

EPISODES OF SEVERE EROSION IN THE JEQUITINHONHA RIVER STRANDPLAIN CAUSED BY CHANGES IN RIVER DISCHARGE AND COASTAL WAVE CLIMATE

José Maria Landim Dominguez¹; Louis Martin²; Abílio Carlos da Silva P. Bittencourt³.

¹ *Ph.D. Geologia e Geofísica Marinha, LEC-CPGG – Universidade Federal da Bahia*

Instituto de Geociências – Campus Universitário de Ondina – 40150-115 – Salvador – Bahia - Brasil

Phone: +55 71 9119-5484. e-mail: landim@ufba.br

² *Dr., IRD - Résidence Les Courtilles, Bât.i 149, Rue Oberkampf, 75011, Paris, France. E-mail: Louis.Martin@noos.fr*

³ *MsC, LEC-CPGG – Universidade Federal da Bahia - Instituto de Geociências – Campus Universitário de Ondina – 40150-115 – Salvador – Bahia – Brasil. e-mail: abilio@cpgg.ufba.br*

RESUMO

A planície costeira do rio Jequitinhonha esteve submetida durante o Holoceno a severos episódios de erosão da linha de costa. Estes episódios foram causados por mudanças climáticas que provocaram diminuição da precipitação na bacia hidrográfica deste rio e mudanças na frequência relativa dos trens de onda que alcançam a linha de costa. Estas mudanças são aqui tentativamente associadas com uma diminuição do avanço das frentes frias para norte, tanto no verão quanto no inverno.

ABSTRACT

The Jequitinhonha river strandplain has experienced severe episodes of shoreline erosion during the Holocene. These episodes have been caused by climatic changes that induced decreases in rainfall on the hydrographic basin and changes in relative frequency of the wave trains reaching the shoreline. These changes are tentatively attributed to a decrease in the northward advance of polar fronts, during both the winter and summer months.

Palavras-Chave: coastal erosion, beach-ridges, climate changes

1. INTRODUCTION

The Jequitinhonha strandplain, located in southern

Bahia state, Brazil, with a total area of 800 km², is the result of a complex interaction of quaternary sea-level and climatic changes, sediments brought by the Jequitinhonha river and the wave dominated longshore drift. The Jequitinhonha river drains an area of approximately 66.000 km² and has an extremely large sediment yield (226,000 ton/km²) when compared with neighboring drainage basins. This large sediment yield is the result of a combination of a high mean relief and precipitation in the drainage basin of that river. Major river discharges occur during the southern hemisphere summer as a result of advection of cold fronts along the hinterland. During winter, the cold fronts advance only along the coastal zone, and precipitation on the drainage basin is very much reduced.

The wave climate changes along the year in response to changes in atmospheric circulation. Although NE/E waves are present yearlong, during fall and winter (march-august) SE and SSE waves plays a significant role.

Several works have called attention to the fact that the Late Quaternary has been a period of significant changes in climate, which resulted in changes in precipitation in drainage basins (Haug et al. 2001, Siffedine et al. 2003) as well as changes in wind-wave patterns in the coastal zone (Martin et al. 1998).

The Holocene portion of the Jequitinhonha strandplain is characterized by impressive sets of beautifully preserved beach-ridges that occur on top of marine terraces formed as a result of extensive progradation of the shoreline, which in some sectors reached more than 10 km.

These beach-ridges can be thought of as a formidable archive of past sediment dispersal patterns along the

shoreline. The geometry of these beach ridges, their orientation and truncation patterns can provide us with a wealth of information concerning changes in wave climate and when near the river mouth changes in solid river discharges related to changes in precipitation over the drainage basin.

2. OBJECTIVES AND METHODS

Major goal of this research was to evaluate the effects of climate changes, as traduced by (i) changes in precipitation on the drainage basin and (ii) changes in wind/wave climate, as significant controls on episodes of severe erosion affecting the coastal plain of the Jequitinhonha river.

This goal has been achieved through the integration of:

- i. documentation of beach-ridge geometries and truncation patterns and their relationships with coastal dispersal systems and river discharges as well as its variations through time.
- ii. numerical modeling of pattern of wave refraction and longshore transport of sediments for different scenarios of wave climate.
- iii. Documentation of shoreline changes during the last 45 years through comparison of aerial photographs and satellite images.

This integration have allowed us to gain new important insights on the evolution of this plain and the role played by climate change in its evolution and in the episodes of severe erosion.

3. RESULTS

Wave trains reaching the shoreline are predominantly from E and NE ($T=5s$, $H=1.0m$) during the summer-spring, and from SE and SSE ($T=6.5s$, $H=1.5m$) during the fall-winter, according to wave/wind statistics available in the literature. These wave trains promote a divergence of longshore drift around the Jequitinhonha river mouth, in such a way that riverborne sediments are redistributed to both sides of the strandplain. At the southernmost portion of the plain however, this longshore drift inverts trapping sediments between this section and the river mouth. Changes in the relative frequency of the wave trains result in significant changes in these dispersion patterns. A decrease in the percentage of SE and SSE waves has as a major effect an increase in the intensity of the south-directed longshore drift in the southern portion of the strandplain and the elimination of the inversion mentioned above. At the same time the north-directed longshore transport in the northern portion of the plain is greatly reduced. On the other hand a decrease in the percentage of NE and E waves has as a major consequence, an intensification of the north-directed longshore drift in the northern and the southernmost portions of the strandplain. At the portion of the strandplain located immediately south of the river mouth, the longshore drift is greatly reduced and inverts becoming directed towards the north.

The beach-ridge geometries at the Jequitinhonha strandplain have been previously studied by Dominguez (1983, 1987), who has shown that beach-ridges can be grouped in three major sets, associated with major changes in location of the Jequitinhonha river mouth, apparently controlled by abrupt changes in relative sea level. If we focus our attention in the southern portion of the strandplain these three major sets can be easily individualized. Set 1 represents the southern distal portion of the strandplain, when the Jequitinhonha river emptied where the city of Canavieiras is located. In this set beach ridges are parallel to each other and shows no truncation pattern. Set 2 was constructed in associations with a river mouth located a little bit north of the present Jequitinhonha river channel. At this set beach ridges are also regular although slight truncations are present. Set 3 is associated with the present day course of the Jequitinhonha river and has been constructed during the last 2500 years. This set presents very peculiar truncations near the river mouth in which the pronounced cusped form associated with the river mouth is almost planned and sediments redistributed to both sides. At the southern portion of the strandplain the small Mogiguiçaba river exhibits a peculiar behavior of lateral migrations in which periods of cusped morphology at the Jequitinhonha river mouth are associated with northward migration of the Mogiguiçaba river whereas periods during which the cusped geometry at the Jequitinhonha river mouth was planned corresponds to periods of southern migration of the Mogiguiçaba river.

Approximately 1200 years BP and extending approximately to 1700 AD. A massive transport of sediments took place from the cusped form at the Jequitinhonha river

mouth to the southern portion of the plains, forcing a migration of the Mogiguiçaba river towards the south for a distance of approximately 10 km. This massive erosion at the Jequitinhonha river mouth culminated approximately 300 years ago, when that city of Belmonte was founded at the mouth of that river. After that, three major cusped forms developed in association with the present Jequitinhonha river mouth, separated by episodes of severe erosion. The last episode culminated in 1906, forcing the transfer of the Belmonte lighthouse from the shoreline to the that city. Afterwards the shoreline reverted its trend and prograded almost 1 km.

4. DISCUSSION

In the light of the results of the wave refraction and dispersal modeling, and the study of the beach-ridge geometries we can argue that since the beginning of the construction of the Holocene portion of the strandplain, up to approximately 1200 years BP, sediment dispersal was somewhat similar to what is observed today, with intercalations of periods of high river discharge leading to the formation of a cusped geometry at the river mouth and periods of low discharge promoting the partial planing of the cusped morphology. These episodes were associated with an increase in the intensity of the NE-E waves which enhanced sediment dispersal towards the southern portion of the plain forcing the migration of the small Mogiguiçaba river mouth in that direction. Testimonies of these episodes are recorded in the beach ridges located in the southernmost part of the plain, and in the immediate vicinity of the river mouth.

However, from 1200 years BP to approximately 300 years ago, a dramatic change in sediment dispersal is recorded in the beach ridges, showing that during this extended period of time, SE and SSE waves have had their frequency greatly reduced in association with a dramatic decrease in sediment supply by the Jequitinhonha river.

These changes are tentatively attributed to an overall decrease in the advance of the cold fronts during both the winter (causing a reduction in the frequency of the SE and SSE waves) and summer (causing a reduction in precipitation at the Jequitinhonha river basin and therefore sediment yield). Such a scenario could very well explain the changes in sediment dispersal archived in the beach ridge sets present at the Jequitinhonha river plain.

5. FINAL REMARKS

The results presented herein points out to the inherent shoreline instabilities associated with river mouths. Although this is a very well known assumption, case studies, particularly in wave dominated coasts such as Brazil are very rare. This paper has shown the intimate linkage between the effects of climate change in drainage basins and episodes of severe erosion at the river mouth. Also, since changes in precipitation will also be coupled with changes in wind patterns, modifications in wave climate and coastal dispersion systems are expected.

Until 2002 the Jequitinhonha river did not have major impoundments. However since march of 2003 with the completion of the Itapebi dam, located ??? km from the

Jequitinhonha river mouth, sediment supply to the river mouth was severely reduced. Coastal erosion will surely ensue in the coming years. The insights acquired from the present study will allow us to better predict the future changes in shoreline resulting from this more recent human interference in the Jequitinhonha's river drainage basin.

REFERÊNCIAS BIBLIOGRÁFICAS

- DOMINGUEZ, J.M.L. 1983. Evolução Quaternária da Planície Costeira Associada à Foz do Rio Jequitinhonha (BA): Influência das Variações do Nível do Mar e da Deriva Litorânea de Sedimentos. Universidade Federal da Bahia – Dissertação de Mestrado.
- DOMINGUEZ, J.M.L. 1987. Quaternary Sealevel Changes and the Depositional Architecture of Beach-Ridge Strandplains Along the East Coast of Brazil. Rosenstiel School Of Marine And Atmospheric Sciences University Of Miami, RSMAS, Estados Unidos. Tese de Doutorado.
- HAUG., G.H.; HUGHEN, K.A; SIGMAN, D.M.; PETERSON, L.C; RÖHL, U. 2001. Southward Migration of the Intertropical Zone Through the Holocene. *Science*, 293: 1304-1308.
- MARTIN, L.; DOMINGUEZ, J. M. L.; BITTENCOURT, A. C. S. P. 1998. Climatic Control of Coastal Erosion during a Sea-Level Fall Episode. *Anais da Academia Brasileira de Ciências*, São Paulo, São Paulo, v. 70, n. 2, p. 249-266,
- SIFEDDINE, A.; ALBUQUERQUE, A. L. S.; LEDRU, M. P.; TURCQ, B.; KNOPPERS, B.; MARTIN, L.; MELLO, W. Z.; PASENAU, H.; DOMINGUEZ, J. M. L.; CORDEIRO, R. C.; ABRÃO, J. J.; BITTENCOURT, A. C. da S. P.. 2003. A 21,000 cal years Palaeoclimatic Record from Caço Lake, northern Brazil: evidence from sedimentary and pollen analyses. *Palaeogeography Palaeoclimatology Palaeoecology*, v. 189, p. 25-34,