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COASTAL DYNAMICS AND CHENIER SANDS IN FRENCH GUIANA

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Abstract

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The Holocene coastal plain of French Guiana is an open chenier plain. The shoreline is characterized by vast migrating shoreface-attached mudbanks. Cheniers develop within the interbank zone. These sandbodies, which rest on the Demerara marine clays, have also been observed in the inner parts of the coastal plain.

This paper deals with the coastal area between Mahuri and the Maroni Rivers in French Guiana. An overview of the present state of knowledge regarding the coastal research in this area is given, and based on new evidence the problem of the provenance of the sandy accumulations will be discussed and further defined.

Introduction

The French Guiana coastal plain is an open ocean chenier plain. The shoreline comprises an extensive shoreface with attached mudflats and is characterized by waterfront mangroves and subcoastal swamps and marshes. Aerial photographs, low altitude flights, SPOT images and field observations enable identification of narrow cheniers along the inner part of the coastal plain. At present, cheniers are still forming along the coastline. These are related to the specific dynamics of this coast.

The development of the coast may be deduced from the combination of data on the present-day morphogenetic processes and those on palaeogeomorphology. In the last decades, numerous investigators have been involved in the study of the French Guiana coast or of its related problems and in recent years the interest in coastal research has increased.

Geographical setting

The coastal plain of French Guiana comprises a zone 320 km long from the Oyapock River to the Maroni River (Fig.1). This area represents only 6% of the 90,000 km^2 of French Guiana, the other 94% being formed by the Precambrian Guianese Shield and covered with rain forest. Two main morphological units have been recognized within the coastal area (Fig.2):

(1) The "young" coastal plain situated approximately at an altitude of between 0 and 5 m and formed by Holocene sediments (marine and fluviomarine clays and silty clays). The inner part of the "young" coastal plain was formed in a paralic environment and is intersected by narrow and elongated cheniers located approximately parallel to the present shoreline and separated by fine-grained deposits, all part of the Demerara Formation.

(2) The "old" coastal plain situated approxi-

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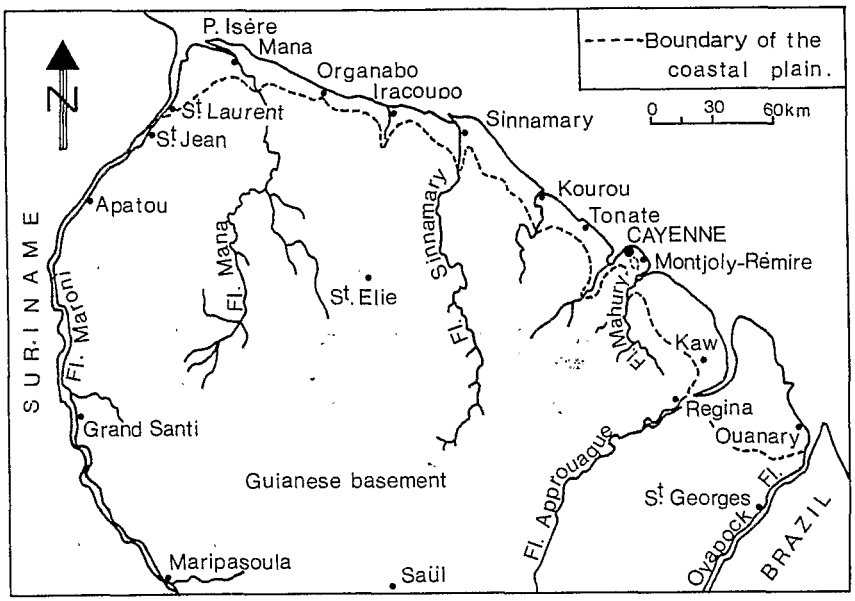

Fig.1. Sketch map of the northern part of French Guiana.

mately at a altitude of between 5 and 15 m and formed by the Pleistocene sediments of the Coswine Formation. This formation is composed of marine clays, silty clays and fine sandy deposits. Between Cayenne and Iracoubo the sandy sediments are mainly concentrated in bars (*barres prélittorales*). The width of the old coastal plain diminishes in an eastward direction, and the young coastal plain becomes more prominent in the opposite direction, especially between Cayenne and the Oyapock River.

Coastal research

During the past 30 years, particularly since the mid-seventies, research concerning the Holocene coastal plain and the shoreline changes has increased. The investigations of the Holocene coastal plain with emphasis on the predominantly clayey deposits and on the sandy coastal formations will be discussed briefly.

The Holocene coastal plain

Geological and geomorphological features have been analyzed, among others, by Choubert (1956, 1959, 1961, 1962), Boye (1959, 1963,), Turenne (1978), Blancaneaux (1981) and Prost (1985, 1986a, b). The importance of the supply of the Amazon River to the coastal sedimentation and the morphological evolution of the coast was emphasized by researchers such as Cruys (1959), Lafond (1967), Bouysse et al. (1977), Jeantet (1982), and reassessed during the research conducted by Pujos et al. (1984, 1985), Pujos and Odin (1986), Jouanneau and Pujos (1988), and Lointier and Prost (1988).

Along the shoreline extensive shoreface-attached mudflats migrate slowly westward, the shoreline undergoing progradation in these areas. Between two mudbanks — in the interbank zones — the shoreline undergoes erosion and retreats. This system of accretion and erosion migrates continually to the west. The frequency and intensity of sedimentation and erosion vary in time and space, and their mutual relationship determines whether there is a net accretion or erosion.

This dynamic process creates very short-term morphological variations and is related to the huge discharge from the Amazon River ($110–130 \times 10^6$ tons per yr of suspended sediment, of which 10–20% moves along the coast

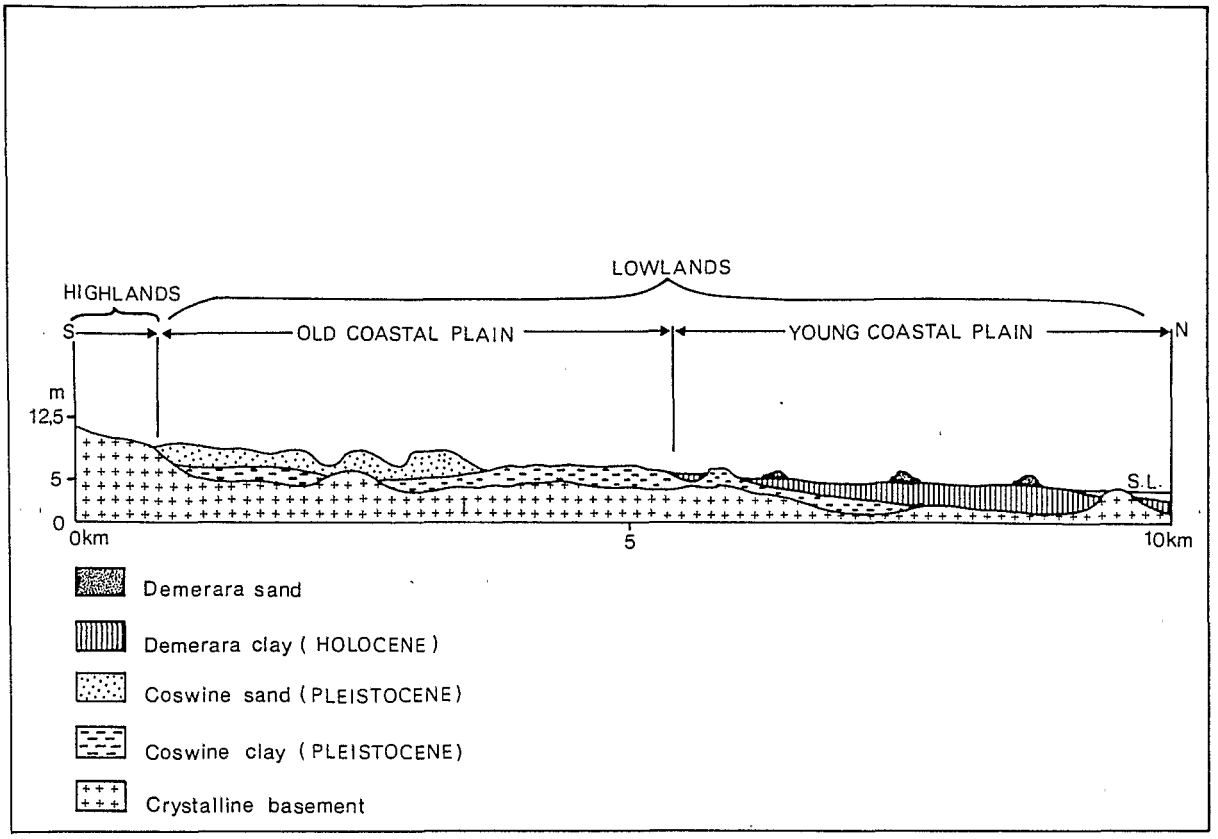

Fig.2. Diagrammatical section of French Guiana coastal plain.

of the Guianas) (Eisma, 1988). The sediment transport takes place in suspension and in the form of migrating mudbanks. The estimated quantities are 140×10^6 m^3/yr and 110×10^6 m^3/yr respectively (Wells and Coleman, 1978). There are presently six mudbanks along the coast of French Guiana, of which the intertidal parts (the mudflats) vary in length from 20 to 40 km. Chenier formation is associated with the shoreline dynamics and takes place in the erosive interbank zones (Augustinus, 1978, 1980; Rine and Ginsburg, 1985; Prost, 1986a, b; Rine, 1988).

Analysis of shoreline changes (Boye, 1959, 1963; Turenne, 1978; Froidefond et al., 1985; Lointier, 1986; Froidefond and Pujos, 1988a, b; Prost, 1988, in press) and displacement of intertidal mudflats has contributed new data to the research on muddy coasts of the equatorial region and their morphosedimentary evolution.

Many papers on estuaries in French Guiana have been published: Brugière (1963), LCHF (1965, 1967), Lafond (1967), Berthois and Hoorelbeck (1968), Bellesort and Martin (1968), Mignot (1970), Dubreuil et al. (1974), Roche (1978), Fritsch (1984), Audige (1986), Lointier (1986), Jouanneau and Pujos (1987, 1988). Lointier and Prost (1988) have shown, using hydrological and sedimentological investigations, that the influence of the local rivers on the coastal sedimentation is minimal — approximately 1% of the suspended load transported along the coast. The supply of alluvial sand is limited, due to hydrodynamic conditions.

The sedimentology and the stratigraphy of the Holocene sediments was studied by Chou-

bert (1959, 1961), Boye and Cruys (1961), Boye (1963), Sourdat and Delaune (1970), Turenne (1978), Guillobez (1979), Prost and Lointier (1987). In his comparative analysis of Suriname and Guyana, Turenne (1978) recognized three sedimentary phases, Mara (8000 yrs B.P.), Moleson (2500–1300 yrs B.P.) and Comowine (1000 yrs B.P.–present). The Mara/Moleson and Moleson/Comowine phases are separated by sandy ridges. The thickness of the Demerara deposits in French Guiana does not exceed 15 m (Leveque, 1962).

Two cores drilled by the Bureau de Recherches Geologiques et Minières (BRGM) on the left bank of the Approuague River passed through 10 m of Demerara clay. The basement formations at this point are at a depth of approximately 30 m (Leveque, 1962). Several other cores drilled by the BRGM and by Marius (1986) in the Mana area were complimented with field observations.

Marius (1966) distinguished two sedimentological facies within the sediments of the Demerara Formation (Mana area): a mangrove facies (a) and a subtidal facies (b). The facies association passes gradually from (b) to (a), with laminations of sand and mud passing into dark grey unstructured clays with many roots and much organic matter.

The muddy environment appears to be dominant, not only along the shoreline but also on the nearby shelf (Bouysse et al., 1977; Jeantet,

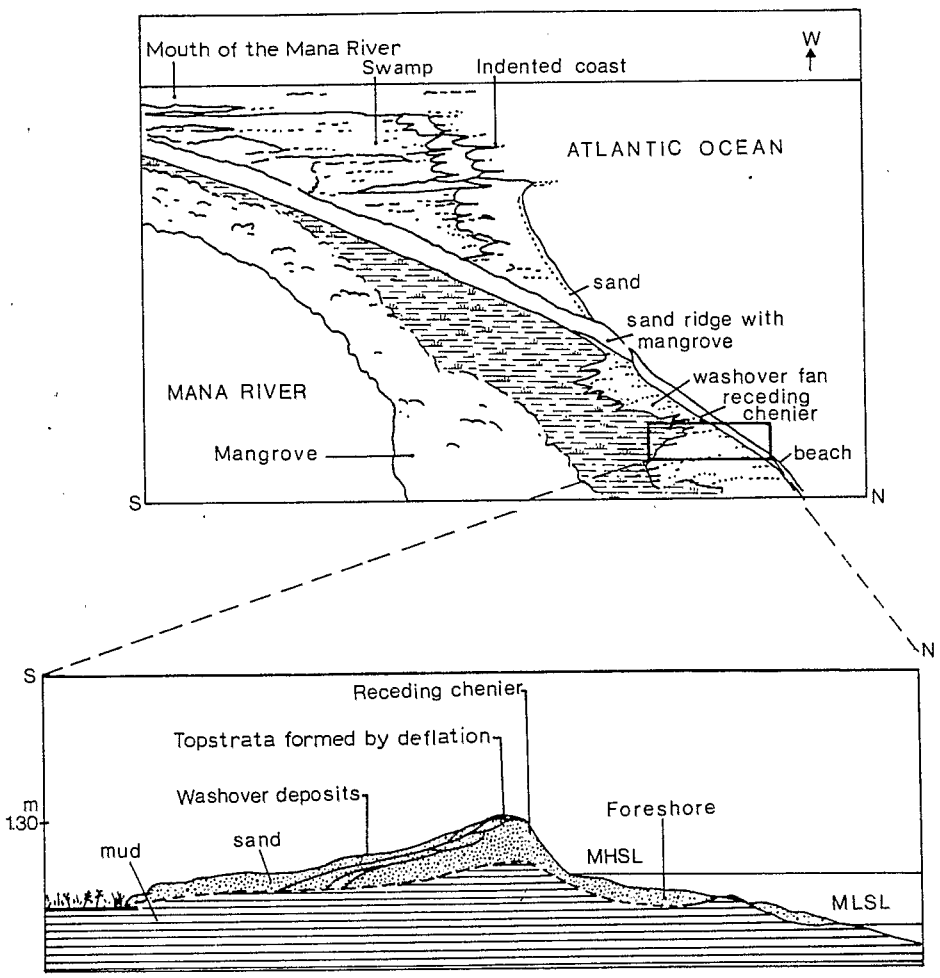

Fig.3. Schematic cross section of Galibi beach, Pointe Isère.

1982; Pujos et al., 1984, 1985; Pujos and Odin, 1986) and is controlled by the Amazon River. In comparison to the muddy environment, sandy material appears to be rare.

The sandy coastal deposits

The sandy deposits have never been studied as extensively as the fine-grained sediments and there are relatively few data available concerning their nature, mineralogical composition and sedimentary structures.

The Holocene sandy ridges were described by Turenne (1978) as being 70–200 m wide, having one or two crests, and consisting of local sands, composed of quartz and heavy minerals. Grain sizes generally range between 0.1 and 1.0 mm ($Md = 0.25$ mm, $He = 0.36$), and the surface texture has a marine water-worn appearance. Turenne indicated two generations of sandy ridges, one located between the Mara/Moleson phases and the other between the Moleson/Comowine phases. These data were obtained using pedological information and compared with results from Suriname. However, Leveque (1962) and Blancaneaux (1981) referred to these sand bodies without making the distinction just described.

On the basis of aerial photographic interpretation, field observations, low altitude flights and comparison with results obtained in Suriname, Prost (1985, 1986b) was the first to identify the Holocene sandy ridges as cheniers directly linked with the shoreline changes.

The cheniers

This research deals with a 250 km coastal area between the Mahury River and the Maroni River. The Holocene ridges are isolated, shallow-based sand bodies resting on Demerara clay deposits. Initially an attempt was made to distinguish between old and recent ridges (Prost, 1985, 1986b), this distinction being based on geomorphological location and degree of pedogenesis. However, these parameters do not appear to be conclusive (Lointier and Prost, 1986; Prost, 1986b).

At present, cheniers are still developing within the interbank zones during periods of high water level (e.g near Cayenne). When more sand is removed than is deposited (e.g. at Point Isere, Fig.3) cheniers are eroded, particularly during spring tides and during periods of strong winds (January to May).

An investigation on beaches and cheniers has been carried out in some key areas (Cayenne, Sinnamary, Marais Sarcelle and Pointe Isere) using field observations, aerial photographs, low-altitude flights, satellite photographs and laboratory analysis. In each key area, sand samples were collected the same day under the same tidal conditions mostly in the foreshore area, and a few were collected from the top strata of the backshore ridges. The sand is mostly coarse grained and composed of almost pure quartz. Shell clasts may occur in some cheniers. (e.g. Tonate and Marais de Mana). At some locations in the lower parts of the foreshore, concentrations of black heavy minerals may occur (e.g. the beaches of Cayenne, Kourou, Sinnamary, Aouara and Les Hattes).

The heavy mineral composition of the chenier deposits in Suriname represents two main associations (Augustinus, 1978; Krook, 1979): (1) the staurolite (45–70%) bearing sands typical of the East Suriname coast and derived from local sources (Maroni and Mana Rivers) and (2) the epidote-hornblende association (20–40%) typical of the fine grained Amazonian sands. In French Guiana the staurolite association appears mainly in the beaches located west of Kourou (Froidefond et al., 1985). On the west coast (Pointe Isère) (Prost, in press), the top strata of the backshore of Galibi beach (Fig.3) contain approximately 93% staurolite, 4% garnet, 1% tourmaline and 3% ilmenite (analysis by Krook, 1989). However, in the Cayenne area, the sands of the beaches have another composition. The black sands of the foreshore of Remire Cove, for instance, have a concentration of opaques of 91% (ilmenite, magnetite, goethite and leucoxene), 9% transparent minerals (mainly zircon (33%) and epidote (32%)). All these

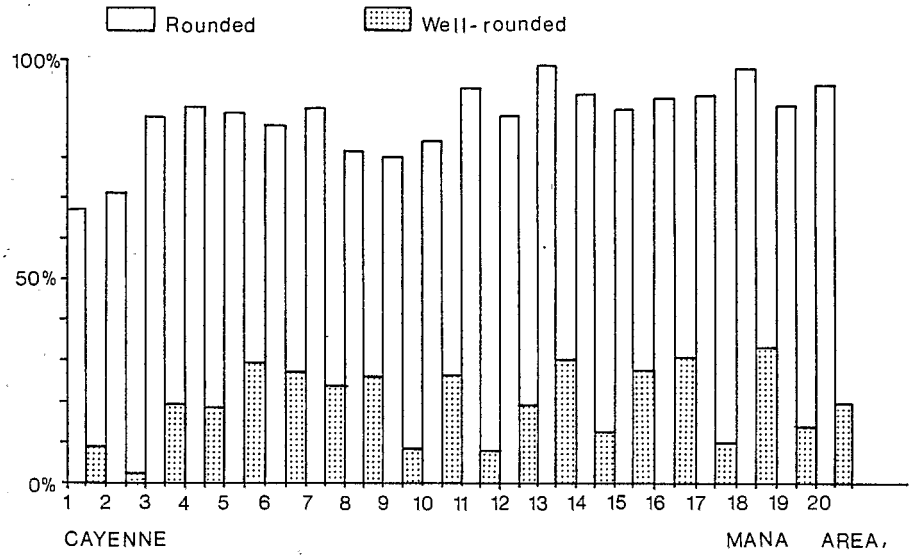

Fig.4. Relationship between rounded and well-rounded sand grains.

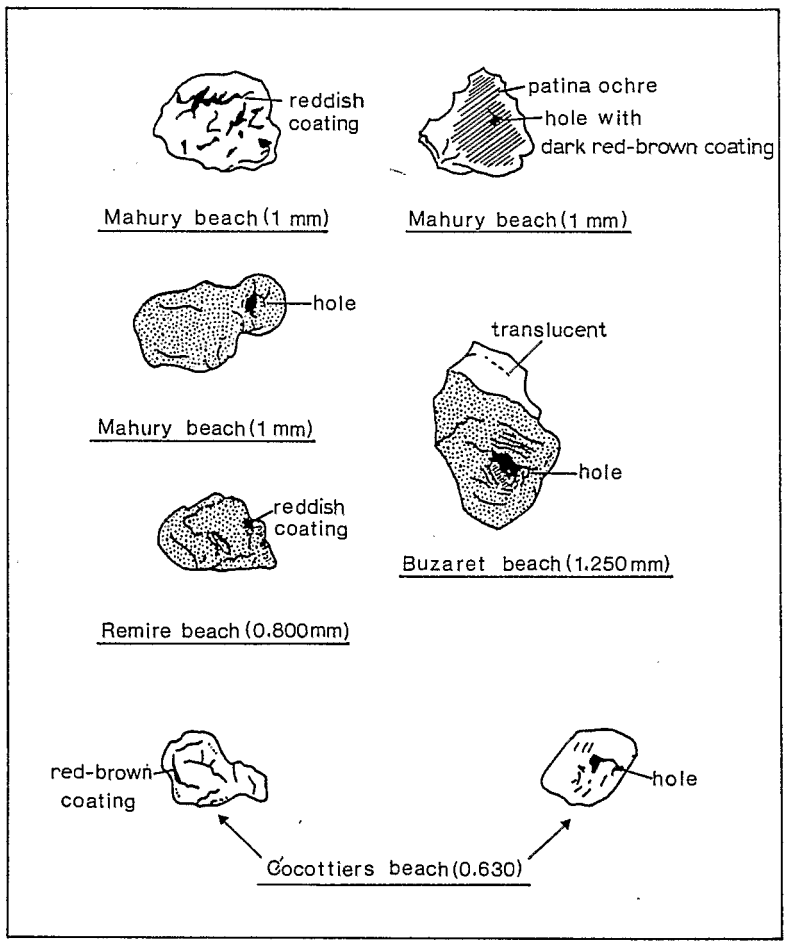

Fig.5. Surface texture of sand grains, Cayenne.

minerals are probably of local origin. The shoreline sand grains are mostly subangular or subrounded (Fig.4); the coarse particles (1.0–0.630 mm) are more rounded than the finer grains.

The surface textures of most sand grains are of shiny and frosty appearance (*Picoté-luisant*). There may be grains which are only frosty and these are mostly found in the top-strata of some of the chenier crests. The percentage of smooth, shining grains ("luisants") is between 15 and 35 on some Cayenne beaches, and indicates reworking of the residual sediments. These sands are ochre in colour, due to a patina component. They have a rough and dented surface, sometimes with voids sufficiently deep to be filled with a dark red-brown coating (Fig.5).

The quartz and heavy minerals at Sinnamary and Mana (Fig. 6) have etched surfaces. These are characteristic of a weathered shield formation and/or pedological processes. Grains with chemically etched V forms were also identified by Jouanneau and Pujos (1987) in the Comte River sand.

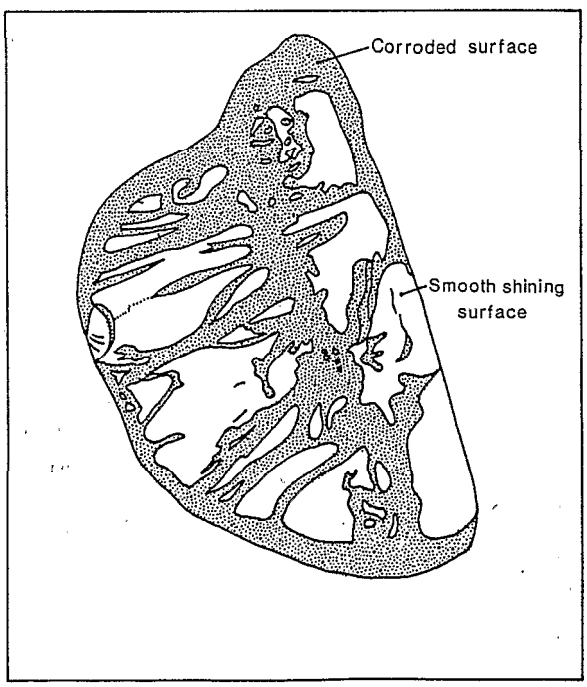

Fig.6. Weathering surface of staurolite's, fraction 1 mm. Pointe Isère.

According to Augustinus (1978), the mineralogical composition of the fine textured chenier sand in Suriname points towards the Amazon River as being the source of the fine sand. Krook (1979) maintains that "part of the fine sand is derived from the Amazon drainage area and is transported mainly in suspension with the silty clays". However, in French Guiana these fine sands have hitherto not been located and further research is required.

Conclusion

Although the cheniers indicate former Holocene coastlines, chenier formation is still active, which demonstrates continuous dynamic coastal conditions related to the huge sediment discharge of the Amazon.

Cheniers sands are coarse and medium grained and supplied by local sources. The characteristics of the sand grains reveal a long evolution. Up till now, fine Amazon-borne sand has not been found in this region.

Chenier evolution is very dynamic. It is strongly associated with the specific shoreline conditions, e.g. the westward migrating mud-banks. These deposit fine grained sediments in the coastal area. Within the erosive interbank zones cheniers are formed.

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