Identification of calcareous tufa in northeast of the state of Goiás, Brazil

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Abstract

Studies in calcareous tufas are of great importance for the development of paleoenvironmental reconstructions and understanding of the landscape dynamics. As features originated from areas of occurrence of carbonate rocks, these concretions solidify in different forms and facies, due to the conditions provided by the environment in which they develop. This research seeks to map and describe the calcareous tufa formations in the northeastern portion of the state of Goiás, Brazil. Some areas of occurrence were identified through field work, involving description and extraction of outcrops. Thus, the carbonate deposits were spatialized with the registration of coordinates, inserting them in a Geographic Information System (GIS) environment, using the QGIS v.3.16.3 with GRASS v.7.8.5 software (v.10.6.1). In this sense, the faciological description of the testimonies was possible to be realized, associating them with depositional environments, identifying cascade, waterfall, dam and inter-dam pool tufas, correlated to the facies typology. In addition, cartographic materials of the spatial distribution of such features were generated, in which certain linearity of the occurrence of outcrops, including in areas without active drainage, was found.

1. Introduction

Over high porosity and solubility rocks, karstic terrains develop, known for being systems of constant interaction between water and the geological environment. The northeastern portion of the state of Goiás, Brazil, is encompassed by three main geological groups (Bambuí, Areado and Urucuia), associated with the Sanfranciscana Basin. The Lagoa do Jacaré formation, which belongs to the Bambuí, has pelite-carbonated outcrops linked to the regressive erosion of the Serra Geral do Goiás (W-E).

Thus, exuberant features such as caves, lapia, sinkholes, tufas and travertines, appears, generating rich and complex landscapes, which can be considered both open and closed systems (TRAVASSOS, 2019). Typical features of karst areas, such as tufas, occur near or in the bed of rivers that, at any moment, were in direct contact with carbonate rocks. Carbonate deposits are the result of the interaction between CO_2-rich waters and carbonate rocks. The supersaturation benefits the precipitation of calcite, a chemical precipitation mineral that constantly occurs in karstic areas (HILL; FORTI, 1997). The reprecipitation of calcite can be indicated by the equation:

$Ca^{+2}+2\ HCO^{-}_{3} \leftrightarrow CaCO_3\downarrow + H_2O + CO_2\ (g)\uparrow$
(Calcium carbonate precipitation equation)

A study by Ford & Pedley (1996) demonstrated that the formation of tufas is linked to climatic periods of great humidity and heat. However, other studies have recognized tufa formations in different environments, such as humid tropical (CARTHEW; TAYLOR; DRYSDALE, 2006) and semi-arid (MOEYERSONS et al., 2006, ORDÓÑEZ et al., 2005).

For interpretation about fossil tufas, environmental models are used, since weathering and burial complicate the stratigraphic and geomorphic characterization, influenced by biological and climatic aspects (CARTHEW; TAYLOR; DRYSDALE, 2006, PEDLEY, 2003). These environmental models are understood as conceptual representations, as they have the morphological characterization of the deposit, association of facies and sedimentation environments (PEDLEY, 1990). The need to use models related to regions with similar climatic factors is emphasized.

Calcareous tufas are extremely fragile, as their formation and conservation directly depend on the use of land throughout their area of influence. Thus, considering that the studied area stands out for agricultural production, the conservation of these features can be directly affected, even before they are properly studied to understand different perspectives (climatic, tectonic and anthropic) (FORD; WILLIAMS, 2007; CAPEZZUOLI; GANDIN; PEDLEY, 2014; MIRAGAYA, 2014, DABKOWSKI, 2020). Therefore, works containing mappings for the spatialization of these outcrops, as well as the development of scientific research on karst landscapes, are extremely important, as they foment conservation and greater understanding of the dynamics of such rich and vulnerable areas.

2. Materials and methods

This study sought to map and characterize the sedimentation environments of calcareous tufas in the northeastern portion of the state of Goiás, Brazil. In this way, a field visit was carried out during the first half of the second semester of 2021, aiming to verify the areas with occurrence of the features and the prior recognition of the characteristics of depositional environments. In order to verify the internal biological content as well as to carry out further analysis, it was necessary to extract samples from the cores.

In the field work, some testimonies were measured in terms of height and width, with coordinates recorded using the Avenza Maps application on an Android device. Photographs were also stored from available cameras. These cartographic and image data were inserted in a GIS environment (QGIS v.3.16.3 with GRASS v.7.8.5), generating the spatialization of the observed features. Other data, such as hydrography and contours (30 meters), were extracted, respectively, from the State Geoinformation System (SIEG) and the Alos PALSAR Digital Elevation Model. (DEM) of the Shuttle Radar Topography Mission (SRTM) project, both acquired from the United States Geological Survey (USGS). The satellite image applied comes from the Google Satellite Plug-in, available within the aforementioned GIS.

The characterization, both in field and in the observations of the samples in the laboratory, were based on the calcareous tufa model for tropical regions influenced by monsoonal systems (CARTHEW et al., 2006). In this way, aspects such as form, biological material, mineral and the place of deposition were considered in the context of the associated hydrography.

3. Results

The mapping procedure demonstrated the occurrence of fourteen points with tufa outcrops, being identified in the rivers and streams Ventura (area 1), Barreiro (area 2) Chumbada (area 3), and São Vidal (area 4). The highest concentration of occurrences, according to this survey, occurs in the pelite-carbonated Lagoa do Jacaré Formation, which belongs to the Bambuí Group (Figure 1ª A).

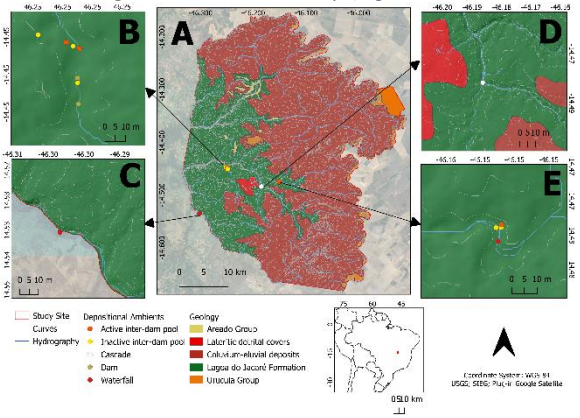

Figure 1ª: A) Spatialization of features; B) Barreiro tufa; C) São Vidal tufa; D) Chumbado tufa; E) Ventura tufa

Through the characterization, it is possible to establish a classification of the types of tufas, which are cascade, waterfall, inter-dam pool and dam. In addition, the classification also encompassed the presence or absence of water activity, as shown in Figure 1ª A, B, C, D, E. In relation to the different depositional environments related to the tufa genesis, in area 1, linked to Ventura, waterfall tufas were analyzed in areas of water spraying, where there was an association of the outcrops with bryophytes (Figure 2ª A) and inter-dam pool, in an area with undergrowth vegetation, such as ferns. Also, tufas with low or no activity were identified (Figure 2ª B, C) in an area associated with what was the drainage gutter in ancient times. Due the proximity to the inter-dam pool area, at a lower ground level, it is inferred that it is part of a system of small waterfalls/cascades. This characteristic is combined with dense laminations in the formation of tufas (Figure 2ª D). As observed in the field, there is a large transport of leaves by rivers, a fact that justifies the marking of incrustations of these in the deposits (Figure 2ª E).

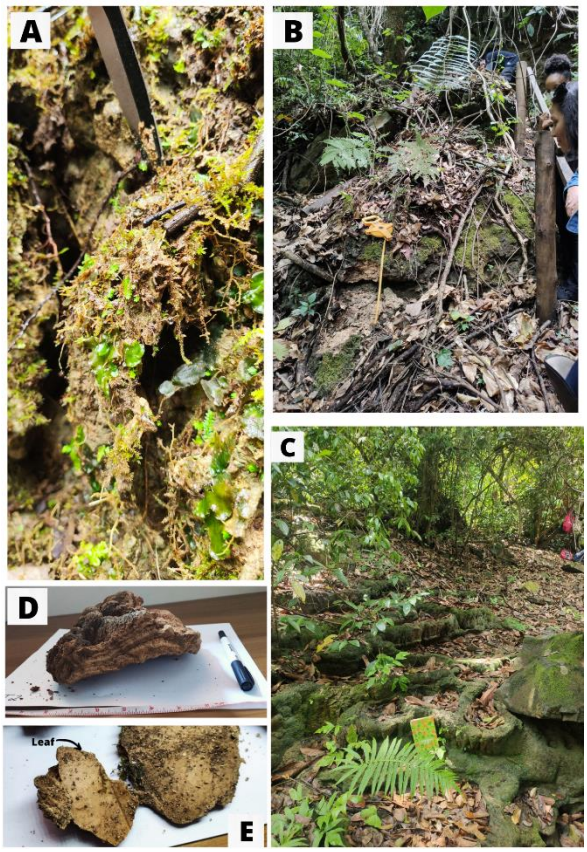

Figure 2ª: A) Funil Waterfall Tufa; B/C) Inter-dam pool tufa; D) Tufa with dense lamination; E) Leaf incrustation on calcareous tufa.

The area 2, linked to the Barreiro stream, presented dam tufas (Figure 3ª A) and an inter-dam pool with stromatolites at the bottom, in a 7-meter U shape, allowing the formation of two pool levels, one measuring 1.70m and the other, 2m wide (Figure 3ª B/D). Its structure shows leaf incrustations. A little further down the same river, there were inactive tufas (Figure 3ª C) of inter-dam pool, possibly forming a foregone large waterfall with a height of 1.93m.

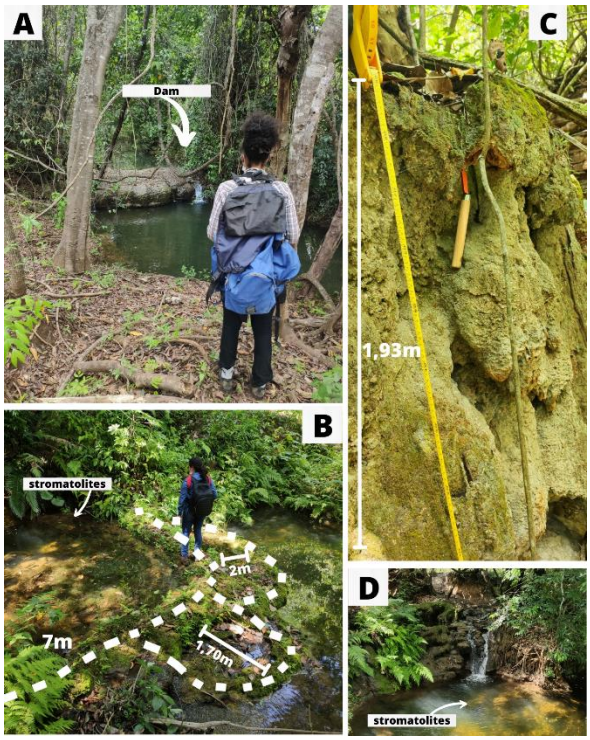

Figure 3ª: A) Dam tufa; B/D) Active inter-dam pool tufa with stromatolites; C) Inactive inter-dam pool tufa formation, possibly an ancient cascade/waterfall.

The Chumbada stream area (area 4) has an environment of tufa formation related to cascades (Figure 4ª A, B). As in the previous cases, the transport of leaves through the river is intense, with the possibility that these plant structures may come to act as supports for calcite. However, no fossil records were found in the collected core. The dimension of the outcrop is 1.70m width by 2.20m height. It is evident that the forming river is in full activity.

Figure 4ª: A) Cascade tufa formation; B) Outcrop measured

Finally, in São Vidal stream (area 4), the outcrops occur originating an active waterfall of large dimensions (Figure 5ª A). Thus, the type of formation environment is predominantly waterfall. The outcrop of the specific extractions, which is 4.17 meters height, is located on the right bank of the waterfall and has a flow variation during the seasons of the year (Figure 5ª B, C).

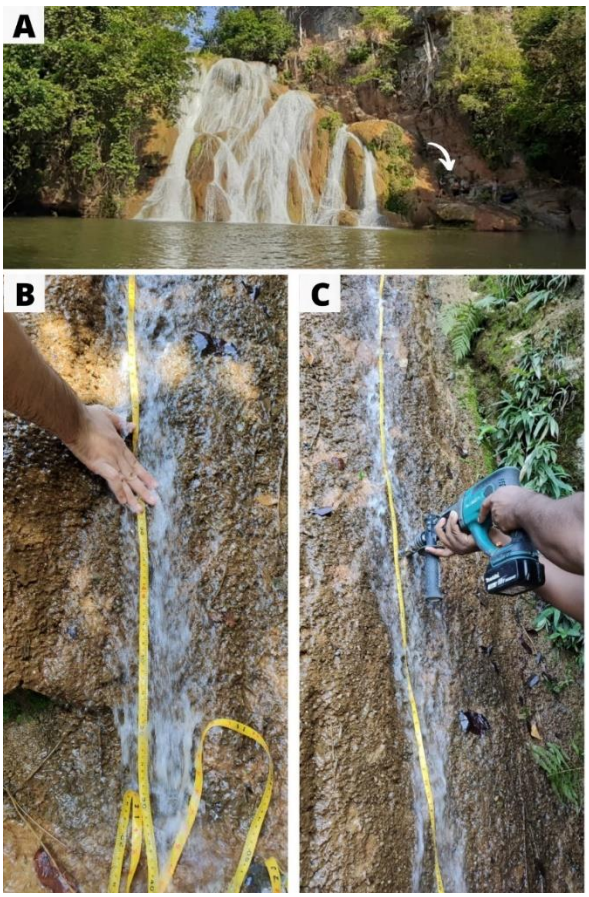

Figure 5ª A) Paraíso do Cerrado Waterfall tufa; B) Paraíso do Cerrado tufa outcrop; C) Tufa extraction process

4. Discussions

The calcareous tufas of northeastern Goiás in Brazil can be a source of information on climate history correlated by

monsoons. It is observed that there is a great variety of types of tufas in active and inactive places, however, well preserved.

The mapping of the tufas allows to observe their distribution in the study area, with a concentration of outcrops in the Barreiro stream, with morphology of altimetric variation along the hydrography, favoring the occurrence of tufa formation of waterfalls, as well as slower flows in flat terrain, with a predominance of dams. The concentration of abandoned outcrops on the edge of the river allows us to deduce that there was a time when the riverbed expanded due to an increase of water flow or that they are products of a river direction change.

Among the types of sedimentation environments, inter dam pool is the most prevalent type, occurring between two types of sedimentation ambients (dam and pool) observed in the field with frequency.

5. Conclusion

The study showed that the concentrations of calcareous tufa outcrops are associated with the Lagoa do Jacaré Formation, belonging to the Bambuí Group. There is a variation of types of environments in which they appear. This identification and the general characterization of the testimonies demonstrates the potential use for several environmental studies. For this reason, the importance of conserving these carbonate concretions is emphasized, regarding the anthropogenic pressure that directly affects their formation process.

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