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Organic matter assemblages from recent sediments of the Tacarigua coastal lagoon (northern Venezuela)

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Abstract

Sediments of the Tacarigua coastal lagoon in northern Venezuela are rich in organic material. The lagoon and its sediments are therefore important as a modern-day analog for the interpretation of palynofacies assemblages in clastic sediments that formed in tropical coastal environments. Samples representative of the most important subenvironments of the lagoon were collected and prepared with standard palynological methods. The organic materials were analyzed in terms of biological origin, source area and textural characteristics. The analytical results were evaluated with standard statistical techniques. Based on Principal Components Analysis (PCA) six sample groups are differentiated. Sample groups A and B are very rich in humic gels and they represent the western part of the lagoon in which sedimentation largely reflects the influence of the River Guapo. Sample group C contains both humic gels and degraded plant material. Group C represents the central part of the lagoon where sedimentation is influenced both by the River Guapo and the lagoon mouth. Sample group F contains sub-equal percentages of degraded algal and/or bacterial material, humic gels and degraded plant material. Group F is representative of the eastern part of the lagoon where autochthonous sedimentation is important. Sample groups D and E which have a high percentage of degraded algal and/or bacterial material, are representative of sediments that were laid down in close proximity to mangrove vegetation.

In view of the varied character of the organic assemblages in these modern lagoonal deposits, the interpretation in environmental terms of similar fossil assemblages is complex and requires a careful consideration of all the evidence.

Introduction

The optical analysis of sedimentary organic matter is an important tool for the study of the thermal history of sedimentary basins (Staplin et al. 1982), the evaluation of the petroleum source-rock potential (Batten 1981), the reconstruction of past sedimentary environments (Batten 1982), and the recording of eustatic variations of sea level (Gorin & Steffen 1991).

At present, a significant effort is being made in the palynological study of organic matter for paleoenvironmental purposes (Lorente 1986). In this context, two main approaches are possible: 1) comparing the results of organic analyses with sedimentological observations, and 2) studying modern analogs, that is, evaluating the nature of organic matter from present-day sedimentary environments. In both cases, characteristic assemblages of organic matter can be shown to characterize specific environments. The presence of similar organic assemblages in present-day and in older palynological samples enables one to infer past environments through the application of the principle of uniformity.

In Venezuela, the study of modern palynofacies analogs has been applied to a variety of environments (Lorente 1986, 1990). The present work contributes through the analysis of subenvironments from a coastal, brackish-water lagoon complex. Its main purpose is to document the relationship between the organic assemblages and the environments in which they have been deposited.

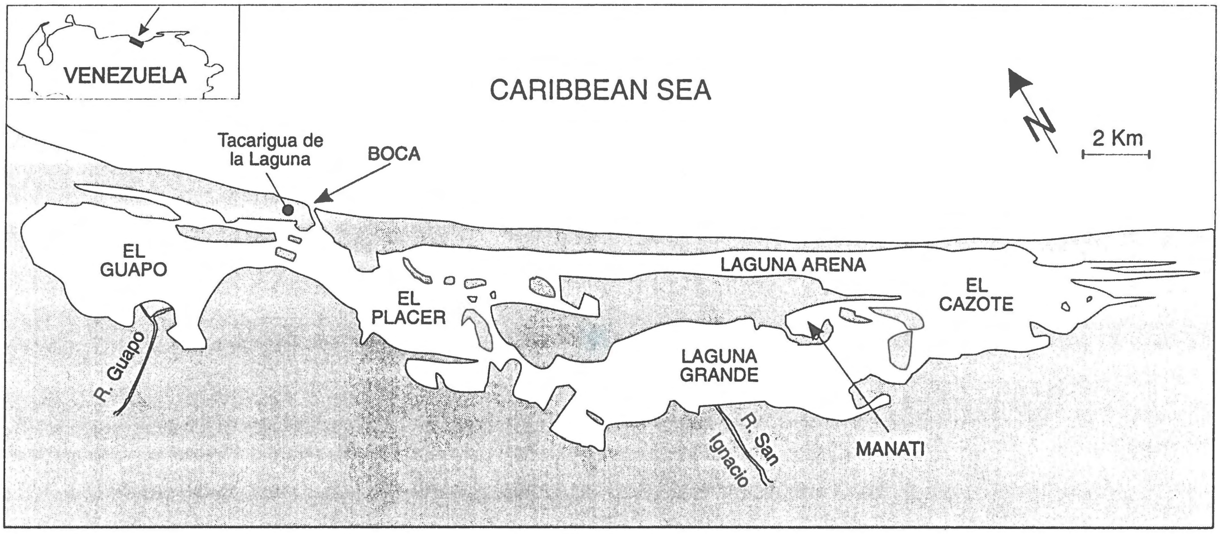

Fig. 1. Location map of Tacarigua Lagoon.

Study area

General characteristics

The Tacarigua coastal lagoon is situated between about 65°42′–65°00′ long W and 10°13′–10°20′ lat N (Fig. 1). It is about 28 km long and 5 km wide, and covers some 78 km^2 (Okuda 1969). Physiographically, it forms part of the coastal plain of Barlovento, which is underlain by the Holocene sediments of the rivers Tuy, Cúpira and Guapo.

The Tacarigua Lagoon became isolated from the sea in the Holocene, following the last marine transgression, during which continental waters were in open communication with the sea. Marine sedimentation caused the formation of a sandy bar, and continental sedimentation took place beyond this bar, forming a complex of small 'lakes' (locally called 'lagunas') and deltas (Chacartegui & Baldy 1978). At present, the bar is cut by a relatively small channel, which connects the lagoon with the sea. However, this channel is sporadically blocked by coastal sedimentation. The incoming of marine water through the lagoon mouth ('boca') determines the development of a tidal delta, with both active and inactive lobes. Groundwater also flows into the lagoon. It can be saline, brackish or fresh, depending on the characteristics of the subterranean interface between salt and fresh water, which is commonly located some 300 m off the southwestern lagoon coast (Chacartegui et al. 1985). The influx of different waters determines a complex pattern of minor currents and salinity distribution within the different parts of the lagoon.

The lagoon is shallow, with an average depth of about 1 m, and a maximum depth of 4.2 m. Water level variations due to tides are lower than those determined by precipitation, which occur seasonally and may reach 60 cm. The pattern of salinity variations is very complex, and changes in both space and time. The salinity ranges from fresh to hypersaline. However, the content of suspended material is constantly high, reaching values of more than 400 mg/l (Balda 1975, Chacartegui & Baldy 1978, Okuda 1969).

The vegetation consists predominantly of mangrove communities, dominated by *Avicennia nitida* L. (Jaq.) and *Rhizophora mangle* L., whereas in the adjacent alluvial plain, lowland gallery forests and marsh communities predominate. According to Ferraz-Reyes (1991) the aquatic biota is dominated taxonomically by diatoms, dinoflagellates and cyanobacteria. In order of abundance, however, the order is cyanobacteria-diatoms-dinoflagellates. The total number of organisms/liter ranges from 5.9×10^4 to 3×10^5. Ecologically, these organisms appear to be more influenced by the rivers than by tides, and their concentrations in one part or other of the lagoon appear to be controlled by the seasonal fluctuations of the river supplies.

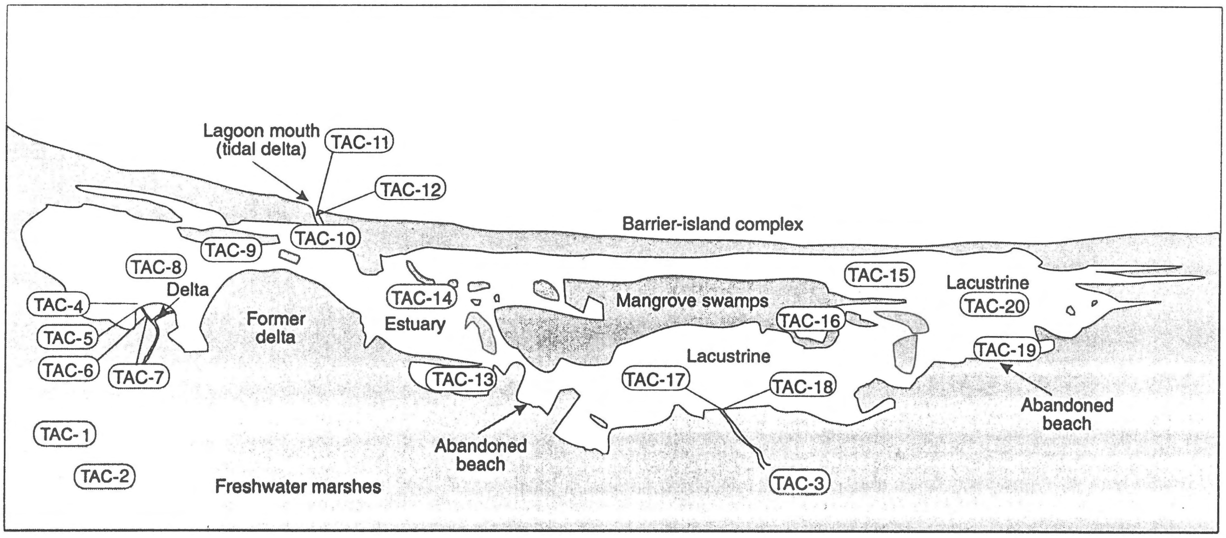

Fig. 2. Sedimentary environments of Tacarigua Lagoon (after Chacartegui & Baldy 1978) and sampling sites TAC-1 to 20.

Previous sedimentological work

Figure 2 shows the different sedimentary subenvironments of the Tacarigua Lagoon. Chacartegui & Baldy (1978) and Chacartegui et al. (1985) carried out detailed sedimentological studies of the lagoon, and their results provide a useful framework for the present study.

The sandy barrier bar forms the coarsest sediment fraction of the lagoonal deposits. It consists of sand supplied by both the sea and the rivers. Sand is also present in the lagunas, but in smaller quantities. Most of this sand is of detrital origin, and quartz predominates.

Conversely, the finest grained deposits (silt and clay) dominate the sediments of the small lagunas. However, there is also a coarser fraction of shell fragments, organic remains and minor sand. The ratio between shell fragments and silt + clay depends on the proximity of mangrove roots, where shellfish thrive. Fine-grained sediments are dominant in the south and west. Kaolinite and illite are the most abundant clay minerals, reflecting the detrital character of the Tacarigua sediments, especially in the west, where the River Guapo flows into the lagoon.

The sediments are mostly allochthonous. They are supplied by the rivers Guapo and San Ignacio, and to a lesser extent by tidal influx into the lagoon and, seasonally, by ground water. Autotochthonous components are of minor importance and consist mainly of biological remains, pyrite, and carbonate and evaporite minerals.

Organic matter is one of the main constituents of the sediments. In the Laguna Grande area (Fig. 1), it forms more than 60% (dry weight) of the sediment. The highest concentrations occur in the east and south, whilst the lowest concentrations (around 10%) were measured in the El Guapo area in the west. The restricted circulation of the lagoon favours the preservation of the organic matter.

Both the amounts and the geochemical characteristics of the sediments in the Tacarigua Lagoon are largely controlled by the rivers that discharge into the lagoon.

Sampling

The sampling of surface sediments was carried out together with the sedimentologist F. Chacartegui after his extensive sedimentological studies, in order to select representative locations for each subenvironment, considering both sedimentological and hydrological features. The following samples were selected (Fig. 2):

Alluvial plains

TAC-1. Recent alluvium (brown clayey sand) from a meander of the River Guapo.

TAC-2. Brown silty soil, from the gallery forest of the River Guapo.
TAC-3. Recent alluvium (clayey sand) from the seasonally flooded gallery forest of the River San Ignacio.

Alluvial deltas

Delta front
TAC-4. Delta front of the River Guapo, water depth approximatley 20 cm. Clay underlying the present-day deltaic sand. The clay was probably deposited in a laguna environment (lake sediments, from a sedimentological point of view), before the progradation of the delta.
TAC-5. River Guapo. Clayey silt overlying a deltaic sand bar. Vegetation: mangrove.
TAC-17. Delta of the River San Ignacio. Brown clay from the mouth of the main channel (30 cm depth). This is an incipient delta which is being colonized by *Avicennia nitida*. At the time of sampling, there was a superficial water current from the laguna into the river mouth.
TAC-18. River San Ignacio. Delta front, near the locality of TAC-17. Brown clay at about 30 m from the river mouth. Brackish water, water depth about 20 cm.

Channels
TAC-6. Silt from the bank of the main channel of the River Guapo delta. Well-developed aquatic vegetation, with the freshwater macrophytes *Sagittaria, Ludwigia, Eichornia, Lotus, Lemna* and *Typha* (field observations, without botanical collection). Fresh water.
TAC-7. Clay from the mouth of the main channel of the River Guapo (depth 50–60 cm). Close to mangrove roots.

Lagunas

Center
TAC-8. Brown organic clay from the center of the Guapo laguna. Slightly brackish water (about 1 m depth).
TAC-16. Black organic lake sediment from the laguna Manatí, which is a small, anoxic laguna surrounded by mangrove vegetation. Saline water (1 m depth).
TAC-20. Center of El Cazote. Black clayey sediment, highly organic. Hypersaline water (1.2 m depth).

Shores
TAC-9. Brown sandy clay from the shore of the Guapo laguna, close to mangrove roots. Very shallow, brackish water (5 cm depth).
TAC-15. Black clays close to mangrove roots, at the very back of the sandy bar in Laguna Arena. Saline water.
TAC-19. El Cazote. Abandoned beach, due to the migration of the whole lagoon complex. Surficial, black, organic layer below a few centimeters of water. The beach deposits are close to an area disturbed by human activities (cattle grazing, crop-farming).

Tidal delta

TAC-10. Brown sandy clay in an inactive part of a tidal delta in the lagoon mouth, close to *Rhizophora mangle* roots, which species is colonizing the site. Water depth about 10 cm.
TAC-11. Active part of the tidal delta. Brown silt from the bank of a distributary channel.
TAC-12. Active part of the tidal delta. Dark organic layer just beneath the surface of a sand bar.

Estuary

TAC-13. Laguna Grande. Black, lacustrine sediment with high organic content from a small anoxic, restricted freshwater laguna (maintained by underground water). This laguna is saline during the dry season, when the seepage of fresh water stops. About 1 m depth.
TAC-14. Laguna Grande. Black, organic clay from the center of the laguna (1.5 m depth), where the hydrological regime is estuarine in character.

Chemical treatment and organic matter analysis

The samples were treated with HCl and HF with an automatic processor. The organic fraction was separated by centrifuging in a solution of Zn-bromide. Mounting was done with glycerine jelly, without sieving.

The organic matter was analyzed microscopically in two different ways: granulometry and identification of composition. The granulometric analysis was done with the package ADIE (Lorente 1989), a system that allows to carry out digital analysis of particles directly on a microscopic image. The parameters computed

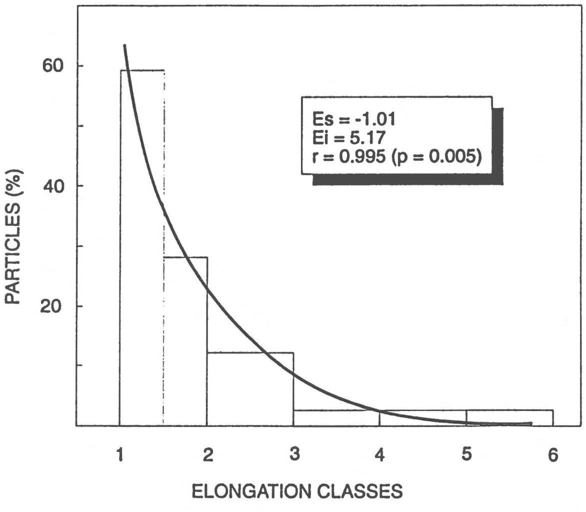

Fig. 3. Hypothetical example of the fitting of a negative exponential function to the histogram of elongation measurements. Es = slope, Ei = intercept, r = correlation coefficient, p = significance level.

Table 1. Tacarigua Lagoon. Mean percentages of the palynomacerals in 20 samples

Palynomacerals	Mean (%)	Var. coef.
Algal and/or bacterial deg. mat.	26.75	127.0
Individual algae	1.43	239.3
Colonial algae	0.83	185.8
Humic gels	48.95	65.6
Carbonaceous particles	0.83	265.1
Degraded plant tissues	16.45	138.1
Cuticles	1.58	120.7
Sporomorphs	1.38	100.6
Fungal remains	1.05	170.7
Animal exoskeleton remains	0.70	313.0
Preserved plant tissues	0.20	249.2
Fluorescence	32.55	108.3

are mean particle size (Mz), kurtosis (K), skewness (Sk1) and standard deviation (De), referred either to the number of particles (P) or to the area occupied by them (A). Size is expressed in the phi-scale (Friedman & Sanders 1978). The number of particles analyzed is between 1000 and 1500 per sample. Since ADIE provides only graphs for parameters such as elongation (E) and irregularity (I), two different methods were used to express them numerically. The irregularity is measured by ADIE as the ratio between particle perimeter and the perimeter of a reference circle with the same area as the particle being evaluated (Lorente 1986). In this study, the logarithm of the percentage of regularly shaped particles, i.e. those having a ratio between 1 and 1.5 was taken as the measure of 'I'.

Elongation is the ratio length/breadth. This gives different classes, ranging from equidimensional to filiform. The elongation plots (histograms) have the typical shape of negative exponential functions. Therefore, the fitting of these types of mathematical expressions with the elongation data was tested for each sample. Linear correlation coefficients ranged between – 0.985 and – 0.999, while the level of significance of the slopes was between 0.05 and 0.005. As a consequence, the parameters of the exponential negative expressions (Slope [Es] and intercept [Ei]) adequately describe the distribution of the elongation classes of particles (Fig. 3).

For the identification of the particles, the classification of Lorente & van Bergen (1990) was used. It is based on the response of the particles to white transmitted and incident light, as well as to the fluorescence under incident UV radiation. The categories distinguished were: algal and/or bacterial degraded material (A/Bd), individual algae (Ai), colonial algae (Ac), humic gels (HG), carbonaceous particles (Cb), preserved plant tissues (T), degraded plant tissues (Td), cuticles (C), sporomorphs (S), fungal remains (F) and animal exoskeleton remains (Am).

Principal components analysis (PCA) was carried out by means of the MVSP package (Kovach 1989), through the diagonalization of the centered covariance matrix. In order to identify the significant components, the test of the 'broken stick' of Frontier (1976) was used. Multidimensional plots were made according to the method of Andrews (1972), which allocates a trigonometric function to each sample, in which the coefficients are the scores from principal components analysis. In this way, each sample is represented by a sigmoidal curve. The shape of the curve allows grouping it with other curves, since the graphic similarity depends on the Euclidean distance of the multidimensional points represented by the curves. In this way, components of a dimension higher than 3 may be represented thus avoiding loss of information (Rull & Vegas-Vilarrúbia 1993).

Table 2. Tacarigua Lagoon. Mean granulometric measures of 20 samples, compared with those of sample TAC-18

Parameter		Mean	Var. coef.	TAC 18
Mean particle size	P	6.21	5.29	6.27
Kurtosis	P	1.13	9.56	1.08
Skewness	P	- 0.11	78.70	- 0.12
Deviation	P	0.93	20.32	0.85
Mean particle size	A	4.79	20.08	5.26
Kurtosis	A	0.92	7.52	0.93
Skewness	A	0.07	178.87	0.08
Deviation	A	1.09	21.70	0.96
E (intercept)		4.85	7.89	5.19
E (slope)		- 0.86	25.37	- 0.98
1n Irregularity		4.46	1.79	4.43

P = referred to number of particles; A = referred to area.

Results and interpretation

General characterization

Table 1 shows for each parameter the average of the variation coefficient of all the samples analyzed. If a reasonable upper limit of 10% of variation is assumed (Cochran 1963, Rabinovich 1980), then none of these mean values are representative of the lagoon as a whole. Therefore, it is not possible to characterize the organic matter of Tacarigua through the composition of a single organic assemblage. However, the general dominance of humic gels, degraded algal and/or bacterial material and degraded plant tissues is clearly evident. The variability of granulometric parameters is lower (Table 2) and some of them may be considered as representative of the entire Tacarigua Lagoon (< 10% of variation). This is the case for the mean size and kurtosis referred to the number of particles, for kurtosis referred to the area, for elongation and for irregularity. The sample which is most similar to the average values is TAC-18 (Table 2), taken in a delta front, in the Laguna Grande area, at about 30 m from the mouth of the River San Ignacio. This sample represents best the mean organic matter granulometry of the lagoon.

Classification

PCA was used to classify the organic assemblages present, using the variability of the parameters measured. Table 3 shows the weighting of the parameters on the significant principal components, as well as the percentage of the total variance accounted for by each of them. Component I is clearly associated with the algal and/or bacterial degraded material, and with the fluorescence, while component II is related to the degraded plant tissues, thus indicating that 76.56% of the total variance is accounted for by degraded remains. Since allochthonous material is dominant in the Tacarigua sediments (Chacartegui & Baldy 1978), it is possible that most organic matter remains reach the lagoon in a degraded condition, carried by rivers, and that they are mixed with the autochthonous elements. Component III is significantly influenced by the mean particle size with respect to area, indicating the importance of granulometry, and highlighting the significance of parameters that measure the particle area. Finally, component IV is related to well-preserved and recognizable individual algae, which are autochthonous, and to humic gels. This component is a factor representing the mixing of autochthonous (algae) and allochthonous (humic gels) elements.

Figure 4 shows the groups formed by the multidimensional plots, considering these four components. Sample TAC-4 (Fig. 5), however, does not belong to any group. It differs mainly by having a lower grain size and a lower content of oxidized terrestrial material. This is consistent with the sedimentological interpretation that the laguna sediments concerned pre-date the present deltaic deposition (see section Sampling).

Composition and environmental relationships

Figure 6 shows the geographic distribution of the six groups identified. Three of these groups are almost restricted to particular subenvironments (A: alluvial plains, E and F: lagunas), while the others comprise samples from different sedimentary settings (Table 4). Group A is formed by samples from the alluvial plain and the main channel of the River Guapo delta, containing almost exclusively humic gels (Figs 7, 8). This indicates that these particles originated in the alluvial plains and were carried to the lagoon by the River Guapo. Group B is very similar to A. In group B about 80% of the organic matter are humic gels supplied by the River Guapo, as the samples are from the El Guapo laguna and the lagoon mouth environments (Fig. 1). Therefore, group B represents the lagoon environments that are more directly influenced by the River Guapo as a source of sediments. The mean particle size is smaller than in group A, reflecting lower energy environments (Table 5). Group C consists of four samples from El

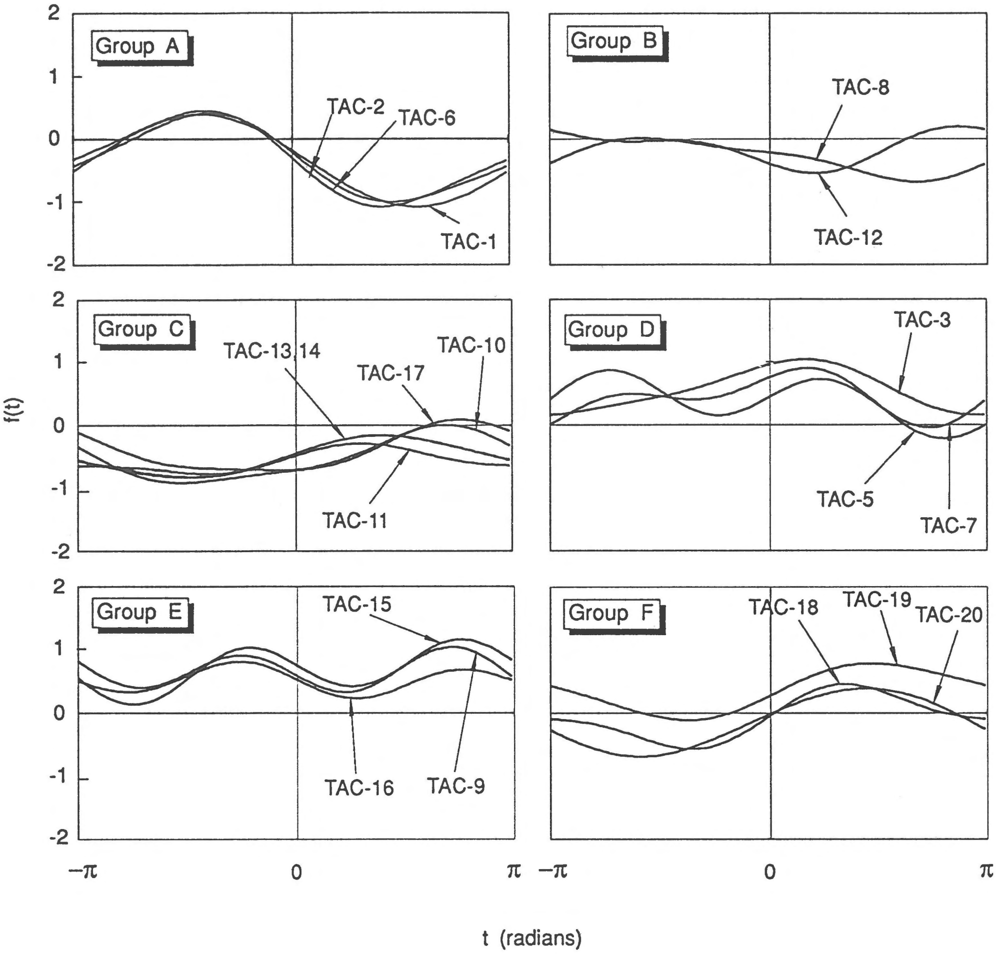

Fig. 4. Multidimensional plots (Andrews 1972) and grouping of 19 samples, using the PCA scores. See Fig. 5 for sample TAC-4.

Placer and adjacent areas, including two from the tidal delta, and of one from the San Ignacio delta. This group is influenced by the River Guapo (on average about 37% of humic gels, Figs 7, 8), and probably also by the lagoon mouth and the River San Ignacio. The connection between the latter river and the El Placer area is narrow and twisting (Fig. 1). Hence, the influence of the River San Ignacio is probably not as important as that of the lagoon mouth. The high proportion of degraded plant tissues (Fig. 7) suggests that some reworking and diagenesis may occur after sedimentation in the El Placer area, possibly under the influence of the lagoon mouth dynamics and of internal currents. This is consistent with the fact that, hydrographically, this area has an estuarine circulation, with alternating inflow and outflow (Chacartegui & Baldy 1978). In addition, the sector from where sample TAC-13 was taken has a seasonally alternating influx of fresh water (ground water) and brackish water, creating internal currents that may cause redistribution of sediments.

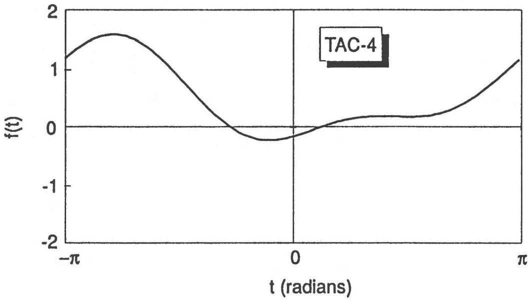

Fig. 5. Multidimensional plot of sample TAC-4.

Groups D and E consist of samples taken close to the mangrove trees (except for one of them, com-

Table 3. Tacarigua Lagoon. Eigenvalues and eigenvectors from the PCA considering all the variables studied

Variable		Components I	II	III	IV
Mean particle size	P	- 0.034	0.054	0.256	0.025
Kurtosis	P	- 0.014	0.016	0.064	0.012
Skewness	P	- 0.002	0.006	- 0.003	0.070
Deviation	P	0.037	- 0.017	- 0.121	- 0.088
Mean particle size	A	- 0.173	0.163	0.667	0.374
Kurtosis	A	0.001	0.005	- 0.020	0.003
Skewness	A	0.011	0.022	- 0.007	- 0.096
Deviation	A	0.037	- 0.066	- 0.127	- 0.041
E (intercept)		- 0.049	0.009	0.124	0.316
E (slope)		0.025	- 0.003	- 0.067	- 0.169
1n Irregularity		- 0.010	- 0.001	0.040	0.055
Algal/Bacterial deg.		0.609	0.346	0.199	0.010
Individual algae		0.190	- 0.035	- 0.224	0.485
Colonial algae		0.147	- 0.013	- 0.287	0.075
Humic gels		- 0.205	- 0.252	- 0.099	0.477
Carbonaceous part.		- 0.066	0.093	- 0.110	- 0.084
Degr. plant tissues		- 0.442	0.804	- 0.275	0.063
Cuticles		- 0.131	0.133	- 0.112	0.012
Sporomorphs		0.076	0.042	- 0.081	0.293
Fungal remains		0.148	0.059	- 0.016	- 0.015
Animal exoskeleton r.		0.101	- 0.050	- 0.376	0.320
Preserv. plant tissues		- 0.004	- 0.045	0.038	0.153
Fluorescence		0.487	0.312	- 0.023	0.109
Cumulative variance		56.1%	76.5%	84.1%	89.5%

Table 4. Tacarigua Lagoon. Numbers of samples belonging to the different environments and groups (sample TAC-4 is not included, see text)

Environments	A	B	C	D	E	F	Total
Alluvial plain	2			1			3
Delta front			1	1		1	3
Delta channel	1			1			2
Laguna (center)		1			1	1	3
Laguna (shore)					2	1	3
Tidal delta		1	2				3
Estuary			2				2
Total	3	2	5	3	3	3	19

ing from the alluvial plain), and in fact are closely associated with mangrove root systems, independent of the general sedimentary environment. The common characteristic of both groups is the high percentage of degraded algal and/or bacterial materials (Figs 7, 8), but they differ in that humic gels are slightly more abundant in D, so that the extent of mixing of autochthonous and allochthonous material is greater in this group. In addition, group D has on average larger and less elongated particles than group E (samples from lower

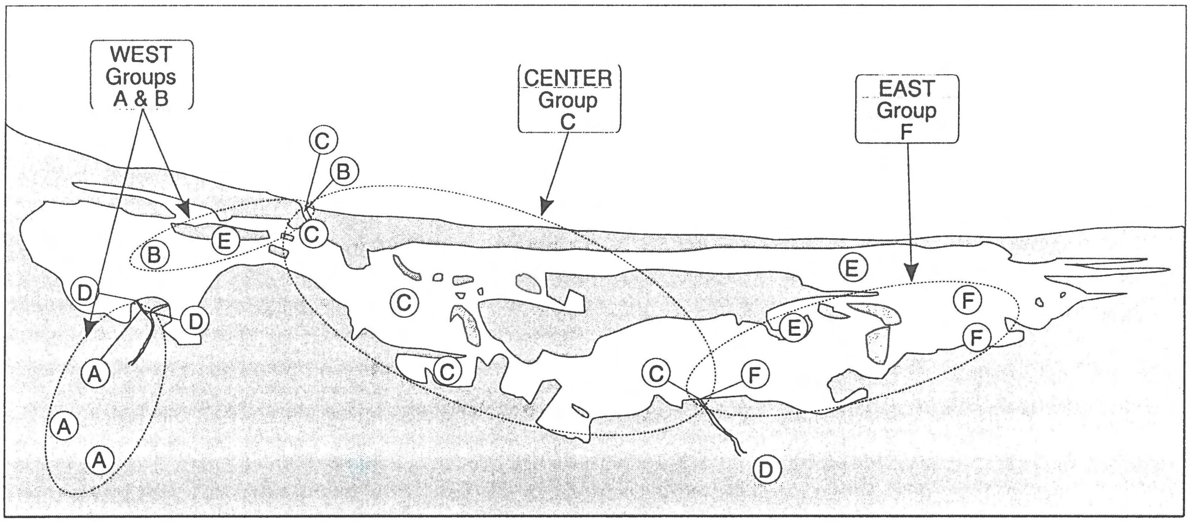

Fig. 6. Areal distribution of the groups of samples defined by multidimensional plotting (Fig. 4).

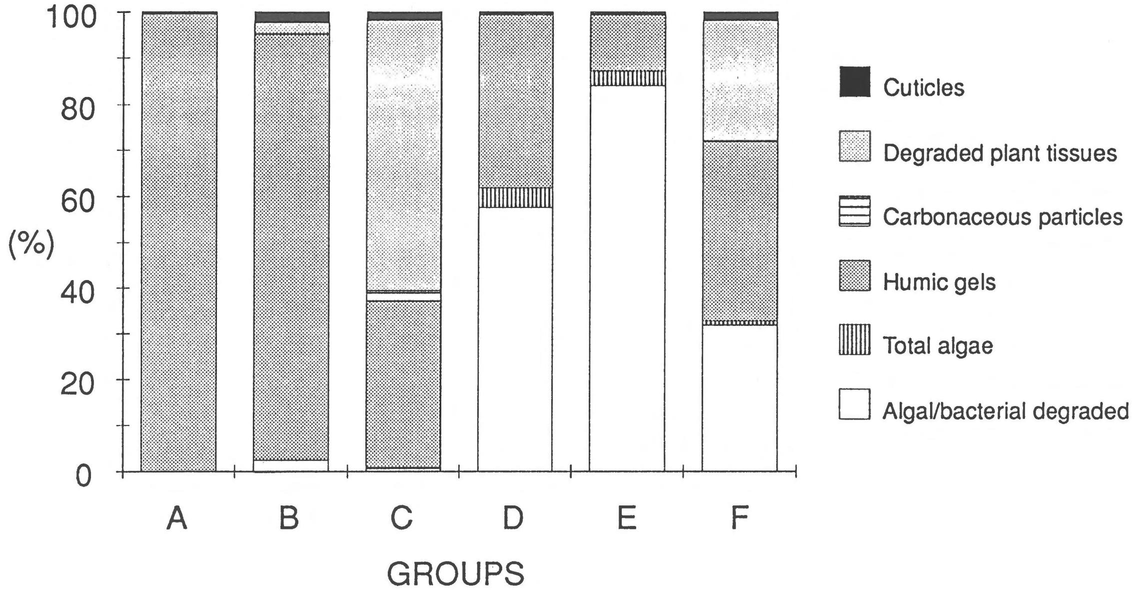

Fig. 7. Average organic matter composition of the groups of samples defined by multidimensional plotting (Fig. 4). Total algae = individual + colonial algae.

energy waters, Table 5). Finally, group F comprises two samples from the El Cazote area, and one from the San Ignacio delta. This reflects the influence of the river on the eastern part of the lagoon complex. This group is similar to E, but differs in that it contains more degraded fragments of plant tissues (Figs 7, 8).

A clear geographic pattern reflecting the influence of the River Guapo can be recognized in the areal distribution of the groups (Fig. 6):

West. Area of direct influence of the River Guapo (represented by humic gels). Groups A and B.

Center. Moderate influence of the River Guapo and lagoon mouth. Group C.

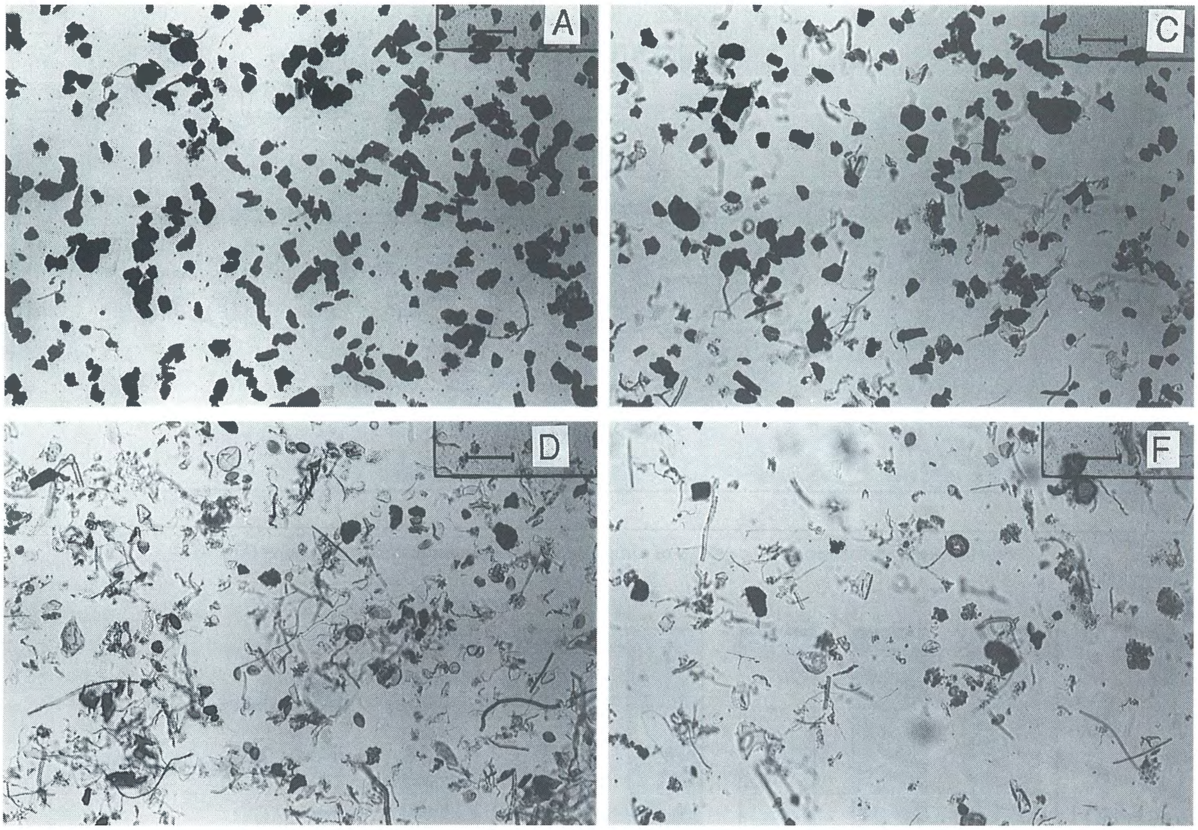

Fig. 8. Photomicrographs of selected samples representing group A (TAC-2), group C (TAC-14), group D (TAC-3) and group F (TAC-19). Length of scale bars is 80 μm.

Table 5. Tacarigua Lagoon. Means for granulometric parameters in each of the groups

Parameters		A	B	C	D	E	F
Mean particle size	P	6.27	5.86	6.38	6.49	6.07	6.30
Kurtosis	P	1.16	0.96	1.22	1.21	1.08	1.13
Skewness	P	- 0.16	- 0.07	- 0.09	- 0.03	- 0.22	- 0.11
Deviation	P	0.89	0.99	0.81	0.81	1.15	0.88
Mean particle size	A	4.79	4.39	5.40	5.46	3.68	5.14
Kurtosis	A	0.89	0.93	0.92	0.93	0.92	0.92
Skewness	A	0.02	0.07	0.06	- 0.04	0.24	0.14
Deviation	A	1.22	1.10	0.92	1.06	1.25	1.00
E (intercept)		4.85	4.98	4.98	5.20	4.20	4.95
E (slope)		- 0.79	- 0.89	- 0.87	- 0.99	- 0.47	- 0.84
1n Irregularity		4.46	4.45	4.51	4.54	4.41	4.44

East. Autochthonous sedimentation with low to moderate influence of the River Guapo. Group F.

This pattern coincides with previously established environmental relationships. The west and east areas reflect the importance of external environmental processes on the composition of organic assemblages, while in the central area the assemblages are also influenced by internal hydrographic processes. In addition to the overall influence of the River Guapo, the geographic pattern also reflects the main sediment sources: the River Guapo in the west, the influx of the lagoon mouth and groundwaters in the center, and the River San Ignacio in the east.

Paleoenvironmental significance and conclusions

Generally, the recent sedimentary organic matter of the Tacarigua Lagoon complex is dominated by allochthonous material, mainly humic gels, degraded plant tissues and degraded algal and/or bacterial remains. However, it is not possible to describe the organic matter deposits in simple terms, because of the heterogeneity in their assemblages.

The most important parameters for classifying the samples studied are the composition and abundance of the different components. Degraded, but still fluorescent, aquatic remains, allochthonous terrestrial material, mean particle size referred to the area, and mixed autochthonous and allochthonous biogenic remains are especially significant. Six groups could be defined through objective methods, on the basis of granulometry and classification of the particulate organic matter. According to the areal distribution of these groups, the lagoon can be subdivided into three areas: west, center and east. From west to east there is a progressive decrease in the influence of the River Guapo together with an increase of the amount of autochthonous material. Sources of organic matter, lagoon mouth dynamics, internal currents and sedimentary environments control the composition and granulometric characteristics of the assemblages. The most uniform environments were found to be the alluvial plains and the lagunas. By contrast, deltaic (both alluvial and tidal) and estuarine samples have a greater diversity of assemblages, depending on the relative importance of the different sources of organic matter, and on postdepositional reworking.

These results must be taken into account in studies of lagoonal paleoenvironments using palynofacies assemblages. Coastal lagoons may have a complex sedimentary record and a notable spatial heterogeneity in their organic assemblages which is determined by the simultaneous action of several controlling factors. Hence paleoenvironmental interpretations from rock samples formed in these types of environments must be addressed very carefully.

This study must be complemented with other analyses including pollen (in progress) and authochthonous preservable aquatic organisms such as foraminifera, diatoms and others. Also, it is desirable that the study of organic matter assemblages is accompanied by research on the molecular scale, in order to provide a biogeochemical basis to compare ancient and modern sedimentary organic matter for paleoenvironmental purposes.

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