

**CONTRIBUTION TO THE INTERPRETATION OF THE EROSIIVE
BEHAVIOR ON THE HILLS OF GUABIRABA, RECIFE – PE,
NORTHEASTERN BRAZIL: SEDIMENTOLOGICAL ANALYSIS OF
THE SUPERFICIAL STRUCTURE OF THE LANDSCAPE**

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ABSTRACT

The hills of the district of Guabiraba, Recife - PE, show evidences of recent geomorphic disequilibrium as a consequence of an unbalanced erosive budget, mostly attributed to changes in land use. This paper seeks to provide a diagnostic for the recent erosive behavior within this environmental unit of the Municipality of Recife, which overlies the Barreiras Formation sediments, based on the application of a morphostratigraphical approach combined to the sedimentological analysis of recent correlative deposits. Initially, through the usage of remote sensing imagery, a comparison was drawn between two different instants of landscape evolution: 1984 and 2002. The geomorphologic dynamics for that time lapse was assessed by the construction of geomorphic and morphodynamic maps according to Tricart (1977). That procedure has permitted the qualitative evaluation of the erosive behavior for the established timeframe, through the confrontation of spatial arrangements resulting from distinct geomorphic processes. The mapping of process-sensitive geomorphic features was coupled with the description of sedimentological properties of correlative deposits and their source areas. This has enabled the characterization of the superficial structure of the landscape. By comparing digital imaging, geomorphic maps and sediment properties, for the time period considered, it was possible to draw the conclusion that the area has evolved towards the stabilization of its morphodynamic units, displaying a sizeable reduction of gullied areas, as a response to the spreading of the “phytoresistatic equilibrium front”, mainly on the hills covered by a second growth anthropicized savanna. Another significant geomorphological change observed, was the elevation of the local base level, on the foot of the widespread

radial gullies by the coalescence of a system of alluvial fans, which are locally dammed and disconnected of the main collecting drainage, by the lanes of an interstate highway. This damming has substantially diminished the erosive energy of the gully system.

INTRODUCTION

Morphological changes have occurred in the past and still are generated in the present as a response to environmental disequilibrium, which is in most cases a result of human actions. Generally speaking, morphogenetic equilibrium is broken as consequence of human interventions which forces nature into a new stability threshold, thus the pursuit for environmental equilibrium is always a dynamic one. This work is aimed at the morphogenetic evolution of a hilly landscape situated to the NW of Recife Municipality, Northeastern Brazil. This area has been suffering geomorphological changes within the last 18 years derived from human activities which were many times, deliberately, put forward by governmental planning agents, that are ultimately responsible for the production of space and nature appropriation within the realm of the city.

Characterization of the Area

The study area is limited by the following coordinates $07^{\circ} 58' 30''$ S / $08^{\circ} 00' 06''$ S and $35^{\circ} 55' 45''$ W / $34^{\circ} 55' 59''$ W. It lies besides BR-101 Interstate Highway, in the district of Guabiraba, Recife, State of Pernambuco (Figure 01). According to the division of the Municipality in geo-environmental units, the focused area lies within the "Dissected Hills Compartment". In the District of Guabiraba the hills are lithologically structured on the sediments of Barreiras Formation – one of the most extensive sedimentary occurrences along the Brazilian seaboard, formed during the Plio-pleistocene. According to Alheiros (1991), the parental material of the relief compartments in question belong to the alluvial fan facies of the Barreiras Formation, which are characterized by the occurrence of "coarse to conglomeratic sands covered by pelitic sediments (...) and frequently overlying fluvial deposits. Each layer is marked by a traditional deposition at the base, which cuts in sharp unconformity the clays and conglomeratic/coarse sands".

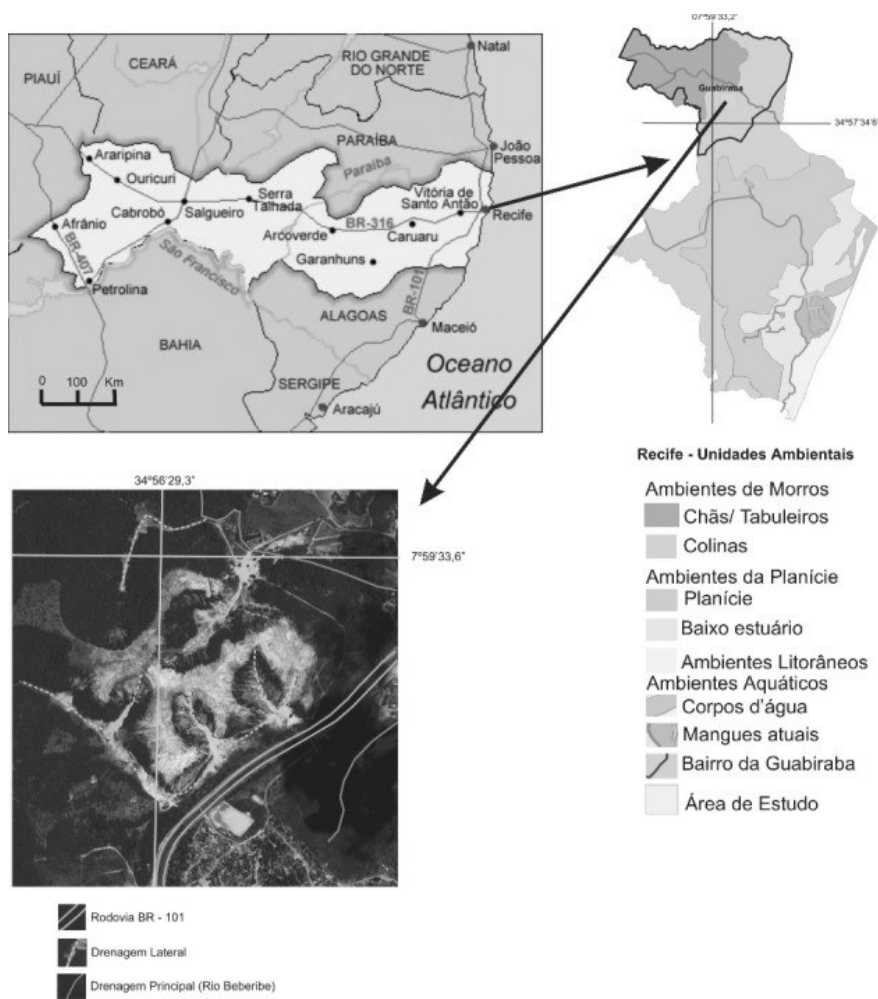


Figura 1 - Localização da área de estudo

Figure 01 – Localization of the Study Area

As for the resulting morphology, derived from the action of exogenic processes, the area is marked by a deep fluvial valley-cutting, followed by alluvial infill that created the flat-bottomed valley-floors. Therefore, interfluves in this area are compartmented in small plateaus and individualized hills, which lie either on the top of the crystalline basement in erosional contact, or over the cretaceous sediments of Pernambuco/Paraíba pericratonic basin (Figure 02).

The weathering mantle in the area is rather deep, showing the predominance of lateritic and podzolic soil covers with high textural and mineralogical maturity. The regional climate is a typical east coast humid tropical variety, with an annual precipitation averaging between 1800 and 2000mm concentrated in the fall/winter, average annual temperature of 26⁰C, and an yearly amplitude of only 3⁰C.

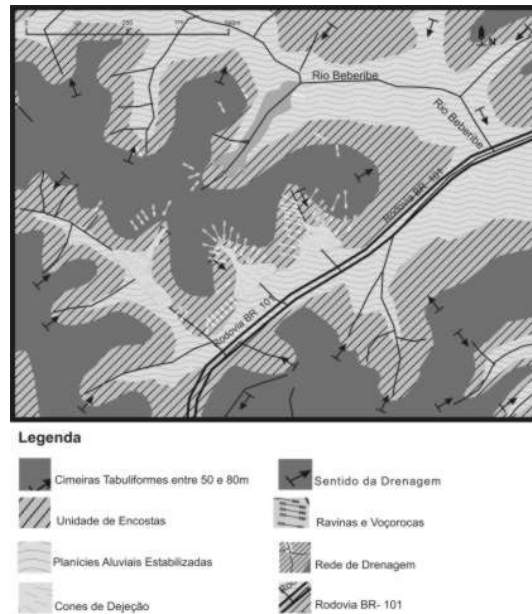


Figure 02 – Geomorphological map of the Guabiraba Hills, Recife, Pernambuco.

Theoretical Review

Landforms derive from the interaction between active and passive forces, resulting from endogenic and exogenic processes. They also become the privileged stage for the development human activities and territorial organization. According to Ross (2000) the geomorphological approach to the environmental studies is based on the concepts of Earth sciences in as much as they provide support for the understanding of the natural environment above which human societies have structured themselves.

In the last decade some attempts were made in order to apply the concepts put forward by Tricart (1977) to the hills of Guabiraba, aiming at establishing a typological ordering of the environmental degradation, based on the resulting forms and their close relationship to the vegetation cover. Corrêa, Albuquerque and Melo (1995) have defined three morphological compartments for the area within a growing gradient of geomorphic disequilibrium: a), morphodynamically stabilized forested hills; b) hills with open savanna vegetation exhibiting incipient erosional forms and an initial break in equilibrium and C) Extensively eroded devegetated hills (highly unstable environments). According to this, the aim of this work is to analyze the recent erosive behavior of this geo-environmental unit of Recife Municipality, based on a morphostratigraphical approach combined to the sedimentological characterization of the superficial structure of the landscape. Hopefully, this study shall indicate areas in which geomorphic processes operate at higher rates.

DISCUSSION OF RESULTS

The population growth in urban areas, in recent years, are accompanied by an increase in land value, which collaborate to spatial segregation of lower income populations. This fact is being accelerated by the dispute for space, once areas that are inhabited by the most affluent populations normally possess the best environmental and urban infrastructure conditions. This process forces part of the population to seek idle or under-used areas, thus occupying the city outskirts where land value isn't so high. In the case of the Guabiraba hills, the degree of environmental sensitivity is high or very high, and urbanization may lead to severe environmental impacts, such as the increase of erosive processes, which alter both the geomorphic landscape as well as rates of sediment production and output. These alterations are directly reflected on the availability of sediments in the river catchments and other channeled flows (Boiko & Santos, 2003).

In the Guabiraba hills erosion was triggered mainly due to the removal of vegetation, which was cleared to the failed construction of a dam. The erosive process is accelerated following the clearing of the land, which leave soil surfaces unprotected and prone to the impact of raindrop splash. Corrêa, Albuquerque and Melo (1995) classified the hills of Guabiraba according to the observation of three distinct stages of morphodynamic equilibrium (Figure 03). The two first stages show, respectively, in their configuration a dense vegetation, although in different successional levels, being both sharply cut by the interstate highway BR 101. Along road-cuts the elaboration of rills and gullies was observed, as a response to the exacerbation of regressive linear erosion, whose energy is sometimes diminished by the incipient vegetation cover. Inside the most developed gullies mass movements also occur, these are dominated by mudflows, slumps and toppling. In the savanna covered hills, mosses have colonized the superficial soil-crust developed by rain-splash, and as a consequence of that erosive features have partly disappeared. Notwithstanding the devegetated hills represent a rather fragile system, in which the removal of vegetation was capital for triggering the erosive processes. In this compartment one can observe the occurrence of process related landforms, such as those generated by dissection or sediment accumulation. Hence in this area gully erosion prevails downstream from rain-splash affected hilltops, which causes the breaking down of soil aggregates and the following sealing of soil surface, thus triggering generalized erosion processes.

Coupled with linear erosion processes, mass movements such as mud flows also occur in the area. These cut through rills and gullies in a channeled fashion, coming to a rest at slope-breaks on the hills foot. These deposits take the shape of alluvial fans that end up raising the

internal base-level of the gullies as well as the base-level of areas situated downstream of the knickpoints that separate the hills from its surroundings. Such mechanisms act in several time scales and are related to a variable precipitation regime, which contributes for the operation of several rates of morphogenetic action through time.

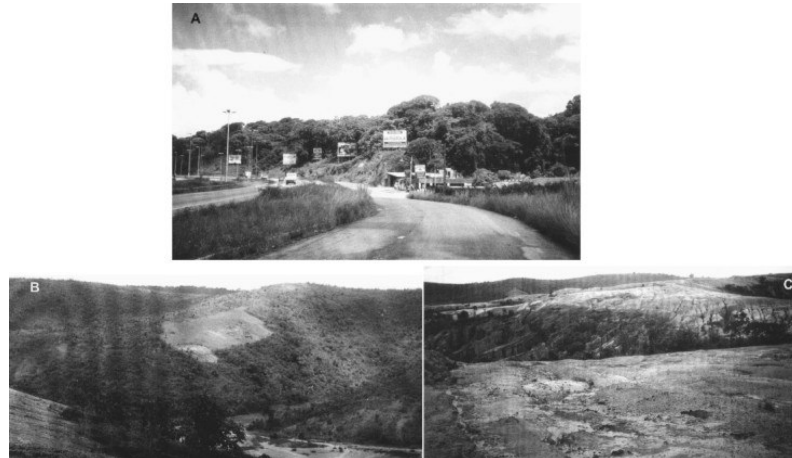
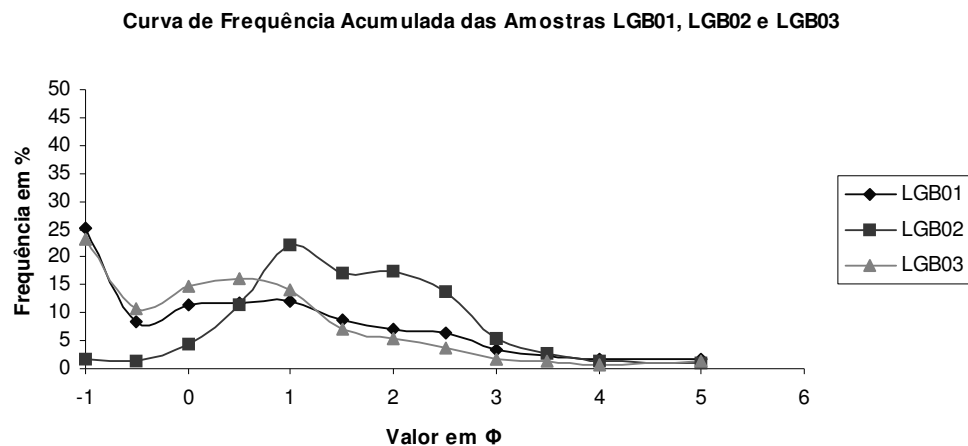


Figure 03: Differing morphodynamic equilibrium stages of the hills of Guabiraba: A – forested hills; B – savanna covered hills; C – unvegetated hills.

Analysis and Interpretation of sedimentological data

The samples LGB01, LGB02 and LGB03 were collected from an alluvial fan situated in the northern extreme of the area. They come from the same vertical section and were collected in intervals of 70 cm. The samples were subjected to grain-size and morphoscopic analysis in the Laboratory of Geological Oceanography at the Federal University of Pernambuco (UFPE). A series of graphs and tables were organized following the results of the sedimentological analysis, as follows: cumulative curve, sorting, asymmetry, curtosis, mean value, rounding and sphericity ratio for the 0,5mm fraction.



Graph 01 – Curve of accumulated frequency for samples LGB01, LGB02 e LGB03

Samples	Mean value	Sorting	Assimetry	Curtosis
LGB01	Coarse sand	Poorly selected	Very Positive	Very platycurtic
LGB02	Medium sand	Moderately selected	Approximately symmetrical	Mesocurtic
LGB03	Coarse sand	Moderately selected	Very Positive	Very platycurtic

Table 01 – Distribution of statistical parameters for samples LGB01, LGB02 and LGB 03.

Sample	Roundness					
	Very angular	Angular	Sub-angular	Sub Rounded	Rounded	Well Rounded
LGB01	NA	NA	F	D	NA	NA
LGB02	NA	NA	F	D	NA	NA
LGB03	NA	NA	F	D	NA	NA

NA – Not applicable

D – Dominant (> 50 % of individuals)

A – Abundant (between 25% and 50 % of individuals)

F – Frequent (between 10% and 25% of individuals)

Table 02 – Morphoscopic analyses of samples LGB 01, LGB02 e LGB03

CONCLUSION

According to the obtained results through the analyses and measuring of 1984 and 2002 remote sensing imagery parameters, it was diagnosed that the area has evolved towards stabilization of its morphodynamic compartments, showing substantial reduction of gullied areas and a steady advance of the vegetation cover, mainly in the savanna covered hills (figures 04 and 05).



Legendas

	Morros Desnudos		Sentido dos Fluxos Superficiais
	Morros Florestados		Ravinas e Voçorocas
	Coneis de Dejeção		Drenagem
	Morros Revestidos por Capoeira		Caminhos e Estradas
	Núcleos Urbanos		Rodovia BR- 101

Figura 04 – Eco-dynamic compartments of the Guabiraba hills in 1984.

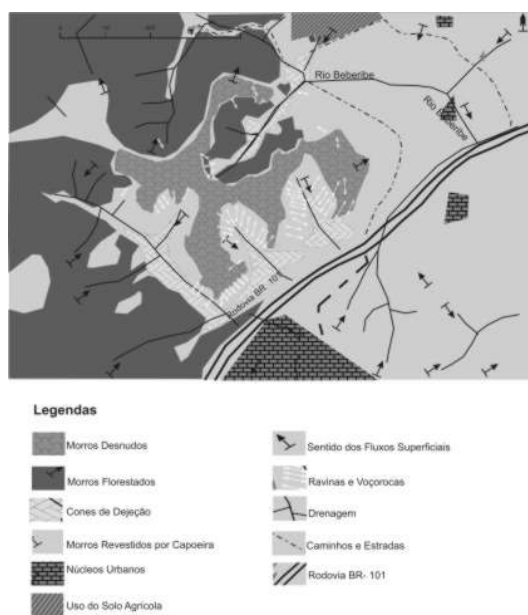


Figure 05 – Eco-dynamic compartments of the Guabiraba hills in 2002.

Another important process involved with the stabilization of the gullies is the raising of base-level inside the gullies themselves, due to the fast deposition of alluvial fans, which in this area are dammed by the interstate Highway BR-101, preventing the drainage system to carry out sediments to the main river – Beberibe river - situated downstream from the highway. This damming helps the base-level rise artificially inside the gullies, thus reducing the available energy for the geomorphic work.

The analyses of the samples collected from the alluvial fan show that the sediments range from poorly to moderately selected. Camargo Filho and Bigarella (1998) believe that ratio of selection is an indicator of varying hydraulic conditions within the transporting fluid, thus the selection should be the result of the sedimentation process that acts upon the material. In this study-case the sedimentary levels within the fan indicate alternating events of more viscous debris-flows and more fluid laminar erosion. Such variations indicate changes in the energy balance within the depositional system as a response to rainfall events of varying magnitudes. As for the modal classes' distribution, it was observed a predominance of sandy classes, with angular grains, hence demonstrating that the material has suffered only a short transport from its source area. The massive presence of quartz in all samples (more than 50%) reflects the mineralogical maturity of the material as a consequence of the humid tropical weathering conditions.

It was also observed that the fast rising of base-level in the northernmost extreme of the area (alluvial fan where samples were collected) has caused a change in the direction of the superficial drainage due to the fast pace of sedimentation on the fan surface. Since the fan lies in front of the gullies, the fast acting processes have also inverted the local relief; turning a concave drainage reception area into a low-lying divide. However, this process is not ubiquitous in the area, apparently due to the gradual diminishing of the erosive energy, especially as vegetation re-colonizes old fans, local base-levels rise and perched water-tables surface (Figure 06).

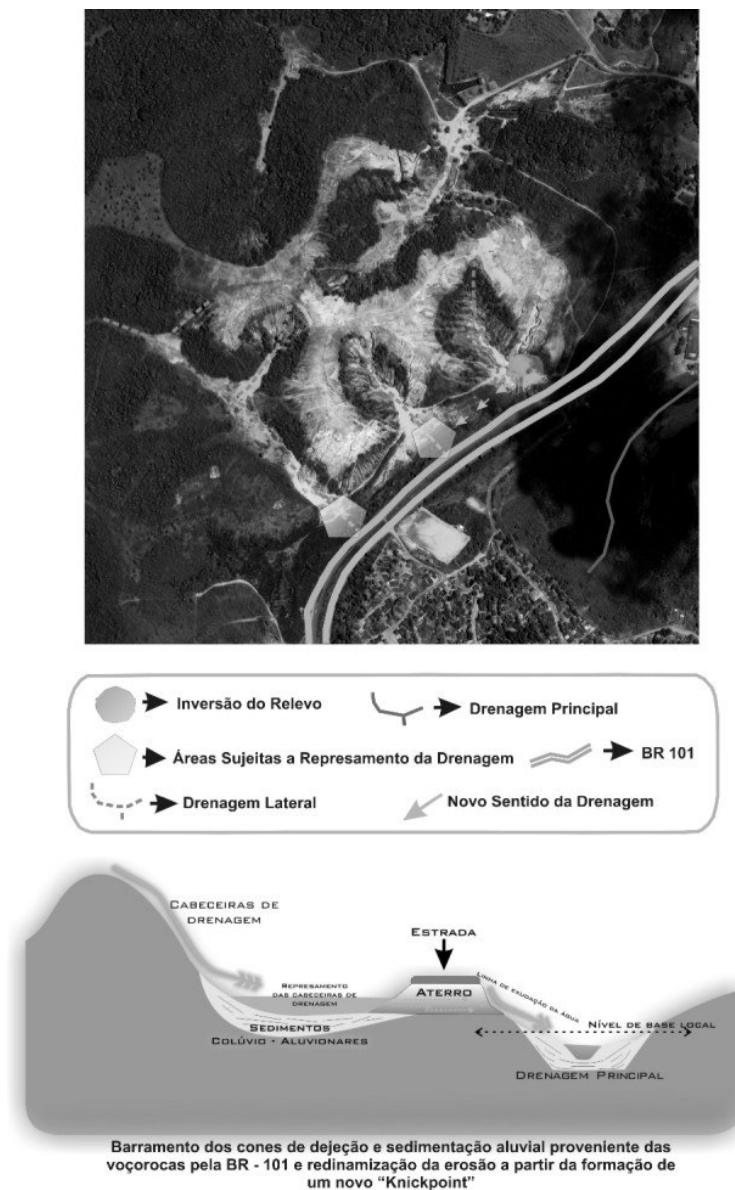


Figure 06 – Damming of an alluvial fan by a highway, forcing local base-level to rise.

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