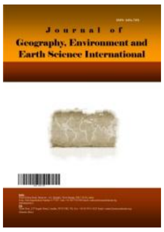

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Geomorphological Mapping of the Meruoca Mountain Range in the State of Ceará, Brazil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present research is the result of the geomorphological mapping project of the Serra da Meruoca located in the northwest of the state of Ceará, having as objective to map the relief based on Ross taxonomy [1]. Geomorphological mapping is one of the main methods and products of geomorphological research, contributing to the understanding of the dynamics of the relief, considering that it presents itself as the stage of human activities. The materials and methods consist of the stage of bibliographic review, systematization of information and generation of cartographic products, followed by analysis and interpretation. The results and discussions present the physical characterization of the area followed by the classification of the relief up to the third taxonomic level. Thus, the systematization of geomorphological information brings important contributions to the geomorphological mapping of the Morphosculpture of the Meruoca Crystalline Massif, which has no research of this nature. The mapping effectiveness was evidenced with the aforementioned methodology.

Keywords: Cartographic record of geomorphological; mapping; Meuoca.

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\# *Research;*
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1. INTRODUCTION

This report refers to the preliminary results of the project entitled "Geomorphological Mapping of the Serra da Meruoca in the state of Ceará, Brazil". For the cartographic representation of the relief and its diversity, mapping is a technique of great value and can be applied in several studies and sciences. In the scope of Geographic Science when applied to the study of the landscape allows the spatialization of phenomena that occur on the earth's surface, pertinent to social or environmental analyses, for evidencing forms, patterns, limits, transition, etc. Correlating a set of items and data that provide an integrated view of the whole.

Understanding the relief forms is important for both the development of science and society. According to [2], the relief is the stage of human activities. Geomorphological mapping "(...) constitutes one of the main methods and products of geomorphological research" [3]. According to Argento [4], through this method there is an information plan, represented by geomorphological mapping, which contributes to the explanation of erosive and depositional processes, as well as complementation with the basic mapping of the elements, enables the elaboration of environmental scenarios, such as risk areas of mass movements and flooding [4].

For this work, the Crystalline da Meruoca Mountain Massif was chosen, located northwest of Ceará by the coordinates 3°35'25" of south latitude and 40°29'40" of west longitude. With the objective of mapping the relief, compartments, units and correlating the physiographic elements and the interaction between these elements due to their importance in the processes of transformation of landscapes over thousands of years through the endogenous and exogenous processes responsible for forming different shapes and sizes of relief.

According to Ross [1], all relief belongs to a morphostructure and on this, result from the current and forethetizing climate action morphosculpture with different resistances. "This resistance is mainly due to the lithological, faciological, petrographic and structural characteristics that are added to increase or decrease the physical-chemical cohesion of the rock in the face of meteorization" [5]. Then, for cartographic characterization of the research area, Ross's methodology [1] was applied, in which he presented a proposal for classification of the relief based on the genesis, age and physiognomic aspect of the different forms and sizes of relief that will be described in the course of the report.

2. MATERIALS AND METHODS

Regarding geomorphological mapping, Ross's methodological guidelines [1] were followed, with the support of the ibge Technical Manual classification [6]. In the present work, it was identified up to the third taxonomic level, as proposed below:

> **1st Taxon:** Corresponds to macrostructure, i.e. morphostructure.
> **2nd Taxon:** Corresponds to Morphosculpture.
> **3rd Taxon:** Morphological units or patterns of similar shapes, these patterns can be pleasantly or denuded.
> **4th Taxon:** refers to the types of relief forms, individualized and inserted in the morphological units of the anterior taxonomic level, relief. Morphology of ridges, hills, hills, hills, valley shapes.
> **5th Taxon:** corresponds to the types of strands or sectors of the slopes of each of the relief shapes. Each type of shape of a strand is genetically distinct, [1]. Rectilinear and convex concave strands
> **6th Taxon**: refers to the smaller forms resulting from the action of erosive processes or current deposits, such as ravines and gullies [1].

The map information of patterns of similar shapes was designed against a scale of 1:250 000. On the map they were increased to 160 000 to 140 000 for cartographic representation.

At first, the research was based on the survey of information about the area of study, as well as the concepts guiding the development of the study through bibliographic reviews, consisting of the systematization of existing information, data collection on the physiographic aspects of the area and the treatment of them in a geoprocessing software consisting of the base mapping, generating the maps for interpretation.

Operationally, the physiographic databases were collected from collections of the Brazilian Institute of Statistical Geography - IBGE, the National Institute of Space Research - INPE, and the Water Resources Management Company -

COGERH. Applied on a digital elevation model (MDE) elaborated from SRTM (Shuttle Radar Topography Mission) images of the topodata/INPE project with resolution of 30 m constituting the elaboration of maps through the geoprocessing program QGIS version 3.16.13 Hannover.

The digital elevation model is a three-dimensional representation of the earth's surface, from it one can obtain planialmetric information of the surface, such as altitude, slope, orientation of slopes, valleys among others. Initially, the mapshipsometric, slope and patterns of similar shapes were elaborated. For the geomorphology map, taxonomy [1] was applied for the classification of relief, however, because Ross methodology was developed for humid environments, the research area even presenting wet is inserted in a semi-arid environment, so there was complementation of the IBGE Classification [6], which maps the features of the relief in detail, as represented in map 2, the third only of Ross' proposal [1], constituting the patterns of Dissection and Accumulation and Planing.

3. RESULTS AND DISCUSSIONS

Initially, the results are because they present a physical characterization of the area, later entering more specifically in the results of geomorphological mapping.

Structurally the Meruoca Massif was formed during the Orogenesis Brasiliana, a geological process responsible for the current structure of the Brazilian relief caused by colisional events associated with tectonics, metamorphism and granite development. According to [7]. The Meruoca Massif was soerected in this event, and since then has been sculpted by the erosive processes that acted in the Cenozoic, thus representing a residue of the shoulders of the rift. Endogenous events create relief, and external agents model such shapes. The massif consists of two fragments, the Serra da Meruoca to the north and the Serra do Rosário to the south, its lithological structure corresponds to the domain of crystalline shields with formation dating from the Precambrian period between the archeozoic and Proterozoic eras. Consisting of metamorphic or intrusive rocks and evolution associated with relief dissection processes [8]. Presenting fault lineations arranged in the Direction SW-NE, forming the western boundary of the Graben Jaibaras.

It has two distinct strands, in part NE the windward slope and the so-windward. In the windward sector the altimetric levels range from 600 to 900 m and can exceed 900 m of altitude, is bathed by orographic rains that give it greater atmospheric humidity and favorable conditions to agriculture.

Being able to be identified on the relief more developed soils and vegetation cover, vegetation characterized by remnants of cloudplet forest and caatinga cover on steep surfaces, covering a vegetation of varied slope between 20% and greater than 75% and carving valleys with greater linear incision capacity, mostly intermittent river flows, forming rivers of 1st, 2nd and 3rd orders [9]. Intermittent or semi-perperennial surface flows, which, as explained [10]. "The drainage of subperennial and intermittent surface at certain times of the year forms small falls of water, coming from the springs, which in this humid slope belongs to the drainage of the Acaraú River".

Due to the humidity in this windward sector, chemical weathering has conditioned the formation of red-yellow Argisols in choline reliefs and spines, over the rocks, in steeper slopes and ridges, with the presence of Litholic Neosols, which are susceptible to laminar erosion and in altitude swamps, surfaces above 600 m there is the development of alveolar plains with variation of alluvial sediments.

Despite the edaphoclimatic conditions favorable to the biodiversity existing in Meruoca, according to [11] the swamp areas are threatened throughout the occupation in the mountains due to the incidence of babassu associated with the form of land use for subsistence agriculture based on planting in rows of corn and beans, influencing erosion processes. In addition to impoverishing biodiversity due to the devastation of native vegetation, it is possible to observe indicators of desertification through the incidence of babassu species that are not native to the Meruoca mountain range.

This is a relief susceptible to accelerated degradation. The windward of the mountain evidences characteristics of "wet island" in the middle of the backlands, with high rainfall and more mild temperatures in relation to the surroundings, with the predominance of chemical weathering the features assume rounded shapes of hills and spines sculpted by a dense river regime in rainy periods that condition the formation of streams and falls by carving valleys of strong linear incision due to the topographic gradient.

On morphosculpture, more developed soils and vegetation are formed, attracting human occupation due to the strong potential of exploitation, which ends up disfavoring the preservation of ecosystems and accelerating erosion processes due to the influence of slope of the slopes with risks to mass movements.

In the windward sector, the natural conditions generated by the opposition to windward trigger morphogenetic processes related to the predominance of mechanical weathering. The rugged relief, with altimetric levels of 600- 800 mm dissected in hills and ridges covered predominantly by forest vegetation and arboreal caatinga, in its steepest slopes there is a great occurrence of rocky outcrops revealing aspects of its lithostructural layer.

The predominance of Red-Yellow Argisols and crests can be highlighted in its hills the presence of Litholic Neosols of medium to high natural fertility [12]. The plant coating strongly mischaracterized by the influence of burning and deforestation practices for planting purposes leave vast sections of soil bare and vulnerable to erosion by the areal and linear processes of the climate, delineating on the crystalline basement a dense river network of dendritic pattern and medium deep valleys in the form of V or U. [12].

At the top of the slope with levels above 600 m, in the municipality of Alcântara there are alveoli that present suspended levels of sedimentation of colonized bottom, formed from the sedimentary decomposition transported and deposited in lower levels and vegetation of semidecidous rain forest granting the area favorable conditions for the planting of fruit trees and housing for the practice of subsistence agriculture.

The massif in general constitutes a large complex organized and despite its potentialities, the degradation process is accelerated by irregular practices of land use and occupation, conditioning changes in characteristics and results throughout the system. The windscreen of the mountain evidences characteristics such as temperature, precipitation and evaporation similar to those of the sertaneja surface of the semi-arid, on the morphosculpture develops shallow soils and caatinga vegetation with little control to the impact of rains on the pedological layer.

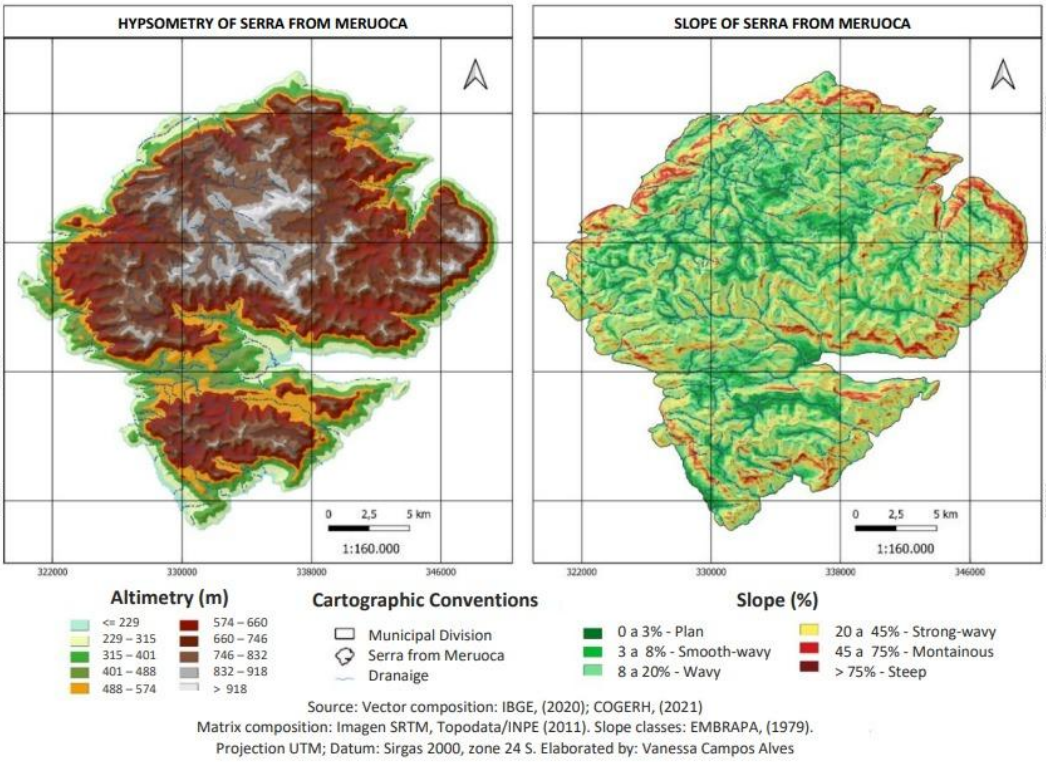
In this context, the fluvial action deserves attention, because it acts in the consolidation of drainage networks, these acts as modeling agents of the relief forms. The surface runoff and evaporation of most of the waters of the river courses encounter resistance to infiltration by the domain of the crystalline basement where simultaneously the acceleration of the water outflow by the accentuated slopes that associated with an open vegetation cover, shallow soils and the land use that favors the preservation of ecosystems, becomes susceptible to erosion processes.

Below are the results of the relief mapping, presenting the geomorphological attributes of slope and altimetric variation of the area and taxonomic classification. In the study of geomorphological mapping, in addition to the identification in this case of the patterns of relief shapes, the data of slope and altimetry are essential in the identification and characterization of geomorphological units.

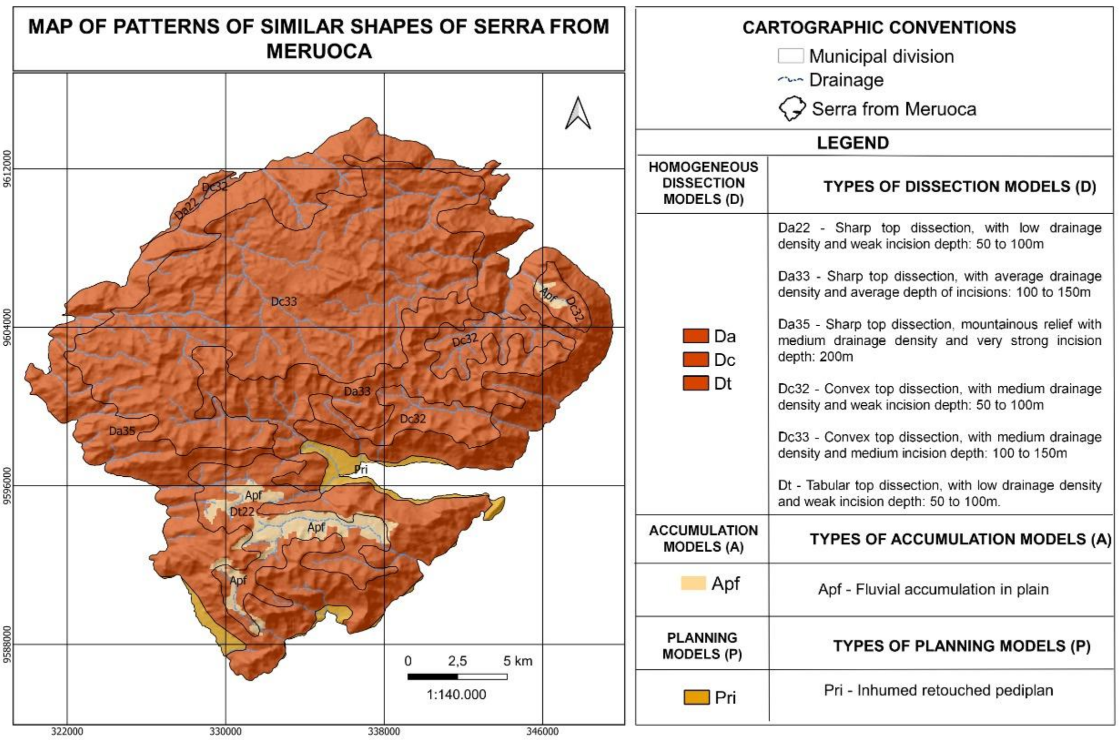
As a result, map 1 presents the first map generated, containing the latter and slope information of the area. The altimetric representation shows the intervals of 86 m, noting that the lower altitudes (229-315) are in the areas of the plains and in the parts of slopes the altitudes are considerable, while the altitudes with higher dimensions are predominant throughout the massif.

The information of slope represent mostly relief soft-wavy to strong-wavy, the areas of slopes present mountainous reliefs to escaped.

Map 2 shows patterns of similar shapes (dissection, accumulation, and planing). The dissection models are predominantly presented. The dissection presented is tied to the denudational processes of relief, such as weathering and erosion. The types of dissection (Da, Dc, Dt), are due to differentiated factors of resistance of lithology. Dissection models with convex tops (hills) are predominant in the wet part from chemical weathering. On the other hand, the tops with sharp dissection (ridges) are predominantly leeward with a physical weathering domain, the main external agent responsible for the morphogenesis of the area.



Map 1. Hypsometry and slope of the Meruoca Mountain range



source: Legend: IBGE (2009); Vector composition: IBGE, (2020); COGERH, (2021). Matrix composition: Imagen SRTM, Topodata/INPE (2011). Projection UTM; Datum: Sirgas 2000, zone 24 S. Elaborated by: Vanessa Campos Alves

Map 2. Patterns of similar shapes of the Meruoca Mountain range

Referring to the Accumulation Models, in this case it is represented by the river plain. It represents a flat area resulting from river accumulation subject to periodic flooding, corresponding to current floodplains. It occurs in valleys with alluvial filling [6].

The planing models are identified by the definition of their genesis functionality, combined with their current state of conservation or degradation imposed by erosive episodes after their elaboration [6].

Referring to the type of planing identified- Flooded Retouched Pediplane, Planing surface elaborated during successive phases of erosion resumption, without, however, losing its planing characteristics, whose processes generated systems of inclined planes, sometimes slightly concave. It may present detritic coverage and/or battleships more than one meter thick, indicating successive remissions (Pri) or little altered rocks truncated by the flattening processes that bared the relief (Pru) [6].

4. CONCLUSIONS

First, it is important to highlight that this work aims to contribute to the geomorphological mapping project of Meruoca mountain range. To meet the proposed objective, detailed studies from the macro level to the more detailed forms of relief are needed. It is from these studies that it is possible to understand the dynamics of relief. This research through the systematization of geomorphological information brings important contributions to the geomorphological mapping of morphosculpture of the Meruoca Crystalline Massif, which has no research of this nature.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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