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Foreshore Morphodynamic Changes in a Bimodal Sediment Beach

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ABSTRACT

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This study intends to examine modifications of the foreshore related to beach profile recovery and the resulting depositional structures after the occurrence of storm events. The experiments were done in the "Concheiros do Albardão" region, located 10Km northward of the Hermenegildo balneary, in Southern Brazil. At both experiments, beach accretion was observed with larger changes recorded at the lower foreshore. During the "runs", significant grain size changes were recorded. A clear zonation in the surficial sediment distribution was noticed with finer, coarser and bimodal sediments located respectively at the upper, intermediate and lower portion of the foreshore. Sediment cores demonstrated laminations alternatively composed exclusively of quartz and carbonate sands or composed by a mixture of both. It appears that at the upper part of the beach rates of beach accretion were induced by moderate wave regime at lower water table levels. Morphological changes in the lower portions can be related to lower water table levels as well as higher turbulence caused by the colliding uprush and backwash.

ADDITIONAL INDEX WORDS: *Beach face sediments, quartz and calcareous sands, profile recomposition*.

INTRODUCTION

Many studies were done focusing the interrelationship between the hydrodynamic of the surf and swash zones of beaches constituted by unimodal sands and the resulting crosshore sedimentation patterns. Similar studies on foreshores characterized by bimodal sands (SONU, 1972, TAIRA and SCHOLLE, 1979; MOUSTAFA, 1988, KLEIN, 1998) are scarce and not well understood.

This work intends to provide additional information regarding the surficial crosshore sediment size distribution and depositional processes of a bimodal beach sand during profile recovering after a storm event.

METHODS

Beach data was collected in a region of southern Brazil called "Concheiros do Albardão" which is located 10 Km northward of Hermenegildo Beach. (Figure 1). The adopted methodology was modified from MOUSTAFA (1988) . Since the main objective was to evaluate the role of the waves on the beach sediment distribution and profile recomposition the experiment was done on a neap tidal cycle during the fall.

The sampling methodology consisted of two experiments named "A" and "B"which had respectively the duration of 7:30 h and 9:30 h and were performed respectively on 16th and 17th of May of 1993.

At each experiment five shores normal transects were placed (Figure 2). In order to indicate its position on the beach face, each transect was subdivided at intervals with numbered rods.

At transect I a Klovan type sediment core modified by GREENWOOD et al (1984) was used to sample changes in beach laminations during the beginning and the end of the experiment. After the coring, dye sand was introduced on each hole in order to evaluate the length of mixing depth.

At transect II to monitor sediment migration, surficial sediment samples spaced 4 m each and distant 20 cm of the rods were taken at one hour interval with the help of cardboards of 100 cm^2 labeled with Vaseline. On the lower foreshore samples were collected by hand.

Beach profile evolution was performed every 30 minutes at transect III by measuring elevation changes related to the top of metal rods driven on the sand. A rule fixed on a metal plate was used to take the mean value of three measurements done in each rod. All the measurement was tied up to a bench mark located at the backshore.

Transect IV was designed to measure changes in the water table from a shallow well log of PVC driven on the beach. Measurements were taken at 30 minutes interval using a stick, greased with a special paste which changed the color when in contact with water.

Significant wave height and period were visually obtained and the tidal variation was obtained from the Rio Grande harbor.

RESULTS

Significant wave height of 1.0 and 0.9 m were respectively observed for experiment "A" and "B". Minimum and maximum wave height and tidal height for both experiments ranged from 0.5 to 1.0 m and 10 cm respectively (Figure 3).

At both experiments net accretion was noticed. The total sediment package thickness changed 38.38cm and 45.16cm for the experiment A and B respectively. The profile obtained at 3.00 P.M. for the A experiment displayed the maximum accretion with values reaching 18.42 cm. For experiment B, the higher accretion rate of 28.79cm was obtained at the 5:30 P.M. profile. At the experiment B was observed erosion at the middle beach face and accretion at the upper and lower beach face (Figure 4).

Small morphological variations were observed on the superior beach face. These variations increase with the seaward crosshore distance (Figure 4). The maximum, average and minimum morphological variation amplitudes were 10.5cm, 3cm and 0cm to experiment A and 14.2cm, 4.3cm and 0 cm to experiment B, respectively.

The morphological changes were ruled by the water level variation and the wave height. However, it was not observed the occurrence of sediment accretion or any morphological changes during low tidal and small wave heights. The wave frequency was the probable variable that ruled these processes.

The standard deviation of morphological changes increased with the seaward crosshore distance at both experiments, but it was observed a peak of the standard deviation near 38m and

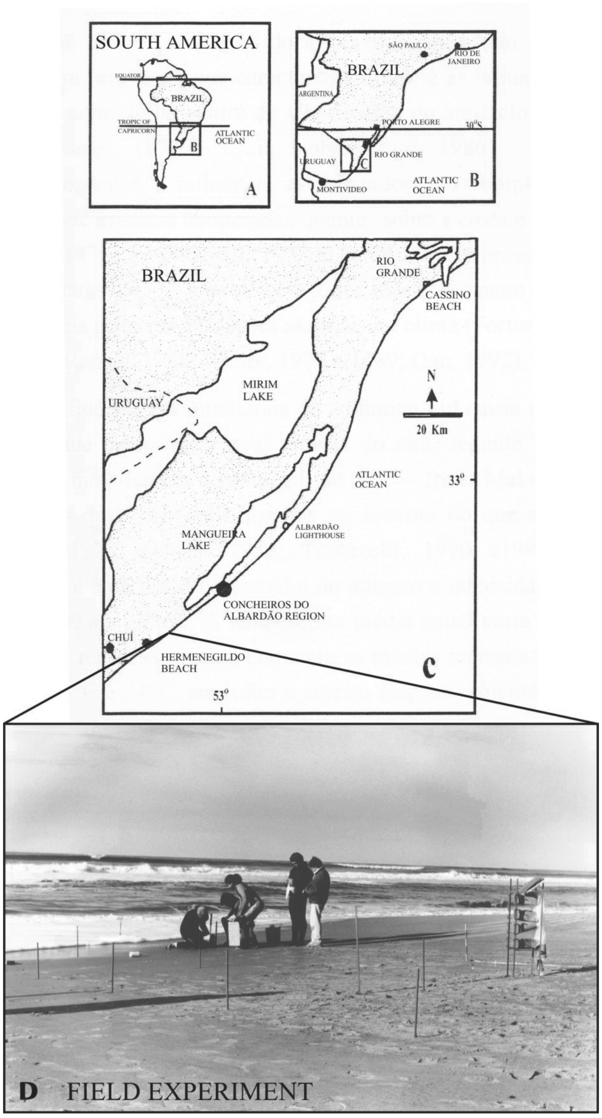

Figure 1. Study area where A is the South America Map, B is the Southern Region of Brazil, C is the Southern Region of Rio Grande do Sul State and D is a Picture of the Field Experiment.

34m crosshore distance to experiment A and B respectively (Figure 5).

It was observed great grain size variability and a clear zonation at the sediment surface distribution at both experiments (Figure 4).

The positive modal value for the quartz sand was 2.5 (phi). The negative modal class represented by the carbonate fraction showed a large variability between the runs.

The identification of three different zones at the beach face was based on the grain size. The zones were called "Upper Portion" with grain size greater than 2, "Intermediate Portion" with grain size between 1 and 2, and "Lower Portion" with grain size minor than 1. Grain size varied between 1 and -2 at lower portion (Figure 4).

The surficial sediment zones presented a landward migration where the coarser sediment of the lower portion migrated over the bimodal sediment of the intermediate region (Figure 4).

At the positions 1 and 2 water table changes and in saturation was observed. However, at position 3 a greater water table variation with saturation was visible.

Sediment cores demonstrated laminations alternatively composed exclusively of quartz and carbonate sands or composed by a mixture of both, but a clear layer intercalation was not observed.

The average mixing depth was 3.7cm for . For experiment B the values were not considered because of the occurrence of erosion events on middle beach face. So the equation to

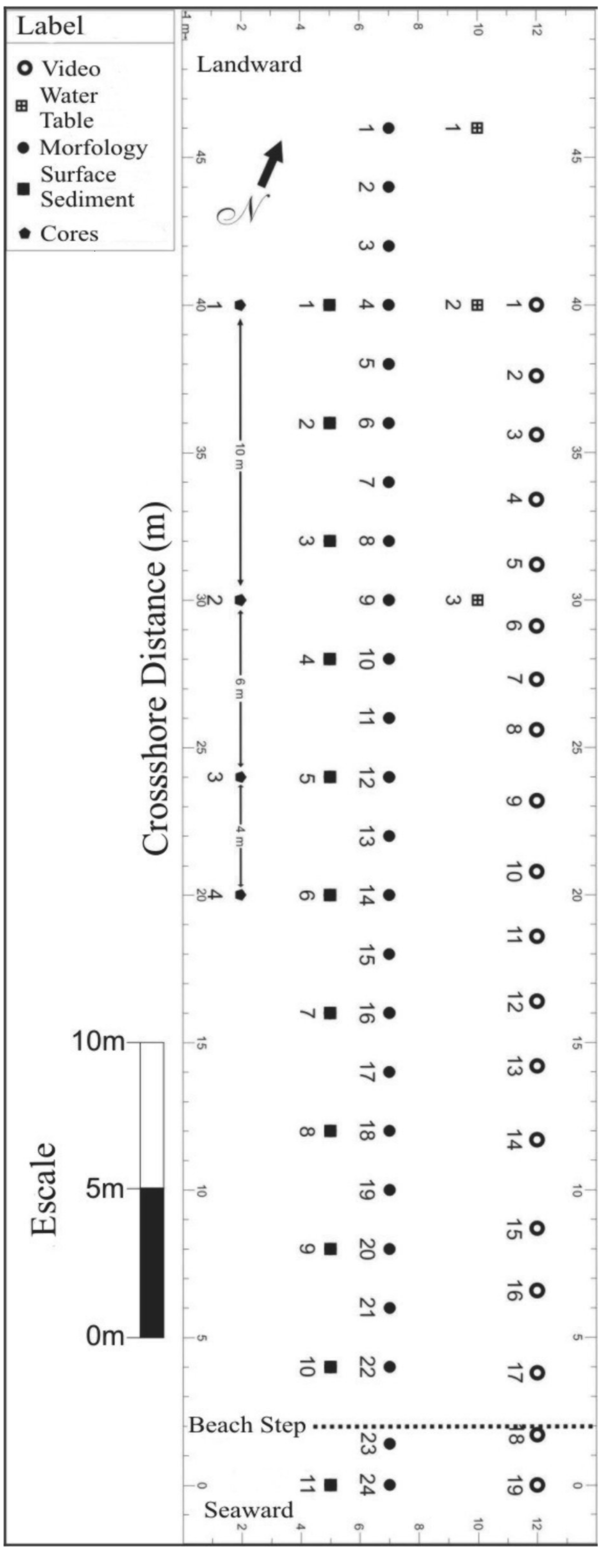

Figure 2. Diagram of the field methodology.

determine the average mixing depth is:

$$Z_m = 0.03H_{bs} \qquad (1)$$

were Z_m is the average mixing depth and H_{bs} is the significant wave height.

DISCUSSION

In this study it was observed that morphological changes and surficial sediment distribution were greater at the lower swash zone due to the greater wave turbulence and saturation by the water table.

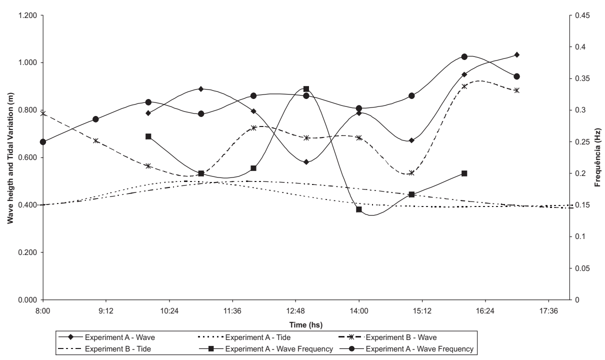

Figure 3. Wave height and tidal variation at both experiments.

It was also observed the occurrence of migration of the sedimentary zones with a small tidal variation. This migration was greater at the lower swash zone, but it also occurs at the upper swash, because of the distinct wave energy and the hydraulic equivalence of the sediment.

As showed by MOUSTAFA (1988) the foreshore presents differences between the subaerial and subaqueous zones due to the wave and tide action which induces modifications on the water table level. Sediment distribution changes and profile elevations on the foreshore are produced by the swash zone migration. These migrations are ruled by the rise and fall of tides. It is also important to consider the beach morphodynamic stage, the tide level and type of incident energy.

Differences in sedimentar zonation and sorting through the swash zone are apparently related with the dominance of specific transport process with selection acting on certain grain sizes.

CONCLUSIONS

The grain size differences and the sedimentary zonation at the beach face were related differences in sediment density. When waves breaks and spreads over the beach face, quartz and calcareous sediment begin the movement at the same time. However, the carbonate grain density is lower than the quartz one and it will require less wave energy to be transported. Thus, coarse grains of calcareous sand are deposited together with the finer quartz grains forming the intermediate portion of the beach face . It is also possible that the two grain sizes deposit at the upper foreshore . The migration of the carbonate sediment over the beach face is related to the wave regime.

The cores demonstrated the occurrence of coarse grained carbonate layers at the upper foreshore. These layers would have been deposited by wave action during storm event or spring tides.

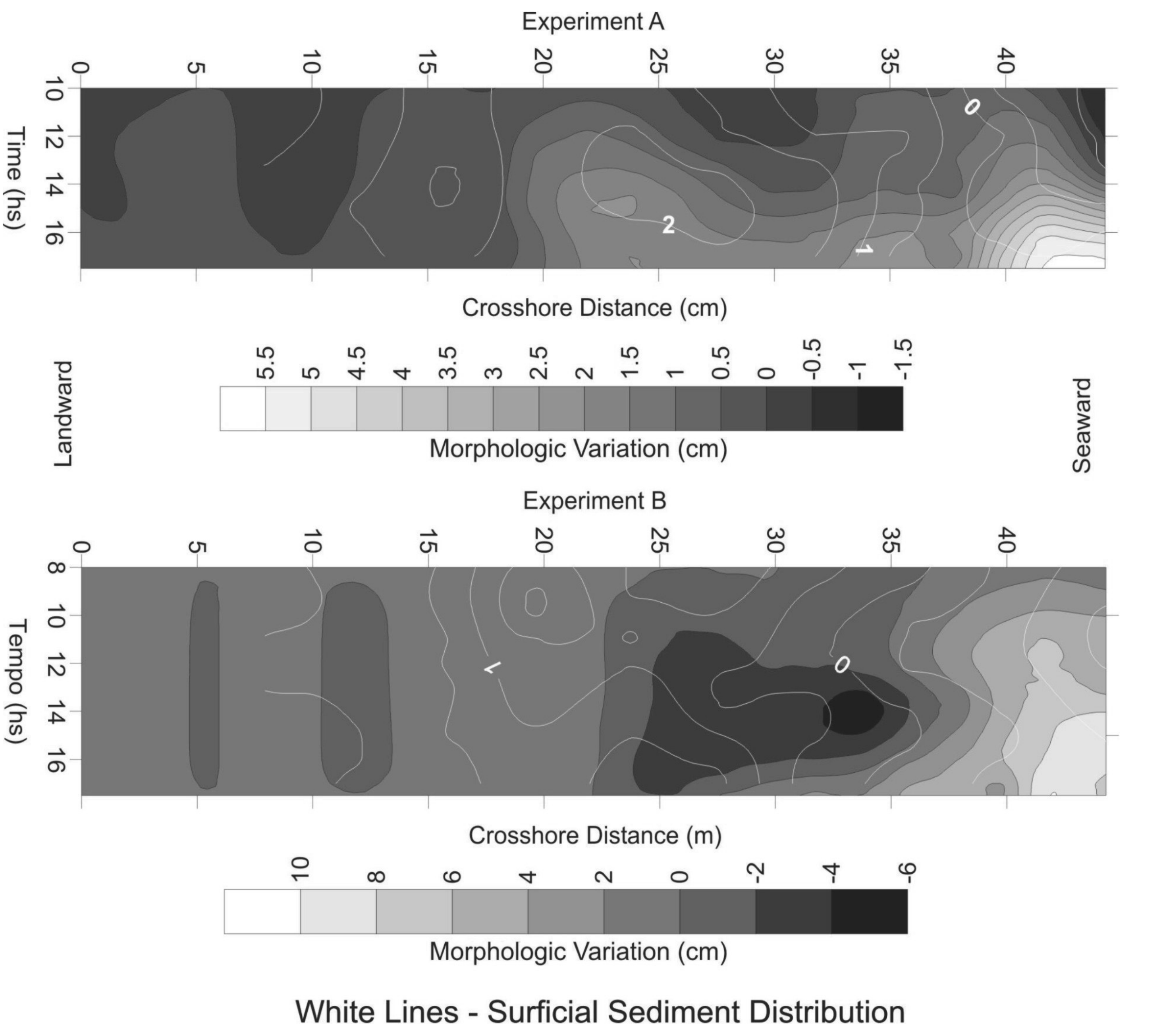

Figure 4. Morphologic Variation (color scale) and Surficial Sediment Distribution (White Lines).

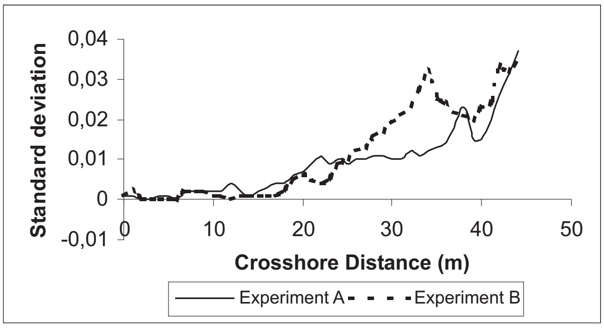

Figure 5. Standard deviation of Morphologic Profiles.

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LITERATURE CITED

ANDREWS, P.B. and VAN DER LINGEN, G.H. 1969. Environmental significant sedimentologic characteristics of beach sands. *New Zealand Journal of Geology and Geophysics, 12, 119-137.*

MOUSTAFA, M.S.J., 1988. Swash Induced Zonation of a Foreshore Sediment Size Distribution. M.A. Thesis, Williamsburg,Virginia: School of Marine Science, College of William and Mary, 139 p.

KLEIN, A.H.daF., 1996. Concheiros do Albardão: Variações Espaço-Temporais dos Sedimentos e da Morfologia Praial. Porto Alegre, Rio Grande do Sul: Universidade Federal do Rio Grande do Sul, Master's thesis.

SONU, C.J., 1972. Bimodal composition and cyclic characteristics of beach sediments in continuously changing profiles. *Journal of Sedimentary Petrology*, 42 (4), 852-857.

TAIRA, A.; SCHOLLE, P.A., 1979. Origin of bimodal sands in some modern environments. *Journal of Sedimentary Petrology,* 49(3), 777-786.