

FIRST RUPESTRIAN REPRESENTATIONS OF *ARAUCARIA ANGUSTIFOLIA* IN SOUTHERN BRAZIL

Primeiro registro de arte rupestre com representações de Araucaria angustifolia, Sul do Brasil

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Abstract

This paper presents the first recorded rupestrian representations of *Araucaria angustifolia* (Bertol.) Kuntze. Located in southern Brazil, the archaeological finding and its substrate are characterized in detail, a discussion being held on the ethnic relations among indigenous populations, this type of vegetation and the local landscape evolution. A panel extending for 0.36 m² consists in of *Araucaria angustifolia* specimens represented on a coarse sandstone surface. In all, 13 representations of *Araucaria angustifolia* and 20 representations of anthropomorphs were identified. The visual discourse established by

the use of a consistent pictorial technique reinforces the hypothesis that the pictures represent either a forest or an isolated group of *Araucaria angustifolia* trees. The surface on which these elements were represented seems to have been selected for that purpose following some sort of criteria. Also, the detailed representations of plant elements and anthropomorphs mark a chronocultural relation between the pictorial panel and members of the Jê populations that inhabited the region.

Keywords: Rupestrian paintings; Rupestrian graphisms; Archaeology; Devonian Escarpment; Campos Gerais do Paraná.

Resumo

Este artigo reporta o primeiro registro de pintura rupestre com representações de *Araucaria angustifolia* (Bertol.) Kuntze. A descoberta arqueológica e o substrato rochoso são caracterizados detalhadamente, discussões são realizadas sobre as relações étnicas de povos indígenas originários com a araucária e os aspectos da evolução da paisagem regional ao longo do tempo. O painel das araucárias foi elaborado em uma superfície de 0,36 m² sobre arenitos de granulação predominantemente grossa, com ocorrência de lentes conglomeráticas compostas por grânulos e seixos de até 4 cm de diâmetro. Ao todo foram identificadas representações de 13 araucárias e 20 antropomorfos. O conjunto de araucárias possui uma continuidade na técnica de representação, o que cria uma uniformidade e consistência no discurso visual que reforça a hipótese de que o painel representa uma floresta ou capão de mata com araucárias. Conclui-se que houve uma seleção da superfície na qual os grafismos foram produzidos e, por reunir representações de espécimes vegetais e figuras humanas e apresentar alto grau de detalhes das pinturas, foi possível integrar crono-culturalmente este painel pictórico aos povos Jê.

Palavras-chave: Pinturas rupestres; Grafismos rupestres; Arqueologia; Escarpa Devoniana; Campos Gerais do Paraná.

1. INTRODUCTION

The Campos Gerais do Paraná correspond to a phytogeographic region first described by Reinhard Maack in the 1940s as consisting of open fields and natural savannah areas typical of the eastern border of the Second Plateau of Paraná (Maack, 1968).

According to Moro and Carmo (2007), the dry and humid fields and savannah areas of the Campos Gerais do Paraná are associated with forest fragments of varied canopy height and extension covering slopes, small depressions, spring areas and drainage segments across the region (CARMO *et al.*, 2007). Such vegetation, referred to as Mixed Ombrophilous Forest, have *Araucaria angustifolia* (araucaria) as their main constituent. Therefore, it can also be named Araucaria Woods or Araucaria-containing Forest (VELOSO *et al.*, 1991).

Both the natural fields and the *Araucaria angustifolia* Forest form the Atlantic Biome, corresponding in the Campos Gerais do Paraná to an ecotone where the southernmost savannah patches are present (RITTER *et al.*, 2010). Both the Atlantic Forest and the Savannah biomes have been identified as global biodiversity hotspots (CEPF, 2001; 2018).

Together with biodiversity elements, the Campos Gerais do Paraná include geodiversity sites of marked scenic beauty, such as canyons, ruiniform relief areas, inselbergs, escarpments, caves and waterfalls (GUIMARÃES *et al.*, 2007; MELO *et al.*, 2007).

Among other regional geodiversity elements, a Devonian escarpment stands out both in scope — extending for over a hundred kilometers and a dozen municipalities — and influence, being an important element in the current landscape configuration and evolution. The relief structure forms a topographic step that sets the boundary between the first and second plateaus of Paraná, at altitudes between 1,100 m and 1,200 m, with local shifts of 100 to 300 m (SOUZA AND SOUZA, 2002). Supported by sandstones of the Silurian-Devonian Furnas Formation, the escarpment resulted from climatic changes and intense, prolonged differential erosion. Its evolution involved a series of endogenous geodynamic phenomena related to the breakup of the great Gondwana continent, mainly during the Cretaceous (SOUZA AND SOUZA, 2002), and during the uplift of the Ponta Grossa Arch (MAGALHÃES, 2009).

A number of cultural elements are present in this natural context, such as pre-colonial and historical archaeological findings (PARELLADA, 2007). The archaeological heritage of the Campos Gerais do Paraná consists of hundreds of sites housing ceramic remnants, lithic materials, engravings and rupestrian paintings. Graphisms found mainly in sandstone shelters and recesses across the Campos Gerais do Paraná include representations of lines, dots and other geometric forms, zoomorphs, phytomorphs, anthropomorphs, hybrid forms, and enigmatic other representations as well. Numerous rock panels depict such elements in great detail, as reported by Silva, Melo and Parellada (2006), Silva, Parellada and Melo (2007), Gomes (2011), Oliveira (2014), Oliveira *et al.* (2015), Parellada (2015; 2016).

According to Parellada (2009; 2015), most rupestrian paintings in Paraná consist of representations of animals, geometric signs and human forms. Vegetation elements are not commonly represented, especially those pertaining to the regional flora (SILVA *et al.*,

2007). Parellada (2015) reports sites in the municipalities of Tibagi and Ventania housing representations probably of cultivated plants such as corn.

Considering the aforementioned authors and the current archaeological knowledge of Paraná, the present communication brings an archaeological record of great cultural value, including the first identified rupestrian depictions of *Araucaria angustifolia*, the main phytophysiognomic element of the Mixed Ombrophilous Forest in the Atlantic Forest Biome. The species is considered a symbol of Paraná, being represented on the state flag itself.

The archaeological site known as the Araucárias Shelter was discovered in rural Piraí do Sul, northern Campos Gerais do Paraná, during speleological and archaeological prospecting works carried out as part of the *EspeleoPiraí: sandstone speleological heritage of the Devonian Escarpment in Piraí da Serra* project (ICMBIO, 2021). The project, coordinated by the Grupo Universitário de Pesquisas Espeleológicas (GUPE), an academic speleological research initiative, involves surveying of underground sandstone cavities and archaeological sites along the Devonian Escarpment front and its immediate surroundings in order to prioritize areas for speleological heritage conservation.

In addition to the Araucárias Shelter, 24 new sites of archaeological importance were discovered at field work. Seven previously known sites were described during the first year of the *EspeleoPiraí* project.

This article characterizes this new archaeological finding through detailed description of both the Araucárias Panel and the homonymous shelter rock substrate. The discussion involves both the establishment of ethnic relations between native populations and the *Araucaria* and evolution aspects of the landscape.

1.1. *Araucaria angustifolia*

In the taxonomic hierarchy of plants, members of the *Araucaria angustifolia* species are classified as belonging to the division Gymnospermae, class Coniferopsida, order Coniferae, family Araucariaceae, genus *Araucaria* (JOLY, 1983). The species corresponds to the most primitive conifer group still alive, having appeared 308±53 million years ago in the Upper Carboniferous period of the Paleozoic Era. Currently, members of the Araucariaceae family occur exclusively in the Southern Hemisphere (ZANETTE *et al.*, 2017).

As a species, *Araucaria angustifolia* (Bertol.) Kuntze was first described in 1820 by European naturalist Antonio Bertolini, based on a tree collected from the Corcovado Peak

in Rio de Janeiro, Brazil (MATTOS, 1994). The dioecious species can reach a canopy height of 50 m and a diameter of 2.5 m, with a cylindrical trunk and a resinous bark (Figure 1a). Younger trees show a conical crown, while in adult forms this structure is corymbose (candelabrum-shaped) due to the loss of basal whorls. Primary branches are arranged in whorls (8 to 15), while alternating secondary branches are grouped at the upper parts of the former (6 to 10 branches per whorl). Secondary branches known as *grimpas* (claws, Figure 1b) sustain the acicular leaves (HERTEL, 1980; CARVALHO, 1994; MATTOS, 1994; BACKES; IRGANG, 2002; IGANCI, 2020).

The first bloom of the *Araucaria angustifolia* usually occurs within 15 and 20 years after planting. The species reproductive organs are arranged in a spiral-shaped structure called strobilus. Females show modified leaves called gynostrobiles, which join other, sterile modified leaves surrounding the fertilized ovule to form the seed, which is called *pinhão*. The mature female strobilus is called *pinha* (pinecone, Figure 1c). Male individuals have modified leaves called androstrobiles, also known as *mingotes*, inside of which millions of pollen grains form in sacs (JOLY, 1983; MATTOS, 1994; ZANETTE *et al.*, 2017). These pollen grains can travel more than 2 km to pollinate female individuals (BITTENCOURT and SEBBENN, 2007).

Pollination occurs by wind (anemophilous). The long reproductive cycle of the *Araucaria angustifolia* takes 28 to 35 months from gynostrobiles becoming visible to the ripening of seeds. Cone development is also slow, taking 10 to 12 months after pollination, followed by a stage of accelerated growth until maturation (ZANETTE *et al.*, 2017).

In early 19th century, French botanist August de Saint-Hilaire described abundant *Araucaria angustifolia* forests on the banks of the Iapó and Tibagi rivers, pointing out that the upper parts of these trees constituted the forest canopies themselves (SAINT-HILAIRE, 1964). Such characteristics make the species stand out in the landscape not only for its grandeur, but also for the marked physiognomic difference from other species.

Araucaria angustifolia is also a timber of important commercial value, having experienced an expressive population reduction, especially between 1920 and 1960, a period of intense exportation of derived products. Studies show that 90% of the Brazilian timber export at that time corresponded to *Araucaria angustifolia*, in "the most devastating systematic forest devastation" according to Backes (2009).

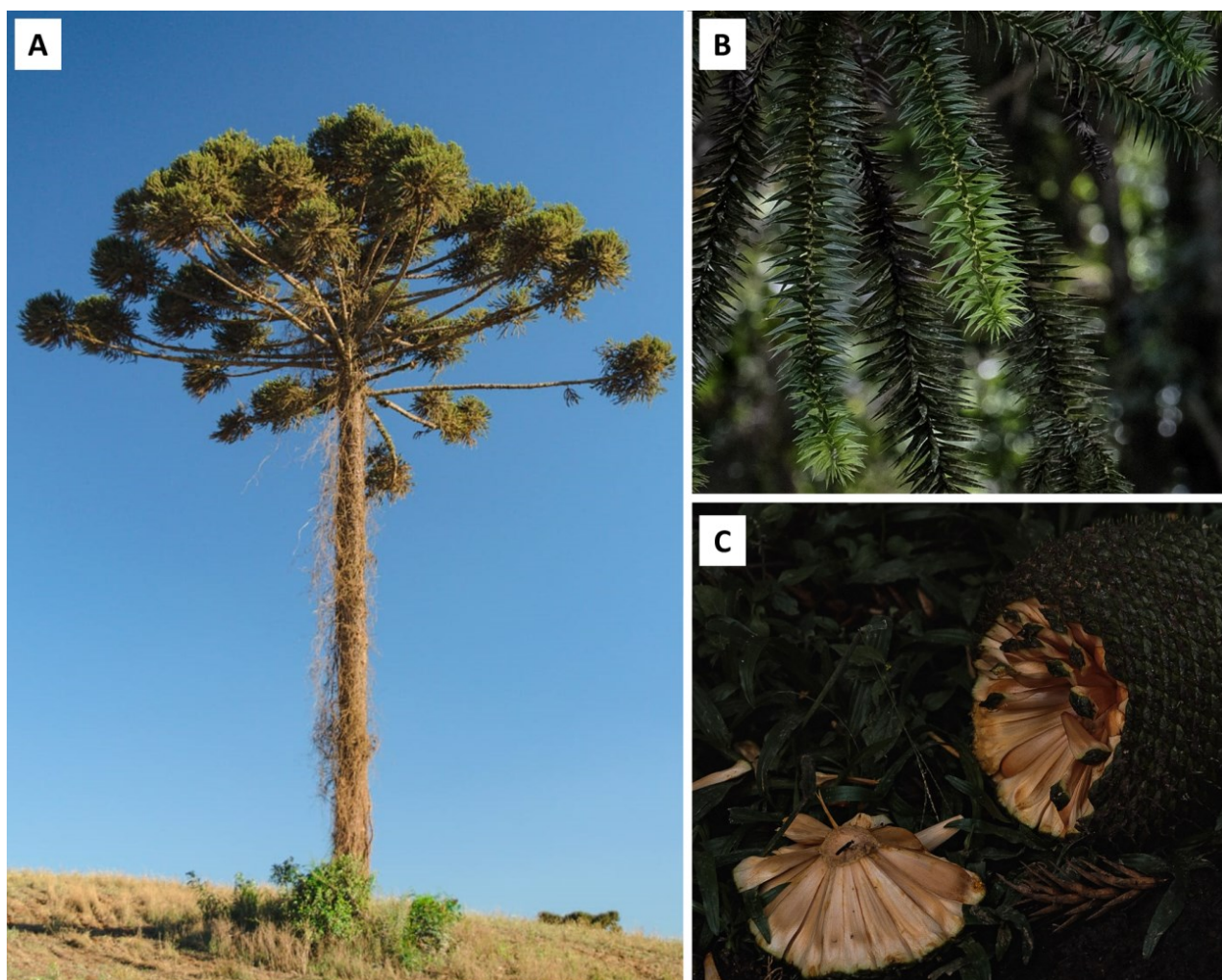


Figure 1 - (a) *Araucaria angustifolia*; (b) claws (secondary branches); (c) *pinha* (pinecone) formed by numerous seeds. Photographs by Bruno de Jesus Kubis, organized by the authors.

Araucaria angustifolia populations are still affected by logging and, despite being protected by law, the species is threatened by the extensive establishment of *Pinus spp* forests, unplanned settlements, expansion of soybean and corn monocultures (Medeiros *et al.*, 2005) and construction of hydroelectric plants (MÄHLER JUNIOR and LAROCCA, 2009). Several fragments of *Araucaria angustifolia* forests have been impacted by the presence of exotic animals, such as wild boars or cattle. All these factors allow to infer that the species has experienced a population reduction of at least 80% (CNCFLORA, 2012).

Decades of logging have resulted in *Araucaria angustifolia* being included in endangered species lists in several Brazilian states, being classified as endangered (EN) in Paraná (SEMA, 1995), Minas Gerais (COPAM, 2008) and São Paulo (SMA, 2016); regionally extinct (REX) in Espírito Santo (SIMONELLI and FRAGA, 2007); vulnerable (VU) in Rio Grande do Sul (CONSEMA-RS, 2014) and critically endangered (CR) in Santa Catarina (CONSEMA-SC, 2014). In the National List of Endangered Flora Species (MMA, 2014) *Araucaria angustifolia* is considered "endangered" (EN). It also appears on the

International Union for Conservation of Nature's Red List of Threatened Species (IUCN, 2021) in the "Critically Endangered" (CR) category.

1.2. The study area

The Araucárias Shelter is a natural underground cavity located in a private property at the base of the Devonian Escarpment in rural Piraí do Sul county, Paraná state, southern Brazil (Figure 2).

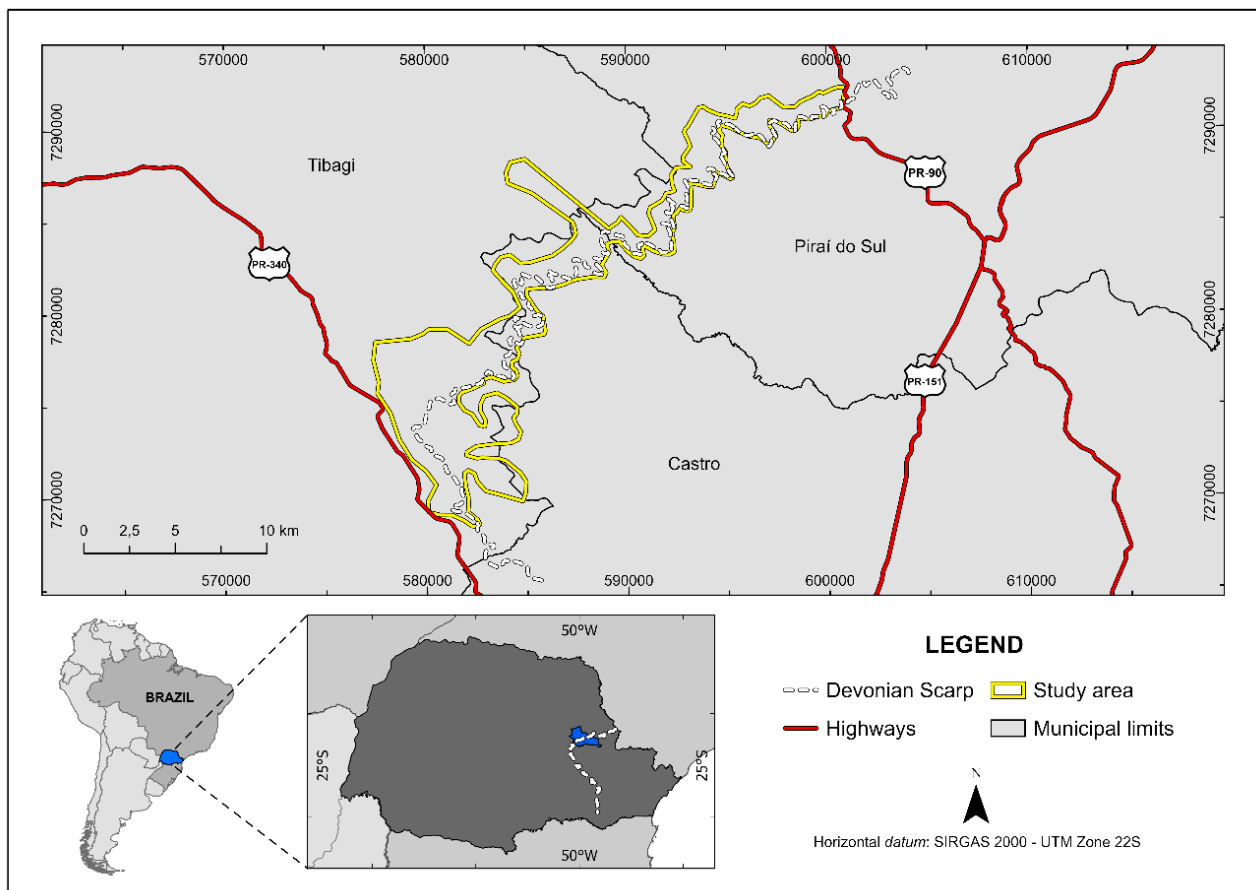


Figure 2 - the study area (EspeleoPiraí Project). For the protection of the archaeological site and at the request of the owner, only an approximate location of the shelter is indicated.

The shelter is located an altitude of 1,130 m on a half-slope near a Piraí-Mirim river tributary. The vegetation around the shelter consists of grasslands (pasture) and secondary (Ombrophilous Mixed) forests at different regeneration stages, partially covering slopes and valley along the water course. The slope between the escarpment foot and the drainage is steep, with metric to decametric boulders (Figure 3) that testify to the erosive retreat of the Devonian escarpment, which explains the formation of natural shelters like the Araucárias Shelter.



Figure 3 - (a) Overview of the Araucárias Shelter and its surroundings, its entrance being indicated by the yellow arrow: (b) the surrounding landscape, as seen from the shelter.

The climate in rural Piraí do Sul and most of the Campos Gerais do Paraná corresponds to a temperate one, with no dry season and mild summer temperatures (Cfb) in the Köppen-Geiser classification (PEEL *et al.*, 2007). The average temperature in the coldest month falls below 18 °C, and the average temperature in the hottest month remains below 22 °C. The average annual rainfall ranges between 1,400 and 1,600 mm (NITSCHKE *et al.*, 2019). Being an elevated area, the Devonian escarpment exerts influence on the local climatic and meteorological conditions, with lower temperatures and higher humidity that are responsible for fog and orographic rain (CRUZ, 2007).

Geologically, the substrate of the study area corresponds to Devonian (400-420 Ma; ASSINE, 1999) sandstones of the Furnas Formation (The Paraná Basin). These sandstones consist in whitish rocks predominantly of medium to coarse texture, cemented by kaolinite and illite and arranged in tabular layers, showing different types of sedimentary structures, among which small to medium-sized cross bedding and tabular to channeled bedding are the most prominent ones. Centimetric to decimetric layers of silty-clayish to conglomeratic materials are interspersed with the sandstone layers (ASSINE, 1996; 1999; MELO and GIANNINI, 2007; MILANI *et al.*, 2007). In the classification of Assine (1996), these sandstones correspond to the inferior portions of the Furnas Formation and were deposited in a deltaic environment.

2. MATERIALS AND METHODS

The first surveying stage of the Araucárias Shelter consisted in speleological mapping and photogrammetry works being performed in order to delimit and characterize the panels containing rupestrian paintings. The speleological mapping was carried out by using open polygons and irradiation from floating bases, following the grading schema proposed by the Union Internationale de Spéléologie (UIS). A Leica DISTO D810 Touch Pack laser measuring tape and a Samsung On 7 smartphone with the TopoDroid 5.0a (Cave Mapping) application installed were the equipment used for field-based collection and pretreatment of topographic data. At office, the topographic data were processed using computer-aided design software. All shelter panels are geospatialized on a speleological map with the location of paintings within the rock cavity.

The survey works did not involve collection of archaeological, geological or pedological material or direct contact with the rupestrian paintings, consisting only in photographic recordings being made. The surveying method applied to the graphisms was based on Bednarick (1994; 2002), Lara (2013), Martínez (2008-2010), López (2009), Collado *et al.*, (2013), Garcia (2013) and Junghans (2018).

Photographs of the panels were taken using a Canon EOS Rebel T3i digital camera. In order to obtain a more detailed record of the rupestrian art elements, images were filtered using the DStretch plugin, an extension of the ImageJ software. With the use of the image enhancement techniques, previously imperceptible painting details could be perceived. For a deeper understanding of the painting techniques and the overlaps found, digital decals were created from the images using free editing software. In order to better analyze the rupestrian representations of *Araucaria angustifolia*, an orthoimage was constructed based on photogrammetric data from 96 high resolution (18 Megapixel) images. From the orthoimage, six images were enhanced using the Dstretch plugin that combined resulted in a digital decal.

Characterization of the geological substrate of the *Araucaria angustifolia* representations involved petrographic description of sedimentary facies and characterization of the brittle planes present in the shelter. For this approach, special emphasis was placed on the stratigraphic horizon on which the panels occur. The description included elaboration of a 1:1 stratigraphic section of the main panel in order to establish possible relationships among granulometric variations, sedimentary structures, the panel's state of preservation and (possibly) choice of painting location.

3. RESULTS

The results obtained from the methodological procedures described are presented below, with a general characterization of the shelter and a detailed characterizations of both its substrate and the representations in the Araucárias Panel.

3.1. Physical and morphological aspects of the shelter

The Araucárias Shelter occupies an internal area of approximately 90 m², with 8.3 m of linear development, 16.4 m of lateral amplitude and a maximum ceiling height of 5.4 m. The ceiling is low in some portions, with decimetric ceiling heights (Figure 4).

The cavity follows a simple morphological pattern typical of an under-rock shelter, with a single-level floor and genesis from chemical and physical weathering processes. Especially in weakness zones in the conglomeratic sandstone, the processes responsible for tectonic structures and sedimentary discontinuities can also cause detachment and subsidence of layers and the development of underground spaces with stair-shaped ceilings (Figure 5).

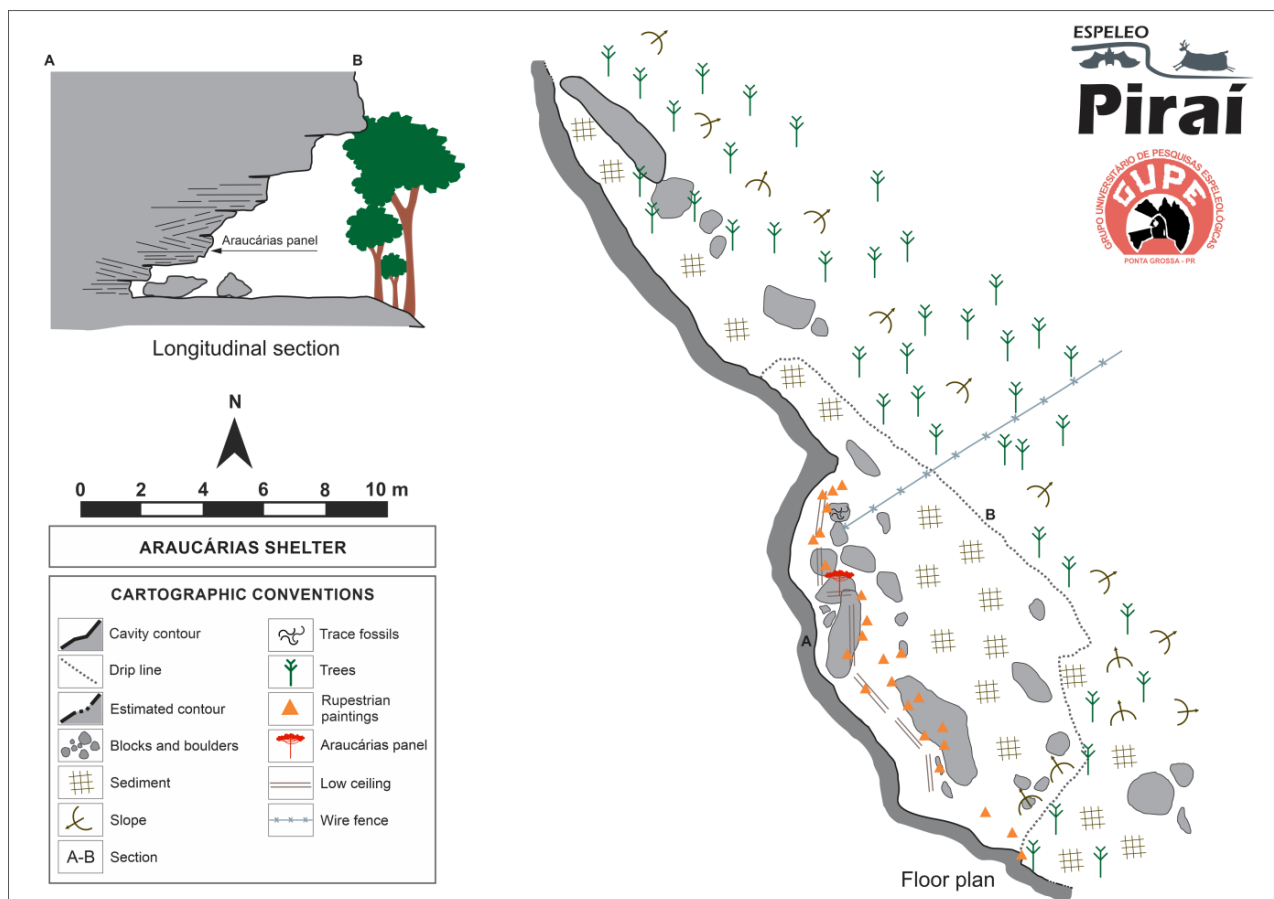




Figure 5 - Internal area of the shelter as viewed from (a) the northwest and (b) the southeast, showing ladder-shaped roof and wall.

No vegetation is present inside the cavity. In its immediate external parts, some tree and shrub species occur adjacent to the line that marks the entrance to the shelter. The floor is formed by a dark sandy soil and small litter areas. Irregular blocks and boulders are present, varying between a few centimeters and 4 meters in diameter, some of them partially buried, some superimposed on the floor. No infiltration or circulation of rainwater is observed in the underground portions of the shelter, which makes it a place capable of providing good protection against the weather.

3.2. Geological substrate of the Araucárias Panel

The representations of *Araucaria angustifolia* are distributed over a rupture surface on the wall caused by transversal fracturing relative to the shelter's entrance line, within limits of a distinct set of sedimentary layers. The irregular surface extends for 38.57 cm at the bottom, 77.2 cm at the top, with a height of 67.2 cm, covering an area of approximately

0.36 m². The panel rests 115 cm above the shelter floor. A large rectangular boulder of metric dimensions lies at approximately 20 cm from the lower portion of the panel.

The substrate of the Araucárias Panel consists predominantly of a coarse sandstone with conglomeratic lenses formed by granules and pebbles up to 4 cm in diameter (Figure 6). In the classification of Assine (1996), these sandstones correspond to the lower portion of the Furnas Formation, having been deposited in a deltaic environment. Plano-parallel and cross-tabular bedding are present, as well as fractures, whose NW-SE orientation follows regional structures associated with the uplift of the Ponta Grossa Arch (MAGALHÃES, 2009; RENNE *et al.*, 1996).

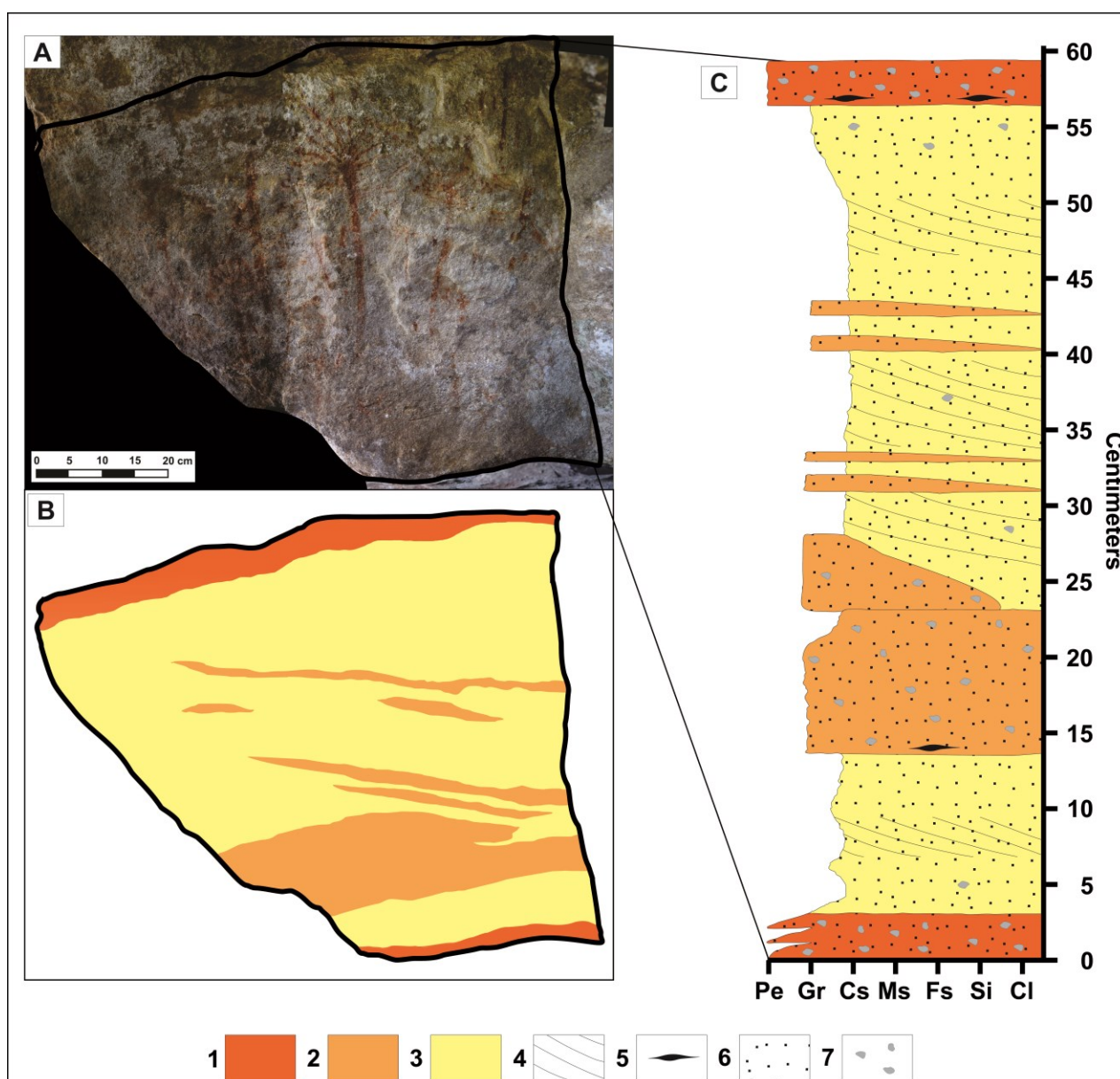


Figure 6 - (a) Limits of the Araucárias Panel, (b) textural distribution of the substrate, (c) stratigraphic column. Granulometric predominance of (1) pebbles, (2) granules and (3) coarse sand; (4) tabular cross bedding, (5) clayey intraclasts, (6) sandy matrix and (7) gravel framework.

Despite consisting of coarse-textured rocks with rough, irregular surfaces, the substrate on which the Araucárias panel was painted underwent slight polishing by the same compressive processes that led to its fracturing and silicification, resulting in a plane more suitable for painting.

Two secondary mineral precipitation forms can be observed in the panel, a white clayish one partially covering the paintings, and a beige one forming botryoidal concretions similar to microspeleothems. In the latter case, pigment material was applied over the concretions.

3.3. Rupestrian paintings

In total, 25 panels in red and black pigments are housed along a continuous 16.4 m linear surface on walls and ceilings in the innermost portions of the Araucárias Shelter. Predominant themes include fingerprints, dots, geometric forms and two small phytomorphs (Figure 7), with the araucaria panel, number 17, an example of these panels. For differing from other panels in terms of forms represented, preservation and rarity, that was the panel after which the shelter was named.

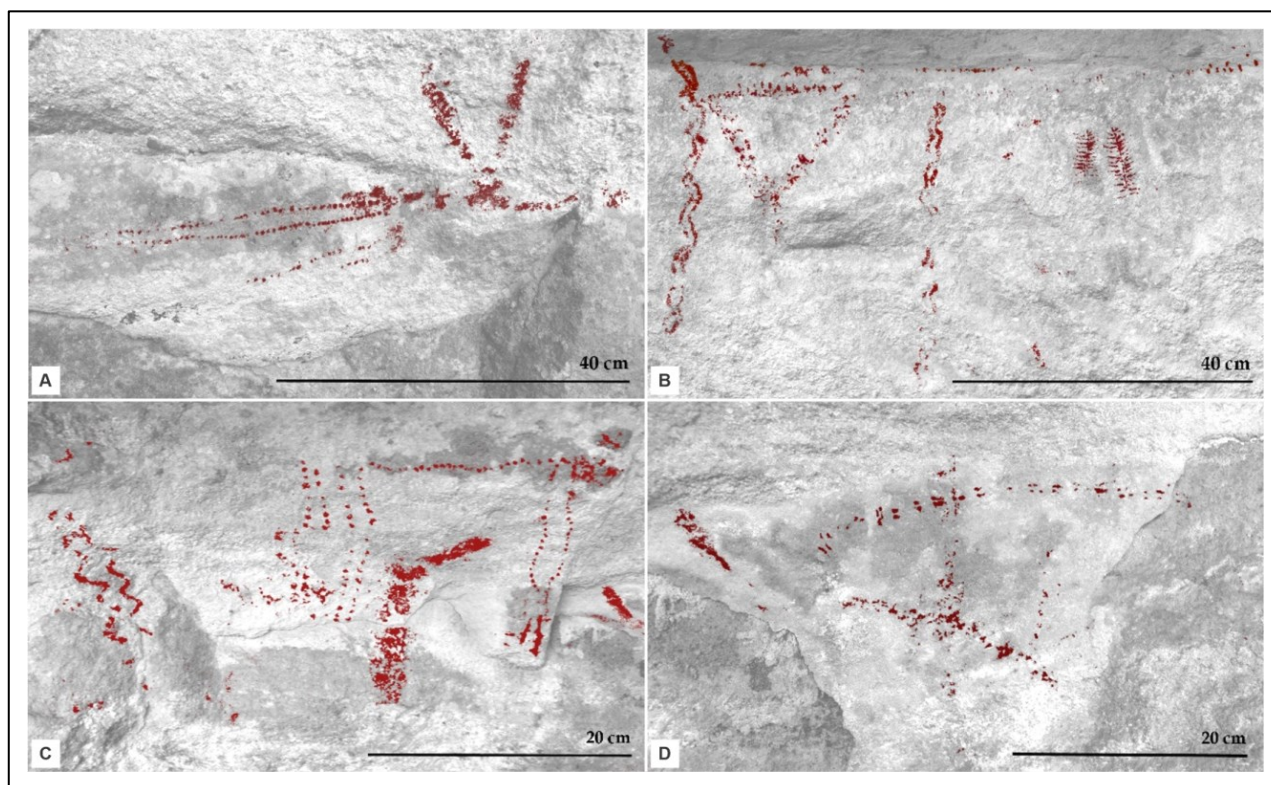


Figure 7 - Processed images of graphisms found at the Araucárias Shelter: (a) Panel 05, (b) Panel 08, (c) Panel 13.1 and (d) Panel 13.2.

Regarding preservation, the shelter's substrate ranges from good to bad. Some of the paintings underwent natural exfoliation and detachment due to weathering and erosion. The fading pigmentation and the reduced dimensions also make it difficult to observe the paintings in detail. However, even under such unfavorable conditions, the panel's degree of preservation allows different arboreal types to be recognized among the pictorial representations.

Altogether, 13 representations of *Araucaria angustifolia* were identified, ranging in size from 12.4 to 35.2 cm from the base to the crown and 8.25 to 24.6 cm in width. Most representations are incomplete due to natural degradation of the substrate. In some situations, identification was only possible after digital image enhancement, as exemplified in figures 8 and 9. Occasional overlapping of representations is present, but with no apparent intention of erasing or disfiguring previously painted elements. In general, the distances between individual representations indicate that the construction of the scene followed the order in which the represented elements occurred.



Figure 8 - Panel 17 (Araucárias Panel), original (unprocessed) image.

About 20 anthropomorphic figures are distributed among the trunks of the *Araucaria angustifolia*, with heights ranging from 1.3 to 3.8 cm. The graphisms are schematic, with a thick segment as the central axis (the torso) and two sets of thinner segments representing the limbs, one at the top and the other one at the bottom. Only one anthropomorph representation shows a thin central segment on its upper portion representing the head. The absence of this characteristic in other anthropomorphs might be determined by the paintings degree of preservation.

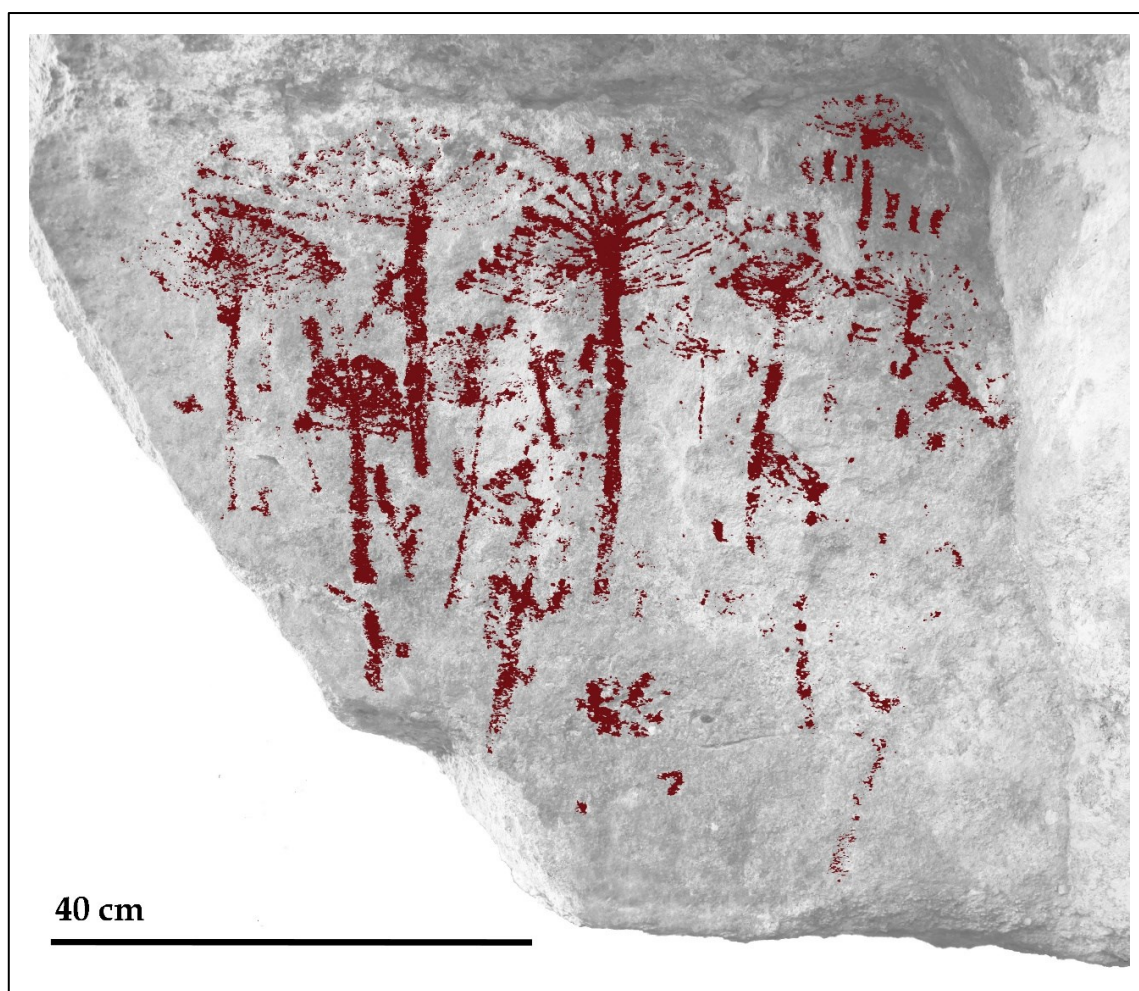


Figure 9 - Digitally enhanced image of the Araucárias Panel.

Three scenes stand out at the Araucárias Panel. The first one, on the upper right corner, is separated from the rest of the panel by a diagonal fracture. Represented on a smaller scale, it consists in six anthropomorphs, three on each side of an *Araucaria angustifolia* tree (Figure 10).

The second scene, in the upper part of the panel, represents the lower branches of an *Araucaria angustifolia* tree as being almost twice their normal length. Starting from the

end of the lower right branch, which is crossed by a diagonal line, at least 10 anthropomorphs extends in a row from the crown rightward (Figure 11).

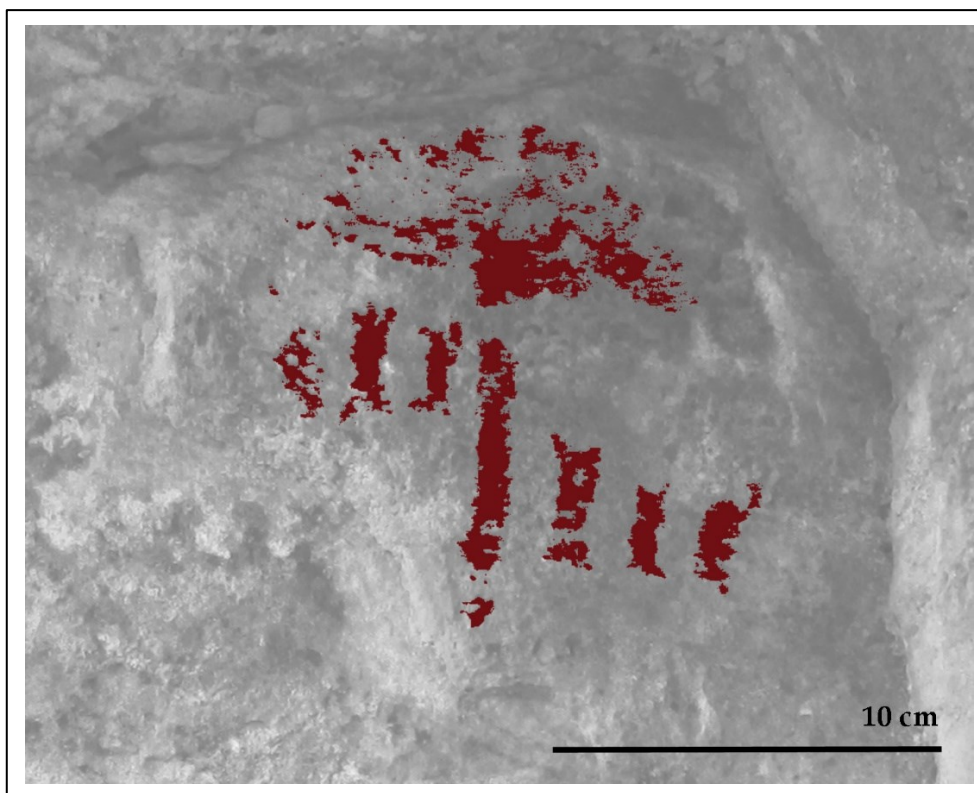


Figure 10 - Top right scene detail of the Araucárias Panel.

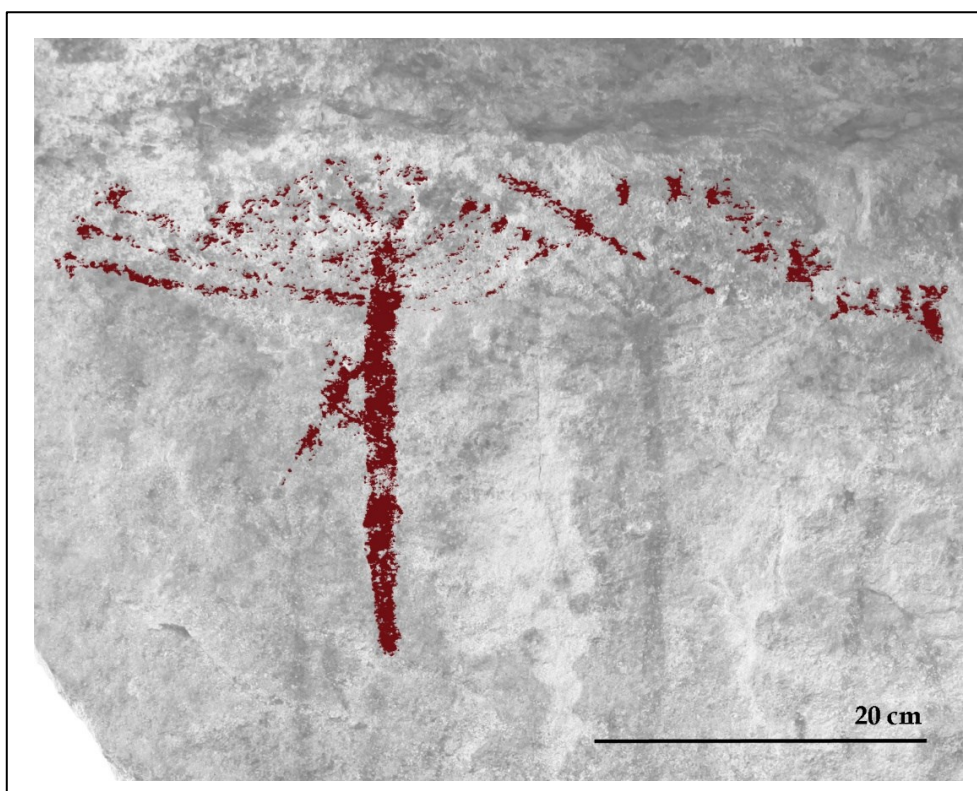


Figure 11 - Detail of a scene represented in the upper part of the Araucárias Panel.

The third scene identified among the representations of *Araucaria angustifolia* possibly depicts, in at least three graphisms, a tree being climbed (Figure 12). Due to flaking of the rock surface, it cannot be ascertained whether anthropomorphs or zoomorphs are represented by the graphisms.



Figure 12 - *Araucaria angustifolia* trees being climbed by zoomorphic or anthropomorphic figures.

In general terms, disregarding scale, and taking only the shapes of the branches into account, some aspects allow the representations of *Araucaria angustifolia* specimens to be identified as corresponding to a transitional stage between youth and maturity. As pointed out by Ferri (2019), young *Araucaria angustifolia* trees show conical crowns with upward-curved primary branches and longer lower branches. In mature specimens, the ascending branches of the crown assume the shape of a calyx.

4. DISCUSSION

In the archaeological site studied, several panels include representations of geometric shapes, isolated points, sets of points, continuous wavy lines, dotted lines,

phytomorphs and other graphisms in shades of red and black. However, it is for housing rupestrian representations of *Araucaria angustifolia* specimens that the shelter is an unique occurrence of scientific, cultural and historical value. Despite some deterioration due to weathering of the substrate and other natural agents, the representations are highly detailed and faithful to the typical aspects of the species, which is unprecedented among other rupestrian findings in the region.

The uniform and consistent visual discourse determined by the representation technique used reinforces the hypothesis that the panel represents an *Araucaria angustifolia* forest or a small isolated group of trees.

Specifically regarding geological aspects of the Araucárias Shelter, the substrate on which the tree representations were made is fundamental to understanding the panel in its context. Almost all the walls in the shelter are rough and irregular due to their coarse texture, which is typical of the Furnas conglomeratic sandstones. However, the polished, more uniform surface resultant from tectonically-conditioned silicification favored painting, especially for allowing trees to be represented in greater detail. This verifies that the graphisms were traced on a deliberately chosen surface.

Inextricable ethnic relations exist between *Araucaria angustifolia* and the different human groups that inhabited the southernmost parts of Brazil, the species being currently considered a symbol. To the original populations, it was of fundamental importance, given its multiple properties and functions, including that of being a source of food. *Araucaria angustifolia* seeds are also a source of food for animals, such as several birds, collared peccaries, tapirs, and howler monkeys (SANTOS, 1973; MIRANDA and PASSOS, 2000). The seeds were also among the main types of food consumed by the original inhabitants of southern Brazil. The Tupi, for instance, used to call *Araucaria angustifolia* seeds *iba*, i.e., the fruit *par excellence* (LÉVI-STRAUSS, 1950). In order to be consumed as food, the seeds were predominantly ember roasted (MABILDE, 1983; LAPPE, 2014), ground into flour, or cooked (PAULA, 1924; URBAN, 1978; NEVES, 2016).

In the Araucárias Panel, at least three of the representations have their trunks climbed by humans or elements of the local fauna such as the howler monkey. In this sense, Peres (2009) points out that the gathering of ripe *Araucaria angustifolia* seeds naturally fallen to the ground would be unfrequent, made only for immediate consumption. Thus, the original inhabitants of the area would have preferred to pick them up directly from the trees. Being *Araucaria angustifolia* a tree of large dimensions, individuals would

have to climb them in order to pick up the *pinhas* (pine cones), a highly complex activity to perform.

The techniques used for picking cones directly from the trees differ according to region, ethnicity and chronology. In the early 20th century, for example, the Xokleng, a population of Jê linguistic lineage inhabiting the district of Dalbérgia, Ibirama county, Santa Catarina state, and mistakenly called Kaingang by Jules Henry, would pick up the cones by wrapping stripes more than 2 m long made of bamboo fiber around *Araucaria angustifolia* trunks (HENRY, 1964). By passing these bands under their arms while leaning in the opposite direction relative to the tree trunk, collectors would be able to support their own weight as the friction force thus generated acted as a natural fall arrester.

The pine cones were separated from the trees by the sudden movement of the branches or by using long bamboo poles (MÉTRAUX, 1946; SANTOS, 1973; BECKER, 1995). The same climbing technique was used to come down from the trees (PAULA, 1924; LAVINA, 1994). Because the bamboo fiber stripes could not be removed from around the trunks, new sets of stripes were positioned in each climbing round (Henry, 1964). Climbers could employ the same technique by placing vines segments around their feet and back.

The paintings in the Araucárias Shelter also include 20 representations of anthropomorphs among *Araucaria angustifolia* trunks. Considering this aspect of the panel, it is possible that the scene represents a group of people involved in the picking of seeds, with some individuals being responsible for climbing the trees while other individuals were in charge of collecting fallen cones from the ground. According to Urban (1978) and Mabilde (1983), the work was divided between men, who performed the climbing and pick-up, and women, who were responsible for collecting and storing the seeds.

Araucaria angustifolia seeds were historically collected between April and June, which in the Southern Hemisphere corresponds to a period between late autumn and early winter (PAULA, 1924; MÉTRAUX, 1946; SANTOS, 1973). According to Peres (2009), in order to allow for storage and later consumption, the seeds needed to be collected before maturation was completed.

Different discussion trends exist on the expansion of *Araucaria angustifolia* across the plateaus of Southern Brazil. One such trend revolves around the influence of climate change, associating their expansion to increased humidity conditions during Late Holocene times. According to another trend of discussion, raising and management of the

species by native populations may have exerted an influence on its expansion across the region. Henry (1964), Santos (1973) and Urban (1978; 1985) consider *Araucaria angustifolia* a non-domesticated species, their seeds being collected from naturally occurring trees. Lévi-Strauss (1950), in turn, argues that the difficulty in distinguishing between wild and cultivated species in South America arises from the influence of variables associated with intermediate stages between the use of wild vegetation and the true cultivation of species. Lappe (2014) reports on the management of *Araucaria angustifolia* by the Kaingangs, an ethnic group of southern Brazil that has the habit of sowing the species in the regions they occupy.

The region traditionally occupied by Jê populations referred to as the Kaingang and the Xokleng coincides with the region across which *Araucaria angustifolia* has spread, currently the Brazilian states of Paraná, Santa Catarina and Rio Grande do Sul (Métraux, 1946). The ancestral relationship between local ethnicities and the species has been recorded by travelers and explorers for centuries (e.g., SAINT-HILAIRE, 1964). For the Kaingangs, the *Araucaria angustifolia* represents not only a natural element by which territories are delimited, but also an element of group identity, medicine and food source, production of purple pigments, varnish and raw material for ax handles and other utensils (LAPPE, 2014).

As pointed out by Appoloni (2010), the rupestrian paintings found in Paraná can be classified as belonging to two specific groups, the oldest one related to hunters-gatherers of the Umbu tradition, while the most recent one is legacy of Itararé-Taquara ceramicist populations of Jê ancestry. According to Parellada (2016), the rupestrian panels left by Jê populations are complex, with numerous representations of human figures, cultivated plants and symbols possibly representing group or clan elements and modes of landscape appropriation or territory delimitation. Parellada (2015; 2016) distinguishes the São José da Lagoa 2 shelter in rural Piraí do Sul from other archaeological sites in southern Brazil based not only in the degree of detail with which elements are represented, but also on the presence of over a hundred anthropomorphs represented in motion, possibly in some sort of ritual.

Along with detailed graphisms, the representations of plant specimens and human figures allow the panel found at the Araucárias Shelter to be chrono-culturally associated with members of the Jê ethnic group. Parellada (2015; 2016) points out that these were the first ceramists and farmers to occupy the territory of Paraná approximately 4,000 years ago. At that time, according to Behling (1997) and Behling *et al.*, (2009), the grassland

vegetation was predominantly controlled by cold and dry glacial conditions. Evidence from palynological studies carried out in peat areas located 28 km southwest of the Araucárias Shelter in rural Tibagi allowed Behling (1997) to consider the prominent advance of the *Araucaria angustifolia* across the Campos Gerais do Paraná as having begun around 1,400 years ago, as indicated by radiocarbon readings.

For Behling (1997) and Behling *et al.*, (2009), the gradual vegetation changes experimented by the Campos Gerais do Paraná were due to the advance of warm and humid conditions, which favored the expansion of forests previously limited to natural shelters along river canyons and valleys, where conditions were favorable for the development of arboreal vegetation.

Holocene climate changes recognized in the Campos Gerais do Paraná must also be taken into account in the evolution of the local landscape. Paleoclimatic analyzes of lake sediments from Lagoa Dourada, municipality of Ponta Grossa, Paraná, indicate three important climatic events at 8,200 and 4,200 years B.P. and during the Little Ice between 1000 to 750 years B.P. (ZOLITSCHKA *et al.*, 2021). At the time of these events, centenary periods of greater rainfall may have influenced both the spatial distribution of species such as *Araucaria angustifolia* and the occupation of the region by native populations.

From data presented by Robinson *et al.*, (2018), the expansion of the *Araucaria angustifolia* across the plateaus of southern Brazil over the last 1,400 years has been associated with the occupation of these areas by native populations, which suggests that the landscape changes were related to demographic changes. The same authors point out that the expansion of proto-Jê groups between 1,410 and 900 years B.P. and their complex cultural particularities were determinant in the expansion of the species. Despite the fact that the investigations by Robinson *et al.*, (2018) were performed about 500 km south of the location of the area covered in the present study, an influence of indigenous populations on the expansion of the *Araucaria angustifolia* across the Campos Gerais do Paraná can be inferred.

For Iriarte *et al.*, (2013) and Robinson *et al.*, (2018), *Araucaria angustifolia* played a central role in religious and social institutions of proto-Jê populations in southern Brazil. As no radiometric datings have yet been performed on the paintings found at the Araucárias Shelter, the original population that was responsible for the archaeological finding cannot so far be established. However, it can be hypothetically pointed out that, given the amount of tree specimens represented, the trees could already constitute small isolated woodlands in the region.

Datings performed by Parellada (2009; 2015) on materials associated with Jê populations from the Jaguariaíva I shelter correspond to an age of $2,858 \pm 35$ years B.P. Thus, if older (about 3,000 years B.P.) Jê populations were responsible for the Araucárias Panel, this might indicate that the species could be found outside the extensive of Iapó and Tibagi valleys since much earlier than proposed by Behling (1997).

5. CONCLUSIONS

The Araucárias Shelter houses one of the most important rupestrian panels ever found in Brazil, being the first record of graphisms representing *Araucaria angustifolia*, an important and iconic arboreal species in southern Brazil. The site stands out not only for its rarity, but also for its high scientific and cultural value as, in addition to several *Araucaria angustifolia* specimens, the scenes depicted include anthropomorphs and possible zoomorphs figures.

The predominance of altered, irregular and imperfect lithological substrates in the Araucárias Shelter evidences selection of the surface on which the representations of *Araucaria angustifolia* were made. Some geological characteristics of the shelter, specifically tectonic silicification, accounted for the generation of a small polished surface, which presented ideal conditions for the elaboration of the rupestrian panel.

Because it includes highly detailed representations of plant species and anthropomorphs, it is possible to establish a chrono-cultural association between the panel and members of the Jê tradition.

Studies are yet to be performed on the role of indigenous populations in the expansion of the *Araucaria angustifolia*, specifically across the Campos Gerais do Paraná. As in the case study presented here, which first records the occurrence of rupestrian paintings with representations of this species, comprehensive further research involving archaeological sites could provide more information on the development of the local prehistoric communities and the palaeovegetational and palaeoenvironmental conditions across the region.

It is essential that archaeological prospecting works in this region of Paraná become permanent, especially along the Devonian Escarpment and its immediate surroundings. The information to be brought by new findings will contribute to the understanding of the regional archaeology, the historical reconstruction and the (re)interpretation of the socio-spatial and cultural organization dynamics of these indigenous populations.

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