
A Geotouristic Coastal Itinerary in the Municipality of João Pessoa, Paraíba

Roteiro Geoturístico Costeiro na Cidade de João Pessoa, Paraíba

Un Itinerario Costero Geoturístico en el Municipio de João Pessoa, Paraíba

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ABSTRACT: The coastal environment is an area of conflict, where the marine dynamics intertwine with the tourist flow, originating, from the environmental point of view, an unstable space, in which the impacts are potentially bigger. The objective of the research is to propose a coastal geotourism route for the city of João Pessoa, which will allow the dissemination of the abiotic and cultural-historical aspects of the landscape, aiming to contribute to its maintenance and conservation in the long term. To this, these places of interest were selected after a thorough fieldwork that involved their inventory and quantitative assessment. The places of interest are: Jacarapé Ferruginous Sandstones, Altiplano Paleodunes, Holocene Marine Terrace, Cabo Branco Cliff, Tambaú Sedimentary Balance, Bar of Gramame, Primitive Mouth of Jaguaribe River and Picãozinho. The existence of interpretative trails assigns a new function, now from the geotouristic point of view, to the itineraries, as they enrich the experience of tourists, to whom is given the opportunity of knowing the abiotic heritage and the cultural heritage from another perspective, apart from enhancing their environmental awareness.

KEYWORDS: Coastal geotourism. Geotouristic route. Places of interest. João Pessoa.

RESUMO: Ambientes costeiros são áreas conflituosas, onde a dinâmica marinha se entrelaça a um adensamento populacional, originando, do ponto de vista ambiental, um espaço instável, no qual os impactos são potencialmente maiores. Paradoxalmente, ambientes costeiros são áreas de grande potencial geoturístico, precisamente por sua dinâmica natural que fornece a estes espaços um alto valor científico. O objetivo da pesquisa é propor um roteiro geoturístico costeiro para o município de João Pessoa, que permitirá divulgar os aspectos abióticos e histórico-culturais da paisagem, visando a longo prazo contribuir para sua manutenção e conservação. Para tanto, estes locais de interesse foram selecionados após um minucioso trabalho de campo que envolveu sua inventariação e avaliação quantitativa. Os locais são: Arenitos Ferruginosos do Jacarapé, Paleodunas do Altiplano, Terraço Marinho Holocênico, Falésia do Cabo Branco, Balanço Sedimentar de Tambaú, Barra de Gramame, Foz Primitiva do Rio Jaguaribe e Picãozinho. A existência de trilhas interpretativas refuncionalizam os itinerários, agora do ponto de vista geoturístico, à medida que enriquecem a experiência dos turistas, dando a eles a oportunidade de conhecer o patrimônio abiótico por uma outra perspectiva, além de aumentar sua consciência ambiental.

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PALAVRAS-CHAVE: Geoturismo costeiro. Roteiro geoturístico. Locais de interesse. João Pessoa.

RESUMEN: *Los ambientes costeros son áreas conflictivas, donde las dinámicas marinas se entrelazan con una densidad de población, creando, desde el punto de vista ambiental, un espacio inestable, en el que los impactos son potencialmente mayores. Paradójicamente, los ambientes costeros son áreas de gran potencial geoturístico, precisamente por sus dinámicas naturales que dotan a estos espacios de un alto valor científico. El objetivo de la investigación es proponer una ruta de geoturismo costero para la ciudad de João Pessoa, que permitirá divulgar los aspectos abióticos e histórico-culturales del paisaje, con el objetivo de contribuir a su mantenimiento y conservación a largo plazo. Para ello, estos lugares de interés fueron seleccionados luego de un minucioso trabajo de campo que involucró su inventario y evaluación cuantitativa. Las localizaciones son: Areniscas Ferruginosas de Jacarapé, Paleodunas do Altiplano, Terraza Marina del Holoceno, Acantilado Cabo Branco, Balance Sedimentario de Tambaú, Barra de Gramame, Foz Primitiva del Río Jaguaribe y Picãozinho. La existencia de senderos interpretativos refuncionaliza los itinerarios, ahora desde un punto de vista geoturístico, ya que enriquecen la experiencia de los turistas, brindándoles la oportunidad de conocer el patrimonio abiótico desde otra perspectiva, además de incrementar su conciencia ambiental.*

PALABRAS CLAVE: Geoturismo costero. Ruta Geoturística. Lugares de interés. João Pessoa.

INTRODUCTION

Geotouristic itineraries are routes, accessed on foot or through vehicles, which include a set of places that have high scientific, cultural, aesthetic, functional and economic value, among others, and that involve both cultural heritage and geoheritage. It is also through them that Geosciences are disseminated and promoted.

The valorisation of physical and cultural aspects in geotouristic activity is a form of creating interaction between the community and the environment that surrounds it, through the discovery and appreciation of elements in the landscape, until then ignored.

As for the abiotic environment, the geotouristic itineraries are important tools for the dissemination of Geosciences because they work as an outdoor field class that assists in the learning about the physical phenomena associated with the landscape. In relation to the cultural environment, it involves the historical record and the characteristics of the georesources used in the construction of assets. By knowing and mapping cultural heritage, including churches, houses, cemeteries, monuments, paved roads, among others, by describing architecture and history, by identifying the lithologies, by characterizing stone materials and, if possible, by identifying origins, it is possible to recommend measures that encourage and guarantee its geoconservation and promote its geodiversity (PEREIRA; AMARAL, 2014; PEREIRA; VIEIRA; OLIVEIRA, 2013).

The geotouristic itineraries disseminate and promote the appreciation of geoheritage, relating it to civilizations and cultures. They consist of the addition of geoheritage elements to

tourist activities, focusing on places of geotouristic interest, which favour local communities and provide visitors with a new tourist experience.

The urban coastline of the city of João Pessoa has numerous tourist spots which are among the most visited in the State. However, the tour guides exclude, due to the lack of information, the abiotic aspects of the landscape. The proposal of the geotouristic itinerary of this area highlights these aspects, seeking to use a language easily understood by the majority of tourists, even those with little knowledge.

Geotouristic maps mix elements of geoscientific information, related with geodiversity and geoheritage *per se*, with cultural and tourist features so that the public can easily interpret them. Therefore, due to the presence of more complete tourist infrastructures, particularly road networks and parking facilities, basic tourist information is prioritized. The proposed itinerary is based on the concept of Geotourism by Pereira (2019, p. 69) as:

[...] an activity that is located in the interface of nature tourism and cultural tourism, always with knowledge as the main motivation. It can be developed both in environments where natural aspects prevail and in urban settings, disseminating and promoting geodiversity and its geoheritage, in a more restricted sense, or its relationship with civilizations and cultures, in a broader sense, all in a sustainably manner.

Thus, geotourism works as a mechanism for the development of a sustainable activity, contributing to the geoconservation and dissemination of its geoheritage and cultural heritage. These improve the quality of life of the population, generating funds through the allocation of new values and meanings to the area where it is developed and encouraging the sense of cultural identity by increasing the awareness of the local population and visitors of this patrimony.

The itinerary includes eight buildings places of interest, being two geological/geomorphological (Jacarapé Ferruginous Sandstones and Cabo Branco Cleef), four geomorphological (Altiplane Paleodunes, Holocene Marine Terraces, Tambaú Sedimentar Balance and Picãozinho), one geomorphological/hydrological (Primitive Mouth of Jaguaribe River) and one geological/geomorphological/hydrological (Gramame Bar).

The objective of the research is to present a coastal geotouristic itinerary for the municipality of João Pessoa, which will allow to disseminate the physical aspects of the landscape (geology, geomorphology and hydrology) and the historical-cultural aspects of the assets aiming, in the long term, to contribute to its maintenance and conservation.

METHODS

The itinerary, the baseline of this article, corresponds to a final phase of the promotion process involving other sequential phases (BRILHA, 2005), namely: identification (in which geoh heritage segment can the site be inserted? Geological, geomorphological, pedological or hydrological?); inventory (creation of a database with the heritage elements, with the completion of descriptive files, containing various information, such as absolute location, means of access, photographic register of the site, a detailed description of geological, geomorphological, pedological and hydrological features, considering the scale of the site, from the outcrop to the landscape); semi-quantitative evaluation (degree of importance of the element for geotourism, as well as the evaluation of the degree of vulnerability, aiming at the creation of geoconservation measures, based on Pereira, Carvalho and Cunha (2019); and promotion of the value of heritage elements, through the elaboration of this Geotouristic Itinerary, one of several that will be published later).

This integrated The QGIS software version 3.0 (GIRONA, 2016) was the operational technique used to create the geotouristic itinerary, using the vectorization of the elements of interest from the coverage area of the study. Google Earth image mosaic was used as a base for this, with the application of the Quick Map Services module. The vector layers used in the elaboration of the maps were applied using the geographical coordinate system DATUM WGS 84 (EPSG 4326 Code).

The geographical scales used in the itineraries varied according to the spatial area of the different maps, so that these could be allocated in their pre-defined layout. The scale of the map was 1: 5,000, but it was considered as a detailed scale map.

OCEANOGRAPHIC DYNAMICS IN THE AREA STUDY

The municipality of João Pessoa is the capital of the state of Paraíba, the most eastern in Brazil. In fact, João Pessoa is known worldwide as the “eastern extreme of the Americas”, which in itself already has a potential for tourism. Its geographical coordinates are 7° 7' S and 34° 53' W and the proximity of Equator provides a lot of sunshine throughout the year and, therefore, high temperatures (annual average of 26°C). The municipality has a population of 809,015 inhabitants (IBGE, 2019) in an area of 211,5 square kilometres, which results in a demographic density of 3825 inhabitants/ km², the largest in the State (figure 1).

Most places of interest are located in the eastern portion of the Nossa Senhora da Penha chart (six), while two points are on the northern chart to this (João Pessoa chart, figure 2). The geology where the study area is based is associated with the marginal

sedimentary basin of Paraíba, with sediments that were deposited as the South America continent moved away from the African continent in Turonian (SZATMARI *et al.*, 1987), beginning the subsidence of the Paraíba Basin (BARBOSA; LIMA FILHO, 2006), superimposed on a crystalline basement deformed by shear zones (JARDIM DE SÁ, 1994). This basin can be subdivided into three sub-basins: Olinda, Alhandra and Miriri. João Pessoa is part of the Alhandra sub-basin. The sedimentation of Paraíba basin not outcrop in the study area. According to Pereira and Farias (2020, p. 61), they are:

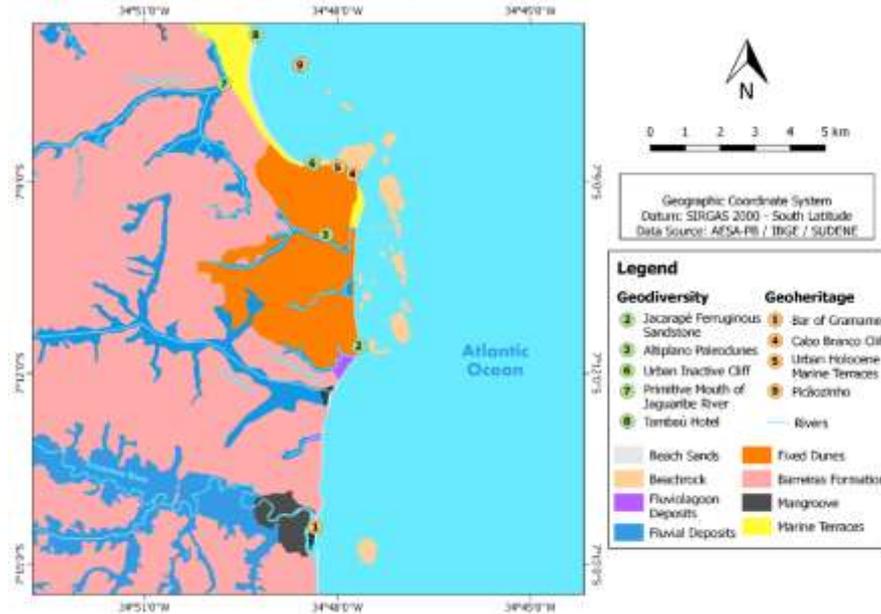
[...] covered by the poorly selected Mio-Miocene sediments of the Barreiras Formation and post-Barreiras sediments, this last being Quaternary in age (marine terraces, swampy deposits, fluvio-lagoonal deposits, eolian deposits, coral reefs, beach rocks, of transitional marine origin; and alluvial fans, fluvial deposits, eluvium-colluvial and colluvial coverings, of continental origin).

Figure 1 – Location of the area



Source: Pereira (2019).

Figure 2 - Geologic and geomorphologic map of the area

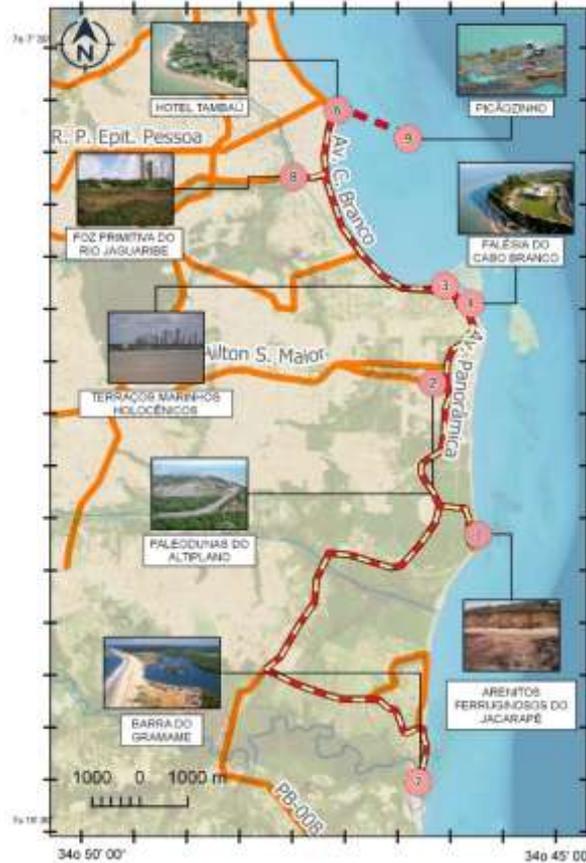


Source: Pereira (2019).

PROPOSED GEOTOURISM ITINERARY

The proposal presented herein involves a geotouristic itinerary consisting of eight places of interest: Jacarapé Ferruginous Sandstones, Altiplano Paleodunes, Holocene Marine Terrace, Cabo Branco Cliff, Tambaú Sedimentary Balance, Bar of Gramame, Primitive Mouth of Jaguaribe River and Picãozinho, according to figure 3.

Figure 3 - Geotourist itinerary in the João Pessoa coast



Source: Pereira (2019).

1st Stop: Picãozinho

Algalic / coral reefs along the Paraíba coast are elongated and discontinuous, parallel to the coast, and can extend for up to four kilometres, whose more prominent bodies are located in front of the city of João Pessoa. Stick corresponds to one of these bodies, about 1500 meters in the sequence in front of Hotel Tambaú and has 45 thousand m² area.

Daily access is boat and catamaran sailing from Tambaú Beach, next to the hotel. According to Fecomércio Research (INSTITUTO FECOMÉRCIO DE PESQUISAS ECONÔMICAS E SOCIAIS DA PARAÍBA, 2014), it is one of the most visited places for tourists, who swim between the reef structures at low tides, where the waters are clear, and you can easily see a wide variety of fish (Figure 4).

In Pernambuco, some samples of coral reefs were dated by the C-14 method, resulting in ages between 1.8 ± 110 ka and 3.1 ± 120 ka (DELIBRIAS; LABOREL, 1971). The reefs on the coast of the research area play a key role in coastal modeling due to its protection against the impact of the wave train, as well as being a nook of great biodiversity. The daily access of the tourists, which run into the reefs, have meals on the boats, pouring garbage

into the waters, taking food to the fish, among other problems, affected the quality of the place, damaging an extremely sensitive ecosystem.

Figure 4 – Aerial view of the algalic-coral reefs of Picãozinho



Source: Photo - Cacio Murilo (2008).

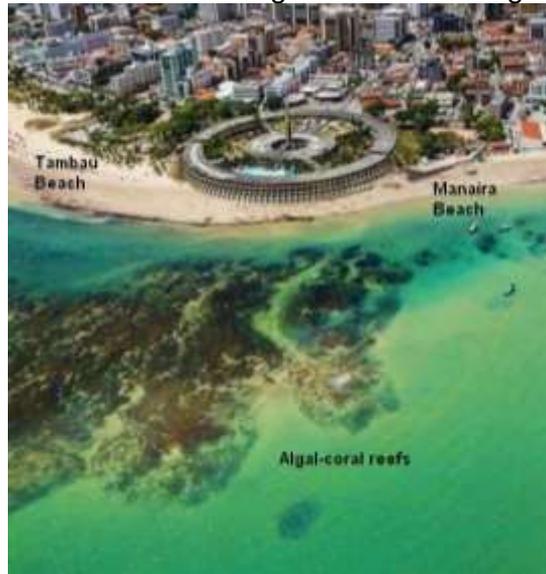
According to an informal conversation with the owners of the catamarans and boats, tourists are informed, during the journey to Picãozinho, which lasts about 15 minutes, on how to proceed on the spot, but most do not respect these rules. In addition, overfishing by local fishermen and the collection of portions of the reefs to be sold for aquarists also caused damage to the environment. The reefs of Paraíba (2015, p. 115) are considered as permanent preservation areas (applications), by the State Constitution, Law no. 6002/2004, art. 227, Sole Paragraph, Item IX and IBAMA restrict access to reefs about 100 people per day and 30 per ship, which helped minimize damage.

2st Stop: Tambaú Hotel Sedimentar Balance

Tambaú Hotel is located at the limit of the Tambaú Beaches, to the south, and Manaíra, to the north. It has become a must-visit place for João Pessoa, both for its very peculiar circular shape, and for its strategic location, on a small ledge that limits two coves.

Tambaú Beach shows a wide backshore covered with native vegetation, with a silting process that reached two meters per year, between 1969 and 1989, according to Reis (2008), probably related to Tambaú Hotel, which was inaugurated in 1971, while the barlamar of the hotel, in Manaíra Beach, erosion consumed about one meter per year of the beach in the same period, a consequence of the refraction effect. Thus, this hotel had the role of a rigid spike, or jetty, extending the cove beach to sotamar, in the case of Tambaú and Cabo Branco, and the portion of Manaíra Beach next to the hotel, to barlamar, underwent a retrogradation process (figure 5).

Figure 5 – Aerial view of the Hotel Tambaú, delimiting the beaches of Tambaú, in the south, with a wide beach, and Manaíra, in the north, with a narrow beach, denoting erosion and algal-coral reefs in the foreground. North to right



Source: Photo - modified from Marco Pimentel (2012).

3st Stop: Primitive Mouth of Jaguaribe River

The place of interest is located at Ministro José Américo de Almeida Avenue (Beira-Rio), towards the center-beach, just after the river crosses that avenue, 200 meters before the turner that gives access to the Altiplano neighborhood Cabo Branco. When it reaches the line of the receding inactive cliffs, it abruptly flexes towards the north (Figure 6), touching the inactive cliff of Bairro João Agripino. At this point, where the place of interest is located, the mouth of the river was probably found before the deposition of the holocene sedimentation that formed the marine terrace, aged between three and seven Ka AP. This lithological difference between the Barreiras sandstone and the beach sediments, added to the low slope in the newly formed coastal plain, is the justification for the diversion that occurs, as soon as the river breaks the line of inactive cliffs.

Both the Jaguaribe River and the Timbó River, its tributary on the right bank, exhumated the sediments of the training of barriers, which in the urban area of João Pessoa are slightly inclined to the east. In the high course, the Jaguaribe River cumulated the plates, generating anfitereters, although, in general, the advice of the urban area of João Pessoa are relatively soft and with low slopes (FURRIER, 2007). This great amphitheater and the intense exhumation of overlapped barrier sediments in the Maltrichtian carbonate layer of the lawn formation, may have diminished this sedimentary layer, through denudational processes, facilitating water penetration and dissolving chemically, generating the subsequent land of depletion.

Figure 6 - Satellite photo showing the beaches and the surroundings of the Holocene marine terraces, at its rear, in its southern, narrower portion. You can see the location of the forested inactive urban cliff (red lines), which delimits the coastal plain, represented by the terraces and the low plateaus, further west (black dashed line). You can also see the settlement of the low-income population of the São José Community, between the foot of the cliff and the Jaguaribe River and some selected locals of interest (1 – Picãozinho; 2 – Hotel Tambau; 3 - Primitive Mouth do Jaguaribe River; 4 – Holoce Marine Terrace; 5 – Cabo Branco Cliff; 6 – Altiplane Paleodunes)



Source: Pereira (2019).

Although Jaguaribe River Valley has its occupation restricted by laws 2101, as of 12/31/1975; 2699, of 11/7/1979 (JOÃO PESSOA, 1975, 1979) and by the constitution of the State, it is, however, a basin intensely addressed through various impacts Anthropics, by deforestation of their slopes, and subsequent erosion with loop, pollution by all types of waste, causing risks of diseases to riverside populations, living in the different "subnormal clusters" located along their margins. Floods, in times of floods, in winter, are also common, causing great inconvenience to these low-income populations.

4st Stop: Holocene Marine Terraces

The Holocene terraces consist of sandy deposits, no more than four meters above the current high tide, which were formed during the marine regression following the Last Transgression (BITTENCOURT *et al.*, 1979) or Santos Transgression (SUGUIO; MARTIN, FAIRCHILD, 1978), between five and seven ka BP, according to studies on the quaternary deposition along the coast between Rio de Janeiro and Alagoas State.

In the urban coastal zone of João Pessoa, the terraces have important physical-environmental characteristics. They are densely occupied by urban neighbourhoods that have the most expensive square metre in the state. They represent the coastal plain, being separated from the coastal strips by a continuous line of inactive forested cliffs, whose limits can be easily discriminated as they can be observed at a long distance, especially in the north sector (Figure 6). They are also important indicators of coastal dynamics, especially in the last seven ka.

They consist of unconsolidated quartz sands, with light tones, fine granulometry, moderately selected, with plane-parallel stratification (ALHEIROS; FERREIRA; LIMA FILHO, 1990) and predominantly fine granulometry (FURRIER, 2007).

In a dating procedure, using the C-14 method and applied to lagoon sediments in the northern coast of the State of Sergipe, the results yielded an age of 7.2 ± 200 ka AP (BITTENCOURT *et al.*, 1983), while shells integrated in these terraces on the coast of Alagoas yielded ages between 2.57 ± 170 ka AP and 3.69 ± 180 ka AP (BARBOSA *et al.*, 1997).

Analysing the beach segment of the municipality, from the point of view of morphology and sediment balance, it is possible to conclude that, where there is a continuous sediment supply and there is a tendency for the position of the coastline to prograde, as is the case, for example, of the majority of the beaches located in north section. The backshore of the sandbank is intensely and disorderly occupied by buildings and engineering works, such as the Jaguaribe River channelling, among others. On some beaches, for example, retention structures were built to minimize the effects of the advance of the coastline, when in fact it was anthropic action that, through uncontrolled urbanization and poorly developed public policies, went too far on the beach.

5st Stop: Cabo Branco Cliff

This place of interest plays the fundamental role in tourism in the capital of Paraíba, the eastern city of the Americas, the closest to Africa. Corresponds to an area that compensates the above mentioned precipice, about 30 meters high, with the Cabo Branco lighthouse and the Science Station, built at the top and from which you have an almost complete view of the entire João Pessoa coast, to the north and Ponta do Seixas, this is the eastern end of the Americas (Figure 7), in the White Cape Municipal Park.

Part of the layers of the rocks on this cliff have an anticline fold, with a sub-horizontal axis, which shows the neotectonic action in this formation, influencing its deposition and affecting the overlapping quaternary sediments (Figure 8). This neotectonic activity is important to demystify that the Brazilian marginal basins, especially the northeastern ones,

are essentially of the passive type, as it has been propagated in scientific circles for a long time (ASMUS 1982; MOHRIAK, 2003, among others).

Figure 7 - Aerial view of Falésia do Cabo Branco and surroundings



Photo modified by Felipe Gesteira. **Source:** Obra... (2011).

Figure 8 - Neotectonic feature in the rock of Cabo Branco cliff



Source: Photo - Pereira (2019).

Despite belonging to a municipal park, little is done to preserve the cliff, which suffers intense marine undermining. A sum of factors (natural and man-made) ended up causing part of it to collapse in January 2018, even reaching the vicinity of the Cabo Branco Lighthouse (Figure 9a). According to aerial photo analysis, erosion advances meters' year by year (Figure 9b). Thus, if the inertia of the public authorities continues, the trend is that in 20 years this lighthouse, an important symbol of the capital of Paraíba, will cease to exist.

Figura 9 – Current situation of the Cabo Branco cliff. a) Aerial photo of the Cabo Branco lighthouse, showing the collapse of part of the cliff; b) Base of the cliff, with a sign warning the possibility of collapsing the area



Source: Photo - a) PMJP ... (2020); b) Pereira (2019).

6st Stop: Altiplane Paleodunes

Corresponds to a thick package of quartz sands, well selected and of fine granulometry, with cream color, that reach 25 meters of thickness, covered by vegetation, being classified as a wind deposit of paleodunes, being best seen along the rivers (Figura 10).

Figura 10 – Fixed dunes adjacent to the Cabelo River



Source: Photo - Pereira (2019).

These wind deposits are important Quaternary paleogeographic and paleoclimatic indicators, they can be internal or external in relation to the coast and are covered by vegetation that prevents their progress. The oldest inmates are found on the boards of the Barreiras Formation, as is the case of the deposit in the place of interest in question and were formed by sediments from the coastal plain itself, while the outer ones cover the Pleistocene marine terraces (FURRIER, 2007). Much of the vegetation that covers

paleodunes in the State of Paraíba, especially around the capital, has been removed for further urbanization.

Thus, the exposure of these sediments, associated with an intense wind flow, caused the silting up of nearby water bodies, such as the Rio Cabelo. Fixed dune sediments located between Tibau do Sul and Touros, in Rio Grande do Norte, were dated by the thermoluminescence method, resulting in ages between 189-186 ka BP (YEE *et al.*, 2000), and are superimposed on the sequence of terraces marine species dated by Barreto *et al.* (2002a) aged 220-206 ka BP.

On the northern coast of the State of Paraíba, the same authors dated sediment samples collected from inactive dunes at different depth levels, resulting in ages between 27.2 ka BP, for the shallower (two meters) up to 61.6 ka BP for the deeper ones (four meters) and suggested, considering the height of the dunes around 30 meters, that the eustatic level was much lower than the current one when the dunes were fixed (BARRETO *et al.*, 2002b).

These deposits, for a long time, were classified as Spodosols (PARAÍBA ..., 2004), therefore having a pedogenetic origin. However, the textural analysis of the grains under a microscope, which presents good roundness, selection and relative homogeneity of the quartz grains, corroborate their wind origin.

7st Stop: Jacarapé Ferruginous Sandstones

From the mouth of the Jacarapé River, a short walk (350 meters) reaches the place of interest (Figure 11a). The point, on a local scale, is marked by the presence of a broad outcrop of the ferruginous facies of the Barreiras Formation, which extends dozens of meters inland to the beach, overlapping a fine sandy facies and below a medium grain sandstone (Figure 11b) of the same formation. It is inserted in the Jacarapé State Park.

They are composed of poorly consolidated sandy sediments, whose matrix is predominantly sandy, with reddish color and plane-parallel stratification and larger millimeter grains of quartz and K-feldspar, subangular to sub-rounded, with low sphericity, with the K-feldspar changed to a clay grayish. These characteristics allow us to state that this package was deposited in a fluvial environment, corroborated by Rossetti *et al.* (2009). What characterizes these facies is the presence of ferricretes, such as iron and aluminum oxy-hydroxide concretions, which, due to their greater resistance to weathering, form an extensive pavement, in the form of abrasion terraces, which extend along the beach and foreground, best visible at low tides.

Figure 11 - Detail of the Ferruginous Sandstones. a) Aerial view with the location of the place of interest (*) and some of its elements; b) Detail of the place of interest in terrestrial view



Source: modified from Pereira (2019).

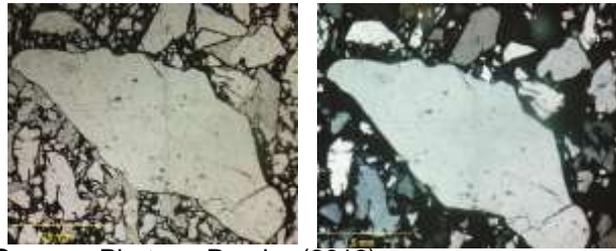


Source: modified from Pereira (2019).

In thin section, the rock consists of 80% of grains and 20% of matrix (interpreted as composed of iron oxide due to its reddish color), and among the grains there is an apparent abundance of quartz (95%) and small traces of tourmaline and feldspar (together they make up the remaining 5%). The grains vary from fine sand to granules, very poorly selected, from angular to subangular with low sphericity (Figure 12). The rock was classified as a monomitic breach, due to its constitution being practically quartz or quartzarenite (FOLK, 1974). The grains are mostly fluctuating, with few point contacts and rare straight ones, denoting loose packaging.

According to Furrier (2007, p. 183), the genesis of these ferricretes is associated with the “[...] downward flow of windy water, due to intense rainfall, high lithological permeability and sudden change in the pH of the environment, a fact that occurs at the freshwater (acidic) wedge with saline (basic) wedge”. According to the author, “[...] relatively acidic waters can complex iron and aluminum, [...] generating soils made up of practically only more insoluble primary minerals such as quartz” (FURRIER, 2007, p. 183).

Figure 12 – Thin section of quartzsandstone, showing a quartz grnaule wrapped by matrix and other grains of the framework, In the image on the left, the granule is observed in parallel nicols. On the right, in crossed nicols



Source: Photos - Pereira (2019).

Thus, this ferruginous horizon does not have a pedogenetic origin, but is related to neotectonic events that allowed the level of the water table to fluctuate, evidenced by the different dimensions of these ferricret lines, as well as by the presence of a very visible lamination and by the high density of concretions. Due to the high concentration of iron oxyhydroxide in relation to the builder. They serve as a testament to the erosive retreat of the cliffs by the action of the waves.

8st Stop: Bar of Gramame

The mouth of Gramame River corresponds to a fluvio-marine plain, with the presence of mangroves, corresponding to a valley trough filled with alluviums and the meandering of the river, in a low energy region, easily flooded by the waters of the sea at high tides and that is tourist point of intense visitation for its scenic beauty.

In the estuary, an infrastructure of snack bars was set up in the middle of the coconut trees and on the fine sand, to receive the tourists who arrive in large numbers, especially in the summer (Figure 13).

Figure 13 - View of Bar of Gramame area, with the great density of snack bars on its right bank, in the middle of coconut groves



Source: Photo - Pereira (2019).

Its margins are occupied by low-income population who live on subsistence agricultural activities. These activities end up causing substantial impacts to the riverbed, such as intense silting up and pollution waste, whether liquid or solid. Furthermore, by crossing the Industrial District of João Pessoa on its medium course, a new pollution load is launched in the basin, aggravating the problem. In the river terraces, the extraction of sand for civil construction and clay for the production of tiles and bricks in potteries contributes to intensify this silting process.

In the nearshore of the estuary there are no beach sandstones, facilitating the direct collision of the train of waves with the waters of the river. Walking towards the south, from the bar, the backshore widens, at the rear of a berm line, with the deposition of holocene marine terraces covered by vegetation, especially coconut trees. Immediately afterwards, inactive cliffs appear, with colluvial deposits at the base, vegetated, whose foot is accompanied by a thin line of curb. These cliffs have neotectonic structures, such as flaws and folds (Figure 14a) and intense scars from continental erosion, with the opening of ravines and gullies and dejection cones (Figure 14b).

Figure 14 - Some features on the cliffs south of Bar of Gramame. a) Dark lines represent the bedding, presenting a fold with open flank and pink lines some of the faults occurring with transpressional regime present, with metric tailing; b) Dejection cones denote continental erosion



Source: Photos: Pereira (2019).

Estuarine coastal zones are protected by federal legislation, starting with Decree n^o 5300/2004 (BRASIL, 2004), which instituted the National Coastal Management Plan. This plan protects, among others, the agents that cause pollution or environmental degradation that threaten the quality of life in the coastal zone. Even so, the environmental impacts are great in the area, due to the spread of snack bars and houses, along the margins of the bar. Adding to the intense flow of visitors, the anthropic vulnerability of the area is intensified, extremely sensitive to human action, therefore subject to water pollution and silting.

CONCLUSIONS

The role of geotourism is to approximate the public to the geoheritage and the cultural heritage of the area visited, through geointerpretation strategies. Thus, the tourist interaction with the abiotic environment will sensitize the tourist/geotourist to perceive it from a new point of view and to promote the appreciation of geodiversity and geoheritage. This interaction will also serve as a tool for the education of the local population and tourists and disseminate Geosciences beyond classrooms, with the purpose of preserving and managing this geoheritage significance and associated cultural heritage.

The main geoproduct obtained from the mapping of the places of interest was the Geotouristic Map, with its itinerary. Its interdisciplinary character and geoeducational material play the role of an awareness creator and sensitizer towards the geoconservation and the promotion of Geosciences.

The proposed geotouristic route has eight places of interest involving from these important elements of geodiversity to geoheritage elements of geological, geomorphological and hydrological bias. The geotouristic itinerary can be used not only for tourist purposes, but also for education, and all the information presented is a way of promoting Geosciences, especially Geology, to the local communities and tourists.

The holistic vision allowed a range of new interdisciplinary discussions to be open, by enabling cultural experiences distinct from traditional ones and by rediscovering its cultural roots, a sense of place and a reverence for the natural world, achieved through the recognition and celebration of the creativity associated with the abiotic heritage.

The 'sun and sea' is the main tourist attraction of the region, allied in a secondary level to a rich history and culture that neglects the latent geotouristic potential. The geotouristic itineraries also serve to promote geotourism as an asset, inserting in the traditional tourist context information about the previously forgotten abiotic environment. Therefore, mass tourism will be promoted for a niche tourism, becoming more sustainable under the environmental bias.

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