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FISIOGRAPHIC SURVEY OF THE HIGH COURSES OF HYDROGRAPHIC SUB-BASINS IN THE CRYSTALINE MASSIF OF MERUOCA, STATE OF CEARÁ

LEVANTAMENTO FISIOGRÁFICO DOS ALTOS CURSOS DAS SUB-BACIAS HIDROGRÁFICAS NO MACIÇO CRISTALINO SERRA DA MERUOCA, ESTADO DO CEARÁ

LEVANTAMIENTO FISIOGRÁFICO DE LOS CURSOS ALTOS DE LAS SUB-CUENCAS HIDROGRÁFICAS EN EL MACIZO CRISTALINO SERRA DA MERUOCA, ESTADO DE CEARÁ

ÉTUDE PHYSIOGRAPHIQUE DES HAUTS COURS DES SOUS-BASSINS HYDROGRAPHIQUES DU MASSIF CRISTALLIN DE LA MERUOCA, À L'ÉTAT BRESILIEN DU CEARÁ

ERNANE CORTEZ LIMA
Professor-doutor do Curso de Geografia e do Mestrado Acadêmico em Geografia da Universidade Estadual Vale do Acaraú – UVA
ernanecortez@hotmail.com

VANDA CLAUDINO-SALES
Professora-doutora do Curso de Geografia e do Mestrado Acadêmico em Geografia da Universidade Estadual Vale do Acaraú – UVA
vcs@ufc.br

ULISSES COSTA DE OLIVEIRA
Mestre em Geografia e Fiscal Ambiental da Superintendência de Meio Ambiente do Estado do Ceará – SEMACE
ucoliveira@msn.com

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ABSTRACT

This study presents a physiographic survey of the high courses of watersheds and sub-basins inserted in the Meruoca Massif, located in the Northwest region of the State of Ceará. The geoenvironmental system was addressed by digital processing of satellite images landsat 8 and Spot 5 and fieldwork. The geosystemic model was used, from which it was defined the existence of a geosystem and eleven geofacies, each geofaceis representing one of the sub-basins studied.The geosystemic research allowed identifying the existence of different environments to leeward and windward of the massif, in term of soils, forms, vegetation cover and fluvial incision, iindicating the wetter windward sector as a result, a fact controlled by orographic rainfall, with more developed soil and vegetation cover and more intense river incision. It was also identified that most of the rivers are of the intermittent type, forming rivers of 1st, 2nd and 3rd orders. The conclusion is that the geosystem is fragile and vulnerable to the uses and occupations that have been suffering, which implies risks of high environmental degradation.
KEYWORDS: Geosystem; Drainage; Environmental analysis.

RESUMO

Este trabalho apresenta levantamento fisiográfico dos altos cursos de bacias e sub-bacias hidrográficas do Maciço da Meruoca (região Noroeste do Estado do Ceará), utilizando processamento digital de imagens de satélite landsat 8 e Spot 5 e trabalhos de campo. Utilizou-se o modelo geossistêmico de Bertrand, definindo-se a existência de geossistema e onze geofácies, cada uma representando uma das sub-bacias trabalhadas. A pesquisa permitiu identificar diferentes ambientes a sotavento e a barlavento do maciço, em termo de solos, relevos, cobertura vegetal e incisão fluvial, indicando como resultado setor a barlavento mais úmido, fato controlado

pelas chuvas orográficas, com solos e cobertura vegetal mais desenvolvidos e incisão fluvial mais intensa. Identicou-se também que a maioria dos fluxos fluviais são intermitentes, formando rios de 1ª, 2ª e 3ª ordens. Conclui-se que o geossistema é frágil e vulnerável aos usos e ocupações que vem sofrendo, o que implica em riscos de elevada degradação ambiental.
PALAVRAS-CHAVE: Geossistema; Drenagem, Análise ambiental.

RESUMEN

Este trabajo presenta un análisis fisiográfico de los altos cursos de cuencas y subcuencas hidrográficas del Macizo da Meruoca (región Noroeste del Estado de Ceará), utilizando procesamiento digital de imágenes de satélite landsat 8 y Spot 5 y trabajos de campo. Se utilizó el modelo geosistémico de Bertrand, definiéndose la existencia de geosistema y once geofacies, cada una representando una de las subcuencas trabajadas. La investigación permitió identificar diferentes ambientes a sotavento y a barlovento del Maciço, en término de suelos, relieves, cobertura vegetal e incisión fluvial, indicando como resultado sector a barlovento más húmedo, situación controlada por las lluvias orográficas, con suelos y cobertura vegetal más desarrollados e incisión fluvial más intensa. Se identificó también que la mayoría de los flujos fluviales son intermitentes, formando ríos de 1º, 2º y 3º orden. Se concluye que el geosistema es frágil y vulnerable a los usos y ocupaciones que ha sufrido, lo que implica en riesgos de elevada degradación ambiental.
PALABRAS-CLAVE: Geosistema; Drenaje; Análisis ambiental.

RÉSUMÉ

Le présent travail porte sur une étude physiographique des hauts cours des bassins et sous-bassins hydrographiques du Massif de la Meruoca (région nord-ouest de l'État du Ceará, au Brésil), par moyen de traitement numérique des images satellites Landsat 8 et Spot 5, ainsi que des travaux de terrain. Le modèle géosystémique de Bertrand a été utilisé pour définir l'existence d'un géosystème et de onze géofaciès, chacune représentant l'un des sous-bassins travaillés. Cette recherche a permis d'identifier les différents milieux sous le vent et au vent du massif en termes de sols, de reliefs, de couvert végétal et d'incision fluviale, désignant le secteur au vent comme le plus humide, un fait réglé par pluies orographiques, et constitué de sols et couvert végétal plus développés et incision fluviale plus intense. Nous avons également identifié la majorité des débits fluviaux comme intermittents, réprésentant des cours d'eau de premier, deuxième et troisième ordres. On en conclut que le géosystème est fragile et vulnérable aux usages et occupations auxquelles il est soumis, ce qui implique des risques de forte dégradation environnementale.
MOTS CLÉS: Géosystème ; Drainage ; Analyse environnementale.

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INTRODUCTION

The crystalline massif Serra da Meruoca is located in the Northwest of the State of Ceará, on the left bank of the Acaraú River, close to the city of Sobral. It presents as geographic coordinates 03 ° 35'27" of south latitude and 40 ° 29'11" of west longitude. Involving an area of 478.8 km2 (from the 200m elevation) and average altitude between 550 and 700m, the massif covers part of the municipalities of Sobral, Coreaú and Massapê, in addition to all the municipalities of Alcântaras and Meruoca.

It is a singular massif, as it is completely delimited by geological faults, forming a high structural rhombus which is distinguished in the northeastern semiarid by the more humid climate it presents in relation to the adjacent areas. Effectively, the research area, despite being embedded in a region of semiarid dominance, represents a humid highland, composing the so-called "brejos de cimeira" mentioned by Ab'Saber (1969) and taken up by Souza (1989) and Bétard et al. (2007). It represents, in this perspective, an exception zone in the context of the semi-arid northeastern region.

Some studies have already been conducted with a view to analyzing natural elements and environmental problems (e.g. LIMA, 1999; LIMA, E. C. 2014; DINIZ et al., 2020). The area lacks, however, studies from the hydrographic point of view, with compartmentalization of river basins, in order to provide the interpretation of the role of rivers in the configuration of the local geomorphological landscape and the geoenvironment as a whole.

This work presents the perspective of defining the physiographic characteristics and compartmentalization of the sub-basins that occur in the Massif of Meruoca, as well as analyzing the ecophysiographic conditions of the region. In order to present and analyze these factors, the research defined as a detail area the upper course of each hydrographic sub-basin that is part of two large hydrographic basins in the state that also have their sources in the Massif of Meruoca, namely the river basins Acaraú and Coreaú.

To this end, the authors adopted the geosystemic approach, in the terms proposed by Bertrand (1972), identifying in the research area the existence of a geosystem (the crystalline massif) and eleven geofacies (the upper course of the hydrographic sub-basins). This methodological option allowed the major objective of the study to be reached, which is the physiographic detailing of the Serra da Meruoca from the analysis of its drainage network.

The geosystem in this research presents great environmental vulnerability due to the use of rudimentary methods by the population in the daily treatment of natural resources. Factors such as occupation and exploitation of the tops,

slopes, and valleys provoke edaphoclimatic alterations translated into degradation problems, producing the most varied environmental impacts.

The main types of use, occupation and situations that generate environmental degradation are associated with subsistence agriculture, lack of basic sanitation, deforestation, burnings, predatory urbanization, among others, which is associated with the lack of a conservation policy. This set of situations produces serious environmental deterioration problems, some considered almost irreversible in the highland environment. In this way, the current state of natural resources in the region reflects the forms of land use and occupation that have been carried out over many years of socioeconomic exploitation.

CHARACTERIZATION OF THE STUDY AREA

The Massif of Meruoca, or Meruoca-Rosário complex, where the hydrographic sub-basins under analysis are located, comprises an area of "stock", from a geological point of view (e.g. BRANDÃO; FREITAS, 2014). It is a reddish coarse granite, formed during the Brasiliano Orogeny (e.g. BRITO NEVES, 1999).

The Brasiliano Orogeny collage on the Gondwana supercontinent into the Proterozoic (550 million years) represents the most important geological event in the Brazilian Northeast, having structured the geological and morphostructural network that exists today (PEULVAST e CLAUDINO-SALES, 2005; CABY; ARTHAUD; ARCHANJO, 1995). Later, in the Upper Cretaceous (120 Ma), the granites were raised in the form of rift shoulders that produced the breakup of Gondwana and the separation of Africa and South America (PEULVAST; CLAUDINO-SALES, 2004; MATOS, 2000). The Massif of Meruoca was raised in this event, and since then it has been sculpted by the erosive processes that acted in the Cenozoic, thus representing a residue from the rift shoulders (CLAUDINO-SALES, 2016).

In fact, the older terrains than the Brasiliano granite (Archean and Lower Proterozoic), for having already undergone two orogenesis throughout the geological history and for being extremely metamorphized and fractured, proved to be less resistant than the granite itself. (CLAUDINO- SALES, 2016). Thus, they were devastated by the tertiary erosion process until they formed the Sertaneja planing surface that characterizes the area surrounding the massif. The granite, more resistant, was exhumed and supports the high relief of the massif (CLAUDINO-SALES; LIRA, 2011).

In addition, and contrary to what seems to have occurred with other crystalline massifs in the northern Brazilian Northeast, which were re-uplifted along the Tertiary (eg MAIA; BETARD; BEZERRA, 2016; GURGEL et al., 2013; MORAIS NETO et al ., 2009),

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The Massif of Meruoca shows no evidence of having undergone a similar process in post-Cretaceous times, despite the presence of structural control: the massif is delimited by Brazilian shear zones, presenting a quadrangular shape (Figure 1) and slopes typically derived from fault scarps. With exception of subsequent research indicating the opposite, there is currently no evidence that may indicate the occurrence of Cenozoic soeruptions along these shear zones (CLAUDINO-SALES, 2016).

The Serra da Meruoca is, therefore, a residual massif. It presents two very distinct faces, one disposed to the north and the other to the south. In the north, the valleys are deep and the tops vary from 700 to 900m of altitude, reaching the 990m level, showing greater atmospheric humidity and morphology of ridges, hills and semi-mamelonized (breast-shaped) forms, as pointed out by Moreira and Gatto (1981). To the south, elevations between 600-800m occur, presenting drier conditions, controlled by the context of leeward slopes (LIMA, 2014, 2011, 1999) (Figure1).

The semi-arid climate in the Northeast has as its main characteristics low rainfall rates, high insolation and evapotranspiration rates, high temperatures with low temperature range, and water deficit. According to Zanella (2014), the high insolation rates and high temperatures are a result of its latitudinal position, since the region is subjected to strong solar radiation throughout the year.

For presenting these climatic conditions, the Residual Massif of Serra da Meruoca is inserted in the Morphoclimatic Domain of Semi-arid Interplanaltic Depressions, which constitutes a region of azonal climate in relation to tropical and subtropical zones (MELO et al., 2005: AB`-SABER, 1974). In the area, the climate is of the humid tropical type (IPECE, 2016), precipitation is generally greater than 1000mm annually (BEZERRA; BEZERRA; MENDES, 1989), and the original vegetation cover is pluvial-cloud forest (FIGUEIREDO, 1997; FERNANDES, 1990). These facts give it a differentiated natural dynamic, contemplated by hydrogeographic and environmental variables specific to the geosystem studied.

At the massif area, there are basically two types of soil: in higher areas, there is the presence of Red-Yellow Argisols, and in lower areas, of Litholic Neosols. In both sectors occur granites of the Meruoca stock, however, the occurrence of these soils varies depending on the arrangement of the slopes to the rains, occurring in the windward sectors Red-Yellow Argissols and in the leeward sectors, Litholic Neosols (LIMA, 2015).

RESEARCH METHODOLOGY

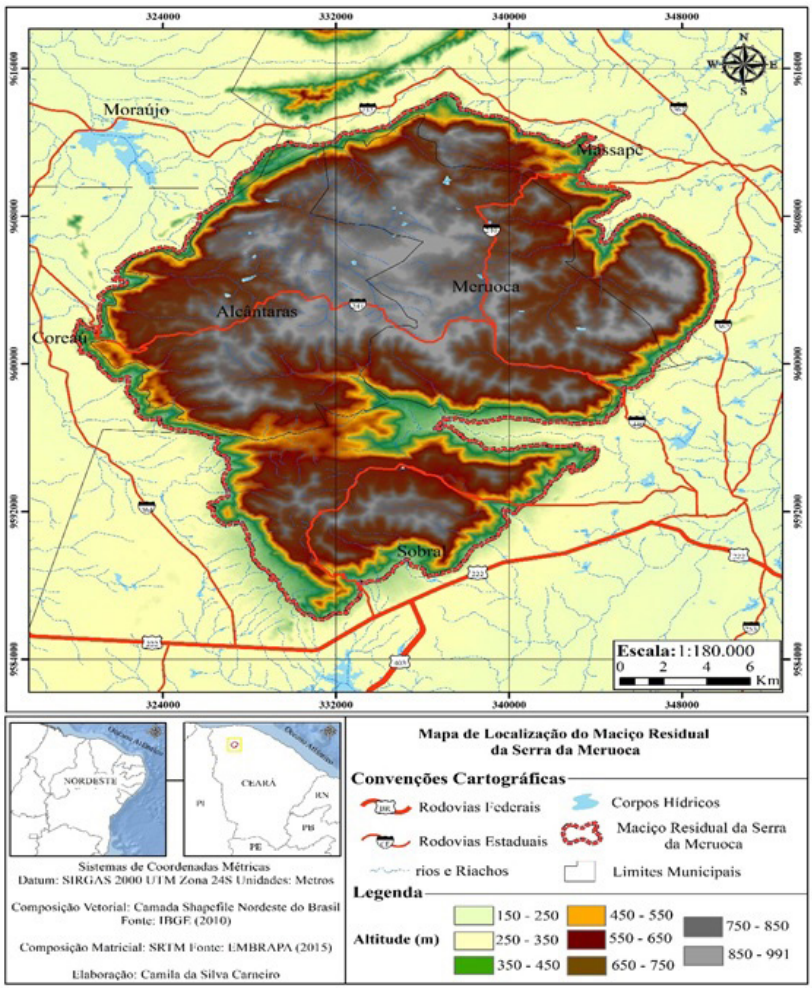
This research is based on the systemic method, being grounded and founded on Bertalanfy's General Systems Theory (1975), adapted by Bertrand

(1972) for the geosciences. The central principle of geosystemic analysis is to analyze the mutual relationships and interdependencies between the natural and anthropic components. It It works on the integration of the geomorphological, hydrographical, pedological, and vegetational components with the natural resource use processes, as a way to obtain the geoenvironmental characterization of the areas defined for the research. The perspective is to build a geoenvironmental analysis that contributes mainly to actions for planning the use of natural resources.

The geosystem and geofacies were identified according to the main environmental attributes inherent to them. It was necessary to survey the geomorphological features such as tops, slopes and valleys, which was done using the Digital Terrain Model (DTM) and fieldwork. Then, based on internal diversities and using the geomorphological criterion, the largest territorial unit (geosystem, represented by the crystalline massif) was defined, and from there, the recognition and delimitation of smaller homogeneous subunits, which represent geofacies (the upper course of the hydrographic sub-basins).

In this work, the main aspects observed were the physiographic survey, including the climatic data and the compartmentalization of the sub-

FIGURA 1 - LOCATION AND HYPSOMETRY OF THE MASSIF OF MERUOCA, STATE OF CEARÁ



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-basins. The sub-basins were compartmentalized in number of 11, labeled "S" (S of sub--basin), involving the entire extent of the Massif of Meruoca. The basins have different shapes and the physiographic and ecological space of each of them depends on diversified combinations between the environmental components responsible for the constitution of the relief (geoforms, hydrography, soils, vegetation, identified from the interpretation of images and maps and fieldwork).

In order to support the analysis, a bibliographic survey and thematic mapping of the sub-basins was carried out, on a scale of 1: 100,000. The maps were generated from the use of the ArcGIS 10.1 GIS (Geographic Information System) manager, based on the Universal Transverse Mercator (UTM) projection, from the SIRGAS 2000 UTM Zone 24S Horizontal Datum, based on a metric coordinate system.

A mosaic was made using the Mosaic Dataset tool, available in ArcGIS 10.1, accessible at the State University Vale do Acaraú - UVA, using Matrix Topographic maps, provided by the DSG (Directorate of Geographic Service of the Brazilian Army) and dated between 1972 and 1984 , considering the location codes referring to the Bela Cruz SA-24-YDI, Frecheirinha SA--24-YC-VI, Granja SA-24-Y-C-III and Sobral SA -24-YD--IV quadrants, produced in a scale of 1: 100,000 . The hydrographic sub-basins were verified using orbital images from the LANDSAT '8' satellite (bands 1 and 8) and Spot 5, Google Earth Pro analysis and fieldwork.

The geoenvironmental units and geofacies were constituted after interpretation of satellite images, accompanied by various checks and field surveys, carried out through walking and in situ recognition of the studied areas. Based on the scientific work of Souza (1994), connections such as lithology, relief, soils, morphopedological conditions and vegetation cover were made in order to achieve consistent information regarding the interactions among the geoenvironmental components.

The generation of the delimitation polygon of the area took place through the technique of automatic delimitation, making it necessary to assemble a mosaic with the images Shuttle Radar Topography Mission (SRTM), Bela Cruz S.A-24-Y-D-I, Frecheirinha S. A-24-Y-C-VI, Granja S.A--24-Y-C-III and Sobral S.A -24-Y-D-IV, image through tools, where the flow direction, the accumulated flow in each cell, the longest flow path and the numerical order for each segment were determined. Next, a drainage file was generated, then a drainage shape. The next step was to delimit the sub-basins from a collection point, after which the point shape was transfor-

med into a polygon vector file. A synthesis map (figure 3) was prepared in which the geosystemic unit (Residual Massif of Serra da Meruoca) and its respective geofacies (its hydrographic sub-basins) are represented.

RESULTS AND DISCUSSION

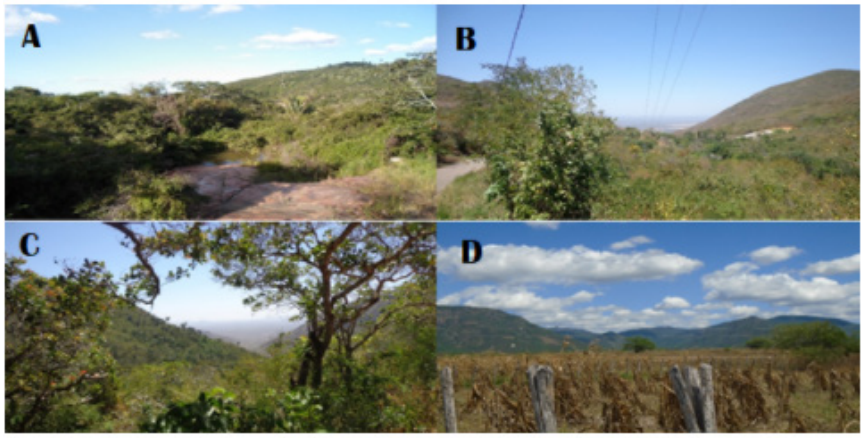
Geoenvironmental compartmentalization of the geosystem / geofacies

The geosystem defined in the research corresponds to the crystalline massif itself (Serra da Meruoca) and the geofacies, to the upper course of the eleven hydrographic sub-basins studied (Figure 3 and Table 1). It is worth mentioning that the morphological features that make up the Residual Massif of Serra da Meruoca show diversifications in terms of altitude, temperature, soil types and the effects of dissection of the relief: these are the characteristics that will significantly define the delimitation and characterization of the main geofacies. Some examples of these configurations are provided in figure 2.

The 11 (eleven) sub-basins are as follows: in the **North**: sub-basin 1, part of sub-basin 2 and part of sub-basin 11; the **Northeast**, sub-basin 2 and sub-basin 3; to the **Northwest**, sub-basin 11; to the **East**, sub-basins 4 and sub-basin 5; **Southeast** sub-basin 6 and part of 7; to the **South**, sub-basin 7, 8 and part of 9; to the **Southwest** the sub-basin 9 and finally, to the **West**, the sub-basin 5 and part of the 9 (Figure 3).

The streams of the sub-basins under analysis, regarding the hierarchy of the channels, are of the first, second and third order, according to Strahler (1952). These are

FIGURE 2 - OVERVIEW OF SERRA DA MERUOCA:
(A) RELIEF DISSECTED INTO HILLS, SUB-BASIN TROUGH IN THE CENTER OF THE PHOTO; (B)THALWEG, SUB-BASIN RIVERBED; (C)"V"- SHAPED VALLEY, WITH STRONG LINEAR INCISION GRADIENT; (D) PARTIAL VIEW OF THE MASSIF OF SERRA DA MERUOCA, SOUTH FACE



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areas of major sources, with altimetric elevations ranging from 550 to 846m. They have "V" shaped valleys with features dissected in hills and narrow interfluves, with a width between valleys of Taking into account the position of the Massif of Meruoca and considering, above all, its altitude, with tops between 700 and 990m, the occurrence of orographic rains in the region, providing high rates of rainfall and configuring the relief as a high altitude swamp, representing an enclave of moisture amidst the planing surface. However, although the massif represents a humid and sub-humid area, it has dry areas. These are areas to the leeward with climatic conditions similar to those of the planing surface (Figure 4).

In the process of compartmentalization of the upper course of the sub-basins, the area of the geosystem and geofacies was calculated, established as follows: Total area of the Massif: 473.92 km2. Area and percentage of the upper course of the hydrographic sub-basins in Km2: S1 = 48.831 (10.3%); S2 = 76.844 (16.2%); S3 = 4.044 (0.8%); S4 = 31.669 (6.7%); S5 = 78.891 (16.7%); S6 = 30.263 (6.4%); S7 = 18.178 (3.8%); S8 = 20.259 (4.2%); S9 = 57.967 (12.2%); S10 = 5.214 (1%); S11 = 105.76 (22.6%).

The dendritic and subdendritic pattern has a predominance in the upper areas of the sub-basins, since the rock material is made up of crystalline rocks, with low infiltration power of rainwater, due to the impermeability of the granite stock (LIMA, 1999). The irregularity of the rains makes the main river and other small streams subperennial and temporary, most of the time without water, except during the rainy season. The most significant rainfall occurs in the months of March, April and May; spending most of the time without rain, thus directly affecting the watercourses.

As for the vegetation cover, it is uncharacterized, but there are a few remnants (enclaves) of Tropical Rain Forest. This natural vegetation has, however, been deforested to plant banana trees, mango trees and elephant grass. The area also has a significant presence of cashew trees.

What is left of the humid forest is often preserved because there is shade-grown coffee cultivation, which needs vegetation. This happens on a small scale, for the consumption of the landowners, and not for commercialization. It is also noticeable that on the steepest slopes a vegetation occurs that is different from the others; this is the "capoeira", which represents areas that have been deforested over many years of exploitation. On the other hand, the alveoli are quite occupied by small residences, sometimes of mud and sometimes of bricks, with subsistence crops and fruit trees. In these areas, the tempera-

ture is milder, reaching around 20 ° C during the day and 18 ° C at night.

With a view to stablishing a classification on the climatic conditions of the areas where the upper course of the hydrographic sub-basins are located in the Massif of Meruoca the following typology is distinguished:

Wet Slope:
Corresponds to the upper course of sub-basins S1, S2, S3, S4, and part of S5;

Wet Top:
Corresponds to the upper course of sub-basins S1, S11, S2, S5, S4

Dry Slope:
Corresponds to the upper course of the sub-basins S10, S11, S5, S9, S6, S7, S8.

Dry Top:
Corresponds to the upper course of sub-basins S10 part of S11, part of S5, S9, S6, S7, S8.

FINAL CONSIDERATIONS

The geosystemic analysis of the upper course of the eleven sub-basins that constitute the sources of the Acaraú and Coreaú rivers brings important information for the knowledge of the natural dynamics of the Northwestern segment of the State of Ceará, and thus, for the process of managing the natural environment.The research clearly indicates that one must preserve the humid tops, where the natural forest vegetation still exists, and adapt the use and occupation for the dry areas, in order to avoid processes of desertification.

Thus, it should be noted that a large number of tributaries of these large rivers are formed by temporary or intermittent rivers, which places the hydrographic complex as vulnerable to aggressive uses, such as irrigation projects. In addition, the windward segment has more humid conditions, with drainage forming incised, V-shaped valleys, which makes the area more susceptible to environmental degradation in the case of subsistence agriculture and deforestation for various purposes.

Through the climatic typology it was possible to stablish different significant climatic conditions for areas of the upper courses of the Serra da Meruoca hydrographic sub-basins. The survey also indicates that the soils are more appropriate for agriculture exactly in this windward segment, which indicates the urgent need for environmental zoning by the management agencies, with the perspective of indicating the environment's support limit (that is, allowing exploration, but controlling the management, the type of occupation, the sectors and the extent to which this can occur), thus overcoming the "development x preservation" dilemma. Research, on the other hand, has shown that native vegetation,

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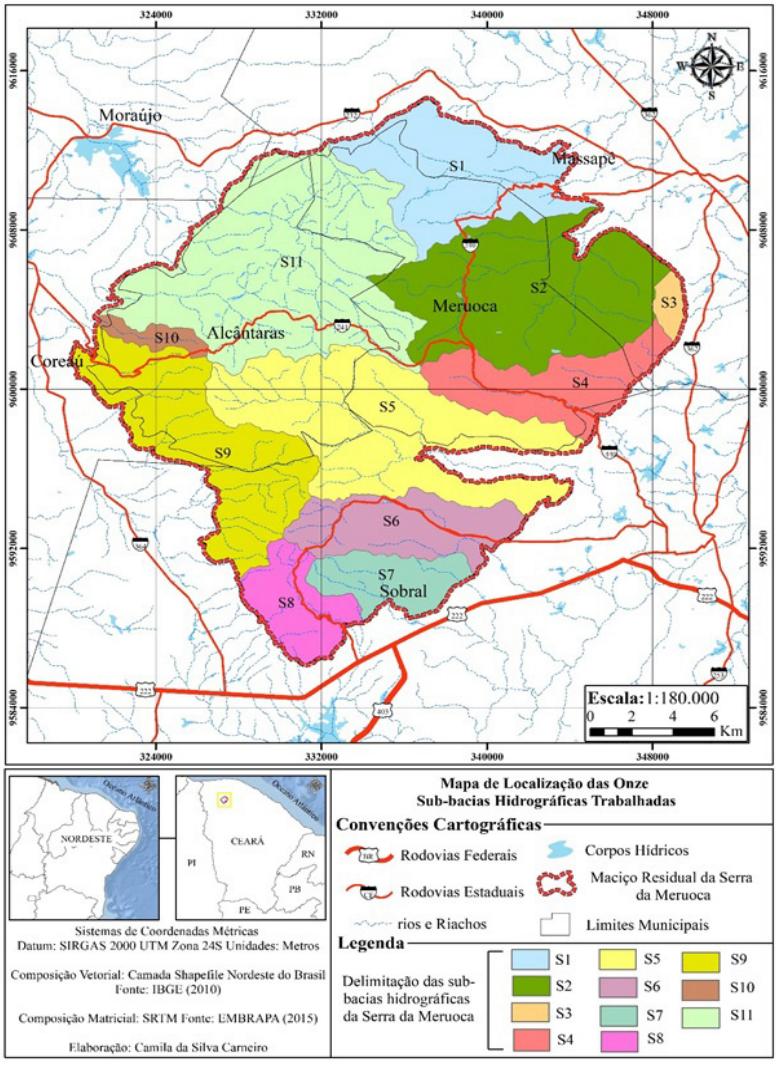
in particular that of the rainforest type, exists only in the residual form in areas that are not very extensive, and should therefore go through a more intense process of preservation. The complete removal of this vegetation cover would probably change the climate and bring lower humidity conditions to the geosystem, thereby modifying the entire natural set, which would also penalize economic activities in the region.

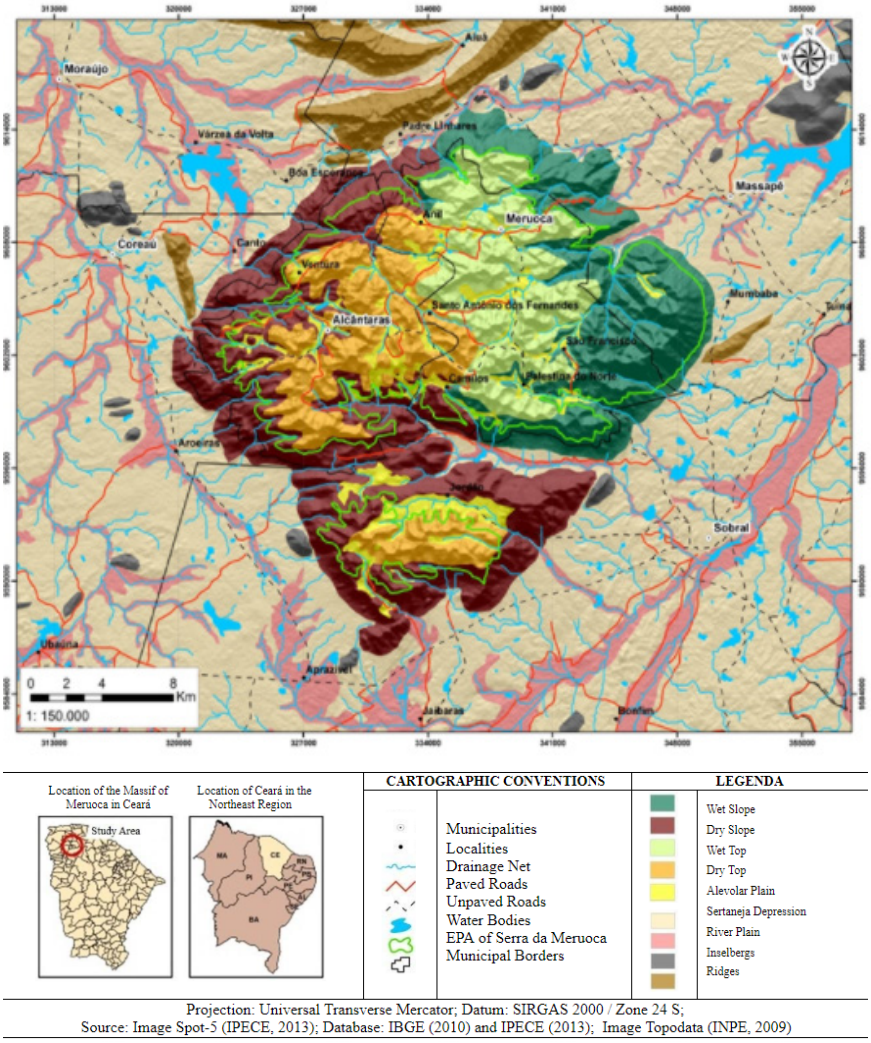
Finally, we can say that this work has produced a large amount of information about the Massif of Meruoca, particularly with regard to the physiographic characterization, which will be useful for increasing the knowledge of the local and external population about the environmental reality of the area in question, promoting an improvement in the process of education and social formation in the region where the analyzed geosystem is inserted.

FIGURE 3 - LOCATION OF THE ELEVEN SUB-BASINS STUDIED (GEOFACIES). THE MAP REFERS TO THE UPPER COURSE OF THE SUB-BASINS ANALYZED



Source: Authors

FIGURE 4 – CLIMATIC TYPOLOGY OF THE RESIDUAL MASSIF OF SERRA DA MERUOCA



Source: Authors

TABLE 1 - GEOENVIRONMENTAL COMPARTMENTATION (GEOSYSTEM / GEOFACIES) OF THE MERUOCA-CEARÁ MASSIF, BRAZIL

Geosystem	Sub-basins	Geofacies
Serra da Meruoca (473 km2)	Upper course of sub-basin 1; northern part of the upper course of sub-basin 11	**I** - They are areas that have wet tops and slopes, and are subjected to regularly distributed rainfall reaching an average of 1,527.9 mm per year according to data from Funceme (2015). As a consequence, there is a predominance of chemical weathering, resulting in thicker soils (Red-Yellow Argisols) and a vegetation cover presenting arboreal size classified as humid forest. The slope classes vary from 20 to greater than 75%, somewhat mitigating deforestation. It is worth noting the occurrence of acute angle "V" valleys, confirming the greater capacity for linear incision and greater valley notching or eventual structural control.

Source: Authors.

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Serra da Meruoca (473 km2)	Upper course of sub-basins 2 and 3; part of the upper course of sub-basin 4	**II** - It is to the northeast of the massif and has wet slopes and tops (higher sectors of the relief with greater precipitation) with "V" shaped valleys with a strong gradient and recess associated with the eroding erosion of the 1st and 2nd order channels. In this area is the Contendas stream, an important water resource that crosses the city of Massapê.
Maciço Residual Serra da Meruoca	Upper course of sub-basins 4 and 5	**III** - East of the Massif and presents a significant indentation called boqueirão, which possibly separates a significant part of Serra da Meruoca from Serra do Rosário by a structural control. These upper courses of the sub-basins are still located in areas of wet slopes and tops with the exception of sub-basin 5, which already has a dry slope (leeward slope, composing the so-called Serra do Jordão), as well as a dry top (a leeward top, with less precipitation) further upstream from the sub-basin
	Upper course of sub-basin 6	**IV** - Southeast of the Massif, with slope area and dry top, alveolus and relief dissected in ridges and shallow hills, and with the presence of physical weathering.
	Upper course of sub-basins 7 and 8; southern part of the upper course of sub-basin 9	**V** - Despite the upper course of these sub-basins being in the same geosystem, they present significant differences from a climatic, edaphic and vegetational point of view. In these sub-basins both the top and slopes are dry with dissected relief in ridges and in suspended levels of pedimentation and alveoli (raised valleys) appear between narrow and deep valleys.

Continue

Maciço Residual Serra da Meruoca	Southwestern upper course of sub-basin 9	**VI** - It has slopes and dry tops, facing the drier wilderness.
	Upper course of sub-basin 10; part of the upper course of sub-basins 9 and 11	**VII** - West of the massif. It is the smallest sub-basin in terms of territorial extension with dry slopes and tops and some alveoli, relief dissected into ridges and low hills.
	Upper course of sub-basin 11	**VIII -** Northwest of the massif, with dry slopes and tops and alveoli.

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