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Dunes of Albardão, State of Rio Grande do Sul

Beautiful aeolian landscape in the far southern coast of Brazil

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The Rio Grande do Sul Coastal Plain was formed as a result of sediment re-working from the upper portion of the Pelotas Basin by glacio-eustatic oscillations throughout the Neogene. The combination of sea level transgressive-regressive cycles and physical features of the coast of the State of Rio Grande do Sul led to the structuring of the Coastal Plain in an alluvial fan system and four lagoon-barrier depositional systems. Each one of these systems is directly related to a transgressive maximum, with estimated ages around 400, 325, 120 and 6 thousand years, respectively. The most recent of these systems - Lagoon-Barrier System IV - which comprises the present coastline, is characterized by long sandy-barriers which isolate several lagoons on along the northern coast of the state, and a large lagoon (Mangueira) in the southern portion, measuring about 100 km in extension. From the beginning of the Holocene this portion of the coastline is being subject to coastal dynamic processes, which originated eolian dunes. As a result of these processes, the middle-southern portion of the eastern margin of Mangueira lagoon is characterized by a large aeolian dune field of great beauty, considerable height and environmental importance. These dunes serve as habitat for several species of mammals, birds, insects and plants, and contain archaeological evidences of the presence of paleo-indians. The presence of "concheiros" is remarkable in the adjoining ocean beach, representing large and thick fossiliferous concentrations, which are long and thick concentrations of mollusk, crustacean and marine vertebrate fossils as well as terrestrial Pleistocene mammals that have been removed from submerged deposits and transported to the beach through coastal dynamics.

Keywords: Holocene, Rio Grande do Sul Coastal Plain, Glacio-eustasy, Aeolian dunes, Megafauna

INTRODUCTION

To the first European explorers that arrived to the southern portion of the Rio Grande do Sul coast, the coastal dunes (Fig. 1) were the only visual aid for navigation. The large sandy landscape that stretched along the coast caused different reactions; while the German naturalist Wilhelm von Feldner described it as a "miserable sand desert" (Seeliger et al., 2004), others foresaw there the opportunity for unknown richness. In the XVII century, British seamen talks about these sands in a sea shanty called "The Rio Grande":

Oh, say, wuz ye ever down Rio Grande?

'Way for Rio!

It's there that the river flows golden sands

(...)

We're bound to the south'ard, me bully boys all

Bound out to the Brazils, me bully boys all

The river that the Europeans spoke of was actually the Patos Lagoon, and the golden sands did not contain gold, but have a underestimated environmental value, which the greedy explorers did not conceive. In recent years the importance of the dunes for the maintenance of the coastal equilibrium,

not only for the organisms that inhabit it but also for its tourism potential, have been assessed.

REGIONAL GEOLOGICAL SETTING

The territory that comprises the Rio Grande do Sul State can be divided in four major geomorphological units (Villwock & Tomazelli, 1995; Fig. 2). The Coastal Plain, the most recent of these units, exhibits an almost straight configuration, and is almost 600 km-long. The sandy sediments which constitute it are essentially terrigenous siliciclastic, and come from the erosion, between the Cretaceous and Neogene, of the rocks of the Rio Grande do Sul Shield, the Central Depression and the Araucárias Plateau, and bears also relict biodetritic concentrations. Drill holes made by Petrobras showed that the oldest sediments of the Coastal Plain date back to the Miocene (Closs, 1970).

From the Upper Pleistocene onwards, as a result of the 100 thousand-year glacial cycles (Schmieder *et al.*, 2000), the glacio-eustatic oscillations cyclically re-worked the sediments of the upper portion of the Pelotas Basin. Following newer geological methods, which replace the conventional lithostratigraphic for the recognition of sedimentary facies as depositional systems in a chronostratigraphic context, the origin of

the Plain can be understood as a response to the sea-level oscillations, that lead to the formation of two major depositional systems (Tomazelli & Villwock, 2005): 1) Alluvial Fans System and 2) four Lagoon-Barrier Systems (Fig. 3).

The Lagoon-Barrier Systems developed in response to the sea-level highstands that occurred about 400, 325, 123 e 6 thousand years ago (Tomazelli *et al.*, 2000). The Lagoon-Barrier System IV is the most recent and constitutes the present coastline.



Figure 1 – View of the Albardão dune field. Photo: R.P.Lopes

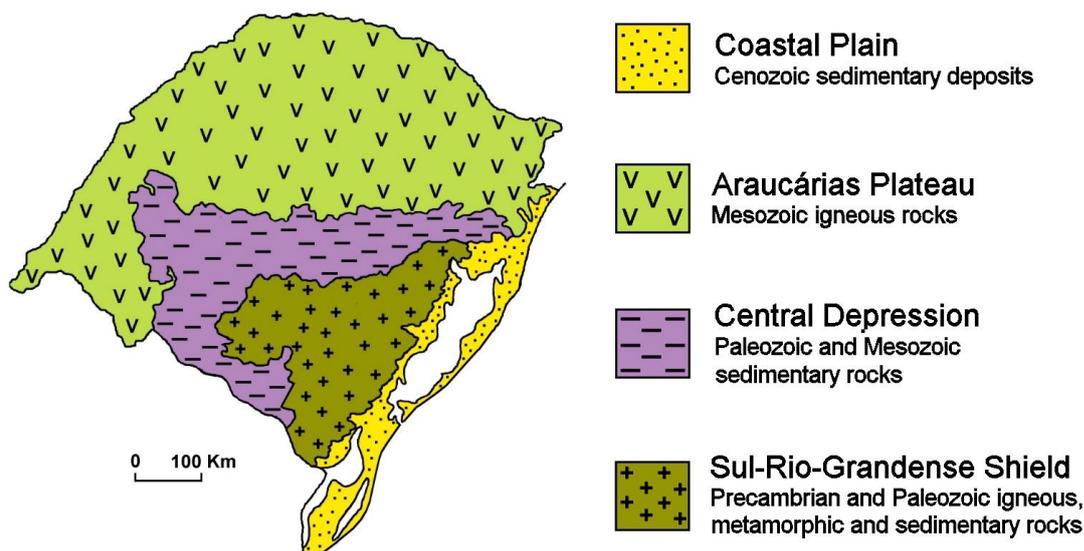


Figure 2 – Main geomorphologic units of the Rio Grande do Sul state

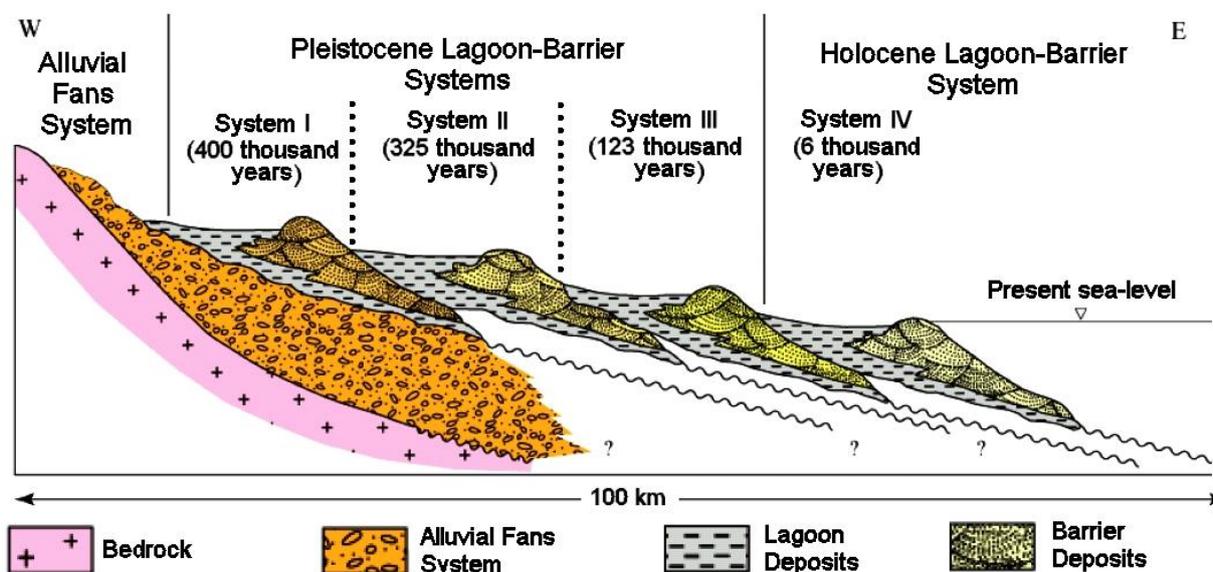


Figure 3 - Schematic section showing the structure of the coastal plain of Rio Grande do Sul (Modified from Tomazelli & Villwock, 2005)

LOCATION

In the coastal area to the south of the Patos Lagoon estuary, the Lagoon-Barrier System IV is represented by a 100 km-long and 5 km-wide in average lacustrine body, called Magueira Lake and located between 32°45'S e 33°30' S (Fig. 4). Its northern edge is Taim wetlands and the southern the Sales wetland. The western margin is constituted by Pleistocene sediments of the Barrier III System and the eastern by the sandy barrier formed by the Holocene transgressive event. In this barrier, some 120 km to the south of the Patos Lagoon estuary, between 33°10'S e 33°40'S, the site described here is located. It is a 87 km-long and 4 km-wide, well-

developed coastal dunefield, presented here as a site of geological, geomorphological and palaeontological importance.

SITE DESCRIPTION

The site is named Dunes of Albardão, after the lighthouse located in its northern edge. It is characterized by a large dunefield that stretches from the upper shoreface to the eastern margin of the Mangueira Lake (Fig. 5). According to the classification proposed by Tomazelli (1994), in the area described here two main types of dunes are found:

a) **Vegetated Dunes** – Found closer to the beach, are composed by embryonic dunes, measuring between 0,6 and 0,9 m in height and formed by sand

accumulated on top of the low vegetation at the foot of the frontal dunes; the frontal dunes are some 4 m-high and subject to erosion by storm waves during autumn and winter; “nebkha”-type or hummocky dunes are small sand accumulations associated to grassy shrubs, that occur landwards in the first 500 m

of the dunefield, where the phreatic is closer to the surface.

b) **Mobile Dunes** – These are better represented some 15 km to the south of the Albardão lighthouse, are of the barcanoid- and transversal-type, and reach some 20 m in height.

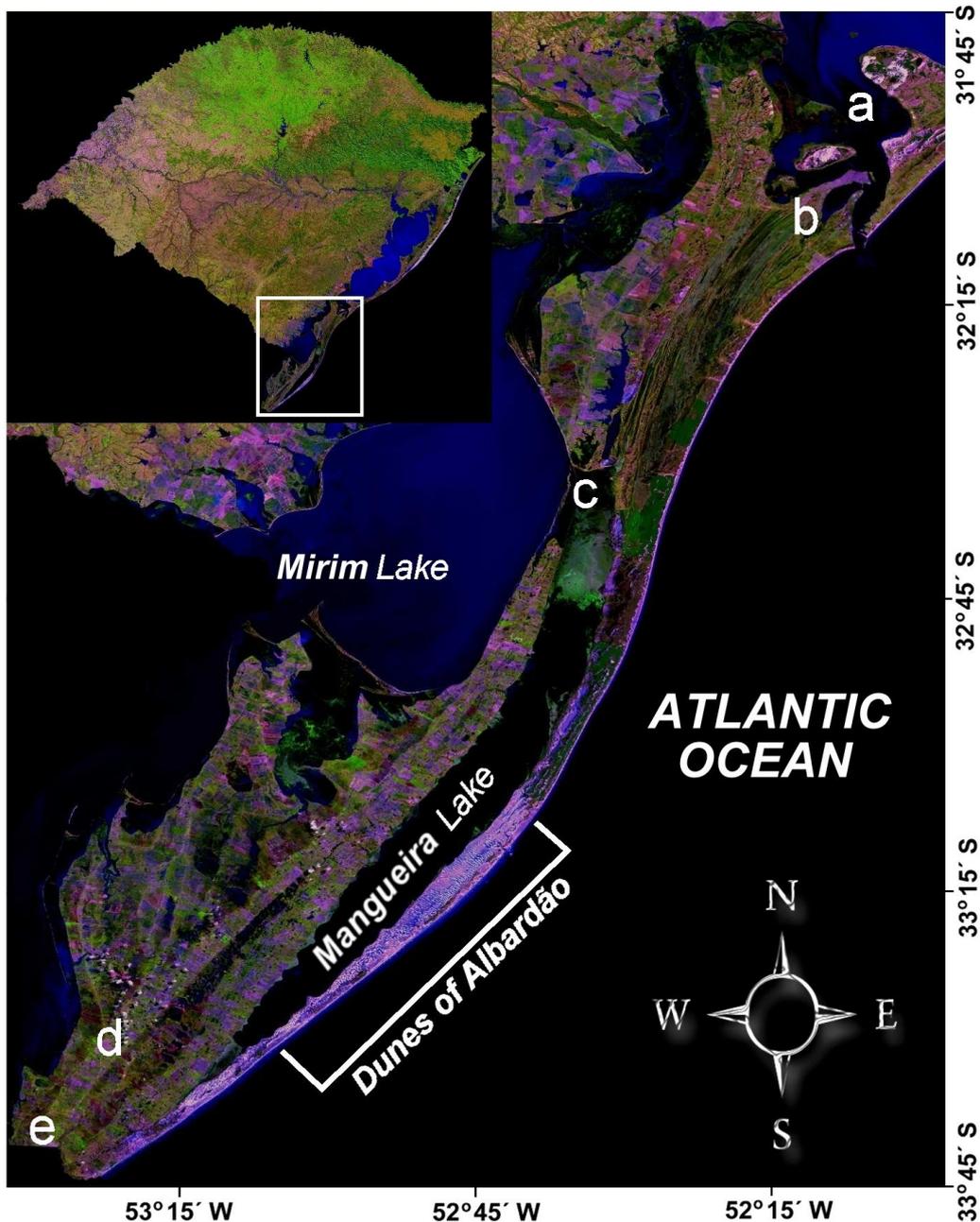


Figure 4 – Image map of the southern portion of the Rio Grande do Sul Coastal Plain, showing the location of the site and other reference points: a) Patos lagoon estuary; b) Rio Grande town; c) Taim wetlands; d) Santa Vitória do Palmar town; e) Chuí town. (Source: satellite mosaic in: <http://www.cnpm.embrapa.br>, accessed in 15/10/2007)

Besides the dunes, other structure present in the area is the sand sheets, formed by the accumulation of sand that is transported landwards by the wind but does not originate dunes. A east-west transect of the sandy barrier between the Atlantic Ocean and the Mangueira Lake (Fig. 6) shows first a line of low, embryonic dunes, followed by the line of frontal

dunes, whose height varies along the coast.

The development of embryonic and frontal dunes is not uniform along the dunefield: in the Albardão lighthouse area there are no frontal dunes, only sand sheets; several kilometers to the south, though, there are well-developed dunes (Seeliger *et al.*, 2004; Fig. 7). Behind the frontal dunes there is a flat zone occupied

by wetlands and quicksands. The end of these wetlands is marked by the mobile dunes, which can reach 20 meters in height and are one of the most beautiful landscapes of the Rio Grande do Sul coast. The spaces between these dunes are filled with water during the rainy seasons, thus forming ephemeral lakes (Fig. 8)



Figure 5 – Detail of the Albardão dune field, between Mangueira lake (on the left) and the Atlantic Ocean (on the right)

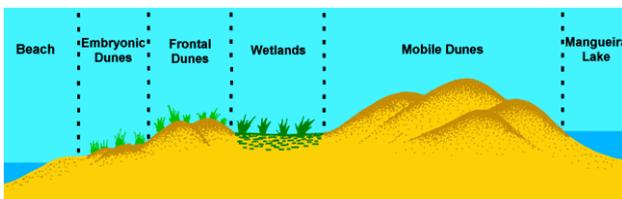


Figure 6 – Transect of the western margin of Mangueira lake, showing the structure of the dune field.



Figure 7 – Well-developed foredunes, to the south of Albardão lighthouse



Figure 8 – Ephemeral lakes, formed between the dunes. In the background, the Atlantic Ocean.

As a result of the prevailing winds from NE and S, the dunes migrate to N-NW. In the last decade this process was intensified due to the lowering of the phreatic caused by the opening of drainage channels between the wetlands and the beach, in an attempt to expand the area for the *Pinus* forests located in the northern portion of the dunefield (Ugri, 2001). These dunes are inhabited by several species of birds, insects and mammals, such as the graxaim-do-campo, the rabbit and the tuco-tuco.

The oceanic beach adjacent to the Albardão dunefield exhibits intermediary morphodynamics, with a tendency to dissipative, and is composed by coarser sand and have a steeper slope (Calliari & Klein, 1993). In this portion of the shoreline there are large bioclastic accumulations made of shell fragments. Such accumulations started to appear in the early seventies, as isolated patches; its origin is attributed to the removal and concentration on the beach of bioclasts from relict deposits along the continental platform (Figueiredo jr., 1975). Surveys made along the last ten years revealed that the concheiros have stretched and are migrating northwards, in response to strong drift currents, but its greater concentration is found between 150 and 190 km to the south of the estuary of the Patos Lagoon. A survey made by Asp (1996) revealed that the concheiros have economic potential as a source of carbonate.

Since the late XIX century the presence of fossils of extinct terrestrial vertebrates brought by wave-generated currents to the beach to the south of the estuary of the Patos Lagoon is known. These remains probably come from continental fossiliferous deposits that were covered by the sea during marine transgressions (Buchmann, 2002). The coastal dynamics and erosive processes that affect the Rio Grande do Sul coast in the present (Dillenburg et al., 2004) promote the re-working of these submarine deposits, removing the fossils and transporting it to the upper shore, mainly during autumn and winter, when the storm surges are stronger (Fig. 9). The taphonomic features of these remains suggest that were originally preserved in continental fluvial environments, similar to the Chuí Creek, but the subsequent exposition to marine environment have made these fossils darker, heavier and more resistant (Lopes et al., in press).

Figure 09 – Fóssil of a terrestrial mammal (glyptodont vertebra, in black), in association to biodetritic accumulations known as “concheiros”, in the oceanic beach of the Albardão dune field.

The fossils of mammals include taxa of the Pleistocene megafauna (ground sloths, glyptodonts, pampatheres, toxodonts, macrauchenias, mastodonts and sabertooth cats, among others) that are also found in the fossiliferous deposits of the Chuí Creek (Lopes

et al., 2005). Although the exact age of these remains is still unknown, the taxonomic groups can be correlated to the Lujanian age (*Equus neogeus* biozone), that spans between 130 and 8,5 thousand years ago. In the concheiros, fossils of some taxons that do not occur in the Chuí Creek such as birds, rodents and reptiles are also found, as well as marine organisms (crustaceans, cetaceans, pinnipeds, bony and cartilaginous fishes and turtles) (Lopes, 2006). Besides the fossils found on the beach, in the dune field are found artifacts that indicate temporary settlements of Guarani paleo-indians; due to the migration of the dunes the archaeologically relevant places are continuously being exposed and covered by sand. The archaeological items found on these places include ceramic fragments and lithic artifacts, such as stone balls and arrow points; sometimes food remains such as bones can also be found. The absence of lithic raw materials in the Coastal Plain indicate that these natives came from other places of the territory; the types of rocks used for toolmaking suggest that they either came from the western portion or the highlands of Rio Grande do Sul, or made exchange with the inhabitants of these places (Schmitz et al., 1997; Oliveira & Teixeira, 2005).

SITE ORIGIN

The formation of the sandy barrier that isolated the Mangueira Lake was attributed by Buchmann (1997) to the growing of a large sand spit in the N-S direction between 5 and 4 thousand years ago, in response to the Holocene transgressive maximum. Other studies suggest that the sandy barrier originated by the landwards migration of a preexistent emergent barrier, in response to the transgression, just as happened in the northern portion of the coast of Rio Grande do Sul (Dillenburg et al., 1998).

As a result of the dynamic processes that affect the coast, the Holocene sandy deposits that constitute the Barrier IV show remarkable morphological variation along the coast (Dillenburg et al., 1998). In the coast sector between the Albardão lighthouse and the Hermenegildo beach, there is a transgressive dune barrier made by large landward-migrating dune fields, originated by the migration of sediments that are reworked by erosive processes. In the southern coast of Rio Grande do Sul the erosive processes are attributed to the sea-level rise, the concentration of wave foci on the beach caused by the presence in the backshore of lithified structures and to negative sediment budget (Tomazelli & Dillenburg, 1998; Calliari et al., 1998; Dillenburg et al., 2004). The dynamics of the dune field is related to the wind regime in the area: the prevailing winds are from the NE quadrant, but the stronger ones come from S-SW-W, which are more frequent between april and august

and associated to the autumn and winter storms. The seasonal oscillations of the wind regime are responsible for the migration of the dunes at rates of some 23 meters per year and height oscillations of up to 5 meters (Arejano, 1999).

SYNOPSIS ON THE ORIGIN, EVOLUTION AND IMPORTANCE OF THE SITE

In the coast of Rio Grande do Sul, a large lagoon-barrier-type depositional systems have developed in response to the sea-level maximum of about 6 thousand years ago. In the sector of the coast to the south of the estuary of the Patos Lagoon this system is dominated by a large lacustrine body, called Mangueira Lake, that is separated from of the Atlantic Ocean by a sandy barrier, that bears large eolian dune fields. The development of these dunes is a result of the erosive processes that affect the coast, which also bring to the beach fossils of marine and terrestrial organisms that are removed from fossiliferous concentrations in the continental platform. The dune field is important not only for the maintenance of the coastal dynamic equilibrium, but also as an permanent and temporary habitat for several native and migrating species, besides keeping palaeontological and archaeological remains. Its visual beauty make it very attractive for sustainable use by ecotourism activities (Fig. 10).

Although in larger time scales the southern portion of the Rio Grande do Sul coast is subject to erosion, in shorter (annual) scales it is in dynamic equilibrium, due to the presence of the frontal dunes. During winter, the storm surges remove great amounts of sand from the frontal dunes, which act as a natural barrier by preventing the sea from penetrating landwards. During summer, the waves bring sediments to the beach, thus making it increase in volume. This cyclic winter-summer equilibrium is essential for keeping the coast a relatively stable environment not only for human occupation, but also for plants and animals. The vegetation have a great importance for the stabilization of the sand that make the frontal dunes. Although in the southern portion of the coast the vegetation cover have spread during the last 50 years, this process is not homogeneous (Ugri, 2004), besides the fact that this vegetation have served as pasture for cattle from the farms near the Mangueira Lake, which have contributed to the removal and landwards migration of the beach sand.

The southern portion of the coast of Rio Grande do Sul is accessible by four-wheel drive vehicles; thus, the only people present in the area are some farmers that live near the margin of the Mangueira Lake and fishermen that inhabit temporary settlements. Sometimes, groups of "jipeiros" use the beach and dunes for recreation, resulting in negative

environmental impact. To the south, there are some acácia woodlands, planted by inhabitants of Santa

Vitória do Palmar and Chuí that use the area for recreation, mainly fishing.



Figure 10 – Images of the site: a) the Albardão lighthouse, the most isolated of the Brazilian coast (distant some 40 km from the nearest locality); b) panoramic view of the dune field towards the Atlantic Ocean; d) inter-dune lakes; e) fossil of an extinct terrestrial mammal (femur of a *Toxodon platensis*), brought to the beach by the waves; f) detail of the dunes showing the surface ripple structures (photos by Renato Lopes)

CURRENT PROTECTION MEASURES

The relative inaccessibility to the eastern margin of the Mangueira Lake have assured its preservation throughout the years. However, in its northern edge,

near the Taim wetlands, the coastal dunes have been obliterated, occupied by *Pinus elliotti* plantations for the extraction of wood and resin. In its southern edge the original vegetation was altered by the inclusion of the acácia woodlands. Only in recent years the

importance of the sandy barrier eastwards of the Mangueira Lake, as an habitat for native and migratory species, have been recognized. This have assured the inclusion of the area in the MaB (Man and Biosphere) program by UNESCO, as part of the Mata Atlântica Biosphere Reserve, and constituting an ecologic link between the Peixe Lake, in the northern RS coast, and the Uruguayan humedales to the south.

The recognition of the dune fields as Geological and Paleontological Patrimony, reinforces the importance of preserving this area, which have its northern and southern limits already altered by anthropogenic action. The presence of archaeological and paleontological evidences justify the scientific interest in its preservation; the natural beauty and virtually unaltered environment along most of this portion of the coast assures a high potential for sustainable tourism, through ecotourism activities.

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Renato Pereira Lopes – A Geography undergraduate by Fundação Universidade Federal do Rio Grande (FURG), have developed research on Paleontology and Stratigraphy, through the project "Paleontologia do Quaternário

Costeiro", focusing on the study of the fossiliferous deposits located in the southern portion of the coast of Rio Grande do Sul State. Currently is pursuing a Master degree in Geosciences, with emphasis in Vertebrate Paleontology, at the Universidade Federal do Rio Grande do Sul (UFRGS).



André Ugri – An Oceanography undergraduate by Fundação Universidade Federal do Rio Grande (FURG), have performed research regarding the alterations in the dune fields in the southern portion of the coast of Rio Grande do Sul State. Nowadays, is

pursuing a PhD degree in Marine Geology at the Universidade Federal do Rio Grande do Sul (UFRGS).



Francisco Sekiguchi de Carvalho Buchmann - An Oceanography undergraduate by Fundação Universidade Federal do Rio Grande (FURG), obtained MSc and PhD degrees in Marine Geology at the Universidade Federal do Rio Grande do Sul

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