

SILICICLASTIC SEDIMENTATION OF THE INNER CONTINENTAL SHELF AS A SOURCE AREA OF SANDY SEDIMENTS FOR THE RECOVERY OF ERODED BEACHES ON THE ISLAND OF SANTA CATARINA, SC, BRAZIL

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ABSTRACT

Beach nourishment describes a process by which sediment (usually sand) lost through longshore drift or erosion is replaced from sources outside of the eroding beach. The applicability of this process has been repeated in several eroded or erosion beaches of the world, considering also the beaches of Brazil. The state of *Santa Catarina* with 538 km-long coastline is one of seventeen Brazilian coastal states, highlighting in its Central coast the Island of *Santa Catarina*, with emphasis on 117 sandy beaches. The main beaches eroded of these coasts are *Barra da Lagoa*, *Moçambique* and *Santinho* (Northeast coast) and *Armação*, *Campeche* and *Joaquina* (Southeast coast). Aiming to looking for possible sources of siliciclastic sediments to recovery eroded sandy beaches have been developed in Brazil the “*Programa de Avaliação da Potencialidade Mineral da Plataforma Continental Jurídica Brasileira* (REMLAC)”. In this sense, the collection of 108 samples of surface sediments along the isobaths of 10 and 50 m over 18 profiles transverse to the coastline of Island of *Santa Catarina* was done, revealing the predominance of fine sand (up 90%), medium sand (up 75%), very fine sand (up 70%), coarse sand (up 48%) and very coarse sand (up 12,5%). The texture of the inner continental shelf adjacent to the Island of *Santa Catarina* showed the predominance of fine to medium sandy sediments in depths closer to the coast. Thereby the sandy sediments of the inner continental shelf can be used for recovery of eroded beaches, respecting their grain size and mineral potential.

Key words: eroded beaches, texture, nourishment, Island of *Santa Catarina*, Brazil.

INTRODUCTION

Marine minerals may represent an important resource in the medium and long term, depending on national and international contexts, and therefore deserve full attention in regards related to its current exploration and exploitation studies. With the exception of oil, which has an important role in global energy production, some marine mineral resources have been mined economically, including: heavy mineral placers, evaporites, phosphorite, carbonate and sands.

Therefore, it is important to locate, map and determine the geometry (shape and volume) of sandy bodies in the regions of the middle and inner shelf. It is also important to develop a database that includes maps, sedimentary characteristics of the bottom and sub-bottom, morphology, texture, composition and other properties of the seabed.

This approach is being implemented in Brazil, the *Programa de Avaliação da Potencialidade Mineral da Plataforma Continental Jurídica Brasileira* (REMPLOC), which aims to develop among other projects, methodology and models for exploration of lithoclastic, bioclastic and placers in strategic areas of our continental shelf, selected according to their geological and oceanographic features. In *Santa Catarina* inner continental shelf, the study is being conducted in the oceanic zone of the Island of *Santa Catarina*, where is located the insular sector of *Florianópolis*, capital of *Santa Catarina* state (Figure 1).

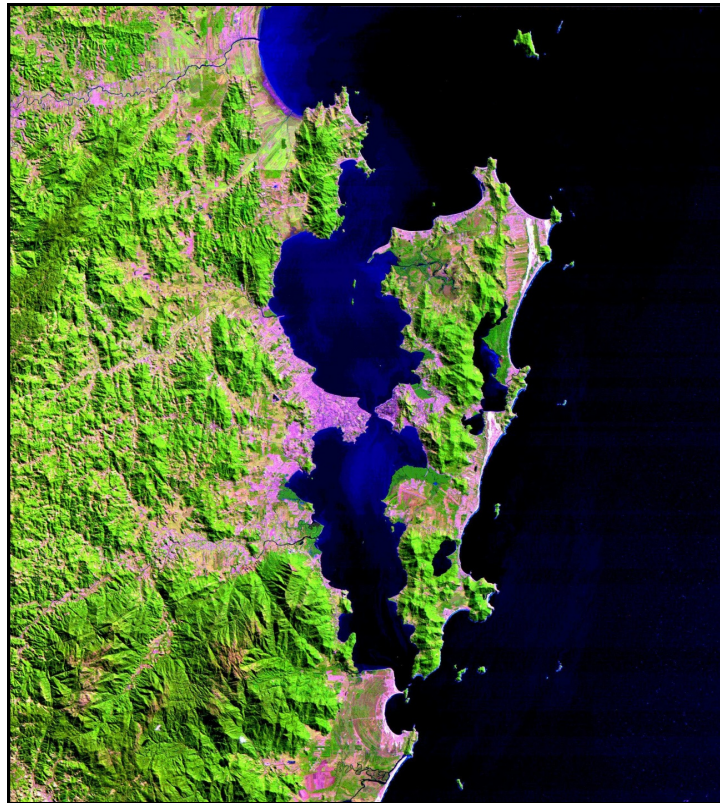


Figure 1. Landsat image showing the Island of *Santa Catarina* on the inner continental shelf, separated from the mainland by the bay of *Florianópolis*, divided into North and South bays.

This island is a typical coastal island, elongated northeast-southwest, with a predominantly subtropical humid climate, and a micro tidal regime (< 2 m). The geographical coordinates are 27°22'45" and 27°50'10" south latitude and 48°21'37" and 48°34'49" west longitude. Throughout its 174,3 km total perimeter, the Island of *Santa Catarina* exhibits a diversity of coastal ecosystems, in which can be found, dunes, lagoons, rocky coasts and mangrove swamps. The length of the island is 52,5 km; the maximum, medium and minimum widths are 18,8 km; 7,6 km and 1,3 km, respectively, and the total area is approximately 399 km².

The field works were carried on the beaches eroded along coastline and onboard in inner continental shelf at depths of 10 to 50 m, whose analysis of surface samples sediments was essential for the implementation of geological and geophysical mapping considering the granular siliciclastic deposits, possible sediment source for the nourishment of beaches in coastal erosion. The beaches considered in this study were *Barra da Lagoa* (Photo 1), *Moçambique* (Photo 1) and *Santinho*, in Northeast coast and *Armação* (Photo 2), *Campeche* and *Joaquina*, in Southeast coast.



Photo 1. Coastal erosion on the beaches of *Barra da Lagoa* (left) and *Moçambique* (right) in the Northeast coast of the Island of *Santa Catarina*.



Photo 2. Coastal erosion on the beach of *Armação* in the Southeast coast of the island of *Santa Catarina*.

MATERIALS AND METHODS

Bibliographic revision and field observations, besides of textural analysis and geoprocessing, consisted in the main activities that were developed in this study.

The field works consisted of topographic-oceanographic monitoring and sampling of surface sediments along beach profiles in the six selected beaches, for a period of 12 months. To implement these topographical surveys were used datum of each profile, considering the mean sea level in situations of low water syzygy tide. Parallel to the monitoring, meteorological and hydrodynamic observations were made. Regarding the hydrodynamic observations (significant wave height in the surf zone and swell period), the determination of the parameters was estimated by visual method.

Onboard activities consisted of geological and geophysical survey and sampling of 108 surface sediments (Figure 2) along the isobaths of 10 and 50 m from 18 transverse profiles, using Van Veen dredge, aboard *Solency Moura* (CEPSUL/IBAMA) and *Atlântico Sul* (FURG) ships. These activities took place in September 2008 and June 2009.

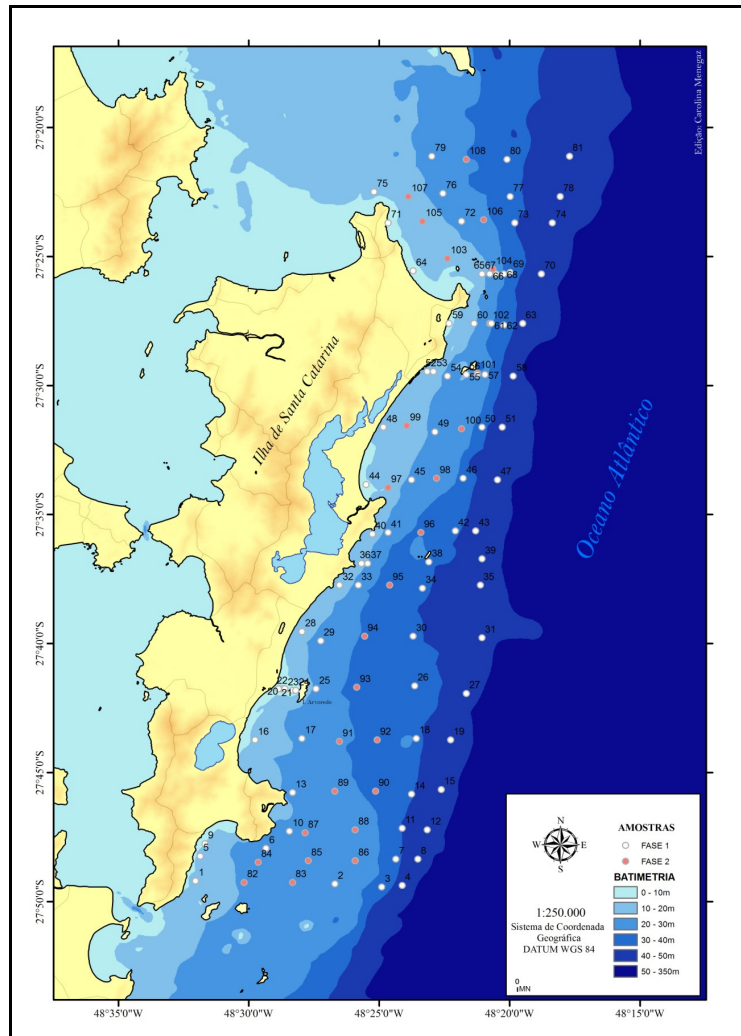


Figure 2. Location map of 108 samples of surface sediments collected along the inner continental shelf of the Island of Santa Catarina in bathymetric classes 0-10 m, 10-20 m, 20-30 m, 30-40 m, 40-50 m and > 50 m (Source: ABREU et al., 2010).

The samples of the beach and inner continental shelf were processed in the Laboratory of Sedimentology of Department of Geosciences of the Federal University of Santa Catarina. The samples were first washed to remove soluble minerals with subsequent drying at 60°C. The sediment was homogenized in macerator ceramic and removed aliquots of 30 g. The determination of the percentage of organic matter was performed according to the chemical method with the use of the reagent hydrogen peroxide 50%. The samples were again washed, oven dried and weighed. For the determination of biodetritral carbonate, the samples were subjected to the reagent hydrochloric acid (HCl) to 30%. To determine the grain size sieving was performed with an interval of 1/2 Ø, and reweighed each sieve interval. The colors of the samples were determined using the Rock Color Chart, before and after removal of soluble minerals.

After obtaining the weights of the samples, the data were processed by computational methods for classification of particles in the sample. Statistical analysis of sediment samples was based on the size classification and triangular diagrams. Statistical parameters were: mean (Mz), standard deviation or degree of selection (σ), skewness (Ski) and kurtosis (Kg).

Faciological maps of the inner continental shelf were elaborated in the Laboratory of Geological Oceanography at the University of Vale do *Itajaí*, having generated 14 faciological maps, 1:250,000 scale, using the ESRI ArcGIS software module - ArcMap and natural neighbor interpolation. The maps refer to the distribution of the following parameters: (1) texture; (2) gravel; (3) sand; (4) very coarse sand; (5) coarse sand; (6) medium sand; (7) fine sand; (8) very fine sand; (9) mud; (10) degree of selection; (11) skewness; (12) kurtosis; (13) biotritical carbonate and (14) organic matter, along with the particle size sheets, histograms, triangular diagrams and cumulative frequency curves.

RESULTS

The same way as the other Brazilian beaches (MUEHE, 2006), erosion processes have also been observed in several sandy beaches on the Island of *Santa Catarina*. The studies that are related to these beach erosion and current field observations highlight the problem, that despite of being a natural process of beach dynamics, the increasing rates of beach erosion are caused by indiscriminate occupations that settle along the beach environment in the various beaches on the island.

According to Figure 3, erosive evidence were identified in 15 beaches on the Island of *Santa Catarina*, located in the South coast (*Naufregados* and *Pântano do Sul*); Southeast coast (*Armação*, *Campeche* and *Joaquina*); Northeast coast (*Barra da Lagoa*, *Moçambique* and *Santinho*) and North coast (*Inglese*, *Brava*, *Ponta das Canas*, *Canasvieiras*, *Jurerê*, *Forte* and *Daniela*). These beaches are found in open and semi-open areas of high and medium oceanographic energy, facilitating the action of agents of local coastal dynamics.

The erosive evidences related to natural processes are generated by natural agents of the beach morphology, like waves, coastal currents, tides and winds. They are most common in the beaches of *Armação* (central and northern sectors); *Barra da Lagoa* (central and northern sectors); *Campeche* (north and south sectors); *Daniela* (southern sector); *Solidão* (central sector); *Forte* (northern sector); *Inglese* and *Joaquina*, in all sectors of the beach; *Jurerê* (central and northern sectors); *Moçambique* and *Morro das Pedras* (central and northern sectors); *Naufregados* (western and central sectors); *Pântano do Sul* (central sector) and *Santinho* (northern sector).

The erosive evidence associated with natural processes and anthropogenic activities are those generated from natural agents of the beach morphology, intensified by human action which is characterized as urban settlements along the beach environment. They are more common in the *Barra da Lagoa* and *Armação* beaches in the southern sector; *Brava* beach in the northern sector; *Canasvieiras* beach in the central sector; *Forte* beach in the central and northern sector; *Inglese* beach in the southern and central sectors; *Jurerê* beach in the central and western sectors; *Naufregados* and *Pântano do Sul* beaches, in eastern sector and *Ponta das Canas* beach in the northern sector. In this study, six beaches were selected, three beaches on the Northeast coast (*Santinho*, *Moçambique* and *Barra da Lagoa*) and three beaches on the Southeast coast (*Joaquina*, *Campeche* and *Armação*), they all had erosive evidence in some specific sectors and monitoring periods.

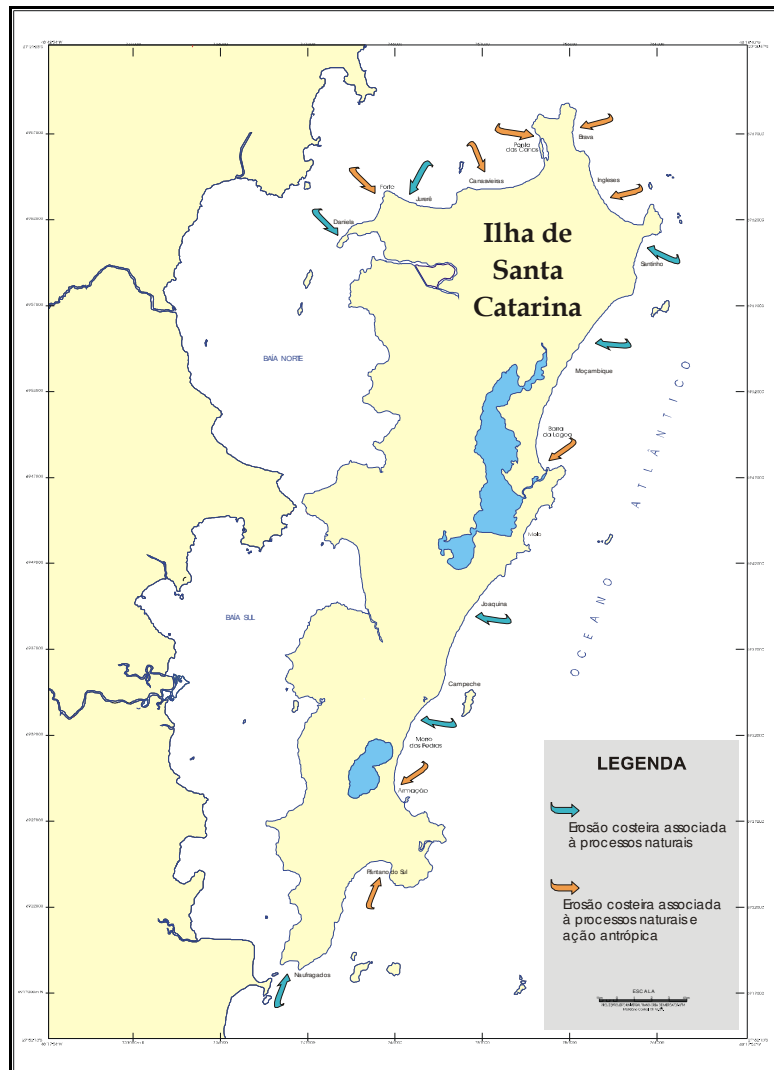


Figure 3. Erosive evidence on the beaches of the Island of *Santa Catarina* (Source: SIMÓ, 2003).

The main studies that described morphological and textural aspects of these eroded beaches were presented by Abreu de Castilhos (1995) on the beach of *Armação*, Leal (1999) on the beaches of *Moçambique* and *Barra da Lagoa*; Torronteguy (2002) on the beaches of *Joaquina* and *Campeche* and Peixoto (2005) on the *Santinho* beach. From the point of view of the texture, the authors identified fine sand in *Santinho*, *Barra da Lagoa* and *Joaquina* beaches; medium sand on the beach of *Campeche* and medium/coarse sand on the beaches of *Moçambique* and *Armação*.

From the point of view of facies, the preliminary results of bathymetric and textural analysis performed on the inner continental shelf of the Island of *Santa Catarina*, describe that the maximum levels of gravel and mud in the samples were 2% and 95%, respectively. The sandy sediments showed the predominance of fine sand (up 90%), medium sand (up 75%), very fine sand (up 70%), coarse sand (up 48%) and very coarse sand (up 12,5%). The degree of selection ranged from very well sorted to very poorly sorted. The average grain texture rated sediment from silt to medium sand.

The textural map of Figure 4 shows the distribution of sandy sediments of the inner continental shelf. In the lower depths nearest shoreline dominate fine sand facies, while in the higher depths dominate very fine sand facies. In isolated spots along the inner continental shelf dominate medium sand facies.

These facies represent areas of potential local sources for the supply of sediment eroded in the six selected beaches and other beaches where erosive evidence have been characterized.

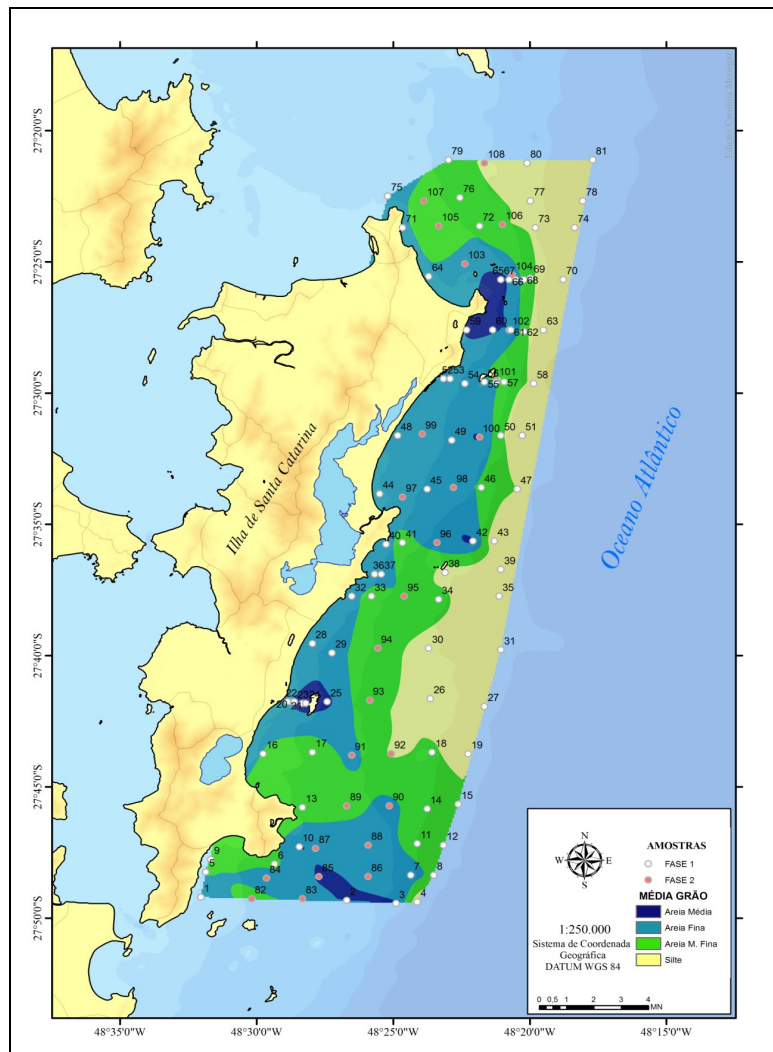


Figure 4. Map of sandy facies distribution along the inner continental shelf of the Island of *Santa Catarina* (Source: ABREU et al., 2010).

CONCLUSIONS

Granulometric studies have been very important for the representation of seafloor facies of continental shelf throughout the world.

The texture of the inner continental shelf of the Island of *Santa Catarina* showed the predominance of sandy sediments in depths closer to the coastline and silty sediments in higher depths, probably related to the smaller hydrodynamic energy and sandy sediment source of the coastal plain and beach system of the Island of *Santa Catarina*.

The sandy sediments mapped on the inner continental shelf may be used in rebuilding eroded beaches, since it is made compatible texture of grain, distance from the coastline, volumetric potential for occurrence of possible mines, always respecting the norms of environmental law.

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