

## CHARACTERIZATION OF SURFACE SEDIMENTS ON THE NORTHERN AND EASTERN BRAZILIAN SHELF

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### SYNOPSIS

Calcareous bottom deposits are the most abundant on the Brazilian tropical shelf. Due to mixing of elements of different origin, grain-size distribution does not characterize such deposits. Therefore, composition of the sediment is the main criterion for distinction. Four facies have been recognized: quartz sand, mud, biotrital sand and algal fragments.

### INTRODUCTION

Data published on the character of surface sediments, sampled from shelf bottoms around the world, utilize generally standard grain-size analyses to show distribution of gravels, sands, muds and their mixtures. Distribution of calcium carbonate content and fauna (foraminifera, mollusks, etc.) usually is given less significance, if reported at all.

The shelf area off northern and northeastern Brazil, between Cape Orange and the Tropic of Capricorn, recently investigated by the authors (summaries: Kempf, Coutinho & Moraes, 1970; Kempf, 1970b; Mabesoone & Coutinho, 1971;

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Mabesoone, 1971), is composed mainly of calcareous sediments, requiring an alteration of the classical analytical scheme. The terrigenous quartz sand zone, as well as the muddy bottoms, are important only at the extremes of the area: the Amazonian shelf and South of Cape Frio. For a better understanding of the sediment distribution, some general oceanographical features of this portion of the Brazilian shelf must be considered.

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## OCEANOGRAPHIC CONDITIONS

The physiography of the shelf shows two different types of cross-sections. (1) The "tropical" area, between the Pará River mouth and Cape Frio (Fig. 1, for all topographical and other reference) shows an almost flat shelf bottom profile, finishing at a depth of 60-70 m, with an abrupt break to a fairly steep continental slope. The major extent of the bottom has a depth less than 50 m. The shelf width varies between 5 and 115 nautical miles, exception made of the broad Abrolhos area. The oceanic banks possess the same flat bottom with a 50-70 m depth and a steep slope. (2) Towards North, "equatorial" area, from the Pará River to Cape Orange, as well as towards South, "sub-tropical" area, from Cape Frio southwards, the shelf is wider, chiefly the 50-200 m depth zone, occurring the break at this latter depth. In the northern area, the 50-100 m depth zone is more extensive; in the southern area, it is the 100-200 m zone.

Hydrologically, there exists a similar contrast between the tropical region, with high salinity and clear waters, and both other regions, North and South, with a lower salinity and more suspended matter. The greater part of the tropical area undergoes direct influence from the South-Equatorial Current which divides into two branches near the northeastern point of Brazil (North Brazilian Coastal Current and Brazil Current). The NE part of the continent has a semi-arid climate, resulting in reduced supply of terrigenous material to the shelf. This leads to stable conditions of salinity, temperature and water transparency, favourable for the growth of vegetal life (calcareous algae) and hermatypical corals, to depths of almost 100 m. In the North West, the continental influence increases considerably near the Amazon River mouth: in the South, the Brazil Current leaves the shelf and is substituted by the so-

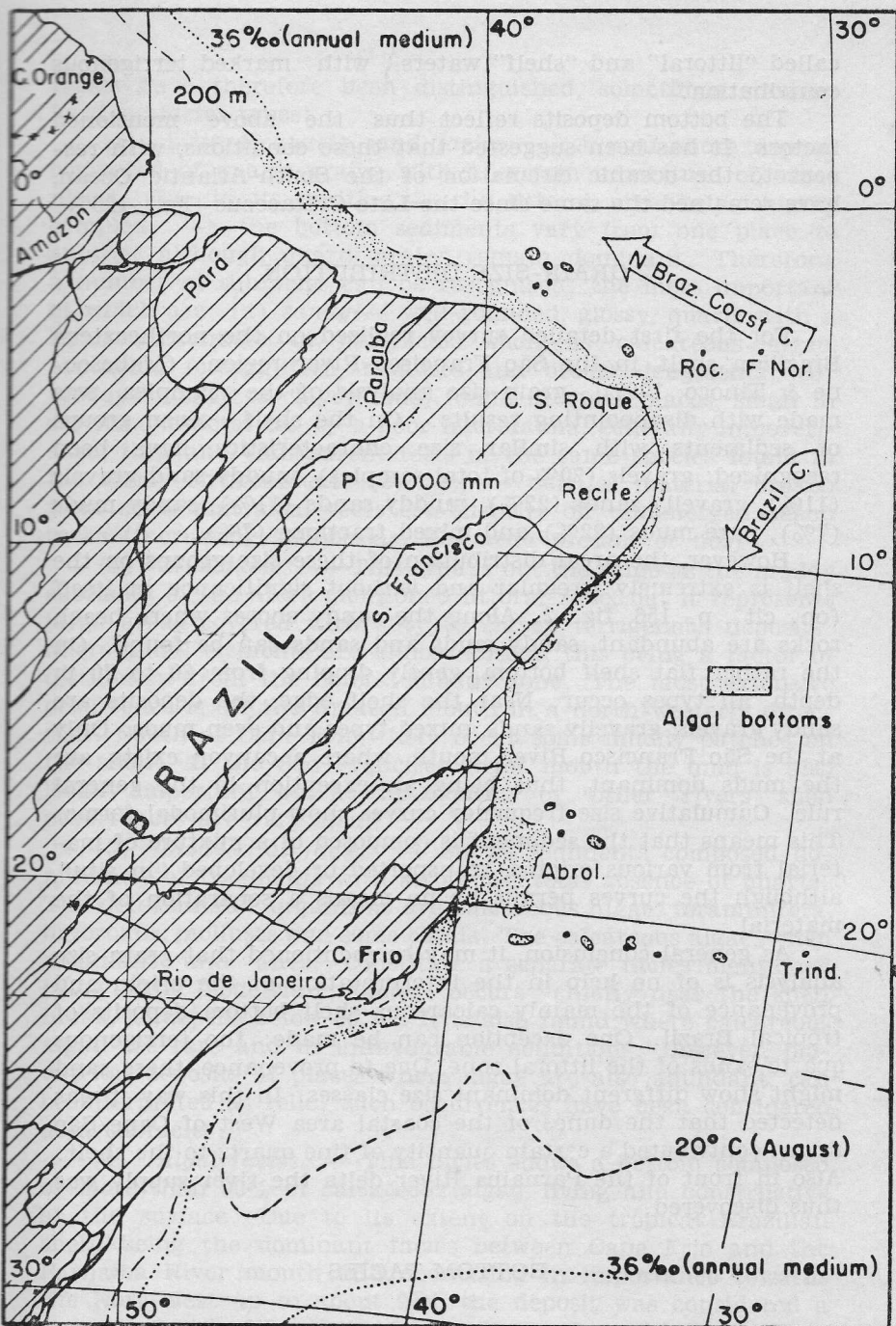


Fig. 1 — Northern and eastern Brazilian shelf: general environmental conditions.

(P 1,000 mm/year = "dry polygon". Minimum 20°C and medium 36‰ S = surface water data. 200 m line = shelf edge (arbitrary).

called "littoral" and "shelf" waters, with marked terrigenous contribution.

The bottom deposits reflect thus the above mentioned factors. It has been suggested that these conditions, with respect to the oceanic circulation of the South-Atlantic Ocean, have remained the same since the Late Cretaceous (Fell, 1967).

## GRAIN-SIZE DISTRIBUTION

For the first detailed survey realized on the northeastern Brazilian shelf, in the São Francisco River region (Mabesoo-ne & Tinoco, 1967), grain-size analysis of the samples was made with disappointing results. On the shelf, seven groups of sediments with similar size characteristics have been recognized: gravels (20% of total samples), muddy sand-gravels (11%), gravelly sands (22%), muddy sands (11%), sandy muds (7%), pure muds (22%) and mixed fractions (7%).

However, the areal distribution of these size groups on the shelf is extremely irregular and without significance in itself (op. cit., p. 156, fig. 2. Along the sandy shores where beach rocks are abundant, sandy muds and sands can be found. On the rather flat shelf bottom, gently dipping from 20 to 70 m depth, all types occur. Near the shelf edge, the deposits are sandy gravels, gravelly sands, mixed types and even muds. Only at the São Francisco River mouth, where a canyon exists, are the muds dominant, thus being an exception to the general rule. Cumulative size frequency curves show plurimodal forms. This means that the sediment is composed of a mixture of material from various origins, transported or developed "in situ", although the curves permit by no means a separation of the material.

As general conclusion, it may be mentioned that grain-size analysis is of no help in the interpretation of the origin and provenance of the mainly calcareous shelf bottom deposits of tropical Brazil. One exception can be made: the terrigenous quartz sands of the littoral zone. Due to provenance, these sand might show different dominant size classes. In this way it was detected that the dunes of the coastal area West of Cape São Roque contributed a certain quantity of fine quartz to the shelf. Also in front of the Parnaíba River delta the river supply was thus discovered.

## BOTTOM FACIES

Thus the composition of the sediment is the most important feature to be taken into consideration. The following bottom



facies have therefore been distinguished, sometimes showing local subfacies types:

(1) *Littoral quartz sand facies*. — A near-shore deposit composed of quartz grains with a certain admixture of organisms. Due to its position — the littoral area being highly complex — the bottom sediments vary from one place to another although quartz grains remain dominant. Therefore, a number of subfacies can be recognized; the most important of which are: (a) *sandy* — well-rounded, glossy, quartz with a small percentage of organisms such as calcareous algae, benthonic foraminifera, molluscs and broken fragments; (b) *muddy* — silty to clayey mud, found at quiet places, small in extent, characterized by a poor microfauna, generally impoverished, thin and transparent tests of the same species found in the sandy environment; (c) *reef* — detrital material broken from coral and algal reefs established on submerged beach rocks (incrusting Melobesiae, *Halimeda* present or not).

(2) *Mud facies*. — This type is not the same as the muddy subfacies of the afore mentioned littoral zone, but it represents large areas covered with silty to clayey terrigenous deposits. Microfaunal elements are almost absent, this being a factor of distinction from the littoral muddy zone. The most extensive occurrence is off the Amazon mouth in a north-westerly direction. South of Cape Frio, there occur some muddy patches on the shelf. At the São Francisco River mouth the mud is also locally important, but at the mouths of other rivers such occurrences are very small.

(3) *Biodetrital facies*. — Shows sediments composed dominantly of fragments with an almost total absence of quartz. The determinable organisms are calcareous algae, foraminifera, bryozoans, molluscs and some corals. The calcareous algae, when dominant and alive, constitute a separate facies mentioned below. The biodetrital facies occurs chiefly near the shelf break, at depths below 60 m. It is also found where calcareous algae are rare and in unfavourable conditions. However, biodetrital deposits at places where algae are also abundant, can be interpreted as relic; such occurrences have been considered as a subfacies.

(4) *Algal facies*. — This facies shows a bottom composed of more than 90% of calcareous algae, living and constructive at the surface. Due to its extent on the tropical Brazilian shelf, being the dominant facies between Cape Frio and the Parnaíba River mouth and decreasing in importance towards the North-West up to about 2°N, the deposit was considered a separate facies. Where the friable *Halimeda* articles constitute more than 50% of the material, a *Halimeda* subfacies was mapped.

Between these facies, zones of mixtures occur. They are often too narrow for representation on a small scale map. Only three mixed facies types are of regional importance:

(1/2) *Mixed quartz sand and mud facies*. — Especially frequent off the Amazon mouth, where the enormous supply of terrigenous mud is partly mixed with sandy material.

(1/3) *Mixed quartz sand and biotrital facies*. — A bottom deposit showing a more or less equal distribution of quartz grains and fragments of organisms. It occurs as a wide zone where also the quartz sand facies has a considerable extent, that is on the eastern Amazonian shelf.

(3/4) *Biotrital facies with algal concretions*. — A special facies in which the sand-size fraction is composed of fragments of various organisms on which cobble and boulder-size concretions of different origin occur. The nuclei of these concretions may be sand, even sandstone, bryozoans or calcareous algae; they are partly covered by Melobesiae. This mixed facies is found where calcareous algae cannot dominate anymore due to unfavourable conditions, that is on the lower and lateral margin of their living range.

For the area off Recife (Kempf, Mabesoone & Tinoco, 1970, Figs. 4 and 5), a general sediment distribution pattern was established, which may be valid for the rest of the Brazilian tropical shelf. Alongside the coast, the littoral facies dominates, with sandy, muddy and reef subfacies, respectively. The quartz sand deposit is also found at the seawards side of the reefs, down to a depth of about 15 m. Between 15 and 20 m, a zone of mixed material, quartz and biotrital sand, is found. Below 20 m, down to the shelf break at about 70 m, the algal facies dominates, with a patch of *Halimeda* concentration (subfacies). The biotrital facies is found near the shelf edge in a very narrow zone. On the calcareous bottoms a rich organic life exists; the benthic bionomy of the area is given in Kempf (1970a). The results of all the studies, considered together indicate why the grain-size distribution is so irregular.

## CONCLUSION

Generally the grain-size distribution of a sediment should reflect local transportation and accumulation conditions of the place where the sample was taken. The irregular distribution found in the area is due to the authigenous calcareous bottom. Part of the fine material is probably trapped in the interspaces of the algal structures. Dead and fossil shells and tests, besides the growth forms of calcareous algae, all of different sizes, make the bottom deposit a mixture of material of various sizes.

A separation based on size is therefore impossible. A separation based on the surface aspect of the proper material may give some results, the ancient material being more worn. In this case, the facies can only be determined and characterized by a study of its components.

At greater shelf depths, between 40 and 70 m, some organisms and their fragments, determined in the sediment, proved not to be representative for that depth. It was found that the actual contribution of living organisms to the sediment decreases with increasing depth. In this case, only the comparison with the actual living benthic populations may lead to some decisive conclusions. Above 40 m, the greater part of the sediment is thus of more recent age; living *Lithothamnium* and *Halimeda* are found to contribute a lot of new material to the bottom deposit.

The facies characterization of the shelf bottom deposits presented here thus proves to be the most useful method for the sedimentological and biological study of the tropical Brazilian shelf.

## RESUMO

Depósitos à base de material calcário constituem a cobertura mais abundante da plataforma continental do Brasil tropical. Devido a mistura de elementos de diversas origens, a distribuição granulométrica não caracteriza tais fundos. Portanto, o critério distintivo principal é a composição do sedimento. Quatro fácies foram reconhecidas: areia quartzosa, lama, areia biotetrítica e fragmentos de algas.

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