Chapter 41

Morphometric analysis of the Serra do Sincorá Geopark, using remote sensing and GIS

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ABSTRACT

The study analyzed the morphometric characteristics of the Chapada Diamantina relief, covering Andaraí, Mucugê, Lençóis and Palmeiras municipalities, which delimits the mountain range of Sincorá, a geopark proposal to be submitted to UNESCO in the coming years. The works were carried out at the Technical Drawing Laboratory in UESB (Universidade Estadual do Sudoeste da Bahia), using Remote Sensing and GIS (Geographic Information System). The orbital database used in raster format are the SRTM (Shuttle Radar Topograph System) elevation data with a grid of 30x30 meters and images from the LANDSAT 8 satellite, with a spatial resolution of 30 meters, bands 4-5-6, available in the USGS (United States Geological Survey) website service. Data in vector format were obtained from websites of Brazilian official institutes (EMBRAPA, IBGE, CPRM, MMA). The analysis first allowed to infer that the mountain range of Sincorá is oriented predominantly in the SW-NE direction, with 32 percent of its relief in this orientation; other alignments correspond to 19-12 percent of the total. Considering the altimetry, the predominant values were for elevations from 300 to 1300 meters, in 95% of the total area, although the maximum value found was 1700 meters of altitude. The relief was distributed as apartment surface, gently undulating, undulating, strongly undulating, mountainous and steep classes. The morphometric data of the relief were produced in 3D modeling, represented with texture from satellite images, grayscale, hypsometry, slope, shaded image and exposure of slopes, with spatial analysis. The results are expected to allow other researchers and technicians to work their planning and management actions with them, especially those from the region of geopark proposal.

Keywords: Geopark, Serra do Sincorá, Chapada Diamantina, Relief

1 INTRODUCTION

The topographic representation of the earth's surface is an important resource for analyzing the morphogenetic transformation processes that a landscape undergoes over time, as well as serving as a subsidy for territorial management and land use planning, so as to cause the least possible impact on the environment, combining the use of the potential resources with ecological balance.

Geomorphological data are essential for an accurate and integrated analysis of the environment. For Almeida and Bergamo (2006), they allow the classification of geomorphological units, that is, the patterns of relief forms, altimetry, slope, drainage patterns besides the potential and/or possible fragilities of the area.

Geomorphological studies in a region with large territorial dimensions, such as the Chapada Diamantina can be performed with the use of Remote Sensing and Geographic Information System (GIS), by the ease of acquisition, manipulation and analysis of the geographic database, providing updated information for territory management. For Veiga (2001, p. 15), "in a country of large proportions like Brazil, a systematic cartography, updated and integrated with modern computer systems, enables works and projects that require a secure and precise information base [...], for correct decision making".

The advances in remote sensing have been accompanied by the development of computer systems, such as GIS's, built for data automation, in order to overcome the deficiency and slowness of manual work. The use of technologies for mapping has been gaining more and more prominence, in order to assist in a better study and planning of land use and its transformation. In geomorphology it would be no different, the use of digital tools has been increasingly adopted by researchers. According to Pissaro, Politano and Ferraudo (2004), the use of images has been of great importance in landscape studies, indicating elements linked to topography, soil and geomorphology.

GIS as an object-oriented relational database is possible to implement a large volume of geographic data information, and can be processed, queried, and spatial analysis, in a computer system, automatically or semi-automatically, without direct contact with the object of study, although, aided by fieldwork.

The orbital sensor data (satellite and radar), provided by private and public companies, are of high quality, with low, medium and high spatial resolution information, in different spectral bands of the visible, infrared and microwave, reaching a number of up to 15 bands, radiometric resolution of up to 11 bits, with collection time ranging from 3 to 28 days intervals (temporal resolution), with the possibility of analyzing different targets, either by methodology of visual analysis of images or digital processing performed in GIS.

The digital image processing when performed in GIS enables an accurate and effective analysis in the survey and cross-referencing of data (IBGE, 2009). Thus, it is possible to obtain a range of data and information about the topography, crossing them with information and/or vegetation cover, land use, environmental degradation, among others.

For Liu (2007) the satellite images enable the generation of new maps and database for management, considering that it is possible to measure different targets, from the spectral response of the components of the earth's surface. The author also points out that it is possible to distinguish, separate and classify objects in urban and rural areas, through the composite model of key bands, based on the analysis of their spectral signatures, because each target has a unique energy curve in the electromagnetic spectrum.

The quality of the orbital products enables studies at different scales, such as applications in synthesis scales or data integration for continental survey; systematic studies of the country; data compilation for regional survey; and partial and detailed studies of a given spatial unit. The studies using remote sensing and GIS meet the demand for the dynamics of natural systems, besides enabling the monitoring of the transformations that take place in this environment.

Regarding the benefits of technological tools, the area of geography has benefited from the technology of remote sensing and GIS, among the applications, Novo (1995) highlights the cartographic; analysis of relief forms; studies of the physical environment; analysis of water resources; surveys and monitoring of land use; geomorphological processes; vegetation analysis; geological mapping, etc. Such information provides subsidies for decision making in watershed management projects, recovery, preservation or conservation of areas of environmental interest, among others.

In recent years, the advances in geoprocessing techniques, and the availability of low, medium and high resolution orbital sensors, have made possible the digital processing of images and numerical terrain modeling, whose technology has been used indirectly for the spatial analysis of environmental characteristics and the physical environment of a given area or region, based on spectral response values (radiance/reflectance), spatial resolution, or altimetry values, obtained by satellite and radar images.

In the conceptual aspects of data modeling using GIS, for Câmara and Medeiros (1998, p.47), "a data model is a set of conceptual tools used to describe how the geographic reality will be represented in the system". In this line, Veiga and Souza (2002) highlight the representation of the real world with use in the computer, where the geographic reality can be realized in the GIS, for certain applications, such as numerical modeling of the terrain, with processing of remote sensing data, performed quickly, in a short space of time.

Florenzano (2008a) dealing with the object of study of geomorphology, points out that "morphology includes morphography, which is the description of the forms of relief, and morphometry which is the characterization of relief through qualitative variables, also called morphometric indices. Thus, the analysis of the relief allows us to understand the processes of formation and changes that a particular area has undergone over time, as well as to dimension the importance of this formation for fauna, flora and human development.

In the geomorphological analysis with the use of GIS, Valeriano (2008) points out that in the representation of the relief can be used the digital elevation model, with 3D modeling, using the morphometric variables, with production of digital data such as terrain segmentation, shaded relief, slope exposure, slope, altimetric extracts, etc., where combinations, interpretation and synthesis can be performed, associated with the generation of qualitative maps. Florenzano (2008b), complements this by highlighting that the representation of the real world in 3D, enables the analysis of the relief and distribution of the topography of a given region, provided by the three-dimensional view of the Earth's surface.

The results generated from the spatial analysis of a land surface, for Veiga and Souza (2002), serve as subsidy instruments for planning and territorial management, providing a basis for acting in an orderly and less traumatic way for the environment. Its importance is based on the planned and sustainable manner, thus avoiding problems of disorderly territorial occupation.

The computer systems for remote sensing applications, when properly used, produce benefits such as: reducing the development time of a project; eliminating repetitive tasks; making the registration of data and information more precise and rapid; facilitating the management and monitoring of a given area.

In the current landscape of Chapada Diamantina there is a need for research focused on spatial analysis of the territory. Thus, in this study we performed a morphometric analysis of the relief of Chapada Diamantina, using geoprocessing, in a region where the creation of the Serra do Sincorá Geopark is being proposed, to be submitted to UNESCO in the coming years.

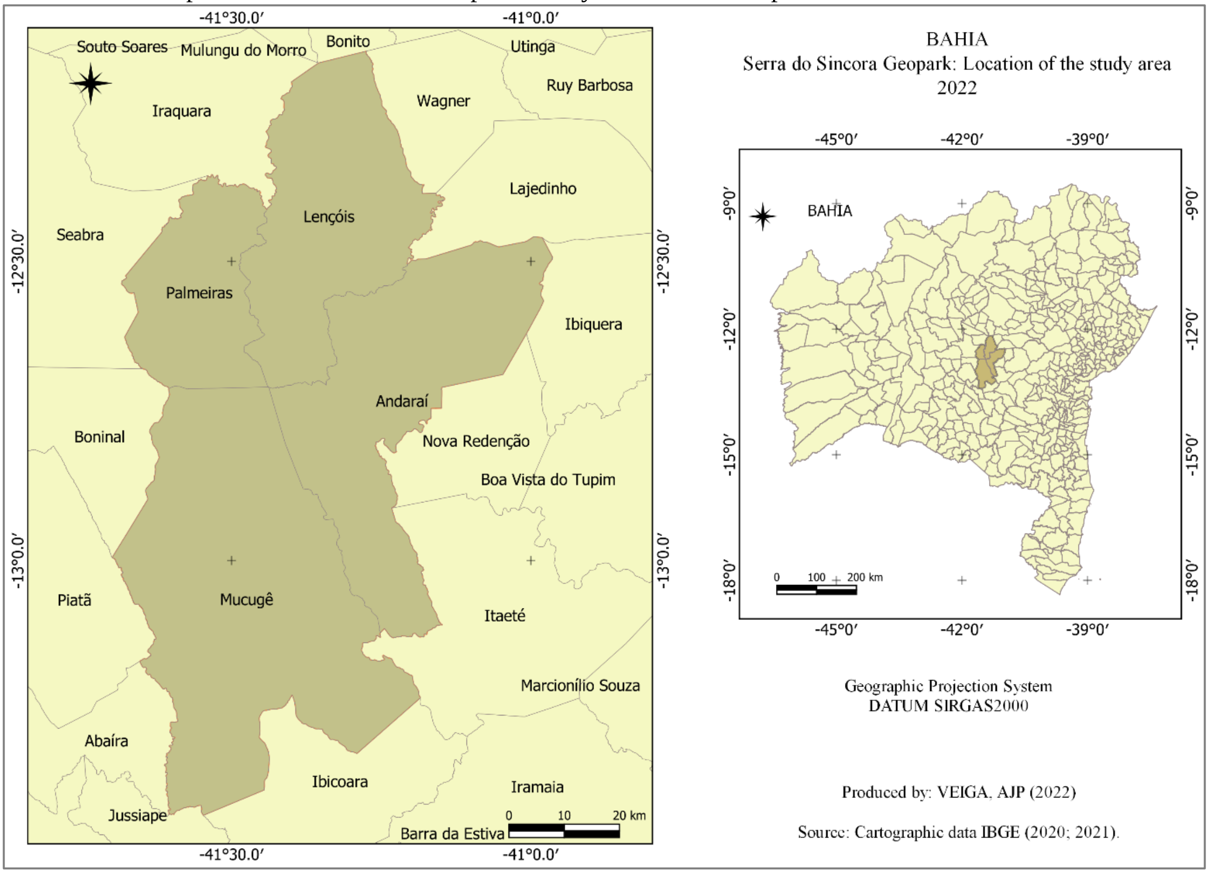
The Chapada Diamantina is a region of environmental interest and studies that contemplate the spatial analysis of its territory are relevant, as a support to territorial planning and management in a sustainable way, especially, due to its natural potential and its biodiversity, in areas that have Conservation Units in the Federal and Municipal spheres.

2 MATERIALS AND METHODS

This research is located in an area delimited by a polygon of 6,080 km², located in the central region of the State of Bahia, Brazil, in the central-southeastern sector of the Chapada Diamantina, where the creation of the Serra do Sincorá Geopark is being proposed (map 1). In the study a spatial cutout was made that corresponds to the rectangle of the geographic coordinates 13°26'00" - 12°08'35" South latitude and 41°43'00" - 40°57'00" West longitude.

The polygonal of the Geopark was delimited from the limits of the municipalities of Lençóis, Palmeiras, Mucugê and Andaraí, whose area surrounds almost the entire Chapada Diamantina National Park - PARNA, part of the Environmental Protection Area - APA Marimbus-Iraquara and northern part of the Serra do Sincorá, and includes a portion of the Mucugê Plateau and the Una Utinga Carbonatic Basin (PEREIRA, ROCHA AND PEDREIRA, 2017). The database used had as reference the limits of the respective municipalities, updated by IBGE in 2020.

Map 1 - Serra do Sincora Geopark: Study area and municipalities localization – 2022

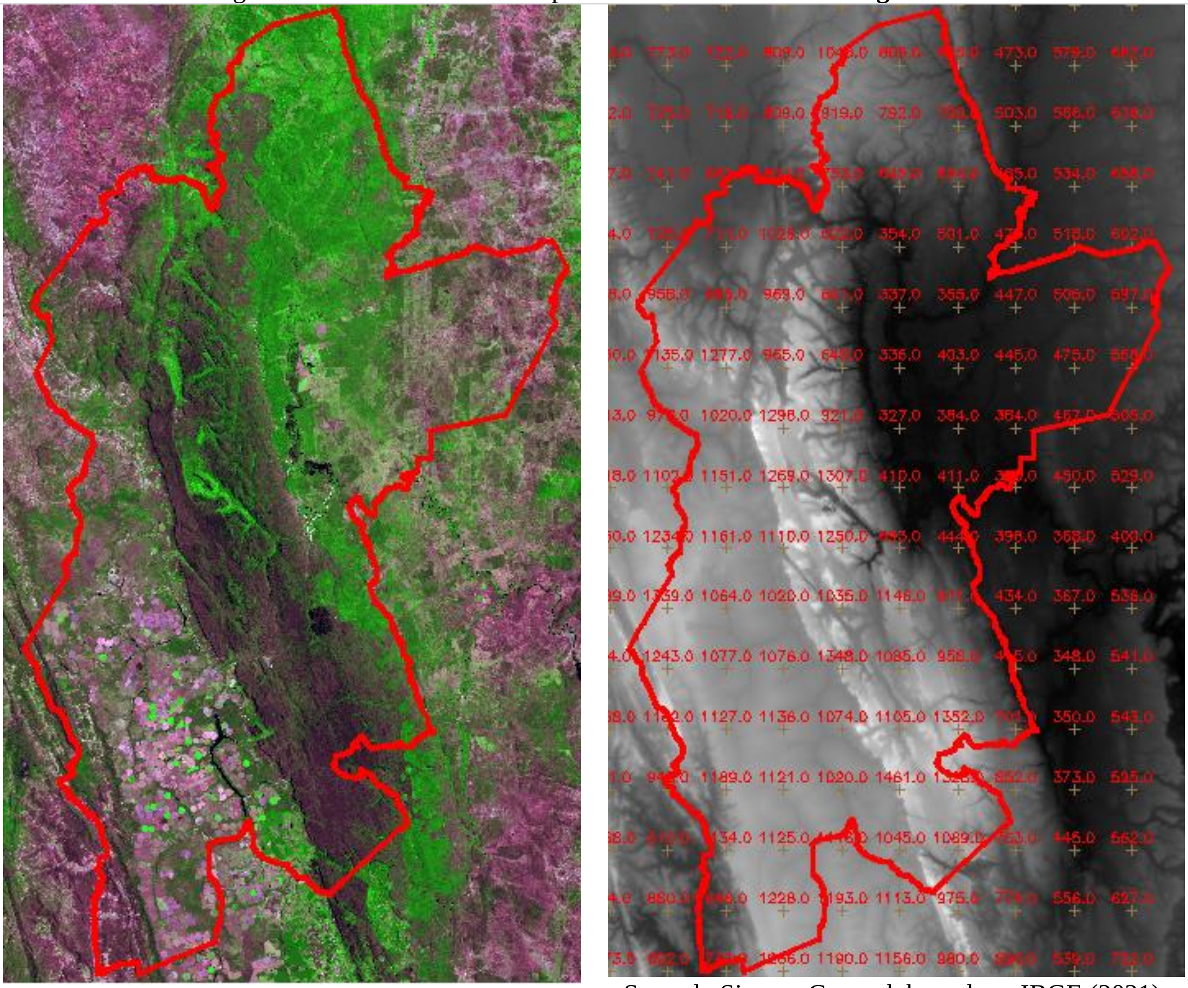


The study analyzed the morphometric characteristics of the Serra do Sincorá Geopark. The work was developed in the LabDesTec (Technical Design Laboratory) of the UESB (State University of Southwest Bahia), in a computational environment, through numerical terrain modeling (MNT), with remote sensing techniques and the use of GIS SPRING (Georeferenced Information Processing System), with remote sensing data (satellite and radar), and the location map was produced in QGIS.

In the morphometric analyses of the relief we used digital images from LANDSAT 8 satellites in the 4-5-6 bands, from the year 2020, with a spatial resolution of 30 meters, and SRTM (Shuttle Radar Topography Mission) topographic images, with a grid of 30 meters, obtained from the USGS (UNITED STATES GEOLOGICAL SURVEY) site, from the year 2020 (figure 1).

The SPRING used in the morphometric analyses of the relief is a software of the category of a Geographic Information System (GIS), of public use, available for free on the INPE (National Institute for Space Research) site, a tool that enables the digital processing of images, spatial analysis, digital modeling and database consultation, thus allowing the manipulations and analyses done on satellite and radar images in raster format, as well as on vector cartographic bases.

Figure 1 - Serra do Sincora Geopark: **Satellite and radar image** - 2022



Serra do Sincora Geopark boundary, IBGE (2021); Landsat image, RGB 4-5-6, USGS (2020)

Serra do Sincora Geopark boundary, IBGE (2021); SRTM image, USGS (2020)

Source: USGS (2020); IBGE (2021); Research data available in the SPRING database (2022)

In the digital processing, besides the orbital images, cartographic bases in vector format were also used, available in official sites such as IBGE (Brazilian Institute of Geography and Statistics); INPE; DNPM (National Department of Mineral Research); MMA (Ministry of the Environment), besides information that was generated during the vectorial editions and in the processing carried out in SPRING.

With SPRING a Database was created with a Project, Data Models and the Information Plans (PI's), with their respective thematic classes. The inputs and the integration of spatial data were made with geometric representation in vector and raster format, inserted in the system from the import of digital files, for further digital processing and spatial analysis. The data were processed with geographic positioning, georeferenced, UTM projection, SIRGAS2000 datum, according to IBGE standards.

The digital processing performed were Numerical Terrain Modeling (NTM), with operations performed on the topographic image, with grid generation, thematic slicing, 3D modeling with production of block diagram with satellite image texture, shaded and gray image, slope exposure, hypsometry and slope. Imports of cartographic bases in vector format were also performed, with editing of the digital files, calculation of areas, cross tabulation, production of maps and spatial analysis.

The research relied on an extensive literature review as theoretical/practical support in the morphometric analyses and that justifies the application of digital terrain modeling methods, used in the digital processing of remote sensing data and cartographic bases, processed in the GIS environment, thus having concise results.

3 RESULTS AND DISCUSSIONS

Geomorphological features have always fascinated people, who seek not only to contemplate the landscapes, but also to understand their formation processes, the different environments constituted throughout the Earth's history, the biodiversity and geodiversity, and the geological heritage, whether through scientific studies or through activities such as geotourism, where it is possible to use a set of strategies integrated protection with environmental education, aiming at the region's sustainable development.

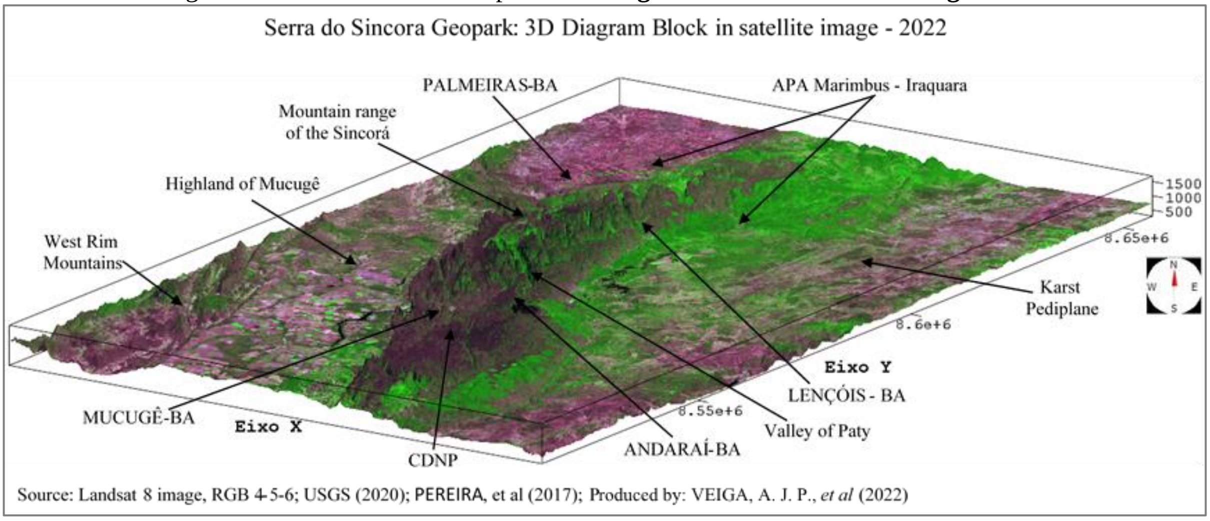
In the area of Serra do Sincorá Geopark, the conditions portrayed in the elements that make up the different landscapes are the result of processes that occurred throughout its geological history, with the formation of environments characteristic of Chapada Diamantina, with its rich biodiversity in different edaphoclimatic conditions and geomorphological formations. With all this and its scenic beauty, there are favorable conditions for geotourism due to its potential geodiversity, in addition to the areas of environmental interest established by law, such as conservation units, present in the region, which can be used with the prospect of sustainability for current and future generations.

The characteristics of the relief, as one of the aspects of the landscapes, in the approaches of Venturi (2006), are considered as natural resources of indirect use, used for agricultural purposes in the choice of areas with flattened modeling or in plains, which, due to its dynamics, involves sedimentation and concentration of moisture. As for the dissected relief, the utilization is strongly conditioned to a greater potential for energy use and water damming in relation to the flattened relief and, as landscape, it offers aesthetic, leisure, spiritual satisfaction, or for educational and scientific purposes.

In the morphometric analysis of the relief, of the rectangle and polygon where the Serra do Sincorá Geopark is located, it was possible to characterize the region's landscapes, represented by the digital modeling of the terrain in 3D, elaborated with different textures, with satellite image; gray image; shaded image; exposure of relief slopes; hypsometry and slope, by means of qualitative and quantitative variables.

Figure 2 shows in the center the Serra do Sincorá mountain range and, due to the scale, the position of the headquarters of the municipalities involved, the National Park (PARNA) of Chapada Diamantina, the Environmental Protection Area (APA) Marimbus - Iraquara, highlighting the relief aspects, the geomorphological units classified by Pereira, Rocha and Pedreira (2017) as the Serra da Borda Ocidental, Planalto Mucugê, Serra do Sincorá and the Carstic Pediplano.

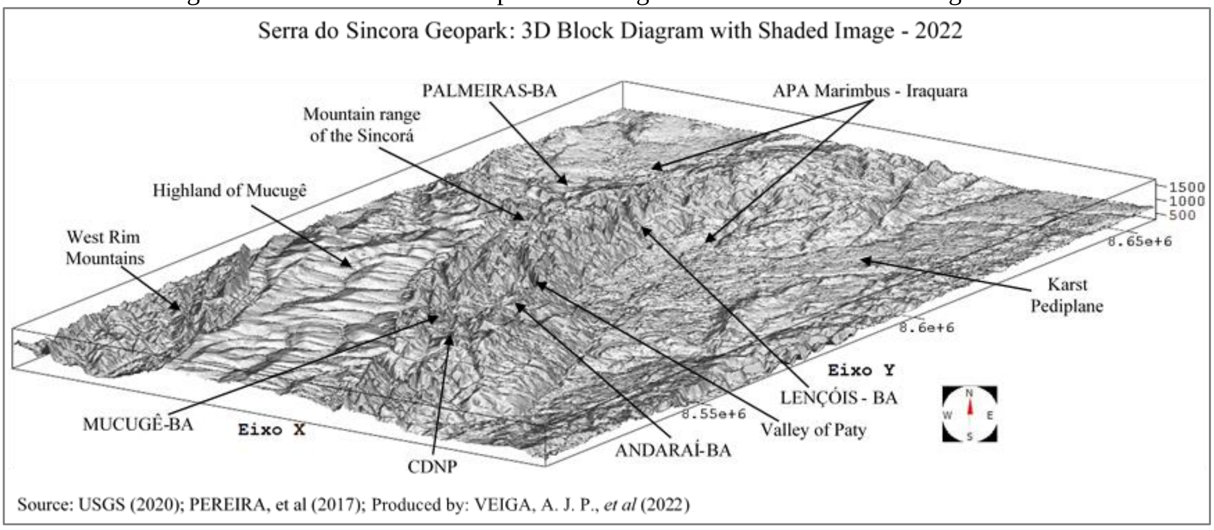
Figure 2: Serra do Sincora Geopark: **3D Diagram Block in Satellite image** - 2022



The shaded image represented in 3D in Figure 3, allows a better observation of the relief, accentuating its shapes, texture and elements. According to Florenzano (2002, p. 49) from the shadow and other elements, such as shape and size, can also be inferred in the interpretation process, allowing to visualize the size and shape that the relief assumes.

According to Moreira, Riedel and Hamburger (2008) "the shading becomes an important ally, and can even be used as a criterion for photointerpretation, where characteristics such as its size, orientation and density can be considered". For Ross (2005), its fundamental importance is in representing the complete view of the relief, and the study of its characteristics must be complex.

Figure 3: Serra do Sincora Geopark: 3D Diagram Block with Shaded Image - 2022

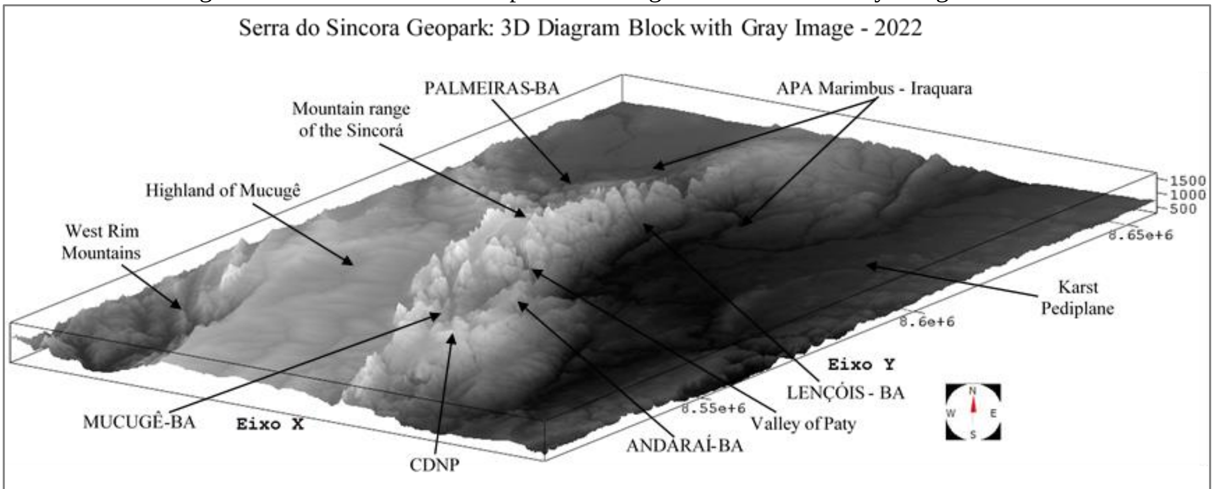


For Christofoletti (1974) geomorphological knowledge is embedded in the idea that the terrestrial modeling evolved as a result of the influence exerted by morphogenetic processes, i.e., endogenous and exogenous processes. In this perspective, the relief is just a stage inserted in a longer one, for thousands of years. The analysis of the relief evolution starts from the morphographic aspects, which are the qualitative variables, and morphometric characterizing it through its quantitative aspects. The correlations between the two models have provided a better visualization of the processes and forms present in the landscapes.

In Figure 4 we observe the forms and dissection of the relief from the 3D representation, having as texture a gray image of the SRTM topographic sensor, where the altimetric values are distributed with a variation from gray to white, being the dark colors the lowest quotas and the variation towards the white, the highest altimetric quotas. The Serra do Sincorá is where the highest altitudes are found.

In the eastern extremities of the Serra do Sincorá, where the gray coloration intensifies, is located the relief of the Karstic Pediplano, in the region lies the "Marimbus Pantanal", belonging to a portion of the Marimbus-Iraquara APA. This is an area of preservation of diverse ecosystems, with a rich biodiversity and of great environmental value, with a rich geological formation, formed by the confluence of the Santo Antônio, Utinga and São José rivers, belonging to the Paraguaçu river basin.

Figure 4: Serra do Sincora Geopark: 3D Diagram Block with Gray Image - 2022

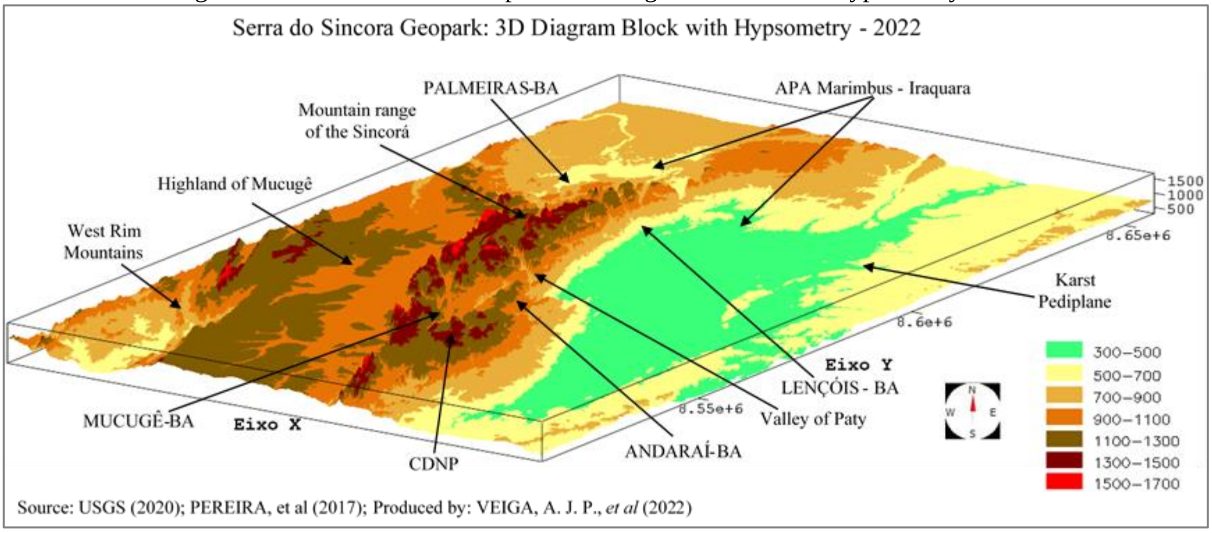


Source: USGS (2020); PEREIRA, et al (2017); Produced by: VEIGA, A. J. P., et al (2022)

Figure 5 shows a 3D representation of the hypsometry, with the spatialization of the altimetric coordinates. According to IBGE (2009), these thematic maps or topographic profiles are an important tool for identifying surfaces based on previously known altimetric levels.

In the analysis of the hypsometry data (figure 5 and table 1), it was observed that the Serra do Sincorá Geopark has a total area of approximately 6,080 km², with a predominance of 95.3% of the relief in the altitudes ranging from 300 to 1300 meters, although, in the region, values with altitudes of up to 1700 meters were found.

Figure 5: Serra do Sincora Geopark: 3D Diagram Block with Hypsometry - 2022



The lowest altitudes found in the Serra do Sincorá Geopark, in the 300 to 500 meters ranges, is the depressed relief, and is where part of the Maribus-Iraquara APA is located, formed by a depression with relief varying from flat to gently undulating, with characteristics of an alluvial plain, produced by the drainage of the tributaries of the Paraguaçu River. In the 500 to 700 m ranges, 853 km² were identified, in 14.03% of the area; in the 900 to 1100 m ranges, the percentage was 23.6%; and, in the 1100 to 1300 m altitudes, the areas were 1465 km², with 24.10%. The higher elevations, between 1300 and 1700 m, represented only 4.73% and that together, constituted 287 km² of areas in relation to the total.

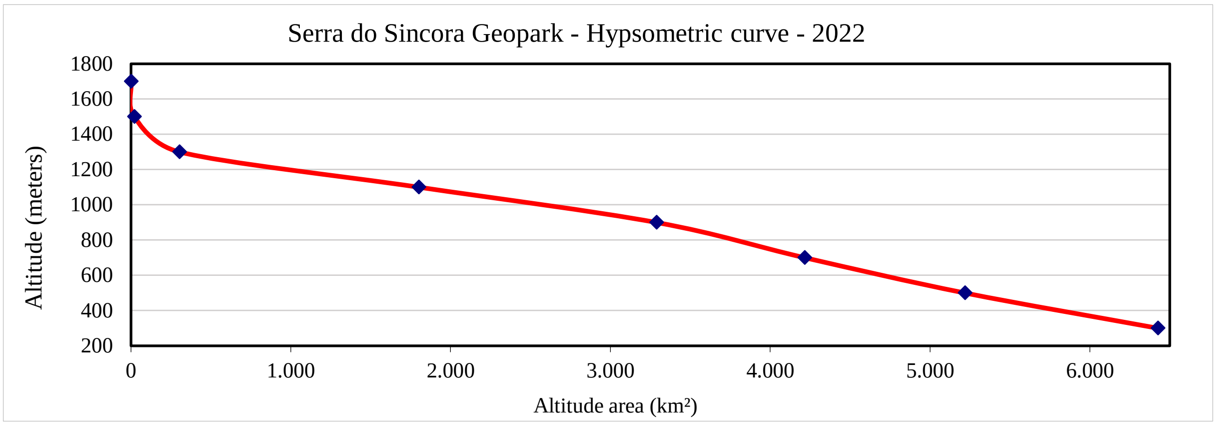
Table 1 - Serra do Sincorá Geopark: **Hypsometry** - 2022

Altitude (m)	Area (km²)	Percentage (%)
300 - 500	1198,58	19,71
500 - 700	853,22	14,03
700 - 900	835,43	13,74
900 - 1100	1439,68	23,68
1100 - 1300	1465,19	24,10
1300 - 1500	267,34	4,40
1500 - 1700	20,15	0,33
Total	6079,59	100

Source: Data processed in SPRING; BONFIM, I.F. (2022)

In the analysis of graph 1 of the hypsometric curve, elaborated from the sum of the accumulated areas of the intervals of the altimetric quotas, in the variations from 300 to 1700 meters of altitude, in the rectangle of the studied area, including the polygonal of the Serra do Sincorá Geopark and, in the external areas, the observed gradient was 1400 meters, where the relief break lines are located on the quotas above 1200 meters and there is a small variation at 900 meters of altitude.

Graphic 1: Serra do Sincora Geopark: Hypsometric curve - 2022

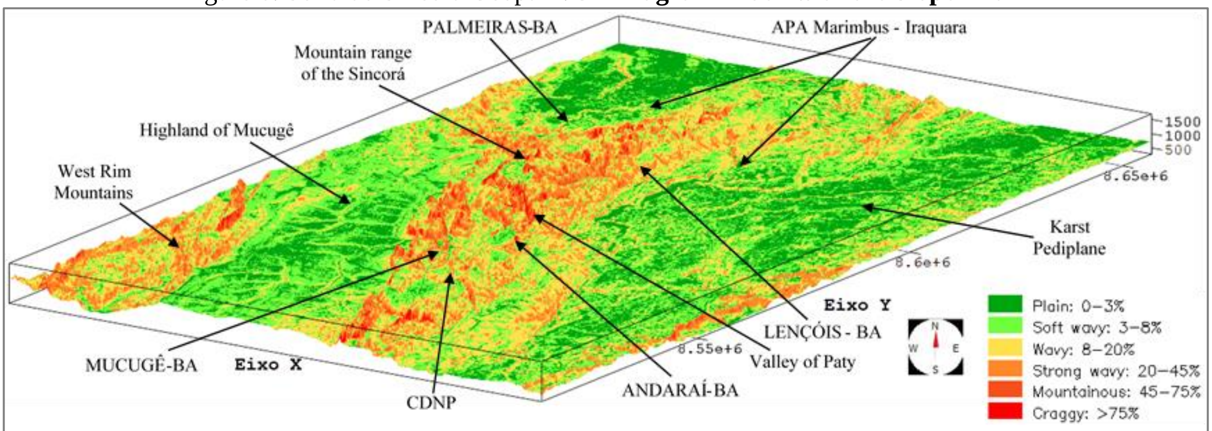


Source: Produced by: VEIGA, A. J. P. (2022)

Christofoletti (1980), dealing with the hypsometric study, considers that in the analysis of the relationship between the horizontal units of a given space with the distribution of variations in altimetric ranges it is possible to investigate the configurations of the relief, its evolution and wear. With the help of the hypsometric curve one can observe the distribution of rock volume from the base to the top.

With regard to topography, the slopes were classified (Figure 6, Table 2), and that for IBGE (2009), represents the variation of terrain gradients in previously established intervals, according to its purpose, being useful in the characterization and delimitation of geomorphological units and regions. The intervals of the slope classes chosen were based on the criteria in percentages used by EMBRAPA (2018), for the relief typologies and their application in the classification action of Brazilian soils.

Figure 6: Serra do Sincora Geopark: **3D Diagram Block with the Slope** - 2022



Source: USGS (2020); PEREIRA, et al (2017); Produced by: VEIGA, A. J. P., *et al* (2022)

In the total rectangle of the study area (figure 6) it was identified the predominance of flat, smooth and undulated relief, formed by topographic surfaces little moved, by hills with gentle and moderate slopes, located above all, in the Mucugê Plateau and in the karstic pediplane. When analyzing the central area of the rectangle, it was possible to observe a greater expressiveness in the classes strong hilly, mountainous and steep, with the dominance of rugged and steep areas, consisting of surfaces with strong slope, steep slopes and busy topography, susceptible to weathering agents, located especially in the Serra do Sincorá and the Serra da Borda Ocidental.

In the cross-tabulation of topography data in the Geopark's polygonal (Table 2), it can be observed that the predominant values were the smooth and undulating relief, with 3-8% slope, corresponding to 2,104 km², making up the percentage of 34.62% of the area; then, the wavy relief, with an index of 8-20% slope, corresponding to 1,747 km² of the areas, whose percentage found was 28.74%. The flat relief, with slope ranging from 0-3% inclination, 1,247 km² were identified, with 20.52% of the area. The other classes, the strongly hilly with slope varying from 20-45%, and the mountainous with slope of 45-75%, and the steep relief, with slope above 75% slope, represented the sum of 980 km², making up the percentage of 16.11% in relation to the total area.

Table 2 - Serra do Sincorá Geopark: **Slopes** - 2022

Slope (%)	Relief	Area (km²)	Percentage (%)
0 - 3	Plan	1.247,84	20,52
3 - 8	Soft - Wavy	2.104,52	34,62
8 - 20	Wavy	1.747,47	28,74
20 - 45	Strong - Wavy	775,63	12,76
45 - 75	Hilly	158,83	2,60
> 75	Escarpado	45,80	0,75
Total		6080,09	100

Source: Data processed in SPRING; BONFIM, I.F. (2022)

In the analysis of the data of the exposure of the slopes of the relief of Serra do Sincorá Geopark (table 3, figure 7) it was possible to observe that the predominant orientation is in the NE direction with 32% of the areas, equivalent to 1,966.14 km²; the other slope orientations are with well distributed and close values. In SE orientation the value found was 1,439.06 km², with approximately 24%; in SW orientation 1,495.83 km² were identified, corresponding to 25%; and for the NW slope, the value was 1,183.20 km², in 19% of the areas in relation to the total polygonal.

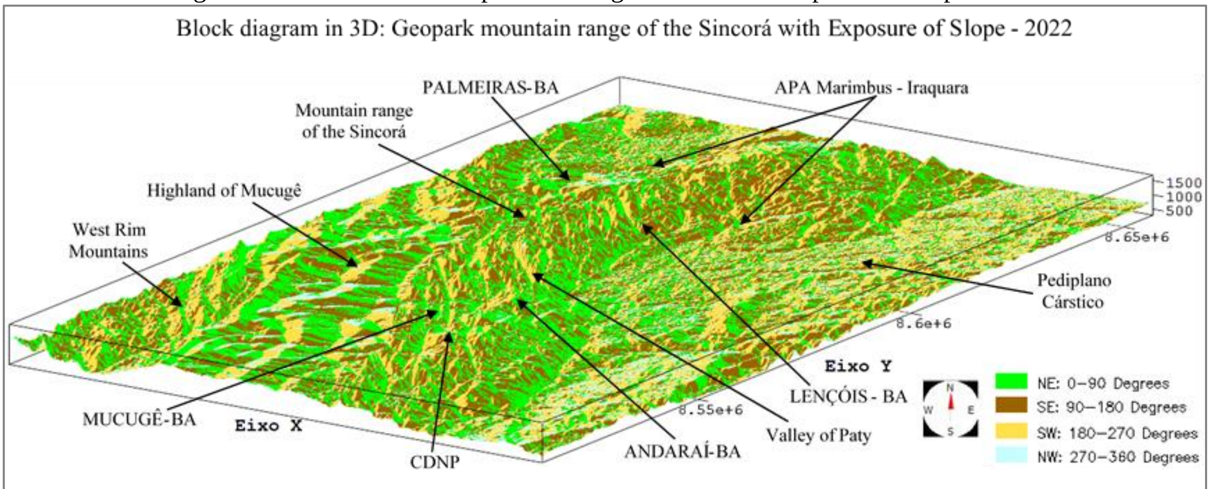
Table 3 - Serra do Sincorá Geopark: **slope exposure** - 2022

Guidance	Degrees	Area (km²)	Percentage (%)
NE	0 - 90	1966,14	32
IF	90 - 180	1439,06	24
SW	180 - 270	1495,83	25
NW	270 - 360	1183,20	19
Total		6084,23	100

Source: Data processed in SPRING; BONFIM, I. F. (2022)

The slope exposure is a measure of the azimuth of the expected direction of surface runoff, measured in degrees relative to geographic north. In areas with greater slope exposure, there is a gain in the energy balance, which can imply an increase in agricultural productivity, with greater photosynthetic activity performed by plants. Besides determining, along with slope, the direction of watersheds and runoff. For Florenzano (2008), the analysis of slope exposure has as main objective the distribution and planning of agricultural crops.

Figure 7: Serra do Sincora Geopark: 3D Diagram Block with Exposure of Slope - 2022



Source: USGS (2020); PEREIRA, et al (2017); Produced by: VEIGA, A. J. P., *et al* (2022)

The relief in Chapada Diamantina, where the Serra do Sincorá Geopark is located, can be explained by the tectonic inversion of the Sedimentary Basin in the Ediacaran (635-542 million years ago) that since 1 billion and 500 million years ago (Mesoproterozoic) accumulated sediments that formed the rocks present there. This inversion promotes a gentle deformation of the rocks by reactivation of pre-existing structures (GUIMARÃES, ALKMIM E CRUZ, 2012). According to these authors, reverse thrust faults directed NNW, which are reflected in the mountain range where the large homoclinal generated has a gentle slope to the east, and the scarps of the same represent its west face.

The geomorphological features found in the Serra do Sincorá Geopark were produced from the tectonic movement of elevation of the relief along the scarps, in a line where the fault zone of compressive nature is located; after this activity that caused the reversal of the movement until then distensive, the weathering and erosive processes acted preferentially on the areas with higher slopes and also on the less cohesive rocks, such as some sandstones little cemented at the base of the sedimentary package, i.e. the oldest rocks. These are located in the northwestern portion of the study area, close to the Guinea District in the direction of Palmeiras.

Another important component in the geomorphological features, and that determines the formation of the drainage network is related to the fractures resulting from the compressive tectonics, in two preferential directions as can be seen in the rivers and valleys, especially those at the top of the mountain, in the zone considered intangible, such as the Paty Valley.

The changes that have occurred throughout the geological history of the Chapada Diamantina and that have resulted in morphogenetic transformation processes, consisting of different landscapes, allow us to measure the importance of this region, with its geological and geomorphological formation, scenic beauty, and rich biodiversity and geodiversity.

In the study area located in the Chapada Diamantina, there are eight environmental protection areas, established by Federal, State and Municipal Laws. The creation of the Serra do Sincorá Geopark aims to further promote in the region, the preservation and conservation of geodiversity, geological and anthropological heritage, with the promotion of geoconservation and geotourism. For Schobbenhaus and Silva, (2012, p.13), "geotourism involves tourists observing natural landscapes, relief forms and rocks, as well as the processes that have shaped them over time."

The creation of the Serra do Sincorá Geopark in the territory of the Chapada Diamantina, adds to the concern with the preservation and conservation of geodiversity, with a set of strategies integrated with environmental education, boosting the economy of the region, with economic, environmental, cultural and social sustainability, added to society as a whole, for present and future generations.

4 FINAL CONSIDERATIONS

Based on the data analyzed in the Serra do Sincorá Geopark, it was observed that in its relief predominates the orientation of the slope in the NE direction with 32% of the areas in this class, and in the other orientations the values are close, ranging from 19 to 25%. The altitude range varied from 300 to 1300 meters, in 95% of the total area. The predominant topography was classified as flat, wavy and smooth-wavy, with a total of approximately 84%, while the relief strong-wavy, mountainous and steep, the indices found were 16% of the total area of the polygon.

Knowledge of the characteristics of the physical environment, geological, geomorphological and environmental aspects of the Chapada Diamantina, with its limits and potential, are essential for planning and management of the territory of the region, in a sustainable way, considering the carrying capacity and resilience of the system. Hence, the importance of analyzing the geographic elements present in these units and thus, measure its importance and the need to preserve it for current and future generations.

The results are expected to serve as subsidies to other researchers and technicians in planning and management, especially in the region where the creation of a Geopark is being proposed, such an important area in the Chapada Diamantina, with its natural resources, and with great ecotourism potential, boosting the economy of several municipalities in the region.

The studies of this nature serve to the unfolding of other research works, projects and actions in the region. To the Federal and State public agencies, as well as the Prefectures of the municipalities located in this area, private institutions and companies, it is expected to contribute to the development of public policies for the preservation and conservation of this region, especially the Geopark

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