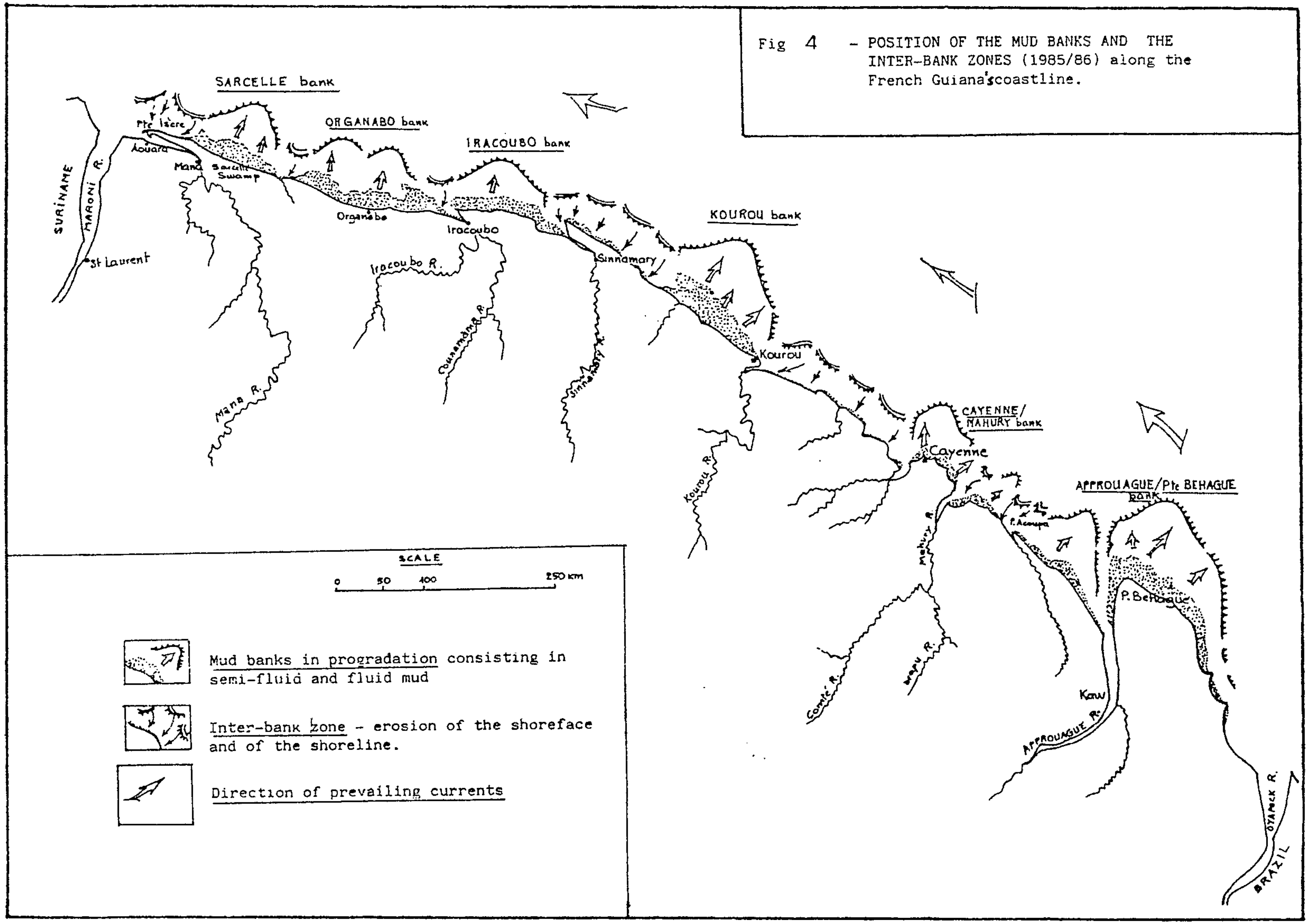
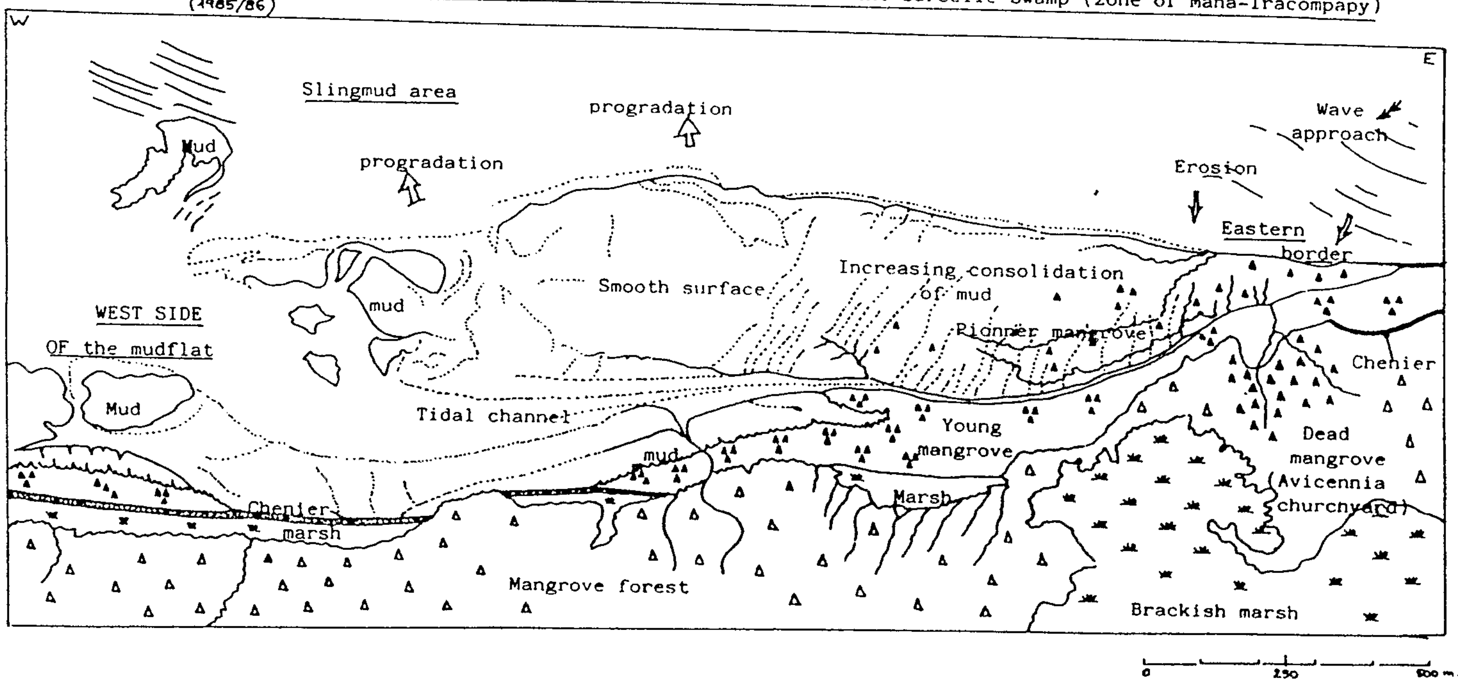


Fig 4 – POSITION OF THE MUD BANKS AND THE INTER-BANK ZONES (1985/86) along the French Guiana's coastline.

Fig 5 -Westward migrating shoreface-attached mudbank - East of the Sarcelle Swamp (zone of Mana-Iracompapy) (1985/86)



deeper and where the substratum is composed of more consolidated mud, erosion takes over and the shoreline recedes. On the whole, these dynamic processes take place in a relatively high energy environment, as noted by RINE and GINSBURG (1985), muds are accumulated by high current and wave activities. In the interbank zones, the waves not only erode the eastern flank of the mudflat but also cause the shoreline to recede. In other words, at the same time, there are as many sectors under accumulation as under recession along the coastline (fig. 6).

Measurements have been taken of the rate of migration of mudbanks and interbank zones. In French Guiana, it averages 900 m annually (between 300 and 1200 m/year - CORDET Report, 1985). In Suriname, it varies between 0,5 and 2,5 km/year (NEDECO, 1968; ALLERSMA, 1971; AUGUSTINUS, 1978, 1980, 1982, 1985). On the Guyana coast, the average rate of propagation is 1,3 km/ year (DELFT, 1962). The differences emphasize the greater angle between the coastline and the direction of the prevailing winds (AUGUSTINUS, 1985). Lastly, the average period of mudbank migration along a given point of shoreline is about 30 years (DELFT, 1962; BOYE, 1962; TURENNE, 1978; AUGUSTINUS, 1978;RINE & GINSBURG, 1985; historical information, etc.).

Then, it is possible to reach the conclusion that:

a) The source of the considerable amount of sediment transported alongshore in suspension or by migrating shore-attached mudflats is related to argillaceous muds supplied by the Amazon River in striking contrast with the small supply from the local rivers.

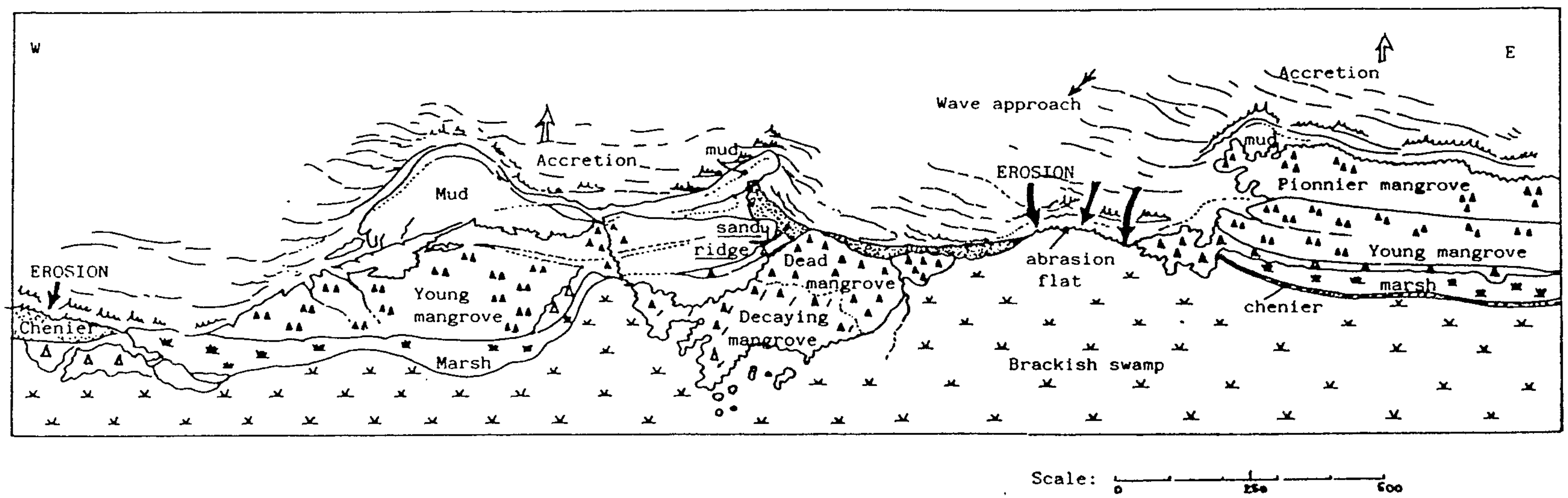
b) The littoral morphogenetic processes take place in a relatively high energy environment.

Controversial points

We will introduce only the three following qustions:

- What is the role played by estuaries in the transport of sediment along the coast?
- What is the origin of the sand composing beaches and present-day sandy ridges?
- What are the repercussions of coastal dynamics on the paralic sub-coastal environment?

Fig 6 - Accretion/erosion coastline east of the Sarcelle Swamp (Mana-Iracompapy zone. 1985)



a) The role played by estuaries

The relative importance of estuaries in the transportation of coastal sediments is still unclear. Some believes that they play an important role; others, only a lesser one. Do local river mouths check the passage of fine-grained sediment?

AUGUSTINUS (1978) observed that the advance and retreat of the 2 m isobath in the western part of the Suriname estuaries does not appear to have a direct connection with the westward shifting mudbanks; the 2-m depth contour seems to change very little over the years. This stability is possibly due to the higher current velocities on the west side of estuaries and caused by river discharge during the ebb tide which prevents the silt from settling down. Research done in Suriname therefore also shows a differential behaviour of river mouths; when they are large, the pressure exerted by the supplied water is too high to introduce major changes. For example, in the case of the Essequibo River, the discharge causes perturbations in the Guiana Current and introduces changes in the transport of sediments (DELFT, 1962).

When river mouths are smaller they are deflected by the coastal sedimentary transport. AUGUSTINUS (1978) has shown that at the Mana River (French Guiana) this development started in the 18th century; in 1785, the river mouth was much further east than at present. After 1865, it began deviating westward and Pointe Isère began to take form. At present, the Mana and the Maroni Rivers share a common mouth, with Pointe Isère became the principal morphological feature of this part of the coast. The same process has resulted in a common river mouth for the Counamama and the Iracoubo Rivers. Several examples of deflection of river mouths can be found in the Young Coastal Plain of Suriname (for instance, the Cottica, Commewijne, Saramacca and Nickerie Rivers).

At which moment and under what conditions are river mouths affected by the westward transport of sediment? Until now, no comprehensive study of the processès has been published. Further information is necessary concerning the hydrological, sedimentary and morphogenetic processes involved particularly when we attempt to assess their critical values of activity. Moreover, observations have been random and local conditions cannot be easily generalized. Although some tendencies can be detected, their extent is still unknown.

b) Origin of sandy beaches and ridges

Sandy material is rather rare in this mud-dominated environment(3). Sand accumulates as cheniers and small beaches. But, from the geomorphological point of view, the sandy material is of a major importance, correlated with a type of coastal landscape defined by AUGUSTINUS (1978). But where do these sands originate?

Researches in Guyana and Suriname are in agreement on two possible sources:

- That of an Amazon-born fine and very fine-grained sands is uphold by KROOK (1976) and by AUGUSTINUS (1978, 1980, 1982, 1985). Accumulated at the mouth of the Amazon, they would be held in suspension and carried along with the pelitic particles by the Guyana Current (MILLIMAN, 1975; EISMA and VAN DER MAREL, 1971). As the result of the erosion of the mudflats, the sands are "washed out" of the muddy sediments. The muds are then carried further and the sands remain as beaches and coastal ridges.

According to KROOK (1976), the heavy mineral association is dominated by epidote and hornblende(20 to 40%). AUGUSTINUS (1978) emphasizes that these sands occurs only at west of the Suriname River.

- Medium and coarse sands are accepted by the majority of authors as river-born. JEANTET (1982) considers it obvious "even if their zone of influence slightly exceeds the estuary or strictly coastal areas". The river-born source is also shared by LEVEQUE (1962), BLANCANEAUX (1981) and FROIDEFOND (1985).

The heavy mineral assemblage is dominated by the staurolite (45/75%). The riverain-supplied sand is not brought far outside the river mouths or estuaries. Some deposits in Suriname seem to be supplied by the Mana and the Maroni Rivers, the latter carrying weathered products of the highly metamorphosed schists of the Armina Formation in Suriname (correlated with the schists of the Orapu Formation in French Guiana).

(3) Only 2% of the total amount of the pelitic sediments (AUGUSTINUS, 1986, in press).

However, the hypothesis concerning the present-day river supply comes up against the problem of the small quantities of suspended load in French Guiana rivers (ORSTOM/Cayenne, 1985-86). The load of colloids is very constant, at about 10 mg/l. Furthermore, the bed load affects only a thin few cm thick layer of the bed. Under these conditions, the solid load is insufficient to nourish and maintain the sandy accumulations along the coast. All the more so as the slopes are extremely small: on the Sinnamary River, for example, the river slopes is 0,90 m for the last 30 km (LOINTIER, 1984).

Subject to new observations and data, river transport of solid matter seems to be very small. This point reveals the complex problem of the present and past causes of the coastal sand accumulations.

c) Repercussions of coastal dynamics on paralic environments

Vast amphibious spaces occupy a very large part of the Younger Coastal Plain and constitute a privileged zone of action of marine and continental processes. They are the object of a recent study in the Sarcelle Swamp zone (LOINTIER & PROST, 1986). Two distinct units have been identified:

- The first, regularly covered by the tide, extends over a very limited area. Occupied by the waterfront mangrove and crossed by tidal channels, it evolves according the rhythm of the ocean (semi-diurnal tides and cycles between the syzygies).

- The second is a marshy area formed by vast depressions of brackish swamps and low vegetation, with little or practically no water circulation. Its evolution depends primarily of rainfall and evaporation.

LOINTIER shows a clear limit between the two units: as a general rule, there is no intrusion of sea water into the brackish water basins. But, when the rainfall exceeds 30 to 50 mm, the overflow of the brackish swamp fills the network of tidal channels which slowly drain the water towards the sea. Thus, at this time - and only under these conditions - a one way connection is established.

The paralic environment under consideration is influenced more greatly by continental rather than marine conditions. Notably, when dry season is more intense or lasts longer than three months, the central basin dries out and become a vast surface of cracked clay, a "dry tanne"(4).

As for the reprecussions of recent coastal dynamics on the evolution of sub-coastal swamps and marshes, it appears that:

- On the one hand, soil development, linked to recent phases of accretion and abrasion of the coast, explains the high salinity of the sub-littoral marsh as there is no saline intrusion into the brackish basins;

- On the other hand, a comparative study done in a neighboring freshwater marsh situated further inland and having developed soils proves the persistance of littoral conditions and the phenomena of the accretion/abrasion cycle.

On the whole, the sub-coastal environment also appears to be very dynamic. If the marine environment appears to be relatively unstable, there is no proof that once the mudbank has migrated westward, the evolution of this environment, as well as the beaches and sandy ridges, will not be modified (LOINTIER, 1986). Actually, it is more than likely. The brackish swamp appears to be rather more stable but this stability is very precarious; only slight modifications are sufficient to change the brackish swamp into a "dry tanne" or a stretch of open water. Finally, the freshwater marsh seems to be the most stable of the three, with developed soils and a dense cover of vegetation.

The enlargement of one unit in the detriment of another has also changed on time, as has been shown by sedimentological and stratigraphic data.

STRATIGRAPHY AND SEDIMENTOLOGY OF THE HOLOCENE FORMATIONS AND SHORELINE CHANGES

Stratigraphy of the Quaternary formations

The stratigraphy of the Guianese coastal plain has

(4) Tanne: expanses with no vegetation or a herbaceous carpet, and situated in the depths of the mangrove.

been object of several studies (BOYE, 1963; MONTAGNE, 1964; BRINKMAN & PONS, 1968; VEEN, 1971; CHOUBERT, 1973; TURENNE, 1978, etc.). The simplified table below is based on research carried out in Suriname and indicates the corresponding series in French Guiana (TURENNE, 1978)

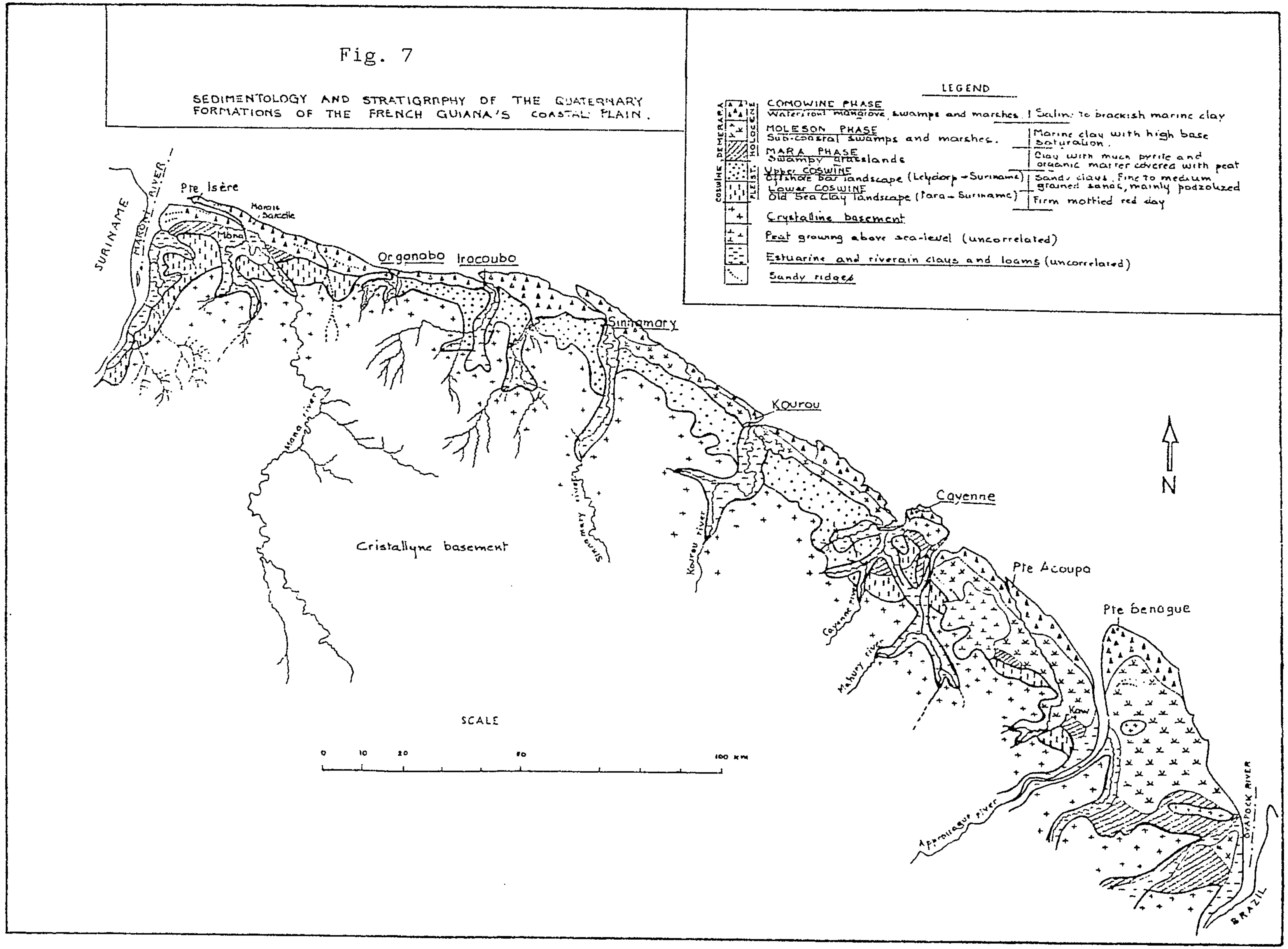
Age	Stratigraphy		Landscape
	Suriname	French Guiana	
Holocene	Demerara series (Coronie)	Demerara series	Young Coastal Plain
Pleistocene	Coropina series (Upper Coropina) (Lower Coropina)	Coswine series Fine-clayey sands Mottled and silty clays	Old Coastal Plain
Pliocene	Coesewijne series (Upper Coesewijne)	Detritic series (S.D.B.)	Precambrian shield edge

- The "Old Coastal Plain" spreads out between the "Young Coastal Plain" in the north and the outcropping shield in the south (Fig. 7). The Pleistocene deposits are not very thick, at most 16/18 m in French Guiana; they are, on the contrary, very wide and cover a larger area in Suriname and Guyana. They form the Coswine series in French Guiana and the Coropina series in Suriname.

Two levels are easily distinguished in French Guiana (see fig.3)
. At about 15 m of altitude they form a system of sandy ridges in close proximity to each other, between 400 to 600 m wide and generally lying in a SE/NW direction; these are old offshore bars formed in deep water off the shoreline (SOURDAT/DELAUNE, 1970).
The sediment has a good sorting in contrast with the Holocene sands.
. At about 5 m of altitude appears the "Old Sea-Clay Landscape", formed by a mottled, desalinated and consolidated clay undergoing pedogenesis. Erosion has cut this landscape: small "islets of dissection" have been formed among the Holocene marshes. This

Fig. 7

SEDIMENTOLOGY AND STRATIGRAPHY OF THE QUATERNARY FORMATIONS OF THE FRENCH GUIANA'S COASTAL PLAIN.



type of morphology is clearly seen in the region of Mana and also in the Cayenne area.

- Holocene deposits (fig. 7), composed mainly of fine-grained marine sediments, occur since 8000 BP up to the present. Stratigraphic data based on studies carried out in Suriname (^{14}C dating, pedological research, pollen analyses, studies on mollusks, etc.) and are presented below in a simplified form.

Serie	Deposit	Phases	Sediments
Demerara	Coronie	Comowine	Saline to brackish marine clay with or without vague or brown mottles.
		Comowine/Moleson	Sandy ridges
		Moleson	Partially desalinated, yellow and brown mottled marine clay
		Moleson/Mara	Sandy ridges
		Mara	Heterogenous clays with organic matter and sand layers.
		Non-correlated	Peat

The Wanica phase (yellow mottled marine clays) - post-Mara and pre-Moleson - decribed in Suriname is not recognized in French Guiana.

The Mara Phase is the oldest, dating to 8,000/6,000 years BP (BOYE, 1959; LEVEQUE, 1962; VAN DER HAMMEN, 1963; ROELEVELD, 1968; BRINKMAN and PONS, 1968; TURENNE, 1978, etc.).

The peat from the Mara phase has been the object of age dating. It is accepted that peat from this period was formed very close to sea-level, frequently in brackish marshes of <u>Rhyzophora</u>. The pollen analyses carried out by ROELEVELD indicated nearly 100% of <u>Rhyzophora</u> pollen. Based on this data, VAN DER HAMMEM accepts a transgressive maximum of +3 m towards 6,000 BP. However, BRINKMAN and PONS believe that this type of deposit precedes the marine maximum of 6,000 BP and that it corresponds to the "Old Mara Phase". In other words, the old Holocene deposits have appeared in several stages and their summits are not found at the same altitude everywhere in relation to present-day sea level. Other studies will be necessary to determine these differences, especially in light of the fact that the littoral sea board has been subjected to subsidence.

The Moleson and Comowine Phases are dated respectively as being 2,600/1,300 BP and 1,000 BP to the present. In Suriname and Guyana, the Wanica/Moleson/Comowine sediments correspond to the Coronie deposits.

BRINKMAN & PONS (1968) estimated that the Wanica phase started about 6,360 BP. This age is based in a layer of a old peat (Mara phase) of a meter in thickness found in the zone of Nickerie; it is situated 1.50 m below average present-day sea level and lies on Pleistocene clays. A 4-m high sandy ridge containing shell fragments sits on top of the peat; it was therefore formed after 6,360 BP, and has been recognized as Wanica phase by the nature and degree of soil developement in the ridge. The end of the Wanica phase is dated at 3,500/3,000 BP.

The beginning of the Moleson Phase in Suriname can be estimated as about 2,800 BP thanks to the ^{14}C analyses of shells in the Hertenrits archeological site situated north of Wageningen (Nickerie). The end of the phase is placed at 1,000 BP (PONS, 1966). Pollen analyses at the Hertenrits site as well as new ^{14}C data permitted the definition of several stages within the Moleson phase and linked them with the advance and retreat os swampland in relation to changes of the shoreline. A few minor differences appear in the ages proposes by BRINKMAN & PONS (1968): beginning of Moleson at 2,500 BP (Old Moleson); intermediate stage at 2,000/1,500 BP (Middle Moleson); end of the phase at 1,300 BP (Young Moleson).

The Comowine Phase is the most recent. Towards 1,055 BP flooding left accumulations of marine clay at the foot of the Hertenrits amerindian mounds, where the *Avicennia* grow. The amerindians were forced to leave the site; they probably moved to the ridges. GEYSKES (1961) found a radiocarbon age of 480 $\pm$ 150 years BP at an amerindian site north of Paramaribo situated in the center of the belt of Comowine sediments.

Geographical maps of the 17th century show Paramaribo as much closer to the sea than at present. Progradation of the coast near the Coronie continued until 1914 (REYNE, 1961). As a matter of fact, the Comowine phase of sedimentation has therefore continued up until present times.

The stratigraphy here presented formed the basis for the identification of the phases of fine sedimentation - and the sandy ridges which separate them - within the three Guianas. In French Guiana, absolute datings are rare and the stratigraphy has been done mainly by analogy with that of Suriname and thanks to pedological studies. Only a few radiocarbon dates exist, taken during the CORDET Project. They show that the coast between Mana and the Maroni River prograded during 3,500 years oceanward while during the same period, it was in regression towards the Sinnamary (CORDET Report, 1985).

Sedimentology of the Holocene formations

a) Fine-grained sediments

The Holocene sediments are composed mostly of marine clays (fig. 7).

The grey clays of the Mara Phase are the most heterogeneous, accumulated in a brackish and/or in a marine environment (TURENNE, 1978) with a transgressive event and sedimentation in the estuaries. They have been accumulated within brackish lagoons and marshes situated behind coastal sandy ridges and in rias. For this reason, these clays contain organic matter and sandy layers. Further inland from the coast (zone of Mana-Iracompapay; Kaw marshes; Pointe Behague)appears a type of loose, acidic spongy and/or fibrous peat, the "pégasse". The soils developed in the Mara sediments are very rich in pyrites (pyrite clay or sulfurous clay) and would give rise to "cat clays" or "acid sulphate clay" after oxidation.

The Mara sediments cover only a small area in French Guiana, especially at the west coast (region of Mana-Iracompapay). Between Organabo and Cayenne, they are scarce and between the Mahury and the Oyapock Rivers, they appear only in small areas. They occur, on the contrary, in large areas in Suriname and especially in Guyana.

The Moleson sediments are composed of soft,brown and yellow-mottled, greyish-blue clays, superficially desalinized. They occur mainly to the east of Cayenne. These sediments correspond partially to the site of brackish marshes and are most frequently located above the highest tide level. BRINKMAN & PONS (1968) observed that in certain cases the Moleson sediments in Suriname occur approximately one meter lower than the present high-tide level. Moreover, no erosion of the surface has been observed in this phase (in contrast with the Mara phase) which indicates that after deposition, the sea level must have remained essentially constant (BRINKMAN & PONS, 1968).

The Comowine Phase, however, is composed of highly saline, blue marine clays, covered by normal high tides. It constitutes the waterfront mangrove landscape and the present-day shoreline which is being subjected to the most striking morphological changes.

b) Peat

Peat has not been found in the Holocene deposits. It should, however, be noted that a large majority of these peat swamps covered mainly the Mara deposits. However, BRINKMAN & PONS point out that besides the "eustatic" peat of the Mara Phase, there exist another kind of peat mounds growing above sea level, known as "ombragenous peat" from their appearence on aerial photos. They correlate these peats with the Wanica/ Moleson phase. At present, they continue to grow.

Because of the great difficulty of access, peat swamps in French Guiana have not been object of systematic studies and dating. However, we hope that radiocarbon dating will be done in future research.

c) Sandy ridges

The perched sandy ridges interspersed within different phases of the fine-grained sedimentation are cheniers ("ritsen" in Suriname and in Guyana). They rest on a substratum of marine clays and their base is very near the present-day sea level.

Cheniers are essentially built up of medium to coarse sand in French Guiana, and by sand and shell fragments in Suriname and Guyana with a small proportion of fine-grained sediments. Sandy ridges have been studied in French Guiana by SOURDAT and MARIUS (1964). According to these authors grain size varies between 0.1 and 1.0 mm although coarser sand (1 to 2 mm) is not uncommon. It is marine, "essentially composed of quartz and rare heavy minerals, containing mica and occasionally shell clastics" (TURENNE, 1978).

These ridges are straight and narrow (width between 70 to a maximum of 200 m) with one or several crests (see fig. 3). They occur mainly east of Cayenne. In the Mana-Aouara-Les Hattes region, they form complex systems curved toward the Maroni's mouth, the same feature occurring at the Suriname bank towards Pointe Galibi.

The cheniers spread out widely in Suriname and Guyana. AUGUSTINUS consecrated a large amount of his research to them from 1978 until 1986. He distinguished two types of cheniers along the Suriname coast; those formed by medium and coarse sands from the Maroni to the Mara River, and cheniers on the west coast, composed of fine grained sand and shell clastics. The fine-grained sands are carried from the Amazon. The author defines a typology of the erosion and accumulation coasts of Suriname; this typology is based largely on chenier development.

The cheniers need further studies in French Guiana, particularly concerning their ages. Until now, we used only relative ages ("old", "recent", "present-day" cheniers), based on their geomorphological position and on their degree of pedogenesis. But such an interpretation is insufficient and imprecise and must be replaced by a more accurate research especially in complex formations of sandy ridges, as often observed in the field.

In general, the cheniers are considered as built up on a relatively stable coast (AUGUSTINUS, 1978), shoreline changes occurring by progradation and retreat as at present. It is certain that they serve as a barrier for the brackish marshes developing behind the sandy ridges. AUGUSTINUS recalls that their development has many consequences for the geomorphology, drainage and the development of soils and vegetation in the coastal zone. He presents a diagram showing a synthesis of these interactions (fig. 8). RINE & GINSBURG (1985) have also emphasized the role of cheniers in the morphodynamic sequences of the French Guianese coast.

The Holocene coastal plain of the Guianas is one of the longuest continuous "open ocean" chenier plain, similar to the one in southwestern Louisiana. It is the result of a continuous and abundant supply of fine-grainde sediments and of the

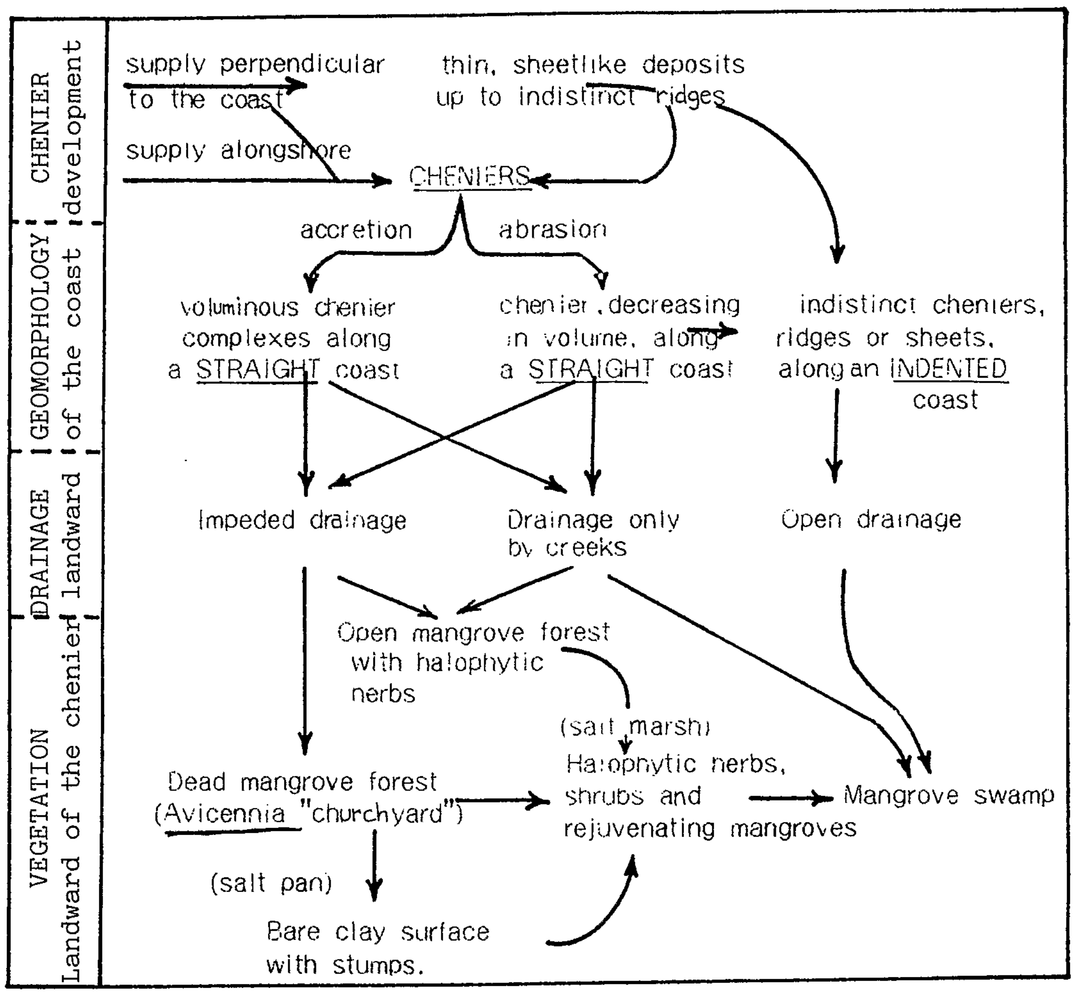


Fig. 8 - Influence of chenier formation on the coastal geomorphology, on the drainage of the adjacent area and the related development of the vegetation (form AUGUSTINUS, 1978).

development of sandy ridges which rest on clay and insert themselves between fine deposits.

Considering the Holocene as a whole, progradation is dominant; in the past 6,000 years the Surinamese coastline advanced seaward for approximately 30 km (RINE & GINSBURG, 1985). However, during this time interval, depositional phases are separated by periods of prevailing erosion or non-deposition (BRINKMAN & PONS, 1968; ROELEVELD & VAN LOON, 1979).

CONCLUSION

We have shown that the Guianas' coast is composed of immense amphibious space situated behind the waterfront mangrove, where cheniers are, apart from a few exceptions, often the only prominent landform. The coastline is generally low-lying and homogeneous. However, the morphogenic processes are not tediously invariable: on the contrary, coastal dynamics are very active and characterized by large accumulations of argillaceous mud supplied from the Amazon and carried westward by currents and waves. Vast mudflats prograde into the ocean and are separated by interbank zones where the coast is undergoing erosion. Mudbanks and interbank zones migrate westward; the intensity and frequency of this migration are variable according to location and time period.

These dynamics have several repercussions in the present coastal environment. However, the paralic space is partially free of the direct influence of the ocean and evolves according to continental conditions. A limited relationship has been observed between these two types of evolution at the Sarcelle Swamp and a comparison was made with neighboring fresh-water marshes.

All the elements show that conditions of "stability" and "instability" can be defined; however, the concept of landscape "stability" is very precarious. In order to provide a better understanding of the evolution of this natural environment, a synthesis of studies on stratigraphy and sedimentology of the Quaternary formations has been made. The aim was to provide the ages of the global changes affecting coastal areas (sedimentation, peat development, etc.). The different phases of sedimentation have been the object of radiocarbon dating establishing a chronology of the main events.

Subject to new data and observations,the behaviour of the Holocene littoral dynamics appears to be similar to those of the present time. It is certain that there was a regular rise in sea-level between 10,000 and 6,000 BP, the maximum transgressive coinciding with the Mara Phase. But - at least up to present day - there is no evidence of any subsequent vertical oscillation in sea level. The chenier characteristics argue in favor of progradation and recession similar to that of the present coastal dynamic. The Guiana's open ocean chenier plain does not seem to have undergone an evolution analogous to that of the Brazilian coastline, where a high number of detailed surveys indicate Holocene sea-levels higher than today.

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