Stratigraphic and Holocene Evolution of the Submerged Platform of the Eastern Margin of the Lagoa dos Patos Lagoon, RS.


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ABSTRACT

It was identified along the eastern margin of the Lagoa dos Patos lagoon, southern Brazil, a wide (up to 1 km) and up to 1 m deep platform that occurs along most of the lagoon margin have been interpreted in previous studies as a drowned lagoonal margin. The Lagoa dos Patos lagoon is the largest lagoon of Brazil, has a length of 240 km, an average width of 40 km, and covers a surface of 10,000 km². The lagoon runs roughly NE-SW and its average depth is almost 6 m, and its means tidal amplitude is 0.30 m. The lagoon can be subdivided into three morphological cells partially separated by sand spits that have grown from its margin. Although preliminary, this paper shows new data could change these previous interpretations. Two radiocarbon dating of mollusk shells from a shallow core (2.7 m long) recently collected near the edge of the submerged platform suggest an alternative origin for this morphologic feature. According to the dating the feature isn’t a drowned lagoonal margin but it is a result of an active progradation of the lagoonal margin under the present dynamics. New data coming from future studies to be carried in the area would point to what is the most consistent hypothesis to explain this morphologic feature of Lagoa dos Patos lagoon margins.

ADDITIONAL INDEX WORDS: Rio Grande do Sul coastal plain, wave-cut terraces, submerged platform.

INTRODUCTION

It was identified along the eastern margin of the Lagoa dos Patos lagoon, southern Brazil, a wide platform (up to 1 km) bordering the lagoonal margins, and limited by the 1 m isobath was described by Villwock (1977), Toldo Jr. (1989 and 1994), Tomazelli (1990), Villwock and Tomazelli (1998), Barboza (1999), Barboza and Tomazelli (2003). These authors suggest that the border of the platform marks the position of an ancient 1 m lower lagoonal level. According to Tomazelli and Villwock (1989) this platform was drowned by a recent sea level rise started at about 1.2 ka.

By studying the subsurface stratigraphy of this platform this paper aims to better define its nature. With this purpose a shallow core (2.7 m long) was collected close to the edge of the platform.

REGIONAL SETTING

The Lagoa dos Patos lagoon, situated in Rio Grande do Sul coastal plain, southern Brazil, is the largest lagoon of the country, covering an area of about 10,000 km² (Figure 1). Its evolution was studied by Villwock (1977), Toldo Jr. (1989 and 1994). In general the long-term evolution of the lagoon follows the model of Zemkovitch (1959). This large coastal water body is permanently connected to the Atlantic Ocean through an inlet situated in its southern part. Because there is only one inlet connecting the lagoon to the ocean, and because the coast is microtidal (mean tide range of about 0.30 m), tidal effects on the lagoon-level and surface area are negligible. Thus, the Lagoa dos Patos lagoon is an open-water lagoon that has a relatively constant water surface whose level is basically controlled by the relative variation of the sea level.

The study area is placed in the area known as “Restinga da Laguna dos Patos”, which is a complex multiple barrier (Villwock, 1984), and whose origin is related to the relative variations of the sea level during the Quaternary Period, associated to changes on climate on sedimentsary supply. The area selected for this study is located in the central portion of the east margin of the Lagoa dos Patos lagoon, between the spits of Cristóvão Pereira and São Simão, and close to Mostardas city (Figure 1).

STRATIGRAPHIC ANALYSIS

The studied core is 2.7 m long (Figure 2) and was collected by a percussion method under a 1 meter deep water column. Three lithofacies were identified: 1) 2.7 to 2.3 m - stained yellow quartzose very fine sand, well sorted, showing roots; 2) 2.3 to 2.05 m gray quartzose very fine sand, well sorted, with organic remnants and well preserved shells of Erodona mactroides; 3) 2.05 to 0 m pale yellow quartzose very fine sand, well sorted and homogeneous textural. Two shell samples from lithofacies showed 14C ages ranging from 240 +/− 50 years to 310 +/− 60 years. Lithofacies 1 is interpreted as the Pleistocene substrate (Barrier III) of the Holocene lagoonal deposits drowned and reworked by the Postglacial Marine Transgression. The top of this unit is limited by a ravinement surface. The succession of lithofacies 2 and 3 is a product of progradation of the lagoonal margin, with the surface of lithofacies 3 corresponding to the 1 m deep platform bordering the lagoonal shoreline. It is suggested here that platform progradation is contemporaneous to the progradation and grow of the modern 2 sand spits. The young 14C ages obtained for lithofacies 2 indicates that lithofacies 3 was formed very recently at the border of the platform, and that progradation is probably still active.

SEDIMENT DYNAMICS ON THE SHOREFACE

Wave statistics of the Lagoa dos Patos lagoon are used to calculate the mean breaker waves depth (dₘ), and the threshold of sediment motion. The results indicated an annual average breaker depth changing between 0.3 and 0.9 m, based on the wave height and beach slope (U.S. Army Corps Of Engineers,
1984, pg. 130), and 3 m to depth where occur near-bottom turbulent conditions to sediment movement under oscillatory water waves (Toldo Jr., 1994; Toldo Jr. et al., 2003), as mathematically defined by Jonsson (1978, cited in: Davies, 1985), Komar and Miller (1974). During the strong wind period (> 14 m.s⁻¹), in which a high frequency of shoaling wave is superimposed on a mean flow, the orbital motions cause a significant turbulent mixing of the entire water column in the lagoon. The sum of the hours with storms of this magnitude in 1988 corresponds to 15 days.

The results of the wave climate prediction show that east side of the lagoon received, during storm conditions, a mean wave power potential change between 1.1 and 2.2 kW.m⁻¹. The lagoonal beach and shoreface are a energetic environment in the Lagoa dos Patos lagoon even for a reduced number of hours with predicted waves.

**POTENTIAL CROSS-SHORE TRANSPORT**

The waves on the shoreface are usually characterized by a shore normal component, and they tend to cause bedload and suspended sediment transport when the near bottom orbital velocities exceed the threshold to the sediment movement.

According to Dyer and Soulsby (1988), the transport of sediments is a phenomenon that has been researched for many years. However, today it is still impossible to predict with safety the transport rate. Even so, this subject can be reduced to an acceptable evaluation to indicate this phenomenon through the transport potential induced by wave energy flow.

The sediment bars which are moving onshore, offshore or show no movement are explained for every lagoonal shoreface from wave energy, derived from the wave hindcaste model. We used the method of Sunamura and Takeda (1984) to calculate the sediment transport in the beach system:

\[ \frac{H_{b,\max}}{gT_{\max}^2} = K(D/H_{b,\max}) \]  

where \( H_{b,\max} \) is maximum wave height (m), \( g \) is the acceleration of gravity (m.s⁻²), \( T_{\max} \) is the maximum period, \( K \) is the adimensional coefficient, \( D \) is the grain size (mm). In this study the maximum wave height (\( H_{b,\max} \)) was changed to significant

Figure 1. Study area showing the submerged platform and core location. Satellite image (LANDSAT TM 7).
The results of this parameter applied on the wave prediction station 22 (near of the core location), point to an offshore migration of the bars during the year. As observed in the Table 1, wave parameters are similar for stations on the same side and for the same seasonality, and this way the control of the direction on-offshore seems be strongly governed by grain size (TOLDO JR., 1994; TOLDO JR. et al., 2003).

Thus base on the model, the distribution of the flow energy of waves at this lagoonal sector indicates that the cross-shore sediment transport dominantly occurs to offshore. This theoretical process could explain the building of this wide platform as a consequence of progradation of lagoonal margins.

**CONCLUSION**

The analysis of the preexistent data together with the new data of this study allowed the interpretation of three
evolutionary phases:

(i) rework by waves (creating a ravinement surface) of vegetated, iron-stained, eolian sands of the Pleistocene barrier during a lagoonal level rise connected to the final stages of the Postglacial Marine Transgression,

(ii) depositional of gray sands with low organic content, containing shells of Erodona mactroides in the form of a platform front (similar to a delta front) Holocene,

(iii) build up of 2 m, and progradation of the platform by pale-yellow sands produced by an offshore transport of sediments (Holocene).

According to the dating the feature isn't a drowned lagoonal margin but it is a result of an active progradation of the lagoon margin under the present dynamics. New data coming from future studies to be carrying in the area would point to what is the most consistent hypothesis to explain this morphologic feature of Lagoa dos Patos lagoon margins.

**LITERATURE CITED**


**Table 1. The seasonal wave parameters along of the lagoon shoreline, from wave hindcast model (Hₜ is the significant wave height, and Tₜ is the peak period).**

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<th>Wave Station</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
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