PALAEOCLIMATIC CONTEXT, ENVIRONMENTAL DYNAMICS AND ARCHAEOLOGICAL SITES IN THE CENTRAL BRAZILIAN HIGH PLAINS: CASE STUDY OF THE MACAÚBA I SITE

CONTEXTO PALEOCLIMÁTICO, DINÂMICA AMBIENTAL E SÍTIOS ARQUEOLÓGICOS NO PLANALTO CENTRAL BRASILEIRO: ESTUDO DE CASO DO SÍTIO MACAÚBA I

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ABSTRACT

This article presents a bibliographic review related to palaeoclimatic aspects of the Central Brazilian High Plains, the environmental dynamics and formation of the archaeological record of the Macaúba I litho-ceramic archaeological site in the Central Brazilian High Plains, excavated in artificial levels and sampling. The results obtained indicate the presence of lithic flakes on the surface and subsurface associated with Cambisols, Litholic Neosols and Plinthosols, reaching a depth of 40 and 50 cm, related to the 2BC horizon of Cambisols. Based on the distribution of the lithic material, two hypotheses were devised for the formation of the archaeological record, where the dynamics of the landscape plays a major role, particularly in relation to establishing moments of occupation at the site. Hypothesis 1 is related to the evolution of the landscape, while Hypothesis 2 is based on the vertical migration of the lithic material.

Keywords: Environmental dynamics and archaeology. Paleoclimate and archaeology. Central Brazilian High Plains

RESUMO

O presente artigo compreende uma revisão bibliográfica relacionada com aspectos paleoclimáticos do Planalto Central Brasileiro e aborda a dinâmica ambiental e a formação do registro arqueológico do sítio lito-cerâmico Macaúba I, escavado por amostragem em níveis artificiais no Planalto Central Brasileiro. Os resultados obtidos indicam a presença material lítico lascado em superfície e subsuperfície associados a Cambissolos, Neossolos Litólicos e Plintossolos, chegando a uma profundidade de 40 e 50 cm, associados ao horizonte 2BC de Cambissolos. Com base na distribuição do material lítico foram elaboradas duas hipóteses para a formação do registro arqueológico, onde a dinâmica da paisagem possui um papel preponderante, especialmente em relação ao estabelecimento dos momentos de ocupação do sítio. A Hipótese 1está relacionada com a evolução da paisagem, enquanto a Hipótese 2 está condicionada a migração vertical do material lítico.

Palavras-chave: *Dinâmica ambiental e arqueologia. Paleoclima e arqueologia. Planalto Central Brasileiro*

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INTRODUCTION

Environmental dynamics, notably geomorphogenesis, surface runoff, fluvial channel patterns, loss of soil and erosion, in addition to weathering, bioturbation and anthropic activity, form part of the set of processes involved in the formation and preservation of archaeological sites. Naturally, the predominant factor depends on the environment. This article is a case study on environmental dynamics and the Macaúba I open-air archaeological site once inhabited by farmers and potters and located in the municipality of Piranhas, Southeastern state of Goiás (Figure 1), in the Central Brazilian High Plains (*Planalto Central* in portuguese), where the Cerrado biome predominates (Figure 2).

Macaúba I was prospected and excavated for the doctoral thesis of Silva (2007), whose final results raised important archaeological issues such as material culture, the management of cultural heritage and neotectonics, in addition to the topic addressed in this article. The state of Goiás is home to a range of sheltered and open-air sites previously inhabited by hunter-gatherers, farmers and potters, currently dated from the late Pleistocene to early Holocene. In order to achieve the desired objective, it is important to characterize the Cerrado biome in the Central Brazilian High Plains as well as the area's paleo-environmental aspects.

The Cerrado biome initially covered 25% of Brazil, including plateaus and depressions with altitudes ranging from 300 to 1,900 m on average. Climate type in the region is Aw (tropical wet) according to Koppen's classification system and rainfall varies between 750 and 2000 mm/annual, with average precipitation of 1500 mm and mean temperature in the coldest month higher than 18° C (MAMEDE, 1993; DA SILVA et al., 2008; RIBEIRO and WALTER, 2008). Regions within the biome are characterized by a climate with two distinct seasons, a dry season in the winter and wet season in the summer, with heavy rainfall from October to March, distributed preferentially in the Central-West (ADÁMOLI et al., 1987; DA SILVA et al., 2008; DIAS, 1992; RIBEIRO and WALTER et al., 2008).

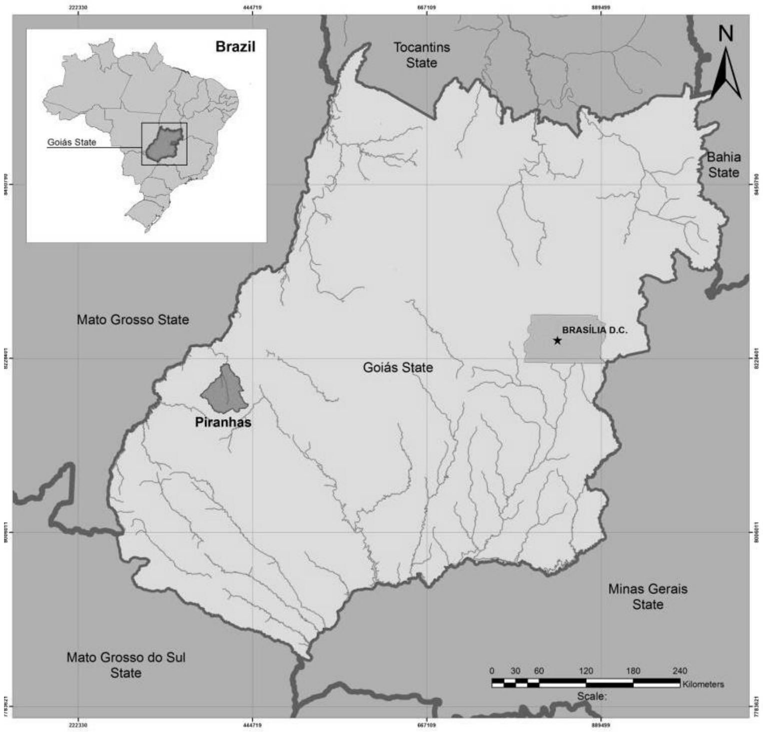

Figure 1. Location of the Piranhas municipality. Source: Silva (2007)
***Figura 1.** Localização do município de Piranhas. Fonte: Silva (2007)*

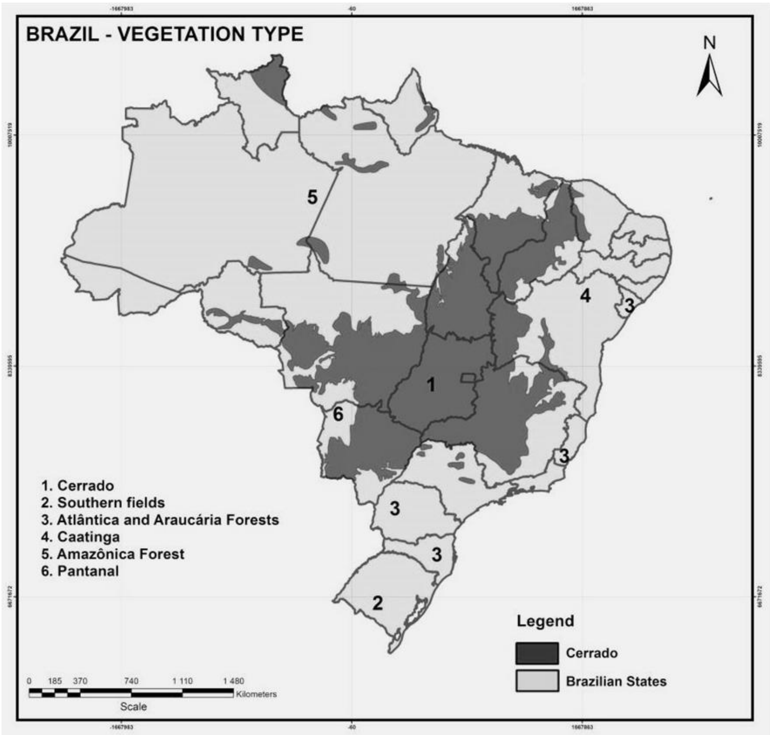

Figure 2. Distribution area of the Cerrado and other Brazilian biomes.
Source: Ribeiro and Walter (2008)
***Figura 2.** Distribuição da área do Bioma Cerrado e outros biomas brasileiros.
Fonte: Ribeiro and Walter (2008)*

Its diversity and floristic and physiognomic complexity mean the Cerrado has prompted extensive research on everything from the characterization of different vegetation types to issues related to Savanna and Cerrado terminology. Although the African Savannas occur in climatically similar regions to the Brazilian Cerrado, they present significant differences regarding vegetation such as a predominance of shallow roots characteristic of deciduous bushy trees, probably due to edaphic aspects since in the African Savanna the soil is often less deep (Belsky and Amundson, 1992; Solbrig, 1996).

Conversely, in the Brazilian Cerrado, deep roots enable access to water in deeper soil horizons, therefore allowing a predominance of evergreen bushes which do not present leaf stomatal conductance, while in the African Savanna there is clearly an efficient stomatal closing mechanism to reduce transpiration during the drought season (Cole, 1986). According to Solbrig (1996), another remarkable difference between the Brazilian Cerrado and the African Savanna is that in spite of their biomes presenting a mosaic of varying phyto-physiognomies, both present particular species endemic to each continent respectively. This may be due to the landscape evolution of worldwide Savanna formations, as this started in the Paleogene, continuing throughout the Neogene and Quatenary period, when the continents were already separated after the fragmentation of Gondwana. Cerrado soils, typically found in pediplains, are acidic, deep and well drained, and exhibit low fertility with high aluminum content (ADÁMOLI et al., 1987; DIAS, 1992; REATTO et al, 2008; WALTER et al., 2008).

According to Ribeiro and Walter (2008), flora in the Cerrado biome is varied rather than homogeneous, exhibiting characteristics specific to each area resulting from the interaction between biotic and abiotic factors that determine qualitative and quantitative changes in plant composition. In light of the objectivity and specificity of their definitions of physiognomies, the classifications adopted here were based on Ribeiro and Walter (2008), who used criteria such as plant structure, floristic composition and environmental aspects. In this context, the term Cerrado represents a set of plant physiognomies distributed into forest, savanna and grassland (campestre, "in portuguese") formations. From a physiognomic perspective, forest formations are areas containing mainly trees forming a continuous or discontinuous canopy that includes riparian, gallery and dry forests, and cerradão (savanna). Savanna formations comprise areas covered in scattered trees and shrubs on a grassy herbaceous stratum with no continuous canopy, and include the vegetation types cerrado *senso strictu* (orchard-like vegetation), parque de cerrado, palmeiral and veredas ("in portuguese") (palm swamp type vegetation), with varying ratios between the herbaceous and tree layers and the presence of buriti palms (*Mauritia sp*), characteristic of veredas vegetation. In grassland formations the predominant species are herbaceous, with the presence of some shrubs, but no trees; included in this vegetation are the campo sujo ("in portuguese") (scattered small trees and shrubs), campo limpo ("in portuguese") (dry grassland with no trees or shrubs) and campo rupestre ("in portuguese") (predominantly herbaceous plants and shrubs) (RIBEIRO and

WALTER, 2008). The study area is located in the Central Brazilian High Plains, a vast region of terraced compartments, plateaus and depressions with altitudes ranging between 300 and over 1,600 m. These developed over a range of lithologies, including Precambrian rocks represented primarily by schists and gneisses predominantly formed in different tectonic cycles, and Phanerozoic sedimentary rocks of the Paraná Sedimentary Basin (MOREIRA et al.,2008). In terms of vegetation, the region is also characterized by the presence of different Cerrado plant types conditioned by the soil, relief and rainfall, as well as anthropized areas covered mostly by grasslands (MAMEDE, 1993; MOREIRA et al, 2008). Given that variations in vegetation and the occurrence of different plant types are partly due to changes in climate, rainfall and temperature, analysis of the sequence of strata that preserve palynomorphs made it possible to establish environmental variations during the Late Holocene and, consequently, the evolution of the environment in areas occupied by prehistoric peoples, thus providing important information to help understand the available resources and adaptation processes. In the central southern region of the state of Goiás and the Federal District, diagrams of palynomorphs show a pattern marked by slight climate changes in the Holocene, more frequent than those observed at the end of the Würm/Wisconsin Glacial Episode (FERRAZ-VICENTINI, 1993; 1999; BARBERI, 1994; 2001; FERRAZ-VICENTINI and SALGADO-LABOURIAU, 1996; SALGADO- LABOURIAU, 1997; SALGADO-LABOURIAU et al., 1997; BARBERI et al., 2000; RUBIN, 2003; RUBIN et al., 2011; GUIMARÃES et al., 2003; LIMA RIBEIRO et al., 2003; PAPALARDO DO CARMO et al., 2003; BARBERI and LIMA RIBEIRO, 2008).

In what is now the center of the Cerrado biome, the end of the last glacial period was marked by a regional phenomenon, at around 18,000 BP (Before Present), known as the Last Glacial Maximum (LGM), characterized by a marked decrease in rainfall and temperature that led to a decline in the number of trees, expansion of open vegetation and changes in surface dynamics. This was followed by a melting period known as the Late Glacial (LG) phase (13,000 to 10,000 years BP) with the early Holocene marked by a significant change in palynomorphs, when characteristic Cerrado vegetation became predominant (SALGADO-LABOURIAU et al., 1998; BARBERI, 2001; BARBERI and LIMA RIBEIRO, 2008; RUBIN, 2003; RUBIN et al. 2011).

In the Federal District region and southeast Goiás, landscape evolution results from the analysis of three sediment sequences, namely deposits from Lagoa Bonita, peat from Águas Emendadas, and peat from Cromínia. In these areas, the early Holocene is marked by a gradual temperature increase and fluctuating humidity from the Late Glacial phase (13,000 to 10,000 years BP), with a drier phase at around 8,000 years BP followed by a wetter phase at about 6,300 years BP, which enabled the return of the veredas (palm swamp type vegetation) absent during the last glacial period. Further falls in humidity are recorded at 5,300 years BP, accentuating the bush fires patterns. Climatic conditions similar to those seen today occur from 3,200 years BP, with continued humidity oscillations resulting in a wetter phase at around 2,100 years BP, when the veredas and forest physiognomies expanded (FERRAZ-VICENTINI, 1993; 1999; BARBERI, 1994; 2001; SALGADO-LABOURIAU et al, 1997; BARBERI et al., 2000; BARBERI and LIMA RIBEIRO, 2008).

In the drainage basin of the upper course of the Meia Ponte river in south-central Goiás, several locations with deposits rich in organic matter and peat lenses were analyzed, providing landscape evolution data from 44,000 years BP onwards for areas previously covered by Cerrado. Initial peat formation in Inhumas, a continuous record that began at 32,000 years BP, is marked by the occurrence of two different sets of vegetation. The lower sequence extends up to 15,000 years BP, with a significant record of forest and Cerrado botanical elements, indicating wetter conditions than those encountered today. This is followed by an extremely dry phase related to the LGM and another in the Holocene, when palynological data indicate the return of wet conditions, though still with lower temperatures than those currently recorded. The upper sequence, from 8,000 years BP toward the present, is marked by a decline in concentration values for both arboreal and herbaceous elements, suggesting fluctuating humidity, but with an increase in temperature (RUBIN, 2003; RUBIN et al. 2011; LIMA RIBEIRO et al., 2003; GUIMARÃES et al., 2003; PAPALARDO DO CARMO et al., 2003; BARBERI and LIMA RIBEIRO, 2008).

In the central region of the cerrados from 7,000 to around 6,000 years BP, the increased humidity and gradual rise in temperature at the end of the last glacial period saw the formation of wetlands or lakes in Central Brazil. The vegetation was likely similar to that seen today, with different categories featuring patches of dense cerrados or semi-deciduous forests, criss-crossed by rivers with gallery forests or veredas. Weather conditions were probably similar to the current climate, semi-humid and hot with a 3 to 5-month-long dry season depending on local characteristics (BARBERI and LIMA RIBEIRO, 2008; RUBIN et al., 2011).

An important aspect to consider in paleoecology analyses of the Cerrado region is that weather patterns are more homogeneous at the end of the glacial period, with generally well-defined records of extremely dry and cold phases for different areas, as with the LGM. However, from the LG (13,000 to 10,000 years BP), to early Holocene, conditions vary from one cerrado region to another, though always exhibiting an overall trend in gradual temperature increases (BARBERI and LIMA RIBEIRO, 2008; RUBIN et al., 2011).

In the Holocene, considering the last 7,000 years BP from the effective onset of increased rainfall and temperature, a noteworthy fact for all the Cerrado areas is the occurrence of nonsynchronous and often short-lived episodes of humidity fluctuation, with both rises and falls in precipitation. The small range and diachronism of these oscillations make it difficult to determine a single cause for the climate changes; however, it is important to underscore that the end of the last glacial period caused a sharp rise in the sea level, reducing the continentality of inland areas in tropical lowlands and, consequently, extreme weather conditions (BARBERI and LIMA RIBEIRO, 2008; RUBIN et al., 2011).

With respect to plant species composition, the early Holocene is marked by a significant change in the tropical lowlands in relation to the glacial period. The increase in temperature resulted in the expulsion of cold weather botanical elements to higher latitudes, or greater altitudes when possible, and the expansion and predominance of botanical elements characteristic of the Cerrado. In general, the onset of conditions similar to those responsible for the distribution pattern of current vegetation in Cer-rado areas occurred at around 2,000 years BP (BARBERI and LIMA RIBEIRO, 2008; RUBIN et al., 2011).

Evidence from fires in the Cerrado biome during the Late Quaternary also provides important data that may be related to prehistoric occupations. Records of fires in Cerrado areas prior to the first human occupation of the Central Brazilian High Plains have been identified by several authors as evidence that the effect of fire on vegetation is an integral part of environmental dynamics and evolution (COUTINHO, 1990; EITEN, 1994; FERRAZ-VICENTINI, 1993; 1999; SALGADO-LABOURIAU and FERRAZ-VICENTINI, 1994; FERRAZ-VICENTINI and SALGADO-LABOURIAU, 1996; SALGADO-LABOURIAU et al.,1998; BARBERI, 1994; 2001; MIRANDA et al., 2002; RUBIN, 2003; RUBIN et al, 2011; GUIMARÃES et al., 2003).

In this respect, Pleistocene records of fires contribute to linking the effect of fire as a natural agent on the structure and maintenance of the Cerrado biome. In addition, the varying intensity of fires in Holocene records can be analyzed in relation to prehistoric occupations to better understand the natural and anthro-pogenic processes in the Central Brazilian High Plains and identify the presence and activity of prehistoric populations. Despite containing no palynomorphs, a sequence analyzed in the region of the upper course of the Meia Ponte river recorded the highest coal particle concentrations in south-central Goiás at a level dated to approximately 3,100 years BP, suggesting the occurrence of intense natural or man-made fires (GUIMARÃES et al., 2003; RUBIN et al., 2011).

METHODOLOGY

The site was delineated using two procedures. An initial surface survey was conducted (RENFREW and BAHN, 1993), whereby the area was traversed by a group of six people spaced 5 m apart, so that the field of vision of each investigator was 5 m. In this technique, all the cultural remains found were labeled and plotted on the map.

Next, 1 m2 grid squares (pits) were dug in two north/south and east/west directions, forming four quadrants (northeast, southeast, southwest and northwest), as per Figure 16. Grid squares along the north/south and east/west directions were spaced 10 m apart, and 20 m in the remaining areas, totalizing 265 grid squares.

From ‘point zero’, the site was divided using letters along the north/south line and numbers from east to west so that grid squares were identified according to the intersecting lines, starting with the quadrant. Squares along the north/south and east/west lines were labeled using cardinal directions (N; S; E; W) followed by sequential numbers starting at ‘point zero’.

The excavation was performed in 10 cm artificial levels, checking and then sieving the soil in each square (ORTON, 2000; HESTER et al., 2009; DOMINGO et al., 2010; BALME and PATERSON, 2014). All the grid squares were described using procedures suggested by the Brazilian Institute of Geography and Statistics (IGBE, 2007), and EMBRAPA (2013) for Brazilian soils, observing the texture, roundness, color, thickness, presence of sedimentary and/or anthropogenic structures, like fire place, bioturbation, erosion of the surrounding surface and, primarily, the presence of cultural remains.

Soil profiles were described for all four walls (N; S; E; W) of each of the grid squares. When these exhibited homogeneity, only one was graphically represented. Based on the characteristics detected, the northern profile was depicted, due to the exceptional quality of these. The soil horizons were described in the field and complemented in the Geoarchaeology and Environmental Laboratory of the Goiás Prehistory and Anthropology Institute of the Pontifical Catholic University of Goiás (PUC GOIÁS) and the Sedimentology Laboratory of the São Paulo State University (UNESP), in addition to contributions by Drs. Jairo Roberto Jimenez-Rueda and Virlei Álvaro de Carvalho.

During the excavation, as issues related to surface dynamics and landscape compartmentalization became more pronounced within the context of the Macaúba I archaeological site, field walks were conducted over a 20 km radius and vehicle-based surveys in a 40 km radius, searching for evidence and information on landscape evolution. Landscape evolution and compartmentalization were assessed based on Mamede (1999) and Latrubesse and Carvalho (2006).

Cultural remains were analyzed in laboratory; the pottery was analyzed in accordance with Skibo (1992) and Sheppard (1985) and the lithic material in line with Tixier et al., (1980) and Fogaça (2001).

RESULTS

The Macaúba I archaeological site covers an area of approximately 2,800 m², in a 4 km long and 0.7 km wide horizontal interflow of the Serra Negra mountain range, bordered by slopes with a 16% grade, on average. It is characterized by the presence of prehistoric ceramic and chipped lithic material (the latter primarily in quartz and lower amounts of chalcedony) on the surface and subsurface within an area of Cerrado vegetation and grasslands, partially intercepted by the road to a hydroelectric power plant and rural properties, on the right bank of the Piranhas river (Figure 3).

The area of the site is anthropized by agricultural activities (cattle trampling and tillage), secondary roads and erosional features (Figure 4), which substantiated a series of procedures adopted during excavation aimed at identifying the soil horizons and horizontal and vertical distribution of the cultural remains. During the excavation stage, 265 grid squares measuring 1m2 (Figure 5) were dug, of which 67 (25,3%) contained ceramic or lithic cultural remains. The remaining 198 were sterile (74,7%) regarding cultural remains. As per Figure 5, the cultural remains identified in the dig were concentrated in the center of the site associated with Cambisols.

Figure 3: Satellite image showing the Macaúba I archaeological site. Source: Google Earth (2016)
Figura 3: *Imagem de satélite indicando o sítio arqueológico Macaúba I. Fonte: Google Earth (2016)*

Figure 4: Partial view of the Macaúba I archaeological site. Source: Silva (2007)
Figura 4: *Vista parcial do sítio Macaúba I. Fonte: Silva (2007)*

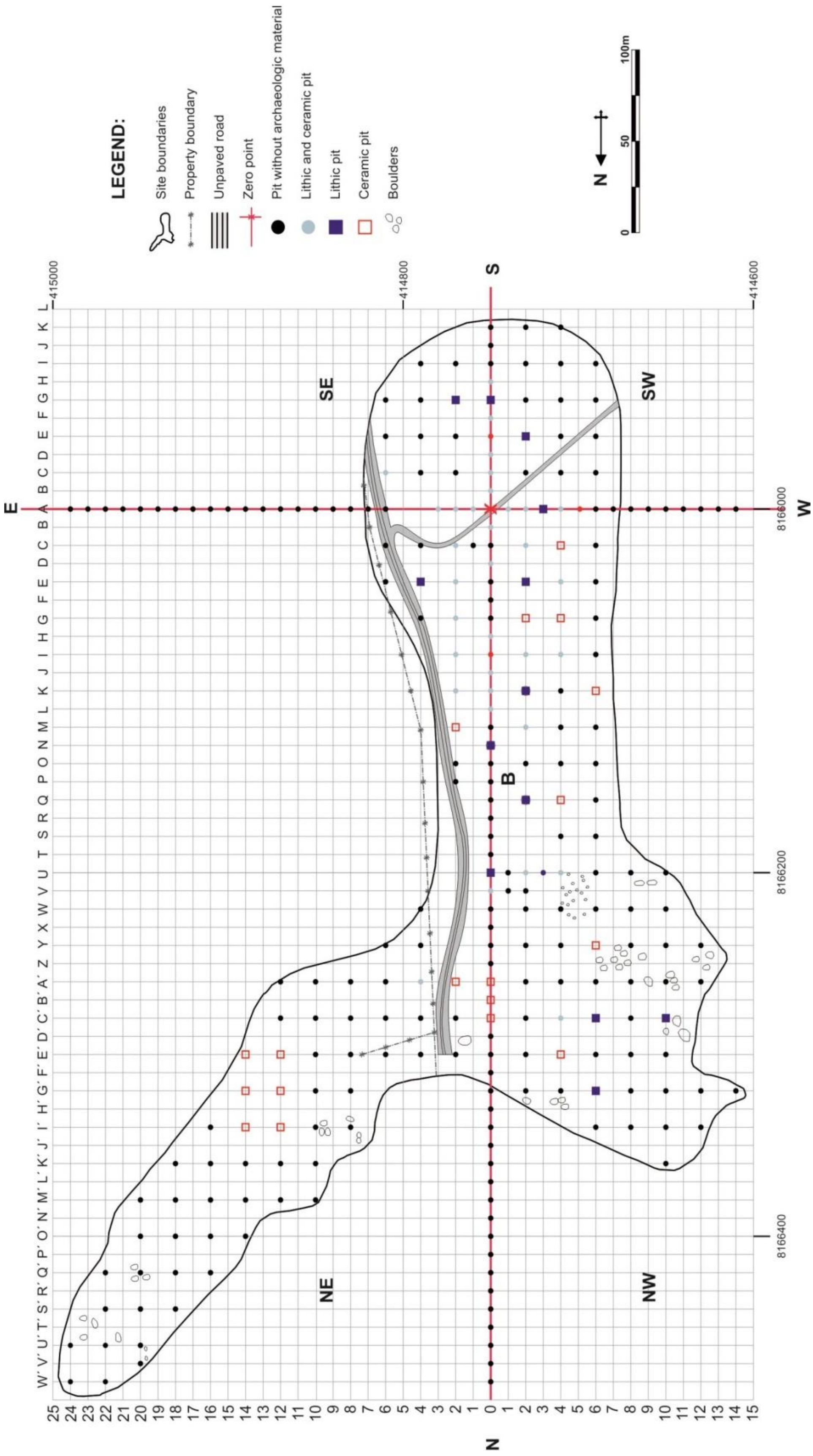

Figure 5: Excavation model of Macaúba I archaeological site. Source: Silva (2007)

***Figura 5:** Croqui de escavação do Macaúba I. Fonte: Silva (2007)*

Figures 6 and 7 show characteristics of the relief around the archaeological site, particularly the Serra Negra mountain range at an elevation of 550 m, bordered on the south by Serra de São João mountain range (800 m), Serra Volta Grande mountain range (750 m), Serra da Taboca mountain range (800 m) and Serra Sucuri mountain range (750 m), forming an almost continuous unit that cuts across the Caiapônia Topographic Map (SE-22-V-B-V) from east to west. Although these four regions have been given different names by their inhabitants, Serra de São João and Serra da Taboca form a single unit, as do Serra Volta Grande and Serra Sucuri (*serra* means "mountain range" in Portuguese).

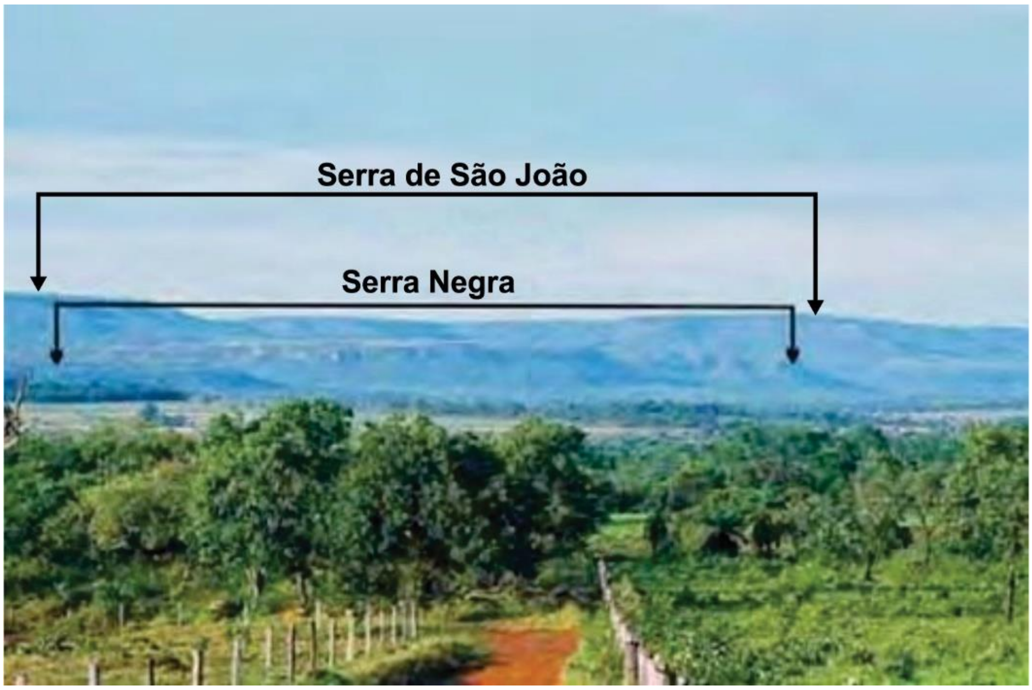

Figure 6: Partial view of the topography of the set of mountain ranges around the Macaúba I archaeological site. Source: Silva (2007)
Figura 6: *Vista parcial da topografia e do conjunto de serras no entorno do sítio arqueológico Macaúba I. Fonte: Silva (2007)*

At the beginning of the study, the surface distribution of cultural remains, landscape compartmen-talization and evolution, as well as soil types formed a unique context and provided a rare opportunity to examine the surface dynamics and formation of open-air archaeological sites in the Cerrado biome. As such, investigation of the geoarchaeological context of the site proceeded in greater detail, particularly in terms of the geomorphic processes that shaped the landscape. The descriptions and interpretations of

soil profiles in the grid squares overlapped (Figure 16), enabling the creation of an analogy on landscape evolution and hypotheses for the formation and preservation of Macaúba I.

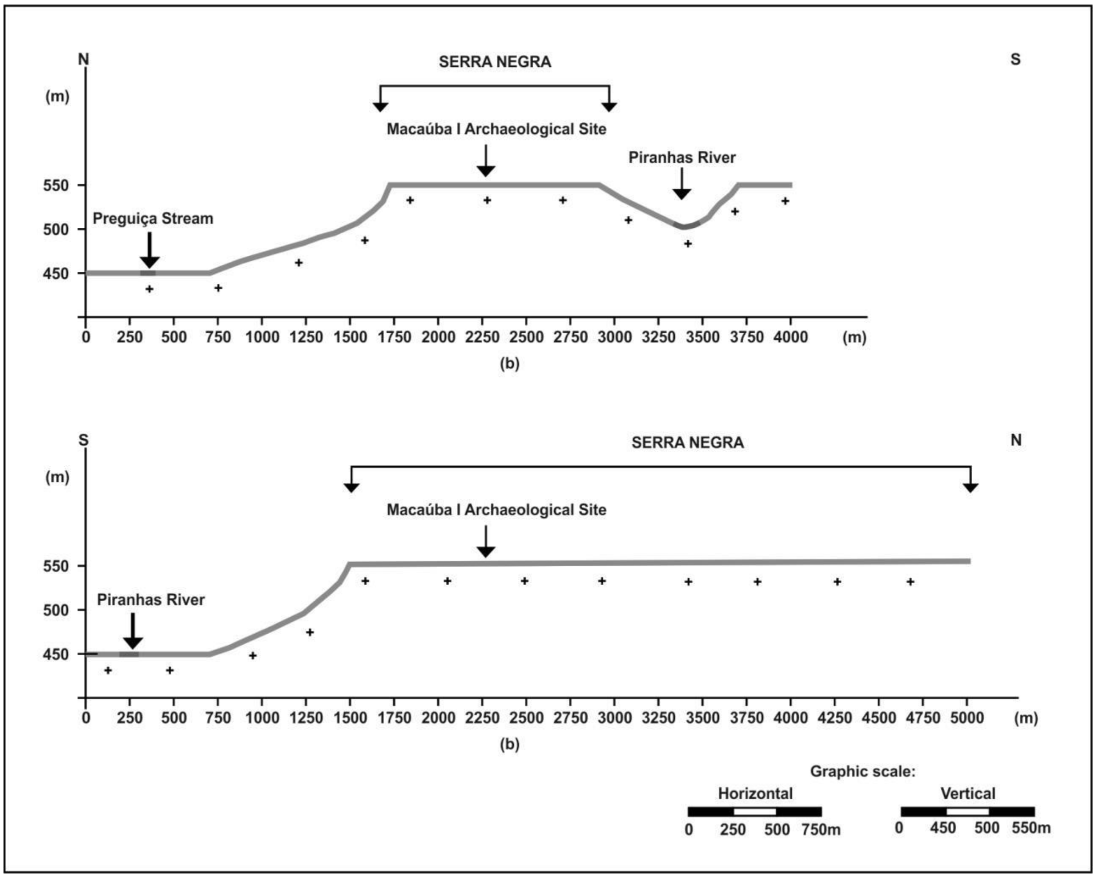

Figure 7: Topographic profiles of Macaúba I archaeological site, with Serra Negra mountain range as reference. Source: Silva (2007)
Figura 7: *Perfis topográficos do Macaúba I, com a Serra Negra como referência. Fonte: Silva (2007)*

Coal samples were collected for radiocarbon dating from grid square NE2B at a depth of 30-40 cm, providing a date of 1088+/-36 BP (Waikato University Lab -17147). These were collected from a ceramic concentration located in soil horizon A classified as Cambisol, in an interflow segment with a grade of around 3%. Since both the horizon and ceramic concentration were structured, we believe that the carbon collected was in its original depositional environment.

The results of morphological descriptions of the soil profiles, conducted in the field, revealed that the archaeological site is located in an area containing Cambisols, Neosols and Plinthosols (Figures 8 to 16), with a maximum thickness of 55 cm. This characteristic is primarily associated with the pedogenesis and dynamics of the area, particularly geo-morphogenesis. Cambisols are underdeveloped soils exhibiting weak pedogenesis and an incipient B horizon following a surface horizon of any nature. Neosols show little development and no discernible B horizon, indicating they are still evolving, either due to the decline in pedogenic processes or characteristics of the parent material. Plinthosols display significant plinthite formation and may contain petroplinthite (ANJOS et al, 2012; EMBRAPA, 2013).

Observations in the field revealed a slight southward slope of around 3% of declivity in the topography of the site area, from Cambisol through Plinthosol to Litholic Neosol

(Figure 16). Given the sparse vegetation, ridges and troughs in the area, indicating the flow direction of rainwater, the material found on the surface may have been carried there and could therefore be in or outside its original depositional environment. Waters (1992), Rapp Jr and Hill (1998), French (2003), Rubin and Silva (2004), Goldberg and Macphail (2006) presented aspects and examples for consideration in archaeological research on this issue.

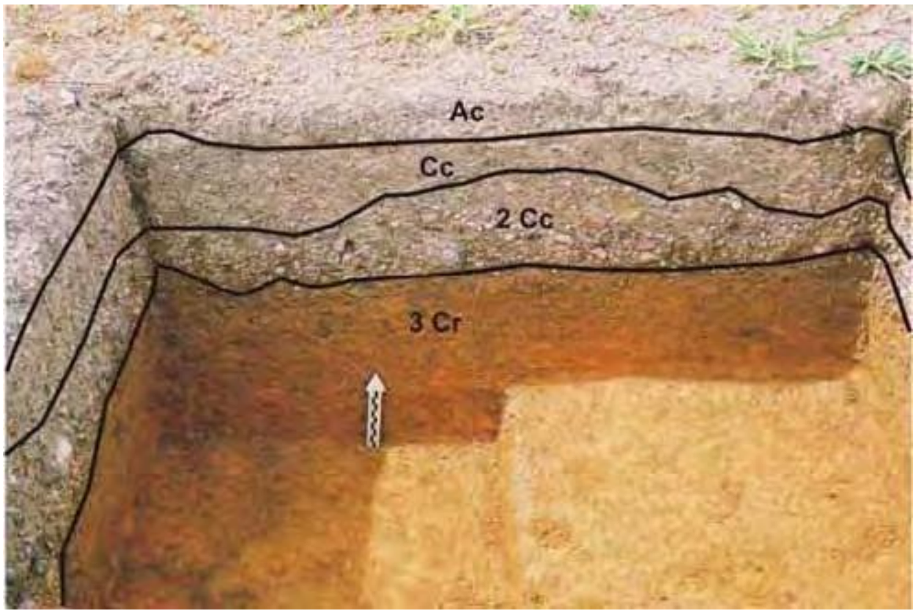

Figure 8: Soil profile of grid square NW2Q, showing horizons Ac, Cc, 2Cc and 3Cr. Concretionary Petric Plinthosol (FFc). Depth 50 cm. Source: Silva (2007)
Figura 8: *Perfil do solo da quadrícula NW2Q evidenciado os horizontes Ac, Cc, 2Cc e 3Cr. Plintossolo Pétrico Concrecionário. Profundidade 50 cm. Fonte: Silva (2007)*

Figure 9: Soil profile of grid square N13, showing horizons A; Bi; 2BC and Cr. Dystrophic Tb Haplic Cambisol (CXbd). Depth 50 cm. Source: Silva (2007)
Figura 9: *Perfil do solo da quadrícula N13 evidenciado os horizontes A; Bi; 2BC e Cr. Cambissolo Háplico Tb Distrófico (CXbd). Profundidade 50 cm. Fonte: Silva (2007)*

Figure 10: Soil profile of grid square NW2K, showing horizons Ac; BA and Bi. Dystrophic Tb Haplic Cambisol (CXbd). Depth 30 cm. Source: Silva (2007)
Figura 10: *Perfil do solo da quadrícula NW2K evidenciando os horizontes Ac; BA e Bi. Cambissolo Háplico Tb Distrófico (CXbd). Profundidade 30 cm. Fonte: Silva (2007)*

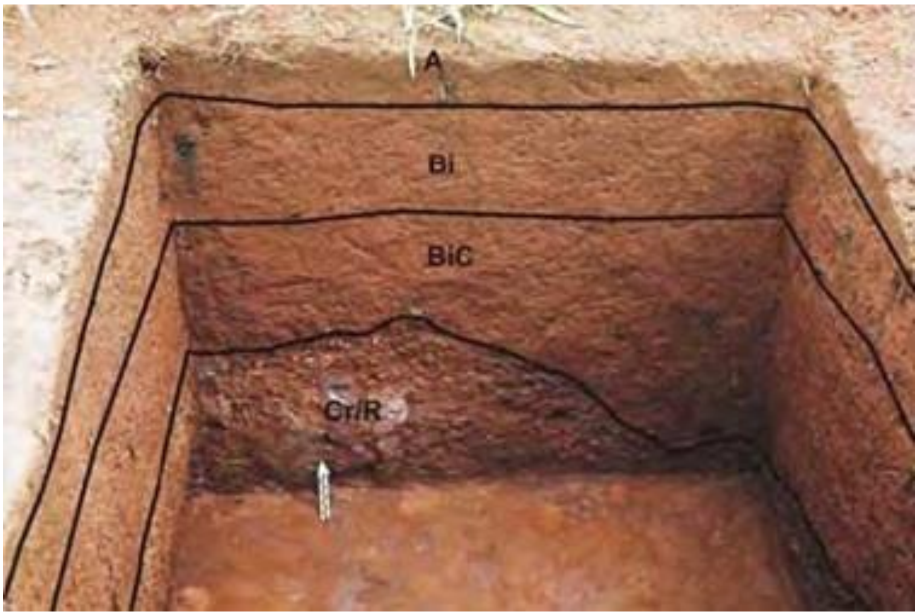

Figure 11: Soil profile of grid square A0 (Point Zero), showing horizons A; Bi; BiC and Cr/R. Dystrophic Tb Haplic Cambisol (CXbd). Depth 70 cm. Source: Silva (2007)
Figura 11: *Perfil do solo da quadrícula A0 (Ponto Zero) evidenciando os horizontes A; Bi; BiC e Cr/R. Cambissolo Háplico Tb Distrófico (CXbd). Profundidade 70 cm. Fonte: Silva (2007)*

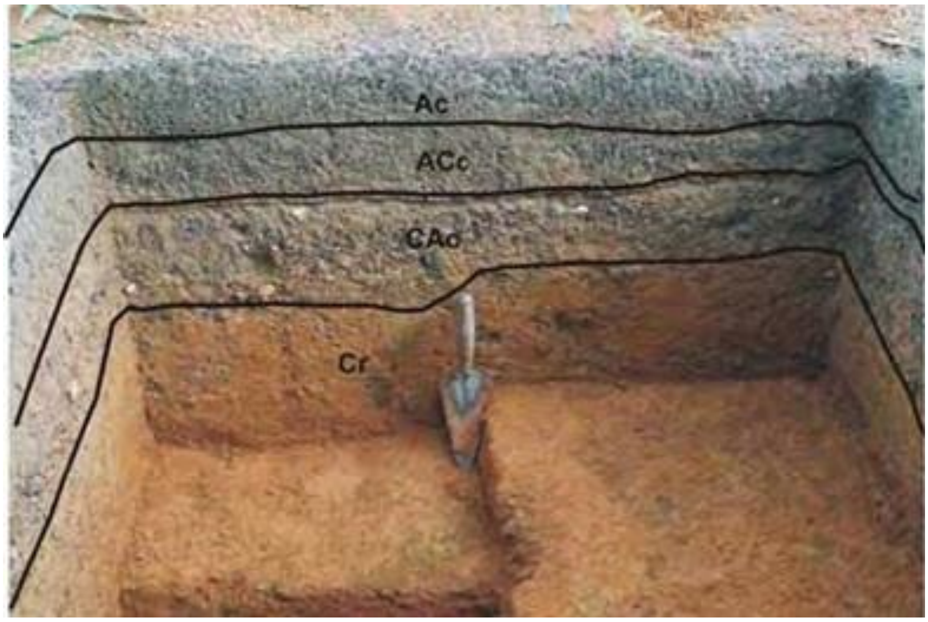

Figure 12: Soil profile of grid square SW2K, showing horizons Ac; ACc; CAc and Cr. Concretionary Petric Plinthosol (FFc). Depth 50 cm. Source: Silva (2007)
Figura 12 : *Perfil pedológico da quadrícula SW2K, indicando os horizontes Ac; ACc; CAc e Cr. Plintossolo Pétrico Concrecionário (FFc). Fonte: Silva (2007)*

Figure 13: Grid square SW4G, showing horizons A; 2Cr and R. Dystrophic Litholic Neosol (RLd). Depth 25 cm. Source: Silva (2007)
Figura 13: *Quadrícula SW4G, evidenciando os horizontes A; 2Cr e R. Neossolo Litólico Distrófico (RLd). Profundidade 25 cm. Fonte: Silva (2007)*

Figure 14: Concretionary Petric Plinthosol resulting from the modeling of the relief, rock weathering and laterization. Source: Silva (2007)
Figura 14: *Plintossolo Pétrico Concrecionário resultante do processo de modelamento do relevo, intemperismo da rocha e laterização. Fonte: Silva (2007)*

Figure 15: Detail from the previous photograph. Source: Silva (2007)
Figura 15: *Detalhe da fotografia anterior. Fonte: Silva (2007)*

Ceramic fragments were found on the surface and subsurface in horizons A; Ac and Bi of Cambisols (Figures 9, 10, 11 and 16) and on the surface in horizon A of Litholic Neosols (Figures 13 and 16). On the other hand, intentionally chipped lithic material was identified in horizons Ac; ACc of Plinthosols (Figures 8, 12 and 16), 2BC of Cambisol (Figure 9) and A of Litholic Neosols (Figures 13 and 16).

These were analyzed separately, as a function of their contexts. Some flakes found near or on the surface in Cambisol, Plinthosol and Litholic Neosol show evidence of being man-made, while others are certainly the result of pebbles, blocks and boulders transported in the relief formation process.

In this case, the key issue was determining the nature of these flakes, with special care taken in laboratory analyses to avoid classifying natural flakes (geofact) as man-made. Knowledge of flaking techniques, surface dynamics, especially colluvial processes, and the fracture patterns of minerals and rocks were vital in identifying lithic material.

Sampling performed in Cambisol showed a 2BC horizon marked by a large amount of rock fragments (quartzite and schists) and minerals (quartz and chalcedony), illustrated in Figure 9.

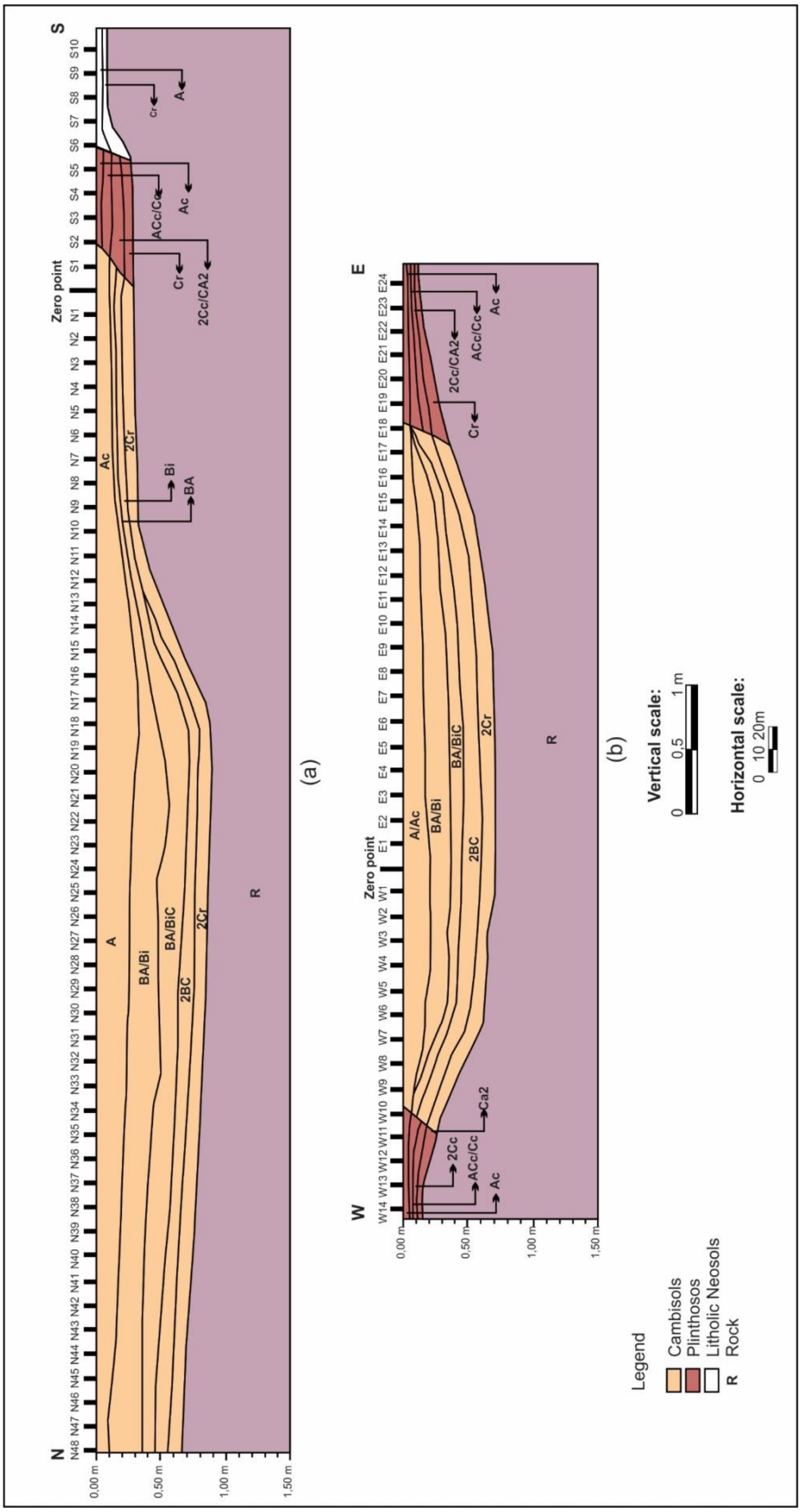

Figure 16: North/South and East/West soil profile along the excavation lines, indicating the soil horizons. Delimitation inferred. Source: Silva (2007)

***Figura 16:** Perfil do solo ao longo das linhas de escavação Norte/Sul e Leste/Oeste, indicando os horizontes do solo. Delimitação inferida. Fonte: Silva (2007)*

This horizon was generally characterized by the presence of granules, pebbles and tabular, prolate and oblate blocks (ZINGG,1935) in a matrix ranging from medium to coarse sand, with predominantly angular to sub-angular grains exhibiting low sphericity, possibly indicating little movement or *in situ* material.

Intentionally chipped lithic material was identified in Cambisol horizon 2BC in 22 grid squares, between 40 and 50 cm depth (Figure 17), primarily in the center of the excavated area, as previously mentioned. This context allowed the formulation of two main hypotheses related to environmental dynamics and the formation of the archaeological site. A major difficulty was obtaining literature references for the approach adopted. In this respect, support was found in studies by Schiffer (1987), Schaetzel (1998), Preece et al. (1998), Diehl (1998), Alexandrovskiy (2000) and Canti (2003).

Hypothesis 1: Horizon 2BC (Figure 9) is a stone layer occupied by pre-colonial groups, subsequently buried by the Cambisol. In this case, excavations using soil sampling and archaeological stratigraphy established two

Ac and Bi and the surface of horizon A of Litholic Neosols, occurred over the current structure of the area and is dated at around 1,088+/-36 years BP, as previously mentioned (Figure 16).

Hypothesis 2: Based on the possibility that Cambic horizon 2BC (Figure 16) is the result of weathered basement rock containing quartz and chalcedony veins in the form of granules, pebbles and blocks, possibly due to the tectonics of the area. In this case the lithic material was inserted into the granules, pebbles possibilities regarding prehistoric occupation of the area:

Initial occupation, characterized by lithic flakes, occurred on the stone layer represented by Cambic horizon 2BC, whose lithic material is similar to that found in Plinthic horizons Ac and ACc and horizon A of Litholic Neosols (Figure 16). This interpretation is based on the fact that during the relief-forming process, at its most intense in the formation of the São João, Volta Grande, Taboca and Sucuri mountain ranges as well as Serra Negra mountain range where the site is located, a large amount of mineral and rock fragments covered the paleosurface over the basement rock and soils, which was then covered by Cambisol also related to geomor-phogenesis. Figure 16 (b) is relevant in this context because it demonstrates that the Cambisol occurs among exposed Plinthosols. In this approach, due to the geomorphic processes that occurred in the area, Cambisol may have been removed and deposited among exposed Plinthosols and between Plinthosol and Litholic Neosol.

The second occupation, represented by ceramics at the surface and subsurface of Cambic horizons A;
and blocks *in situ* via vertical migration (see ARAUJO, 1995 and RUBIN et al., 2013). It is important to note that the lithic material was identified in the middle portion of the horizon, whose average thickness was 50 cm.

Anthropic activity, particularly the use of tillage for farming, may explain this migration; however, horizon 2BC was well-preserved and defined, with no signs of disturbance. As such, migration may also be due to bioturbation or processes involving erosion, deposition and subsequent masking.

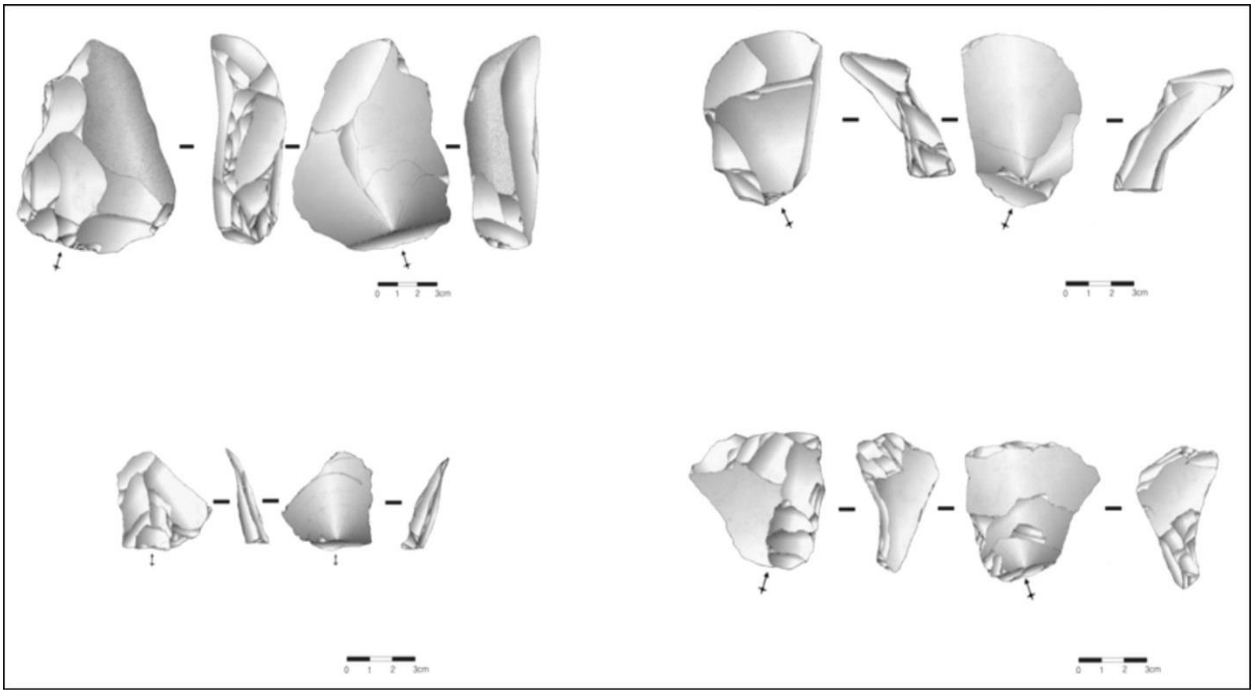

Figure 17:Typology of the flakes associated with Cambic horizon 2BC. Source: Silva (2007)
Figura 17: *Tipologia do material lítico lascado associado com o horizonte 2BC do Cambissolo. Fonte: Silva (2007)*

DISCUSSION

The discussion of the results centers on the two hypotheses formulated based on data concerning landscape evolution and compartmentalization, and particularly environmental dynamics. As previously mentioned, Hypothesis 1 is unique for the region since it takes into account the variables mentioned and lends considerable weight to the distribution of soil types and removal of Cambisol deposited on horizons 2BC. The frequent association between lithic flakes and horizon 2BC cannot be interpreted as an isolated occurrence, but rather as a pattern. As such, the investigation sought to work with the variables observed and make certain inferences. Soil profiles with prominent features were described and interpreted according to methodological criteria, supporting the suggestion that the accumulation of granules, pebbles and blocks in horizon 2BC are related to landscape evolution. This is corroborated primarily by the lithological diversity of the horizon, consistent with the lithologies identified in a 40 km radius of the site and not only the basement rock.

This preponderance of evidence in support of Hypothesis 1 is also substantiated by the distribution of cultural material, since the pattern of flakes found in horizon 2BC is similar to that found at the surface, indicating the same group may have occupied the area. In this respect, they may have witnessed the transformations that took place at the site.

The complexity of Hypothesis 1 is challenging, in which the different variables used form a complex geoarchaeological context that requiring analyzes from a multi-disciplinary perspective.

By contrast, Hypothesis 2 is conservative and represents a set of well-known archaeological processes related to the vertical migration of cultural remains, either through natural processes (bioturbation and erosion, for example) or anthropic activity (tillage, the weight of heavy machinery). Upon analysis of the spatial distribution of the grid squares in association with the lithic flakes and Cambic horizon 2BC, in the case of Hypothesis 2, it is important to consider the extent of the area in which vertical migration of archaeological remains occurred, a fact which also carries a degree of complexity in relation to a single square, for example.

Bioturbation is undoubtedly a key element in this process, which strengthens the hypothesis and should always be considered in similar situations. The unique feature of this case study is the context of the area and the Macaúba I archaeological site, which broadens the discussion and lends considerable weight to landscape evolution and dynamics. Although vertical migration is often used to explain situations such as that of Macaúba I, it should not limit new perspectives, particularly when the context of the archaeological site exhibits a number of variables and evidence to suggest new possibilities.

CONCLUSION

The geoarchaeological context of the Macaúba I archaeological site favored the formulation of the hypotheses and interpretations presented regarding the horizontal and vertical distribution of cultural remains, as well as regional and local landscape evolution and compartmentalization. Particularly prominent are the cultural remains associated with Cambic horizon 2BC, a rare occurrence, not previously reported in the region, that introduced new variables in the interpretation of similar archaeological records.

Although the limitations of the results prevented us from reaching a definitive conclusion, we feel that working with a conservative (Hypothesis 2) and more complex approach (Hypothesis 1) provides a new perspective to regional archaeology, especially in relation to Hypothesis 1, offering new possibilities for the study of open-air sites in the Cerrado biome and highlighting the importance of interdisciplinary research.

Both hypotheses were investigated with the precision and independence that scientific thinking demands. A comparison of the two approaches clearly establishes the complexity of Hypothesis 1, which is supported by paleoenvironmental elements and based primarily on landscape compartmentalization and dynamics.

The unique features identified at Macaúba I archaeological site may also favor the review of results from other excavations with similar contexts which, in many cases, were halted once horizon 2BC was identified, interpreted as the result of rock alteration. The basic function of new approaches is to provide support for further research, often by breaking paradigms.

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