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Inventory and geoconservation strategies for the southern agreste of Paraíba – Brazil

Inventariação e estratégias de geoconservação para o agreste meridional da Paraíba – Brasil

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Abstract: Inventorying is one of the most used tools in scientific productions allowing to identify physical and socio-cultural elements, thus being able to carry out geoconservation proposals in a given region. The work was developed in the Southern Agreste of the state of Paraíba due to the presence of local geodiversity that extends over an area of 274km², covering 5 municipalities: Natuba, Salgado de São Félix, Mogeiro, Ingá and Itatuba. The study territory is geologically inserted in the Salgadinho, Floresta and Sertânia complexes of Paleoproterozoic age and granitic intrusions of Neoproterozoic age. The main objective was to carry out an inventory of the geodiversity of the aforementioned area and the associated cultural and social aspects, proposing geoconservation strategies for the inventoried geosites and geodiversity sites. The methodology consisted of a bibliographical survey, field visit, selection of sites and inventory developed by SIGEP (Geological and Paleobiological Sites) and Progeo (European Association for the Conservation of Geological Heritage). 05 geosites and 04 geodiversity sites were inventoried, listing the geoscientific potential and the current socio-environmental discussions at each of them. It was identified that some of these sites have anthropic degradation, lack of demarcation of trails and information panels, in addition to low geoscientific knowledge by the local community. In this way, some geoconservation proposals were established so that the geoheritage of the studied region can be valued, even enabling geoeducation, geotouristic practices, dissemination of geosciences and management plans in view of the potential of regional geodiversity.

Keywords: Inventory; Geoconservation; Geoheritage.

Resumo: A Inventariação consiste numa das ferramentas mais utilizadas em produções científicas permitindo identificar elementos físicos e socioculturais, podendo assim realizar propostas de geoconservação numa determinada região. O trabalho foi desenvolvido no Agreste Meridional do estado da Paraíba devido a presença da geodiversidade local que se estende por uma área de 274km² abrangendo 5 municípios: Natuba, Salgado de São Félix, Mogeiro, Ingá e Itatuba. O território de estudo está inserido geologicamente nos complexos Salgadinho, Floresta e Sertânia de idade paleoproterozóica e intrusões graníticas de idade neoproterozóica. O objetivo principal foi realizar a inventariação da geodiversidade da área supracitada e dos aspectos culturais e sociais associados, propondo estratégias de geoconservação para os geossítios e sítios de geodiversidade inventariados. A metodologia constou de levantamento bibliográfico, visita de campo, seleção dos sítios e inventariação desenvolvidas pelo SIGEP (Sítios Geológicos e Paleobiológicos) e Progeo (Associação Européia para Conservação do Patrimônio geológico). Foram inventariados 05 geossítios e 04 sítios de geodiversidade, elencando o potencial geocientífico e as discussões socioambientais vigentes à cada um deles. Se identificou que alguns desses sítios possuem degradação antrópica, ausência de demarcação de trilhas e painéis informativos, além do baixo conhecimento geocientífico pela comunidade local. Dessa forma, foi estabelecido algumas propostas de geoconservação para que ocorra a valorização do geopatrimônio da região estudada, possibilitando até mesmo a geoeducação, práticas geoturísticas, divulgação das geociências e planos de manejo diante o potencial da geodiversidade regional.

Palavras-chave: Inventariação; Geoconservação; Geopatrimônio.

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1. Introduction

The study of geodiversity is a recent discussion that took on greater proportions at the end of the 20th century. It is considered essential in triggering geoscientific postulations. Gray (2004) points out that historically the term geodiversity was created in England to designate the abiotic environment, highlighting the geological, geomorphological, pedological and mineralogical aspects. Geodiversity consists of the existing terrestrial variety, namely: geological, geomorphological, pedological, water aspects, endogenous and exogenous processes, also adding anthropic relations in its formation process (KOZLOWSKI, 2004). Geodiversity is taken as the existing geological, geomorphological and pedological diversity, including its compositions, relationships, systems and interpretations (Pessoa et al, 2019).

Geodiversity corresponds to the variety of environments, geological phenomena and processes and other superficial aspects essential for life on Earth (STANLEY, 2000). Geodiversity elements correspond to soils, relief units, geological units, water resources (PEREIRA ET AL., 2013). But it is important to highlight that geodiversity goes beyond the intrinsic physiographic character, but can also involve sociocultural agents that directly or subjectively corroborate the existence of the elements present in the landscape. Geodiversity corresponds to a broader set of geological aspects included (SANTOS, 2016).

The Southern Agreste of Paraíba has geodiversity potential identified through its geological features and associated social and cultural aspects. Therefore, it became essential to carry out a geodiversity survey of the region through an inventory so that the existing geoheritage could be valued and thus establish geoconservation strategies. Geoheritage consists of the diversity of rocks, fossils, minerals and petrogenetic and geomorphological properties that result from climate and terrestrial forces (BROCX, SEMENIUK, 2007). Geoconservation corresponds to establishing strategies that enable geological conservation, as it has scientific, pedagogical, cultural and tourist value, among others (BRILHA, 2005). Therefore, geoconservation strategies in this region become essential as a final product, as they make it possible to minimize the anthropogenic impacts observed, disseminate geosciences, produce management plans, and promote educational and tourist practices.

5 municipalities were selected to list characteristics found in the region, the municipalities were: Natuba, Salgado de São Félix, Mogeiro, Ingá and Itatuba. In each municipality, sites were selected that outline local geodiversity and the importance of valuing geoheritage. 9 sites were inventoried based intrinsically on geological characteristics, namely: Pedra Pintada (Natuba-PB), Pedra do Bico (Salgado de São Félix-PB), Pedra do Navio (Salgado de São Félix-PB), Pedra da Base (Salgado de São Félix-PB), Poço do Sapateiro (Mogeiro-PB), Pedra do Ingá (Ingá-PB), Pedra dos Batentes I (Itatuba-PB), Pedra dos Batentes II (Itatuba-PB) and Pedra Lajes (Itatuba-PB) BP).

It should also be noted that the sites were defined in accordance with the proposal by Brilha (2015), in which those areas with greater scientific relevance are considered geosites, while sites with less scientific potential and which still have educational value are named as sites of geodiversity, separating them into geosites (G) and geodiversity sites (SG).

In order to catalog the present geodiversity, an inventory produced by SIGEP (Geological and Paleobiological Sites) and Progeo (European Association for the Conservation of Geological Heritage) was used. Inventory is the main tool to promote the identification, management and characterization of these areas, especially those that have superlative value. It is essential to present the physical, cultural and socioeconomic characteristics of the delimited region. Its diagnosis is carried out through summation methods that represent the value of a certain spatial segment. The Inventory enables qualitative and quantitative analyzes of elements present in the geological heritage (GUIMARÃES, 2016). In this way, it is the first step towards the development of a geoconservation strategy, proving to be an essential tool for identifying, selecting and characterizing the representative elements of geodiversity worthy of protection (LIMA, 2008).

Pereira (2010) highlights that the first Inventory proposal appeared in Great Britain in 1977, characterized by frameworks based on: paleontology, stratigraphy, geology and geomorphology. Pereira et al. (2006) presents geomorphological heritage in its Inventory proposal, separating it into framework categories. Lima (2008) states that an Inventory must take into account the theme, value, scale and use. García-Cortés & Urquí (2009) emphasize that an inventory must be based on geological units based on 12 areas of geology.

The choice to use the SIGEP Inventory (Geological and Paleobiological Sites) and Progeo (European Association for the Conservation of Geological Heritage) is because it has a geoscientific structure that is a global reference in the cataloging of areas presented in: geological framework, geomorphological, stratigraphic, hydrogeological interest, sedimentological, paleogeographic, aesthetic, historical, cultural, tourist, scientific; in addition to the local or regional area of influence. Through the inventory, it was possible to identify the need for geoconservation of these sites, as they have high geoscientific and geoheritage potential. Santos (2016) highlights that geoconservation proposes the sustainable use and management of geodiversity, highlighting elements that have high geoscientific value. Therefore, it is finally proposed

to demarcate trails, information panels, booklets, guide training, collaborative maps and dissemination of geosciences, as a support for the results identified in the inventory and essential to local geoconservation.

2. Characterization of the study area

The geology of the study area is characterized by the occurrence of the Salgadinho, Floresta and Sertânia Complexes; of Paleoproterozoic age, and the Dona Inês intrusive suite of Neoproterozoic age, which intrudes into the Floresta Complex (Figure 1). The Salgadinho complex is located on Folha Surubim (SB.25-Y-C-IV) scale 1:100,000 (Neves, et al., 2017) in the states of Paraíba and Pernambuco, in the eastern portion of the Transversal Zone Domain, located between the Patos and Pernambuco shear zones, Borborema Province, Northeast Brazil. The orthogneisses present in the area are similar from a petrographic, textural and chemical point of view (Santos, 1995; Brito Neves et al., 2001; Neves et al., 2006).

According to Bezerra (2018), the Floresta complex consists of gneiss with a granitic to dioritic composition, gray color and fine to medium grain, with easy mafic, monzogranitic composition and locally mylonitized. In contrast to Paleoproterozoic age claims, Lima et al. (1985) (apud Santos, 1995) define it as a set of metaplutonic rocks of intermediate to basic composition and Archean age. Santos (2012) also reinforces that the Floresta Complex has a compositional gneiss band, with complex folded structures and migmatitization, also presenting intrafolial folds. The Dona Inês intrusive suite, of Neoproterozoic age, intrudes into the Floresta complex and consists of small bodies of leucogranites and monzogranites, equigranular or microporphyritic, with medium to fine texture. They are essentially made up of plagioclase (oligoclase), microcline and quartz, with biotite as the main mafic mineral (GUIMARÃES, ET AL., 2008).

The Sertânia complex is composed of schists and paragneisses with the occurrence of marble, quartzite and calciosilicate rocks. It represents the metasedimentary domain corresponding to an association of schists and paragneisses with two micas, garnet and sillimanite, with a rare volcanic contribution in the study area. The rocks of this complex can still be migmatized, presenting stromatic, folded and nebulitic structures. The main mineral association is composed of quartz + plagioclase + potassium feldspar + biotite + muscovite + sillimanite (SANTOS, 2012).

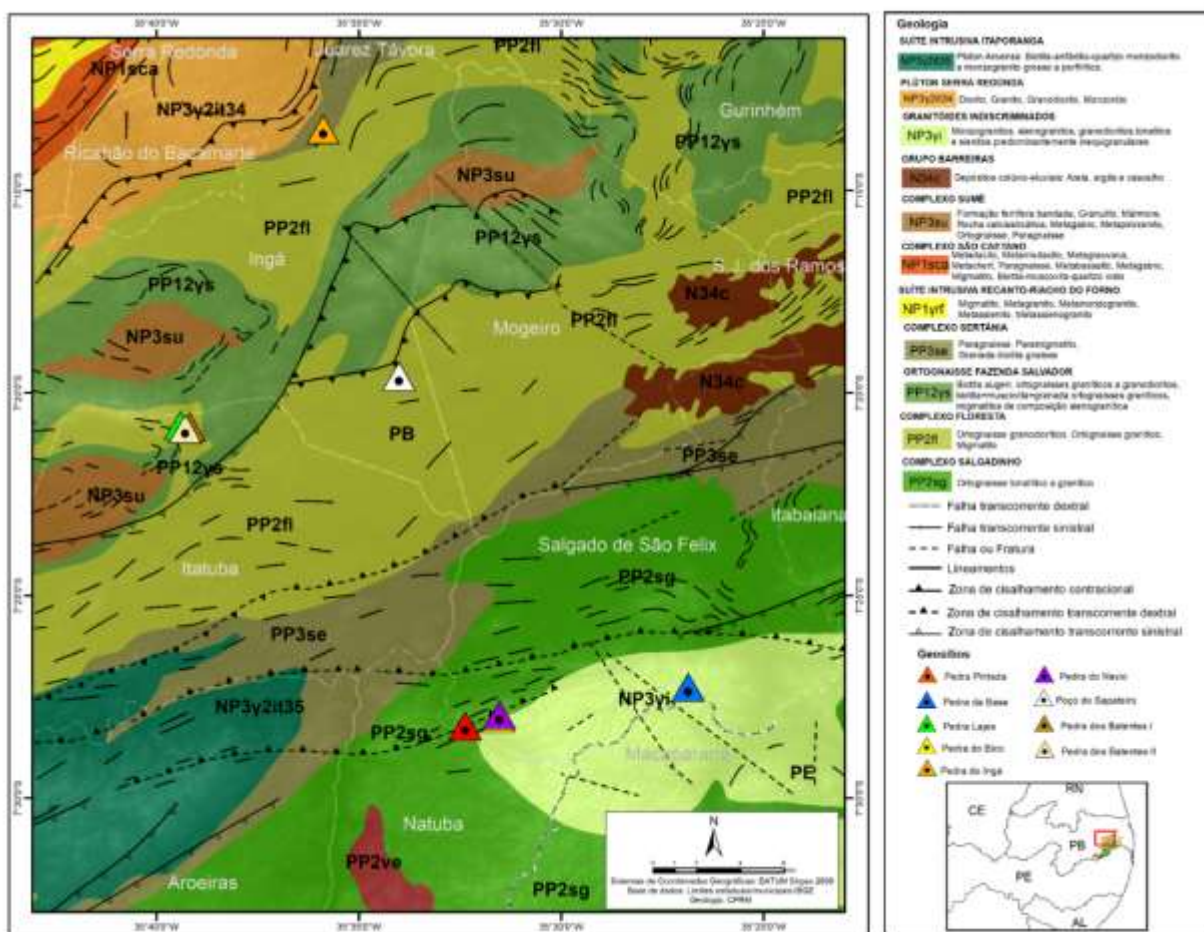


Figure 1 – Map of the local geology of the municipalities with the sites inventoried in the delimited section. Source: Authors (2021). Based on the geological sheets of Sapé (Guimarães, et al., 2017), Campina Grande (Rodrigues, et al., 2011), Limoeiro (Barbosa, 1990) and Surubim (Neves, et al., 2017), on a scale of 1 : 100,000.

3. Methodology

The present work is supported by research stages that culminated in the results and perspectives expected after scientific practices, using exploratory research and case study with the Southern Agreste of the state of Paraíba as its locus. It consists of research with a methodological approach that is divided into stages, namely: bibliographical survey, inventory using the ProGEO (European Association for the Conservation of Geological Heritage) form, analysis of the Inventory form using the methodology of Brilha (2015), in which geosites are considered to be those areas with the greatest scientific relevance; and geodiversity sites those that involve other related characteristics, separating them into geosites (G) and geodiversity sites (SG). After the final result of the inventory, it was possible to propose geoconservation strategies (Figure 2).



Figure 2 – Methodological steps of the research Source: Authors (2021).

The bibliographic survey involved digital resources, such as national and international repositories, museums, library libraries, articles and academic productions where the time frame of searches was based on literary productions from the mid-1990s to 2020.

Fieldwork favored the selection of geosites and geodiversity sites (BRILHA, 2015), considering the locus of greatest geodiversity predominance that would enable the dissemination of geosciences and identifying the needs for geoconservation practices. 3 field stages were carried out, with technical visits in October 2019, September 2020 and December 2020, where after initial analyses, georeferencing, photographic records, geoprocessing, inventory sheets were used for each cataloged site.

The inventory was carried out using the Inventory form proposed by PROGeo and IGME (Mining Geological Institute of Spain) which supports the characterization of sites and inference with the area worked, based on consultation of bibliographical references and relatively more important spaces. The choice of model is based on the premise that it is one of the worldwide disseminated inventories used in Brazil, with the CPRM (Brazilian Geological Survey) as a highlight. The form contains essential information for surveying local geodiversity, such as: geographic coordinates, altitude, geological description, geomorphological, stratigraphic, sedimentological, aesthetic, historical, cultural, tourist, scientific interest (low, medium, high); in addition to accessibility, vulnerability, ownership and need for conservation. After the inventory, it is possible to define that geosites are not highlighted by scientific bias while geodiversity sites address similar criteria (BRILHA, 2015).

Finally, geoconservation strategies, based on the results prepared in the inventory. In this way, techniques and proposals were made for each geosite and geodiversity site so that geological heritage can be valued, enabling geotouristic practices and the development of geoeducation. Geotourism is presented as a link with ecotourism (Piekarz and Liccardo, 2007). However, it is important to highlight that the physiographic and sociocultural aspects of the territory are taken into account. Geoeducation allows understanding between the anthropic relationship and the abiotic environment, regardless of its scale (GUIMARÃES, 2016). Given this, geoconservation measures are based on geoeducation and geoconservation techniques designed and developed by the authors, in which we highlight: applications, educational games, collaborative maps, non-formal education, management, dissemination of geosciences, interpretive panels.

4. Result and discussion

After carrying out an inventory based on the methodology proposed by Brilha (2015), he identified 4 geodiversity sites and 5 geosites, namely: Pedra Pintada (G1), Pedra do Bico (G2), Pedra do Navio (G3), Pedra da Base (SG1), Poço do Sapateiro (SG2), Pedra do Ingá (G4), Pedra dos Batentes I (SG3), Pedra dos Batentes II (SG4) and Pedra Lajes (G5) (FIGUEREDO, 2021)

Pedra Pintada (G1) consists of a geosite composed of orthogneisses inserted in the Salgadinho Complex, with the presence of leucosomes being notable and may resemble granite dikes. The great highlight of this geosite is the cave paintings that are unique in the region and are extremely important in terms of scientific and didactic content (Figure 3).



Figure 3 – Pedra Pintada Geosite (G1). (A) Cave painting with fauna features on the rock. (B) Dimension scale of rock figures with faunal features on the rock. (C) Fine to medium grain visible in the rock. (D) Pegmatite dike present in the rock.

Source: Authors (2020).

Pedra do Bico (G2) is located in the Pirauá district and consists of Neoproterozoic granite that intrudes into the Salgadinho Complex. This geosite also stands out for presenting differential erosion giving rise to grooves and the occurrence of lichens in the monzogranitic features. Another major highlight of this site is the cultural character of the area, with religious activities that encourage the flow of visitors to the area as well as economic movement in the region around the belief in Saint Anthony (Figure 4). It is a site of great tourist activity with direct impacts on the conservation status of the area, which has already been significantly degraded and impacted by human actions.



Figure 4 – Pedra do Bico Geosite (G2). Granite, syenogranitic to granodioritic composition, consisting of microcline, plagioclase, quartz, amphibole, biotite. (A) View of Pedra do Bico and its whitish color. (B) Chapel built in Pedra do Bico in reference to the region's beliefs. (C) Fine to medium grained rock. (D) Panoramic view of the geomorphological domain with valley and seas of hills.

Source: Authors (2020).

Pedra do Navio (G3) also located in the district of Pirauá, inserted in the Salgadinho Complex and is close to Pedra do Bico (G2). It is commonly named this way due to the shape that the outcrop has, resembling a ship. It has a gray to pinkish color, fine to medium grain, with minerals visible to the naked eye. However, the differential erosion in this rock is more visible, giving rise to grooves and “cacimbas”, a popular term to designate excavations in crystalline rocks as a result of chemical weathering. It also has the presence of visible lichens in the monzogranitic features, enabling the resilience of wild botanical species (Figure 5). It stands out for having a privileged view of cities in the countryside of Paraíba as well as the geomorphological features of the countryside in contrast to the local humid forest domain. Based on this characteristic, it was classified as a viewpoint geosite based on the characterization in frameworks (FUERTES-GUTIÉRREZ & FERNÁNDEZ- MARTÍNEZ, 2010) which defines according to the size of these sites, namely: points, sections, viewpoints, area and complex area.

Pedra da Base (SG1) located in the district of Boa Vista and belonging to the indiscrimido granitoids (Neves, 1996) composed of metamorphic rocks and amphibolitic gneisses. The site presents lithological similarities with other geosites with visible minerals as well as the presence of differential erosion that allowed “cacimbas” in the rock. However, the great highlight of this geodiversity site is its historical value, as it has a military base installed during the Second World War, where at the top of the outcrop there is still a landmark (Figure 6).

Campos (1999) states that there was a fear that they would invade the Northeast from Dakar or the Azores archipelago, so it was necessary to create strategies to protect this coastline, which led to the construction of base facilities to carry out this inspection. One of these bases corresponds to this site previously unknown to several people, but with its identification initials in the testimony, which leads to the name of the outcrop “Pedra da Base”.



Figure 5 – Pedra do Navio Geosite (G3). Granite, syenogranitic to granodioritic composition, consisting of microcline, plagioclase, quartz, amphibole, biotite. (A) Visible grooves in the rock resulting from differential erosion. (B) ‘Cacimbas’ present in the outcrop as a consequence of differential erosion. (C) Fine to medium grains visible in the rock, along with the pink color, characteristic of the Salgadinho Complex. (D) Agrestina botany in the rocky outcrop of G3.

Source: Authors (2020).



Figure 6 – Pedra da Base geodiversity site (SG1). (A) Scale of the military base landmark from the Second World War. (B) View of the Base Stone (SG1). (C) Testimony of the geographic North used by the military base during the Second World War. (D) Panoramic view of Pedra da Base for the local geomorphological domains and surrounding cities.

Source: Authors (2020).

Poço do Sapateiro (SG2) is located on the border between the municipalities of Mogeiro and Ingá in a section called Acaraí. Inserted in the Floresta Complex, it follows the lithological features in terms of migmatized gneisses with small outcrops and it is also possible to find portions with a yellowish color. This site is located on the Ingá River, a watercourse of extreme influence in the region and it is possible to find rock engravings known as: Itacoatiras; thus being the first inventory point in the Floresta complex. The engravings were made by perforating and could represent the daily lives of these populations with beliefs, people, hunting and animals of the time. It is also worth mentioning that this site has a low altitude, being 120m, a fact resulting from being inserted in the river channel of the Ingá River, which consequently has its course geomorphologically lower than the surrounding areas, such as the river terraces (Figure 7).



Figure 7 – Poço do Sapateiro Geodiversity Site (SG3). (A) Ingá River where the site is located presents features resulting from river erosion with the formation of giant marmites. (B) Dotted perforation found in Poço do Sapateiro. (C) Itacoatira of probable human representation found on the panel at Poço do Sapateiro. (D) Marks of water depths found in waterholes on the Ingá River showing local water influence.

Source: Authors (2020).

Pedra do Ingá (G4) is located in a granitic body of the Dona Inês type present in the Campina Grande sheet intruding into the Floresta Complex, characterized by small bodies of leucogranites and monzogranites, equigranular or microporphyritic, with medium to fine texture and xenoliths of the enclosures. Unlike the aforementioned geosite, Pedra do Ingá consists of the most widespread outcrop among the geofoms of the Southern Agreste of Paraíba. Also located on the bed of the Ingá River, it has a topography of 128 m considered low because it is geomorphologically located along the river course. Its size is larger and it presents various engravings of the Itacoatiras type in an excellent state of visualization and understanding. It has greater scientific, cultural and historical relevance, and its engravings, as usual, are believed to correspond to the daily life experienced by these indigenous populations, being grouped and dispersed capsules, zoomorphs, cosmogonic and anthropomorphs (Figure 8).

This geosite within the research meets practically all the requirements adopted in Brilha's (2015) quantification methodology, having: security, accessibility, prepared guides (still few), museum containing megafauna fossils, geoproducs, international dissemination and appreciation within the municipality itself, thus placing it as unanimous within the research.

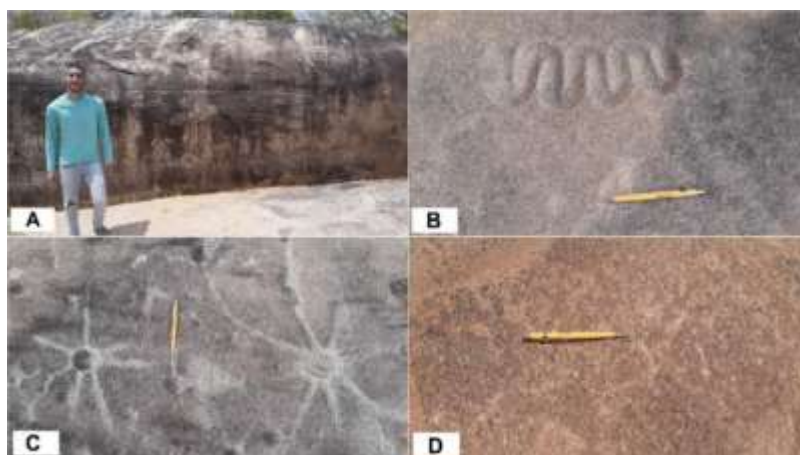


Figure 8 – Pedra do Ingá Geosite (G4). (A) Pedra do Ingá as a reference in the background. (B) Probable zoomorph representation in Pedra do Ingá. (C) Cosmogenic engravings representing stars at the Pedra do Ingá geosite. (D) Small leucocratic outcrop with yellowish color, fine to medium grained.
Source: Authors (2020).

Pedra dos Batentes I (SG3) was also classified as a geodiversity site due to its lower degree of scientific dissemination. However, it presents other abiotic, cultural and archaeological characteristics. It is inserted in the Floresta complex with small outcrops, locally migmatized granite orthogneiss. It has an easily accessible location and due to the low topography of the space, it is possible to observe the typical wild vegetation in the pedological steps of the slopes (Figure 9). It also contains a sign along the way informing the path to be followed to Pedra dos Batentes and Pedra Lajes.

Pedra dos Batentes II (SG4), classified as a geodiversity site, also belongs to the Floresta Complex with small outcrops, granite orthogneiss and migmatite. Pedra dos Batentes is located in the intermittent bed of the Surrão River, a tributary of the Ingá River, at an altitude of 129 m. Because the river is intermittent, it has periods of flow when rainfall occurs in the region and periods of drought, making it possible to view the engravings engraved on them. Also produced by perforation, it has capsular, zoomorphic, cosmogenic and anthropomorphic aspects (Figure 10).

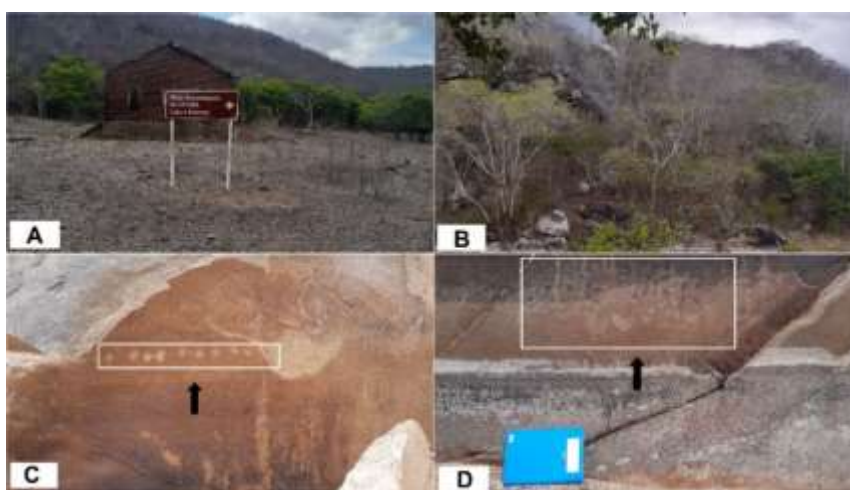


Figure 9 – Pedra dos Batentes I (SG3) (A) Information sign indicating the route to the archaeological sites Pedra dos Batentes and Pedra Lajes. (B) Characteristic wild vegetation, possible to be observed due to local topographic conditions. (C) Punching at Pedra dos Batentes I in a small outcrop of medium to fine equigranular granite. (D) Punching at Pedra dos Batentes I, along with a record of water depths during the flood period of the Surrão River.
Source: Authors (2020).

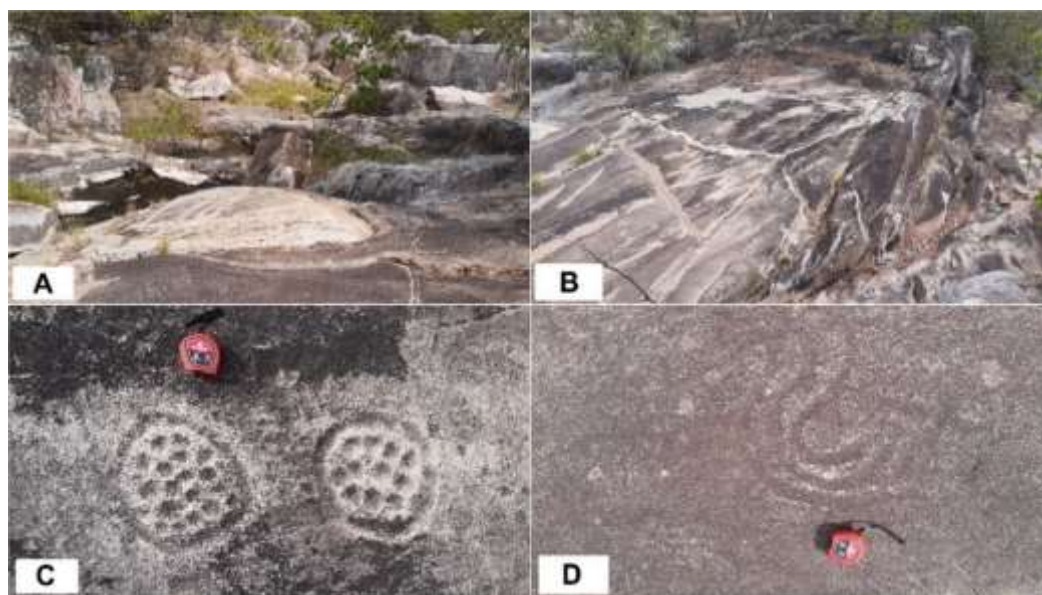


Figure 10 – Pedra dos Batentes II (SG4) (A) Surrão River in its intermittent bed. (B) Pedra dos Batentes II with no sharpness of the engravings due to river action. (C) Hammering at Pedra dos Batentes II. (D) Hammering at Pedra dos Batentes II.

Source: Authors (2020).

Like the other geoforms, the Pedra Lajes geosite (G5) is also inserted in the Floresta Complex with small outcrops, locally migmatized granite orthogneiss. The name Lajes comes from being contained in a slab and is 100m long, privately owned and 268m above sea level. The engravings found at this site correspond to: capsular, zoomorphic and cosmogonic (Figure 11).

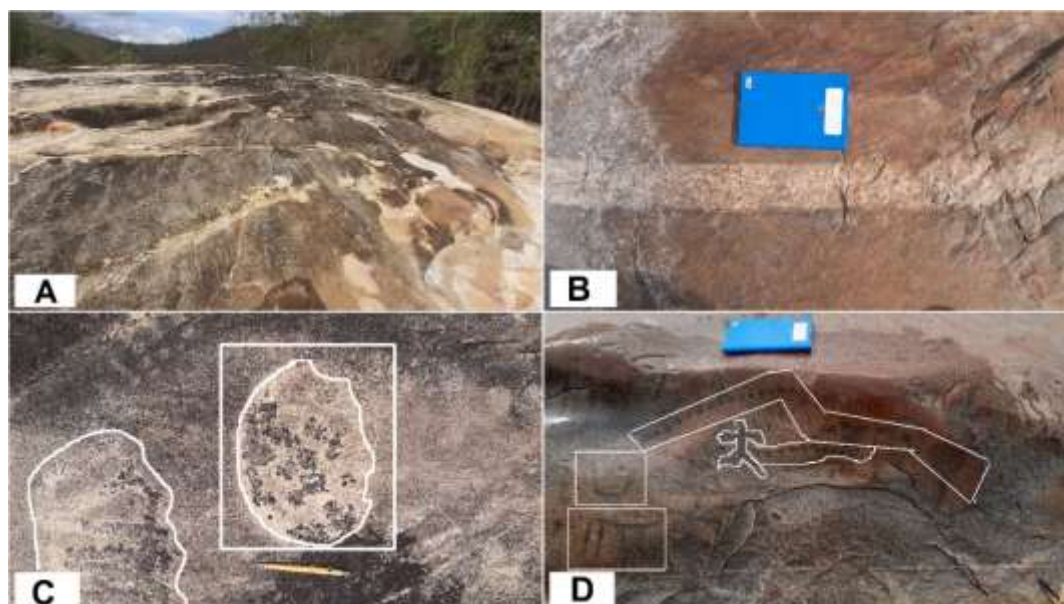


Figure 11 – Lajes Geosite (G5) (A) Main panel of the Lajes Geosite. (B) Pegmatite dike present in the peraluminous rocks of the Lajes geosite. (C) Cosmogenic aspects evidenced at the Lajes geosite. (D) Punching near anthropomorphic engravings at the Lajes geosite.

Source: Authors (2020).

4.1 Geoconservation strategies for inventoried geosites and geodiversity sites

Given the established bibliographical research, technical visits and inventory, it was realized that it is essential to establish management measures that are appropriate to geoscientific and environmental principles so that the local geoheritage can remain preserved. It was also identified that there are no studies on carrying capacity or forecast of infrastructure necessary for visitation, which increases the risk of degradation of geodiversity elements present in the region. In this way, through the geoconservation proposals presented by this work, it will be possible to encourage local society to protect geoheritage, as well as encourage visitation through the practice of geotourism.

Through the survey carried out, the need for training guides was identified so that they could instigate visits. Furthermore, there is no ready-made script and it is just another proposal listed by the research. Therefore, management plans are necessary so that balance, appreciation and dissemination of local geosciences can be established, in addition to the possibility of reducing anthropogenic impacts reported at each inventoried site.

As a result of the inventory, it is noted that Pedra Pintada (G1), Pedra do Bico (G2), Pedra do Navio (G3), Pedra da Base (SG1), Poço do Sapateiro (SG2), Pedra dos Batentes I (SG3), Pedra dos Batentes II (SG4) and Pedra Lajes (G5), require some geoconservation strategies. (Figure 12).

1. Demarcation of trails;
2. Information panels for visitors;
3. Informative booklets;
4. Training of guides;
5. Dissemination of local geoscientific importance through techniques such as: applications, geoeeducational games, collaborative maps and non-formal education; as a mechanism for valuing the wealth of elements present in the area.

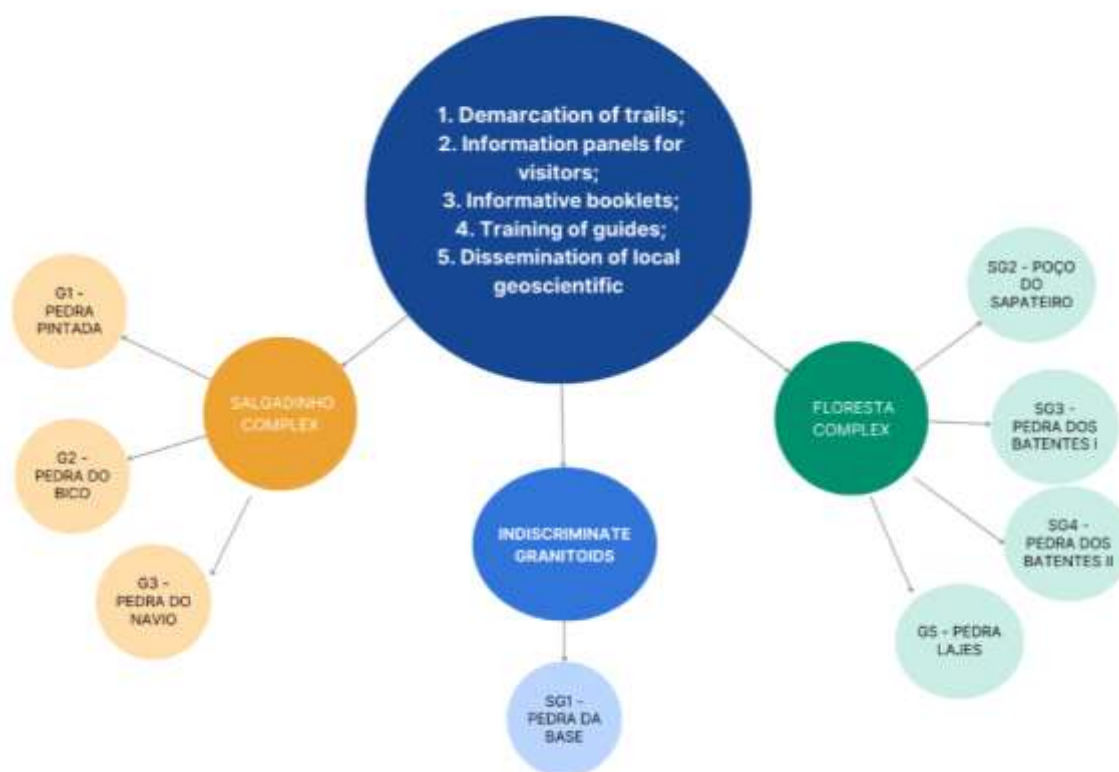


Figure 12 – Systematization table with geoconservation strategies and information on local geodiversity. Source: Authors (2023).



Figure 13 – (A) Pedra Pintada, showing difficulty in access and the need for structural works (G1). (B) Base of Pedra do Bico (G2) with graffiti in violation of geoheritage, a fact resulting from easy access to the site and lack of visitation control. (C) Access to Pedra do Navio (G3), with lack of security and poor infrastructure. (D) Easy access to Pedra da Base (SG1) due to its location on the banks of the municipal road.

Source: Authors (2020).

Of the inventoried sites, the only one that establishes good geoconservation conditions is Pedra do Ingá (G4), as this geosite presents dissemination of geosciences, appreciation of geoheritage, guided trails, informative booklets, local security, geoproducts and a museum for visitation. G4 only needs to train more guides, as they serve a larger audience and are considered a geosite of national relevance due to all the aforementioned infrastructure. (Figure 14) In this way, G4 becomes a reference for other sites in the region, aiming for adequate management in other geosites and geodiversity sites.



Figure 14 – Security and Accessibility at Pedra do Ingá (G4), offering visitors good conditions for getting to know the place.

Source: Authors (2020).

Geoeducation and the dissemination of geosciences are decisive requirements for the valorization of geoheritage and are consequently a strong agent that favors the principles of geoconservation. In this way, it is possible to work transversally with educational management proposals such as games and other techniques, and on top of that, develop the valorization of geoheritage as an essential mechanism for geoconservational balance.

Furthermore, demarcated trails emerge as a possibility for non-formal education, being capable of practicing geoconservation, as one of the techniques that support the reduction of the risk of degradation in inventoried sites based on the recognition of the geoscientific importance of each geosite and geodiversity site. Marked trails can occur in both complex area I and complex area II. In complex area I, it begins at the Pedra Pintada geosite (G1), passing through Pedra do Bico (G2), Pedra do Navio (G3) and Pedra da Base (SG1); covering 20km, lasting 4 hours and also using a car (Figure 15).



Figure 15 – Marked trail in complex area I
Source: Authors (2021).



Figure 16 – (A) Trail towards Pedra do Bico (G2). (B) Tank found on the trail towards Pedra do Bico (G2). (C) Facheiro, characteristic of the caatinga vegetation. (D) Drone image of Pedra do Navio (G3).
Source: Authors (2021).

It is important to highlight that this trail proposal is guided by local professionals who know the territory and intend to present it to the community that wants to visit it. Therefore, there is no pre-established trail with security and appropriate infrastructure to receive visitors, which makes the process of promoting local geoheritage difficult. The pioneering spirit of this research makes it possible to discuss and organize strategies that can present to the regional community the physiographic aspects of high potential that exist in this territory.

One of the ways to publicize geodiversity is the use of informative booklets that, in a didactic way, outline the importance of the elements present there. The technique for disseminating geological heritage can use associative elements, digital and printed resources and even the region's own biotic and abiotic characteristics. It is a tool that reaches the most varied audiences and allows you to present the potential of a given area and thus begin geotourism practice.

Based on the information collected, another proposal for disseminating geosciences for this work is an informative booklet produced in an educational way, which used the geological heritage and all the geodiversity of the region with the use of a mascot with a name associating the local biodiversity. . To mention, the Fachinho, in reference to the facheiro, a common species in the caatinga vegetation; as well as the representative image of Mocó (*Kerodon rupestres*), a faunal species that predominates in the region (Figure 17).

The geoconservation proposals and strategies presented can benefit local public entities, teaching and research institutions; as well as the regional community so that one of the objectives can be achieved, which is the dissemination of geosciences, reaching ideal levels of geoconservation. Work such as that developed in this territory, although pioneering, allows geoscientific discussion and encourages more productions that identify the geodiversity of places, value geoheritage, carry out inventory practices and propose geoconservation strategies so that appreciation can be established in this way. of the identified elements.



Figure 17 – Example of an informative booklet to publicize the geoscientific potential of the southern countryside of Paraíba

Source: Authors (2021).

5. Final considerations

The search carried out through previous work and the inventory through field visits enabled the necessary characterization using the ProGEO and Instituto Geológico Mineiro form. Therefore, geodiversity elements could be identified, cataloged and defined as geosites and geodiversity sites, in addition to geologically understanding the aspects of the inventoried areas, namely: Salgadinho, Floresta and Sertânia complex; as well as indiscriminate granitoids and the intrusive Dona Inês suite.

It is important to emphasize that, as these data become public, they can be used for geotourism and geoconservation purposes through secretariats and even geopark projects in this region. However, it is necessary to invest in accessibility measures, legal protection, dissemination of geosciences and marketing so that the geoheritage of the Agreste Meridional da Paraíba can be used appropriately as mentioned above in this research through geoconservation proposals.

In this way, it is expected that the results achieved in the work will reach society in general, disseminating geosciences and also the geodiversity potential of the Southern Agreste of Paraíba. It is also hoped that the ideals of geoconservation become present from this work, enabling the appreciation of the dynamism present in this region. In this sense, the presence of academic institutions that can increasingly carry out surveys regarding local potential appears necessary, as this is the first academic inventory work carried out in the region.

Research like this helps in the academic process and becomes essential in the social, environmental and economic spheres, where management plans, geoconservation strategies, geoeducation and even geotourism practices can be carried out. In addition to stimulating the production of inventory and conservation strategies in the academic sphere, thus developing more geoscientific knowledge, disseminating and valuing the potential of regional geoheritages.

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ANEXX – INVENTORY FORM MODEL

DESCRIPTION SHEET MODEL FOR GEOSITES INVENTORY			
Adapted from models developed and applied by ProGEO (European Association for the Conservation of Geological Heritage) and IGME (Mining Geological Institute of Spain)			
Sduty area			
Geosite		Code	
A – GEOGRAPHIC LOCATION			
County		Distrito	-
Dimension of geosite	<input type="checkbox"/> Point <input type="checkbox"/> Section <input type="checkbox"/> Area <input type="checkbox"/> Complex area <input type="checkbox"/> Lookout		
Coordinates UTM		Altitude	
Topographic map (1/25 000)		Geological chart (1:500.000)	
B – GEOLOGICAL FRAMEWORK			
Geological domain	<input type="checkbox"/> Plutonic <input type="checkbox"/> Volcanic <input type="checkbox"/> Metamorphic <input type="checkbox"/> Sedimentary		
Brief geological description			
C - INTERESTS			
Content and Interests (B – Low; M – Medium; A – High)			
Geomorphological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Mineralogical	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Stratigraphic	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Tectonic	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Hydrogeological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Petrological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Sedimentological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Paleontological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Paleogeographic	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Miner	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Aesthetic	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Ecological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Historic	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Archaeological	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A
Cultural	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A	Others	
Usage Capacity (B – Low; M – Medium; A – High)			
Tourist	<input type="checkbox"/> B <input type="checkbox"/> M <input checked="" type="checkbox"/> A	Didactic	<input type="checkbox"/> B <input type="checkbox"/> M <input type="checkbox"/> A

