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Artigo de Pesquisa

Geodiversity Index for identifying priority areas for geoheritage along the BR-174 route in Roraima, northern Brazil

Índice de Geodiversidade para identificação de áreas prioritárias ao geopatrimônio no trajeto da BR-174 em Roraima, norte do Brasil

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Abstract: Geodiversity, as the abiotic variety of nature, provides the foundation for identifying geoheritage elements. Roraima, located within the Guiana Shield, exhibits high geodiversity but lacks regional-scale quantification studies. This study aimed to quantify geodiversity along the BR-174 corridor and identify priority areas for future geosite inventories. The geodiversity index method was applied using GIS, analyzing class richness of lithology, geomorphology, and pedology on a 15 × 15 km grid classified by the Jenks natural breaks method. Results revealed a heterogeneous distribution, with 37% of the area classified as "high" and "very high", concentrated in the central region (Caracaraí, Iracema, Mucajaí, Amajari). A total of 67% of previously cataloged geological interest points coincided with these areas. We conclude that the index is an effective tool for regional-scale geoheritage prospecting, and the sectors mapped as priority along the BR-174 represent targets for future investigations, supporting geoconservation policies and territorial planning.

Keywords: Geodiversity; Geoheritage; GIS; Mapping; Roraima.

Resumo: A geodiversidade, enquanto variedade abiótica da natureza, constitui a base para a identificação de elementos do geopatrimônio. Roraima, inserido no Escudo das Guianas, apresenta elevada geodiversidade, mas carece de estudos de quantificação em escala regional. Este trabalho objetivou quantificar a geodiversidade ao longo do corredor da BR-174 e identificar áreas prioritárias para futuros inventários de geossítios. Aplicou-se o método de índice de geodiversidade em SIG, analisando a riqueza de classes de litologia, geomorfologia e pedologia em malha de 15 x 15 km, classificada pelo método *Jenks*. Os resultados revelaram distribuição heterogênea, com 37% da área classificada como "alta" e "muito alta", concentrando-se na região central (Caracaraí, Iracema, Mucajaí, Amajari). Verificou-se que 67% dos pontos de interesse geológico previamente catalogados coincidem com essas áreas. Conclui-se que o índice é uma ferramenta eficaz para a prospecção de geopatrimônio em escala regional, e os setores mapeados como prioritários ao longo da BR-174 representam alvos para investigações futuras, subsidiando políticas de geoconservação e planejamento territorial.

Palavras-chave: Geodiversidade; Geopatrimônio; SIG; Mapeamento; Roraima.

1. Introduction

The concept of Geodiversity, defined as the natural variety of geological, geomorphological, pedological, and hydrological elements and process (Gray, 2013; Tukiainen; Toivanen; Maliniemi, 2023), has become a central paradigm for understanding Earth systems. This abiotic diversity constitutes the physical framework that supports ecosystems (nature's stage), as variation in geological substrate and geomorphology directly influences biodiversity patterns (Hjort et al., 2024; Maliniemi et al., 2024; Tukiainen; Bailey, 2023).

Quantifying geodiversity is fundamental for geoconservation and the management of geoheritage – portions of the territory with scientific, educational, or tourism value (Brilha, 2016). This study aligns with the approach that quantifies class richness of abiotic elements (lithology, geomorphology, and pedology), a systematic and reproducible method for regional-scale analyses that prioritizes the measurement of physical heterogeneity, distinct from qualitative valuation (Manosso et al., 2021; Silva et al., 2021). Thus, a conceptual distinction is established: geodiversity constitutes the quantified physical basis; geoheritage comprises the portions of this geodiversity that hold value; and geotourism represents the activity that promotes the sustainable use of this heritage (Brilha, 2016).

In the Brazilian context, marked by the absence of a coordinated national policy for geodiversity protection (Kuhn et al., 2022), quantitative studies become imperative to support decision-making. This gap is particularly relevant in the Amazon, where the geological complexity of the Guiana Shield contrasts with the scarcity of detailed geodiversity mapping to complement biodiversity inventories (Alsbach; Seijmonsbergen; Hoorn, 2024).

The state of Roraima, located within this geotectonic domain, presents a landscape of notable abiotic heterogeneity. The BR-174 highway, crossing this diverse environment, provides a strategic logistical corridor whose planning can benefit from a scientific assessment of its geodiversity. Accordingly, the quantification proposed here serves as a spatial screening tool to identify candidate areas to host geoheritage – the so – called geodiversity hotspots (Bétard; Peulvast, 2019) – whose validation as sites of interest will require subsequent qualitative inventory stages.

Given the above, this study aims to: (i) quantify geodiversity along the BR-174 corridor in Roraima by applying the geodiversity index method in a GIS environment; and (ii) identify geodiversity hotspots, delimiting priority candidate areas for future geoheritage investigations and exploration planning of geoconservation actions. The results may supports public and provide a technical bases for initiatives that reconcile environmental conservation and socio-economic development in the Amazon region.

2. Study Area

The BR- 174 highway, which crosses Roraima in a north-south direction, is marked by great diversity of geological formations. Its geographic location in the far north of Brazil is strategic (Figure 1), with borders to the north with the Bolivarian Republic of Venezuela, to the south with the states of Amazonas and Pará, to the east with the Cooperative Republic of Guiana, and to the west with the states of Amazonas and again with Venezuela (Júnior; Lima Gomes; Maia, 2023). The geodiversity along the highway results from the fact that it makes a N-S transect of the Guiana Shield – an ancient terrane with high lithological and structural diversity, formed by crystalline rocks overlain alluvial deposits (Bartorelli; Teixeira; Brito Neves, 2010; Mendes et al., 2023).

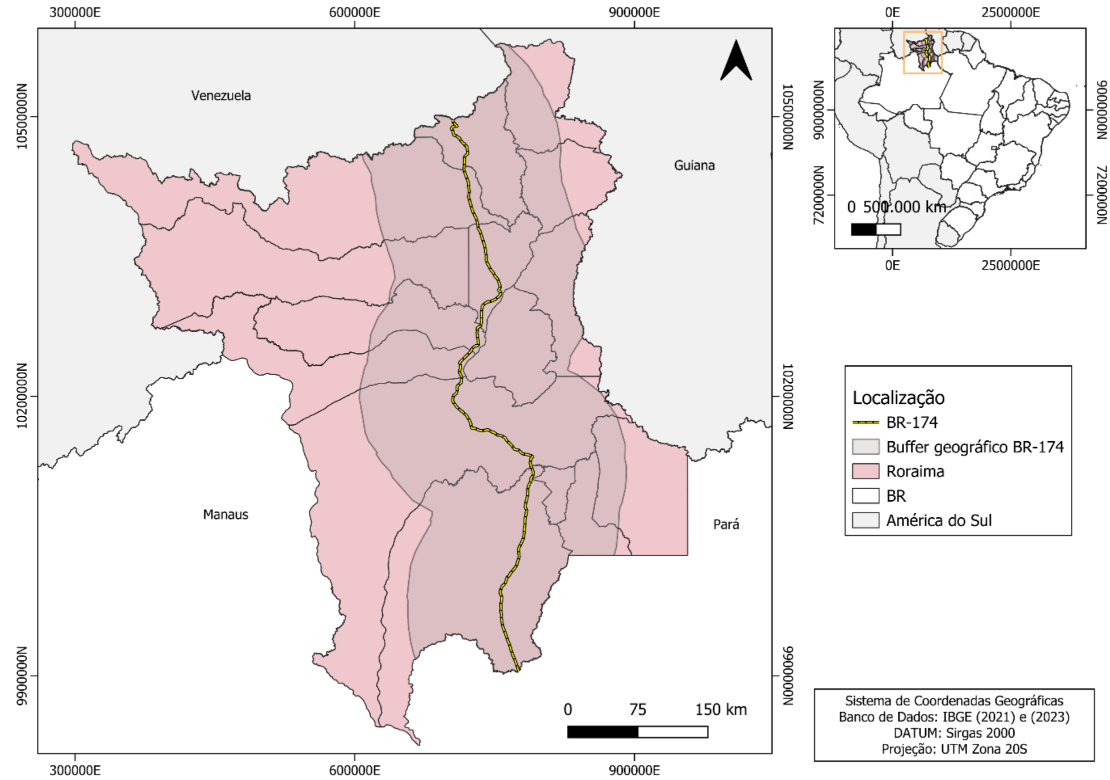

Figure 1. Location map of the study area, identifying the geographic buffer and the municipalities of the state.

According to Reis et al., (2003), the state of Roraima can be divided into four main tectonoestructural domains, which, according to Holanda, Marmos e Maia (2014), exhibit distinct lithological, geomorphological, and phytogeographic characteristics (Chart 1).

The geological and geomorphological (and climatic) heterogeneity along BR-174 contributes to the occurrence of soil diversity, resulting from various pedogenetic processes influenced by past and present bioclimatic conditions (Benedetti et al., 2011; Holanda; Marmos; Maia, 2014).

According to the Koppen climate classification, the state of Roraima is characterized by three climate types: Af (tropical rainforest), Am (tropical monsoon), and Aw (tropical savana) (Alvares et al., 2013; Barni et al., 2022).

Chart 1. Characteristics of the tectonostratigraphic domains of the state of Roraima.

DOMAIN	LOCATION	MAIN LITHOLOGY	RELIEF	VEGETATION COVER	OBSERVATION
Surumu	North and Northeast	Volcanic-plutonic and metasediment ary rocks	Homogeneous landforms; Amazonas-Orinoco Interfluve Plateau and Roraima Sedimentary Plateau. Appalachian-type ridges, cuesta relief, and inselbers	Forestes and Savannas	Diverse relief with variation between mountain ranges and flat areas

Parima	Northwest	Granite-greenstone terranes	Rolling hills ("Mares de morros")	Dense forest	Area with gently undulating relief
Guiana Central	Central region	Paleoproterozoic units and metamorphic belts; unconsolidated sediments	Transition between the Guiana Plateau and the Amazon Plain; forested rolling hills; pediplain with inselbergs	Forest	Marked geomorphological transition area
Uatumã-Anauá	Sourtheast	Granite-gneiss terrane and sedimentary covers	Homogeneous landforms; Amazonas-Orinoco Interfluve Plateau; rolling hills	Dense tropical forest with anthropized areas	Region with increasing impact from agricultural settlements

2. Materials and Methods

The methodological approach was structured with the main objective of quantifying geodiversity along the BR-174 corridor. The procedures were based on the analysis of digital spatial data using Geographic Information Systems (GIS), following a quantitative analyses protocol focused on the class richness index. This stage aims to determine the abiotic heterogeneity od the study area, providing a spatial basis for identifying macrozones of interest that will serve as candidate areas for future geoheritage investigations.

2.1 Database and Study Area

Vector cartographic bases from the Brazilian Institute of Geography and Statistics (IBGE), at a scale of 1:250,000, were used, complemented by bases from the Geological Survey of Brazil (CPRM), ar a scale of 1:1,000,000, and by reports from the Ecological-Economic Zoning of Roraima (ZEE-RR), at a scale of 1:850,000. To ensure compatibility between the different sources, standardization was performed to the most detailed scale (1:250,000), adopting cartographic generalization of the lower-resolution bases to the corresponding taxonomic level, as described in Table 1.

Table 1. Variables used in the study.

Elements	Original scale	Classes used
Geology	1:250,000	Geological unit
Geomorphology	1:250,000	Geomorphological unit
Pedology	1:250,000	Soil order

Source: The authors.

The study area was delimited by a 100 km geographic buffer from the BR-174 route. This distance was established to encompass the transition between the main tectonostructural domains of the Guiana Shield adjacent to the highway, ensuring that the analysis captured the geological variability at a scale compatible with regional exploratory studies.

2.2 Processing of Geographic Data

Data processing and modeling were carried out in a GIS environment using the free software QGIS (version 3.34.13), with the Universal Transverse Mercator (UTM) projection system, zone 20N, SIRGAS 2000 datum.

The thematic layers were processed individually to determine class richness for each variable. Initially, the bases were treated to harmonize the projection among the input data. Subsequently, the vector data for Geology, Geomorphology, and Pedology were converted to raster format using a spatial resolution of 15 x 15 km.

For each grid cell, the partial diversity index value was calculated as simple class richness, i.e., the absolute number of distinct classes (geological units, geomorphological units, or soil orders) whose spatial representation intersected the cell, regardless of the area occupied by each class. No area weighting or prior normalization of values was applied, since the input variables were already on a compatible categorical scale. The absence of weighting is based on the assumption that the presence of a class, even over a small extent, contributes to the abiotic heterogeneity of the cell.

The 15 x 15 km resolution was adopted as a compromise between the detail of the baseline data (1:250,000) and the need for generalization for regional analysis, being suitable for identifying geodiversity hotspots. It is recognized that this scale may not capture specific features or interest, thus constituting an exploratory tool to guide future studies at a more detailed scale.

This step resulted in raster maps where each cell stores the class richness value, following an approach similar to that used by Araujo and Pereira (2017).

2.3 Geodiversity Index Method

Geodiversity quantification was performed based on the Geodiversity Index method, a quantitative approach that accounted for the variety of abiotic elements within a defined area. This approach has been applied and adapted in different Brazilian contexts (Araujo; Pereira, 2017; Pereira et al., 2013; Silva et al., 2021), being grounded on the class richness principle.

2.3.1 Calculation of Partial and Integrated Indices

For each variable analyzed (geology, geomorphology, and pedology), partial diversity indices were calculated from the 15 x 15 km raster grid. The value of each cell was determined by simple class richness, i.e., the absolute number of distinct classes (geological units, geomorphological units, or soil orders) whose spatial representation intersected the cell, regardless of the area occupied by each class.

No area weighting or prior normalization of values was applied, since the input variables were already on a comparable categorical scale. The absence of weighting is based on the assumption that the presence of a class, even over a small extent, contributes to the abiotic heterogeneity of the cell. This procedure ensures that all abiotic components contribute is a balanced manner to the final analysis (Pereira et al., 2013).

The Geodiversity Index (Igeo) was obtained by the arithmetic sum of the partial indices, according to the following equation:

$$Igeo = IDL + IDG + IDP$$

Where:

Igeo: Geodiversity Index

IDL: Lithological diversity index (number of lithological classes per cell)

IDG: Geomorphological diversity index (number of geomorphological classes per cell)

IDP: Pedological diversity index (number of soil classes per cell)

The quantification was performed using map algebra in the QGIS environment (version 3.34.13).

2.3.2 Classification and Interpretation of Results

The value obtained for the integrated index were classified into five categories (Table 2) using the natural breaks (Jenks) method. This technique identifies natural groupings in the data, minimizing within-class variance and maximizing between-class variance, being particularly suitable for geodiversity data as it respects the original statistical distribution of the values.

Table 2. Class intervals resulting from the application of the natural breaks (Jenks) method to the thematic map data.

Classification/Variable	Geology	Geomorphology	Pedology	Geodiversity
Very high	> 4.2963	> 2.9900	> 3.4268	> 9.9988
High	3.6803 – 4.2963	2.5399 – 2.9900	2.9470 – 3.4268	8.8658 - 9.9988
Moderate	3.0644 – 3.6803	2.0899 – 2.5399	2.4672 – 2.9470	7.7329 - 8.8658
Low	2.4484 – 3.0644	1.6399 – 2.0899	1.9873 – 2.4672	6.5999 - 7.7329
Very low	≤ 2.4484	≤ 1.6399	≤ 1.9873	≤ 6.5999

Source: The authors.

The Igeo results were interpreted as indicators of abiotic heterogeneity, delineating macrozones with greater richness of physical elements. These areas are configured as priority candidates for future geoheritage investigations.

2.3.3 Regional Spatial Analysis and Exploratory Convergence

To facilitate the regional interpretation of geodiversity patterns, the study area was compartmentalized into three geographic zones (Chart 2). This compartmentalization is based on the transition between the main tectonostructural domains and allows a differentiated analysis of geodiversity patterns along the highway corridor.

Chart 2. Compartmentalization of geodiversity zones.

Zone	Location
North	Extends from the border with Venezuela and Guyana to the confluence of the Tacutu and Uraricoera rivers.
Central	Comprises the areas between the confluence of the Tacutu and Uraricoera rivers and the lower course of the Branco River.
South	Convers from the lower course the Branco River to the borders with the states of Amazonas and Pará.

Source: The authors.

To contextualize the results, an exploratory spatial convergence analysis was performed between areas of high Igeo and previously cataloged geological interest features in the region (waterfalls, rapids, and mountain ranges), obtained from vector data provided by Holanda, Marmos and Maia (2014). Is should be emphasized that this cross-analysis is purely illustrative and exploratory in nature, not constituting an assessment of geotourism potential nor a qualitative validation of the elements as geosites. Its objectives is merely to verufy the spatial correspondence between the quantified abiotic heterogeneity and features already recognized in the literature, providing a preliminary indication to guide future field inventories.

3. Results

The quantitative analysis of geodiversity within the geographic buffer of the BR-174 highway revealed a heterogeneous spatial distribution of the indices, reflecting the geological, geomorphological, and pedological complexity of the region. The integration of the partial indices allowed the delimitation of macrozones within high abiotic heterogeneity, which constitute priority areas for future geoheritage investigations.

3.1. Geological Diversity

Geological diversity, represented by the variety of lithotypes within the geographic buffer of the BR-174 highway (Figure 2), presents an asymmetric spatial distribution. The highest values are concentrated in the central portion of the corridor, predominantly on the right bank of the highway, where the Guiana Central and Uatumã-Anauá tectonostratigraphic domains are located.

The classification of the Geological Diversity Index into five categories shows that areas within "high" and "very high" diversity predominate in the central and southern zones of the buffer, near the highway axis. In contrast, the lowest values are located in the northern and in the eastern and western extremities of the other zones.

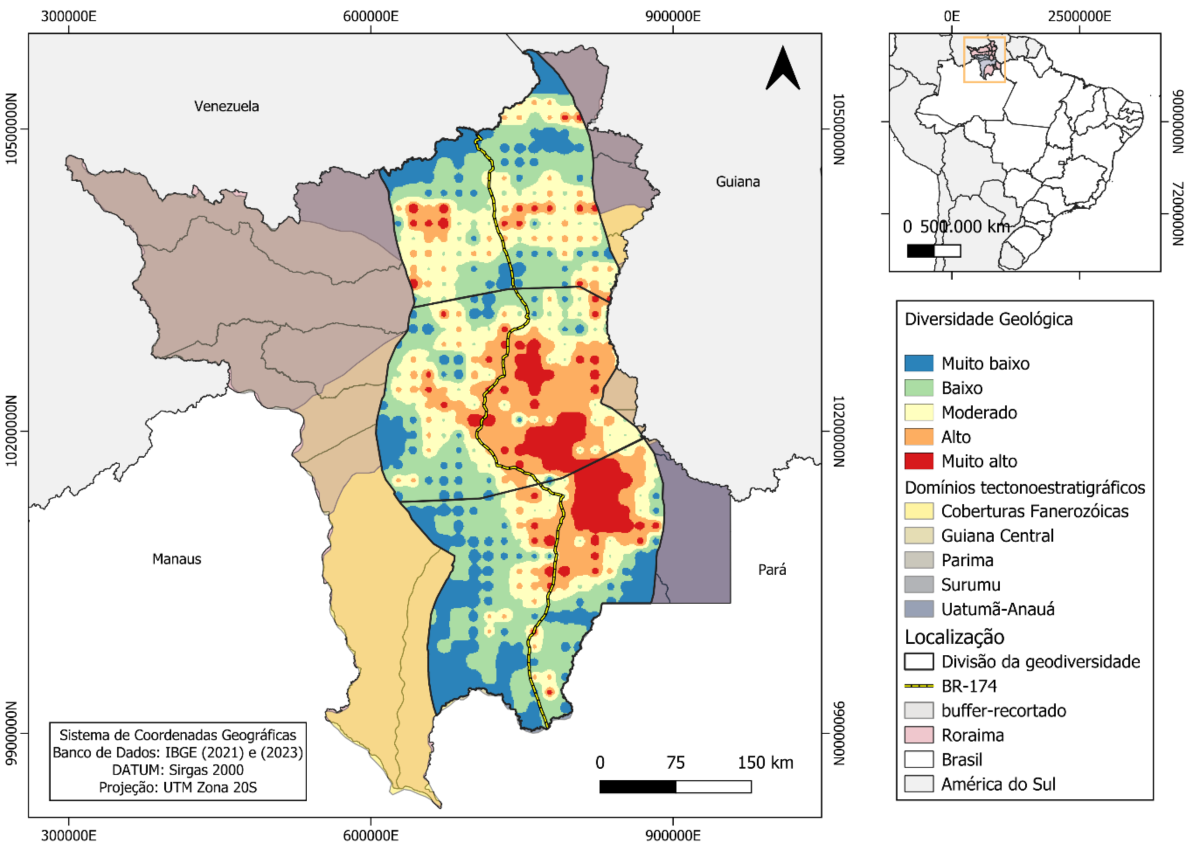

Figure 2. Geological diversity map of the study area.

The areas with “high” and “very high” diversity spatially coincide within lithological transition zones and the influence of complex geological structures (Figure 3). In the central zone, the presence of the Tacutu hemi-graben, a Mesozoic normal fault system, juxtaposes Paleoproterozoic lithological units with Jurassic-Cretaceous volcano-sedimentary sequences, resulting in the observed high heterogeneity (Sander et al., 2024). In this domain (Guiana Central), high-grade metamorphic supracrustal rocks (Cauarane Complex), anorthosite-mangerite-rapakivi magmatic associations (Mucajaí Suite), and the gneisses, migmatites, and charnorckites of the Rio Urubu Complex occur. In the southern zone, the Uatumã-Anauá domain is composed of granitoids from the Uatumã volcano-plutonic association and the Juaperi Complex. In both zones, the presence of Pleistocene deposits (Boa Vista and Içá Formations) and recent colluvial and alluvial deposits contributes to the diversity patterns identified (Alsbach; Seijmonsbergen; Hoorn, 2024; Holanda; Marmos; Maia, 2014).

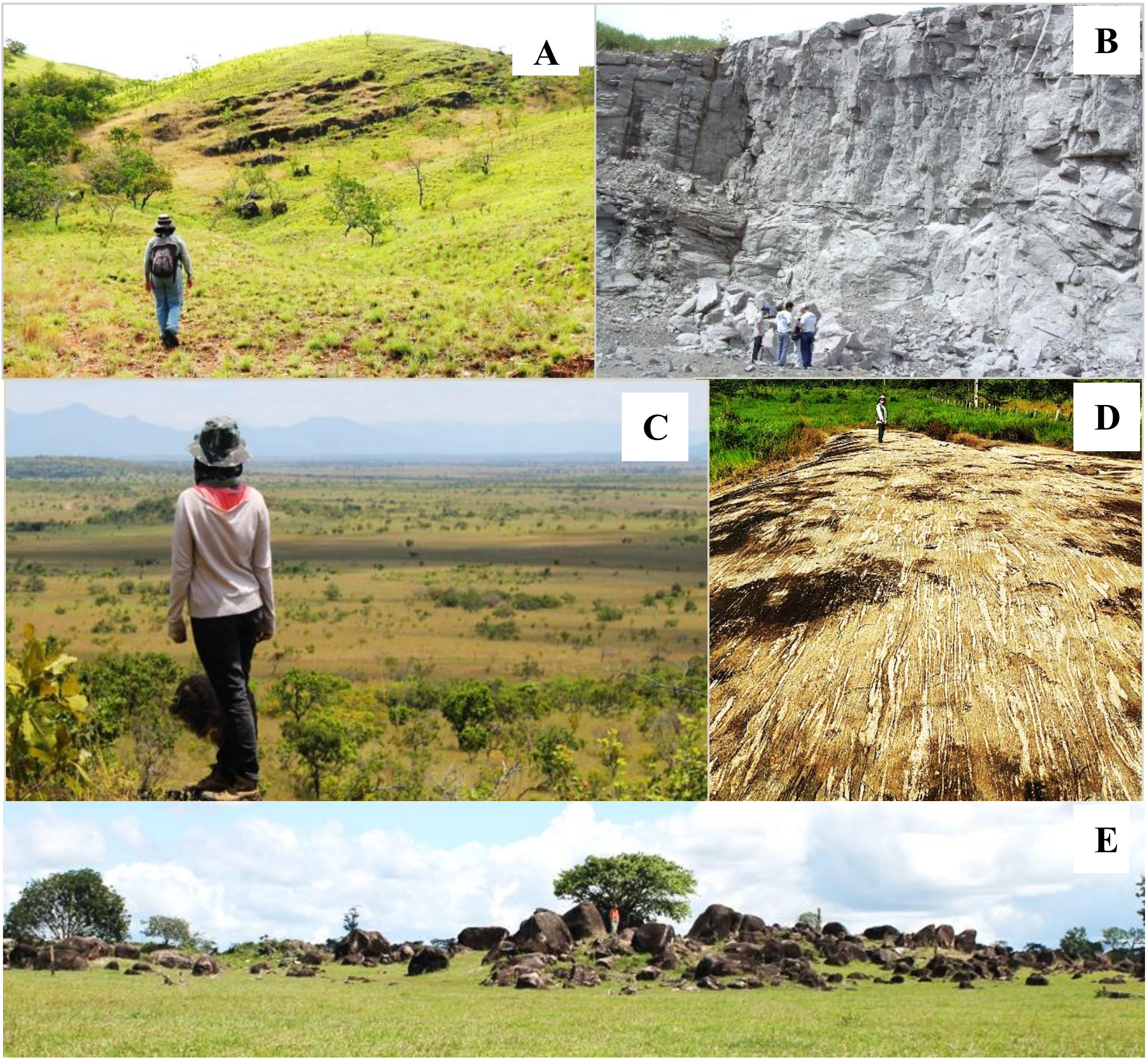

Figure 3. Representative geological features of high diversity áreas: A) tilted strata of the Cauarane Complex; B) exposure of Rapakivi Granite (Mucajaí Suite); C) contact between lithotype of the Mucajai/Cauarane groups and sediments of the Boa Vista Formation; D) migmatites of the Rio Urubu Belts; E) granitoids of the Uatumã volcano-plutonic association. Source: The authors.

In contrast, the northeastern border (Northern Zone) and the southeastern portion (Southern Zone) present "low" and "very low" values of geological diversity. The former is dominated by the Roraima Supergroup, a thick and homogeneous Paleoproterozoic volcano-sedimentary sequence, while the latter is covered by Cenozoic sedimentary covers, including alluvial deposits, fluvial terraces of the Viruá Formation, and sediments of the Içá Formation (Mendes et al., 2023).

The spatial distribution pattern reflects the regional geotectonic compartmentalization: the greatest lithological diversity is associated with the crystalline terrains of the Guiana Shield, characterized by the superposition of Proterozoic magmatic and metamorphic events, whereas the sedimentary basins exhibit lower heterogeneity. As demonstrated in previous studies (Silva et al., 2021), geological diversity constitutes one of the main controls of geomorphological and pedological variability, contributing to the definition of sectors with greater diversity along the BR-174 corridor.

3.2 Geomorphological Diversity

The geomorphological diversity map (Figure 4) reveals the spatial distribution of this component along the BR-174 corridor. The analysis shows a well-defined pattern: the highest values ("high" and "very high") are concentrated in the central axis of the study area, coinciding with the highway alignment. In contrast, the "low" and " very low" classes predominate in the western and southeastern extremities of the geographic buffer.

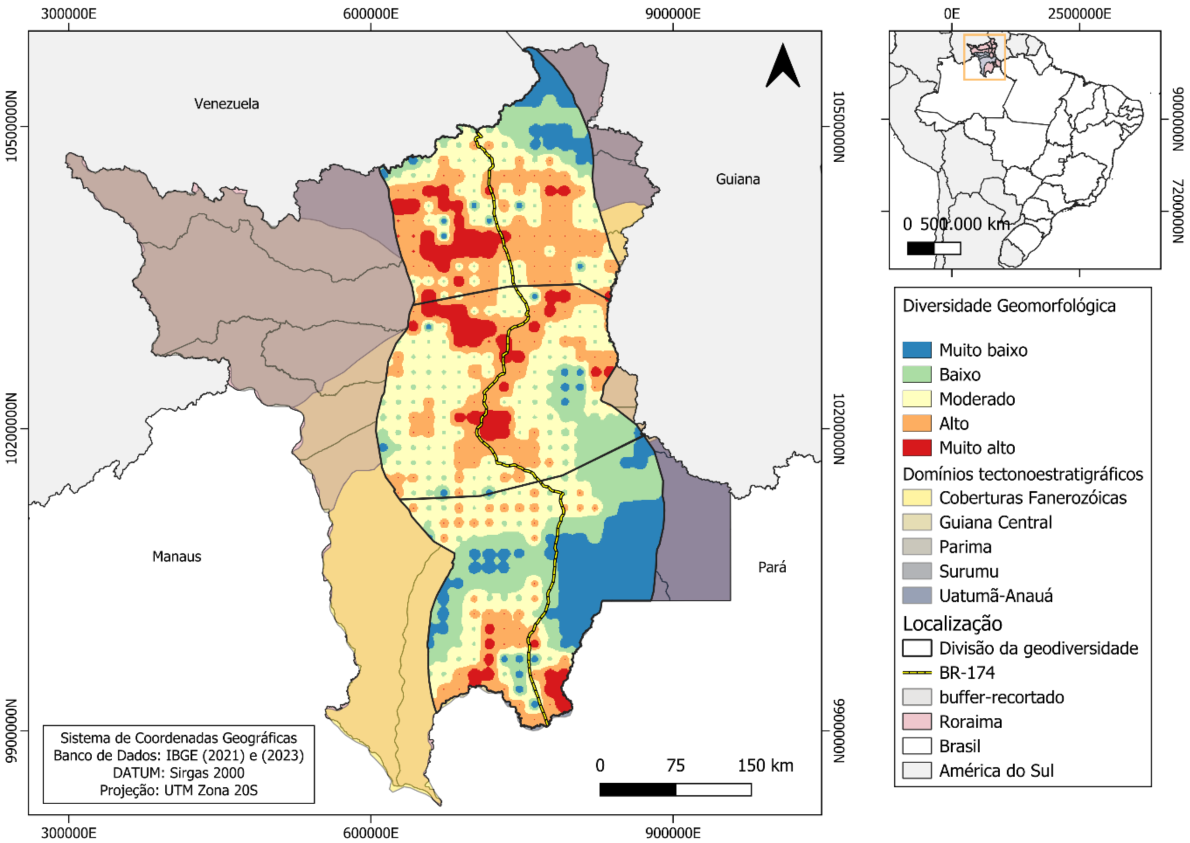

Figure 4. Geomorphological diversity map of the study area.

The high diversity areas in the central portion are associated with residual plateau landforms and dissected reliefs, where the drainage network acted as a modeling agent. Watercourses such as the Maú and Contingo rivers, originating from the Monte Roraima massif, are characterized by high topographic gradient, with a predominance of rapids and waterfalls (Figures 5A, 5B, 5D) that enhance weathering and erosion processes (Schaefer; Dalrymple, 1995). The Branco River (Figure 5C), the main fluvial axis, integrates these distinct geomorphological domains from its headwaters to its confluence with the Negro River (Holanda; Marmos; Maia, 2014).

In the northern zone, geomorphological diversity is expressed by aligned mountain ranges with strong structural control, such as the Serra do Guariba (Figure 5A), bordered by sediments of the Pleistocene pediplain of the Boa Vista Depression. Also noteworthy are residual granitic features (inselbergs), such as the Pedra Pintada Archeological Site (Figure 5B), which associate rugged relief with cultural records.

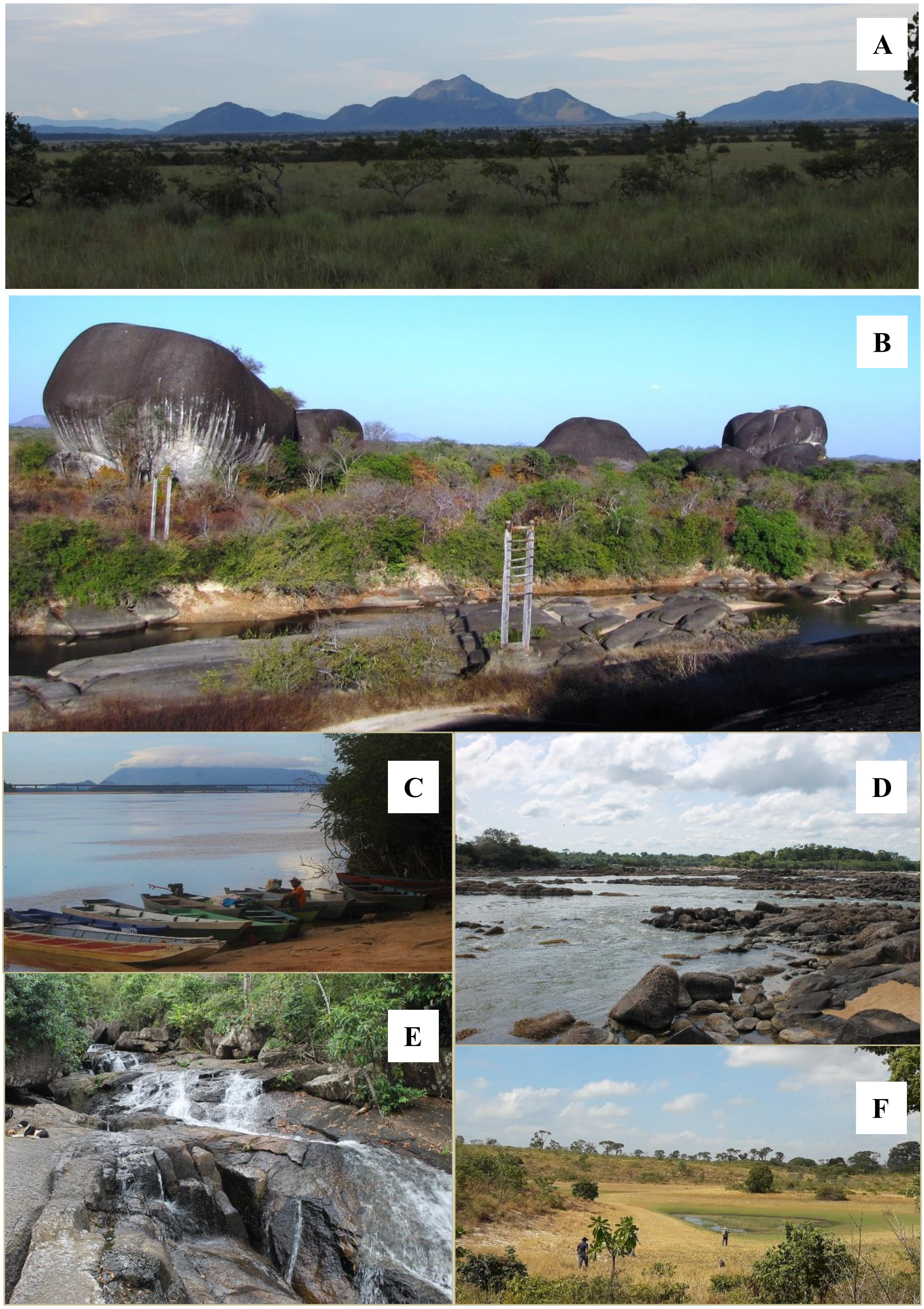

Figure 5. Representative geomorpgological features: Northern Zone– (A) Serra do Guariba; (B) Granitic inselberg (Pedra Pintada). Central Zone – (C) Branco River and Serra Grande; (D) Bem-Querer Rapids; (E) Evando Waterfall; (F) Parabolic paleodunes. Source: The authors.

In the central zone, in addition to rapids and waterfalls, singular features such as the parabolic paleodunes of the Boa Vista municipality (Figure 5F) occur, serving as evidence of dry paleoclimates that contribute to regional geomorphological heterogeneity. The Bem-Querer Rapids (Figure 5D), in the Caracaraí municipality, represent a base leve that morphologically separates the upper and lower courses of the Branco River.

In contrast, the low diversity recorded in the western and southern extremities is associated with homogeneous relief compartments, notably the extensive surfaces of the Rio Branco-Rio Negro Pediplain and the Amazon Plain. Landscape morphology thus establishes itself as a primary control on the distribution of soils and the drainage network, constituting a key variable for understanding regional abiotic heterogeneity.

3.3 Pedological Diversity

Pedological diversity, a component of geodiversity, represents the variety of soils and their formative processes (Hjort et al., 2024; Tukiainen; Toivanen, 2025). The pedological diversity map (Figure 6) reveals na asymmetric spatial distribution, with a concentration of "high" and "very high" values in the central region adjacent to the BR-174 highway, while the lowest values ("low" and "very low") predominate in the southeastern portion.

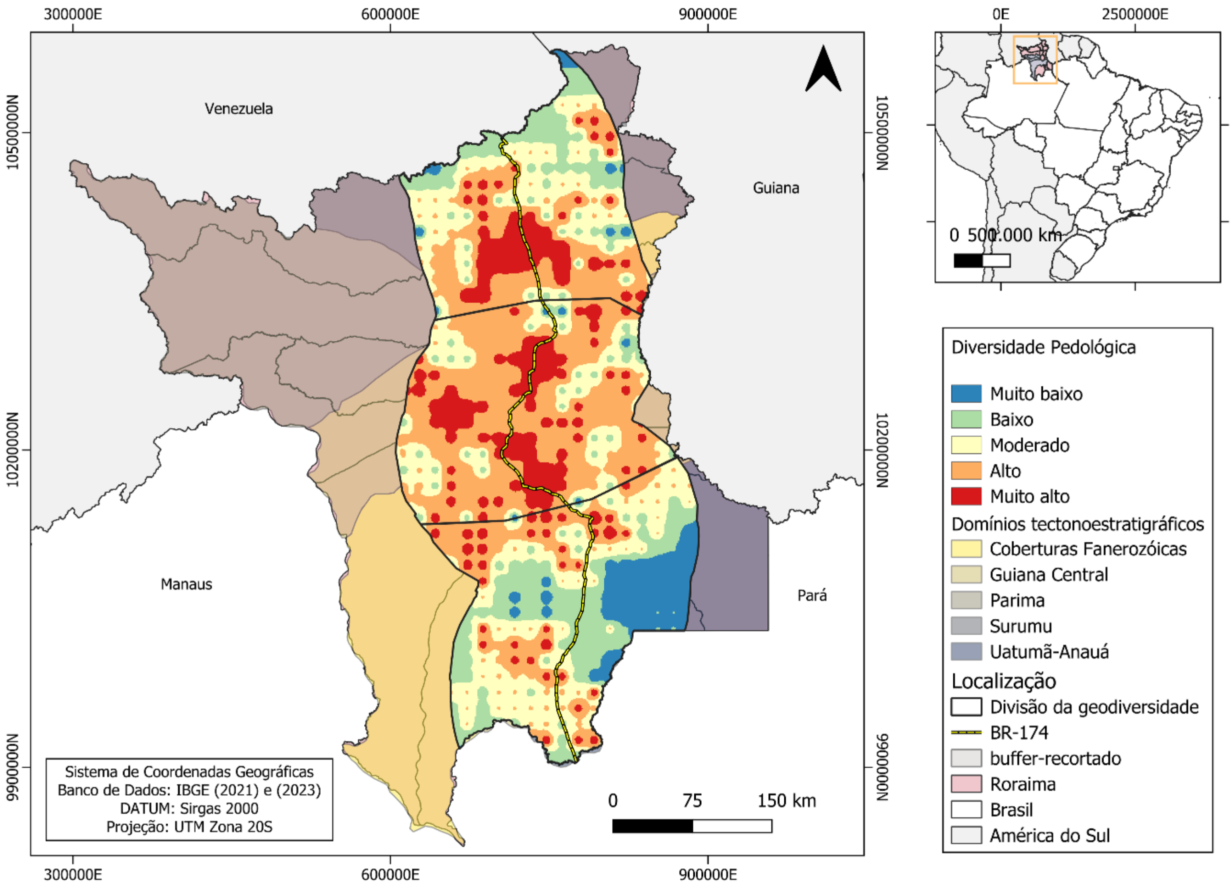

Figure 6. Pedological diversity map of the study area.

This heterogeneous distribution reflects the spatial variation of the controlling factors of pedogenesis. The pedological diversity hotspots in the central portion coincide with the transition zone between the Guiana Central and Uatumã-Anauá geological domains. In this sector, the juxtaoisition of contrasting lithologies and the convergence of distinct geomorphological compartments, notably the interface between the Guiana Plateau and the Amazon Plain, generate a complex mosaic of conditions for soil formation (Holanda; Marmos; Maia, 2014; Sander et al., 2024). Additional geomorphological processes, such as eolian deposition that formed paleodunes (Dias et al., 2025), contribute to the expansion of pedological variability.

In contrast, the low diversity indices recorded in the southeastern portion correlate with the lithological and geomorphological homogeneity of the crystalline basement of the Uatumã-Anauá domain, associated with the gently undulating surfaces of the Rio Branco-Rio Negro Pediplain (Dias et al., 2025). This uniformity of substrates and relief restricts the range of pedogenetic processes, resulting in a less diverse edaphic landscape (Vale Júnior; Cruz; Nascimento, 2017).

4. Discussion

4.1 Geodiversity Index

The Geodiversity Index (Igeo), a quantitative methodology recognized in the literature (Hermuche et al., 2022; Manosso et al., 2021; Silva et al., 2021; Toivanen et al., 2024), revealed a heterogeneous spatial pattern along the BR-174 corridor, with a concentration of high values in the central region, associated with the Guiana Central and Uatumã-Anauá tectonostructural domains (Figure 7). This pattern reflects the geological complexity of the Guiana Shield, where the juxtaposition of varied lithologies and complex structures, combined with dissected relief, results in greater abiotic class richness (Holanda; Marmos; Maia, 2014; Mendes et al., 2023). In contrast, the low diversity in the western and southeastern borders corresponds to geologically homogeneous environments, with a predominance of recent sedimentary convers and low-relief topography (Benedetti et al., 2011; IBGE, 2006, 2023).

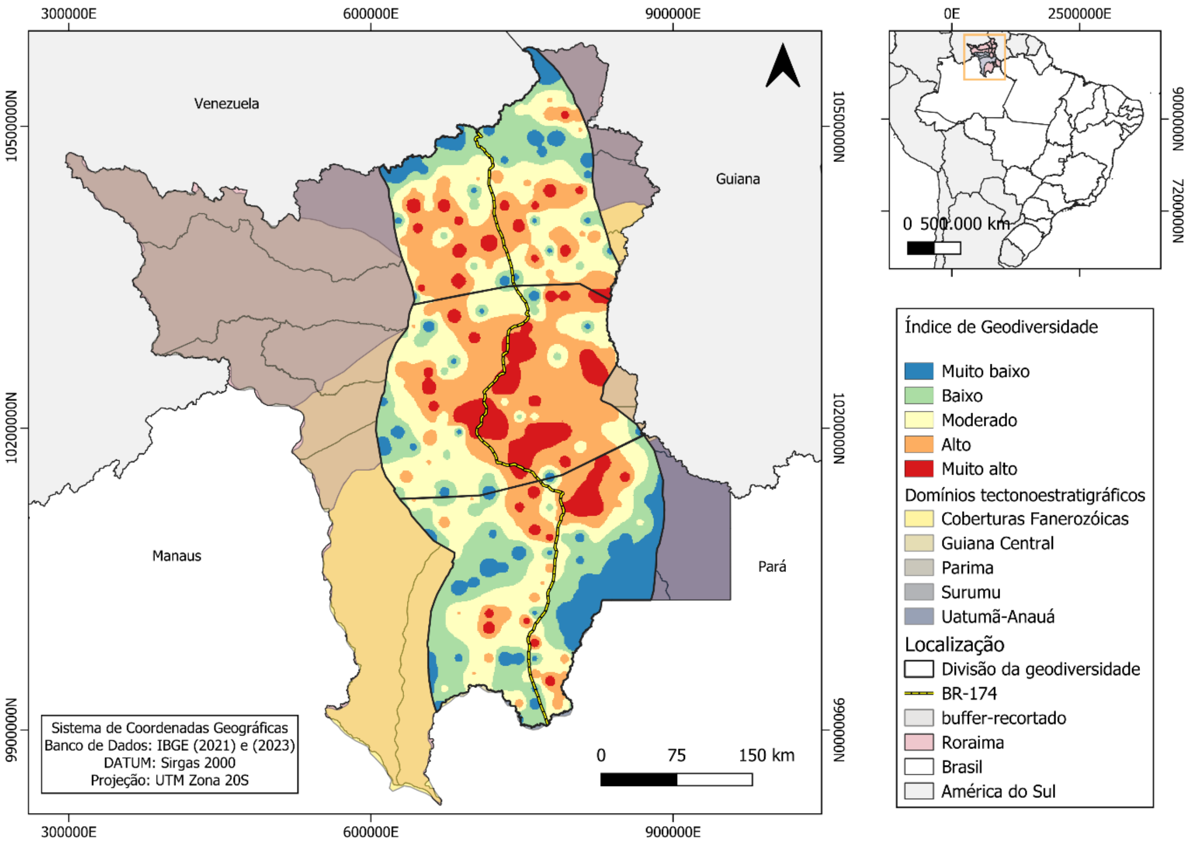

Figura 7. Geodiversity Index (Igeo) map of the study area.

It is important to highlight that the Igeo quantifies the variety and distribution of abiotic elements, bur does not, by itself, assign value to these elements. This distinction is central to the interpretation of the results: areas of high geodiversity are configured as priority zones for geoheritage prospecting, i.e., hotspots where the probability of occurrence of elements with potential scientific, educational, or tourism value is statistically higher (Hjort et al., 2024; Tukiainen; Bailey, 2023). The spatial convergence observed between areas of high Igeo and previously cataloged features of interest (waterfalls, rapids, mountain ranges), whose quantification will be demonstrated below, reinforces this premise, indicating that the index acts as a filter to guide future investigations.

The BR-174 corridor, by intersecting high abiotic heterogeneity, constitutes a strategic axis for geoconservation actions. However, it is important to emphasize that the results presented here do not constitute a direct measure of geotourism potential, which depends on additional criteria not evaluated in this study, such as accessibility, infrastructure, safety, and scenic value (Carrión-Mero et al., 2022). The quantification of geodiversity thus represents the initial stage of a broader process that must include qualitative geosite inventories, geoheritage valuation, and socioeconomic diagnoses.

The results obtained provide a technical basis for territorial planning, supporting abiotic heritage conservation strategies in accordance with sustainable development guidelines for the Amazon (Alsbach; Seijmonsbergen; Hoorn, 2024; Santo et al., 2021; Tukiainen; Bailey, 2023). Complementary studies at a detailed scale, including field geological characterization and vulnerability assessments, are necessary to consolidate the areas identified here as candidates for future geoconservation and geoeducation initiatives (Costa; Nascimento; Silva, 2022; Valdati et al., 2022).

4.2 Areas of Geological Interest (Geoheritage Prospecting)

The quantification of geodiversity through the integrated index (Igeo) in a GIS environment revealed a heterogeneous spatial pattern along the BR-174 corridor, with high values concentrated in the central sectors, coinciding with the Guiana Central and Uatumã-Anauá tectonostructural domains. This methodological approach, consolidated in the literature (Araujo; Pereira, 2017; Hermuche et al., 2022; Silva et al., 2021), provides objective subsidies for the identification of hotspots – sectors with a high concentration of abiotic elements that constitute the physical basis for geoheritage propecting (Brilha, 2016; UNESCO; IUGS, 2023).

The spatial convergence between areas of high Igeo and previously cataloged geological interest features – such as waterfalls, rapids, and notable geological formations (Figure 8) – demonstrates the effectiveness of the method as a filtering tool for identifying priority areas. Quantitative analysis reveals that 67% of the cataloged features spatially coincide with high-diversity sectors, indicating a significant correlation between the measured abiotic heterogeneity and the occurrence of known geological interest elements.

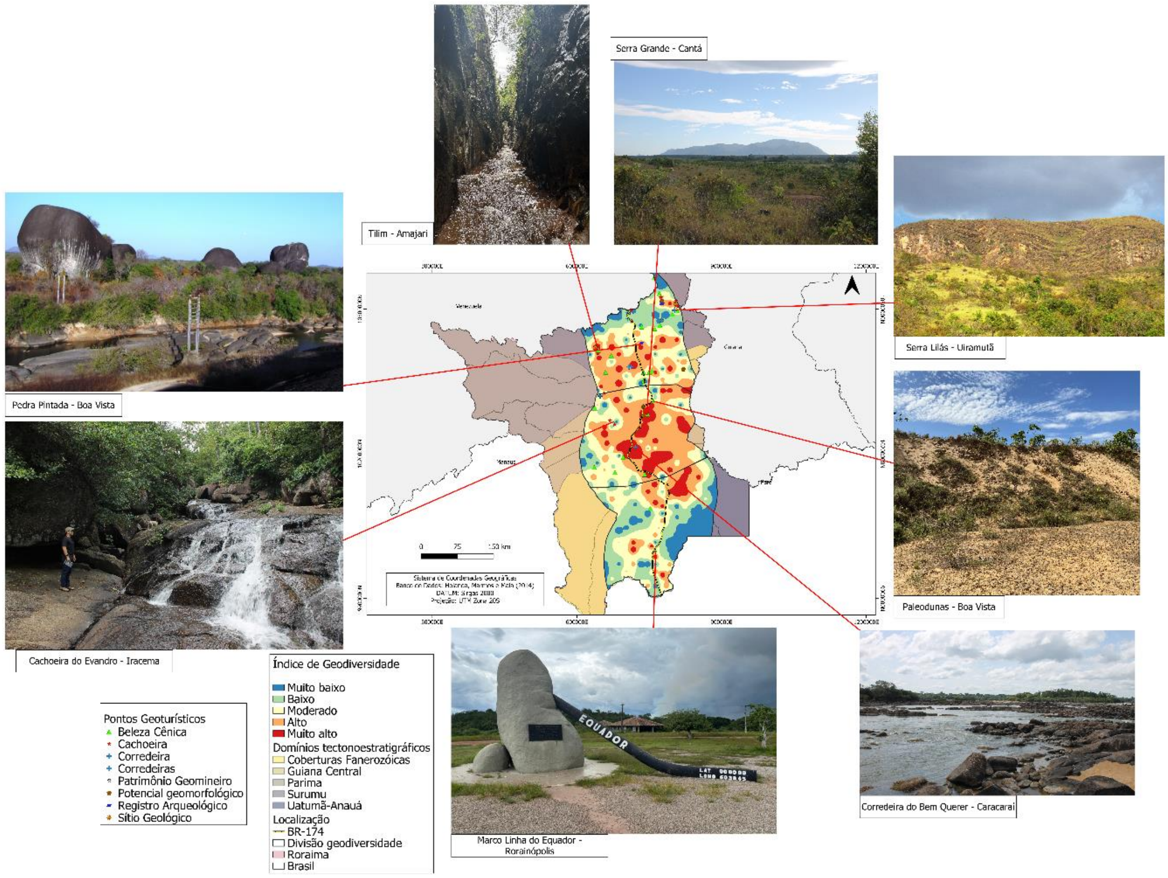

Figure 8. Geodiversity index map with previously cataloged geological interest elements. Source: The authors (databse: personal collection, Dias et al. (2024), Holanda, Marmos & Maia, (2014) e Veras et al., 2020).

These sites present multidisciplinar interest for the Geociencias, encompassing: (i) stratigraphic and paleoclimatic studies in Proterozoic sedimentary covers; (ii) petrological investigations of the igneous-metamorphic associations of the Mucajaí Suite and Cauarane Complex, and (iii) geomorphological and geological risk analyses in areas if greater structural instability (Alsbach; Seijmonsbergen; Hoorn, 2024; Holanda; Marmos; Maia, 2014).

It is essential to emphasize, however, that this spatial relationship does not constitute automatic validation of geotourism potential. Municipalities such as Alto Alegre, Amajari, and Boa Vista, which present medium Igeo values bur possess notable landscape features, exemplify how areas of lower abiotic diversity can equally harbor relevant elements for geoheritage (ANDRADE et al., 2021; Cunha, 2013; Dias et al., 2025; Falcão et al., 2018). This scenario ecidences that geodiversity quantification, although necessary, does not exhaust the assessment of territorial potential.

The regional approach adopted thus fulfills its functions as an exploratory tool, identifying priority areas that should be subjected to subsequent investigation stages. The systematic cataloging and qualitative valuation of geological interest sites constitute a process for transforming quantified diversity into valued geoheritage (UNESCO; IUGS, 2023). The consolidation of this potential will depend on the elaboration of territorial management plans that integrate the conservation of abiotic heritage with sustainable regional development strategies.

5. Conclusions

The quantitative analysis of geodiversity along the BR-174 corridor in Roraima allowed the identification of a heterogeneous spatial pattern, with values ranging from moderate to high – corresponding to 37% of the study area – concentrated mainly in the central sectors of the highway alignment. The application of the geodiversity index proved effective as an exploratory tool for identifying priority areas for abiotic heritage conservation at a regional scale.

This study constitutes one of the first integrated analyses of geodiversity along the entire BR-174 corridor, filling as important gap in regional scientific knowledge. The sectors that presented the highest geodiversity values spatially coincide with the Guiana Central and Uatumã-Anauá tectonostructural domains, notably in the municipalities of Mucajaí, Amajari, Iracema, and Caracaraí. The spatial convergence analysis revealed that 67% of previously cataloged geological interest elements coincide with high geodiversity areas, evidencing occurrence of known features of interest.

However, it is essential to emphasize that geodiversity quantification represents a preliminary step in the geoheritage valuation process. The results presented here provide technical subsidies for future investigations, but do not constitute, by themselves, an assessment of geotourism potential, which depends on additional criteria not addressed in this study, such as accessibility, infrastructure, safety, and scenic value.

It is recommended that the areas identified as priorities be targets of subsequent investigations, including: (i) geosite inventory with detailed geological characterization; (ii) environmental vulnerability and carrying capacity assessment; (iii) specific studies on accessibility and infrastructure.

The consolidation of a scientific basis for public geoconservation policies in the region will depend on the integration between the geodiversity quantification carried out here these subsequent stages of qualitative valuation of abiotic heritage.

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