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# PETRIFIED FOREST OF ALTOS (PI) AS GEOLOGICAL AND GEOMORPHOLOGICAL HERITAGE FOR GEOCONSERVATION

*Floresta Petrificada de Altos (PI) como Patrimônio Geológico e Geomorfológico para a Geoconservação*

*El Bosque Petrificado de Altos (PI) como Patrimonio Geológico y Geomorfológico para la Geoconservación*

**Adriana Oliveira SILVA** – Universidade Federal do Piauí (UFPI)
*ORCID ID*: https://orcid.org/0000-0002-0884-1918
*URL:* http://lattes.cnpq.br/0914403423335713
*EMAIL*: silvaaotrabalho@gmail.com

**Elisabeth Mary de Carvalho BAPTISTA** – Universidade Estadual do Piauí (UESPI)
*ORCID ID*: https://orcid.org/0000-0002-2885-7968
*URL*: http://lattes.cnpq.br/5386103931112605
*EMAIL*: baptistaeli@gmail.com

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## ABSTRACT

Occurrences of petrified forests have been recorded in various parts of the world and have been included in a protection perspective. In the opposite context, the Petrified Forest of Altos (PI) has no legal protection, no appreciation and no recognition of its importance as a heritage site for the municipality. Thus, the general aim of this article is to analyze the importance of the Petrified Forest of Altos, Piauí, as a geological and geomorphological heritage from a geoconservation perspective. In methodological terms, this research is classified as descriptive, explanatory and exploratory, adopting a qualitative approach, and in order to achieve the objectives the procedures carried out were: bibliographical, documentary and field research, with direct observation, photographic recording and cartographic study as a complement. A characterization of the study area in terms of its physical and natural aspects is presented, highlighting some sites of geological and geomorphological interest (LIGs). It is emphasized that the observations took place between 2019 and 2022, in order to identify changes over time. The work presents suggestions for possibilities and actions for geoconservation of the heritage, such as a legal framework, the creation of a geodiversity museum, the creation and fixing of an interpretive/informational panel, the production of an educational booklet and postcards. The aim is to sensitize society in general to the importance of the Petrified Forest, in order to contribute to the appreciation and dissemination of this heritage site in the municipality of Altos (PI).

**Keywords:** Fossilized Forests; Geodiversity; Geopatrimony; LIGs.

**RESUMO**

As ocorrências de florestas petrificadas têm sido registradas em várias partes do mundo e inseridas numa perspectiva de proteção. Num contexto ainda oposto a este, a Floresta Petrificada de Altos (PI) encontra-se desvinculada de proteção legal, de valorização e reconhecimento da sua importância como um patrimônio para o município. Assim, o objetivo geral deste artigo é analisar a importância da Floresta Petrificada de Altos, Piauí, como patrimônio geológico e geomorfológico numa perspectiva de Geoconservação. No aspecto metodológico, esta pesquisa classifica-se como descritiva, explicativa e exploratória, adotando-se a abordagem qualitativa, e para o alcance dos objetivos os procedimentos realizados foram: pesquisa bibliográfica, documental e de campo, com observação direta, registro fotográfico e estudo cartográfico como complemento. Apresenta-se, então, a caracterização da área de estudo em seus aspectos físico-naturais, destacando alguns locais de interesse geológico e geomorfológico (LIGs). Enfatiza-se que as observações ocorreram entre os anos de 2019 e 2022, com o intuito de identificar mudanças ao longo do tempo. O trabalho apresenta sugestões de possibilidades e ações para a Geoconservação do patrimônio como, o enquadramento legal, a criação de um museu da geodiversidade, a elaboração e fixação de um painel interpretativo/informativo, confecção de cartilha educativa e cartões-postais. Almeja-se a sensibilização da sociedade de forma geral quanto ao reconhecimento da importância da Floresta Petrificada, visando contribuir para a valorização e divulgação deste patrimônio do município de Altos (PI).

**Palavras-chave**: Florestas Fossilizadas; Geodiversidade; Geopatrimônio; LIGs.

**RESUMEN**

Se han registrado apariciones de bosques petrificados en diversas partes del mundo y se han incluido en una perspectiva de protección. En el contexto opuesto, el Bosque Petrificado de Altos (PI) carece de protección legal, de valoración y de reconocimiento de su importancia como patrimonio del municipio. Por lo tanto, el objetivo general de este artículo es analizar la importancia del Bosque Petrificado de Altos, Piauí, como patrimonio geológico y geomorfológico desde una perspectiva de geoconservación. En términos metodológicos, esta investigación se clasifica como descriptiva, explicativa y exploratoria, adoptando un enfoque cualitativo. Para alcanzar los objetivos, los procedimientos llevados a cabo fueron: investigación bibliográfica, documental y de campo, con observación directa, registro fotográfico y estudio cartográfico como complemento. Se presenta una caracterización del área de estudio en cuanto a sus aspectos físicos y naturales, destacando algunos lugares de interés geológico y geomorfológico (LIGs). Se destaca que las observaciones tuvieron lugar entre 2019 y 2022, con el fin de identificar los cambios a lo largo del tiempo. El trabajo sugiere posibilidades y acciones para la geoconservación del patrimonio, como un marco legal, la creación de un museo de la geodiversidad, la creación y fijación de un panel interpretativo/informativo, la producción de un folleto educativo y de postales. El objetivo es sensibilizar a la sociedad en general para que reconozca la importancia del Bosque Petrificado, con el fin de contribuir a la valorización y difusión de este patrimonio en el municipio de Altos (PI).

**Palabras clave:** Bosques Fosilizados; Geodiversidad; Geopatrimonio; LIGs.

## 1 INTRODUCTION

The discussions about geodiversity, geological heritage, geomorphological heritage and Geoconservation have been gaining more and more space with relevant studies and

themes, making it necessary for society to have knowledge about their elements, their importance and strategies for the conservation of these heritage sites. In this context, geography can play a relevant role in the studies of such themes, discussing, analyzing and interpreting the different aspects and landscapes.

The concepts of geodiversity, geological heritage and integrate a new way of understanding the landscape, especially in the abiotic aspect. The natural landscape is the result of the inseparable relationship of biotic and abiotic elements, which in some moments one stands out visually in relation to the other (Meira; Morais, 2016). Therefore, to understand this relationship, specifically, what are these abiotic elements, it is necessary to first understand what are these concepts that have been discussed.

Starting with geodiversity, which is defined by Nieto (2001), as number of variety of structures (tectonic, sedimentary, geomorphological, petrological, hydrological) and geological materials (minerals, fossil rocks and soils) that constitute the natural physical substrate of a region. For Gray (2004), geodiversity must be conserved, because, in addition to being valuable, it is threatened by a wide variety of anthropogenic activities. Also according to the author, geodiversity is made up of values: intrinsic, cultural, aesthetic, functional, economic, educational and scientific.

According to Rodrigues and Fonseca (2008, p. 4) geodiversity can be understood as: “[...] the set of natural elements (geological, geomorphological, pedological, hydrological, scenic, etc.) existing in a given space”. In their conceptions, the greater the variety of these elements in a given area, the greater the geodiversity present there. Given the discussion on geological heritage Meira and Morais (2016), they emphasize that geodiversity comprises abiotic elements as a whole, whereas geological heritage is one that acquires exceptional value through human evaluation.

Thus, according to Nascimento, Ruchkys and Mantesso-Neto (2008), the concept of geological heritage is represented by the set of geosites, being then a small portion of geodiversity, presenting special characteristics and, therefore, should be conserved. For Brilha (2005), geological heritage is defined by the set of geosites inventoried and characterized in a given area or region, which have singular value, scientific, cultural, tourist and pedagogical value.

Regarding the geomorphological heritage, for Pereira (2006, p. 63), this: “[...] is made up of geoforms to which one or more types of value have been assigned”. According to the author, all geoforms have value in one or more aspects, thus, the geomorphological

heritage or places of geomorphological interest (LIG) are attributed scientific, cultural, aesthetic, economic and ecological values.

The geomorphological heritage, according to the point of view of Figueiró, Vieira and Cunha (2013), is based on the value that the different forms of use attribute to this heritage, to which different classes of value are associated: functional value, cultural value, economic value, and scientific-pedagogical value. Being that the functional value of the geomorphological heritage has a substantial link in ecology, referring both to the relief and support of life development (Figueiró; Vieira; Cunha, 2013).

In this context, Geoconservation arose from the need to conserve and manage geological heritage, analyzing both the values given to it, as well as its vulnerabilities. According to Sharples (2002), Geoconservation aims to preserve the natural diversity of significant geological, geomorphological and soil aspects while maintaining their natural evolution, that is, geodiversity.

According to his point of view, Geoconservation recognizes that non-living elements of the natural environment are just as important as living ones. For this, Brilha (2005) points out that Geoconservation strategies consist of the realization of a systematized work methodology and grouped into sequential stages: inventory, quantification, classification, conservation, valuation, dissemination and monitoring.

Through the discussions and based on the literature, it is understood that geodiversity results from the interaction of several factors and integrates geological and geomorphological diversity and, within the set of this diversity, fossils are elements of geodiversity that, like the others, have values and need protection. In Carvalho's conception (2018), fossils represent records preserved in different conditions and make it possible to understand the history and evolution of life during the existence of the Earth.

Considering the theme addressed in this work, petrified or fossil forests fall within these categories, and that over time the occurrences of these have been recorded in various parts of the world, and inserted in a legal protection perspective, which evidences the concern to conserve and disseminate the relevance of these heritage sites (Silva, 2022; Dias-Brito *et al*., 2009). However, in a context opposite to this, the Petrified Forest of Altos (PI) is disconnected from legal protection, valuation and recognition of its importance as a heritage for the municipality.

Thus, the general objective of the article is to analyze the importance of the Petrified Forest of Altos, Piauí, as a Geological and Geomorphological Heritage from a Geoconservation perspective. Specifically, the objectives are to characterize the study area

in its physical-natural aspects and suggest geoconservation actions for the geological and geomorphological heritage studied.

In the methodological aspect, this research is classified as descriptive, explanatory and exploratory, because it sought to observe, describe, characterize, interpret and explain the object of study, adopting a qualitative approach. To achieve the objectives, the procedures carried out were: bibliographic, documentary and field research, with direct observation carried out in August 2019, October 2020, April 2021, January and June 2022.

Photographic record and cartographic study were carried out as a complement, presenting the characterization of the study area, highlighting some sites of geological and geomorphological interest (LIGs). It should be noted that for the cartographic study, initially a search was carried out for maps of the area, in the second moment, instruments and technological resources were used such as Global Positioning System (GPS) navigation and application “Minhas Coordenadas GPS” to mark location points, Google satellite (2021), Qgis 3.10.6 (2022), source of cartographic bases of the Brazilian Institute of geography and Statistics (IBGE, 2020; 2021) and the National Institute of Colonization and Agrarian Reform (INCRA, 2022), for research and map production.

Thus, this text is organized talking about the study area and its characteristics, especially the present geodiversity, in order to situate its relevance in the scope of Geoconservation and then points out the geoconservative strategies designed for the protection of the forest, also aiming at the awareness of the local community and engagement of municipal management.

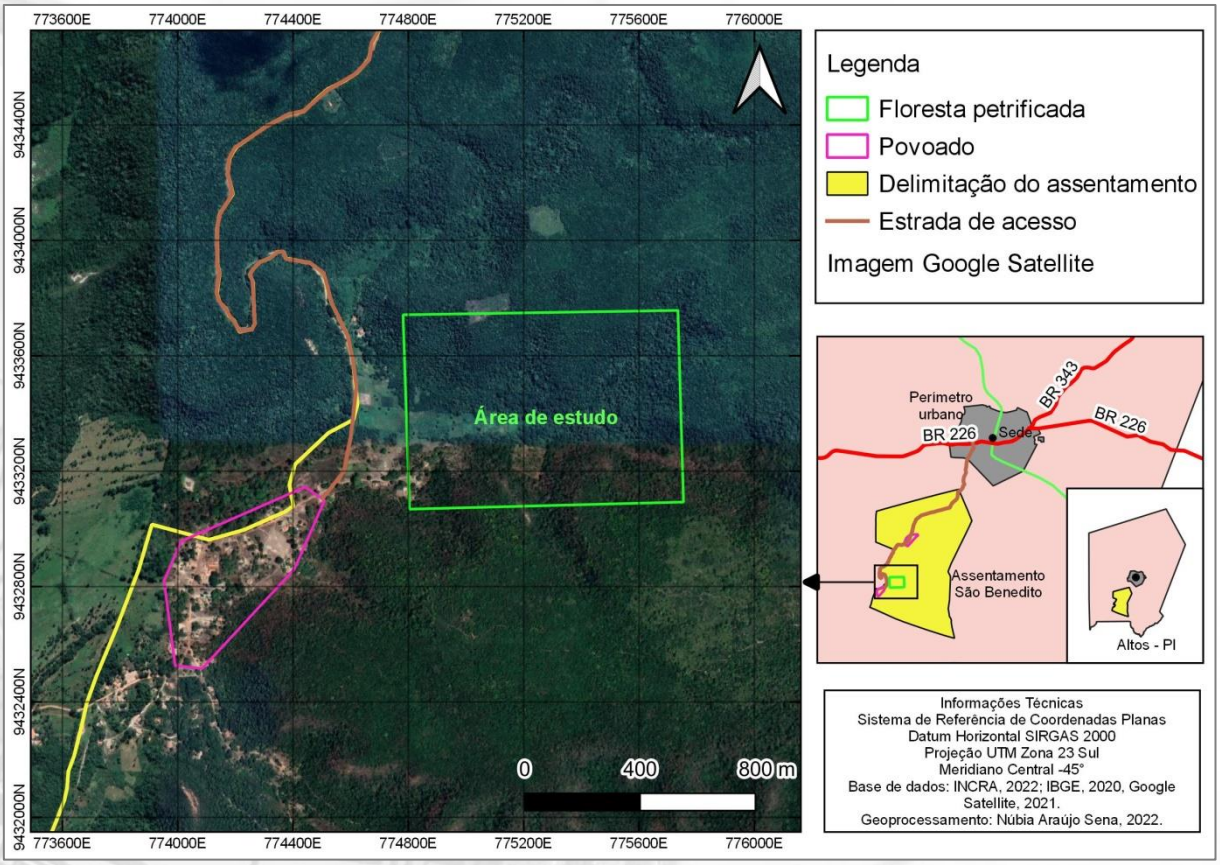
## 2 PETRIFIED FOREST OF ALTOS (PI): GEOCONSERVATION OF THE GEOLOGICAL AND GEOMORPHOLOGICAL HERITAGE

The municipality of Altos is located in the Teresina microregion and is bordered by the municipalities of José de Freitas and Campo Maior to the North, Beneditinos and Pau D'arco do Piauí to the South, Campo Maior and Coivaras to the East, and Teresina and Demerval Lobão to the West. The geographical coordinates of the municipal seat are 05° 02’17” lat. S and 42° 27’36” long. the e is 37 km from Teresina (Aguiar; Gomes, 2004; Piauí, 2013).

The Petrified Forest of Altos (PI) is located in the community Brejo São Benedito, settlement of the National Institute of colonization and Agrarian Reform (INCRA) and is 13.5 km from the urban area of the municipality (Figure 01). Access to the area is by road or dirt

road in the southern direction and it is considered that the route to the Petrified Forest is easy.

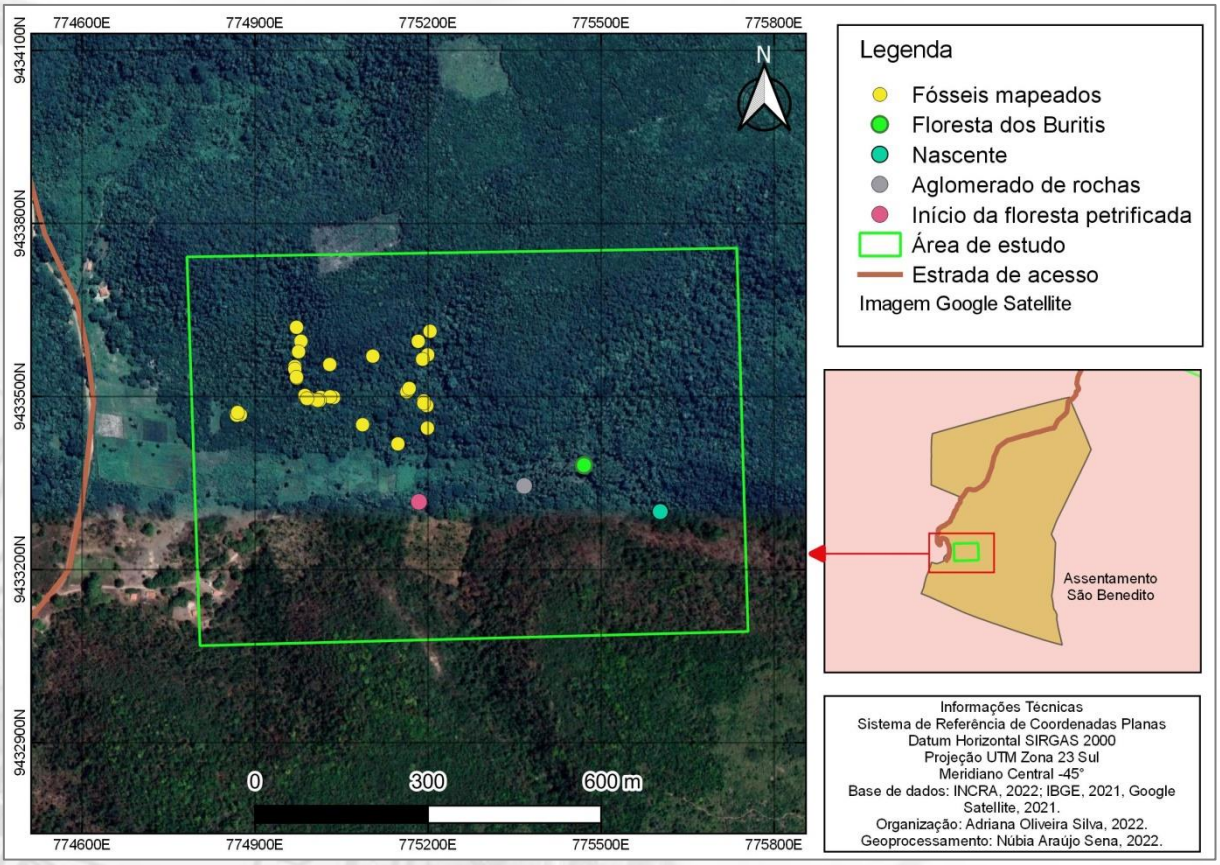
**Figure 01** – Location of the study area: Altos Petrified Forest (PI)




**Source:** The Authors (2024).

The delimitation of the study area was carried out based on the field survey in January 2022 with the help of GPS navigation, presenting the indication of some fossil trunks, also highlighting four other elements: spring, buritis forest, cluster of rocks and beginning of the Petrified Forest (Figure 02). The spring, the buritis forest and the cluster of rocks are inserted in the context of the object of study as constituent elements of the geodiversity itself analyzed, and as for the point indicated as the beginning of the Petrified Forest, this was selected because it was always the starting point to enter the forest.

**Figure 02** – Study area with mapped fossils




**Source:** The Authors (2024).

The indication of these points was complemented with a new survey carried out in June 2022, with the help of the “Minhas Coordenadas GPS” application available on the internet, in order to continue the research objective and demonstrate that there is significant geodiversity in a significant area, thus reinforcing the importance of the forest and its geodiversity that needs to be studied, disseminated and protected.

It should be noted that a more comprehensive extension of the Altos Petrified Forest was previously mapped in studies carried out by Conceição, Cisneros and Iannuzzi (2016), cataloging a relevant amount of fossil trunks. However, it was decided to carry out a new survey of the area aiming at a proper delimitation for the cut of this research, covering a space of about 1.8 km in length, based on the georeferencing of the selected points. The study site consists of an outcrop of the Pedra de Fogo Formation (CPRM, 2006), which according to Caldas *et al*. (1989), is recognized for its content in fossil trunks.

The concentration of fossil trunks of the Petrified Forest of Altos is covered by dense vegetation that in the rainy season makes it difficult to access the site, because in this period the trails are closed by vegetation. The municipality of Altos has a tropical sub-humid and semi-arid climate, with average temperatures between 22°C and 37°C. The average annual rainfall is between 800 and 1,600 mm, with about 5 to 6 months as the wettest and the remaining period of the year dry season. The rainy period lasts from December to May, with maximum precipitation in February and March (CEPRO, 2013; Gomes, 2022).

The study area is located on the slope of a hill and, through observation, it was possible to perceive a significant amount of fossil trunks of different sizes, many have preserved structure, some seem to be in a position of life and others, due to weathering processes, are in a vulnerable state, broken and deteriorating.

Due to the slope, it was noticed that several fossil fragments are dragged by rainwater, which can cause “loss”, be covered by sediments or dragged further away, to areas where agriculture is developed, because in the vicinity of the forest there is occurrence of these activities and the breeding of animals such as goats and pigs that can cause impacts to fossil trunks. Based on field observation, table 01 was prepared with the general characterization of the area, considering the natural and anthropic physical aspects, as well as the approach and objectives of the research regarding the geological and geomorphological heritage studied.

**Table 01** – General characterization of the study area

| **Field observations considering physical-natural and anthropic aspects** | |
|---|---|
| **Legal Framework**: None | **Type**: Not applicable |
| **Description** | |
| **Geological Aspects -** Rocks; Fossils; Minerals. | |
| Significant presence of overlapping rocks with varying diameters in the vicinity of the buritis forest and the spring, on a sloping surface. There are fossils and fragments throughout the forest area of varying sizes, presenting characteristics of the bark, of the growth rings, of the “core”, being some with preserved structures, others vulnerable, broken, rolled, some seem to be in a position of life. This concentration occurs mainly in the lower areas, that is, the closer one approaches the elevated areas of the hill the presence of fossils decreases and no fossils were visualized in the higher areas traveled. The minerals are quite visible in the fossils, many have quartz crystals both on the outside and inside. Some rocks found in the forest also have crystals, which can be seen after breaking. | |
| **Geomorphological aspects** - Hills | |
| The entire area around the study site has expressive relief forms, such as hills with peculiar characteristics, covered with dense vegetation, with the presence of coca forest and water upwelling (Water Spring – source). | |
| **Hydrological Aspects** - Springs | |

| |
|---|
| The spring is inserted in an area of buritizais, which by the height of these are believed to be ancient. The site is not preserved, so it is vulnerable, which also impacts the flow of water. The spring is surrounded with palm trunks (placed by the locals), there is a lot of organic material such as straw, leaves, and waste left by people at times who visit the place. |
| **Soils** - Sandy; Stony; Soggy; Organic. |
| On the way to the Petrified Forest, buritis forest/buritizais and the spring, the soils are sandy (fine sand), partly with the presence of piçarra. In the buritizais and spring, the soils are soaked, especially in the rainy season, also presenting as organic by the presence of organic matter from vegetation. In the area of the Petrified Forest, on the slope of the hill the soil is Sandy, but as you go deeper into the forest to the top of the hill you can see a stony soil, with the presence of several rocks. The study area is located in the pedological unit: Concretionary Petric Plinth. The soils of the region are composed of alic, podzolic plinths of red-yellow colors, plinths and non-plinths with caatinga/cerrado deciduous vegetal transitions, sandy soils essentially quartzose, deep, drained, devoid of primary minerals, of low fertility (EMBRAPA, 2018; Aguiar; Gomes, 2004). |
| **Biodiversity -** Vegetation; Animals. |
| The area has rich vegetation, with coconut forest, buritizal forest, typical trees of the region such as, for example, caneleiro (*Cenostigma Macrophyllum Tul*), sapucaia (*Lecythis pisonis Cambess.*), jatobá (*Hymenacea courbaril L.*), Copaíba (*Copaífera duckel*), angico branco (*Anadenathera colubrina*), mufumbo (*Combretum leprosum Mart*), among others (Gomes, 2022). It has been observed that there are fish (small) in the spring, cobracipó in the forest (*Chironius quadricarinatus*), fire-extinguished birds (*Columbina squammata*), black anu (*Crotophaga ani*) and burrows that may be of armadillos (*Dasypodidae*), armadillos-peba (*Euphractus sexcinctus*) or other animals (Altos, 2023). |
| **Natural vulnerability** - Erosive processes |
| Water is the main agent of these processes, since in the course of the spring it occurs in a natural way. However, agricultural planting was observed on part of the route. In the buritis forest pigs interfere with the growth of new palm trees. In the Petrified Forest there is erosion caused by rainwater. |
| **Occupation Area** - Surrounding community |
| The surrounding community does not live so close to the study area, but it is noticed that some activities are carried out nearby. |
| **Activities -** Agriculture; Animal husbandry; Extractivism. |
| The activities of notable visualization in the vicinity of the Petrified Forest are cultivations (swiddens), animal husbandry (pigs, goats, cattle), collection of buritis (*Mauritia flexuosa*) and logging (Altos, 2023). |
| **Degradation** - Pollution; Logging; Forest fire. |
| It was possible to observe that the spring is not protected and not well cared for, there are bottles, plastic bags, fabrics on the site). It was possible to observe the occurrence of a tree (medium-sized) cut in the Petrified Forest, even compromising the fossils, because it is on these. In one part of the forest it was observed that there was an occurrence of burning, reaching some fossils and the presence of broken glass in a well accessible area of the forest. |

**Source**: Organized by the Authors (2024).

Geodiversity consists of areas with potential and should be known, studied and disseminated for protection and enhancement purposes, however, Ruchkys (2007), points out that the promotion and conservation of geological heritage is a great challenge. In order to identify, describe, disseminate and contribute to the Geoconservation of geological

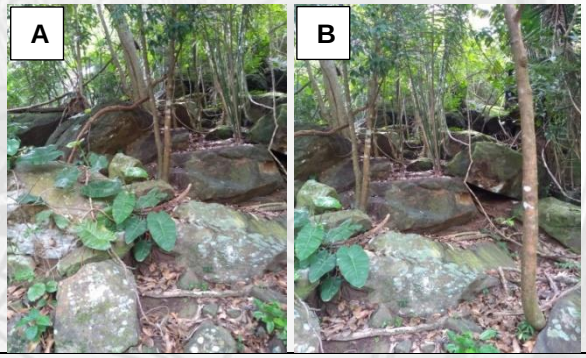
heritage and its existing categories in the studied area, some points were selected to exemplify the diversity of the site, demonstrating the richness of elements and the need to create strategies to ensure the conservation of heritage indicated in Figure 03 as sites of geological and geomorphological interest (LIGs).

The description of the selected LIGs was designed as a way to create a nomenclature for them, considering their characteristics and the possibility of creating and fixing nameplates. Regarding the description of the potentials, the objective was to point out possibilities of uses, such as educational and scientific, also describing the forms, structures and other possibilities.

**Figure 03** – Highlighted Places of Geological and Geomorphological Interest (LIGs)

**LIG 1 – Cluster of rocks**. Latitude S 5°7'18.27984'; Longitude: W 42°30'58.563' Potential/observations: Aesthetic, educational, scientific – arouses curiosity for the beauty, size, structure and details of rocks when viewed closely; can be observed and analyzed by students in field classes; enable studies, analyzes and research on outcrops, types of rocks, geological formation of the area, among others.

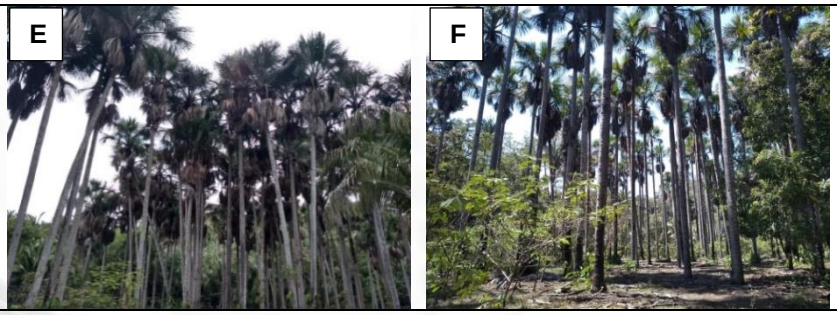
**LIG 1**



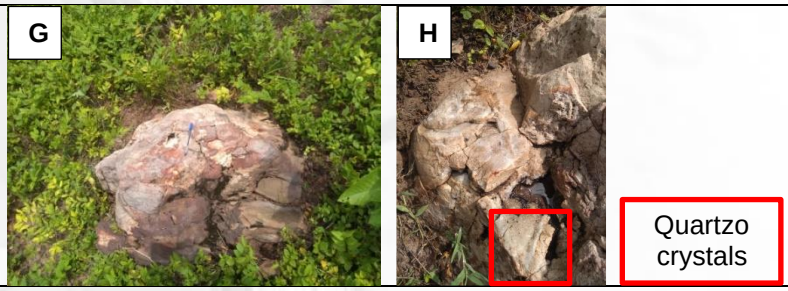

**LIG 2**


**LIG 2 – Spring of the Buritis**; **Water spring of the Buritis**. Latitude: 5°7'19,30656'; Longitude: W 42°30'50,99904"
Potential/observations: Aesthetic, educational, scientific-in view of the very natural beauty of the place, the existence of a spring in itself is of fundamental importance for nature and for living beings; it can be visited in field classes, through which it can be approached from the processes of formation to the importance of preservation/conservation of the; studies can be carried out on the water, whether it is suitable for "direct" consumption and its importance to the local community, which has already used spring water for its own consumption.

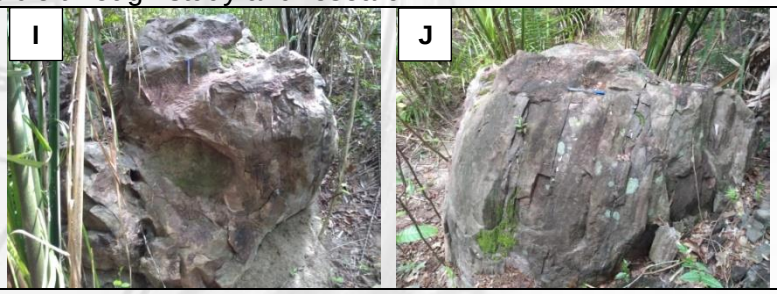
**LIG 3 – Buritis Forest**. Latitude: S 5°7'17,20812'; Longitude: W 42°30'55,31904 "
Potential/observations: Aesthetic, educational, subsistence-the area presents distinct landscapes in rainy and dry periods, they are palm trees that arouse attention for their height, which leads to understand that they have been around for a long time, the fruit falls when ripe and is collected by the residents of the; the forest can be visited in field classes to address the entire context in which it is constituted as, for example, a typical tree of the region, means of subsistence, food for animals, importance of conservation.




**LIG 4 – Fossil 1 - "Crystals".** Latitude: S 5°7'1435332'; Longitude: W 42°31 ' 14.754' Potential/observations: Aesthetic, educational, scientific – one of the easily accessible fossils, not exactly inserted within the forest, that is, the densest area; it is in a clean area, can be easily visited, including by students to know a petrified tree fossil, viewing crystals (possibly Quartz) in the fossil and know the existence and importance of a petrified forest in the region where they live.




**LIG 5 – Fossil 2 – "The biggest?"** Latitude: S5°7'13.22688'; Longitude: W42°31'10.9182' Potential/observations: Aesthetic, educational, scientific – the largest fossil of the forest visualized at the first moment, the size draws a lot of attention, which demonstrates that the trees that existed there were of significant sizes, arouses interest in knowing the history of the area, being possible through study and research.




**LIG 6 – Fossil 3 - "Life position"?** Latitude: S 5°7'13,4706'; Longitude: W 42°31'10,3026' Potential/observations: Aesthetic, educational, scientific – presents a structure that draws attention to detail, position (Life?) and bark shape and structure of the center of the tree even though it is only a small part.

**LIG 6**



**LIG 7**



**LIG 7 – Fossil 4 – "Fallen"** Latitude: S 5°7'13,33848'; Longitude: W 42°31'10,04304' Potential/observations: Aesthetic, educational, scientific – this fossil is in a fallen position,

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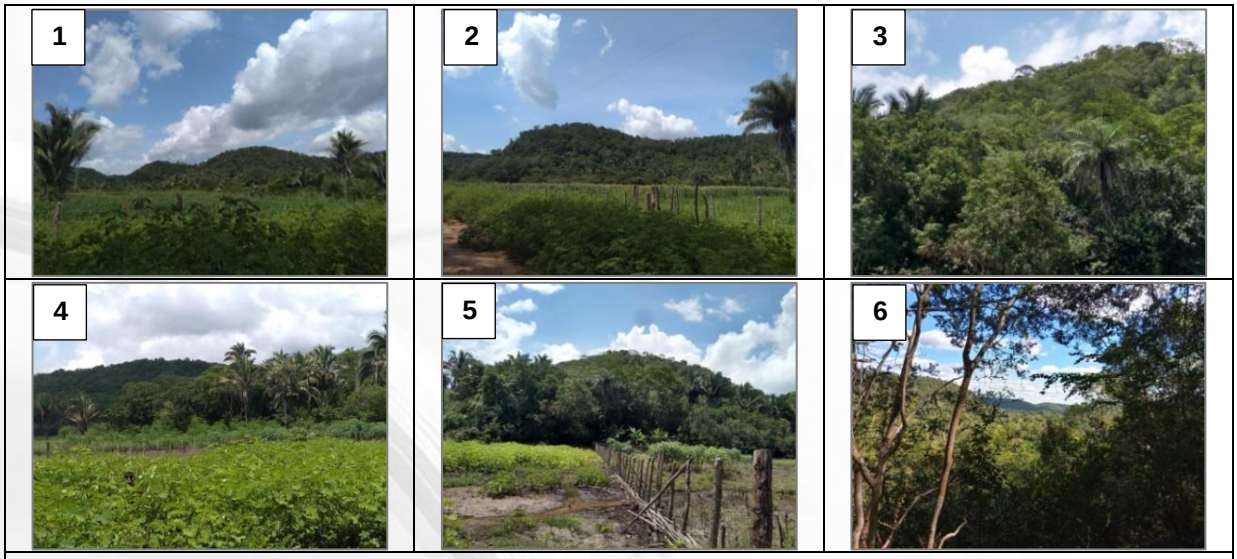
|---|
| presents details of the structure of wood, including due to the action of nature visibly looks like wood. |
| **LIG 8 – Fossil 5 – "Big fossil - life position?"** Latitude: S 5°7'13,45368"; Longitude: W 42°31'10,07724<br>Potential/observations: Aesthetic, educational, scientific – many details are observable, in addition to the diameter, the position in which it is (of life?), the structure of the center, with the presence of crystals, a part apparently detached in block and/or in fragments. |
| **LIG 8**<br>  <br><br>**LIG 9**<br>  <br> |
| **LIG 9 – Fossil 6 – "With hole in the center"** Latitude: S 5°7'13.32768'; Longitude: W 42°31'9.30504'<br>Potential/observations: Aesthetic, educational, scientific – with expressive detail, this fossil presents a "clean" structure, being possible to observe the marrow (term used by Conceição, Cineros and Annuzzi (2016) to designate the center of the fossil) highlighted by the central hole that did not petrify, with slight growth ring shapes - Permian period according to Conceição, Cisneros and Annuzzi (2016). |
| **LIG 10 – Fossil 7 - "Fossil palm trees"** Latitude: S 5°7'15.93948'; Longitude: W 42°31'5.67552'<br>Potential/observations: Aesthetic, educational, scientific - fossil of easy access, it is a little distanced in relation to the other fossils of the area, in a place where there is the presence of some palm trees such as babassu and macauba. It may be one of the appropriate visitation by students, considering access.<br>  <br> |

**Source**: The Authors (2024).

It is important to select, also within this context, landscapes and/or geoforms that have relevant significance as places of geomorphological interest that make up the geodiversity of the environment, as they attract attention for their expressiveness, as shown in Figure 04.

**Figure 04** – Landscapes and geoforms – Geomorphological Patrimony

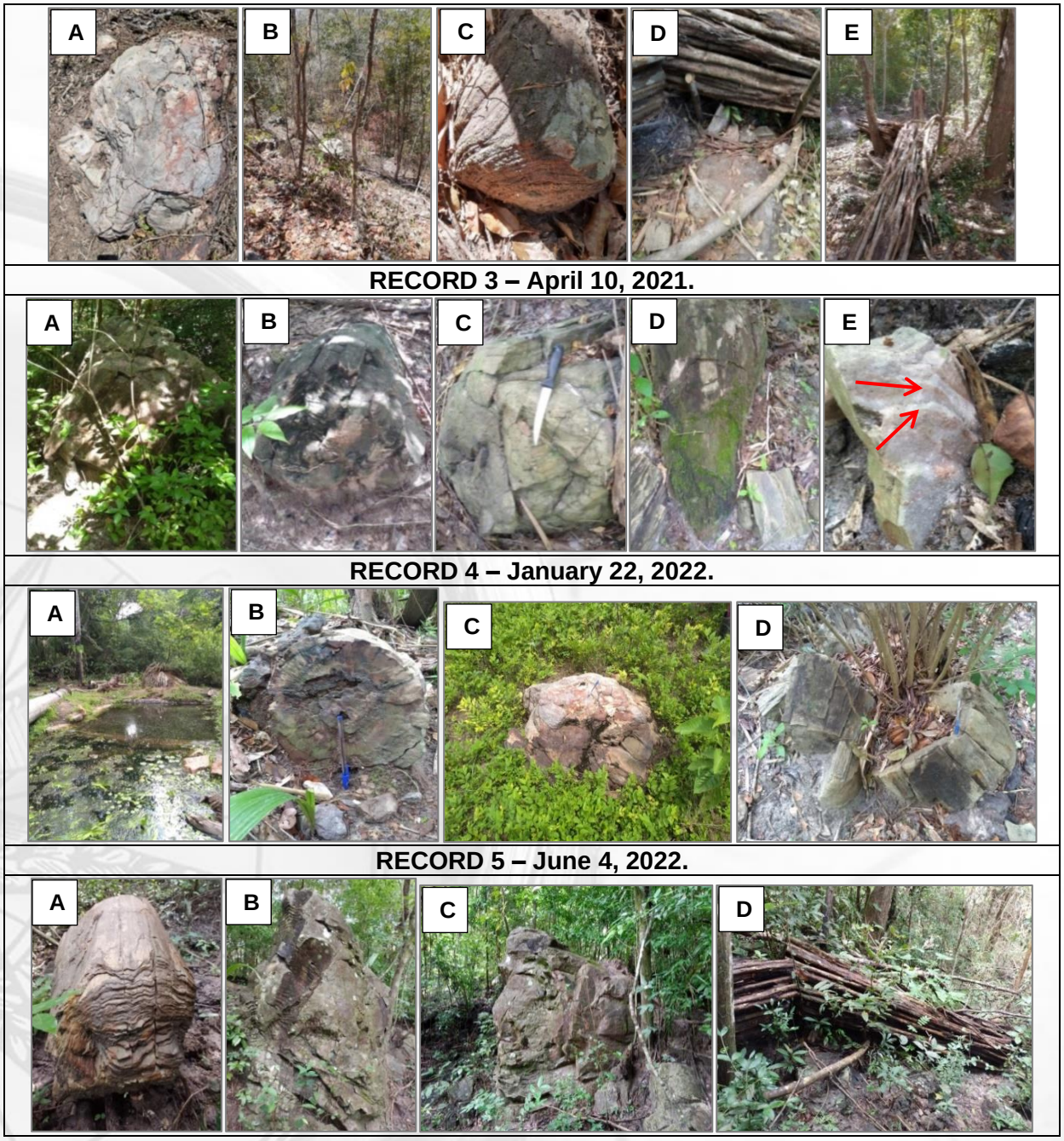



Photos 1 and 2 were recorded from the access road, sense location of the study area, and it is possible to observe some hills. Photos 3, 4 and 5 were taken in the vicinity of the Petrified Forest, showing a portion of the surrounding landscape and typical vegetation of the region, such as babassu palms, in Photo 5 it is possible to visualize a small path of spring water and presence of cultivation activity, and Photo 6 was recorded from a high point in the study area.

**Source**: The Authors (2024).

The photographic record gathered in Figure 03 shows that the entire surrounding area is an expressive landscape by modeling the relief and vegetation. To have a more comprehensive view of the heritage studied, the objective was to make an analysis of the landscape observing its changes over time. Figure 05 summarizes the records of the observations carried out in the period from 2019 to 2022.

**Figure 05** – Field observation between August 2019 and June 2022




**Source**: The Authors (2024).

In light of the explanation, we can highlight some points and changes from one record to another. Through observation in the forest, it was possible to visualize a significant number of petrified trunks and distinct positions, demonstrating considerable diversity and drawing attention due to their structures. A particularly noteworthy point that requires special attention was the presence of burn marks in the area (photo F) in record 1 (August 2019).

Record 2 (October 2020) vividly illustrates the dry season, highlighting changes in vegetation (photos A, B). During this survey, as shown in photos D and E, a fallen tree of the species caneleiro (*Cenostigma Macrophyllum Tul*) was documented, which impacted

and damaged fossil trunks. In Record 3 (April 2021), differences in vegetation, fossils, and soil are evident. Some fossils display darker and greenish parts due to the presence of substances from organic matter caused by the rainy season. In photo E, part of a fossil with quartz veins can be seen.

Record 4 occurred in January 2022, in photo A, the source is observed with a significant water volume due to the rainy season, although the water is not clear. Photo C displays the same fossil as in photo A from record 2 in 2020, and a noticeable change in vegetation is apparent, reflecting the different periods (dry/rainy seasons). Photo D shows that the fossil from photo E in record 1 (August 2019) has undergone changes over time, breaking into pieces. The likely cause of this fossil's fragmentation is exposure to atmospheric elements such as rain, sunlight, wind, and heat.

Record 5 was made towards the final phase of the study (June 2022), still during a period of rainfall. The fossils documented in this record do not appear in previous records, as they were observed only at this last moment. Photo A presents one of the most striking fossilized trunks due to its shape, with visible details of the tree bark's texture. Photos B and C show the same fossil from different angles, this being the largest one recorded. An important observation is made regarding photo D, which shows the same tree as in photos D and E from record 2 in 2020, despite nearly two years having passed, the trunk has not been removed from the site.

Through the analysis of the records, it is evident that the study area possesses a rich diversity of geodiversity elements that attract attention becauso of their shape, size, color, peculiarities, beauty, or simply the privilege of observing something from such a remote period that has survived to the present days. It can be ascertained that the studied area has strong and distinct potentialities, encompassing aesthetic aspects with its landscape appeal, and scientific value, due to its wealth of elements that should be studied and disseminated through scientific and educational works. This is perhaps the most prominent aspect from the perspective of strategies to achieve Geoconservation of the patrimony.

## 3 STRATEGIES FOR GEOCONSERVATION OF THE PETRIFIED FOREST FROM ALTOS (PI)

The promotion and conservation of geological patrimony is a significant challenge, with one of the main threats, as emphasized by Brilha (2005), being the lack of knowledge

about the importance of this patrimony. Given the confirmation of the representativeness and importance of geodiversity, and the understanding that it is impossible to conserve what we do not know, it is necessary for topics related to geodiversity to become as well-known and valued as possible, and in this context, educational environments are essential (Silva; Aquino, 2018).

According to Baptista and Lima (2020, p. 272): "[...] Geodiversity increasingly requires to be recognized and valued by social groups, and for this condition to be realized, educational processes in a continuous and meaningful way will be essential". In this context, as stated by Moura-Fé, Nascimento, and Soares (2017), Environmental Education, which presents itself as an articulated, interdisciplinary educational process aiming to promote social change in a critical and innovative manner, brings together all the theoretical elements necessary for the development of Geoeducation.

Geoeducation is defined as a set of: "[...] educational practices oriented towards geoconservation, it should be encouraged alongside formal education, as content of curricular components in schools, but also in non-formal teaching environments" (Meira *et al*., 2019, p. 391). According to the authors, Geoeducation should be one of the pillars of practices aimed at valuing this kind of patrimony, thus contributing to its conservation, because through Geoeducation, it will be possible to discuss concepts and topics related to geodiversity and its segments.

Several examples are presented related to the educational value of Geodiversity as geo-educational actions and strategies, including field classes, geotourism, guided visits to museums, workshops, application of games, postcards, panels, folders, interpretive trails, didactic scripts, among others (Baptista; Lima; Silva, 2019; Baptista; Lima, 2020; Silva; Lima; Baptista, 2022). These actions aim to raise awareness, disseminate and enhance geological and geomorphological heritage.

Based on the integration of education and environmental interpretation, Silva and Aquino (2018), suggest actions aimed at teachers and students in basic education, specifically in Piauí. According to the authors, despite the rich geodiversity and significant heritage in the state, these topics are seldom addressed in school environments. Therefore, it becomes necessary to create spaces within these environments that enable the connection of these topics to teaching practices, providing mechanisms for students to learn about, and consequently value and promote the geodiversity and geoheritage within their own living context.

In the light of the development of this study, it becomes evident that the geodiversity of the studied area presents itself as highly attractive, and as a patrimony that needs to be recognized as something worthy of being protected and preserved, while also acknowledging its scientific, educational, and touristic values. One of the goals of this study is to suggest possibilities and actions that contribute to the appreciation, dissemination, and recognition of the importance of the patrimony and its conservation, as outlined in table 02, including their respective objectives. These actions are directed towards those who can directly and indirectly influence the scenario of the Petrified Forest of Altos (PI).

**Table 02** – Strategies of Geoconservation to the Petrified Forest in Altos (PI)

| Strategies | | Objectives |
|---|---|---|
| **Legal Framework** | | To develop policies aiming the protection of the heritage analyzing the criteria and standards for a legal framework for the area. |
| **Creation of a Museum** | | Preserve samples ex situ; Promote exhibitions and visitations to enhance, disseminate, and conserve local geodiversity. |
| **Stickers** | | Establish an identity through a logo that promotes the museum, geodiversity, and geological-geomorphological heritage. |
| **Geoeducational actions** | Informational/ Interpretative Panel | Facilitate the knowledge of the petrified/fossil forest among the population of Altos and the broader society. |
| | Booklet and Postal Cards | Promote the dissemination of the geological-geomorphological heritage of the forest. |

**Source**: The Authors (2024).

With regard to the legal framework, it is understood that this is a concern and that it should be known to managers and public bodies responsible for such tasks. It is known, as for the establishment of a protected area, that it must be justified in scientific and legal norms and criteria. In this context, we can mention Law No. 9,985 of July 18, 2000, which established the National System of Conservation Units (SNUC), which establishes criteria and standards for the creation, implementation and management of Conservation Units (UCs) at the federal, state and municipal levels (Brasil, 2000).

Among the objectives of the SNUC, it is aimed to: “[...] protect relevant characteristics of a geological, geomorphological, speleological, archaeological, paleontological and cultural nature” (Brasil, 2000, article 4, item VII). Considering the characteristics of the study area, there is a possibility that it corresponds to the SNUC criteria, and it is necessary to analyze in which group of UCs it is integrated: Integral

Protection Units, which basic objective is to preserve nature, being admitted only the indirect use of its natural resources; Sustainable Use Units, with the basic objective of making nature conservation compatible with the sustainable use of a portion of its natural resources (Brasil, 2000).

Each group has distinct categories of UCs with specific objectives, such as that of a Natural Monument, which has as its main objective to preserve rare, unique or scenic beauty natural sites, and can be constituted by particular areas, as long as it is possible to reconcile the objectives of the unit with the use of the land and natural resources of the site by the owners (Brasil, 2000). Is this, then, a possibility?

What must be remembered and considered is that the Petrified Forest is located in an INCRA settlement and there is a community in the surroundings, thus having a relationship and interaction with the elements of the environment. Therefore, it is necessary to know in detail the protection and conservation policies in which the area fits and that the legal protection is in fact concretized. That is, in the possible legal protection of the area, the bodies responsible for such tasks must be aware of the local reality.

Regarding the creation of a museum in the proximities of the Petrified Forest is a suggestion that arose during field surveys to observe that there are several fragments of fossils scattered in the area, which implies that they are carried away by rainwater, and can be covered by sediments. It was also observed that among these fragments some have expressive crystals, attracting attention for their beauty, and in the case of an unprotected area these fossils may disappear. Another aspect observed was the presence of crystals in apparently "common" rocks found at the site, for this reason, a museum would be a way to preserve and value these elements.

It is important to understand what museums are and their attributes, which according to the law of No. 11,904 of January 14, 2009, which established the statute of museums in Art. 1, are considered as non-profit institutions that investigate, preserve, communicate, interpret and exhibit, sets and collections of historical, artistic, scientific, technical or any other cultural value for purposes of preservation, study, research, education, contemplation and tourism, open to the public, at the service of society and its development (Brasil, 2009).

Every museum must have a legal basis, a document defining its legal status and administrative nature, internal regulations, a museum plan, a place of installation, a plan for occupying exhibition halls, a space for educational and cultural action. Its basic functions are preservation, research and communication, with the general purposes of education and

leisure, emphasizing that it is essential to take advantage of all opportunities for the development of the educational and social dimension (Chagas; Nascimento Junior, 2009).

It is possible to understand, although succinctly, that the process of creating a museum is not something simple, but it is something that can make a difference for the appreciation of the heritage studied and for society. However, it is a project that in addition to resources, requires planning and the involvement of society in general, public agencies, managers, researchers, students and the local community. A museum in the proximity of the Petrified Forest of Altos is a relevant possibility that will contribute to valorization, dissemination, conservation, practices and activities of interaction of society with the geological and geomorphological heritage, among which Geotourism, Educational and Economic activities stand out.

With the creation of a museum, the economic issue can be worked from sales of geoproducts that can be made by the community itself, and a suggestion for this is to create an identity for these products through a logo that promotes the museum, geodiversity and geological and geomorphological heritage (Figure 06). From a logo, stickers can be made to stick to products, with images of the elements of geodiversity, such as the fossils that attract the most attention or other elements.

**Figure 06** – Suggestion of stickers for promoting the Petrified Forest of Altos


**Source**: The Authors (2024).

In relation to educational activities, geotourism tours can be carried out by students to know the fossils on display and the geodiversity of the environment with the help of a script and tourist guide, in addition to conducting lectures with delivery of pamphlets, folders, infographics among others, aiming to sensitize the public about the importance of the heritage. These activities are configured as geo-educational activities, covering different audiences and using a variety of resources and possibilities. This suggestion was thought

as a significant point, with the intention of involving society in general, awakening a reflective look at the importance of heritage and its conservation *in situ* and *ex situ*, developing the potential of local heritage.

It is understood that the geoeducational activities proposed as strategies for the dissemination of the elements of geodiversity and geological-geomorphological heritage, are initiatives that can become effective tools in the search for the realization of Geopreservation, and can be developed in different contexts and spaces, making use of varied resources.

Based on the discussion presented by the authors Silva, Lima and Baptista (2022), Baptista and Lima (2020), Baptista, Lima and Silva (2019), Meira *et al*. (2019), Silva and Aquino (2018), Moura-Fé, Nascimento and Soares (2017), there are a range of possibilities to be developed and put into practice from the perspective of Geoconservation. Considering the set of geoeducational activities and actions that can be developed, in formal and non-formal scope, it is suggested as actions for the valorization and dissemination of the Petrified Forest of Altos the elaboration of informative and/or interpretative panels, primers and postcards.

Regarding the informative and/or interpretative panels Moreira (2014, p. 94), points out that these: “[...] they are the most popular interpretative means”. However, it is necessary to take into account some precautions such as elaboration, implementation, attractiveness, an easy-to-understand vocabulary and its location, which is a relevant factor in its effectiveness (Moreira, 2014).

These panels are usually fixed in parks and conservation units, so that visitors can interpret the site and its elements. As the study area does not yet fit into this context, the target of this suggestion is the production and fixing of an information panel in the vicinity of the Altos Municipal Library, a strategic and central location for publicizing the heritage.

Regarding the size, we suggest 90 cm high by 120 cm wide, in a horizontal position. The material should be resistant, as it will be on display in an open area. Figure 07 shows the suggestion for the information and/or interpretive panel, featuring photos of the forest's geodiversity elements, information about the heritage site and an example of the route from the exit of Altos to the entrance to the Petrified Forest.

**Figure 07** – Informative panel for promoting the Petrified Forest of Altos


**Source**: The Authors (2024).

Among the printed materials that can be used to disseminate and value geodiversity and its elements, we can highlight booklets as instruments with significant potential. According to Santos (2016), booklets can greatly assist the teaching of geosciences and the appreciation of geological heritage in schools, but they need to have an accessible language and the target audience must be taken into account.

When designing an educational and interpretive booklet, it is important to select information that enables society to understand the importance of the heritage and its conservation, helping with interpretation, appreciation and recognition of the geological and geomorphological heritage, and to use images that bring the public and the heritage closer together.

Society can then become interested in finding out more, learning about and becoming aware of the importance of protecting the heritage in question. Figure 08 shows a suggested thematic cover for an educational booklet. The aim is to create and produce a booklet on the Altos Petrified Forest and local geodiversity and use it to promote the heritage.

**Figure 08** – Suggestion of cover for educational booklet


**Source**: The Authors (2024).

Tourist attractions are known to attract attention because of their landscape, so the elements of geodiversity can be used in printed images such as postcards. According to Silva, Lima and Baptista (2022, p. 43), postcards are an important strategy for publicizing Geosites: “[...] mainly because, due to its low cost, visitors can keep and even give gifts to friends and family, thus being a kind of “advertisement” of the aforementioned geological heritage”.

From this perspective, according to Meira *et al*. (2019), postcards, as well as being souvenirs disseminated at tourist sites, have a varied audience since the information they contain is passed on to both visitors to the site and their recipients. As a way of adding value and spreading the word, this study suggests postcards measuring 10 cm in height by 15 cm in length, with images of the geodiversity elements of the petrified forest and their names on the front and a short interpretative text, the stamp, a small space for writing and the zip code on the back (Figure 09).

**Figure 09** – Suggestion of postcard for promoting the Petrified Forest of Altos, Piauí.


**Source**: The Authors (2024).

The suggestions for possibilities and actions to enhance and publicize the Altos Petrified Forest are intended to reach as many people as possible from all walks of life. In this sense, it is intended that the authorities become aware of and analyze the possibilities for developing effective strategies for recognizing the heritage, conserving it and enhancing it from a legal point of view, making the creation of the museum an essential factor for the appreciation and geoconservation of the geological and geomorphological heritage.

This requires collaboration and support between the relevant bodies, researchers, society in general and the local community. The geoeducational actions need to be developed and put into practice as soon as possible, and through the implementation of this set of activities, it will be possible to recognize and sensitize the population to the importance and value of the heritage for the municipality and, consequently, Geoconservation.

## 4 FINAL CONSIDERATIONS

The Petrified Forest of Altos (PI) is undoubtedly a heritage that needs to be conserved and protected, recognizing that there are several potentials to be developed. This research was carried out with the aim of contributing to the development of Geoconservation strategies aimed at reaching the surrounding community, the population of Altos and society in general, managers and the competent bodies responsible for these tasks. The aim is to present the suggestions to managers so that they are aware of the possibilities and actions that, when carried out, will benefit and protect the heritage, which is the main objective, since the research, discussions and suggestions revolve around the importance of protecting the heritage, including legally.

It is hoped that in each possibility presented, the actions will be implemented, that the suggestion of a legal framework for the area will be accepted by the municipality's managers and forwarded to the competent bodies, because it is known that it is a long process and the more time passes, the more the heritage will be subject to actions and processes that can cause negative impacts. As for the suggestion of creating a museum on the site, it is something that will undoubtedly bring many positive points for the local community, for the municipality of Altos, for education, for research and, above all, it will be a conservation strategy for the elements of geodiversity that are subject to vulnerabilities.

The suggestion of fixing an information panel at a strategic point is an action that should be carried out as soon as possible, as it is a way of presenting and publicizing the heritage to society as a whole, encouraging a reflective look and an awareness-raising initiative through the display of the panel. To complement this, postcards can be inserted in this same context to carry the message forward, and can be "sold" or distributed on site or near the information panel.

And the suggestion of an educational booklet, which at first was just a suggested cover, is a resource that we hope to develop in the near future. In order to do this, it will be necessary to plan and look for support and partnerships to carry out the actions with different audiences.

In view of the perspectives presented, it is hoped that this research will contribute to a reflection on the importance of the Altos Petrified Forest as a geological and geomorphological heritage, which needs to be recognized, legally protected and structured so that the existing potential can be awakened and used in the best possible way.

It is hoped that the strategies for Geoconservation are prioritized and applied, and that the science of geography and the Geography teacher are present, as they can contribute a great deal to carrying out these studies and developing strategies, in other words, the elaboration and systematization of geoconservationist processes.

## REFERENCES

AGUIAR, R. B.; GOMES, J. R. C. **Projeto cadastro de fontes de abastecimento por água subterrânea:** estado do Piauí: diagnóstico do município de Altos. Fortaleza: Serviço Geológico do Brasil, 2004.

ALTOS. **Proposta de criação da unidade de conservação Floresta Fóssil do Brejo de São Benedito, Altos, Piauí**. Altos: [*S. n.*], 2023.

BAPTISTA, E. M. C.; LIMA, I. M. M. F. Geoeducação e geoconservação no litoral do Piauí: valorização da geodiversidade através de ferramentas didáticas. *In*: BAPTISTA, M. P. C.; NASCIMENTO, F. A. S.; BAPTISTA, E. M. C.; SILVA, B. R. V. (org.). **Dos tempos à viração, dos ventos à amarração**: Estudos Histórico-Geográficos do Litoral do Piauí. Teresina, EDUFPI, 2020. p. 257-294.

BAPTISTA, E. M. C.; LIMA, I. M. M. F.; SILVA, B. R. V. Práticas geoconservacionistas como ferramentas para o ensino de Geografia Física. **REGNE**, Natal, v. 5, Número Especial, p. 86-104, 2019.

BRASIL. Presidência da República. **Lei nº 9.985, de 18 de julho de 2000.** Regulamenta o art. 225, § 1º, incisos I, II, III e VII da Constituição Federal, institui o Sistema Nacional de Unidades de Conservação da Natureza e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil_03/leis/l9985.htm Acesso em: 28 mai. 2024.

BRASIL. Presidência da República. **Lei n° 11.904, de 14 de janeiro de 2009**. Institui o Estatuto de Museus e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l11904.htm Acesso em: 28 mai. 2024.

BRILHA, J. **Patrimônio Geológico e Geoconservação:** A Conservação da Natureza na sua vertente Geológica. Braga: Palimage, 2005.

CALDAS, E. B.; MUSSA, D.; LIMA FILHO, F. P.; ROSLER, O. Nota sobre a ocorrência de uma floresta petrificada de idade permiana em Teresina, Piauí. **Boletim IG-USP**, Publicação Especial, São Paulo, v. 7, 69-87, 1989.

CARVALHO, I. S. Fósseis: importância econômica e social do patrimônio paleontológico. *In*: GUERRA, A. T., JORGE, M. C. O. (org.). **Geoturismo, Geodiversidade e Geoconservação**: abordagens geográficas e geológicas. São Paulo: Oficina de Textos, 2018. p. 163-196.

CHAGAS, M. S.; NASCIMENTO JUNIOR, J. (org.). **Subsídios para a criação de Museus Municipais.** Rio de Janeiro: Ministério da Cultura/Instituto Brasileiro de Museus e Centros Culturais/Departamento de Processos Museais, 2009.

CONCEIÇÃO, D. M.; CISNEROS, J. C.; IANNUZZI, R. Novo registro de floresta petrificada em Altos, Piauí: relevância e estratégias para geoconservação. **Pesquisas em Geociências**, Porto Alegre, v. 43, n. 3, p. 311-324, set. / dez. 2016.

DIAS-BRITO, D.; ROHN, R.; CASTRO, J. C.; DIAS, R. R.; RÖSSLER, R. Floresta Petrificada do Tocantins Setentrional – O mais exuberante e importante registro florístico tropical-subtropical permiano no Hemisfério Sul. *In*: WINGE, M.; SCHOBBENHAUS, C.; SOUZA, C. R. G.; FERNANDES, A. C. S.; BERBERT-BORN, M.; QUEIROZ, E. T.; CAMPOS, D. A. **Sítios Geológicos e Paleontológicos do Brasil**. v. 2. Brasília: CPRM, 2009. p. 337 - 354.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. **Sistema Brasileiro de Classificação de Solos**. Brasília, DF: EMBRAPA, 2018.

FIGUEIRÓ, A. S.; VIEIRA, A. A. B.; CUNHA, L. **Patrimônio geomorfológico e paisagem como base para o geoturismo e o desenvolvimento local sustentável**. CLIMEP – Climatologia e Estudos da Paisagem, Rio Claro, v. 8, n.1, p. 49-81, jan. / jun. 2013.

GOOGLE SATELLITE. Map data ©2021 Google. **Imagem**. Disponível no software QGIS versão 3.10.3. Link de permissão: https://www.google.at/permissions/geoguidelines/attr-guide.html Acesso em: 19 mai. 2022.

GRAY, M. **Geodiversity:** valuing and conserving abiotic nature. Chichester, England: John Wiley and Sons, 2004.

GOMES, F. C. **Ambiente fluvial e ocorrência de fósseis vegetais no município de Altos (Piauí)**: busca de valorização e conservação do patrimônio natural e ambiental. 2022. 143 f. Dissertação (Mestrado em Geografia) – Universidade Federal do Piauí, Teresina, 2022.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Malhas municipais Piauí.** 2021. Disponível em: https://geoftp.ibge.gov.br/organizacao_do_territorio/malhas_territoriais/malhas_municipais/municipio_2021/UFs/PI/PI_Municipios_2021.zip Acesso em: 05 mai. 2022.

INSTITUTO NACIONAL DE COLONIZAÇÃO E REFORMA AGRÁRIA. **Assentamentos Brasil Piauí.** 2022. Disponível em: https://certificacao.incra.gov.br/csv_shp/export_shp.py Acesso em: 05 mai. 2022.

MEIRA, S. A.; MORAIS, J. O. Os conceitos de geodiversidade, patrimônio geológico e geoconservação: abordagens sobre o papel da geografia no estudo da temática. **Boletim de Geografia**, Maringá, v. 34, n. 3, p. 129-147, 2016.

MEIRA, S. A.; NASCIMENTO, M. A. L.; MEDEIROS, J. L.; SILVA, E. V. Aportes teóricos e práticos na valorização do geopatrimônio: estudo sobre o projeto geoparque Seridó (RN). **Caminhos de Geografia**, Uberlândia, v. 20, n. 71, p. 384-403, 2019.

MOREIRA, J. C. **Geoturismo e interpretação ambiental**. Ponta Grossa: UEPG, 2014.

MOURA-FÉ, M. M.; NASCIMENTO, R. L.; SOARES, L. N. Geoeducação: princípios teóricos e bases legais. *In*: PEREZ FILHO, A.; AMORIM, R. R. **Os desafios da Geografia Física na fronteira do conhecimento**. v.1. Campinas: UNICAMP, 2017. p. 3054-3065.

NASCIMENTO, M. A. L.; RUCHKYS, U. A.; MANTESSO-NETO, V. **Geodiversidade, geoconservação e geoturismo:** trinômio importante para a proteção do patrimônio geológico. São Paulo: Sociedade Brasileira de Geologia, 2008.

NIETO, L. M. Geodiversidad: propuesta de una definición integradora. **Boletín Geológico y Minero**, Jaén, Departamento de Geología, Universidad de Jaén, Espanha, v. 112, n. 2, p. 3-12, 2001.

PEREIRA, P. J. S. **Patrimônio geomorfológico:** conceptualização, avaliação e divulgação. Aplicação ao Parque Nacional de Montesinho. 2006. 370 f. Tese (Doutorado em Ciências – Geologia) – Universidade do Minho, Braga, Portugal, 2006.

PIAUÍ. Superintendência de Estudos Econômicos e Sociais. **Diagnóstico socioeconômico do município de Altos, Piauí**. Teresina: CEPRO, 2013.

RODRIGUES, M. L.; FONSECA, A. **A valorização do Geopatrimónio no desenvolvimento sustentável de áreas rurais**. Colóquio Ibérico de Estudos Rurais: cultura, inovação e território. Coimbra, Portugal, 2008.

RUCHKYS, U. A. **Patrimônio Geológico e Geoconservação do Quadrilátero Ferrífero, Minas Gerais.** Potencial para criação de um Geoparque da UNESCO. 2007. 189 f. Tese (Doutorado em Geologia) – Instituto de Geociências, Universidade Federal de Minas Gerais, Belo Horizonte, 2007.

SANTOS, E. M. **A geoconservação como ferramenta para o desenvolvimento sustentável em regiões semiáridas:** estudo aplicado à mesorregião do agreste de Pernambuco, nordeste do Brasil. 2016. 242 f. Tese (Doutorado em Geociências) – Programa de Pós-graduação em Geociências, Universidade Federal de Pernambuco, Recife, 2016.

SERVIÇO GEOLÓGICO DO BRASIL. **Mapa geológico do estado do Piauí**. Teresina: CPRM, 2006. Escala 1:1.000.000.

SHARPLES, C. **Concepts and principles of geoconservation**. Published electronically on the Tasmanin Parks & Wildlife Service web site. 3. ed. 2002.

SILVA, A. O. **Importância da floresta petrificada de Altos (Pi) como patrimônio geológico e geomorfológico e a relação com a comunidade local**: uma perspectiva de Geoconservação. 2022. 117 f. Trabalho de Conclusão de Curso (Graduação em Geografia) - Universidade Estadual do Piauí, Teresina, 2022.

SILVA, B. R. V.; LIMA, I. M. M. F.; BAPTISTA, E. M. C. Estratégias de valorização e divulgação dos geossítios da zona litorânea piauiense. *In*: SCABELLO, A. L. M.; VIANA, B. A. S.; ALBUQUERQUE, E. L. S. (org.). **Dinâmicas ambientais-urbanas e formação docente no espaço geográfico piauiense**. v. 5. Sobral: Sertão Cult, 2022. p. 31- 47.

SILVA, J. F. A.; AQUINO, C. M. S. Ações geoeducativas para divulgação e valorização da geodiversidade e do geopatrimônio. **Geosaberes**, Fortaleza, v. 9, n. 17, p. 1-10, 2018.

***