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Cultural Ecosystem Services of Geodiversity in the Inselberg Fields of São Rafael - RN

Serviços Ecossistêmicos Culturais da Geodiversidade no Campo de Inselbergues de São Rafael - RN

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Abstract: This study analyzes the cultural ecosystem services provided by geodiversity in the Inselberg Field of São Rafael, Rio Grande do Norte, Brazil, emphasizing the role of granitic rock formations in the construction of local identity, spirituality, and collective memory. A mixed-methods approach was adopted, combining theoretical research, fieldwork, and the application of the methodological framework proposed by Araújo, Diniz, and Souza (2024). Data were collected from four inselbergs (Lágea Formosa, Serra Branca, Serra do Desterro, and Serra da Pindoba) where cultural benefits such as diversity, spiritual values, education, aesthetic appreciation, artistic inspiration, sense of place, and recreation were identified. The results indicate that, beyond their high scientific and geological value, inselbergs are fundamental elements in shaping the cultural and natural heritage of the region. Among the analyzed sites, Serra do Desterro stood out as the most relevant, with eleven CES identified. However, anthropogenic pressures threatening the conservation of these formations were observed, particularly mineral exploitation and the presence of solid waste in the study area. The study proposes geoconservation strategies, including environmental education, regulation of ecotourism, and training of local guides, aiming to enhance the appreciation and preservation of geopatrimony and to strengthen the relationship between society and nature.

Keywords: Environmental Services; Geoheritage; Cultural Identity; Geotourism; Geoconservation.

Resumo: O presente trabalho analisa os serviços ecossistêmicos culturais proporcionados pela geodiversidade no Campo de Inselbergues de São Rafael – RN, destacando o papel dessas formações rochosas graníticas na construção da identidade, espiritualidade e memória coletiva da comunidade local. Utilizando uma metodologia mista, com base teórica, visitas de campo e aplicação da ficha metodológica de Araújo, Diniz e Souza (2024), o estudo coletou dados em quatro inselbergues (Lágea Formosa, Serra Branca, Serra do Desterro e Serra da Pindoba) onde identificou-se benefícios culturais como diversidade, valores espirituais, educação, estética, inspiração artística, sentido de lugar e recreação. Os resultados demonstram que os inselbergues, além do seu rico geopatrimônio, são elementos fundamentais na configuração do patrimônio cultural e natural da região. Entre os locais estudados, a Serra do Desterro apresentou maior relevância em todos os aspectos analisados, sendo identificados 11 SEC. No entanto, foram identificadas pressões antrópicas que ameaçam a conservação dessas formações, especialmente pela exploração mineral e resíduos encontrados na área de estudo. O estudo propõe estratégias de geoconservação, como educação ambiental, regulamentação do ecoturismo e capacitação de condutores locais, visando a valorização e preservação do geopatrimônio e o fortalecimento da relação entre sociedade e natureza.

Palavras-chave: Serviços Ambientais; Geopatrimônio; Identidade Cultural; Geoturismo; Geoconservação.

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1. Introduction

Inselbergs are large rocky masses with steep slopes, whose shapes combine concave and convex curves, standing out individually or in groups within areas worn down by erosion (MIGOŃ, 2006). The term inselberg, meaning "island hill" refers to isolated rocky outcrops with steep gradients and varying elevations that rise prominently above the surrounding lowered surfaces, representing peculiar landforms of granitic rocks and/or rocks associated with igneous basement formations (MIGOŃ, 2006; MAIA; NASCIMENTO, 2018; BASTOS *et al*., 2022).

Common in tropical and subtropical regions, as well as in semi-arid and arid environments, their formation is associated with long-term landscape leveling cycles throughout geological time (BÜDEL, 1957; MILLOT, 1977). Among the main theories regarding their genesis and evolution, the concept of etchplanation proposed by Julius Büdel (1957) stands out, explaining the exhumation of granitic bodies after long periods of relative tectonic stability under semi-humid climatic conditions favorable to the development of planation surfaces (MIGOŃ, 2006; MAIA; NASCIMENTO, 2018).

In the northern portion of Northeastern Brazil, these landforms are notable for their landscape impact and scientific relevance, as they record the geomorphological evolution of the crystalline basement and display differential resistance to weathering and erosion, contributing to the understanding of the dynamic evolution of the landscape (MATMON *et al*., 2013; MAIA et al., 2015; MAIA; NASCIMENTO, 2018). In the state of Rio Grande do Norte, these outcrops occur within the Superfície Sertaneja (Diniz *et al*., 2017), with special emphasis on the São Rafael Inselberg Field, which presents an expressive landscape mosaic (ARAÚJO; OLIVEIRA; DINIZ, 2025).

These structures constitute a remarkable testimony of geodiversity, understood as the variety of abiotic elements and processes of the planet (GRAY, 2013; CLAUDINO-SALES, 2018; 2021; 2025), which hold scientific, cultural, and scenic values, but are currently under pressure from different human activities, reinforcing the need for geoconservation actions (GRAY, 2005; NASCIMENTO; MANSUR; MOREIRA, 2015).

In this context, some of these elements may be recognized as geoheritage when they present scientific, educational, cultural, or aesthetic relevance, thus justifying their conservation and sustainable use (BRILHA, 2005; GRAY, 2013). The valorization of this heritage may occur through different strategies, among which geotourism stands out, understood as a modality focused on the appreciation and interpretation of geodiversity, contributing to environmental awareness and local development (NASCIMENTO; MANSUR; MOREIRA, 2015).

Geodiversity provides a wide range of ecosystem services, including abiotic services classified into provisioning, regulating, supporting, and cultural services (GRAY, 2011; GRAY; GORDON; BROWN, 2013). Among these categories, cultural ecosystem services are especially relevant, as they are associated with aesthetic, symbolic, spiritual, recreational, and educational values (MA, 2003; GRAY; GORDON; BROWN, 2013). In the São Rafael Inselberg Field, these services are strongly predominant and directly influence the identity, sense of belonging, and well-being of local communities (SOUZA *et al*., 2025). Therefore, this study aims to analyze the cultural ecosystem services provided by geodiversity in this area, identifying strategies for valorization and geoconservation in the face of environmental and social pressures.

2. Materials and methods

2.1 Study area

The study area is composed of four inselbergs located within the Inselberg Field in the eastern portion of the municipality of São Rafael, Immediate Geographic Region of Açu, State of Rio Grande do Norte, eastern sector of the Borborema Province. These granitic monoliths rise above the flattened topography of the Superfície Sertaneja. Among these residual landforms, the following inselbergs stand out: Lágea Formosa, Serra Branca, Serra do Desterro, and Serra da Pindoba (Fig. 1). It is noteworthy that some local residents identify the eastern side as Serra Branca, while the western side is referred to as Serra do Jatobá.

Figure 1 – Spatial Distribution of the São Rafael Inselberg Field.
Source: Authors (2025).

These landforms reach elevations ranging from 150 to 400 meters above sea level, generating a significant scenic impact. In terms of spatial distribution, the municipal center is located approximately 10 km from the main cluster of inselbergs, while Serra da Pindoba, which contains the highest elevations, lies about 12 km away. Regarding the proximity between the massifs, variations can be observed: the inselbergs of Serra Branca and Serra do Desterro are practically contiguous, separated by only 68 meters, which may indicate a possible shared geological origin; in contrast, the distance between Serra do Desterro and Serra da Pindoba is more substantial, reaching approximately 5 km. Measurements were obtained using the ruler tool in Google Earth software.

According to Diniz *et al.* (2017), with nomenclature adapted to CEN/SBCR (2022), the study area, located in the municipality of São Rafael (RN), is part of the morphostructural unit of the Brasiliano Orogenic Belt, the morphosculptural unit *Superfície Sertaneja*, and the morphosculptural subunits "Piranhas–Açu Interplanaltic Surface" and "Inselbergs and Inselberg Field," as indicated in the geomorphological map (Fig. 2). The *Superfície Sertaneja* unit is characterized by extensive flattened areas developed over crystalline rocks of the Precambrian basement, resulting from long denudational processes under structural control. These surfaces reflect phases of relative tectonic stability associated with the intense action of chemical and physical weathering under wetter paleoclimatic conditions, later reworked by the present semi-arid climate, which gives the relief gently undulating forms and low topographic dissection (AB'SABER, 2003; ROSS, 1992).

In this context, the inselbergs of the *Superfície Sertaneja* stand out, being associated with structural discontinuities (fractures and faults) present in the area (ARAÚJO; OLIVEIRA; DINIZ, 2025). These granitic landforms result from the differential resistance of rocks to weathering and erosion and are common in the Northeastern Brazilian semi-arid region (TWIDALE, 2002; DINIZ *et al*., 2017). Furthermore, the Piranhas–Açu Interplanaltic Surface highlights the role of fluvial processes in landscape shaping, intensified by the dynamics of the Piranhas–Açu River and by the presence of the Engenheiro Armando Ribeiro Gonçalves Dam, which alters local drainage patterns and sedimentary processes.

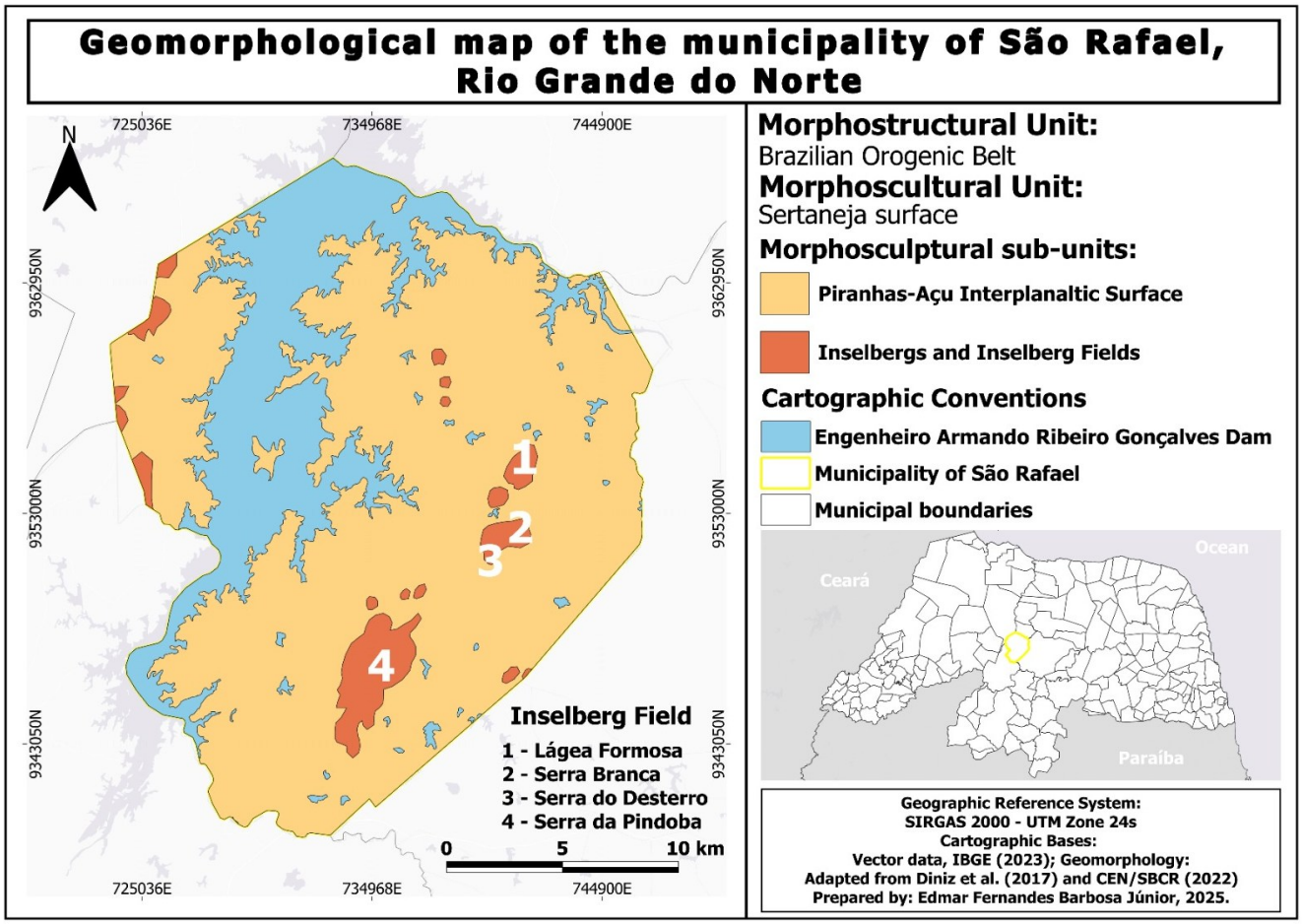

Figure 2 – Geomorphological Map of the Municipality of São Rafael.
Source: Authors (2025).

From a geological perspective, according to Dantas, Medeiros, and Cavalcante (2021), the study area presents a lithological framework predominantly composed of granitic rocks associated with the Itaporanga Intrusive Suite (where the Lágea Formosa, Serra Branca, and Serra do Desterro inselbergs occur) and with the Undifferentiated Brasiliano Granitoids (in the Serra da Pindoba area) (Fig. 3).

These igneous bodies, highly resistant to weathering, constitute the lithological base of the local inselbergs, favoring their persistence as prominent features in the sertanejo landscape due to their greater mechanical strength compared to the surrounding lithologies. Thus, the local geology plays a determining role in the genesis, distribution, and preservation of these landforms, reinforcing the importance of understanding the regional geological structure in order to properly interpret landscape dynamics (DANTAS; MEDEIROS; CAVALCANTE, 2021).

The climate of the area is Tropical Semi-arid, characterized by an annual dry season lasting approximately 7 to 8 months (DINIZ; PEREIRA, 2015). According to data from EMPARN (2025), the municipality's average rainfall over the last 30 years is 750 mm, concentrated mainly during the rainy season between March and June. This strong climatic seasonality is clearly reflected in the landscape, allowing observation of the same location under contrasting dry and rainy periods, which reinforces the influence of climate on the environmental dynamics of the area.

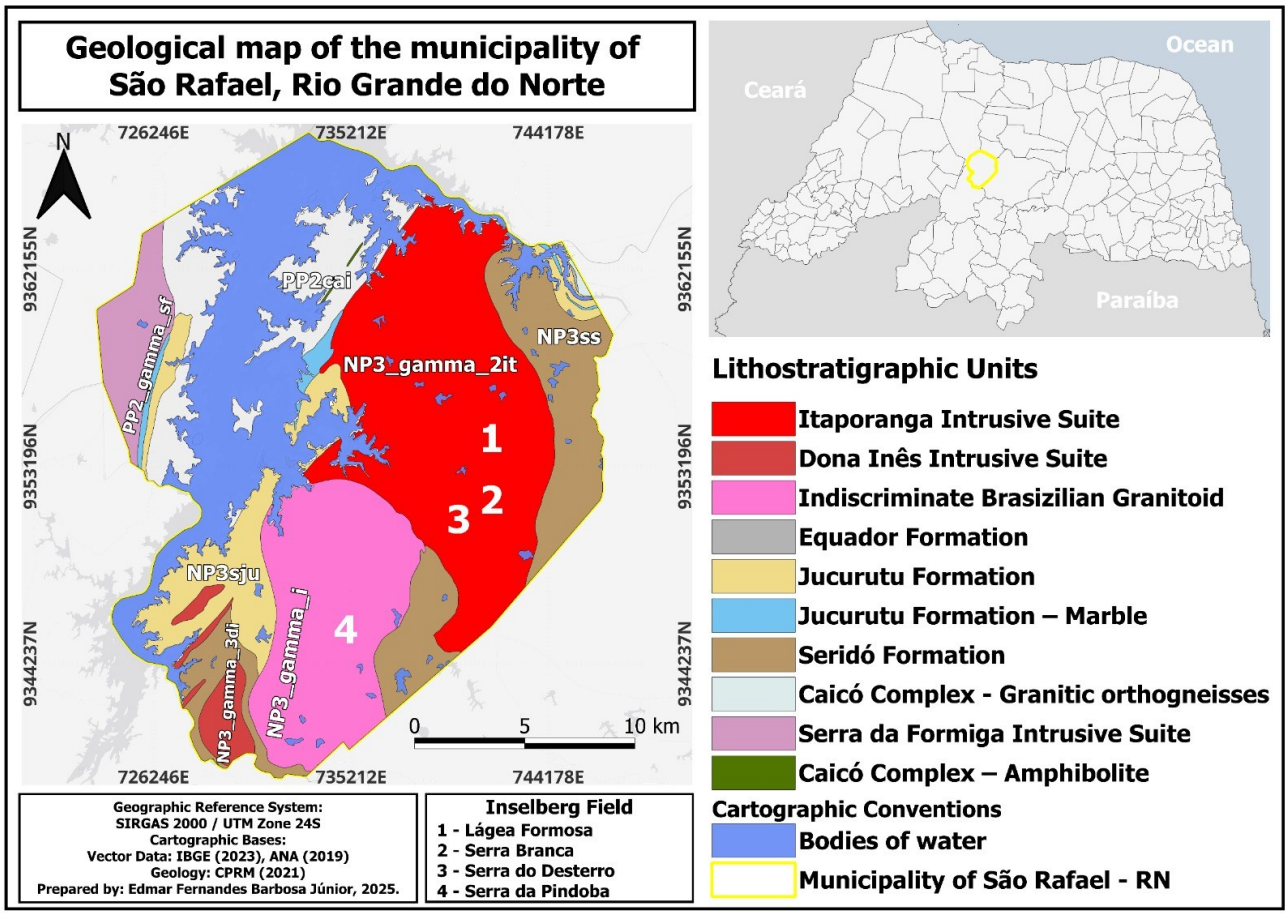

Figure 3 – Geological Map of the Municipality of São Rafael.
Source: Authors (2025).

In this context, the inselbergs play a fundamental role in the organization of the local landscape, since their exposed rocky morphology responds directly to semi-arid climatic conditions. The alternation between long dry periods and concentrated rainfall favors physical weathering processes, such as thermoclasty, and surface runoff, contributing to relief dissection and the formation of shallow soils in their surroundings. According to Santos, Costa and Guedes (2022), the predominant soils in the study area are Neosols and Luvisols. According to IBGE (2015), Neosols are shallow soils, formed by mineral or organic material with less than 30 cm in thickness, whereas Luvisols have moderate depth and a reasonable differentiation between surface and subsurface horizons.

2.2 Methodological Procedures

The research adopted a mixed methodological approach, with an exploratory and descriptive character, integrating qualitative and quantitative methods to analyze the cultural ecosystem services associated with geodiversity in the São Rafael/RN inselberg field. In the qualitative scope, interpretative analyses were carried out based on bibliographic and cartographic surveys in databases such as SciELO, CAPES Journals, and Google Scholar, using keywords such as "ecosystem services," "cultural ecosystem services," "inselbergs," "São Rafael - RN," and "cultural heritage." In addition, an exploratory investigation was conducted on digital media, with emphasis on Instagram and Facebook (Meta Platforms), due to their wide use and the higher incidence of georeferenced and image-based content, aiming to identify perceptions, representations, and forms of sociocultural valorization of the landscape by society.

Technical field visits enabled direct observation of the landscape and the identification of the cultural and symbolic

uses of the inselbergs, applying the methodological framework proposed by Araújo, Diniz, and Souza (2024) for the assessment of ecosystem services associated with geodiversity. Fieldwork covered the Lágea Formosa, Serra Branca, Serra do Desterro, and Serra da Pindoba inselbergs, with records obtained through systematic notes and aerial images captured by an Unmanned Aerial Vehicle (UAV).

The analysis of ecosystem services integrated qualitative and quantitative procedures: in the qualitative dimension, cultural ecosystem services were identified, described, and categorized, considering their uses, symbolic meanings, and forms of appropriation by the local community; in the quantitative dimension, the occurrence of these services was counted, distributed into 11 types and classified as "Direct," "Indirect," and "Absent," allowing the evaluation of their relative representativeness among the different inselbergs. The results were organized in tables, described, and represented through image mosaics derived from field activities and digital media, relating the identified services to their spatial distribution and contributing to strategies for the valorization and conservation of these environments.

The spatial characterization of the study area was carried out through the preparation of geomorphological and geological maps at a scale of 1:500,000 using QGIS 3.36 software, based on data from Diniz *et al*. (2017) and the Geological Survey of Brazil (DANTAS; MEDEIROS; CAVALCANTE, 2021).

3 Results and Discussion

3.1. Identification of Cultural Ecosystem Services

This study presents the benefits classified within the category of cultural ecosystem services associated with the municipality's inselbergs, specifically Lágea Formosa, Serra Branca, Serra do Desterro, and Serra da Pindoba. Table 1 systematizes the provision of these benefits, indicating their direct occurrence, indirect occurrence, or absence, as well as the respective areas.

The analysis of cultural ecosystem services in the study area reveals the predominance of direct services in all analyzed areas, although with significant variations. Serra do Desterro stands out in the identification of cultural ecosystem services, presenting 11 direct services, with no occurrence of indirect or absent services, which reinforces its high cultural functionality.

Table 1 - Assessment Table of Cultural Ecosystem Services in the São Rafael-RN Inselberg Field.

Cultural Ecosystem Services	São Rafael Inselberg Field (RN)			
	Lágea Formosa	Serra Branca	Serra do Desterro	Serra da Pindoba
3.1 Cultural diversity	D	D	D	A
3.2 Spiritual and religious values and cultural meanings	A	A	D	A
3.3 Knowledge systems	D	D	D	D
3.4 Education	D	D	D	D
3.5 Artistic inspiration	D	D	D	I
3.6 Aesthetics	D	D	D	D
3.7 Social relationships	D	D	D	D
3.8 Sense of place	D	D	D	D
3.9 Cultural heritage and geoheritage	D	D	D	D
3.10 Environmental quality	D	D	D	D
3.11 Nature-based recreation and tourism	D	D	D	D

Legend: D = Direct, I = Indirect e A = Absent.
Source: Authors (2025).

Lágea Formosa records 10 direct services and only 1 absent service, with no indirect services, likewise demonstrating a high degree of cultural functionality. Similarly, Serra Branca presents 10 direct services and 1 absent service; as in the previous inselberg, this absence is related to the lack of provision of the benefit associated with religiosity, although the site demonstrates a balanced dynamic between practical uses and symbolic representations. Finally, Serra da Pindoba gathers 8 direct services, 1 indirect service, and 2 absent services, combining immediate experiences with mediated perceptions.

Cultural diversity (3.1) reflects the richness of symbolic, historical, and social relationships built by the local population around this unique landscape. The inselbergs function as identity landmarks that influence traditional practices, religious manifestations, oral histories, and particular ways of perceiving and using the territory. This continuous interaction between the physical environment and social groups favors the emergence of multiple cultural expressions, ranging from recreational and educational activities to rituals and traditional knowledge associated with nature. Thus, the area stands out as a space of multiscalar influence where culture thrives, diversifies, and renews itself, strengthening the sense of belonging and the appreciation of the intangible heritage of the people of São Rafael.

The diagnosis based on field data and digital media indicates that the inselbergs also play a relevant role for the local religious community, configuring themselves as sacred spaces of faith with symbolic and spiritual references (3.2). In Serra do Desterro specifically, symbols, religious rituals, and devotional cultural manifestations were observed, such as the Cross and the Sanctuary installed at the summit of this inselberg and linked to the Catholic religion, expressed through pilgrimages for the celebration of masses and prayers associated with Our Lady of the Conception, patron saint of the city, at the Cruzeiro do Desterro (Fig. 4, image 2).

Figure 4 – Serra do Desterro Inselberg as a Sacred Space of Faith and Devotion.
Fonte: Images via Instagram from the following profiles: 1 and 3 da Prefeitura Municipal de São Rafael. 4 Paróquia de Nossa Senhora da Conceição, and 2, acervo dos autores, 2025.

In addition to its strong symbolic and religious significance, Serra do Desterro presents conditions favorable for access and climbing practice, contributing to its appropriation by different audiences. The site has an identification sign and trail markers along the route, especially in the sections with greater circulation during pilgrimages, which helps guide visitors and reinforces the sense of safety. The access trail is relatively well-defined and easy to identify, with rocky outcrops that allow progression without the need for advanced climbing techniques, making the route more accessible both for worshippers and practitioners of recreational activities.

It should be noted that, among the four analyzed inselbergs, Serra do Desterro presents the lowest degree of difficulty, while the others require higher levels of effort. This greater accessibility broadens its use as a space for religious, recreational, and contemplative experiences, strengthening its relevance as a natural and cultural heritage site of the municipality. In the inselbergs of Lágea Formosa, Serra Branca, and Serra da Pindoba, such spiritual value practices were classified as absent. This absence is related to access limitations resulting from the presence of very difficult and unstable

sections with loose rocks, which restrict ascent by individuals unfamiliar with rugged terrain.

The categories of knowledge systems (3.3) and education (3.4) presented direct provision in the four analyzed areas. The systematization of the collected data indicated the frequent use of the hills for educational and research activities, with field classes conducted by teachers and students from schools and universities interested in exploring the region, which stands out for its history, geodiversity, and biodiversity (Fig. 5).

Figure 5 – Inselbergs: Open-Air Laboratories of Geodiversity.
Fonte: Images via Instagram from the profiles: 1 Colégio Imaculada Conceição, 5 Escola Estadual Professora Claudeci Pinheiro Torres, 2 Visite São Rafael – RN, and images 3, 4 and 6 Authors' archive, 2025.

The studied area is therefore consolidated as an important space for scientific investigation and academic knowledge production, being used for data collection that supports the preparation of scientific articles, such as those by Carvalho (1966), Oliveira (1973), Santos and Guedes (2019), Araújo et al. (2024), Souza et al. (2025), Araújo, Oliveira and Diniz (2025), and the municipal atlas by Santos, Costa and Guedes (2023). The study field has also hosted undergraduate theses, such as those by Peixoto (2019), Ferreira (2022), and Lima (2023), master's dissertations, such as Amaral (2000) and Ferreira (2025), as well as undergraduate research projects such as School Atlas of the Municipality of São Rafael (RN), Survey of Caatinga Vegetation in the Inselberg Fields of São Rafael/RN, and Geoenvironmental Compartmentalization of the Municipality of São Rafael/RN, promoted by the Department of Geography of State University of Rio Grande do Norte (UERN)/CAA/Assú-Brazil, in addition to extension courses such as Environmental Protection of Underground Natural Cavities, carried out in partnership with Federal University of Rio Grande do Norte (UFRN) and the Câmara Cascudo Museum.

Although the data indicate direct provision in the four analyzed areas, an exploratory survey on the main digital media platforms, Facebook and Instagram, shows that Lágea Formosa stands out in all aspects, whether in research or field classes. In this site and in Serra da Pindoba, geodiversity has favored the development of a highly diversified phytogeography; the altitude, the forms of the outcrops, and the existence of different pedological portions over these rocky formations have enabled the development of varied species of the Caatinga biome (LIMA, 2023). These are important biodiversity refuges, in contrast with the advance of degraded areas over the flatter portions of the relief corresponding to the *Depressão Sertaneja* (PEREIRA NETO; SILVA, 2012).

The presence of visible and accessible geological elements gives the site notable potential for environmental and geographical education, allowing geodiversity itself to be used as a rich pedagogical tool. This finding reinforces the role of inselbergs as open-air natural laboratories, where students and researchers in contact with nature can observe and

establish associations with the theoretical content studied, thereby promoting integration between science, education, community, and conservation. This integration is not merely a pedagogical proposal, but something fundamental for dealing consciously and ethically with global problems that influence our existence and the future of Earth (AULER, 2011).

Field research also revealed that the studied area possesses elements that characterize it as a geosite. Araújo et al. (2024) evaluated Lágea Formosa as having high scientific, geological, aesthetic, cultural, and educational potential, whose characteristics allow the narration of the history and evolution of that environment over thousands of years. In the 1970s, an important paleontological discovery occurred on the granitic slabs near Lágea Formosa (Fig. 6). In these rocks, which contain tanks and natural pools sculpted by weathering, Oliveira (1973) identified fossils of Pleistocene megafauna preserved in sandy-clayey or conglomeratic sediments. Among the specimens found, the giant sloth, mastodon, giant armadillo, giant horse, and saber-toothed tiger stand out.

Figure 6 – Surroundings of Lágea Formosa (Images 1, 3, and 4), Natural Tank at Lágea Formosa (Image 2), Area Where Megafauna Fossils and Rock Inscriptions Were Found at Pedra Ferrada (Images 5, 6, 7, and 8). Source: Authors (2025).

In addition, rock inscriptions attributed to the Janduís Indigenous people and ancient structures were identified, which were also verified during fieldwork and are documented in the works of the local historian and poet popularly known as Professor Djalmir (Costa, 2020). In his poetic narratives, the author details the events surrounding the disappearance and later reemergence of São Rafael in a new geographical location. His writing addresses conflicts and discoveries that recover and disseminate the history of his community.

Regarding cultural ecosystem services, the categories of artistic inspiration (3.5) and aesthetics (3.6) presented direct provision in three of the four analyzed areas. The exception was Serra da Pindoba, classified in item (3.5) as indirect provision due to the insufficiency of records available for analysis. Although it is the most imposing, due to its greater extension and altitude, it was the least highlighted in these aspects by the local community. Even so, Serra da Pindoba presents significant aesthetic potential associated with pareidolia, since the natural forms of the granitic outcrops evoke symbolic images perceived by observers, conferring visual singularity to the landscape.

Pareidolia is a psychological and perceptual phenomenon in which the human brain identifies familiar shapes, faces, animals, or objects in random visual stimuli, such as clouds, rocks, shadows, or natural landforms (QUEIROZ et al., 2025). This interpretation occurs due to the cognitive tendency of the brain to recognize known patterns in the environment, even when these were not intentionally formed. In Serra da Pindoba, a peculiar rock formation known as Cabeço do Oratório stands out (Fig. 7), which, according to observers' perceptions, may be interpreted as the figure of a person with hands joined in prayer, as well as associated with animals such as a turtle or a camel, depending on the

symbolic and cultural reference of the observer. This phenomenon enhances the cultural value of the inselberg by stimulating subjective interpretations and symbolic bonds with the environment, indicating that, although still little recognized locally, the area possesses relevant aesthetic attributes that deserve greater appreciation and further investigation in future studies.

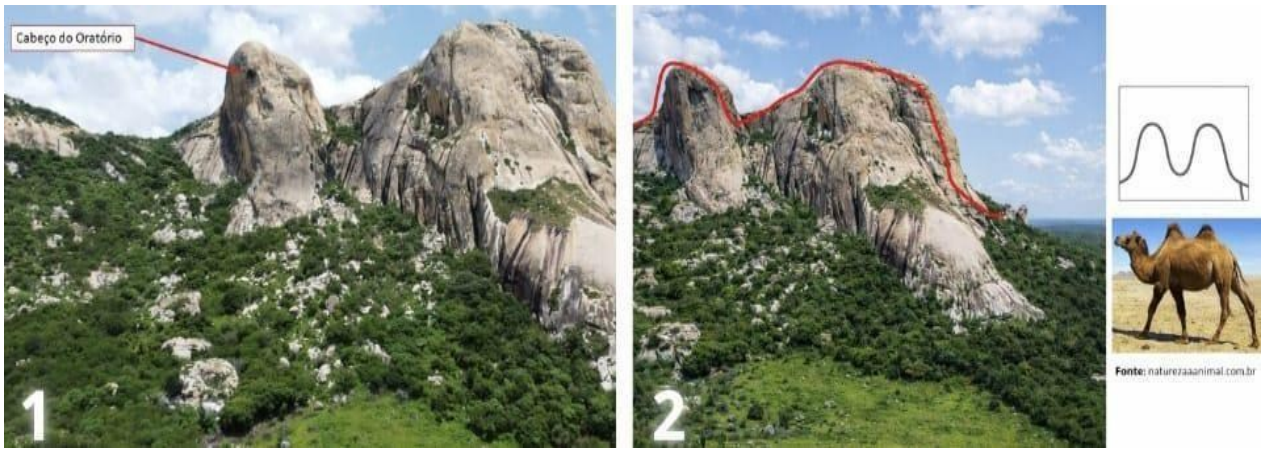

Figure 7 – Cabeço do Oratório in Serra da Pindoba, with Its Aesthetics and Pareidolia.
Source: Authors (2025).

The landscape of the study field is marked by imposing rock formations, panoramic views, and a strong contrast with the surrounding *sertaneja surface*, which evokes a sense of identity, belonging, and admiration. Due to its symbolic value for local history, this scenic grandeur is constantly reinterpreted, becoming a source of artistic inspiration for photographs, paintings, comic illustrations, book covers, and decorative artworks displayed in the city council building and in numerous residences (Fig. 8).

However, this appreciation and affection for the place extends far beyond the municipal boundaries. It is a living sentiment that transcends territorial barriers, revealing the emotional and cultural connections maintained by people even when they are geographically distant from their place of origin. Such attachment demonstrates that the symbolic value of the inselbergs is not restricted to the local scale, but also resonates in broader social and spatial contexts through memory, identity, and cultural representation.

An example of this broader reach can be seen in Figure 8, image 3, which shows a painting of Serra da Pindoba displayed in an art exhibition at Osceola Arts, located in Kissimmee, Florida. The artwork was exhibited and offered for sale during the celebration of Hispanic Heritage Month in September 2023. Its presence in an international cultural event highlights how the landscape of São Rafael can circulate beyond Brazil, becoming a visual and emotional reference in other countries. This case illustrates how cultural ecosystem services linked to landscape aesthetics and identity may project local heritage onto transnational spaces, strengthening ties between diaspora communities, artistic expression, and collective memory.

Figure 8 – Influence of the Inselbergs on Artistic and Cultural Representations.
Fonte: Images via Facebook and Instagram from the following profiles: 1 Prefeitura Municipal de São Rafael and Santos, Costa e Guedes (2023), 2, 5, 6, 7 and 8 Wanderline Freitas - local visual artist, 3 Professional photographerJb_segundo and 4 Visual artist Jaraujo.arte.

Sporadic leisure and social interaction practices in the hills, such as hiking, picnics, and stargazing, were shown to be directly associated with the strengthening of social relations (3.7) (Fig. 9). Carried out mostly by young people, these activities serve as a form of recreation and mental relief from the overload of work and study. In this way, such uses not only benefit individuals, but also reinforce the community dimension of the inselbergs, strengthening social bonds and the cultural values shared by the group.

Figure 9 – Nature-Based Practices for Strengthening Social Relations.
Source: Authors (2025).

Although all analyzed inselbergs present geomorphological, scenic, and cultural relevance, observations and experiences with the local community indicate that Lágea Formosa stands out as the most important formation for the local population. It is an integral part of the stories and memories of those who once stopped to contemplate it or allowed themselves to climb it, feeling, with a mixture of enjoyment and admiration, the strength and attachment inspired by this "granitic giant."

Sense of place (3.8), classified as a direct provision, is manifested through the affective and symbolic relationship built between the local population, visitors, and practitioners of outdoor activities with these landscapes. These environments are perceived as fundamental references of collective memory, associated with experiences, stories, and meanings that contribute to the consolidation of local identity and to the feeling of belonging to the territory.

In this sense, the results obtained demonstrate that these spaces are not limited to the condition of geological features, but play a relevant role as cultural and landscape landmarks. They influence the way the territory is recognized, valued, and socially appropriated, reinforcing the importance of integrated planning and geoconservation approaches that consider, in addition to physical attributes, the symbolic and cultural values attributed by society.

Among the identifications associated with the cultural ecosystem service of "Sense of Place," Fazenda Lágea Formosa stands out (Fig. 10, image 1). The property, acquired in 1901 by Baron Felipe and Baroness Belízaria of Serra Branca, inherited its name from the inselberg that dominates its landscape, becoming its most expressive geographical landmark. The symbolic relevance of this rock formation transcends the boundaries of the farm, being adopted as an identity element in the coat of arms of the State School Professor Claudeci Pinheiro Torres, where its stylized outline represents a bond of belonging and local representativeness.

Figure 10 – Affective Relationships and Local Representativeness.
Source: Images via Instagram profiles Images: 1 and 3 Acervo dos autores, 2 Escola Estadual Professora Claudeci Pinheiro Torres, 4 Em busca de Aventura., 2025.

Another singular and representative aspect of the site is the production and commercialization of *Nosso Mel* ("Our Honey"), which uses the image of the Serra Branca inselberg as a symbolic brand, highlighting the integration between geodiversity and local identity. The honey is produced by an association of beekeepers who live in the community of the same name. The population's affective relationship with the landscape is also expressed through symbolic practices, such as marriage proposals held at the summit of Lágea Formosa, revealing the cultural and emotional dimension attributed to this space. Cultural heritage and geoheritage (3.9) were identified as direct provisions in all analyzed areas, with recurring emphasis on Lágea Formosa, which presents a singular appreciation by the local community.

This empirical recognition is supported by the qualitative geodiversity assessment of Lágea Formosa carried out by Araújo *et al*. (2024), which considered its scientific, cultural, aesthetic, and educational values. The results reinforce the understanding of these granitic formations as heritage elements of high relevance that transcend their strictly geological function and become landmark references in the landscape. Thus, they influence local experiences and the construction of collective memory, being perceived as symbols of identity and belonging and, by visitors, as points of connection between history and nature, constituting a basis for the development of geotourism and for the preservation of the memory of the place.

Among the long-standing relationships between humans and the natural environment, the presence of stone fences was identified on top of Lágea Formosa and in surrounding areas (Fig. 11). Through State Law No. 12,156 of 2025, stone fences are officially recognized as Historical, Cultural, Tourist, Scenic, and Architectural Heritage of the State of Rio Grande do Norte, as a way of valuing the cultural heritage of fences built with carefully stacked granite blocks, which were used to delimit property boundaries and contain free-range cattle (ALRN, 2024; RIO GRANDE DO NORTE, 2025a).

Figure 11 – Lágea Formosa (Images 1, 2, and 4) and Territorial Landmarks Formed by Stone Fences (Image 3).
Source: Authors (2025).

These constructions, beyond their practical use and importance, help us understand and recover fragments of local history. They are territorial landmarks that allow recognition of the wisdom and ancestral efforts of a resilient and hardworking people who, despite the difficulties of their time, did not see them as limiting factors in achieving their goals.

Environmental quality (3.10) and nature-based recreation (3.11) were also classified as direct provisions in all areas. The landscape diversity of these environments favors the provision of ecosystem services, which are perceived and enjoyed by the population through various recreational activities identified in the survey conducted on digital media. Among them, hiking, cycling (such as the Pedal Rota das Águas organized this year by the Municipal Sports Department), rappelling, excursions, and intermunicipal tourism were observed, in addition to camping and scenic viewpoints, all used to promote leisure and nature tourism (Fig. 12).

Figure 12 – Nature-Based Recreational Practices.
Source: Images retrieved via Instagram profiles: 1, 5, 8, 9, 10, and 11 Em Busca de Aventura. 3 and 6 Trilheiros do interior. 4 Equipe de ciclistas canela cheia. 2 and 7 Authors' archive, 2025.

The practice of recreational and contemplative activities plays a fundamental role in reestablishing the bond between humans and the natural environment. Throughout these experiences, especially when overcoming the challenges of an ascent or when faced with the grandeur of the landscape, direct contact often provokes profound reflections. Human beings, in their limited condition, frequently tend to consider themselves superior; however, before the immensity of nature, they are invited to recognize their own smallness and the fragility of life in the face of the magnitude of the landscape.

This reconciliation not only enriches the subjective experience, but also generates tangible benefits, promoting a considerable improvement in the physical and mental health of individuals. Beyond individual gains, such activities also represent an opportunity to foster sustainable tourism, integrating contemplation, self-knowledge, and local development.

3.2. Threats to the Conservation of Inselbergs and Measures for Geoconservation

Human activities constitute the main threats to the integrity of the inselbergs in the municipality of São Rafael/RN, with direct implications for the maintenance of ecosystem services associated with geodiversity. Among these pressures, irregular disposal of solid waste (Fig. 13) and, above all, granite extraction stand out, as they promote significant changes in the structure and functionality of these environments.

Figure 13 – Accumulation of Solid Waste in the Surroundings of Serra Branca.
Source: Authors (2025).

Although economically relevant, mining activity has advanced over the inselbergs, resulting in the degradation of landforms, the suppression of the natural landscape, and the deterioration of unique habitats. The degradation caused by this activity represents a direct risk to natural heritage and goes beyond the material dimension, as it also compromises cultural identity, since these formations constitute symbolic references and spaces of historical significance for populations that maintain long-standing ties and memories with them.

Field observations reveal the occurrence of extractive activities aimed at the production of paving blocks, crushed stone, and ornamental coverings in the surroundings of Serra Branca and Serra do Desterro (Fig. 14), associated with predominantly informal productive dynamics. According to local residents, granite from São Rafael supplies several municipalities in the region, such as Jucurutu, Itajá, Assú, Mossoró, Florânia, and São Vicente, highlighting its economic importance and its distribution within the regional context. However, this activity intensifies the vulnerability of these systems, since the removal of rocky material directly affects the integrity of geodiversity and reduces its potential use for scientific, educational, and tourism purposes.

Figure 14 – Granite Extraction in the Inselberg Field.
Source: Authors (2025).

As an example of the impacts resulting from mineral exploitation, the degradation of the surroundings of a subterranean natural cavity near Serra Branca (Vítor Cave, Fig. 15) stands out, whose structure was partially suppressed due to extractive activities. This case illustrates the irreversible loss of geodiversity elements and their associated values, reinforcing the need to adopt measures aimed at geoconservation.

Figure 15 – Vítor Cave, in the Surroundings of Serra Branca.
Source: Authors (2025).

In view of this scenario, it becomes essential to strengthen territorial and environmental management instruments, with emphasis on the regulation of economic activities and the creation of protected areas. These initiatives are fundamental to ensure the maintenance of geodiversity ecosystem services and to promote the sustainable use of these environments in the Brazilian semi-arid region. In this context, geoconservation comprises an articulated set of actions aimed at the protection, valorization, and sustainable use of geodiversity, especially geological and geomorphological features of scientific, educational, cultural, and scenic relevance (SHARPLES, 2002; NASCIMENTO; MANSUR; MOREIRA, 2015).

Considering the relevance of the records gathered throughout this research, the implementation of measures that ensure their preservation and valorization becomes necessary. The creation and consolidation of geosites, through specific public policies, may enhance scientific knowledge production, while also fostering tourism and the local economy, in accordance with the principles of geoconservation. Furthermore, the adoption of internationally consolidated methodologies, such as that proposed by Brilha (2016), contributes to improving the stages of inventory, quantification, and valuation of geosites, providing greater robustness to analyses and supporting more effective management strategies.

Among the priority measures, the adoption of legal protection instruments, the inclusion of geoheritage in territorial planning policies, and closer engagement with local communities through educational processes that value the knowledge and meanings associated with landscapes stand out (BRILHA, 2005). In this perspective, geotourism is configured as an important awareness strategy, as it promotes environmental interpretation and the conservation of geological heritage while simultaneously generating socioeconomic benefits (NASCIMENTO; MANSUR; MOREIRA, 2015).

Geoparks, in turn, are territories recognized for their geological heritage of international relevance, in which integrated actions of conservation, education, and local development are articulated, based on participatory governance models and cooperation in networks linked to the United Nations Educational, Scientific and Cultural Organization (UNESCO) (ZOUROS, 2004; MCKEEVER; ZOUROS, 2005). Thus, they represent a consolidated approach to the sustainable management of geodiversity.

At the local level, different initiatives may be implemented to strengthen geoconservation and expand the valorization of the inselbergs. These include the systematic inventory of geodiversity and biodiversity, associated with their scientific and educational dissemination, as a means of recognition and public awareness. In addition, continuous environmental education actions should be promoted, such as campaigns focused on the importance of nature and the encouragement of sustainable practices in the use of these spaces.

It is also proposed to implement educational routes aimed at schools in the municipality of São Rafael and the surrounding region, structured according to different age groups and linked to the contents addressed in the classroom. These activities may include guided visits to the inselbergs, with interdisciplinary approaches integrating physical, cultural, and historical aspects of the landscape, favoring the construction of a critical and sensitive perception of the local environment.

Additionally, investments in infrastructure, such as interpretative signage, trail delimitation, and the installation of support points, contribute to visitor safety and to the reduction of environmental impacts. The regulation of tourism activities and the strengthening of inspection mechanisms are also important for the proper management of the use of these spaces.

Another relevant aspect is the development of Community-Based Tourism (CBT) (EMMENDOERFER; MORAES; FRAGA, 2016), with the training of residents to act as guides and protagonists of activities. In this model, management remains within the community itself, ensuring the distribution of benefits within the territory and valuing local infrastructure, ways of life, and cultural identity in visitor experiences. Guided by principles of sustainability and social empowerment, CBT requires investments in infrastructure and support from public management, constituting an alternative for income generation and sociocultural valorization associated with the inselbergs. Recently, the state of Rio Grande do Norte (2025b) established the State Policy for Community-Based Tourism, regulating and encouraging this modality.

These measures are essential for the valorization and conservation of local geodiversity in a context of intensifying anthropogenic pressures. Thus, strengthening geoconservation and sustainable use emerges as a key element for maintaining the ecosystem services associated with these environments.

4 Final considerations

From its perspective, this research provided a visual, descriptive, and perceptual account of the different cultural ecosystem services offered by these monumental structures, which are dispersed across and contrasted with the surrounding sertaneja surface. Although they are present in the daily routine of local residents, such benefits still remain "imperceptible," since a large part of the community is unable to establish the relationship between the activities carried out and the concept of ecosystem services.

The methodological framework adapted from Araújo, Diniz, and Souza (2024) constituted a fundamental element in structuring the research, serving as the basis for the development of a visual and descriptive account. This instrument made it possible to highlight the diversity of perceptions and cultural uses attributed by the local community, in addition to identifying the main threats and proposing geoconservation measures for these environments. The relevance of this study is consolidated as an important milestone for local geodiversity, by making it visible and valued. Its contributions serve as a foundation for new scientific discoveries, may be used as educational material in municipal school classrooms, and, most importantly, help any person discover a little of the history of the place where they live.

Knowing the geology, history, and reality of the São Rafael Inselberg Field invites us not only to contemplate and explore this exuberant scenic richness, but also to immerse ourselves in experiences, memories, and the connection of deep bonds that transcend the material dimension of the environment. Knowledge is the key to preserving these ecosystems. Through it, residents living in rural areas where the inselbergs are located, as well as the general population, may demand from public authorities strategies that promote awareness, prevent fragmentation, and avoid the loss of cultural ecosystem services.

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References

AB'SÁBER, A. N. Os domínios de natureza no Brasil: potencialidades paisagísticas. São Paulo: Ateliê Editorial, 2003. ISBN 978-85-7480-355-5. Disponível em: https://www.academia.edu/44486804/Os_Dom%C3%ADnios_de_Natureza_no_Brasil_Aziz_Ab_S%C3%A1ber_4aed_2003_ Acesso em: 11 dez. 2025.

ALRN. ASSEMBLEIA LEGISLATIVA DO RIO GRANDE DO NORTE. Lei de autoria de Ezequiel Ferreira reconhece cercas de pedra como patrimônio. Natal, 2024. Disponível em: https://www.al.rn.leg.br/noticia/32094/lei-de-autoria-de-ezequiel-ferreira-reconhece-cercas-de-pedra-como-patrimonio. Acesso em: 23 nov. 2025.

AMARAL, C. A. Correlação entre contexto morfoestrutural e sismicidade nas regiões de João Câmara e São Rafael (RN). 2000. 87 f. Dissertação (Mestrado em Geodinâmica; Geofísica) - Universidade Federal do Rio Grande do Norte, Natal, 2000. Disponível em: https://repositorio.ufrn.br/server/api/core/bitstreams/4a8281f9-1f85-4344-bb31-c272ec67711c/content . Acesso em: 21 nov. 2025.

ARAÚJO JÚNIOR, H. I.; PORPINO, K. O. Mamíferos fósseis da Fazenda Lajea Formosa, São Rafael, Rio Grande do Norte, Brasil: interpretações paleoecológicas. In: Anais do VIII Congresso de Ecologia do Brasil, Caxambu, MG, 23 a 28 de setembro de 2007. Caxambu: SEB, 2007. Disponível em: https://www.seb-ecologia.org.br/revistas/indexar/anais/viiiceb/pdf/603.pdf. Acesso em: 15 dez. 2025.

ARAÚJO, F. H. R.; DINIZ, M. T. M.; SOUZA, M. A. Comparison of abiotic ecosystem services in exception landscapes

conditioned by relief in the Martins-Portalegre massif, Brazilian semi-arid region. Discover Geoscience, v. 2, n. 100, p. 1-18, 2024. Disponível em: https://link.springer.com/article/10.1007/s44288-024-00106-1 . Acesso em: 2 jun. 2025.

ARAÚJO, F. H. R.; OLIVEIRA, A. M.; DINIZ, M. T. M. Geomorfologia granítica do Campo de Inselbergs de São Rafael, Rio Grande do Norte – Brasil. William Morris Davis - Revista De Geomorfologia, v. 6, n. 1, p. 304–318, 2025. Disponível em: https://williammorrisdavis.uvanet.br/index.php/revistageomorfologia/article/view/416. Acesso em: 2 fev. 2026.

ARAÚJO, F. H. R.; SILVA, F. E. B.; CHAGAS, M. D.; ARAUJO, I. G. D.; Diniz, M. T. M. Análise Qualitativa da Geodiversidade da Lágea Formosa, Zona Rural De São Rafael-RN. In: Antonio Carlos de Barros Corrêa; Daniel Rodrigues de Lira; Lucas Costa de Souza Cavalcanti; Osvaldo Girão da Silva; Riclaudio Silva Santos. (Org.). Mudanças ambientais e as transformações da paisagem no Nordeste brasileiro. Ananindeua: Itacaiúnas, 2024, v. 1, p. 1845-1858.

AULER, D. Novos caminhos para a educação CTS: ampliando a participação. IN: SANTOS, W.L.P.; AULER, D(org). CTS e Educação científica: desafios tendências e resultados de pesquisa. Brasília, Universidade de Brasília, Editora UnB, 2011. Disponível em: https://pt.scribd.com/document/791014171/auler-novos-caminhos-para-a-educacao-cts . Acesso em: 21 nov. 2025.

BASTOS, F. H.; LIMA, D. L. S.; CORDEIRO, A. M. N.; MAIA, R. P. Relevos graníticos do Nordeste brasileiro: Uma proposta taxonômica. In: Osmar Abílio de Carvalho Júnior; Maria Carolina Vilaça Gomes; Renato Fontes Guimarães; Roberto Arnaldo Trancoso Gomes. (Org.). Revisões de literatura da Geomorfologia brasileira. Brasília: Selo Caliandra, 2022, v. 1, p. 733-758.

BRASIL. Decreto nº 10.935, de 12 de janeiro de 2022. Dispõe sobre a proteção das cavidades naturais subterrâneas existentes no território nacional. Diário Oficial da União: Seção 1, Edição Extra, 12 jan. 2022. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2022/decreto/d10935.htm. Acesso em: 22 nov. 2025.

BRILHA, J B. Património geológico e geoconservação: a conservação da natureza na sua vertente geológica. Braga: Palimage, 2005. Disponível em: http://www.dct.uminho.pt/docentes/pdfs/jb_livro.pdf. Acesso em: 18 dez. 2025.

BRILHA, J. Inventory and quantitative assessment of geosites and geodiversity sites: a review. Geoheritage, v. 8, n. 2, p. 119–134, 2016. DOI: https://doi.org/10.1007/s12371-014-0139-3 Disponível em: https://link.springer.com/article/10.1007/s12371-014-0139-3 . Acesso em: 15 jan. 2026.

BÜDEL, J. Die doppeleten Einebnungsflächen in den feuchten Tropen. Zeitschrift für Geomorphologie, Stuttgart, n. 1, p. 201-288, 1957. Disponível em: https://journals.sagepub.com/doi/abs/10.1177/03091333840080030. Acesso em: 2. jun. 2025.

CARVALHO, J. N. C. de et al. Relatório preliminar das investigações geo-paleontológicas na área fossilífera pleistocênica da Fazenda Lágea Formosa, município de São Rafael. Arquivos do Instituto de Antropologia, Natal, v. 2, n. 1/2, p. 371-390, mar. 1966. Disponível em: https://repositorio.ufrn.br/items/1e7dc96c-926b-49d1-90ca-3f8960209bba . Acesso em: 21. nov. 2025.

CEN/SBCR – COMITÊ EXECUTIVO NACIONAL DO SISTEMA BRASILEIRO DE CLASSIFICAÇÃO DE RELEVO. Breve estado da arte do Sistema Brasileiro de Classificação de Relevo (SCBR): contribuições de e para a sociedade científica geomorfológica. Revista Brasileira de Geografia, Rio de Janeiro, v. 67, n. 2, p. 212-227, 2022. Disponível em: https://rbg.ibge.gov.br/index.php/rbg/article/view/4580. Acesso em: 20. out. 2025.

CLAUDINO-SALES, V. Geodiversity and geoheritage in the perspective of geography. Bulletin of Geography. Physical

Geography Series, v. 21, n. 1, p. 45-52, 2021. Disponível em: https://apcz.umk.pl/BOGPGS/article/view/36733. Acesso em: 30. maio. 2025.

CLAUDINO-SALES, V. Morfopatrimônio, morfodiversidade: pela afirmação do patrimônio geomorfológico strictu sensu. Revista da Casa da Geografia de Sobral, v. 20, n. 3, p. 3-12, 2018. Disponível em: https://rcgs.uvanet.br/index.php/RCGS/article/view/409. Acesso em: 29 maio. 2025.

CLAUDINO-SALES, V.; DINIZ, M. T. M.; ARAÚJO, I. G. D.; SÁ, A. C. D. S. We need climate in the geodiversity concept / Nós precisamos de clima no conceito de geodiversidade. Margarida Penteado Revista de Geomorfologia, v. 2, n. 1, 2025. DOI: https://doi.org/10.29327/104. Disponível em: https://revistaaprogeomg.org.br/index.php/margaridapenteadorevista/article/view/104. Acesso em: 19 dez. 2025.

COSTA, D. A. São Rafael: A história da cidade que o progresso naufragou. 2 ed. São Rafael: Cactos Editora, 2020.

DAILY, G. C. (Ed.). Nature's services: societal dependence on natural ecosystems. Washington, D.C.: Island Press, 1997. Disponível em: https://www.islandpress.org/books/natures-services. Acesso em: 7 jun. 2025.

DANTAS, E. P.; MEDEIROS, V. C.; CAVALCANTE, R. Mapa geológico do Estado do Rio Grande do Norte e mapa de recursos minerais do Estado do Rio Grande do Norte. Brasília: CPRM, 2021. Disponível em: https://rigeo.sgb.gov.br/handle/doc/22401 . Acesso em: 14 nov. 2025.

DINIZ, M. T. M. et al. Mapeamento geomorfológico do estado do Rio Grande do Norte. Revista Brasileira de Geomorfologia, v. 18, n. 4, 2017. Disponível em: https://rbgeomorfologia.org.br/rbg/article/view/1255 . Acesso em: 11 nov. 2025.

DINIZ, M. T. M.; PEREIRA, V. H. C. Climatologia do estado do Rio Grande do Norte, Brasil: sistemas atmosféricos atuantes e mapeamento de tipos de clima. Boletim Goiano de Geografia, Goiânia, v. 35, n. 3, p. 488–506, 2015. DOI: 10.5216/bgg.v35i3.38839. Disponível em: https://revistas.ufg.br/bgg/article/view/38839 . Acesso em: 05 nov. 2025.

EMMENDOERFER, M. L.; MORAES, W. V.; FRAGA, B. O. Turismo Criativo e Turismo de Base Comunitária: congruências e peculiaridades. El periplo sustentable, Toluca, n. 31, 2016. Disponível em http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1870-90362016000200002&lng=es&nrm=iso . Acesso em: 19 mar. 2026.

EMPARN. Empresa de Pesquisa Agropecuária do Rio Grande do Norte. Relatório pluviométrico. Disponível em: https://meteorologia.emparn.rn.gov.br/relatorios/relatorios-pluviometricos?tipo=acumuladaCorrente. Acesso em: 10 nov. 2025.

FERREIRA, J. S. Análise multitemporal do uso e cobertura da terra em unidades de paisagem do município de São Rafael/RN (1979–2024). 2025. Dissertação (Mestrado em Geografia) – Universidade do Estado do Rio Grande do Norte, Mossoró, 2025.

FERREIRA, J. S. Compartimentação geoambiental do município de São Rafael/RN: Potencialidades e limitações. Assú/RN, 2022. 41f. Monografia (Licenciatura em Geografia) – Universidade do Estado do Rio Grade do Norte, Assú, 2022. Disponível em: https://drive.google.com/drive/folders/1t1AwA5GYG7wafL1EwqmCHDo3-kDCuZ_s. Acesso em: 7 jun. 2025.

GORDON, J. E. Rediscovering a sense of wonder: geoheritage, geotourism and cultural landscape experiences. Geoheritage, v. 4, p. 65-77, 2012. Disponível em: https://link.springer.com/article/10.1007/s12371-011-0051-z. Acesso em: 22 maio. 2025.

GRAY, M. Geodiversity and geoconservation: what, why, and how? Geodiversity & Geoconservation, v. 22, n. 3, p. 4-12, 2005. Disponível em: https://www.researchgate.net/publication/237586700_Geodiversity_and_Geoconservation_What_Why_and_How. Acesso em: 7 jun. 2025.

GRAY, M. Geodiversity and the ecosystem approach: the contribution of geoscience in delivering integrated environmental management. Environmental Conservation, v. 38, n. 3, p. 271-274, 2011. Disponível em: https://www.sciencedirect.com/science/article/abs/pii/S0016787813000047. Acesso em: 6 jul. 2025.

GRAY, M. Geodiversity: valuing and conserving abiotic nature. 2. ed. Chichester: John Wiley & Sons, 2013. Disponível em: https://books.google.com.br/books?hl=pt-BR&id=idc7AAAAQBAJ. Acesso em: 14 maio. 2025.

GRAY, M.; GORDON, J. E.; BROWN, E. J. Geodiversity and the ecosystem approach: the contribution of geoscience in delivering integrated environmental management. Proceedings of the Geologists' Association, v. 124, n. 4, p. 659–673, 2013. DOI: 10.1016/j.pgeola.2013.01.003. Disponível em: https://www.sciencedirect.com/science/article/abs/pii/S0016787813000047?via%3Dihub. Acesso em: 20 maio 2025.

IBGE. Instituto Brasileiro de Geografia e Estatística. Manual técnico de pedologia. 3. ed. Rio de Janeiro: IBGE, 2015. 428 p. (Manuais técnicos em geociências, n. 4). Disponível em: https://biblioteca.ibge.gov.br/visualizacao/livros/liv95017.pdf . Acesso em: 10 nov. 2025.

LIMA, A. A. de. Levantamento fitogeográfico da Serra de Lájea Formosa, no município de São Rafael/RN. 2023. Trabalho de Conclusão de Curso (Licenciatura em Geografia) – Universidade do Estado do Rio Grande do Norte, Assú, 2023.

MAIA, R. P.; BEZERRA, F. H. R.; NASCIMENTO, M. A. L. do; CASTRO, H. S.; MEIRELES, A. J. de A.; ROTHIS, L. M. Geomorfologia do campo de inselbergues de Quixadá, Nordeste do Brasil. Revista Brasileira de Geomorfologia, São Paulo, v. 16, n. 2, p. 239–253, 2015. DOI: https://doi.org/10.20502/rbg.v16i2.651. Disponível em: https://rbgeomorfologia.org.br/rbg/article/view/651/469 . Acesso em: 10 fev. 2026.

MAIA, R. P.; NASCIMENTO, M. A. L. Relevos graníticos do Nordeste brasileiro. Revista Brasileira de Geomorfologia, v. 19, n. 2, p. 373-389, abr. 2018. Disponível em: https://rbgeomorfologia.org.br/rbg/article/view/1295 . Acesso em: 30 maio. 2025.

MATMON, A. et al. Erosion of a granite inselberg, Gross Spitzkoppe, Namib Desert. Geomorphology, v. 201, p. 52-59, 2013. Disponível em: https://www.sciencedirect.com/science/article/abs/pii/S0169555X13003152. Acesso em: 14 maio. 2025.

McKEEVER, Patrick J.; ZOUROS, Nikolaos. Geoparks: celebrating Earth heritage, sustaining local communities. Episodes, v. 28, n. 4, p. 274–278, 2005. Disponível em: https://www.episodes.org/journal/download_pdf.php?doi=10.18814/epiiugs/2005/v28i4/006 . Acesso em: 18 dez. 2025.

MIGOŃ, P. Granite geomorphology. In: GOUDIE, A. S. (ed.). Encyclopedia of geomorphology. Londres: Taylor & Francis, 2006. p. 490-493. Disponível em: https://archive.org/details/encyclopediaofge0001unse. Acesso em: 10 maio. 2025.

MILLENNIUM ECOSYSTEM ASSESSMENT (MA). Ecosystems and human well-being: a framework for assessment. Washington, D.C.: Island Press, 2003. Disponível em: https://www.millenniumassessment.org/documents/document.356.aspx.pdf. Acesso em: 31 maio. 2025.

MILLOT, G. Géochemie de la surface et formes du relief. Société Géologique Bulletin, Paris, v. 30, n. 4, p. D229-D233,

1977. Disponível em: https://www.persee.fr/issue/sgeol_0302-2692_1977_num_30_4 . Acesso em: 31 maio. 2025.

NASCIMENTO, M. A. L.; MANSUR, K. L.; MOREIRA, J. C. Bases conceituais para entender geodiversidade, patrimônio geológico, geoconservação e geoturismo. Revista Equador, Teresina, v. 4, n. 3, p. 48–69, 2015. Disponível em: https://www.researchgate.net/publication/280925520_BASES_CONCEITUAIS_PARA_ENTENDER_GEODIVERSIDADE_PATRIMONIO_GEOLOGICO_GEOCONSERVACAO_E_GEOTURISMO. Acesso em: 10 fev. 2026.

OLIVEIRA, L. D. D. Ocorrência de carnívoro fóssil em São Rafael, Rio Grande do Norte. Arquivos do Instituto de Antropologia "Câmara Cascudo", Natal, n. 2, p. 4-11, 1973. Disponível em: https://repositorio.ufrn.br/server/api/core/bitstreams/5a686d40-74d0-4398-99b9-1dcb67dca50d/content. Acesso em: 21 nov. 2025.

PEIXOTO, P. M. N. Distribuição espacial de Cactaceae e Bromeliaceae em um inselberg no município de São Rafael/RN. 2019. 26f. Trabalho de Conclusão de Curso (Licenciatura em Geografia) – Universidade do Estado do Rio Grande do Norte, Assú, 2019.

PEREIRA NETO, M. C.; MEDEIROS DA SILVA, N. Relevos residuais (maciços, inselbergues e cristas) como refúgios da biodiversidade no Seridó potiguar. Revista Geonorte, [S. l.], v. 3, n. 4, p. 262–273, 2012. Disponível em: www.periodicos.ufam.edu.br/index.php/revista-geonorte/article/view/1824 . Acesso em: 21 nov. 2025.

QUEIROZ, L. S. et al. A methodological contribution to assess rock landform geomorphosites related with pareidolia: a case study in Northeast Brazil. Geomorphology, p. 109858, 2025. DOI: https://doi.org/10.1016/j.geomorph.2025.109858 . Disponível em: https://www.sciencedirect.com/science/article/pii/S0169555X25002685 . Acesso em: 19 set. 2025.

RIO GRANDE DO NORTE. Lei nº 12.156, de 09 de maio de 2025. Reconhece como Patrimônio Histórico, Cultural, Turístico, Paisagístico e Arquitetônico do Estado do Rio Grande do Norte as “Cercas de Pedra”. Disponível em: https://www.al.rn.leg.br/storage/legislacao/2025/jqfufxwdvhkmfosk8sji9vahbwd6jv.pdf . Acesso em: 05 nov. 2025a.

RIO GRANDE DO NORTE. Lei nº 12.454, de 06 de outubro de 2025. Institui a Política Estadual de Turismo de Base Comunitária no Estado do Rio Grande do Norte e dá outras providências. Disponível em: https://www.al.rn.leg.br/storage/legislacao/2025/vj0np5uz3ijk3yg07hi980mq1k40q6.pdf . Acesso em: 19 mar. 2025b.

ROSS, Jurandyr Luciano Sanches. O relevo brasileiro, as superfícies de aplanamento e os níveis morfológicos. Revista do Departamento de Geografia, n. 5, p. 7-24, 1991. Disponível em: https://revistas.usp.br/rdg/article/view/47097/50818. Acesso em: 11 nov. 2025.

SANTOS, M. G. M.; GUEDES, J. A. O atlas escolar municipal de São Rafael-RN: processo de elaboração e importância para o ensino de Geografia. Revista de Ensino de Geografia, v. 10, p. 145–165, 2019. Disponível em: https://seer.ufu.br/index.php/revistadeensinodegeografia/article/view/76740/40572 . Acesso em: 30 maio 2025.

SANTOS, M.; COSTA, G.; GUEDES, J. Atlas geográfico escolar de São Rafael-RN. [S. l.]: UERN, 2023. E-book. Disponível em: https://portal.uern.br/wp-content/uploads/sites/14/2024/09/EBook-Atlas-escolar-de-Sao-Rafael-RN-1.pdf. Acesso em: 21 nov. 2025.

SHARPLES, C. Concepts and principles of geoconservation. 2002. Disponível em: http://www.parks.tas.gov.au/geo/conprin/define.html . Acesso em: 19 mar. 2026.

SOUZA, F. C. S. Escafandristas do tempo: narrativas de vida e regeneração da memória em São Rafael-RN. 2011. 237

f. Tese (Doutorado em Educação) - Universidade Federal do Rio Grande do Norte, Natal, 2011. Disponível em: https://repositorio.ufrn.br/items/061447d5-f1b3-433c-9b79-5df3d22f9d0e. Acesso em: 21 nov. 2025.

SOUZA, M. A. et al.. Serviços ecossistêmicos da geodiversidade fornecidos pelos inselbergues do município de São Rafael/RN. Anais do XV SIMPÓSIO NACIONAL DE GEOMORFOLOGIA... Campina Grande: Realize Editora, 2025. Disponível em: < https://editorarealize.com.br/artigo/visualizar/123467 >: Acesso em: 14 out. 2025.

TWIDALE, Charles Rowland. Granite Landforms. Amsterdam: Elsevier, 1982. 372 p. Disponível em: https://archive.org/details/granitelandforms0000twid Acesso em: 13 dez. 2025.

ZOUROS, Nikolaos. The European Geoparks Network: geological heritage protection and local development. Episodes, v. 27, n. 3, p. 165–171, 2004. Disponível em: https://eclass.aegean.gr/modules/document/file.php/SUMSCHOOLS104/ZOUROS%20N%202004%20Episodes%20273%20165-171.pdf. Acesso em: 18 dez. 2025.