

PRELIMINARY INVESTIGATIONS OF THE SEDIMENTS
BETWEEN CABO FRIO AND SÃO SEBASTIAO ISLAND,
(BRAZIL) (1)

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RESUMO

O estudo das amostras recolhidas pelo NOc. Almirante Saldanha na plataforma continental entre Cabo Frio e Ilha de São Sebastião, permitiu a identificação de cinco tipos de fácies, distribuídas segundo uma certa zanação paralela à costa.

A fácies de areia terrígena ocupa uma faixa, relativamente estreita, próxima à costa. Ao norte da área é uma areia grossa quartzosa tornando-se mais fina para o sul. Ela é seguida por uma areia biodetrítica que cobre a maior parte da área, exceto ao sul da Ilha Grande e em frente a Cabo Frio, onde os depósitos de vasa arenosa dominam. A fácies de algas calcárias ocorre em certos lugares em frente a Cabo Frio, tornando-se porém mais abundante para o norte onde muitos "algal patches" são encontrados. Finalmente, a vasa de Globigerina é uma fácies muito especial típica de grandes profundidades, tendo sido encontrada apenas na estação 506 a 465 m.

Por outro lado, a distribuição dos diversos parâmetros estatísticos destes sedimentos mostram igualmente uma certa zanação paralela à costa.

INTRODUCTION

The oceanographical observations in the Brazilian coastal area between Cabo Frio and São Sebastião Island were carried out during september 1961 by the R/V Almirante Saldanha of

(1) Trabalho realizado com a colaboração da Diretoria de Hidrografia e Navegação (DHN) da Marinha do Brasil.

the Brazilian Navy. In this region, which is an important fishing area, there were anomalous signs which meant the total vanishment of the sardine.

This paper presents a preliminary report on the distribution of the sediments in this area.

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GENERAL DESCRIPTION OF THE AREA

Moreira da Silva (1957) and Emilsson (1956, 1959) has reported the oceanographical conditions in this area. Generally during the month of september the region is reached by polar incursions alternating with pre-frontal winds of NE-NW with cold winds of SE-SW. On the shelf there is a situation of complete up-welling which produce high values of phosphate, oxygen and plankton.

Very little work has been published on the recent sediments of the south coast of Brazil. In 1956 the vessel Tôkô-Marú has made the survey of the area for fishing exploration, and at the same time additional studies were made on oceanography and bottom samples were collected. Ottmann (1961) has studied the sediments distribution of the region between Cabo Frio and Vitória.

The topography of the area is known only in general way, and systematic surveys have not been made. The shelf off Cabo Frio is narrow, sloping seaward with a sharp break. Towards south it widens considerably with a gentle slope at the depth of 150 m. The narrowest part of this shelf covers about 25 miles from the coast, and is its flatness. However this characteristic is interrupted at a depth of 80 m when many ridges parallel to the coast appear. Ottmann (1961) has observed also at north the Cabo Frio ridges and troughs relatively oriented in the direction NE-SW. This type of depression appears to continue towards north till the region of Abrolhos. These features are probably of granitic nature whose forms are products of a residual erosion, which might or might have not been modified by later growth of organic reefs.

Mention should be made to the existence of two wide terraces that according to prof. Nasu (personal communication) could be interpreted as wave cut terraces related with the low level of the sea in the pleistocene.

SIZE ANALYSES OF SEDIMENTS

Field and laboratory investigations

The area was sampled at intervals of 12 to 15 miles, extending from Cabo Frio to São Sebastião Island and from the coast of the offing of about 100 to 120 miles. The bottom samples were taken with a dredge and also with a gravity core. The core samples will be treated in another paper. The situation of the investigated area has been presented in figure 1. At various stations the dredge did not bring up any sample. This means that the bottom may be considered as hard ground formed probably by algal limestone, and on the chart these places have been marked as of algal facies.

The color of each sample was estimated by comparison with a standard color chart (Godard & others, 1948). Ignoring minor transitions, most samples could be assined as olive brown (5Y 4/4) and olive gray (10Y 4/2).

The samples, after having been dried at 100°C, were weighed and washed on a 270-mesh stainless-steel sieve. The grain-size analyses of the coarse fraction were made by sieving. The median diameter ($Md\phi$), the quartile deviation ($Qd\phi$) and skewness ($SKq\phi$) were obtained from the cumulative curves. The percentage of calcium carbonate was determined by weight loss on treatment with dilute hydrochloric acid. It was determined on sand and mud fractions, of the sediments. The calcium carbonate is mostly in the form of organic debris.

Authigenic glauconite of the area is of two types. Most samples contain fine grained angular light-green glauconite while others show round dark-green grains. The first seems to form presently in the sediments and the second probably reworked.

Foraminifera are present in almost every sample, but is abundant in sandy-mud, particularly near the zone of up-welling. The algal fragments and bryozoans are very common, while coral and micro-molluscs are frequent. Boltovskoy (1959) state that among the benthonic species the most abundant are: *Bulimina marginata*, *Uvigerina peregrina* (forma parvula), *Cibicides bertheloti*, *Cassidulina curvata* and *Elphidium discoidale*, the latter being frequent near the coast. Of the planktonic forms, *Globigerinoides rubra*, *Sphaeroidina bulloides* and *Globorotalia menardii* are also well distributed. This faunistic assemblage differs considerably from that determined by Tinoco in northeastern Brazil. In this latter area the microfauna shows a predominance of *Amphistegina* and *Archaias*, which constitute up to 50% of the total sediment.

The distribution of the sand fraction (fig. 2), shows a higher concentration along the coastline, gradually decreasing away from the shore, in parallel bands well reflecting the isobath of 100 m. The percentage increases again in the central part of the area, due the presence of the coarse material of organic origin, i. e., calcareous sand. This central patch of high concentration of sand size material coincides with the zone of minor value of mud size material, as can be seen when the two maps are compared.

The pattern of distribution of the mud fraction is near that of the sand fraction, increasing gradually away from the coast. The fine material tends to concentrate towards south of the area, following the current pattern. Also a tongue-like of elevated concentrations of mud fractions project towards the great bay formed by the Grande and São Sebastião Islands. This feature is also shown in the map of the median diameter distribution of sediments. This map is identical with that of distribution of the sand and mud fractions. It shows very well the two zones of deposits of fine sediment separated by a band of sand size organic material over the entire area. The median diameter of the samples ranges from 1.20 ϕ to 7.00 ϕ (fig. 3).

The coefficient of sorting varies from 0.25 to 0.52 and only few samples have values to classify them as well sorted sediments. Most of them have a values between 1.10 and 1.62 suggestive of their normally sorted nature. The pattern of distribution of the coefficient of sorting shows a reduction in the selection of sediments with the increase in the distance from the coast following closely the others statistical parameters. Well sorted sediments are those near the coast corresponding with the terrigenous sand facies.

The distribution pattern of the coarse and fine fractions of calcium carbonate content (fig. 4) shows closeness with the pattern of distribution of sand and mud fractions. The gradual increase shown by the CaCO_3 content, away from the coast, is entirely due the presence of biogenic material such as algae, bryozoans, foraminifera, etc. The lowest concentrations of terrigenous matter off the coast is due to the long distance from the shore and the higher rate of biogenic sedimentation in the area. The pattern of distribution of carbonate content is, therefore, the inverse to that shown by the terrigenous minerals.

FACIES DISTRIBUTION

The sedimentary facies on the shelf off Cabo Frio and São Sebastião Island seems to be distributed in a certain zonation away from coast, showing a progressive change (fig. 5).

The terrigenous facies occupies a narrow band parallel to the coast over the entire area. From south of the city of Rio de Janeiro, it widens up until it reaches the island of São Sebastião. It is next followed by the biotrititic sand that cover the greater part of the shelf, and at few places, it reaches up to the outer shelf edge. The algal facies is found at many places off Cabo Frio, becoming more abundant from the north of the area, where many patches were found.

Within the area occupied by the biotrititic sand many sandy-mud areas were found, mainly south of Ilha Grande and in front of Cabo Frio. Globigerina ooze was only found at station 506 in 465 meters depth.

Terrigenous sand facies. — The material that is transported along the coast by littoral currents which builds the beach and near shore deposits, is essentially coarse quartz sand. Both the medium grain and the degree of sorting decrease slightly with the distance from the coast (Coutinho, 1967). The medium diameter of the grains range from 1.20 ϕ to 2.25 ϕ . Most of the samples have a negative skewness between — 0.02 to — 0.15. The coefficient of sorting varies from 0.27 to 0.65, thus classifying them as well sorted sediments.

The sands are texturally uniform and the little variation observed is due to fluctuations in the shell and organic contents, as well as the littoral current action. The bulk of organic material may attain up to 30% of the total sediment and consists of calcareous organisms chiefly pelecypods and micro-molluscs. Fragments of ferruginous sandstone and other rocks were also found. The foraminifera association is represented by the miliolids, elphididae and cibicididae.

Algal facies. — The coralligenous algae associations are well known in all tropical seas, principally of the type *Lithothamnium*, that form the true calcareous constructions. In the investigated area the algal deposits appears often as big fragments but at many places they form a real hard crust. In northeastern Brazil this facies is well exposed, and constituted mainly by the genus *Halimeda*. These bottom deposits have been studied on the shelf off Alagoas and Sergipe (Mabesoone & Tinoco, 1967). From south of Cabo Frio this facies seems to disappear having been replaced by the biotrititic sand. On the investigated shelf the algal deposits were found at depths up to 165 m. but have been particularly well developed between 40 to 80 meters depths, and generally on hard bottom. Associated with the algal facies occur coral fragments, bryozoans, micro-molluscs, spicules, foraminifera, etc. This biocenose is typical of the coralligenous bottom (Pérès & Picard, 1963).

In this region also occur small and isolated calcareous algae, which gives to the sediment the aspect of the "mearl" of Brittany. They are algae of the type *Lithophyllum solutum* (Ottmann, 1961) that unlike other calcareous algae may live in sand bottoms, mixing up with the sand grains.

On the hard bottom of the algae deposits there is a layer of fine sediment indicating that this topography is probably relict. Another characteristic is the depth of the hard bottom, always deeper than 50 meters, as also its dark gray color. This fine material with a content of calcium carbonate varying from 30 to 80%, has its origin in the biochemical disaggregation of the organic material, especially that of calcareous algae. Hyne & Goodell (1967) have reported that the layer of fine sediment covering the bottom of the coarse material on the shelf of Choctawhatchee Bay, suggests that the topography is relict and possibly related with the change of sea level.

Biotrititic. — sand facies. — This facie that covers the greater part of the shelf, occupies a large central band over the entire area. It is narrow off Cabo Frio and towards south it widens considerably. The organic fraction consists of bryozoans, calcareous algae fragments, coral, and different fragments of shells. The terrigenous fraction is represented chiefly by quartz grains and mica from the terrigenous facies. This sediment is also found on the many troughs of the algal deposits. The modal mixtures characteristics are: 10% of terrigenous sand, 70% of organic material and 20% of silt-clay size particles. In the greater part of the samples, bryozoans fragments constitute the bulk of the organic fraction.

Sandy-mud. — This is a typical facie of coastal plains, having been found off Cabo Frio, and in some places within the biotrititic facie mainly south of Ilha Grande. The fine sand fraction varies from 30 to 50% of the total sediment. The calcium carbonate content of the sand and mud fractions is less than 20% in the former and 15 to 30% in the latter.

Globigerina ooze. — It is a special facie of great depths, having been found only at the station 506 in 465 meters. The organic fraction consists chiefly of *Globigerinoides rubra* and *Globorotalia menardii*.

SUMMARY AND CONCLUSIONS

This paper is based on the results of the studied bottom samples collected by R/V Almirante Saldanha of the Brazilian Navy.

The various sedimentary facies on the shelf off Cabo Frio and São Sebastião Island seems to show a certain zonation parallel to the coast.

The terrigenous sand facies is confined to a narrow strip over the entire shelf. In the north of the area it is essentially a coarse quartz sand; southwards, however, fine quartz sand dominates. It is followed by the biotrititic sand which covers the greater part of the area, excepting the southern part of Ilha Grande and in front Cabo Frio where sandy-mud deposits occupy a wide area. The algal facies is found at many places off Cabo Frio, becoming more abundant in the north, where many algal patches were found. Finally, the *Globigerina ooze* was found only at station 506 at a depth 465 m.

The distribution pattern of the different statistical parameters of these sediments shown also a gradual zonation from the coast seawards. The organic material increases towards the central and southeastern parts of the area, what explains the high calcium carbonate content in the sediments there. On the other hand, the percentage of terrigenous material decreases in the same direction.

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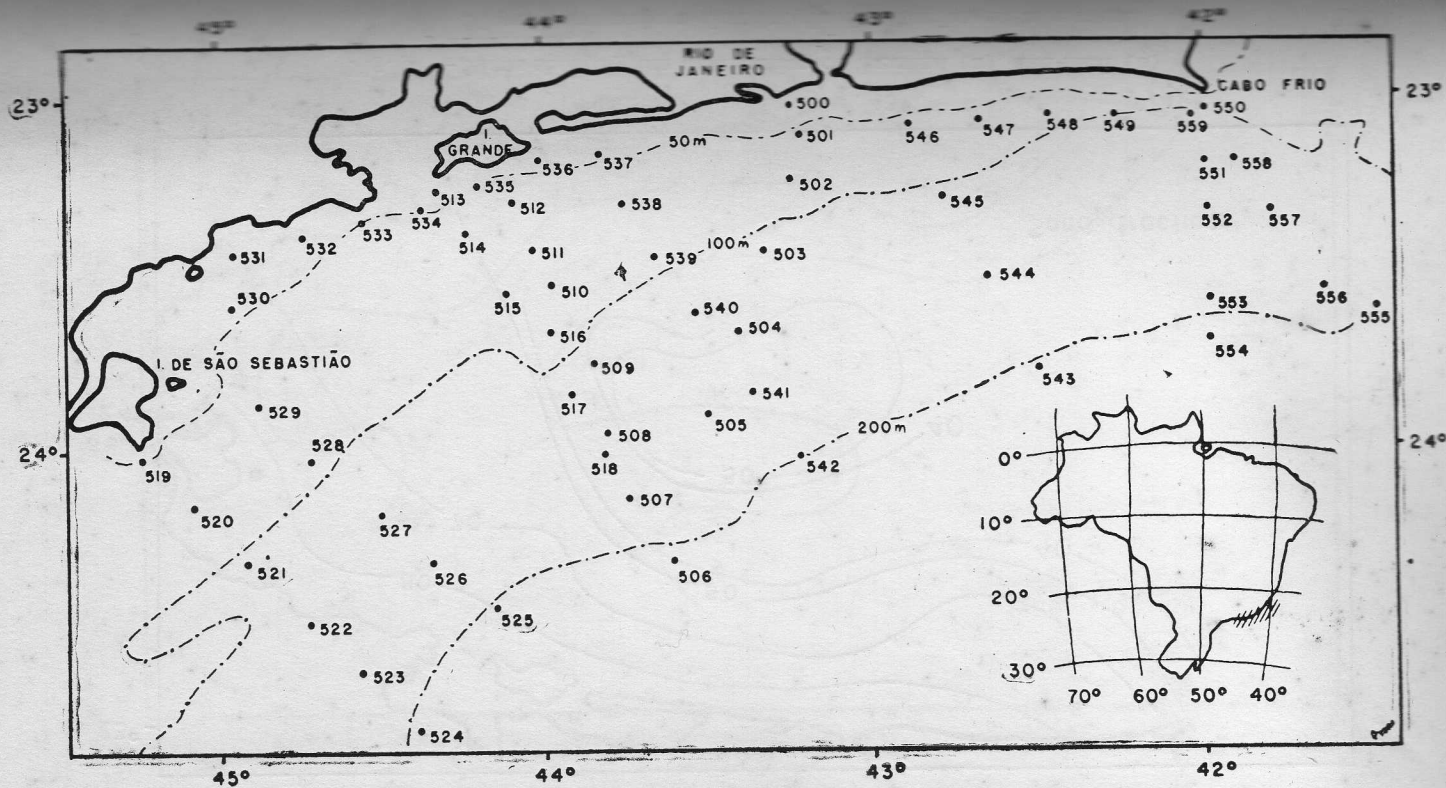


Fig. 1 — Situation of the investigated area and sampling localities
 Situação da área estudada com as estações de amostras.

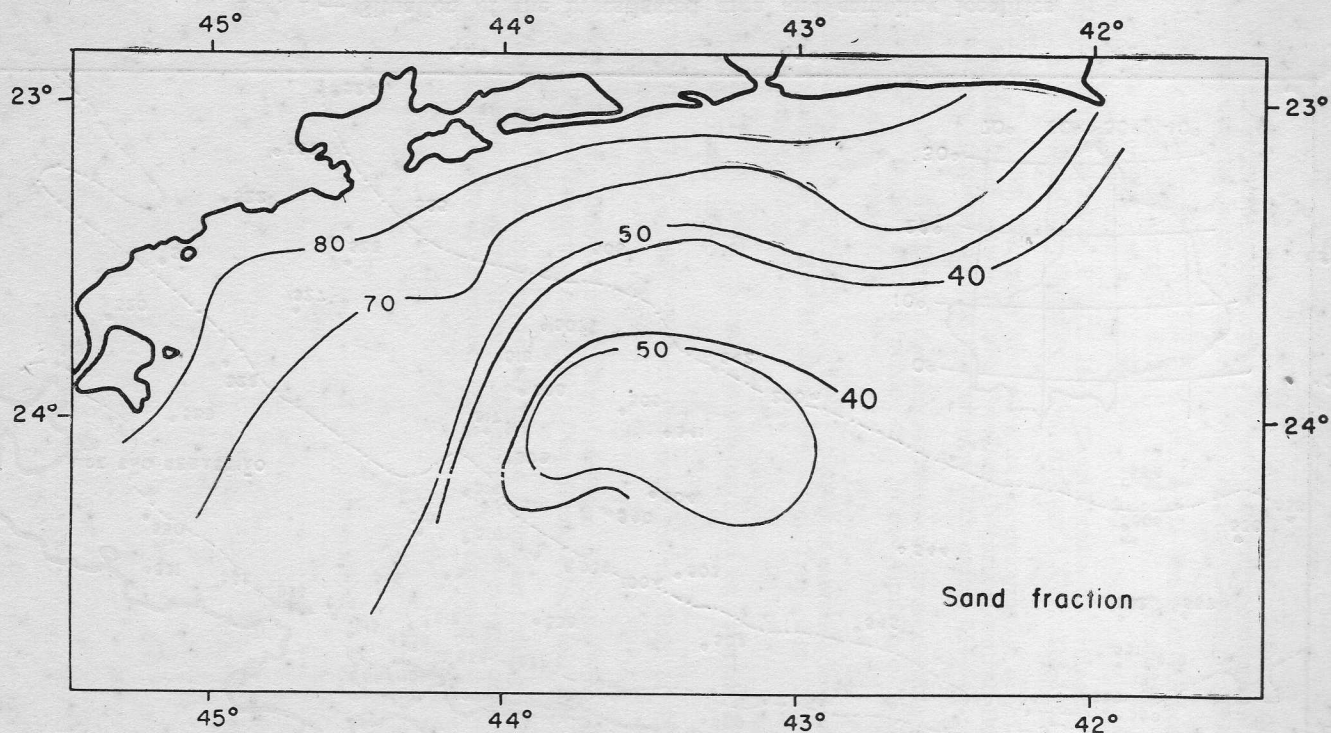
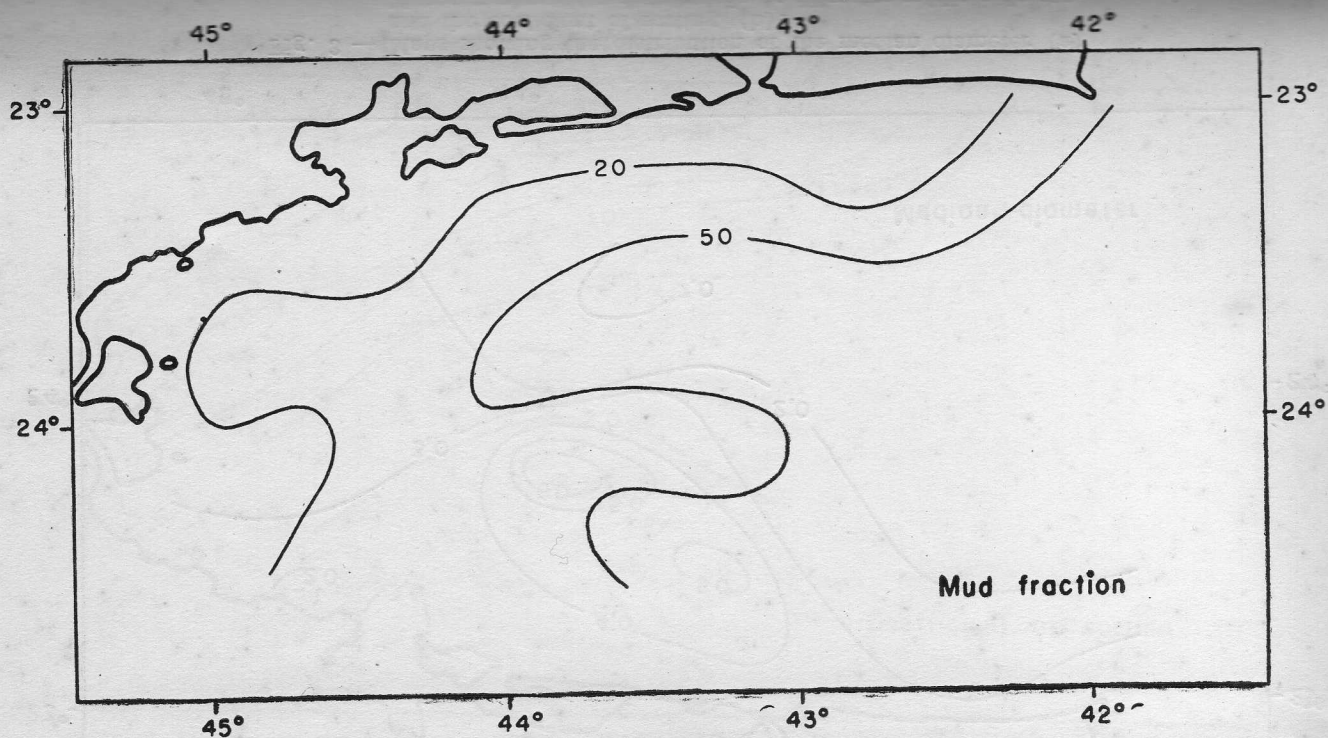


Fig. 2 — Maps showing the distribution of the sand (a), and mud (b) fractions.
Mapas mostrando a distribuição das frações areia e vasa.



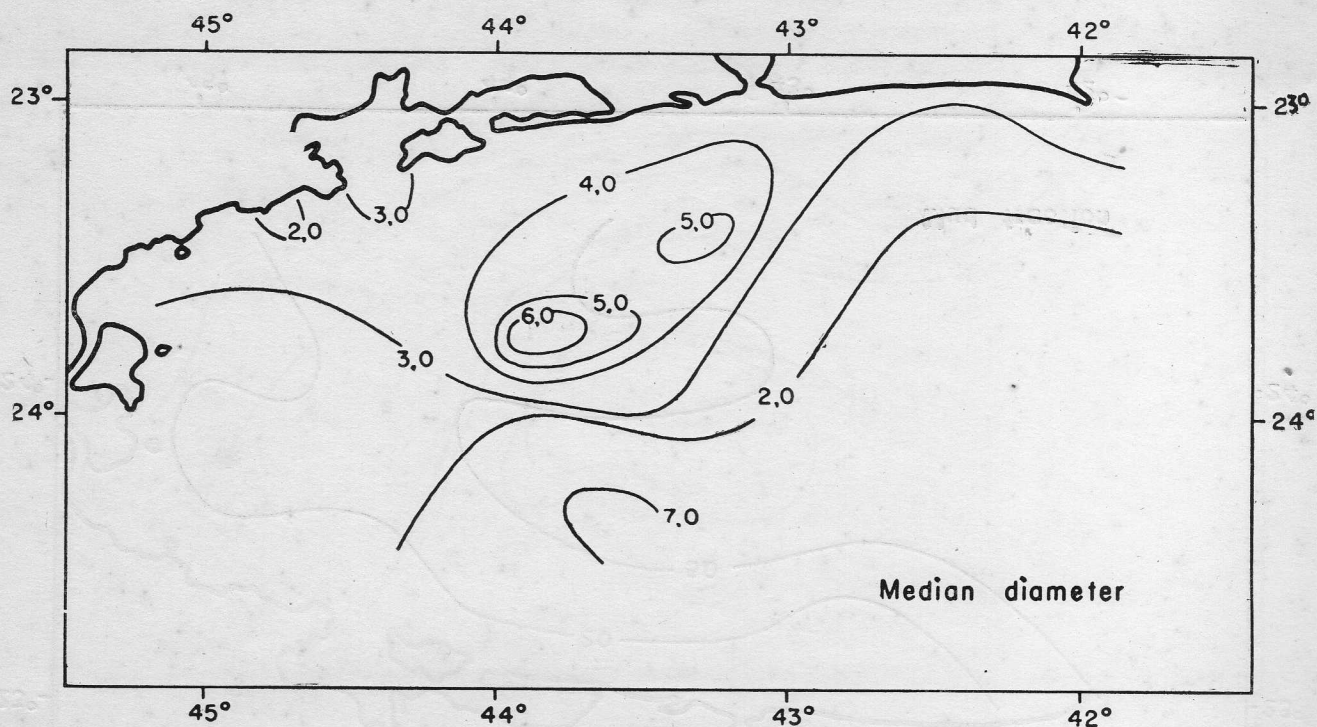
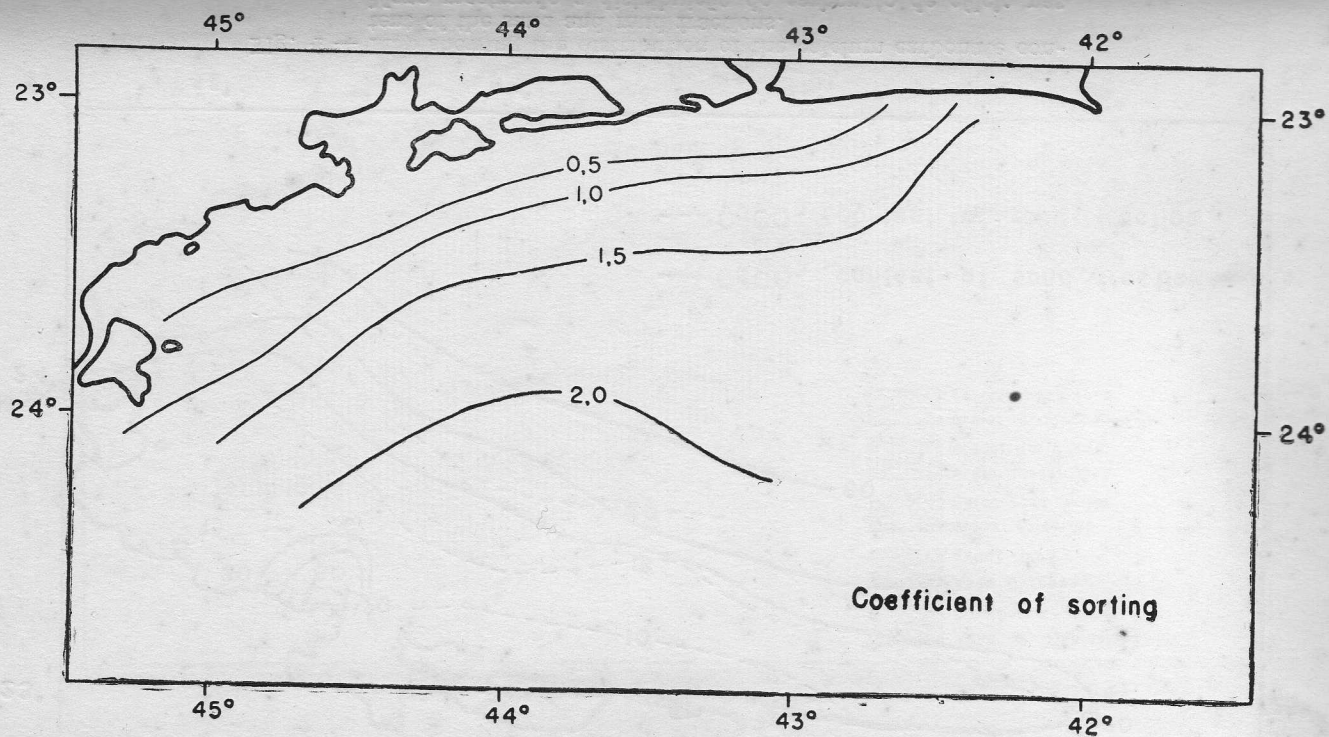


Fig. 3 — Maps showing the distribution of the median diameter (a) and the coefficient of sorting, (b).
Mapas mostrando a distribuição do diâmetro médio e do coeficiente de seleção.



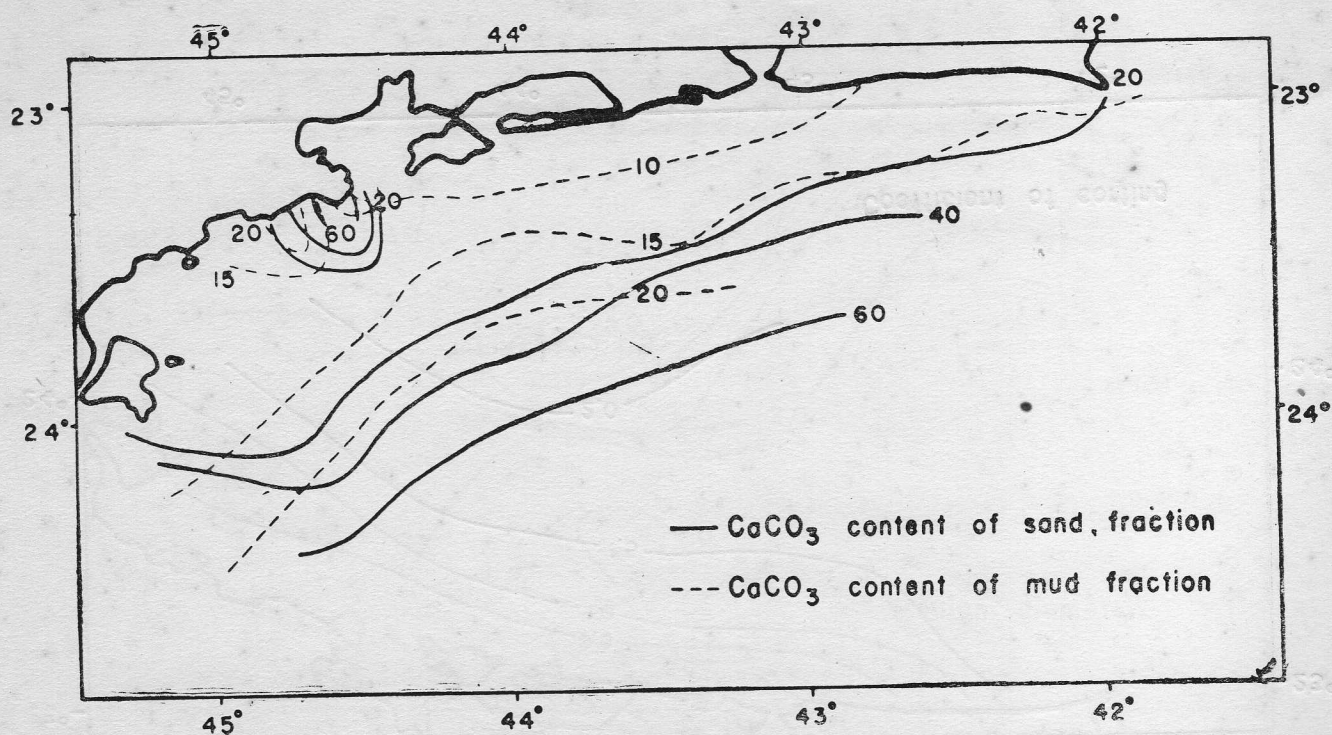


Fig. 4 — Map showing the distribution of the calcium carbonate content of the sand and mud fractions.
 Mapa mostrando a distribuição do carbonato de cálcio nas frações areia e vasa.

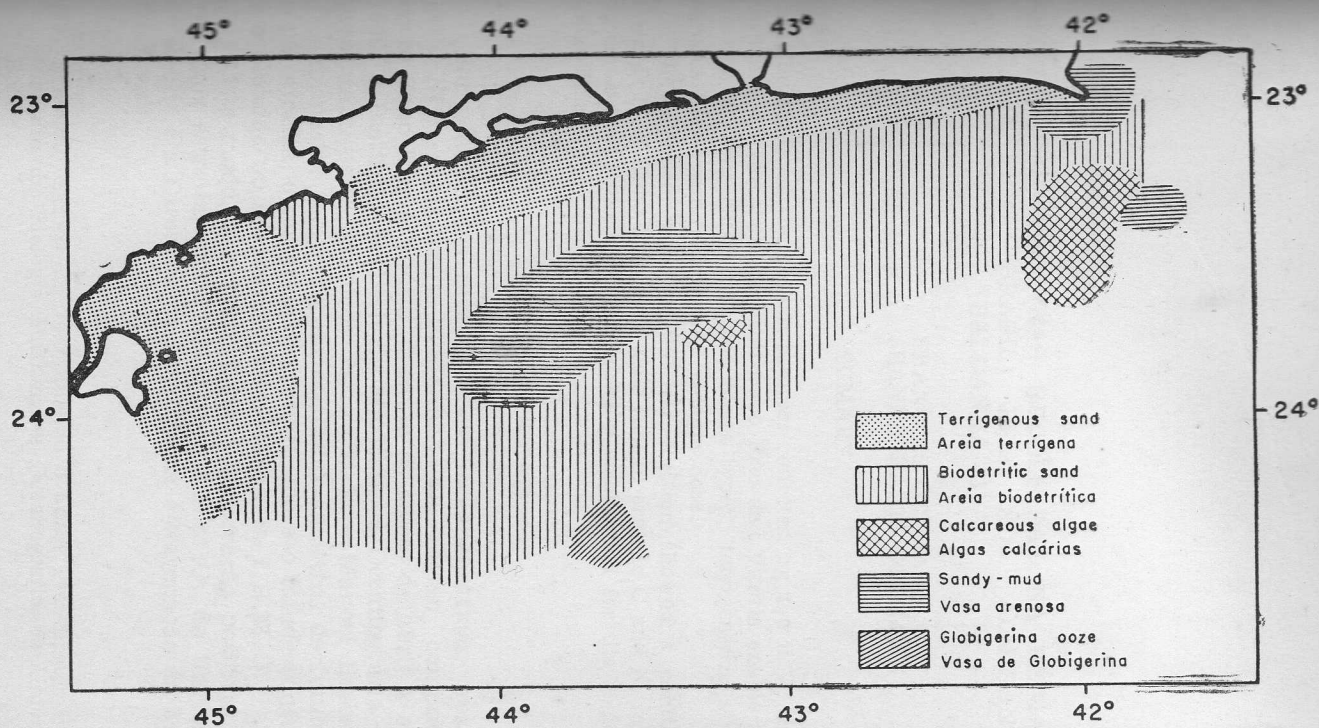


Fig. 5 — Areal distribution of the sedimentary facies.
 Distribuição superficial das fácies sedimentares.