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Shoreline changes in French Guiana

ABSTRACT

Shoreline changes in French Guiana are discussed within three temporal scales: present-day dynamic variations, Holocene shoreline changes and Late Quaternary sea-level variations. Some remarks concerning sea-level data are proposed in conclusion.

RESUMEN

Los cambios en la línea de costa en la Guayana francesa se discuten dentro de tres escalas en el tiempo: las variaciones dinámicas actuales, los cambios en la línea de costa durante el Holoceno y las variaciones del nivel del mar durante el Cuaternario Tardío. En conclusión, se proponen algunas observaciones con respecto a datos sobre el nivel del mar.

INTRODUCTION

French Guiana coastal evolution involves some important problems concerning sea-level research of the north of South America.

This paper deals with shoreline changes within three temporal scales: present-day dynamic variations, Holocene shoreline changes and Late Quaternary sea-level variations.

Present-day shoreline changes in French Guiana - and within the Guiana's region - are striking and specific, directly linked with the huge Amazon discharge. Fine-grained sediments are transported from the Amazon's mouth to the Orinoco delta by the action of currents and swell. One part of this immense supply moves like extensive shoreface-attached mudbanks, there are continually migrating to the W-NW. At the same time shoreline is prograding and retreating.

Field indicators of Holocene shoreline changes are cheniers, narrow relic beach ridges which crossed, sub-coastal paralic environment. They represent relic beach ridges.

An evolutionary morpho-sedimentary model of the shelf during the past 30.000 years is proposed by I.G.B.A. researchers. The part of glacio-eustatic changes is stressed.

Some remarks concerning sea-level data are proposed in conclusion.

1 PRESENT DAY SHORELINE CHANGES

Present-day shoreline changes in French Guiana are directly linked with the huge sediment discharge of the Amazon River: approximately 250 million m^3 of fine-grained sediments are transported annually along the Guiana's coastline by the equatorial current and longshore currents created by trade-wind-driven waves (Wells and Coleman, 1977; Rine and Ginsburg, 1985). Evidence for this northwest transport is supplied by Nedeco (1968), Allersma (1971), Eisma and Van der Marel (1971) and Gibbs (1976).

One part of Amazon's output moves in suspension; the other part (some 110 million m^3/y) moves in the form of very large shoreface-attached mudbanks which migrate continually westwardly. Rine and Ginsburg (1985) defined a typical mudbank in Suriname as up to 5 m high, 50 to 60 km long, 10 to 20 km wide, and oriented at oblique angles to the coastline. In French Guiana there are presently 6 mudbanks with approximately 20 to 40 km long (Froidefond J.M. **et al.**, 1985).

When a mudbank is attached to the coast, the shoreline is undergoing progradation. Between two mudbanks - within the interbank zone - shoreline is undergoing erosion and is retreating. The shoreline is constantly changing because this dynamic creates very short-term morphological variations. Measurements have been taken of the migration's rate of mudbanks and interbank zones along the Guiana's coast. In French Guiana recent research (CORDET-IGBA Report, 1985) showed that between 1979 and 1984 mudbanks have moved in a

W/NW direction at speeds varying from 250 and 1250 m/y. The average rate of migration is 900 m/y (Froidefond J.M. **et al.**, 1985; Froidefond J.M. **et al.**, in press).

Frequency and intensity of sedimentation varies along the coast. Within the mudbank zones sedimentation is high because muds are generally so fluid that they interact with surface waves causing them to be altered and damped (Rine and Ginsburg, 1985). Within the interbank zones, on the contrary, wave energy is relatively high because of lack of wave dampening, producing erosion of the shoreline and shoreface. Sedimentation's rate varies also during the year: long term periods of higher wind speed (December to May; Nedeco, 1968; Allersma, 1971) seems to be important and coincide with periods of high concentrations of suspended matter within the coastal waters (Rine and Ginsburg, 1985). In fact, during this annual period of high winds we observed, within an interbank zone of the west coast (Pointe Isére), high-waves amplitudes, washover process and heavy erosion.

In conclusion:

- The most striking phenomenon influencing the present-day coastal evolution is the supply of the enormous mass of fine-grained sediments discharged by the Amazon River and carried steadily westward by the combined action of swell and currents.
- Mudbanks and interbank zones move westwardly along the French Guiana shoreface. Evidence of this northwest transport is also supplied by the deflected mouths of several rivers (Sinnamary, Iracoubo, Mana...).
- Rine and Ginsburg (1985) showed how the stacking of sediments from migrant mudbanks creates on the shoreface a vertical sequence of laminated and massive muds with discontinuity features and, on the coastal plain, a dynamic horizontal sequence of mud marshes and sand cheniers.

2 HOLOCENE SHORELINE VARIATIONS

French Guiana Holocene coastal plain is roughly situated between 0 and 5 m high and is composed of marine clays (Demerara Formation), waterfront mangrove and swampland. The latter is criss-crossed by narrow cheniers that are shallow - based perched sandy ridges which rest on clay.

Cheniers have a general disposition roughly parallel to the present shoreline. Two major systems of cheniers have been recognized in French Guiana owing to their morphological situation and to their pedological evolution. The "old" cheniers are generally situated between the marine clays of the Mara Phase (8000/6000 BP) and those of the Moleson Phase (2600/1300 BP). "Recent" cheniers are of the Moleson Phase (2600/1300 BP). "Recent" cheniers are separating the Moleson clays from those of the Comowine Phase (1000 BP to Present).

We observed, however, that cheniers disposition could be much more complicated, particularly within the estuaries environment. On the west coast, for instance, cheniers disposition are rather complex in character (Prost M.T., 1987). Furthermore, in the present-day cheniers formation continues to occur in the interbank zones (for instance, along a part of the west coast). Cheniers' formation takes place in a narrow zone around high water level; ridges migrate westwardly by beachdrifting. When more sand is being removed than deposited, cheniers are eroded, particularly during highs winds period and high-waves amplitudes.

The chenier's sands have local origine (Lafond L.R., 1967; Krook L., 1968; Turenne J.F., 1978; Froidefond J.M. and **al.**, 1985). The analysis of grain-size distribution have been done in the ORSTOM-Center (Cayenne) as well as preliminary remarks on mineralogical composition and on shape, roundness and surface texture of quartz grains of "raw" samples. Sandy formations are roughly similar as well as in present-day beaches and in cheniers. Heavy mineral composition should be defined to supply further information, but there is no doubt that cheniers represent relic beach ridges.

Rine and Ginsburg (1985) claimed that chenier plain morphology in Suriname was created by lateral stacking of mudbank deposits (marshes) separated by interbank beaches (cheniers). Migration of mudbanks is probably "a process that has occurred annually for the last 3.500 years" (Rine, 1980). If we accepted Rine's conclusion that means that vertical changes on sea-level during Holocene are only one componenet among others factors which influence French Guiana's shoreline evolution.

3 LATE QUATERNARY SEA-LEVEL CHANGES

An evolutionary morpho-sedimentary model of the French Guiana shelf during the Late Quaternary is proposed by Bouysse **et al.** (1977); Jeantet D. (1982) and Pujos and Odin (1986). It implies major sea-level changes and accounts for two trangressions and one regression. The Amazon River controls the sedimentary pattern of the shelf in relation with glacio-eustatic sea-level changes.

During a high sea-level (30.000 BP) the suspended load of the Amazon was discharged by the Guiana's current over the inner shelf in the form of a massive mud wedge. This "fossile" mud is presently below the present mud wedge. As the fossile and the modern mud present similar characteristics Pujos and Odin think that paleogeographical environment's conditions were similar to those of present-day.

During low glacio-eustatic sea level stillstands (-100/-90 m) the process was modified. The shoreline regressed to the shelf edge and the Amazon sediments were directly channeled onto the abyssal plain via the Amazon cone and deep sea fan. On the platform there are remains of a barrier reef (17.000/12.000 BP) and relict facies (rubified coarse-grained sands of the Maroni's delta, fine to very fine "verdine" sands, etc). When the sea-level was near present 30 m isobath, the suspended load of the Amazon begins to accumulate again, at about 8.000 BP (Pujos and Odin, 1986).

This evolutionary model shows how the epicontinental sedimentation took place on the French Guiana stable margin adjacent to an old peneplain and stress the Amazon River's controls on the coastline evolution. Sedimentation was continuous: fine-grained sediments from Amazon accumulate during high sea-levels and autochtonous sands and reef complexes develop during low sea-levels.

Remarks concerning paleoclimatic variations correlated with sea-level changes are done by Pujos and Odin (1986). The authors stress that between 20.000 and 17.000 BP climatic conditions were drier. In French Guiana "there are more climatic contrasts with sudden worsening of drought conditions", thereby allowing the extension of savanna to the detriment of the forest. That coincides with "intense evacuation of continentally-derived sediments". The region which is at present overlain by seawater masses is transected by river valleys and locally occupied by lagoons. From about 12.000 BP to the present, during sea-level rising, the climate becomes gradually similar to the present and there are extension of forests and mangroves at the expense of savannas (Pujos and Odin, 1986).

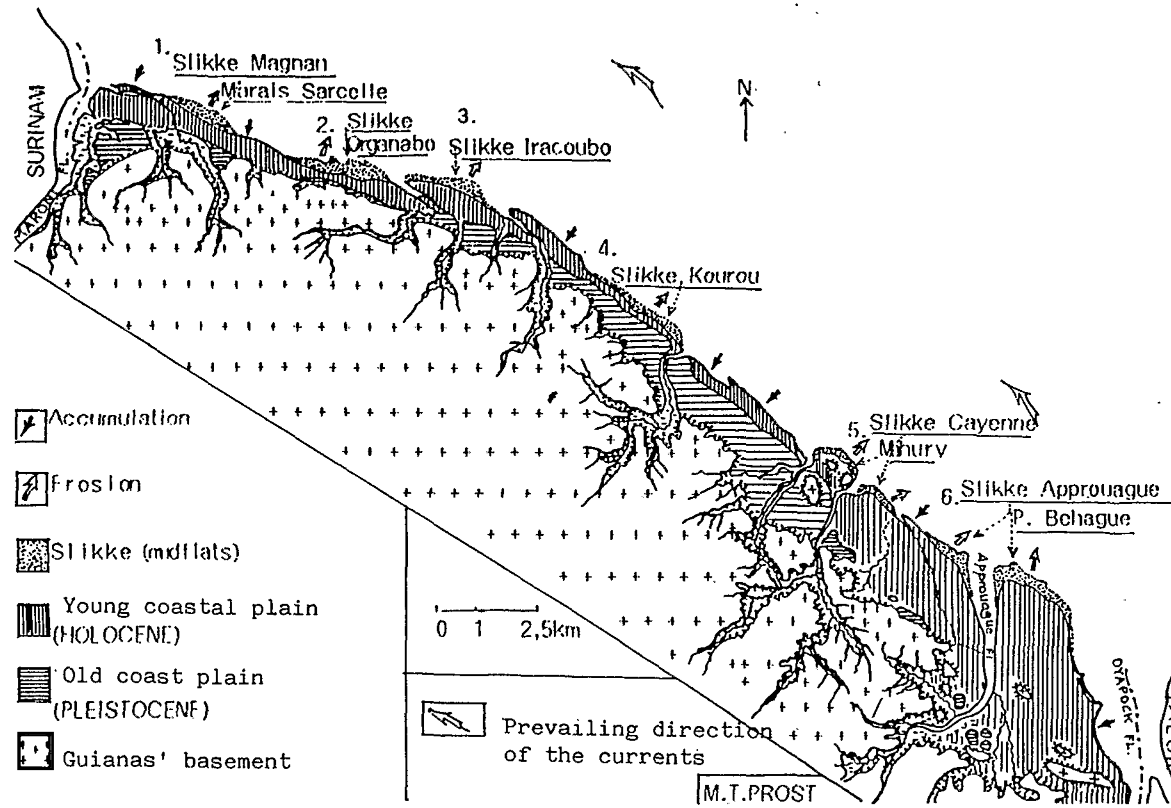

Figure 1. French Guiana Coastal Plain, July 1986. Prograding and retreating area.

4 DISCUSSION

Shoreline changes in French Guiana involves several problems concerning sea-level research. Studies of the Holocene coastal plain and of the continental shelf, based on field records, showed a variety of shoreline changes indicators.

On one hand, the morpho-sedimentary model of the French Guiana shelf evolution from the Late Quaternary to 8.000 BP draws attention to glacio-eustatic sea-level changes. The variations on the Amazon River's supply are connected with these changes. During Holocene, after the maximum sea-level rise of 6.000 BP, Brinkman and Pons (1968) indicate a "stable" sea-level. But relative sea-level changes in Suriname coast must be regarded with caution because until now the part of relative changes in land level lacks of definition.

On the other hand, Rine and Ginsburg (1985) demonstrated that chenier coastal plain of Suriname was formed by lateral stacking of mudbanks deposits separated by interbank beaches, dynamic that has probably ocurred since 3.500 BP. Moreover, present-day coastal evolution clearly shows that shoreline changes are directly linked-up with the sedimentary input of the Amazon River and with coastal hydro-dynamic conditions.

Discriminate the nature of sea-level changes in French Guiana is still extremely difficult. We need much more research on paleogeographical and paleoecological environment and on present-day coastal area evolution. Only detailed and rigourous studies within the regional context may provide new SL data and reassessment of existing studies. On one hand, IGCP Projects 61 and 200 have shown that no part of the earth's crust can be considered stable and that the relationship between eustatic change and isostatic movements is very complex. On the other hand, the concept of geoidal eustasy shows that eustasy as a world-wide phenomenon "can no longer be regarded as valid" (O. Von Plassche, 1986). Curves based in detailed studies (eg. Brinkman and Pons, 1968) but without considering geoidal variations must be referred to with very high caution. In the Brazilian coast, on the contrary, high sea-levels are interpreted as due to variations in the geoid surface (Martin **et al.**, 1979-1980). Furthermore, Newman W.S. (1985) demonstrate, owing to an elevation vs. time plot of more than 4000 radiocarbon-dated sea level indicators for the past 16.000 years, that the magnitude of "eustatic" sea-level rise is exceed by both neotectonic as well as geoidal changes in level.

Morner A.N. (1986) stress that dynamic sea level changes (linked with various meteorological, hydrological and oceanographic factors) may occur very rapidly (rates in the order of some 100 mm/y). Changes in oceanic circulation system may induced dynamic sea-level changes of a wide, geographical extension (Morner, 1986). They also lead to a redistribution of the heat stored in the oceans, and may have a climatic effect.

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