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Beaches and cheniers in French Guiana

ABSTRACT

The French Guiana Holocene coastal plain is an open ocean chenier plain. The shoreline is composed of extensive shoreface attached mudflats and characterized by waterfront mangroves and by sub-coastal swamps and marshes. There are presently six migrating mudbanks along the French Guiana's coast, each 20 to 40 km long. When a mudbank is attached to the coast, the shoreline is undergoing progradation. Within the interbank zones, on the contrary, shoreline is undergoing erosion and sandy deposits create specific types of accretionary and erosional coasts. In the inner part of the coastal plain, narrow sandy ridges are observed thanks to aerial photos. They are isolated, perched and shallow-based sandbodies resting on marine clays, i.e. typical cheniers.

This paper deals with the coastal area between Cayenne and the Maroni River. Our aim is to provide information concerning sandy material of beaches and cheniers and to discuss some points related with them. After a brief review of the dynamic and the morphology of the shoreline, the significance of chenier's evolution is presented within the Guianese's environment. The characteristics of the sandy formations are shown within three key-areas. General results are discussed in conclusion.

RESUMEN

La planicie costera holocena de la Guayana Francesa es una planicie de chenier, océnica abierta. La línea de costa está compuesta por planicies fangosas extensivas yuxtapuestas a la costa y caracterizadas por manglares, pantanos y marismas subcosteras. Hoy, al presente, seis planicies fangosas migratorias a lo largo de la costa de la Guayana Francesa, cada una de ellas de 20 a 40 km de largo. Cuando una planicie fangosa se yuxtapone a la costa, la línea de la ribera está sufriendo progradación. Dentro de las zonas interbancos, por el contrario, la línea de costa está registrando erosión y los depósitos arenosos crean tipos específicos de costas acrecionales y erosivas. En la porción interior de la planicie costera, crestas arenosas angostas son observadas gracias a fotos aéreas. Ellas son cuerpos arenosos aislados, colgados, poco profundos, que descansan sobre arcillas marinas, por ejemplo, cheniers típicos.

Este trabajo se ocupa del área costera entre Cayena y el río Maroni. Nuestro objetivo es proveer información concerniente a materiales arenosos de playas y cheniers y discutir algunos puntos relacionados con ellos. Luego de una breve revisión de la dinámica y la morfología de la línea de costa, se presenta la significancia de la evolución de los cheniers dentro del ambiente guyanés. Las características de las formaciones arenosas se muestran en tres áreas clave. En las conclusiones se discuten los resultados generales.

INTRODUCTION

The French Guiana Holocene coastal plain, called the "young coastal plain", faces the open equatorial Atlantic Ocean. It has an altitude which ranges between 0 and 5 m and stretches along 320 km. Located between the Oyapock River (Brazil border) and the Maroni River (Suriname border), it is part of the 1600 km long open ocean chenier plain of the Guianas region which itself stretches from the Amazon mouth in Brazil to the Orinoco delta in Venezuela. This coastal area presents similar dynamic conditions and morphological features.

This paper deals with the coastal area between Cayenne and the Maroni River where cheniers have been identified thanks to both aerial photos interpretation and field observations. The I.G.C.P./201 Project (International Geological Correlation Program: Quaternary of South America. IUGS/UNESCO) has promoted this research since 1984. Currently, research has been taken over by the ORSTOM-Center of Cayenne, under the Coastal Environment Programme.

MUDBANKS AND SANDY RIDGES

Present-day shoreline changes in French Guiana are directly linked to the huge sediment discharge of the Amazon River that supplies 250 million m3/y transported along the Guiana's coast. A "blanket" of mud covers the nearby continental shelf at least down to the isobath of 20 m and, on average, the shelf is 30 km away of the shoreline (Bouysse et al., 1977; Jeantet, 1982; Pujos and Odin, 1986). As a result, this coastal system presents an inverse sedimentological transition (nearshore muds to offshore sands) of the "typical coastal system" defined by Reineck and Singh (1986). Offshore sands in French Guiana nearby continental shelf are relict deposits.

One part of the Amazon discharge (110 millions m3/y) is carried steadily westward along the nearshore by the combined action of the equatorial current and the longshore currents created by the trade-wind-waves (Wells and Coleman, 1977; Rine and Ginsburg, 1985). Consequently, vaste migrating mudbanks are formed, specific of the Guiana's coastline. In French Guiana there are presently six migrating mudbanks each 20 to 40 km long (Froidefond et al, 1985). When a mudbank is attached to the coast, the coastline is undergoing progradation. Within the interbank zones, on the contrary, shoreline is undergoing erosion. These phenomenons are alternative and simultaneous. They occur in very short-term periods and shoreline changes are really striking (Prost, 1986). Stacks of sediments from migrating mudbanks create on the shoreface a vertical sequence of laminated and massive muds and, on the coastal plain, a dynamic horizontal sequence of mud marshes and sand cheniers (Rine and Ginsburg, 1985).

Muddy environment appears as dominant not only along the shoreline but also on the nearby continental shelf. In comparison, sandy material appears as rather rare. However, Augustinus (1978) has clearly shown how important are sand deposits concerning the geomorphological evolution of shoreline. They create specific types of accretionary and erosional coasts within the interbank zones. Moreover, the narrow sandbodies observed in the inner part of the coastal plain thanks to aerial photos, are recorded with former coastlines. The study of sandy environments, in conclusion, is significant for the present-day shoreline changes and for the understanding of the Holocene coastal plain evolution.

THE CHENIERS

Two major systems of sandy ridges have been recognized in French Guiana: "old" ridges are situated between the marine clays of the Mara Phase (8000/6000 BP) and those of the Moleson Phase (2600/1300 BP); "recent" ridges are separating Moleson sediments from those of the Comowine Phase (1000 BP to present). "Old" and "recent" ridges are disposed roughly parallel to the present shoreline.

The geomorphological disposition of the ridges is an insufficient field indicator (Seurin, 1975); their degree of pedogenesis, though more accurate, cannot be the only data. As regard to this problem we are able to present the following given points:

-Holocene ridges are isolated, perched and shallow-based sandbodies resting on the Demerara clays, i.e. typical cheniers.

-Cheniers disposition must be rather complicated, particularly within the estuaries environment as in the key-areas of Mana and Sinnamary (Prost, 1986; Lointier, 1986).

-Present-day shoreline cheniers formation continues to occur within the interbank area, in a narrow zone around high water level (key-area: Cayenne). Ridges migrate westwardly due to beach-drifting.

-When more sand is removed than it is deposited (key-area: Pointe Isere), cheniers are eroded, particularly during spring tides and during the high wind period (January to May).

Two major problems are linked with chenier formation:

1) The first one concerns the origin of the sand. The original theory was that chenier sand was supplied by local rivers. Krook (1968) and Augustinus (1978) reported that the chenier sand in the eastern part of the young coastal plain of Suriname originates from the Maroni and from the coast of French Guiana, owing to mineralogical data. However, they also emphasize that sometimes this sand has a local admixture of sand from the pelite deposits off the coast. As regard to this problem, Krook defined two heavy mineral associations within Suriname sandy coastal area: a) the staurolite bearing sand is supplied by the Maroni and the French Guiana coast; b) the epidote-hornblende sand probably originates from the Amazon River.

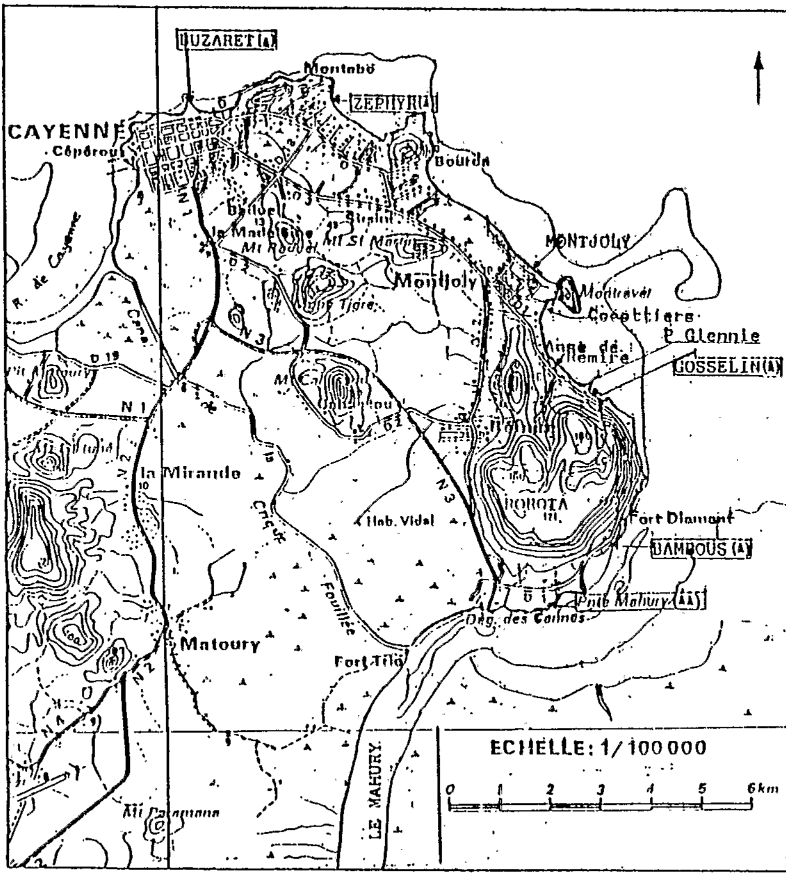
2)The second point involves the problem of the shoreline evolution. What are the respective parts of sea-level changes and progradation and retreating sequences?. A rapid sea-level rise between 10000 BP and 6000 BP is a given point (Brinkman and Pons, 1968; Turenne, 1978). But we know very little about the post-Mara evolution. On one hand, cheniers are considered as built up on a relatively stable coast (Augustinus, 1978). On the other hand, no part of the Earth crust can be considered as stable and the relationship between isostatic movements and eustatic changes is very complex. This problem is specially significant in Suriname where the coastal plain is part of the Berbice subsidence area.

This paper only deals with the first point. The aim is to provide more detailed information about the sandy morphological units and material of French Guiana.

CHARACTERISTICS OF THE SANDY FORMATIONS

It is known that sediment grain parameters - as grain-size distribution, mineral composition, shape, roundness and grain surface texture - are environmental indicators. Such studies present, of course, several limitations and need more data to be completed; nevertheless, they can provide interesting information. Grain-size distribution is controlled by the hydro-dynamic conditions existing exactly at the moment of deposition; shape, roundness and grain surface texture provide a more long-term data.

KEY-AREA: CAYENNE



▲- Areas where samples were collected

Figure 1. Sketch map of Cayenne area.

To obtain information concerning present and Holocene sandy material, samples were first collected along the beaches of Cayenne and then compared with other samples taken from beaches and cheniers situated between Sinnamary and the Maroni River. Laboratory's analyses were carried out at the Center-ORSTOM of Cayenne and supervised by J.L. Duprey; they concerned grain-size distribution, including histogram and cumulative curves and the values of Qdphi, So and He. Shape, roundness and grains surface texture were analyzed with a binocular microscope. Approximately 900 grains were counted and a great number have been drawn. The results of the counts have been represented graphically. Some graphs have been place on one sheet for correlation purposes.

1 CAYENNE KEY-AREA

The "Isle of Cayenne" is one of the rare points of the coast where the rocks of the shield are in contact with the ocean. As a result, the coastline is a succession of rocky points and isolated hills separing sand coves and straight beaches (Figure 1). Between the Mahury River mouth, in the east, and the Cayenne River mouth, in the west, there is a sequence of sandy formations, with good accessibility. The samples were collected the same day and under the same tidal conditions, mostly in the foreshore area and a few in the topstrata of the backshore ridges. This east-west sequence is also a dynamic one: beaches of the Rorota coast are situated presently within an interbank zone; beaches near Cayenne town center, on the contrary, are fixed behind the mudbank and the mangrove and, as a result, out of the wave action.

1.1 GRAIN-SIZE DISTRIBUTION

Table 1 presents the mean grain-size and the compared values of Qdphi, So and He values. It defines sedimentation units taken in 1987 (May 31th). Sands are mostly coarse-grained and composed of almost pure quartz. Shell clastics are rare and appeared only near some rocky points (Buzaret). Black concentration of heavy minerals is found within some foreshore area and linked with the backwash of the waves (pointe Glennie; Gosselin beach).

Table 1. Median particle diameter and Qdphi, He and So values.

Beaches of CAYENNE

Beaches and ridges	Md	Qdphi	He	So
ZEPHYR	0,195 mm	0,2	0,19	1,16
COCOTTIERS	0,315 mm	0,15	0,10	1,12
GOSSELIN	0,355 mm	0,2	0,2	1,12
MAHURY (ridge)	0,360 mm	0,15	0,12	1,12
MONTJOLY (ridge)	0,340 mm	0,3	0,3	1,24
MONTJOLY (foreshore)	0,222 mm	0,375	0,35	1,30
ANSE DE REMIRE	0,320 mm	0,375	0,2	1,30
BUZARET	0,365 mm	0,45	0,4	1,38
BAMBOUS	0,290 mm	0,5	0,3	1,42
MAHURY (ridge)	0,250 mm	0,625	0,5	1,55

Three kinds of sorting have been distinguished:

-Sorting is excellent (=1,1/1,2) at the foreshore area of Zephyr, Cocottiers and Gosselin, and at the crest of the backshore ridges of Montjoly and Mahury. Cumulative curves have a straight form (as an S) which indicates a homogeneous material (Figure 2).

-Sorting is good (=1,3/1,4) at the foreshore of Montjoly and Anse de Remire, slightly less homogeneous than the previous samples. Cumulative curves are also less straigth (Figure 2).

-Sorting is not so good (more than 1,4) at the foreshore area of Buzaret and Bambous and mostly at the newly formed beach of Mahury point. Cumulative curves revealed a more heterogeneous material (Figure 2).

Figure n° 2

KEY-AREA CAYENNE: Cumulative curves

Grain size distribution

N°2- Foreshore area of ZEPHYR's beach
N°6- Foreshore area of MONTJOLY's beach
N°3-Foreshore area of COCOTTIERS' beach
N° 7- Crest of the ridge. Backshore.MAHURY
N° 4-Foreshore area of GOSSELIN's beach

N° 1-FORESHORE AREA OF BUZARET'S BEACH
N°10-Crest of the ridge.MONTJOLY.
N° 5-Foreshore. ANSE DE REMIRE
N° 8-FORESHORE. BAMBOUS.
N° 9- FORESHORE. P.du MAHURY

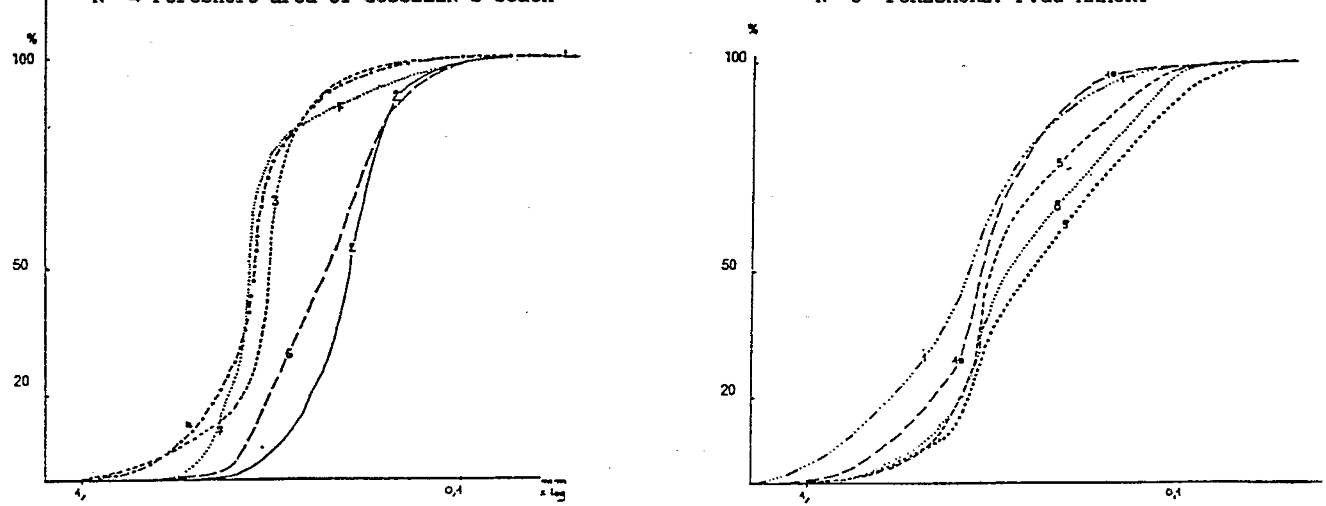


Figure 2. Cayenne key-area: cumulative curves; grain size distribution.

Table 2. Surface texture of sand grains.

BEACHES OF CAYENNE

BEACHES	ROUNDNESS %	WELL ROUNDED %
Buzaret	58,4	6,7
Zéphyr	62	1
Montjoly (estran)	79	16
Montjoly (cordon)	81,4	15,4
Cocottiers	79,8	24,8
Anse de Rémire	77,2	22,8
Gosselin	80,8	16,8
Bambou	71	21,5
P. du Mahury (estran)	70	6,4
P. du Mahury (cordon)	73	22

BEACHES AND SANDY RIDGES (W of CAYENNE)

BEACHES	ROUNDNESS %	WELL ROUNDED %
Isère 1	85	5,5
Isère 2	78,8	15,5
Isère 3	90,4	25
Isère 4	83,7	9,8
Van Uden 1	80,3	22,7
Van Uden 2	82,7	26
Amarante	83,5	7,4
Goulet	89,6	28
Piste Hattes	81,2	11
Route 8	85,8	16,1
Trou Poisson	82,5	15,1
Sinnamary	71,7	2,2

In conclusion, grain-size distribution shows that:

-Foreshore sands and backshore ridges are formed by the same material, though the topstrata of the ridges has a better sorting. The latter is related with wind action, as we observed in the field.

-Sands have a good sorting. Qdphi, He and So values are respectively less than 0,6; 0,5 and 1,5.

-Sorting of sandy material that is accumulating within the interbank zone is roughly better from the east to the Cayenne River mouth.

These analyses, as well as our field observations, allow us to consider the Mahury River as the major source of sandy material that is accumulating along the Cayenne's shoreline.

1.2 SHAPE AND SURFACE TEXTURE OF GRAINS

Six classes for roundness determination were used: angular (NU = non-usés); sub-angular (Sub-Ang. = Sub-angulaire); sub-rounded (CA = coins-arrondis); rounded (Arr ▫ arrondi); ovoid (Ov ▫ Ovoide) and well-rounded (R ▫ rond). Sands of Cayenne beaches have good roundness, 80 to 52% of grains rounding (Table 2). But when we compared this percentage with those of the last three classes (Arr, Ov and R, i.e. grains with the best rounded = "bien faconnés"), it appeared that they do not exceed, in the best situation, 25% of the sample. In some cases, as in Zephyr, they represent only 1% of the sandy material. This means that roundness is still in an early stage. Most of the grains are sub-angular and sub-rounded.

Sand grains of the backshore's ridges show a better rounding as compared with beach sands, feature linked with a selective action of the wind. The roundness of sand grains also shows a relationship with grain size: coarse fractions (1 mm; 0,800 mm; 0,630 mm) have in general better roundness than finer ones.

Concerning the surface texture of sand grains (Figure 3), we distinguished five kinds of grains: angular and sub-angular bright grains (EN = éclat naturel); smooth shining grains (EL = émoussés luisants); smooth grains with shining and frosted surface (PL, picotés-luisants), smooth frosted grains (M = mats) and opaque grains (OP).

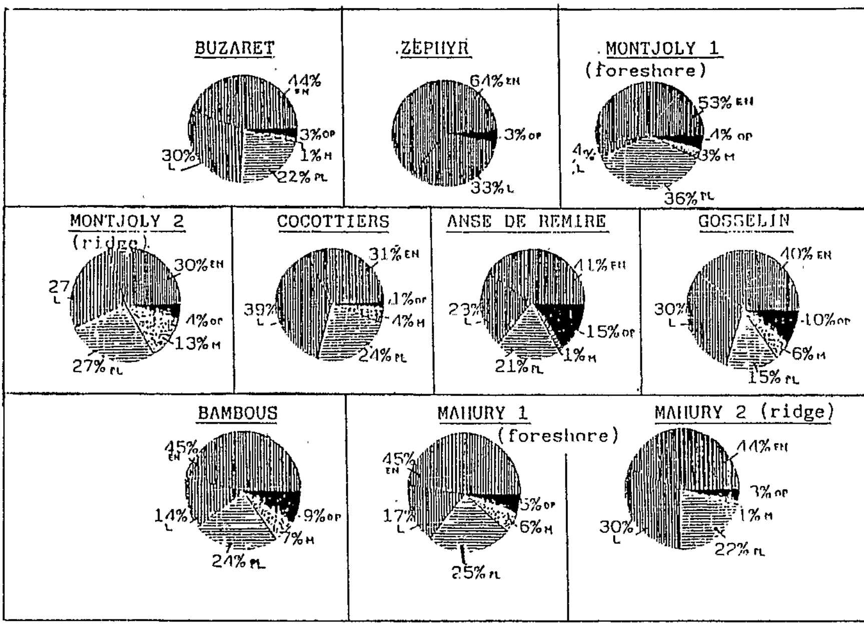


FIGURE N° 3

SURFACE TEXTURE OF SAND GRAINS.

BEACHES OF CAYENNE. May 1987.

—EN – Angular and subangular shining grains (éclat naturel)
—L – Smooth shining grains (émoussés-luisants)
—PL – Smooth grains with shining and frosted surfaces. (picoté-luisant)
—M – Rounded frosted grains (mats)
—OP– Opaque grains

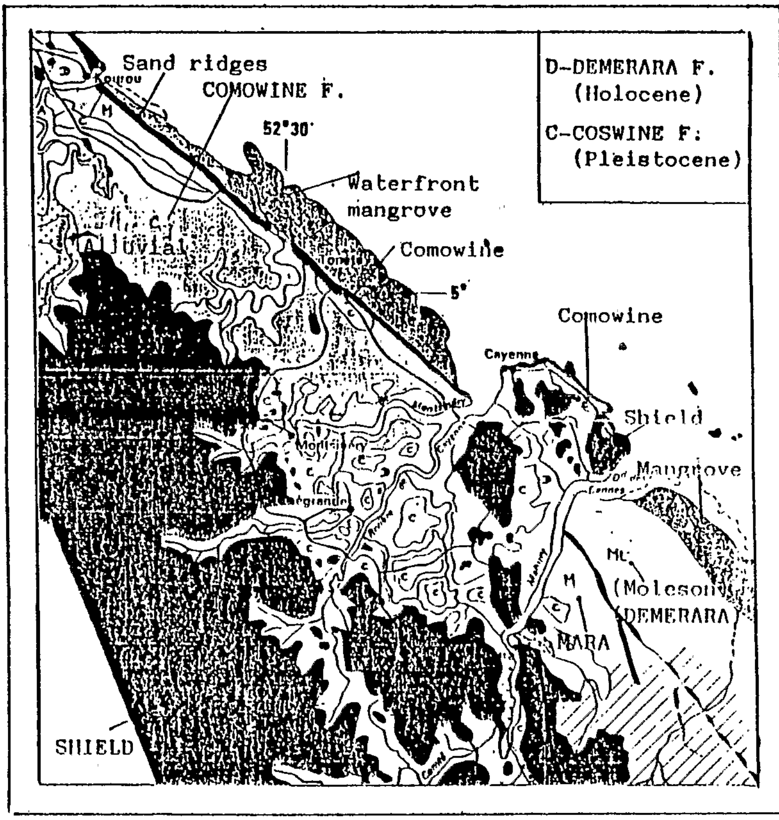
Bright grains are common (from 31 to 64% of samples), indicating neighbouring of the supply and its immaturity. On the opposite, the EL grains form between 15 to almost 40% of the sample; a reworking, with the mixture of sand grains is very likely. The most significant part of quartz grains is composed by PL grains. Frosted grains (M) are little, linked with the topstrata of backshore ridges.

Opaque grains show heavy mineral concentrations and polymineral grains. They are linked with the basement rocks. The hills of Cayenne belong to the Ile de Cayenne Formation (quartzites, granites, migmatites, etc) and to the Paramaca Formation (volcanic rocks) (Figure 4). In the hinterland the shield is composed by the schistes of the Orapu and the Bonidoro Formations. All these formations supplied heavy minerals. Staurolite and disthene, for instance, appeared in the alluvial deposits of little "creeks" and valleys in the north of the Montagne des Chevaux, and tourmaline in those of Montsinery-Tonegrande area.

The last point - but not the least - is that sandy formations of Cayenne shoreline are mostly coloured. The ochre colour of the sands is produced by a sort of frosted or water polished patine. Quartz grains present a ragged and tapped surface, with deep holes (as tooth caries) filled with dark red-brown coating. Some grains seem corroded. These characteristics are those of a weathering formation (weathering shield profiles and pedogenesis).

In short:

- Shoreline sands show an average roundness, with a majority of sub-angular and sub-rounded grains. A reworking of residual sediments is, however, very likely, owing to the percentage of smooth shining grains.
- The roundness of grains shows a relationship with grain-size and with the selective action of the wind.
- Sands are composed by almost pure quartz with a lower percentage of opaque grains and heavy minerals. A shield supply and a fluvial transport are significant concerning the heavy mineral composition.
- Coloured and tapped quartz grains indicate a weathering action.



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(modified of GUILLOBEZ S., 1979)

Figure 4. Geological sketch.Key-area Cayenne-Kourou

Sand formations that are accumulating along the Cayenne coast are very likely supplied by the Maroni River and they are reworking in a marine environment.

2 Mana-Pointe Isere Key-area

We compared the results of Cayenne with the sands of some beaches and cheniers of the Mara-Pointe Isere key-area (Figure 5).

This area has been studied in detail since 1984 in the framework of the IGCP-201 Project and by the Hydrology-Geomorphology Department of the ORSTOM-Center of Cayenne (Lointier and Prost, 1987; Prost, 1986; 1987).

2.1 SAMPLES OF THE GALIBI BEACH. POINTE ISERE

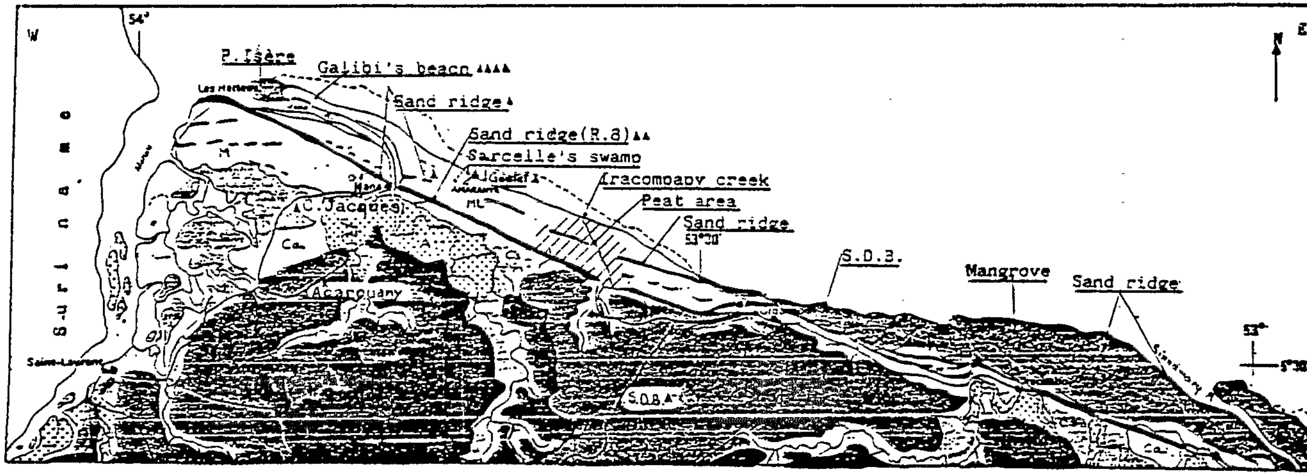
The Galibi beach is situated on the seaward side of the Pointe Isere, in the site of an old Galibi village now deserted. In 1955, the Pointe Isere was very large owing to a prograding muddy coast. Presently, it is the site of a strong erosion.

Samples have been taken under the same physical conditions in January 1987 during spring tide. They concern the foreshore surface, the receding chenier of the backshore area, the toplamina of the latter and the washover sand of the landward side of the chenier (Figure 6).

Four cumulative curves concern the Galibi area. Samples 87-6 and 87-7 have similar curves. Sample 87-4 is more homogeneous and sample 87-5 is the finest one (Figure 7b).

Sample 87-6 was taken on the surface of the washover fan - very coarse-grained material, eroded from the coastal sand and distributed inland by the waves of spring tide, during high winds and heavy sea period. Such kind of material indicates a typical straight erosion coast. Sample 87-7 concerns the topstrata of the receding chenier. It presents a significant heavy mineral concentration owing to deflation (mostly sherry coloured grains). The roundness of these samples is good (more than 80%) but it is obvious that washover sands have a more heterogeneous stock concerning the surface texture of grains (Figure 8).

KEY-AREAS: POINTE ISERE, MANA, ORGANABO-SINNAMARY (modified of GUILLOBEZ,1979)



DEMERARA FORMATION (Holocene) – Waterfront mangroves (Comowine phase)
ML – Swamps and marshes (Meleson phase)
M – Fresh water swamps (Mara phase)

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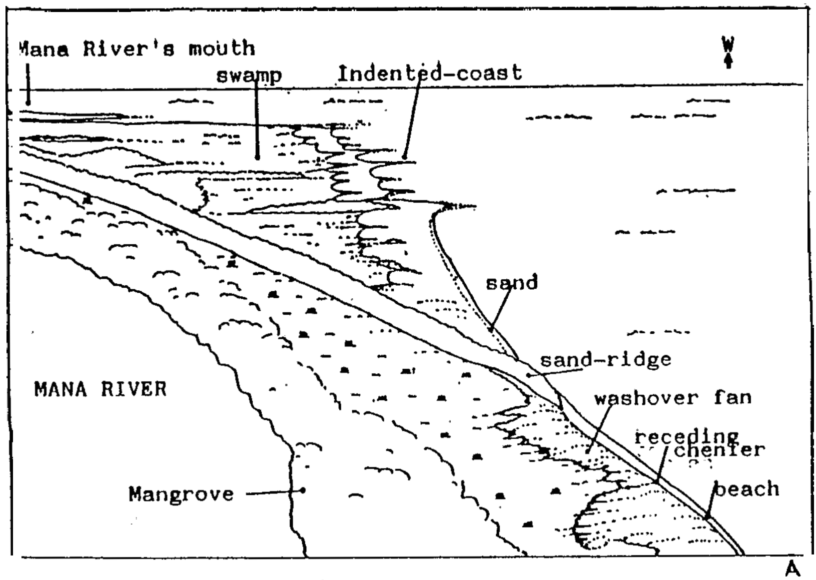
COSWINE FORMATION (Pleistocene)– Cs – Sandy Coswine (offshore bar landscape)
Ca – Clayed Coswine (Clay's landscape)

A – Alluvial deposits

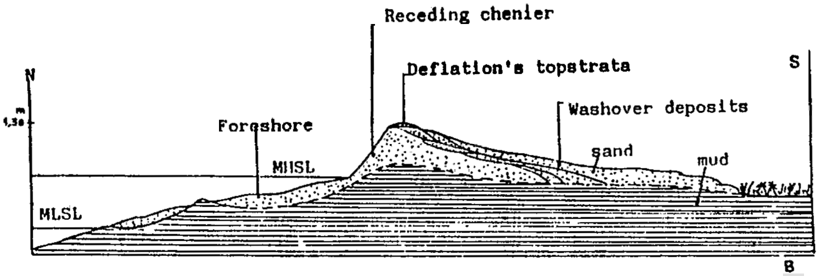
▲ – Areas where samples were collected

S.D.B.-Serie Détritique de Base

Figure 5. Sketch map.



POINTE ISERE - January 1987



Pointe Isere. French Guiana.

Figure 6. Partial view of Pointe Isere and Schematic cross-section of Galibi Beach.

The other two curves (87-4 and 87-5) concern sands of the receding chenier and of the foreshore area. The latter is the finest. The percentage of the best rounded grains is more significant than within previous samples (sample 87-4, 15,5%; sample 87-5, 25%).

To obtain further information we compared these samples with those of some neighbouring cheniers (Figure 7b). Samples 87-3 ("recent" sandy ridge within Van Uden's rice fields) and 87-8 (road Mana-Aouara, km 1) show cumulative curves superposed to washover sands curve. Sand is also very coarse-grained. The roundness is good (more than 80%) and the percentage of the best rounded grains sometimes significant - 23% within the sample 87-3, i.e. almost the same value as in the foreshore of Galibi beach.

2.2 SAMPLES FROM NEIGHBOURING BEACHES: AMARANTE AND GOULET

Some samples have been taken more eastbound along the Sarcelle swamp shoreline. The swamp area is 20 km long and 4 km wide (Figure 5). The free-water central area has 450 ha, with an average depth of 25 cm (July 1985). Sarcelle swamp is separated from the sea by a straight coast with very narrow beaches and by the waterfront mangrove. One part of the shoreline was under mud progradation in 1984-1985 (Goulet and Amarante beaches enclosed). Currently, mud is going out and these beaches are undergoing erosion.

Cumulative curves show homogeneous material (Figure 9a) with an S form. Comparison with the material of the receding chenier of Galibi point shows similar features; sands have the same granulometrical parameters. Roundness and grains surface texture are also comparable (Figure 8). The percentage of opaque grains is relatively high, mostly at Amarante foreshore (19%); sherry-coloured grains form 16% of the sample, very likely staurolite. It is interesting to notice that sherry-coloured grains have frosted surface, mostly at the coarser fractions (1 mm; 0,800 mm; 0,630 mm). However, these dull features do not cover all the grain, and bright parts (looking like shock marks) often appeared.

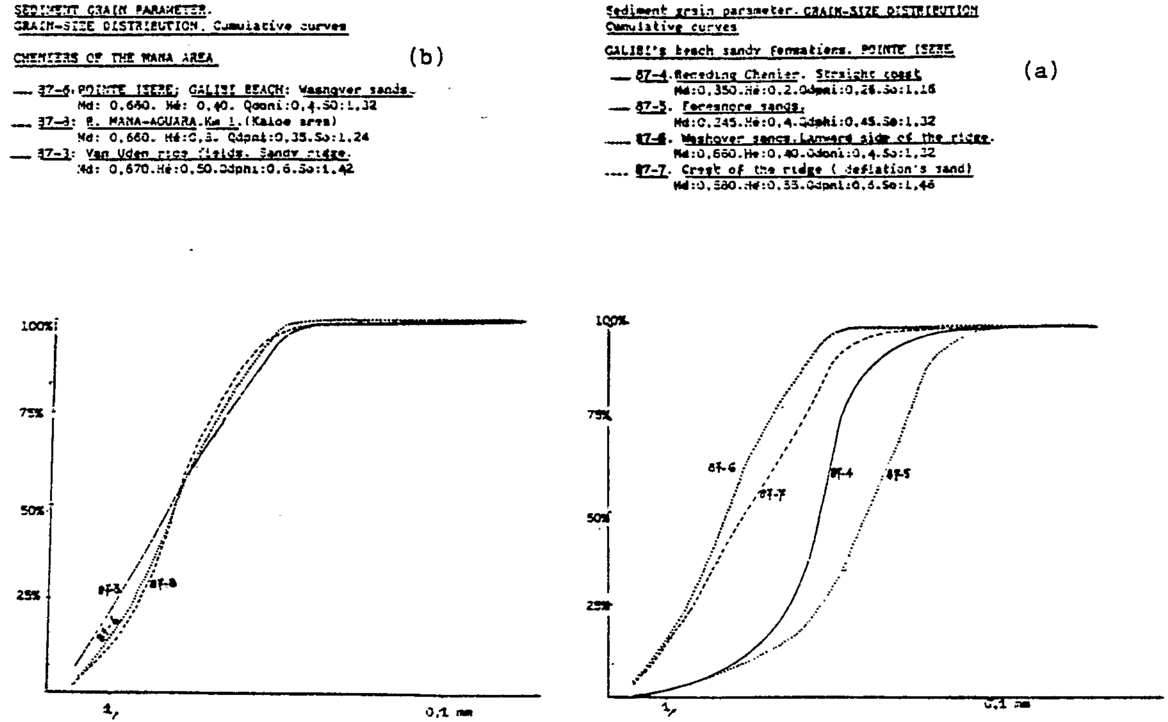
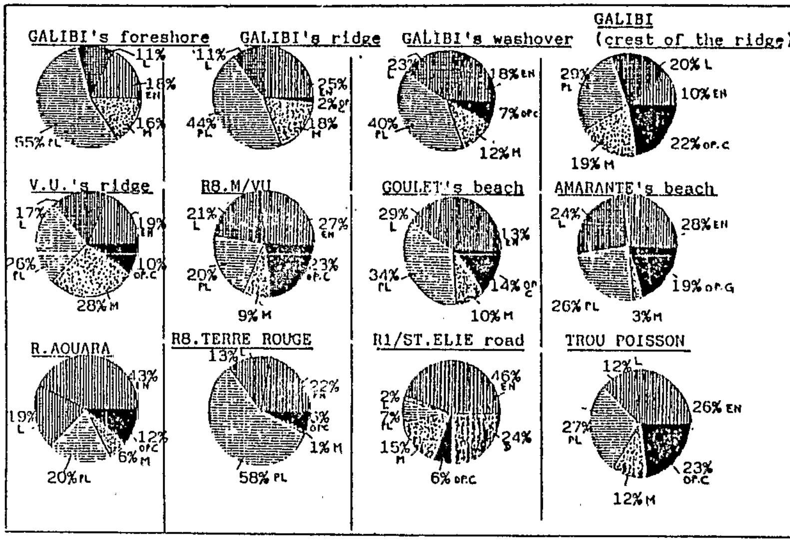


Figure 7. Key-area: Mana. Cumulative curves



- EN. Angular and subangular shining grains (éclat naturel)
- L. Smooth shining grains (émoussés-luisants)
- PL. Smooth grains with shining and frosted surfaces.
- M: Rounded frosted grains (mats)
- D. Grains with an etched surface (dépolis)
- OP.C.G. - Opaque, sherry couloured and pink grains (opaques, caramels translucides et grenats translucides)

Figure 8. Surface texture of sand grains. Key-areas: Pointe Isere, Mana, Sinnamary

These results were compared with sandy formations of some cheniers situated a few kilometres away from the shoreline, behind the Sarcelle swamp (Figure 9b). Only one example is presented here; it concerns the sands situated 2 m deep over silty clays, along the junction channel between the Mana River and Van Uden rice fields (road no 8). Sands are well sorted, pure quartz, with high concentration of sherry-coloured and pink grains (very likely staurolite and garnet), a typical Mana-Maroni heavy mineral association (Krook, 1968; Augustinus, 1978).

3 SINNAMARY KEY-AREA

To conclude, these results were finally compared with sandy material of two "old" ridges along the no 1. The first is a sand quarry situated at the crossing of road no 1 and Saint Elie road (Figure 10). Sand is very white. Cumulative curve is similar to those of several sandy ridges at the old coastal plain (Mana region). The 24% of the grains have an etched surface, characteristics that are similar to those of the S.D.B. sand quarry (km 149, road no 1).

The ridge of Trou Poisson, on the contrary, shows similar features to those of the inner coastal cheniers (Sarcelle's swamp area) (Figure 9b).

GENERAL RESULTS

1. Comparison of the mean grain-size of all samples shows that sandy material is, in general, coarse-grained (Figure 11). Very few samples concern medium sands. Fine sand and shell clastic cheniers, known in Suriname (Krook, 1968; Augustinus, 1978), have not been found here.
2. Sands present a good sorting. Comparison of the Qdphi, So and He values (Figure 12) presents roughly the same features.
3. Relationship between rounded sand grains and well-rounded sand grains (Figure 13) shows that roundness is not too developed, with a majority of sub-angular and sub-rounded grains. That seems obvious owing to the migrating mudbanks and the low-to-medium energy of the marine environment.

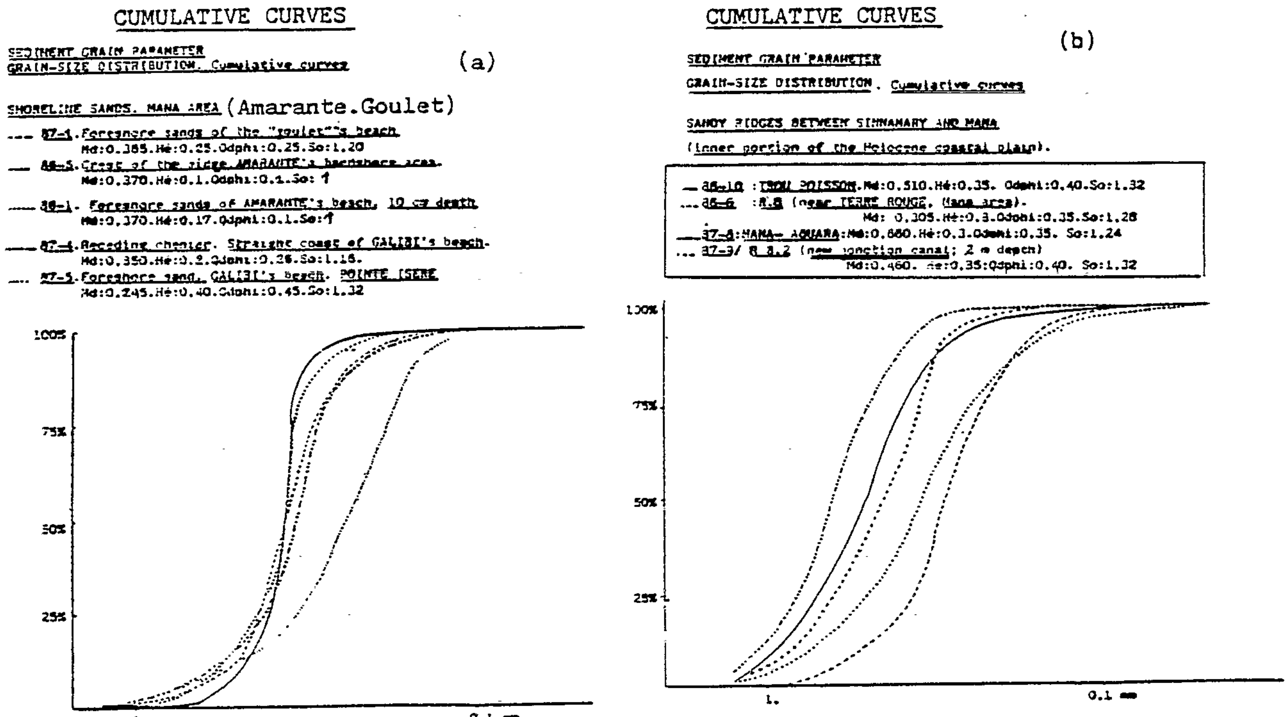


Figure 9. Sandy formations (W of Cayenne). French Guiana coast.

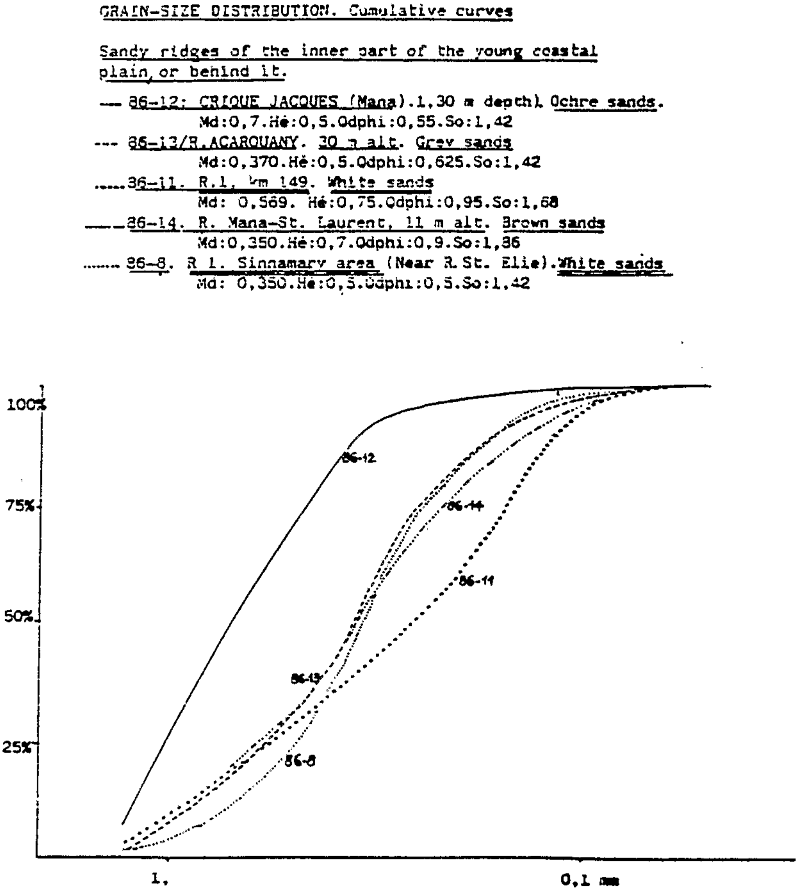


Figure 10. Sediment grain parameter.

4. Reworking of residual formations (older cheniers for instance) is very likely if we considered the part of the smooth shining grains, typical marine.
5. Heavy minerals concentrations appeared along the coastline. In the west coast they form dark red-brown deposits (Mana, Les Hattes area). Krook (1968) and Augustinus (1978) report that almandite and staurolite bearing sands of the east coast of Suriname are supplied by the Maroni and the neighbouring coast of French Guiana. A

concentration of sherry-coloured and pink grains (very likely staurolite/garnet association), has been found in the Mana zone.

6. Weathering is observed owing to the coloured and tapped surfaces of quartz grains of Cayenne and thanks to the etched surfaces of quartz and some heavy minerals (Sinnamary and Mana key-areas). Krook (1968) also reports that decreasing of garnet within chenier sands indicates the increase of weathering; the absence of garnet of the Wanica Phase in Suriname (Post-Mara and Pre-Moleson) is significant if compared with garnet percentage of the Moleson and Commowine ridges.

7. Figure 14 shows the relationship between Qdphi and the Md. We can observe that sandy material from Cayenne beaches and from shoreline formations of the west coast have similar dispositions. A relationship appeared between the washover deposits of Pointe Isere and the chenier of the Mana-Aouara road. Cheniers of Van Uden area are correlated with Pleistocene sands. At least, and "old" ridge of the Pleistocene coastal plain has similar position in the graph as the S.D.B. sands of the road no 1 (km 149). So, the supplies of S.D.B., Coswine sands and shield formations are evident.

CONCLUSION

These results show that:

- Chenier sands are (and were) supplied by local sources (basement weathering formations, S.D.B. Formation, Coswine Formation) transported by rivers and reworked by the sea. Reworking of old cheniers is also very likely.
- Until now, we have no data concerning sandy Amazon supply, as in Suriname. However, heavy minerals studies must be done to provide mineralogical data. Such information is necessary to discuss weathering problems and to define cheniers generations.
- Chenier evolution is very dynamic. It is (and always was) directly correlated with the specific shoreline conditions of the Guiana coast.
- Chenier formation continues to occur presently along the coastline. Accretionnary sandy coasts are very clearly expressed within the Cayenne Key-area (for instance, at Anse de Remire and at the eastern part of Montjoly beach). Erosional sandy coasts, on the contrary, appeared mostly on the west coast (Pointe Isere Key-area).

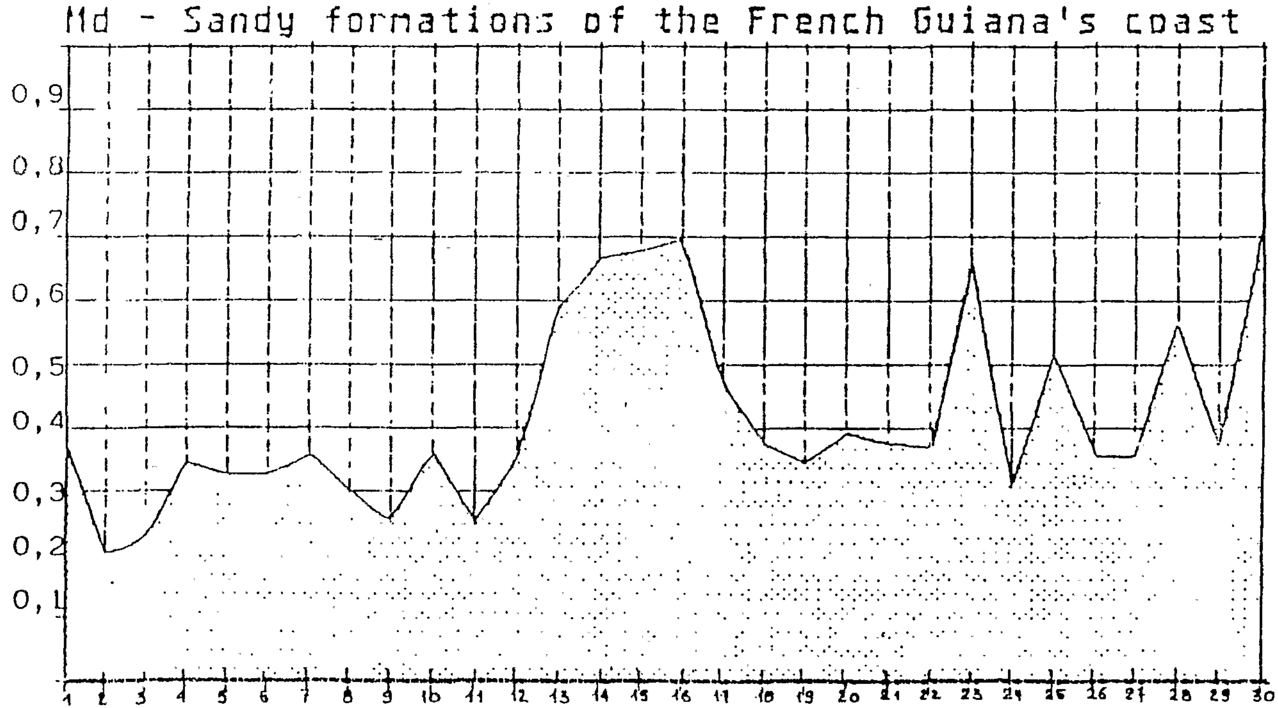
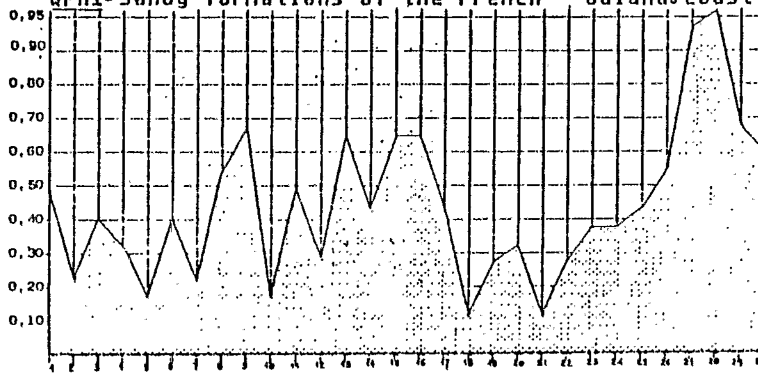


Figure 11. Median particle diameter.

A- QPHI- Sandy formations of the French Guiana's coast



B - QdPHI, SO and HE values (comparison)

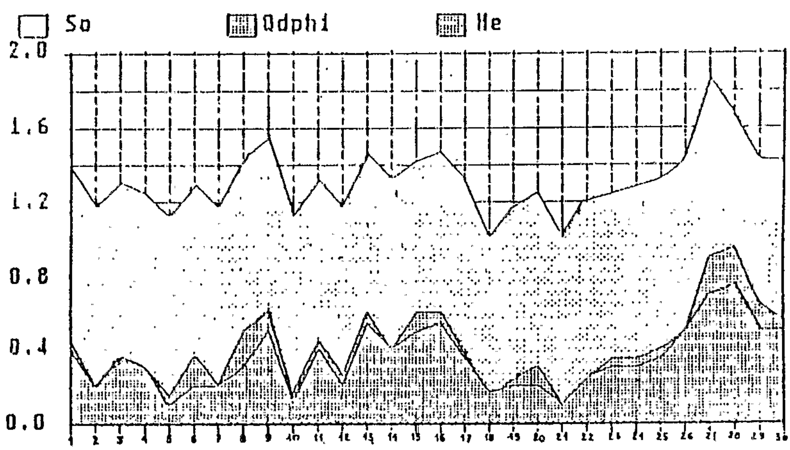


Figure 12. QPHI. Sandy formations of the French Giuana coast.

FORESHORE ZONE	CREST OF THE RIDGE	CHENIER
1. BUZARET's beach		
2. ZEPHYR's beach		
3. MONTJOLY's beach		
4. ——→	4. MONTJOLY's ridge	
5. COCOTTIERS' beach		
6. ANSE DE REMIRE's beach		
7. GOSSELIN's beach		
8. BAMBOUS's beach		
9. MAHURY's beach		
10. ——→	10. MAHURY's ridge	

KEY AREA: POINTE ISERE

FORESHORE ZONE	CREST OF THE RIDGE	CHENIER
11. GALIBI's beach		
12. Receding ridge. GALIBI's beach		
13 ——→	11. GALIBI's ridge	
14. Washover sand. GALIBI's beach		

KEY-AREA: MANA/MARAIS SARCELLE

FORESHORE ZONE	CREST OF THE RIDGE	CHENIER
15. ——	15. ——	——→ 15. VAN UDEN's ridge
16. ——	16. ——	——→ 16. " " (10 cm depth)
17. ——	17. ——	——→ 17. New channel (2 m depth)
18. AMARANTE's beach (10 cm depth)		
19. AMARANTE's beach (20 cm depth)		
20. AMARANTE's beach (30 cm depth)		
21. ——→	21. AMARANTE's ridge	
22. COULET's beach		
23. ——	23. ——	——→ 23. R. AOUARA (Kaloe)
24. ——	24. ——	——→ 24. R 8., TERRE ROUGE
27. ——	27. ——	——→ 27. R. MANA-ST. LAURENT 11 m alt.
29. ——→	29. ——	——→ 29. R. ACAROUANY. 30 m alt.
30. ——	——	——→ 30. CRIQUE JACQUES

KEY-AREA SINNAMARY-ORGANABO

FORESHORE ZONE	CREST OF THE RIDGE	CHENIER
25 ——→	25 ——	——→ 25. TROU POISSON
26. ——→	26. ——	——→ 26. R. 1 / ST. ELIE

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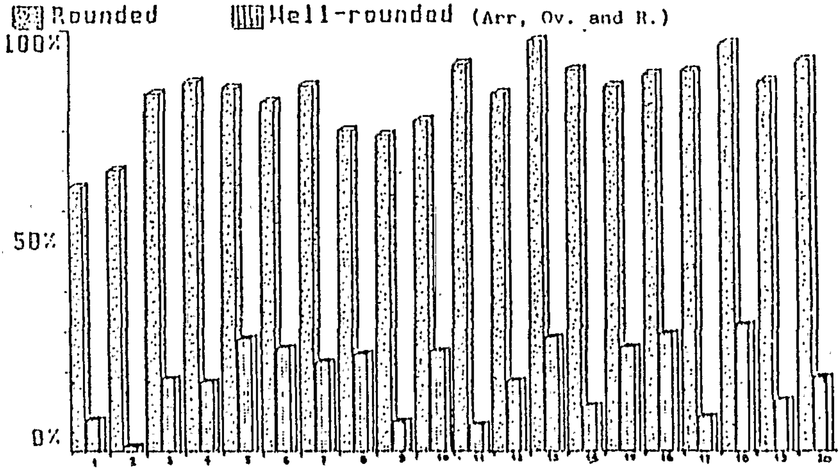
28. SAND PIT OF THE S.D.B. FORMATION. (Serie Detritique de Base). Km 149, R. 1.

Key area: Cayenne. Key of figures 11 and 12



French Guiana's coast

KEY-AREA: CAYENNE

1. BUZARET's beach
2. ZEPHYR's beach
3. MONTJOLY's beach
5. MONTJOLY's: crest of the ridge
6. COCOTTIERS' beach
6. ANSE DE REMIRE's beach
7. GOSSELIN's beach
8. DAMNOUS' beach
9. MAHURY's beach
10. MAHURY: crest of the ridge.

KEY-AREA: POINTE ISERE

11. Foreshore zone of the GALIBI's beach
12. Receding chenier of the GALIBI's beach
13. Crest of the ridge (deflation's surface). GALIBI's beach
14. Washover sand. Landward side of the ridge. GALIBI's beach

KEY-AREA: MANA-MARAIS SARCELLE

15. Chenier. Van Uden's rice fields
16. New jonction channel between the Mana River and VAN UDEN's rice fields. 2 m depth.
17. Foreshore zone of the AMANANIE's beach (10 cm depth)
18. Foreshore zone of the COULET's beach.
19. R. Mana-Aouara (Kaloe's rice fields)
20. R.B/TERRE ROUGE's road

Figure 13. Relationship between rounded sand grains and well-rounded sand grains.

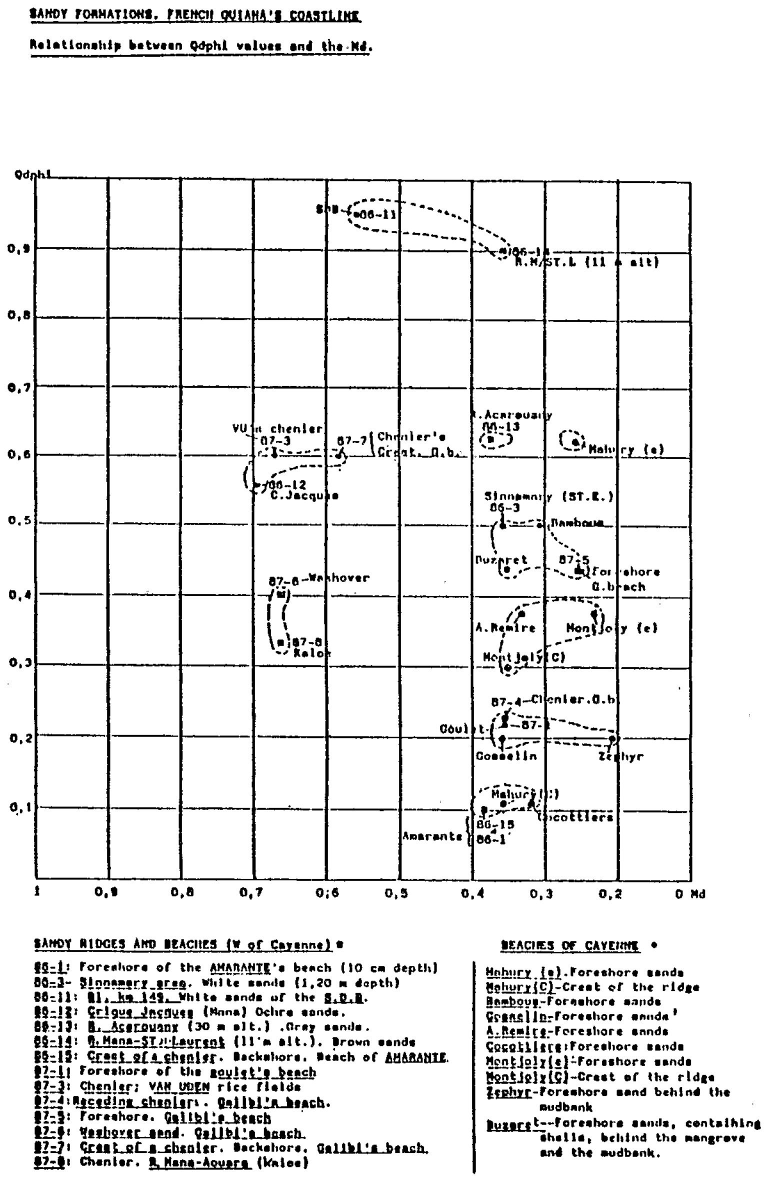


Figure 14. Relationship between Qdphi values and the Md.

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