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## QUATERNARY EVOLUTION OF RIO ITABAPOANA COASTAL PLAIN AND ITS RELATION WITH VULNERABILITY

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### ABSTRACT

Quaternary evolution from Rio Itabapoana Coastal Plain is studied with the perspective of Geomorphology and field work. Seven stations were sampled, being one on the beach, where a profile was made comprising 3 ancient beach ridges. Sixteen samples were statistically analyzed, and morphoscopy and faciology were determined. As Holocenic beach-ridges are evident at the northern part of the river, it apparently stayed as a barrier-lagoon system for a long period before reaching the coast. When it happened, southward currents were more intense. The article finishes with a Quaternary evolution scheme regarding sea-level fluctuations.

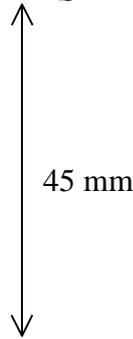
### INTRODUCTION

According to MARTIN *et al.* (1996), the state of Espírito Santo has two geomorphological units composing the landward boundaries separating the coastal plain from inland: a Tertiary plateau (Barreiras Formation) and another composed of crystalline rocks. Presidente Kennedy is located at the southern border of Espírito Santo, where this Plateau is in contact with the Quaternary deposits. The municipality is classified within the Sector 6, with a very important Quaternary deposit (MARTIN *et al.*, 1996).

The objective of the present work is to study the characteristics of Rio Itabapoana Coastal plain Quaternary evolution in comparison with other rivers in Brazil and correlate it with its vulnerability to inundation.

### MATERIAL AND METHODS

Aerial photographs were first obtained from *Instituto Estadual do Meio Ambiente* (IEMA, 2008) and from RADAM survey (1970's) in order to study the coastal plain evolution through Geomorphology and also to monitor morphological changes over time. After the definition of the coastal plain features a field survey was done, collecting subsuperficial samples for each geomorphological feature, in a total of five. One last station was surveyed with 3 samples (current riverbed). On the beach, a topographical profile was made, comprising 500 meters (3 ancient beach ridges), and one sample was collected, at the beach face.



Sediment analysis was done based on the method proposed by Suguio (1973), separating in classes according to Folk and Ward (1957) and analyzing morphoscopy as L.I.G.U.S (1958) and Pettijohn (1957). The software Gradistat® was used to give the statistical parameters of the samples. As the content of mud and organic matter was analyzed, the faciology could be determined according to Larssonneur (1977), modified by DIAS (1996). Using the “Powers roundness scale” (Powers, 1953), 100 grains from each of the fractions 1,0φ; 1,5φ and 2,0φ of each of the samples were analyzed. SRTM data from INPE (Instituto Nacional de Pesquisas Espaciais – National Institute for Spatial Research) were used to create an altimetry map.

## RESULTS AND DISCUSSION

Seven geomorphological features could be identified, as listed below:

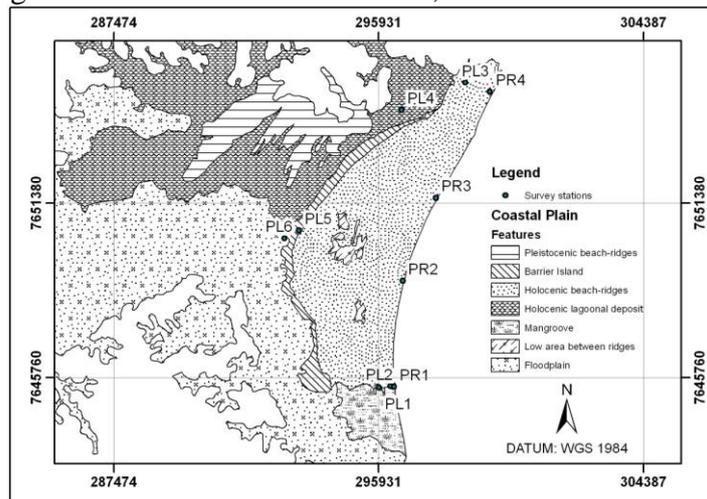
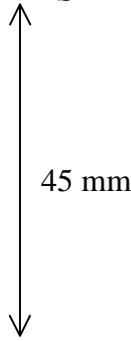


FIGURE 1 – Geomorphology features on the area

The Holocenic and Pleistocenic beach ridges can be seen in aerial photographs and were also observed on the beach profile done in station one (comprising three stations: PL1, PL2, PR1). The 500m – profile comprised 3 different beach ridges, ranging from 3,8m to 2,8m above sea-level, with lower areas within them, where groundwater may eventually outcrop. Pleistocenic beach ridges presented poor to moderate grain sorting, and very high mud and organic matter content (quite similar to the Floodplain), but no carbonate content, as well as the paleo-barrier island. There are three main possible reasons for this: time-action; dissolution by low pH, high [CO<sub>2</sub>] and/or organic acids, which can be found in fluvial environment and is coherent with DILLENBURG & HESP (2009) who say that the internal terraces are not as continuous as the external because of erosion during events of lower sea-level. At last, in a low sea-level stage the sedimentary coverage of the continental shelf disabled carbonate organisms to procreate, as they depend on illuminated and shallow environments to develop. Holocene sea-level rise was responsible for the Pleistocenic materials withdraw over substrate, and then the organisms could procreate and give the current beaches carbonate material. The high mud



and organic matter content found on the Pleistocenric ridges and the Floodplain is resulting from their geological history as a lagoon system (TOMAZELLI & DILLENBURG, 2005). The Holocenric beach ridges showed the same faciological characteristics as the current beach: medium to coarse lithoclastic sand, moderately to well sorting, low mud content and high carbonate content compared to the other features. As ANJOS *et al.* (2006) also describe, the influence of the Tertiary cliffs over southern Espírito Santo's Quaternary basins can be seemed under two aspects. First at their flanks, with higher mud content, that may represent a talus deposit from the cliffs and second, the morphoscopy. The immature aspect of the ridges grains, similar to the cliffs (no roundness or slightly rounded and dirty, accordant with TAMARA, 1995, who found the Formation's grains subrounded in Espírito Santo) evidences the last as a sediment source, thus, there must be currents responsible for longshore transport from those cliffs to Marobá and Praia das Neves beaches. As the distance between the cliffs and the beaches is small, the sediment would still be immature and with no roundness. Considering the ridges show a NE-SW orientation, the prevailing currents present a southward direction. The formation of theses ridges is related to sea-level drop, with longshore currents being trapped by the river mouth, probably after 5.800 yrs BP (ANGULO *et al.*, 2006), according to the hydraulic jetty model (SUGUIO & MARTIN, 1981). It is worth to note that the Pleistocenric beach ridges (black circle) reach over 8 to 10m high (FIGURE 2), according to the sea-level high found for Brazilian east coast during Pleistocene (BARRETO *et al.*, 2002). Altimetry is one of the most important aspects in vulnerability studies (TAGLIANI *et al.*, 2010).

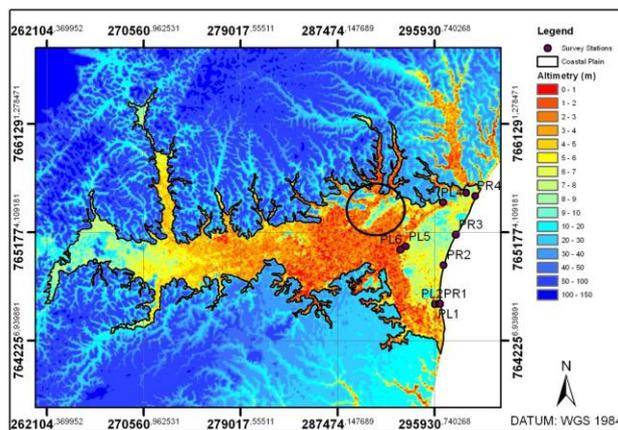
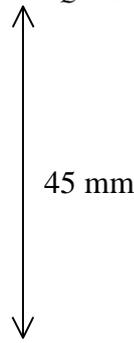


FIGURE 2 – Altimetry map

As MODOLO (2010) attests, vulnerability is related to the geological history of the plain: the presence of mud in the nearshore covering the coarser sediment that would probably be incorporated to the beach, the exposure degree to waves, shape of the plain and so on. Studying Itabapoana Plain's evolution, it is remarkable that it differs from the model proposed by Dominguez *et al.* (1981) for the Rivers São Francisco (SE/AL), Jequitinhonha (BA), Doce (ES) e Paraíba do Sul (RJ). As Suguio (1992) attests, when a river has beach ridges along both sides, it is result of the deflection of local paleo-currents, probably due to long-term El



Niño events. Itabapoana presents beach ridges only on its northernmost part. The low force of the river's hydraulic jetty could explain the reason for which it stayed as a lagoonal system for a greater period, and reached the coast very recently, when no great events of El Niño took place. This might have happened over the last  $5.230 \pm 230$  years, age found for Holocenic lagoonal deposits in the area (MARTIN *et al.*, 1996). As it reached the seashore, it could act as a hydraulic jetty, and trap sediment of southward longshore currents. Since that time, the currents followed almost the same current pattern (southward), showing the symmetrical and homogeneous shape of beach ridges. Figure 3 presents the evolution scheme for the Coastal Plain during the Quaternary period.

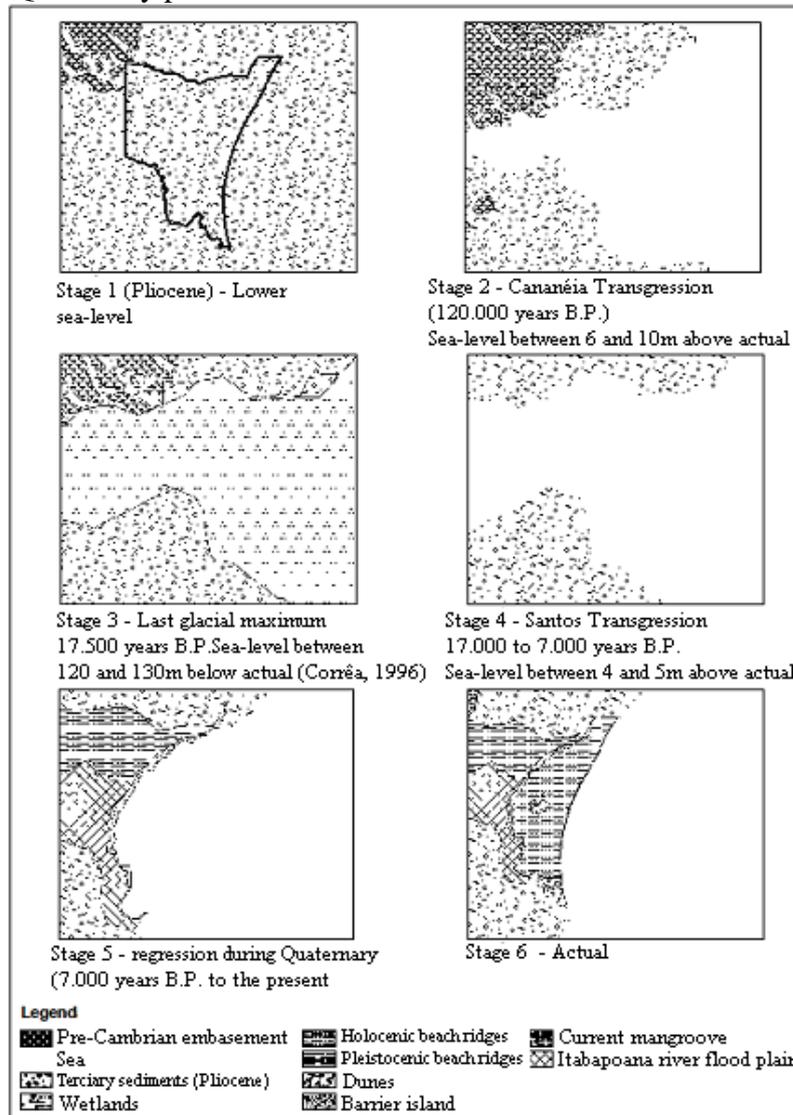
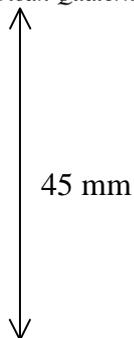


FIGURE 3 – Evolution scheme



## CONCLUSIONS

It could be attested that there is a great link between Geomorphology, Altimetry and Vulnerability. The Geomorphology study showed that Itabapoana River was confined by the Barrier Island for a long period. This resulted in a huge swamp area, which is represented today by the Pleistocene beach ridges and the floodplain. As the river reached the shore, Holocenic beach ridges were then constructed, by southward longshore current trapping. The altimetry of the swamp area is the lowest, reaching sea-level; while Holocenic beach ridges reaches up to 8 m high. The plain is surrounded by cliffs reaching up to 100m high. As the vulnerability is a result of altimetry, the most vulnerable area is found on the swamp, which is flooded easily, while the Holocenic beach ridges are the less vulnerable area, which is the highest.

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