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Pripiri Geosite, Coração de Jesus, Minas Gerais, Brazil: paleontological relevance, quantitative assessment, and initiatives for its promotion

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Abstract

The Quiricó Formation is the richest fossiliferous unit of Sanfranciscana Basin. Its paleoasis context (a paleolake record inserted in a desert setting) includes vertebrates, diverse microfossils, and paleobotanical content. This study presents new findings regarding the fossil content of the formation, focusing on discoveries made at the Pripiri Geosite, located in Coração de Jesus municipality, northern part of the state of Minas Gerais, Brazil. Among the discoveries are poorly informative fragments of putative archosaurs and novel microfossiliferous taxa. The microfossil assemblage includes dinocysts and Euglenophyceae, both associated with microbial mat-forming cyanobacteria. These, in turn, comprise the filamentous *Pseudoanabaena* sp. and the coccoidal cells of *Aphanocapsa* sp. or *Chroococus* sp. These microbial mats are recurrent throughout the analyzed stratigraphic succession, primarily observed in sandstone bars featuring distinct evaporitic features. This assemblage provides ecological insights concerning the biota resistance to extreme climatic conditions, and their occurrence in oxygen-rich waters. The preservation of these cells in evaporite-rich rocks is also of great interest for astrobiological studies and the search for past life on Mars. Therefore, due to the importance of Pripiri locality, a quantitative analysis of its geodiversity and geoheritage value were performed, revealing that Pripiri comprises a geosite of national relevance in terms of its scientific, touristic and educational values. In this sense, some initiatives have been carried out to geoconservation and to promote the local geodiversity, aiming to contribute to the paleontological knowledge of the Early Cretaceous, as well as to the social and economic development of Coração de Jesus.

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1. Introduction

The Sanfranciscana Basin, located on the São Francisco Craton, constitutes the Phanerozoic sedimentary cover. It encompasses diverse sedimentary formations deposited over the São Francisco Supergroup, including the glacial sediments of the Santa Fé Group deposited during the Carboniferous–Permian interval, the arid to fluvial-paleoasis deposits of the Lower Cretaceous Areado Group, and the desertic and volcanic rocks of the Upper Cretaceous Urucuia and Mata da Corda groups (Zalán and Silva 2007). These formations, spanning a wide temporal range, document significant climatic changes and biotic evolution, rendering the Sanfranciscana Basin a pivotal window into the continental interior during the Pangea's breakup and the emergence of South America.

The fossil assemblage within the Sanfranciscana Basin comprises specimens ranging from invertebrate to vertebrate fossils, as well some palynomorphs (Arai et al. 1995; Bittencourt et al. 2022). The stratigraphic sequence reveals an evolutionary narrative, with initial fossil occurrences confined to lacustrine deposits of the Santa Fé Group (Permian–Carboniferous sequence) and include ichnofossils whose precise origins remain debated (Bittencourt et al. 2022).

Subsequently, the Areado Group (Lower Cretaceous), particularly the Quiricó Formation, emerges as a significant paleontological repository within the basin (Carmo et al. 2004; Leite et al. 2018, 2024; Leite and Carmo 2021; Coimbra 2020; Cabral et al. 2021; Bittencourt et al. 2022). Notable findings from this formation include the terrestrial squamata *Neokotus sanfranciscanus* (Carvalho and Santucci 2018; Bittencourt

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et al. 2020) and diverse bony fish fragments such as Semionotiformes, Amiiformes, fin spines, teeth, and denticles from at least three different species of Hybodontiformes sharks, and remains of coelacanthiform fish from the genus *Mawsonia* were also found (Fragoso et al. 2019). Comprising invertebrates, there are described species of conchostraceans and a great number of ostracods taxa (Leite and Carmo 2021; Bittencourt et al. 2022). Additionally, palynomorphs, larvae of insects of the species *Saucrolus silvai*, thousands of specimens of the ray-finned fish *Dastilbe moraesi*, and some species of plants were recorded in the Presidente Olegário (State of Minas Gerais) region: conifers *Brachyphyllum obesum* and *Podozamites lanceolatus*, the nymphaceous *Nymphaeites choffatti* and the grass *Paraleptaspis varjensis* (Arai et al. 1995; Duarte 1997), among others, further enrich the paleontological record.

The Areado Group also preserves a distinct marine fossil record. This includes radiolarians, dinoflagellates, acritarchs, sponge spicules, and foraminifera recovered in western portion of the state of Minas Gerais (Kattah and Koutsokos 1992; Pessagno and Dias-Brito 1996; Arai 1999; Dias-Brito et al. 1999; Azevedo et al. 2024). This fossil record supports the occurrence of an intracratonic wide sea, namely Arai Sea, during the Aptian. Although still under debate, this idea is reinforced by the occurrences of evaporites deposits and a series of marine fossil assemblage in other Brazilian intracratonic basins, such as Parnaíba and Araripe basins (see deeper discussion in Azevedo et al. 2024).

In Coração de Jesus (State of Minas Gerais) region, the first complete skull of a titanosaurid in South America, *Tapuiasaurus macedoi,* was founded in the deposits of Areado Group (Zaher et al. 2011). In addition, noasaurid theropod bones and a complete skull from an abelisaurid specimen (*Spectrovenator ragei*) were described (Silva 2013; Zaher et al. 2020). The region also features ichnofossils, lizard remains, lepisosteiformes, lungfish, and a large variety of ostracods (Cabral et al. 2021; Carvalho and Santucci 2021). The Três Barras Formation hosts dinosaur footprints attributed to theropods, ornithischians, and sauropods (Mescolotti et al. 2019).

Conversely, the Mata da Corda Group primarily preserves macrovegetation represented by dicotyledonous leaves and palynomorphs in the Coromandel (State of Minas Gerais) region (Leonardos et al. 1995). This includes several gymnosperms spores and angiosperms pollens, as well as fewer specific spores. Also, fungi and undetermined spores were also recovered. Authors attributed a tropical climate during the deposition of the above assemblage, which took place between 80 to 85 Ma, based on the occurrence of these same taxa in the Brazilian marginal basins.

All this geodiversity points to the high potential of the Sanfranciscana Basin sedimentary succession record for geoheritage and geoconservation purposes, considering the geological, paleontological, and speleological richness (e.g. Campos and Dardenne 2002) observed among the most notable localities, with not only scientific value, but also for touristic and social usefulness and value. This geological context may be of great importance for economic development purposes as well. This is because the area where the deposits recorded of the Sanfranciscana Basin occur is among the poorest regions in Brazil, presenting a Human Development Index (HDI) of 0.642, considered a low index for social development (PNUD 2024). In this sense, geosites and abundant occurrence of geodiversity sites (*sensu* Brilha 2016), can serve as tools for territorial management, economic, and social improvement through cultural and tourism activities, enhancement of services provisions, and of the development of other associated economic activities (Nascimento et al. 2015).

Here, we describe the Pripiri locality as a geosite. It is located in the vicinity of the municipality of Coração de Jesus, in the northern part of the Minas Gerais state. We propose its classification as a geoheritage based on its scientific relevance, due to the recent discovery of new fossils here presented, in addition to its fossil content previously published. The area of Coração de Jesus comprises Precambrian carbonate rocks of the Lagoa do Jacaré Formation and an abundant lacustrine to the desertic record of the Cretaceous Areado Group, within which the geosite is situated. In addition, considerations concerning the conservation of this geosite and its potential educational and touristic uses are also presented. Thus, in the near future, the initiatives listed here may serve as a guideline for the establishment of social and economic politics in Coração de Jesus, aiming for its social development.

2. Geological context

The subject of this study is situated within the São Francisco Basin, which, as described by Alkmin and Martins Neto (2001), constitutes the western segment of the São Francisco Craton. It has received sedimentary deposits from at least four distinct geological events since 1.8 billion years ago, filling successive basins with varying ages, tectonic histories, and paleogeographic scenarios. These basins include Precambrian formations (Espinhaço and São Francisco supergroups) as well as Phanerozoic successions (Santa Fé, Areado, Mata da Corda, and Urucuia groups). The Phanerozoic strata, covering sequences from the Permocarboniferous to the Cretaceous interval, represent the final depositional cycle of the São Francisco Basin and form part of the Sanfranciscana Basin (Campos and Dardenne 1997a; Sgarbi et al. 2001).

The Sanfranciscana Basin spans approximately 150000 km^2, oriented in a north-south direction, with dimensions of roughly 1100 km in length and 200 km in width, and it is exposed in the states of Minas Gerais, Bahia, Tocantins, Maranhão, and Piauí (Sgarbi et al. 2001). According to Campos and Dardenne (1997b), it can be characterized as an intracontinental sag basin type with low subsidence, occasionally influenced by taphrogenic processes. Tectono-stratigraphically, it can be subdivided into two sub-basins: Urucuia (north) and Abaeté (south), separated by the Alto do Paracatú, which outcrops west of the city of Coração de Jesus (Campos and Dardenne 1997b). The basin is delineated by five units, separated by significant regional disconformities. From bottom to top, its stratigraphy comprises the Santa Fé (Permo-Carboniferous), Areado (Lower Cretaceous, Albian interval), Mata da Corda (Upper Cretaceous), and Urucuia (Upper Cretaceous) groups, as well as the Chapadão Formation (Quaternary - recent sedimentary deposits) (Campos and Dardenne 1997a, 1997b).

The Areado Group, the focus of this study, is exposed in both the southern and northern portions of the basin. Deposition of the Areado Group is associated with crustal stretching during the opening of the South Atlantic Ocean, followed by a phase of mechanical subsidence (Campos and Dardenne 1997a, 1997b; Fragoso et al. 2011). From base to top, it comprises

the following formations: 1- Abaeté Formation, characterized by conglomerates and sandstones interpreted as alluvial fans and fluvial deposits (Campos and Dardenne 1997a, 1997b, Mescolotti et al. 2019); 2- Quiricó Formation, the primary focus of this work, of Barremian–Albian age (Figure 1), primarily composed of sandstones, mudstones, and siltstones, with subordinate occurrences of cherts, pseudomorphic salt layers, and limestones, indicative of a lacustrine and playa-lake environments (Campos and Dardenne 1997; Sgarbi et al. 2001; Fragoso et al. 2011; Mescolotti 2019; Simplício et al. 2017, Cardoso et al. 2022, 2024); and 3- Três Barras Formation, consisting of sandstones, mudstones, occasional conglomerates, and chert lenses, interpreted as fluvio-deltaic and aeolian paleoenvironments (Sgarbi 2000; Simplício et al. 2017). The uppermost part of the Três Barras Formation is interbedded and overlain by effusive and pyroclastic volcanic alkaline rocks, plutonic alkaline rocks, and epiclastic sedimentary rocks of the Mata da Corda Group (Sgarbi et al. 2004).

In the Coração de Jesus region, units of the Sanfranciscana Basin outcrop as small plateaus in angular unconformity with the Bambuí Group rocks, a succession of carbonate-siliciclastic rocks ranging up to 1000 m in thickness and of Ediacaran to Cambrian age (Warren et al. 2014). The studied sedimentary succession is represented exclusively by deposits from the Quiricó Formation, the middle portion of the Areado Group.

Age		Lithostratigraphic units			Age and/or data source
Holocene Pleistocene Pliocene		Chapadão Formation			Correlation with eluvial and alluvial covers of other chronocorrelative basins in Brazil
Late Cretaceous	Campanian	Mata da Corda Group	Capacete Formation		88.5 ± 1.9 to 71.5 ± 1.8 Ma based on K-Ar radiometric dating of illites Stratigraphic correlation Biostratigraphic correlation
	Coniacian		Patos Formation		87 to 83 Ma based on kimberlite clusters 81 to 68 Ma based on U-Pb radiometric dating ca. 90 Ma based on Ar-Ar radiometric dating 87 to 80 Ma based on K-Ar radiometric dating
		Urucuia Group	Serra das Araras Formation		Field relationship with the Mata da Corda Group
			Posse Formation		Field relationship with the Mata da Corda Group
Early Cretaceous	Albian	Areado Group	Três Barras Formation	Olegário Member	No chronostratigraphic studies
				Quintinos Member	106.1 ±2.2 88.8 ± 1.8 Ma, based on K-Ar radiometric dating of authigenic K-feldspar microcrystals Stratigraphic correlation
			Quiricó Formation		Biostratigraphic correlation based on non-marine ostracod fauna and fish-bone fragments
			Abaeté Formation		No chronostratigraphic studies
Permian Carboniferous		Santa Fé Group			Paleomagnetism Ichnofossils Stratigraphic correlation

Figure 1. Geochronologic chart of the Sanfranciscana Basin. Ages: Albian between 113 and 100.5 Ma; Coniacian between 89.8 ± 0.3 and 86.3 ± 0.5 Ma; and Campanian between 83.6 ± 0.2 and 72.1 ± 0.2 Ma. Modified from Maraschin et al. (2016), and references therein.

3. Materials and methods

The Pripiri Geosite (16°40'9.30"S, 44°37'8.46"W) encompasses an area of 170000 m², situated near the São Geraldo village, within the municipality of Coração de Jesus, in the northern region of the state of Minas Gerais, Brazil (Figure 2). This site contains micro- and vertebrate fossils, a diverse array of sedimentary structures, and intriguing chemical features within a paleoasis context, deposited immediately following the breakup of Pangea, at the end of the Early Cretaceous.

For data acquisition, four field trips were conducted between 2022 and 2023 for rocks and structural reconnaissance, drone surveys, and sample collection. Concerning geoconservation, a qualitative assessment of several sites in the area was conducted during fieldwork, following the four parameters outlined by Brilha (2016), such as representativeness, integrity, rarity, and scientific knowledge. Subsequently, a quantitative assessment of its scientific value, potential for educational and touristic purposes, as well as the risk of degradation, was conducted for the Pripiri site using the GEOSSIT simulator provided by the Brazilian Geological Survey website https://sgb.gov.br/geossit. This simulator adheres to criteria outlined by Garcia-Cortés and Urquí (2009), Brilha (2005), and Brilha (2016), with certain parameters adapted to better evaluate Brazilian specificity.

The scientific value is estimated based on seven criteria: representativeness, key locality, scientific knowledge, integrity, geological diversity, rarity, and use limitations. Considering the evaluation of potential educational and touristic uses, ten criteria are shared, which are vulnerability, accessibility, use limitations, safety, logistics, density of population, association with other values, scenery, uniqueness, and observation conditions. Also, didactic potential and geological diversity are criteria specific for quantifying the educational potential, and interpretative potential, economic level, and proximity of recreational areas are relevant only for the evaluation of potential touristic use. The degradation risk, which is related to human activities, is based on five criteria: deterioration of geological elements, proximity to areas/activities with the potential to cause degradation, legal protection, accessibility, and density of population.

The microfossiliferous and mineral assemblage were observed in 25 thin sections produced at Lamination Laboratory of the Centro de Estudos em Geociências, Universidade Federal dos Vales do Jequitinhonha e Mucuri (CeGeo/UFVJM) and now included in the repository of the Laboratory of Paleontology of CeGeo/UFVJM in serial number from C.LAM-19 through C.LAM-23. Thin sections were analyzed under a petrographic microscope Zeiss, model AxionVision 2.0, coupled to acquiring and analyzing image system at the Microscopy Laboratory, also at UFVJM.

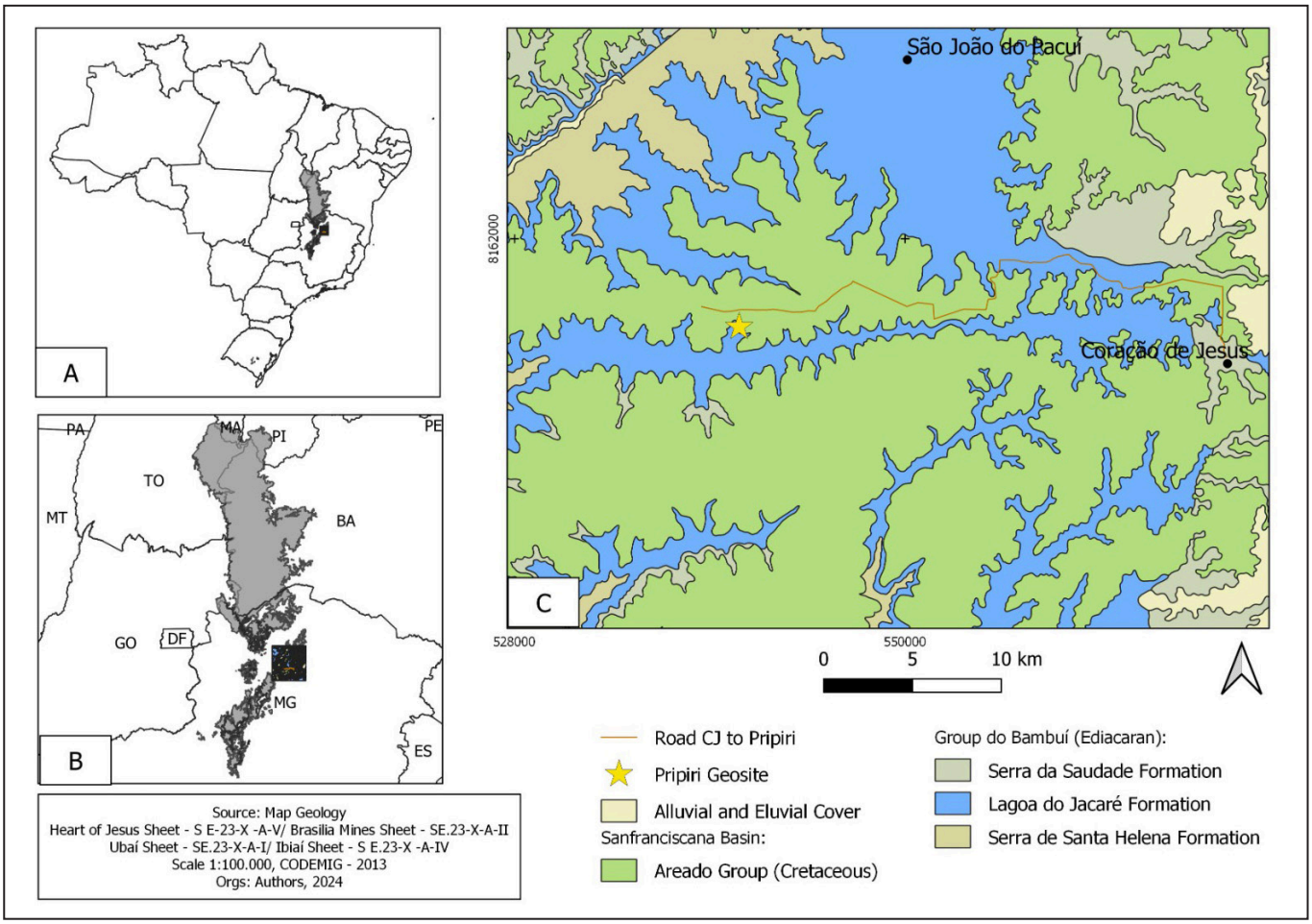

Figure 2. Geological map of Sanfranciscana Basin and the localization of Coração de Jesus municipality and the Pripiri Geosite. A: The Sanfranciscana Basin in the context of Brazilian territory. B: Detail of Sanfranciscana Basin in central Brazil. The color square corresponds to the image in C. C: The geological context of Pripiri Geosite and the access route from Coração de Jesus (CJ) to the site.

4. Results

4.1. New paleontological data and its paleoenvironmental context at Pripiri Geosite

The data collected at the Pripiri Geosite showed that it records approximately 30 meters of pelite-fine sandstone strata alternating to decimetric medium to coarse tabular sandstone bars, resulting in decametric sedimentary cycles (Figure 4a). Pelite strata are light beige to dark brown, with centimetric layers containing a considerable amount of highly friable fine to medium sand. Sandstone bars are reddish to brown, well-cemented, and represent the levels responsible for the stability of the entire outcrop (Figures 4a). Distinct evaporitic features occur from the middle portion of the succession upwards. Sandstone bars contain abundant millimetric white globular structures, randomly distributed among the grains, identified as popcorn and cauliflower-like evaporitic structures (Figures 4c and 4d). They may also appear in the pelite strata at the top of the succession. Decimetric anhydrite crystals also comprise the evaporitic features of this succession and were identified at the uppermost pelite level (Figure 4e). According to petrographic analysis, these structures comprise pseudomorphs of salt and Ca-sulfate replaced by calcite.

The newly discovered paleontological record of Pripiri Geosite includes vertebrate macrofossils and an abundant microfossiliferous assemblage, including dinoflagellate cysts (dinocysts), Euglenaceae green algae, and cyanobacteria. The former ones were recovered in two pelite levels in the middle portion of stratigraphic succession, while the organic-walled microfossils were recovered in the sandstone bars.

The new macrovertebrate record comprises hundreds of long-bone fragments and one rib (Figures 5a-b). Based on the paleontological context of other sites at Coração de Jesus, and due the size of the rib bone and fragments, they are tentatively attributed to archosaurs. However, since they are highly fragmented and poorly preserved, they are not very informative and cannot be classified taxonomically, similar to previously described occurrences in the Sanfranciscana Basin, as noted by Bittencourt et al. (2015).

The organic-walled microfossils were observed in thin sections and occur as microbial mats associated with popcorn structures and centimetric to decimetric anhydrite crystals (Figures 5c-d). The microbial mats presented eukaryotic

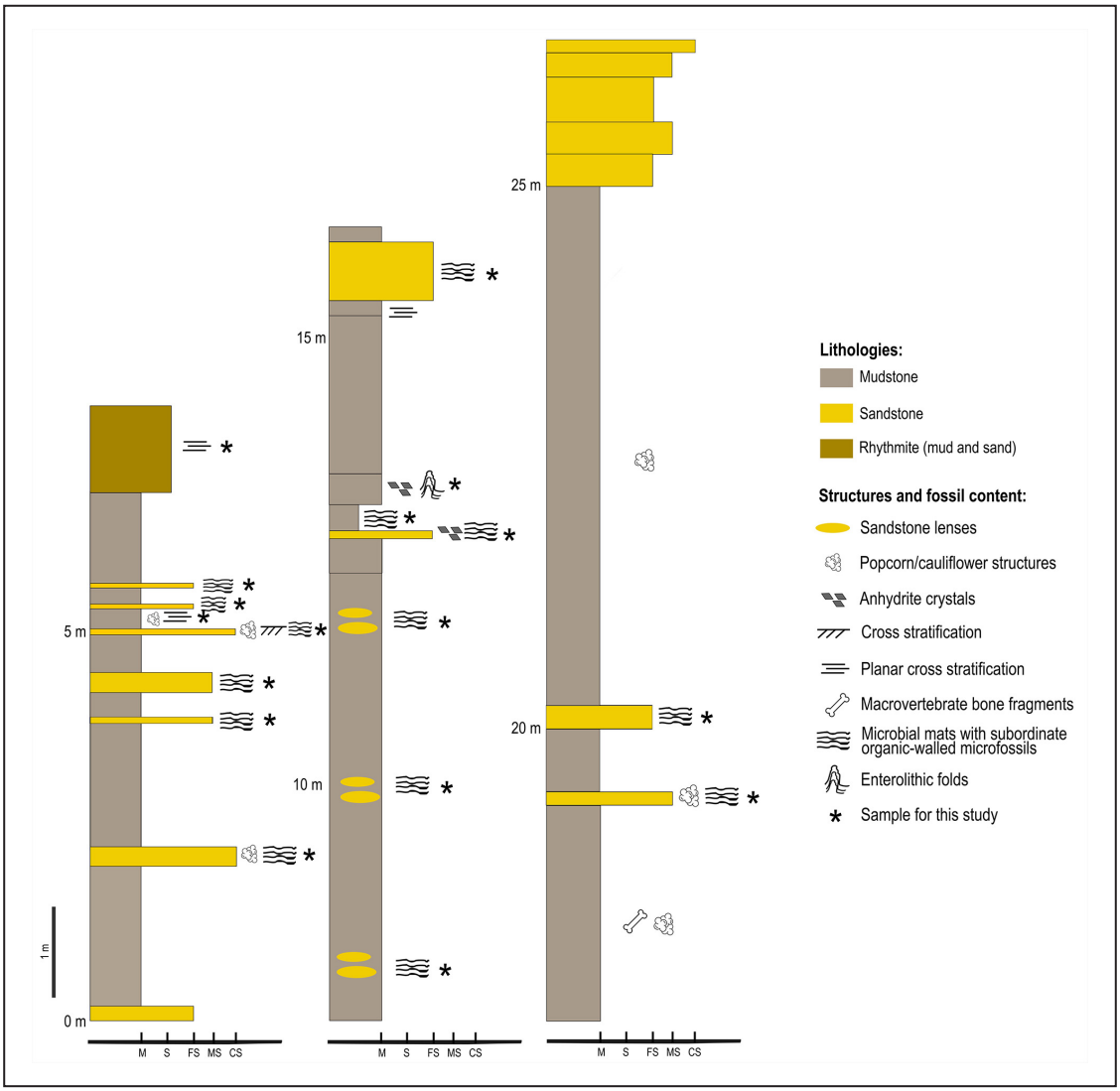

Figure 3. Simplified stratigraphic column of Pripiri Geosite showing the its evaporitic feature and the fossiliferous levels. The granulometric scale stands M for mud, S for silt, FS for sine sandstone, MS for medium sand, and CS for coarse sand.

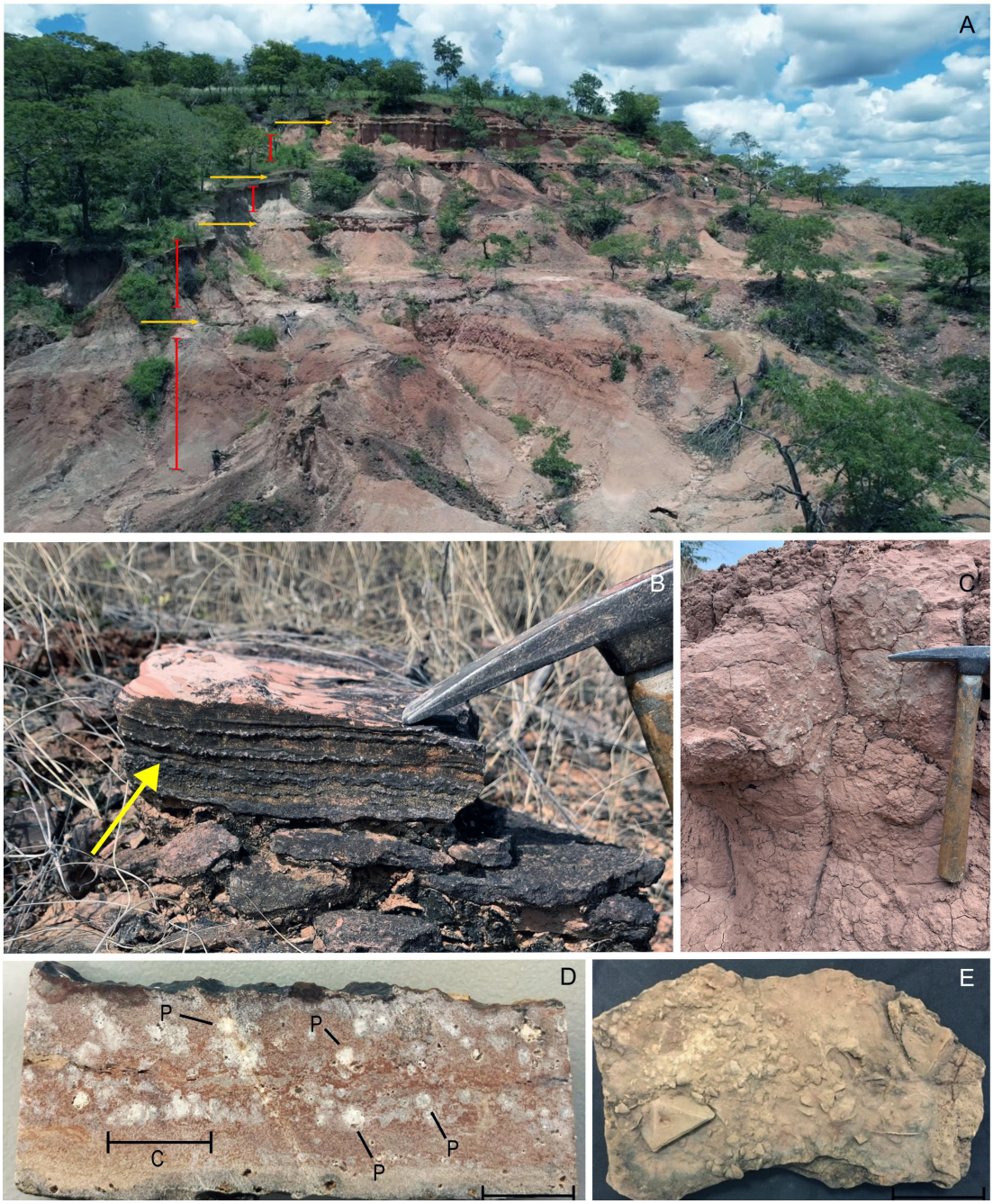

Figure 4. GImportant sedimentary aspects of Pripiri Geosite. A: The general view of the outcrop showing the sandstone bars (yellow arrows) intercalated with pelite levels (red bars) and the resulting sedimentary cycles. B-D: Evaporitic features in sandstones of Pripiri Geosite. B: Popcorn and cauliflower-like structures *in situ* (yellow arrow) preserved in a well-cemented sandstone bar. C: Popcorns in the topmost mudstone level in the outcrop. D: Hand sample containing both cauliflower-like (C) and popcorn structures (P). E: decimetric anhydrite crystals collected in the middle portion of the analyzed succession. Scales: 1 cm in D and 2 cm in E.

fossils of dinocysts (Figures 5e-f) and green algae of the family Euglenaceae (Figure 5f), as well as prokaryote cells represented by two cyanobacteria taxa (Figure 5g). In Pripiri Geosite material, they occur as abundant and dispersed cells among the former extracellular polymeric substance, now preserved as organic matter within the crystalline net. Detailed studies on their taxonomy and paleoecological potential will be carried out in the next steps of this research.

The mat-forming cyanobacteria taxa include two morphotypes, one filamentous and one coccoid taxon. They were identified based on their morphology, size, and mode of occurrence. The filamentous taxon (Figure 5g) was identified as *Pseudoanabaena* sp., a typical filamentous cyanobacteria found in lacustrine microbial mats and already identified in the fossil record. This taxon comprises simple, short, solitary, straight to slightly waved, unbranched trichomes that may present narrow envelopes. The Pripiri materiallacks tricome cells, meaning that the observed specimens correspond to empty sheaths, fitting all other *Pseudoanabaena* diagnosis features.

The cocoidal taxon comprises empty, single-layered, round to oval sparse cells (Figure 5g), occurring associated with the filaments. Due to their poor preservation and, thus, lack of

informative features, they are attributed either to *Aphanocapsa* sp. or *Chroococus* sp. Both taxa fit the morphology, ecology, and mode of occurrence as mat-forming groups and have been identified in the Phanerozoic fossil record.

4.2. Quantitative assessment of Geosite Pripiri

Considering the research undertaken so far, the Pripiri may be classified as a geosite of national importance and relevance (Table 1). Considering the seven criteria to evaluate the scientific value (i.e., representativeness, key locality, scientific knowledge, integrity, geological diversity, rarity, and use limitations), the high score is mainly related to the fact the site is the best-known exposure/outcrop in the area to represent the elements of interest. Also, the fact that there are previous publications regarding its stratigraphy and fossil record in international magazines and chapter books (i.e., Bittencourt et al. 2017, 2022; Cabral et al., 2021). There are at least four types of geological scientific interest, such as paleontologic, stratigraphic, astrobiologic, and evaporitic layers for paleoenvironmental analysis.

In contrast, the tourism and educational values of Pripiri Geosite presented low rates in almost all parameters, mainly due to a lack of appropriate infrastructure. Aspects such as security, accessibility, vulnerability, and exclusivity received a score of 1. On the other hand, logistical support, regional singularity, infrastructure for landscape and geological features observation, infrastructure for tourism activities, and the requirement for intense outreach activity received a score of 3. The educational potential and geological diversity, key aspects for a geoheritage and geoconservation role, received a score of 4. The sum of these scores classified the Pripiri Geosite as of national importance.

The evaluation of the degradation risk, represented in table 1 by the drawbacks, included several aspects related to the possible loss of this rock record. It assessed the likelihood of deterioration of all geological features due to erosion and the impact of cattle grazing. Despite its restricted nature, the geosite is not classified as an area susceptible to protection under any environmental law or statute. Another negative aspect identified during the evaluation in the GEOSSIT system is related to difficulties in accessing the site: even though the site is less than 1 kilometer from the main access road, it is not easily accessed by those who do not know the region or the farm where it is inserted, and there is currently no direct route. To access the geosite, one should follow the unpaved road

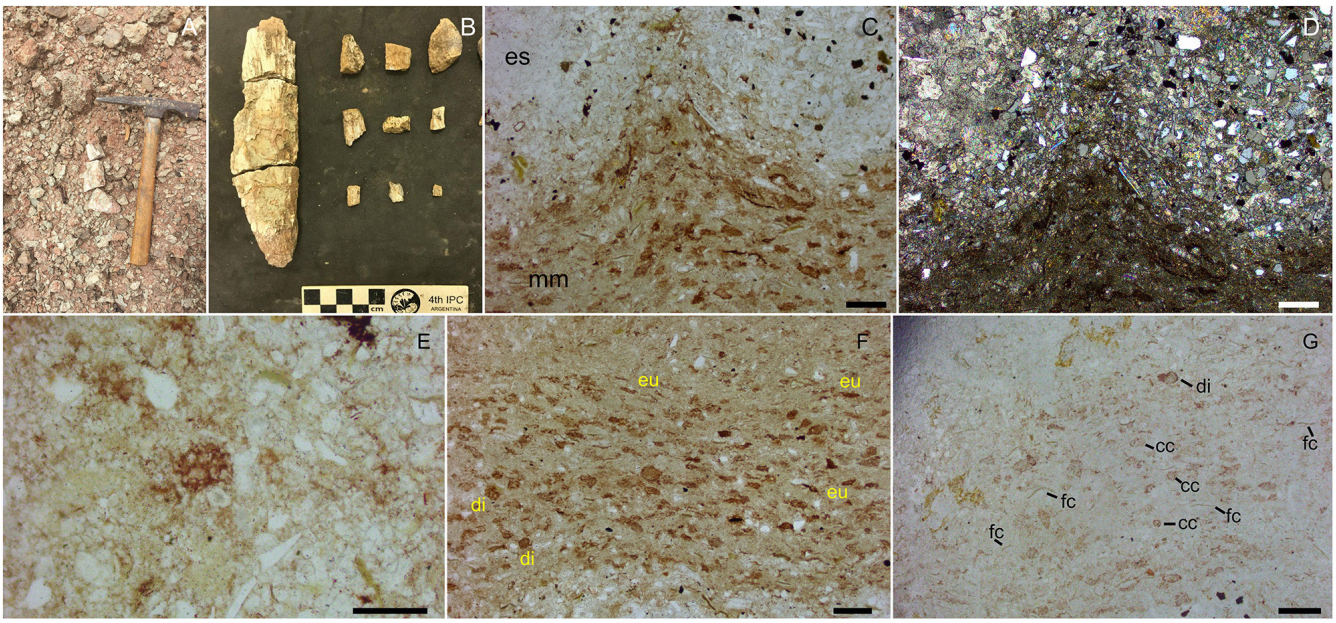

Figure 5. SiFigure 5. The newly discovered paleontological content of Pripiri Geosite. A: fragments of putative archosaur in the outcrop. B: fragments and one partially preserved rib. C-D: microbial mats associated with pseudomorphs of evaporitic minerals in parallel nicols (C) and crossed nicols (D); mm= microbial mat, es= evaporitic structure. Note in C the interaction between the microbial laminae and the evaporitic pseudomorph minerals, as well as abundant quartz grains in D. E: details of a dinocyst. F: dinocysts and Euglenaceae cells embedded in a former extracellular polymeric substance of a microbial mat; di= dinocysts, eu= euglenoid cells. Note their deposition as authigenic elements deposited over the mat. G: mat-forming cyanobacteria; fc= filamentous cyanobacteria (*Pseudoanabaena* sp.), cc= coccoidal cyanobacteria (*Aphanocapsa* sp. or *Chroococus* sp.), di= dinocyst.

Table 1. Quantitative Assessment of the Geosite Pripiri and some of its characteristics.

	Scientific value	**Potential educational use**	**Potential touristic use**
Classification and quantification	Geosite of national relevance (215 points)	National relevance (235 points)	Regional or local relevance (145 points)
Positive aspects	Types of interest: paleontology, stratigraphy, mineralogy, paleoenvironment and paleoclimate, Astrobiology	Geodiversity features relevant for all teaching levels	Paleontological and paleoenvironmental interest
Drawbacks	High degradation risk	Safety facilities must be built	Distance and infrastructure

to the São Geraldo village and then follow to the northwest. Figure 2 shows the route to reach the farm where the Pripiri Geosite is located.

Discussion

Numerous fossil-based investigations (e.g. Zaher et al. 2011; Bittencourt et al. 2017; Carvalho and Santucci 2018; Cardoso et al. 2022, 2024) have been conducted to elucidate the hypothesis of a lacustrine origin regarding sediment deposition within the Quiricó Formation. Conversely, some studies still pose some questions about this paleoenvironmental scenario (Bittencourt et al. 2019). According to these authors, based on the fossil assemblage identified in samples of rocks from the Coração de Jesus and Lagoa dos Patos region, it is suggested that some levels of the Sanfranciscana Basin, northern Minas Gerais, were deposited in a continental brackish water environment subject to vertical variation in salinity, but not lake, and thus, more paleontological and sedimentary data are needed for better interpretations.

The concept of salt pseudomorphs reported here (popcorns, cauliflower-like structures, and decimetric salt crystals) is extensively discussed by Cardoso et al. (2022) in other areas of the Sanfranciscana Basin. The authors presented evidence of halite residues within the central portions of calcite nodules. Through various analyses, they hypothesize a shallow saline lake scenario, wherein halite was replaced by calcite during early diagenesis. In this study, we also identified a sedimentary depositional regime represented by intercalation of siltstone and mudstone layers (composed of clay and micrite) with fine to coarse sandstones, evidencing deposition in alternating sedimentary flow regimes and associated with salt pseudomorphs. Microscopic studies showed that these pseudomorphs are replaced by calcite.

Although the environment was averse to life, some fossils were recovered at the Pripiri Geosite. Despite their low abundance, these fossils hold significant value. Macrofossils are very fragmented; however, their occurrence is valuable and paves the way for interpretations beyond paleobiological diversity, allowing future studies of taphonomical approaches applied to sedimentary dynamics of the paleolake. In this sense, the search for other complete macrofossil specimens must continue, similar to the paleontological site of Sesmarias locality also in Coração de Jesus, which is chronocorrelative to the Pripiri Geosite based on its lithostratigraphic succession and only 22 km away from each other.

The new microfossil content is the most promising source of data on the paleoecology and paleoclimate aspects of the Quiricó Formation. The dinocysts and euglenoids microfossils still devoid taxonomic classification, but their occurrences shed light on paleoenvironmental aspects of Quiricó Formation at Coração de Jesus, mainly regarding the understanding of life occurrence and preservation in extreme, arid, and hypersaline environments, as well contributes to the elucidation on climate cyclicity when coupled to the stratigraphic succession observed at the Pripiri Geosite (Köhher and Clausing 2000). Also, the association dinocysts-Euglenaceae-cyanobacteria may be applicable to interpretation concerning trophic stages in lake environments (e.g. Makri et al. 2019). Although the euglenoids and dinocysts comprise the phytoplankton components, they were observed among the cyanobacteria cells as mat dwellers, not mat-forming components. Finally, another important insight is that the occurrence of dinocysts points to well-oxygenated waters of the Coração de Jesus paleoasis, following the data of Köhler and Clausing (2000) for Lake Enspel, Upper Oligocene, Germany.

On the other hand, cyanobacteria microfossils were identified to genus level (however, a future reclassification cannot be ruled out), and their occurrence represents a yet-to-be-explored paleoecological window into a Cretaceous paleoasis system. Nevertheless, another outstanding potential may also be explored: as simple, prokaryotic cells preserved in association with salt minerals, these microfossils are of interest to Astrobiology, mainly for the search for past life in the rock record of Mars. If life once existed, it would have inhabited evaporitic oases, like those in Coração de Jesus, as a refuge during the drying period of Mars in the Hesperian Period, 3.6 Ga (Mancinelli et al. 2004). In addition, evaporitic rocks may preserve confident biosignatures (e.g. microfossils of halophilic bacteria) due to their short-term, aqueous deposition, and paleoenvironments like this have been pointed out as good targets for the search of past life on Mars for the next missions (Barbieri and Stivaletta 2011). Therefore, the occurrence of prokaryote records in an evaporitic-rich rock from Coração de Jesus fits the model for the life conditions on Mars during the Hesperian, and thus, this material would serve as a template for the search for past life on our neighboring planet.

Looking at the Pripiri Geosite through the prism of geodiversity and geoheritage, the criteria *representativy* enhances the importance of this geosite on the quantitative assessment (Brilha 2016). Its fossil assemblage, combined with the well-exposed stratigraphic content (it is certainly the best outcrop in the region to observe the relevant geological aspects) and the paleoenvironmental and paleoclimatic data preserved at Pripiri Geosite, support its national scientific value and relevance for Geoscience. Taken together, all these geological features also imply a high educational potential that may be applied at all levels of the Brazilian educational system.

Regarding its touristic use, factors such as its distance from the city (approximately 40 km from downtown), road conditions, access to the geosite, lack of other attractions, and poor scenic view are characteristics that decrease its potential. In addition, it must be taken into consideration that some knowledge of sedimentary processes, rock formation, and paleontology may be necessary to comprehend the geodiversity features of the site, which may complicate tourist activity. Special attention during the development of interpretation material is required to overcome this disadvantage. Also, infrastructure and facilities must be built for visitors, including those intended for students.

The brittle condition of rocks, coupled with geomorphology and land use, favors erosion processes. In addition, the lack of specific legislation to protect the area implies a high risk of degradation. Considering that the City Hall of Coração de Jesus intends to promote the geosite for education activities and tourism, careful planning and attention are necessary. Especially because, as discussed by Brilha (2016), a high degradation risk coupled with a high scientific value requires special attention to conciliate the preservation of the site and the educational and touristic uses.

Considering its scientific relevance and the social context in which the geosite is located, its use in educational activities and geotourism is desirable. Its potential would be amplified if actions were taken to associate and include other geosites and geodiversity sites in the vicinity. It should be noted that

a series of actions regarding the geoheritage of Coração de Jesus has been carried out by the Universidade Federal dos Vales do Jequitinhonha e Mucuri since 2022, in technical cooperation with City Hall of Coração de Jesus. Several lectures and classes with students of elementary and high school ages, as well as teachers, have been promoted, focusing not only on the geoheritage of Coração de Jesus but also on its potential for local economic development and social improvement through geotourism and geoconservation (following the ideas of Nascimento et al. 2015). These actions may stimulate a sense of belonging among residents while promoting the geoheritage. The development of geotourism in this context might occur in the future, only if educational activities are consolidated.

Conclusions

This study provides new insights into the fossil content of the Pripiri Geosite and the fossil record of the Sanfranciscana Basin and highlights its value for geotourism and geoconservation. The occurrence of newly reported eukaryotic and prokaryotic unicellular microfossils, which are significant for paleoenvironmental, paleoecological, and astrobiological analysis, was discussed. The abundance of microfossils in this succession shed light on paleoenvironmental aspects of Coração de Jesus paleoasis, and helps to understand the occurrence and maintenance of life in extreme environments, with important implications for the search for past life on Mars. Taken together, these findings and their contributions make the Pripiri Geosite an important Brazilian paleontological site.

In relation to geoconservation, the excellent exposure to the stratigraphic succession and the paleontological content coupled with the paleoenvironmental data reinforce the scientific, touristic, and educational relevance of the Pripiri Geosite at a national level. This scenario is going to be useful as a tool for social and economic development in Coração de Jesus municipality.

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Authorship credits

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A - Study design/ Conceptualization **B** - Investigation/ Data acquisition
C - Data Interpretation/ Validation **D** - Writing
E - Review/Editing **F** - Supervision/Project administration

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